CLASSIFICATION

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The outline classification presented below is principally of fossil sponges treated in this volume. It summarizes taxonomic relationships and presents stratigraphic ranges of the various taxa. Numbers in parentheses indicate the number of recognized fossil genera in each suprageneric group, from family to class, with the number of subgenera included being the second number, listed after the semicolon. Because some differences in taxonomic approaches exist between sections in this volume, particularly in dealing with the Demospongea, the classification below should be considered as a work in progress. It does not necessarily reflect systematic concepts presented in chapters written by R. E. H. Reid or R. M. Finks.

The order of taxa in the outline represents taxonomic relationships and may be different from the order presented in the systematic sections because taxa in those sections are generally separated into Paleozoic and Mesozoic-Cenozoic occurrences. As a result, some major categories may be represented in two or three systematic sections. For example, the section treating hypercalcified sponges documents sponges strictly included in the class Calcarea and also some demosponges (noted by the symbol ** after the stratigraphic ranges) that have calcareous skeletons. In other sections, a family with a long stratigraphic range may be represented in both Paleozoic and Mesozoic sections or chapters where those demosponges or hexactinellid sponges are treated (marked by the symbol †). Question marks on some geologic ages indicate questionable occurrences of that taxon in rocks of that age.

Phylum Porifera Grant, 1836 (1,183;30). Cryogenian–Holocene.
- Class Demospongea Sollas, 1875 (615;11). Cryogenian–Holocene.
  - Subclass Clavaxinellida Lévi, 1956 (54). Cryogenian–Holocene.
    - Order Protomonaxonida Finks & Rigby, herein (39). Cryogenian–Holocene.
      - Family Leptomitidae de Laubenfels, 1955 (4). Cambrian–Silurian.
      - Family Sinospongiidae Finks & Rigby, herein (1). Cryogenian–Ediacaran.
      - Family Hamptoniidae de Laubenfels, 1955 (4). Middle Cambrian–Middle Ordovician.
      - Family Ulospongiellidae Rigby & Collins, 2003 (2). Middle Cambrian.
      - Family Choiidae de Laubenfels, 1955 (4). Lower Cambrian–Middle Cambrian.
      - Family Wapkiidae de Laubenfels, 1955 (1). Middle Cambrian.
      - Family Halichondritidae Rigby, 1986 (2). ?Middle Cambrian, Upper Cambrian–Carboniferous (Serpukhovian).
      - Family Piraniidae de Laubenfels, 1955 (2). Middle Cambrian.
      - Family Sollasellidae von Lendenfeld, 1887 (7). Devonian (Lochkovian)–Holocene.
      - Family Tethyidae Gray, 1867 (1). ?Paleogene, Holocene.
      - Family Hazeliidae de Laubenfels, 1955 (4). Middle Cambrian–Lower Devonian.
      - Family Takakkawiidae de Laubenfels, 1955 (1). Middle Cambrian.
      - Family Mahalospongiidae Rigby & Stuart, 1988 (1). Silurian–Devonian.
      - Family Heliospongiidae Finks, 1960 (5). Carboniferous (Middle Pennsylvanian)–Permian (Changhsingian).
    - Order Clavulina Vosmaer, 1887 (15). Ordovician–Holocene.
      - Family Clionaidae Gray, 1867 (9). Ordovician–Holocene.
      - Family Adociidae de Laubenfels, 1936 (1). Triassic (Carnian)–Holocene.
      - Family Spirastrellidae Hentschel, 1909 (2). Paleogene–Holocene.
      - Family Suberitidae Ridley & Dendy, 1886 (3). Cretaceous–Holocene.
  - Subclass Choristida Sollas, 1880 (52;2). Ordovician–Holocene.
    - Order Plakinida Reid, 1968 (5). ?Upper Jurassic, Lower Cretaceous (?Albian), Upper Cretaceous (?Cenomanian–?Santonian, Campanian)–Holocene.
      - Family Plakinidae Schulze, 1880 (3). Lower Cretaceous (?Albian), Paleogene (upper Eocene)–Holocene.
      - Family Thrombidae Sollas, 1887 (1). ?Upper Cretaceous, Paleogene (upper Eocene)–Holocene.
      - Family Acanthastrellidae Schrammen, 1924 (1). ?Upper Jurassic, Upper Cretaceous (Campanian).

Order Pachastrellida Reid, herein (13). Carboniferous–Holocene.
Family Pachastrellidae Carter, 1875 (10). Carboniferous (Mississippian)–Holocene.
Subfamily Pachastrellinae Carter, 1875 (2). Carboniferous (?Mississippian), ?Jurassic, ?Cretaceous, Paleogene (?upper Eocene), Holocene.
Subfamily Calthropellinae von Lendenfeld, 1907 (1). ?Cretaceous, Holocene.
Subfamily Halininae de Laubenfels, 1934 (2). Lower Cretaceous (?Albian), Paleogene (upper Eocene–Holocene.
Subfamily Uncertain (5).
Family Costamorphiidae Mostler, 1986 (1). Upper Triassic.
Family Theneidae Gray, 1872 (2). Upper Cretaceous (?Turonian, Coniacian)–Holocene.
Order Ancorinida Reid, 1968 (19;2). Carboniferous (Mississippian)–Holocene.
Family Ancorinidae Schmidt, 1870 (6). Jurassic–Holocene.
Subfamily Ancorininae Schmidt, 1870 (3). Jurassic–Holocene.
Subfamily Stellettinae Carter, 1875 (3). ?lower Lower Jurassic, Cretaceous (?Albian, Turonian)–Holocene.
Family Geodiidae Gray, 1867 (11;2). Carboniferous (Mississippian)–Holocene.
Subfamily Geodiinae Gray, 1867 (9). Carboniferous (Mississippian)–Holocene.
Subfamily Erylinae Sollas, 1888 (2;2). Upper Jurassic–Holocene.
Family Paelospongiidae Mostler, 1986 (2). Upper Triassic.
Order Craniellida Reid, 1968 (2). Upper Cretaceous (Campanian)–Holocene.
Family Tetillidae Sollas, 1886 (2). Upper Cretaceous (Campanian)–Holocene.
Order Uncertain (13).
Family Cephaloraphiditidae Reid, 1968 (7). Jurassic–Neogene.
Family Helminthophyllidae Schrammen, 1936 (1). Upper Jurassic (Kimmeridgian).
Family Scolioraphididae Zittel, 1879 (2). Cretaceous.
Family Uncertain (3).
Subclass Tetractinomorpha Lévi, 1953 (30). Ordovician–Holocene.
Order Streptosclerophorida Dendy, 1924 (13). Middle Ordovician–Permian (Lopingian).
Suborder Eutaxicladina Rauff, 1894 (13). Middle Ordovician–Permian (Lopingian).
Family Hindiidae Rauff, 1893 (13). Middle Ordovician–Permian (Changhsingian).
Order Hadromerida Topsent, 1898** (17). Permian–Triassic.
Family Celyphiidae de Laubenfels, 1955** (13). Permian (Guadalupian)–Cretaceous.
Family Ceotinellidae Senowbari-Daryan, 1978** (1). Triassic (Ladinian–Carnian).
Family Polysiphonidae Girty, 1909** (3). Permian–Triassic.
Subclass Ceractinomorpha Lévi, 1953 (479;9). Cambrian–Holocene.
Order Dictyoceratida Minchin, 1900 (5). Lower Jurassic–Holocene.
Family Spongiidae Gray, 1867 (1). Holocene.
Family Dysideidae Gray, 1867 (3). Lower Jurassic–Holocene.
Family Uncertain (1).
Order Dendroceratida Minchin, 1900 (0). Holocene.
Order Verongida Bergquist, 1978 (3). Middle Cambrian–Holocene.
Family Verongiidae de Laubenfels, 1936 (2). Middle Carboniferous–Holocene.
Family Vauxiidae Walcott, 1920 (1). Middle Cambrian.
Order Halichondrida Topsent, 1898 (2). Paleogene (Oligocene)–Holocene.
Family Halichondriidae Gray, 1867 (1). Holocene.
Family ?Hymeniacidonidae de Laubenfels, 1936 (1). Paleogene (Oligocene)–Neogene (Miocene).
Order Poecilosclerida Topsent, 1928 (16). Cretaceous–Holocene.
Family Myxillidae Hentschel, 1923 (3). Paleogene–Holocene.
Family Tedaniidae Ridley & Dendy, 1886 (4). Paleogene–Holocene.
Family Cladorhizidae de Laubenfels, 1936 (2). Paleogene–Holocene.
Family Amphilectidae de Laubenfels, 1936 (2). Paleogene–Holocene.
Family Latrunculiidae Topsent, 1922 (1). Paleogene–Holocene.
Family Acarniidae de Laubenfels, 1936 (2). Cretaceous–Holocene.
Family Uncertain (2).
Order Haplosclerida Topsent, 1898 (18). Jurassic–Holocene.
Family Spongillidae Gray, 1867 (10). Jurassic–Holocene.
Family Haliclonidae de Laubenfels, 1932 (2). Paleogene (?Eocene), Holocene.
Family Petrosiidae Van Soest, 1980 (2). Paleogene (Eocene)–Holocene.
Family Desmacidonidae Gray, 1867 (2). Paleogene–Holocene.
Family Uncertain (2).

Order Agelasida Verrill, 1907** (145). Ordovician–Triassic.
Family Catenispongiidae Finks, 1995** (4). Permian (Artinskian)–Triassic.
Family Virgolidae Termier, Termier, & Vachard, 1977** (14). Permian–Triassic.
Subfamily Virgolinae Termier & Termier, 1977** (6). Permian (Kungurian)–Triassic.
Subfamily Preeudinae Senowbari-Daryan, 1996** (6). Permian (Kungurian–Changhsingian).
Subfamily Pseudohimatellinae Rigby & Senowbari-Daryan, 1996** (1). Permian.
Subfamily Parahimatellinae Rigby & Senowbari-Daryan, 1996** (1). Permian (Lopingian).
Family Sphaeropontiidae Rigby & Senowbari-Daryan, 1996** (1). Permian (Lopingian).
Family Exotubispongiidae Rigby & Senowbari-Daryan, 1996 (1). Permian (Lopingian).
Family Sestrostomellidae de Laubenfels, 1955** (8). Triassic–Lower Cretaceous.
Family Pharetrospongiidae de Laubenfels, 1955** (9). Permian (Guadalupian)–Cretaceous.
Subfamily Pharetrospongiinae de Laubenfels, 1955** (2). Triassic (Carnian)–Cretaceous.
Subfamily Leiofungiinae Finks & Rigby, herein** (7). Permian (Guadalupian)–Cretaceous.
Family Auriculospongiidae Termier & Termier, 1977** (9). Permian (Asselian–Changhsingian).
Subfamily Auriculospongiinae Termier & Termier, 1977** (3). Permian (Asselian–Changhsingian).
Subfamily Daharellinae Rigby & Senowbari-Daryan, 1996** (1). Permian (Changhsingian).
Subfamily Gigantospongiinae Rigby & Senowbari-Daryan, 1996** (1). Permian (Guadalupian).
Subfamily Spinospongiinae Rigby & Senowbari-Daryan, 1996** (1). Permian (Changhsingian).
Subfamily Acoeliinae Wu, 1991** (3). Permian (Guadalupian–Lopingian).
Family Stellispongiellidae Wu, 1991** (3). Permian (Guadalupian)–Triassic (Norian).
Subfamily Stellispongiellinae Wu, 1991** (1). Permian (Guadalupian)–Triassic (Norian).
Subfamily Prestellispongiinae Rigby & Senowbari-Daryan, 1996** (1). Permian (Lopingian).
Subfamily Estrellospongiinae Rigby & Senowbari-Daryan, 1996** (1). Permian (Lopingian).
Family Preperonidellidae Finks & Rigby, herein** (14). Upper Ordovician–Upper Triassic.
Subfamily Preperonidellinae Finks & Rigby, herein** (3). Permian (Guadalupian)–Upper Triassic.
Subfamily Permocorynellinae Rigby & Senowbari-Daryan, 1996** (3). Permian (Lopingian)–Upper Triassic.
Subfamily Precorynellinae Termier & Termier, 1977** (6). Upper Ordovician–Upper Triassic.
Subfamily Heptatubispongiinae Rigby & Senowbari-Daryan, 1996** (2). Permian (Lopingian)–Upper Triassic.
Family Fissispongiidae Finks & Rigby, herein** (2). Devonian (Eifelian)–Permian.
Family Maeandrostiidae Finks, 1971** (6). Carboniferous (Middle Pennsylvanian)–Triassic.
Family Angullongiidae Webby & Rigby, 1985** (5). upper Lower Ordovician–upper Upper Ordovician.
Family Phragmocoeliidae Ott, 1974** (2). Devonian (Lochkovian)–Triassic (Carnian).
Family Intrasporeocoeliidae Finks & Rigby, herein** (4). Permian (Guadalupian–Lopingian).
Family Cryptocoeliidae Steinmann, 1882** (5). Silurian (Ludlow)–Upper Triassic.
Family Palermocoeliidae Senowbari-Daryan, 1990** (1). Upper Triassic.
Family Girtyocoeliidae Finks & Rigby, herein** (9). Ordovician–Triassic.
Family Thaumastocoeliidae Ott, 1967** (7). Middle Ordovician–Triassic.
Family Aphrosalpingidae Myagkova, 1955** (10). upper Upper Ordovician–Triassic.
Subfamily Fistulosponginae Termier & Termier, 1977** (5). upper Upper Ordovician–Permian (Lopingian).
Subfamily Vesicocauliinae Senowbari-Daryan, 1990** (4). Triassic.
Subfamily Palaeoschadinae Myagkova, 1955** (1). Silurian (Ludlow).
Family Glomocystospongiidae Rigby, Fan, & Zhang, 1989** (2). Permian (Lopingian).
Family Sebargasiidae de Laubenfels, 1955** (13). ?Ordovician, Carboniferous–Triassic.
Family Olangocoeliidae Bechstädt & Brandner, 1970** (1). Middle Triassic.
Family Cliefdenellidae Webby, 1969** (3). Middle Ordovician–Upper Ordovician.
Family Girtycoeliidae Finks & Rigby, herein** (2). Carboniferous (Upper Pennsylvanian)–Triassic.
Family Guadalupiidae Girty, 1909** (7). Carboniferous–Triassic (Norian).
Family Uncertain** (3).

Order Vaceletida Finks & Rigby, herein** (51). Lower Cambrian–Holocene.
Family Solenolmiidae Engesser, 1986** (13). Lower Cambrian–Triassic, ?Jurassic.
Subfamily Solenolmiinae Senowbari-Daryan, 1990** (12). Lower Cambrian–Triassic, ?Jurassic.
Subfamily Battagliinae Senowbari-Daryan, 1990** (1). Triassic (Norian–Rhaetian).
Family Colospongiidae Senowbari-Daryan, 1990** (13). Lower Cambrian–Triassic.
Subfamily Colospongiinae Senowbari-Daryan, 1990** (6). Lower Cambrian–Triassic.
Subfamily Corymbospongiinae Senowbari-Daryan, 1990** (7). ?Lower Ordovician–?Middle Ordovician, upper Upper Ordovician–Triassic (Rhaetian).
Family Gigantothalamiidae Senowbari-Daryan, 1990** (2). Upper Triassic.
Family Tebagathalamiidae Senowbari-Daryan & Rigby, 1988** (3). Permian–Triassic.
Family Cheilosporitiidae Fischer, 1962** (1). Triassic (Carnian–Rhaetian).
Family Salzburgiidae Senowbari-Daryan & Schäfer, 1979** (1). Permian–Triassic (Rhaetian).
Family Cribrothalamiidae Senowbari-Daryan, 1990** (1). Triassic (Norian–Rhaetian).
Family Verticillitidae Steinmann, 1882** (16). Permian (Guadalupian)–Holocene.
Subfamily Verticillitinae Steinmann, 1882** (9). Permian (Guadalupian)–Holocene.
Subfamily Polytholosiinae Seilacher, 1962** (4). Permian (?Lopingian), Triassic.
Subfamily Fanthalamiinae Senowbari-Daryan, 1990** (2). Triassic (Carnian–Norian, ?Rhaetian).
Subfamily Polysiphospongiinae Senowbari-Daryan, 1990** (1). Triassic (Norian–Rhaetian).
Family Uncertain** (1).
Order Sigmatosclerophorida Burton, 1956 (4). Lower Ordovician–Upper Ordovician.
Family Dystactospongiidae Miller, 1889 (4). Lower Ordovician–Upper Ordovician.
Subclass Lithistida Schmidt, 1870 (114). Cambrian–Permian (Lopingian).
Order Orchocladina Rauff, 1895 (114). Middle Cambrian–Permian (Lopingian).
Family Anthaspidellidae Miller, 1889 (63). Middle Cambrian–Permian (Lopingian).
Family Streptosolenidae Johns, 1994 (17). Upper Cambrian–Silurian.
Family Chiastoclonellidae Rauff, 1895 (8). Silurian (Wenlock)–Permian (Lopingian).
Family Anthracosyconidae Finks, 1960 (5). Lower Devonian–Permian (Capitanian).
Family Astylospongiidae Zittel, 1877 (21). Upper Ordovician–Permian (Roadian).
Order Tetralithistida Lagneau-Hérenger, 1962 (93;9). Upper Triassic (Norian)–Holocene.
Suborder Tetracladina Zittel, 1878 (70;9). Upper Triassic (Norian)–Holocene.
Family Radiocelliidae Senowbari-Daryan and Wurm, 1994 (1). Upper Triassic (Norian).
Family Protetraclisidae Schrammen, 1924 (3). Jurassic (Kimmeridgian).
Family Siphoniidae d'Orbigny, 1849 (27;4). Jurassic–Holocene.
Subfamily Siphoniinae d'Orbigny, 1849 (10;4). Jurassic–Holocene.
Subfamily Phymatellinae Schrammen, 1910 (14). Upper Jurassic–Cretaceous.
Subfamily Lerouxiinae Moret, 1926 (3). Upper Cretaceous (Cenomanian–Campanian).
Family Astrocladiidae Schrammen, 1901 (2). Upper Cretaceous (Cenomanian–Maastrichtian).
Family Phymaraphiniidae Schrammen, 1910 (7;3). Lower Cretaceous (Aptian)–Upper Cretaceous.
Family Theonellidae von Lendenfeld, 1904 (21;2). Cretaceous–Holocene.
Subfamily Theonellinae von Lendenfeld, 1904 (8). Lower Cretaceous (Aptian)–Holocene.
Subfamily Acrochordoniinae Schrammen, 1910 (7;2). Cretaceous–Neogene (Miocene).
Subfamily Phymaplectiinae Reid, herein (2). Upper Cretaceous (Coniacian)–Paleogene (Eocene).
Subfamily Uncertain (4).
Family Plinthosellidae Schrammen, 1910 (3). Cretaceous (Albian–Campanian).
Family Chenendoporidae F. A. Roemer, 1864 (4). Cretaceous (Aptian–Maastrichtian), Paleogene (?Eocene).
Family Uncertain (2).
Suborder Dicranocladina Schrammen, 1924 (16). Upper Jurassic (upper Oxfordian)–Holocene.
Family Corallistidae Sollas, 1888 (15). Upper Jurassic (upper Oxfordian)–Holocene.
Subfamily Corallistinae Sollas, 1888 (6). Upper Jurassic (upper Oxfordian)–Holocene.
Subfamily Gignouxiinae de Laubenfels, 1955 (8). Cretaceous (Aptian)–Neogene (Miocene).
Subfamily Pachinioninae Schrammen, 1924 (1). Cretaceous (Aptian–Campanian).
Family Pseudoverruculinidae de Laubenfels, 1955 (1). Cretaceous (Aptian–Santonian).
Suborder Pseudorhizomorina Schrammen, 1901 (2). Cretaceous–Holocene.
Family Macandrewiidae Gray, 1859 (1). ?Upper Cretaceous, Holocene.
Family Neopeltidae Sollas, 1888 (1). Cretaceous– Holocene.
Suborder Didymmorina Rauff, 1893 (5). Middle Jurassic–Upper Jurassic (Kimmeridgian).
Family Cylindrophymatidae Schrammen, 1924 (5). Middle Jurassic–Upper Jurassic (Kimmeridgian).

Order Megalithistida Reid, herein (28). Lower Ordovician–Holocene.
Suborder Helomorina Schrammen, 1924 (6). Upper Jurassic (Kimmeridgian)–Cretaceous (Maastrichtian).
Family Carterellidae Schrammen, 1901 (6). Upper Jurassic (Kimmeridgian)–Cretaceous (Maastrichtian).
Subfamily Carterellinae Schrammen, 1901 (3). Cretaceous (Albian–Maastrichtian).
Subfamily Isoraphiniinae Schrammen, 1924 (3). Upper Jurassic (Kimmeridgian)–Cretaceous (Maastrichtian).
Suborder Megamorina Zittel, 1878 (22). Lower Ordovician–Holocene.
Family Archaeodorydermatidae Reid, 1968 (1). Carboniferous (Visean).
Family Saccospongiidae Rigby & Dixon, 1979 (6). Lower Ordovician–Silurian (Ludlow, ?Pridoli).
Family Nexospongiidae Carrera, 1996 (1). Lower Ordovician.
Family Pleromatidae Sollas, 1888 (14). Carboniferous (?Mississippian), Upper Jurassic (Kimmeridgian)–Holocene.
Subfamily Pleromatinae Sollas, 1888 (7). Carboniferous (?Mississippian), Cretaceous (Albian)–Holocene.
Subfamily Heterostiniinae Schrammen, 1924 (7). Upper Jurassic (Kimmeridgian)–Upper Cretaceous (Campanian).
Order Axinellida Bergquist, 1967 (1). Permian–Holocene.
Family Axinellidae Verrill, 1907 (0). Holocene.
Family Agelasidae Verrill, 1907 (1). Permian.
Order Monalithistida Lagneau-Hérenger, 1955 (18). Lower Jurassic (Pliensbachian)–Holocene.
Suborder Megarhizomorina Schrammen, 1924 (2). Upper Cretaceous (Cenomanian–Campanian).
Family Megarhizidae Schrammen, 1901 (2). Upper Cretaceous (Cenomanian–Campanian).
Suborder Sphaerocladina Schrammen, 1910 (16). Lower Jurassic (Pliensbachian)–Holocene.
Family Vetulinidae von Lendenfeld, 1904 (11). Middle Jurassic (Bathonian)–Holocene.
Subfamily Vetulininae von Lendenfeld, 1904 (9). Middle Jurassic (Bathonian)–Holocene.
Subfamily Macrobrochinae Reid, herein (2). Upper Cretaceous (Santonian–Campanian).
Family Lecanellidae Schrammen, 1924 (4). Upper Jurassic (Oxfordian)–Upper Cretaceous.
Family Uncertain (1).
Order Uncertain (7).
Family Criccospongiidae Mostler, 1986 (1). Triassic.
Family Uncertain (6).
Order Spirosclerophorida Reid, 1963 (114;9). Middle Cambrian–Holocene.
Suborder Rhizomorina Zittel, 1895 (88;9). Middle Cambrian–Holocene.
Family Haplistiidae de Laubenfels, 1955 (18). Lower Ordovician–Permian.
Family Uncertain (1).
Superfamily Azoricoidea Sollas, 1888 (29;2). Upper Jurassic–Holocene.
Family Azoricidae Sollas, 1888 (25). Upper Jurassic–Holocene.
Subfamily Azoricinae Sollas, 1888 (7). Cretaceous (Aptian)–Holocene.
Subfamily Cytoraciinae Schrammen, 1924 (3). Upper Jurassic–Neogene (Miocene).
Subfamily Aulosominae Schrammen, 1924 (6). Upper Jurassic–Upper Cretaceous (Campanian).
Subfamily Leiochoniinae Schrammen, 1924 (3). Cretaceous (Aptian–Campanian).
Subfamily Astroboliinae de Laubenfels, 1955 (5). Upper Jurassic–Upper Cretaceous (Maastrichtian).
Subfamily Siphonidiinae von Lendenfeld, 1904 (1). Cretaceous (Campanian).
Family Cnemidiastridae Schrammen, 1924 (4;2). Upper Jurassic (Oxfordian)–Neogene (Miocene).
Superfamily Platychonioidea Schrammen, 1924 (12;2). Jurassic–Holocene.
Family Platychoniidae Schrammen, 1924 (5). Jurassic–Holocene.
Family Discostromatidae Schrammen, 1924 (6;2). Jurassic.
Subfamily Discostromatinae Schrammen, 1924 (4). Upper Jurassic (Oxfordian–Kimmeridgian).
Subfamily Pyrgochoniinae Schrammen, 1924 (2;2). Upper Jurassic.
Family Aretotragosidae Malecki, 1966 (1). Jurassic.
Superfamily Scleritodermatoidea Sollas, 1888 (28;5). Upper Jurassic (Callovian)–Holocene.
Family Scleritodermatidae Sollas, 1888 (8;5). Upper Jurassic (Oxfordian)–Holocene.
Subfamily Scleritodermatinae Sollas, 1888 (1). ?Cretaceous, Holocene.
Subfamily Leiodorellinae Schrammen, 1924 (2). Upper Jurassic (Oxfordian–Kimmeridgian).
Subfamily Amphithelioninae Schrammen, 1924 (4;5). Cretaceous–Neogene (Miocene).
Subfamily Uncertain (1).
Family Jereicidae Schrammen, 1924 (5). Upper Jurassic (Callovian)–Holocene.
Family Seliscothonidae Schrammen, 1924 (9). Cretaceous (Aptian)–Holocene.
Family Uncertain (6).
Suborder Uncertain (26).

Class Hexactinellida Schmidt, 1870 (432;19). Lower Cambrian–Holocene.
Subclass Amphidiscophora Schulze, 1887 (160). Lower Cambrian–Holocene.
Order Amphidiscosa Schrammen, 1924 (41). Lower Cambrian–Holocene.
Family Hyalonematidae Gray, 1857 (1).Cretaceous (Turonian)–Holocene.
Family Pattersoniidae Miller, 1889 (3). Middle Ordovician–Upper Ordovician.
Family Pelicaspongiidae Rigby, 1970 (24). Lower Ordovician (Tremadocian)–Triassic (Carnian).
Family Stiodermatidae Finks, 1960 (13). Lower Cambrian–Permian.
Order Reticulosa Reid, 1958 (118). Ediacaran–Holocene.
Superfamily Protospongioidea Hinde, 1887 (20). Lower Cambrian–Jurassic.
Family Protospongiidae Hinde, 1887 (20). Lower Cambrian–Jurassic.
Superfamily Dierespongioidea Rigby & Gutschick, 1976 (24). Middle Cambrian–Holocene.
Family Dierespongiidae Rigby and Gutschick, 1976 (6). Middle Ordovician–Permian (Artinskian).
Family Hydnodictyidae Rigby, 1971 (2). Middle Cambrian–Upper Ordovician.
Family Amphispongiidae Rauff, 1894 (1). upper Silurian.
Family Multivasculatidae de Laubenfels, 1955 (1). Upper Cambrian.
Family Titusvillidae Caster, 1939 (6). Upper Devonian–Holocene.
Family Aglithodictyidae Hall & Clarke, 1899 (8). Upper Devonian–Carboniferous (Visean).
Superfamily Dictyospongioidea Hall & Clarke, 1899 (62). Ediacaran–Upper Triassic (Carnian).
Family Dictyospongiidae Hall & Clarke, 1899 (55). Ediacaran–Permian (Roadian).
Subfamily Dictyospongiinae Hall & Clarke, 1899 (17). Ediacaran–Permian (Roadian).
Subfamily Prismodictyinae de Laubenfels, 1955 (8). Upper Ordovician–Carboniferous (Serpukhovian).
Subfamily Hydnoceratinae Finks, herein (10). Middle Cambrian–Carboniferous (Lower Mississippian).
Subfamily Calathospongiinae Hall & Clarke, 1899 (9). Upper Devonian–Carboniferous (Serpukhovian).
Subfamily Physospongiinae Hall & Clarke, 1899 (4). Middle Devonian–Carboniferous (Lower Mississippian).
Subfamily Thysanodictyinae Hall & Clarke, 1899 (7). Devonian (Frasnian)–Carboniferous (Serpukhovian).
Family Dododermatidae Finks, 1960 (5). Silurian (Ludlow)–Permian (Roadian, ?Wordian–?Capitanian).
Family Stereodictyidae Finks, 1960 (2). Carboniferous (Visean)–Upper Triassic (Carnian).
Superfamily Hintzespongioidea Finks, 1983 (12). Lower Cambrian–Carboniferous (Upper Mississippian).
Family Hintzespongiidae Finks, 1983 (5). Lower Cambrian–Devonian (Givetian).
Family Teganiidae de Laubenfels, 1955 (7). Cambrian (Furongian)–Carboniferous (Upper Mississippian).
Order Hemidiscosa Schrammen, 1924 (1). Carboniferous (Upper Pennsylvanian).
Family Microhemidisciidae Finks & Rigby, herein (1). Carboniferous (Upper Pennsylvanian).
Subclass Hexasterophora Schulze, 1887 (272;19). Ordovician–Holocene.
Order Lyssacinosa Zittel, 1877 (36). Ordovician–Holocene.
Family Pheronematidae Gray (2). ?Upper Jurassic, Cretaceous–Holocene.
Family Euplectellidae Gray, 1867 (11). Lower Triassic–Holocene.
Subfamily Euplectellinae Ijima, 1903 (1). Holocene.
Subfamily Taegerinae Schulze, 1887 (8). Lower Triassic–Holocene.
Subfamily Uncertain (2).
Family Asemematidae Schulze, 1887 (1). Paleogene (?middle Eocene), Holocene.
Subfamily Asemematinae Schulze, 1887 (0). Holocene.
Subfamily Caulophacinae Schulze, 1887 (1). Paleogene (?middle Eocene), Holocene.
Family Rossellidae Schulze, 1887 (1). ?Paleogene–?Neogene, Holocene.
Subfamily Rossellinae Schulze 1887 (1). ?Paleogene–?Neogene, Holocene.
Family Stauractinellidae de Laubenfels, 1955 (1). Jurassic (Oxfordian)–Neogene.
Family Leucopsacidae Ijima, 1903 (1). Paleogene (Eocene).
Family Uncertain (6).
Superfamily Crepospongioidea Finks and Rigby, herein (1). Triassic (Carnian).
Family Crepospongiidae Finks and Rigby, herein (1). Triassic (Carnian).
Superfamily Brachiospongioidea Beecher, 1889 (11). Upper Ordovician–Permian (Guadalupian).
Family Brachiospongiidae Beecher, 1889 (4). Upper Ordovician–Silurian (Ludlow).
Family Pyruspongiidae Rigby, 1971 (1). Upper Ordovician.
Family Malumispongiidae Rigby, 1967 (5). Upper Ordovician–Carboniferous (lower Tournaisian).
Family Toomeyospongiidae Finks, herein (1). Permian (Guadalupian).
Superfamily Lumectospongioidea Rigby & Chatterton, 1989 (1). Silurian (Ludlow).
Family Lumectospongiidae Rigby & Chatterton, 1989 (1). Silurian (Ludlow).

Order Hexactinosa Schrammen, 1903 (134;8). Upper Ordovician–Holocene.
- Family Euryplegmatidae de Laubenfels, 1955 (1). ?Cretaceous, Holocene.
- Family Farreidae Schulze, 1885 (4;1). Cretaceous (Turonian)–Holocene.
- Family Euretidae† Zittel, 1877 (38;2). Triassic (Carnian)–Holocene.
  - Subfamily Euretinae Zittel, 1877 (23;2). Triassic (Carnian)–Holocene.
  - Subfamily Polythyridinae Schrammen, 1912 (2). ?Lower Cretaceous, Upper Cretaceous–Holocene.
  - Subfamily Pseudobecksiinae Reid, herein (1). Cretaceous (Coniacian–Maastrichtian).
  - Subfamily Chonelasmatinae Schrammen, 1912 (9). Jurassic (Oxfordian)–Holocene.
  - Subfamily Uncertain (1).
- Family Craticulariidae† Rauff, 1893 (30). Triassic (Carnian)–Holocene.
  - Subfamily Craticulariinae Rauff, 1893 (8). Triassic–Paleogene (Thanetian).
  - Subfamily Laocoetidinae de Laubenfels, 1955 (6). Triassic (Carnian)–Neogene (Miocene, ?Pliocene).
  - Subfamily Leptophragmatinae Schrammen, 1912 (7). ?Jurassic, Cretaceous (?Berriasian–?Aptian, Albian)–Holocene.
  - Subfamily Caseariinae Schrammen, 1936 (5). Triassic (Carnian)–Upper Jurassic.
  - Subfamily Uncertain (4).
- Family Cribrospongiidae F. A. Roemer, 1864 (15;3). Middle Triassic–Holocene.
- Family Staurodermatidae Zittel, 1877 (6). Jurassic–Neogene.
- Family Aphrocallistidae Gray, 1867 (1). Lower Cretaceous–Holocene.
- Family Tretodictyidae Schulze, 1887 (9;2). Upper Jurassic–Holocene.
  - Subfamily Tretodictyinae Schulze, 1887 (7;2). Upper Jurassic–Holocene.
  - Subfamily Placotrematinae Reid, herein (2). Cretaceous (Turonian).
- Family Cystispongiidae Reid, herein (1). Upper Cretaceous (Coniacian)–Neogene.
- Family Aulocalycidae Ijima, 1927 (1). Upper Jurassic.
- Family Emplocidae de Laubenfels, 1955 (1). Middle Jurassic.
- Family Uncertain (16).
- Superfamily Pillaraspongioidea Rigby, 1986 (1). Devonian (Frasnian–Famennian).
  - Family Pillaraspongiidae Rigby, 1986 (1). Devonian (Frasnian–Famennian).
- Superfamily Pileolitoidea Finks, 1960 (9;1). Upper Ordovician–Holocene.
  - Family Pileolitidae Finks, 1960 (2). Permian (?Asselian–?Sakmarian, Artinskian)–Middle Triassic.
  - Family Wareembaiidae Finks & Rigby, herein (2). Upper Ordovician.
  - Family Euretidae† Zittel, 1877 (2). Upper Devonian (Frasnian).
  - Family Craticulariidae† Rauff, 1893 (5). Upper Devonian.
  - Family Pileospongiidae Rigby, Keyes, & Horowitz, 1979 (1). Carboniferous (Serpukhovian).

Order Lychniscosa Schrammen, 1903 (81;11). Jurassic–Holocene.
- Family Calyptrellidae Schrammen, 1912 (1). Cretaceous (Coniacian–Maastrichtian).
- Family Callodictyonidae Zittel, 1877 (23;4). Upper Jurassic–Holocene.
  - Subfamily Callodictyoninae Zittel, 1877 (9). Upper Jurassic–Upper Cretaceous.
  - Subfamily Microblastidinae Schrammen, 1912 (2). Cretaceous.
  - Subfamily Becksinae Schrammen, 1912 (6;2). Cretaceous–Paleogene (Oligocene).
  - Subfamily Callicylicinae Reid, herein (6;2). Jurassic–Holocene.
- Family Coeloptychidae F. A. Roemer, 1864 (4;3). Lower Cretaceous–Upper Cretaceous.
  - Subfamily Coeloptychinae F. A. Roemer, 1864 (2;3). Lower Cretaceous–Upper Cretaceous.
  - Subfamily Cameroptychinae Reid, herein (2). Upper Cretaceous.
- Family Ventriculitidae Smith, 1848 (21). Jurassic–Upper Cretaceous.
  - Subfamily Ventriculitinae Smith, 1848 (17). Jurassic–Upper Cretaceous.
  - Subfamily Bolitesiinae Schrammen, 1912 (1). Cretaceous (Coniacian–Maastrichtian).
  - Subfamily Stauronematinae Sollas, 1877 (1). Lower Cretaceous (Albian)–Upper Cretaceous (Turonian).
  - Subfamily Lychniscaulinae Reid, herein (2). Upper Jurassic.
- Family Camerospongiidae Schrammen, 1912 (4;2). Lower Cretaceous (Valanginian)–Upper Cretaceous.
- Family Polyblastidiidae Schrammen, 1912 (2). Upper Jurassic–Cretaceous (Coniacian).
- Family Dactylocalycidae Gray, 1867 (10;2). Jurassic (Bajocian)–Holocene.
  - Subfamily Dactylocalycinae Gray, 1867 (5;2). Jurassic (Bajocian)–Cretaceous (Maastrichtian).
  - Subfamily Ophrystomatinae Schrammen, 1912 (1). Cretaceous (Albian–Cenomanian).
  - Subfamily Uncertain (4).
- Family Sporadopylidae Schrammen, 1936 (3). Upper Jurassic–Cretaceous (Cenomanian).
- Family Pachyteichismatidae Schrammen, 1936 (3). Upper Jurassic–Lower Cretaceous.
- Family Cypelliidae Schrammen, 1936 (5). Jurassic.
- Family Uncertain (5).

Order Uncertain (20).

Class Heteractinida de Laubenfels, 1955 (32). Lower Cambrian–Permian (Cisuralian).
Order Octactinellida Hinde, 1887 (26). Lower Cambrian–Permian (Cisuralian).
Family Astraeospongiidae Miller, 1889 (10). upper Lower Cambrian–Devonian.
Family Eiffeliidae Rigby, 1986 (8). Lower Cambrian–Carboniferous (Middle Pennsylvanian).
Family Wewokellidae King, 1943 (5). Carboniferous (Mississippian)–Permian (Cisuralian).
Family Nuchidae Pickett, 2002 (3). Lower Cambrian–Middle Cambrian.
?Order Hetairacyathida Bedford & Bedford, 1937 (4). Lower Cambrian.
Family Hetairacyathidae Bedford & Bedford, 1934 (4). Lower Cambrian.
Order Uncertain (2).
Class Calcarea Bowerbank, 1864** (57). Lower Cambrian–Holocene.
Subclass Calcinea Bidder, 1898 (3). Holocene.
Order Murrayonida Vacelet, 1981 (3). Holocene.
Family Murrayonidae Kirkpatrick, 1910 (1). Holocene.
Family Paramurrayonidae Vacelet, 1967 (2). Holocene.
Order Clathrinida Hartman, 1958 (0). Holocene.
Family Clathrinidae Minchin, 1900 (0). Holocene.
Family Soleneiscidae Borojevic & others, 2002 (0). Holocene.
Family Levinellidae Borojevic & Boury-Esnault, 1986 (0). Holocene.
Family Leucaltidae Dendy & Row, 1913 (0). Holocene.
Family Leucascidae Dendy, 1893 (0). Holocene.
Family Leucettidae Borojevic, 1968 (0). Holocene.
Subclass Calcaronea Bidder, 1898 (54). Lower Cambrian–Holocene.
Order Leucosolenida Hartman, 1958 (0). Holocene.
Family Leucosoleniidae Minchin, 1900 (0). Holocene.
Order Sycettida Bidder, 1898 (4). Carboniferous–Holocene.
Family Sycettidae Dendy, 1893 (0). Holocene.
Family Grantiidae Dendy, 1893 (3). Carboniferous–Holocene.
Family Leuconiidae Vosmaer, 1887 (1). Lower Jurassic–Holocene.
Family Heteropiidae Dendy, 1893 (0). Holocene.
Family Amphoriscidae Dendy, 1893 (0). Holocene.
Order Stellispongiida Finks & Rigby, herein (32). Permian–Holocene.
Family Stellispongiidae de Laubenfels, 1955 (28). Permian–Neogene (Miocene).
Subfamily Stellispongiinae de Laubenfels, 1955 (19). Permian–Paleogene (Eocene).
Subfamily Holcospongiinae Finks, herein (9). Permian–Neogene (Miocene).
Family Endostomatidae Finks, herein (2). ?Lower Triassic–?Middle Triassic, Upper Triassic (Norian)–Paleogene (Eocene).
Family Lelapiidae Dendy & Row, 1913 (2). Holocene.
Order Sphaerocoeliida Vacelet, 1979 (5). Permian–Cretaceous (Cenomanian).
Family Sphaerocoeliidae Steinmann, 1882 (5). Permian–Cretaceous (Cenomanian).
Order Lithonida Doederlein, 1892 (12). Jurassic–Holocene.
Family Lepidoleuconiidae Vacelet, 1967 (1). Holocene.
Family Minchinellidae Dendy & Row, 1913 (10). Jurassic–Holocene.
Family Petrobionidae Borojevic, 1979 (1). Holocene.
Order Uncertain (1).
Class and Order Uncertain (46)
Family Polyactinellidae Mostler, 1985 (9). Lower Cambrian–Permian.
Family Stromatidiidae Finks, 1960 (1). Permian (Guadalupian).
Family Tadassiidae Zhuravleva & Pyanovskaya (1). Middle Cambrian–Upper Cambrian.
Family Uncertain (35).
Unrecognizable Genera (235).

PALEOZOIC DEMOSPONGES

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[Department of Geology, Queens College (CUNY); Department of Geology, Brigham Young University]

Class DEMOSPONGEA Sollas, 1885

[*nom. correct.* DE LAUBENFELS, 1955, p. 36, *pro* class Demospongiae MINCHIN, 1900, p. 145, *nom. transl. ex* order Demospongiae SOLLAS, 1885a, p. 395]

Spicules of opaline silica are monaxonic or tetraxonic with axial canal of triangular cross section; spongin and mesoglea commonly abundant; architecture of aquiferous system of rhagon type, with small choanocyte chambers and small choanocytes (see Fig. 92). [The Demospongea was apparently first proposed as a taxonomic unit by SOLLAS in a short article in 1885, although SOLLAS's (1887) extensive article on sponges in the ninth edition of *Encyclopaedia Britannica* has been commonly cited as the publication where the Demospongea was proposed. The article has been commonly dated as 1875, but that volume of the encyclopedia was actually published in 1887, although publication dates for various volumes of the series do range from 1875 to 1889.] *Cryogenian–Holocene.*

Subclass CLAVAXINELLIDA Lévi, 1956

[Clavaxinellida LÉVI, 1956, p. 167; *emend.,* FINKS & RIGBY, herein]

Skeleton typically fibrous with abundant spicules; fibers typically of plumose or subparallel sheaves of oxeas (most primitive), or styles, or tylostyles (most advanced); microscleres absent, or microrhabds or spinispires (most advanced); oviparous in living forms, larva typically a parenchymella. *Cryogenian–Holocene.*

Order PROTOMONAXONIDA new order

[Protomonaxonida FINKS & RIGBY, herein]

Fibrous skeleton composed of oxeas alone. *Cryogenian–Holocene.*

Family LEPTOMITIDAE de Laubenfels, 1955

[Leptomitidae DE LAUBENFELS, 1955, p. 69]

Thin-walled, tubular to fan-shaped sponges whose skeleton is composed of monaxons arranged in two layers, outer layer of vertically oriented, small spicules (possible oxeas). With moderately widely spaced, coarse, vertical, parallel rods composed of en echelon oxeas; and inner layer of horizontal, irregularly spaced to bundled, small oxeas. [The family was considered within the lyssacinosid sponges by DE LAUBENFELS (1955, p. 69–70) but was moved to the monaxonid demosponges by RIGBY (1986a, p. 22), following reinterpretation of the skeleton as a two-layered structure rather than a single, reticulate, layered structure like that in the protosponge hexactinellids.] *Cambrian–Silurian.*

Leptomitus WALCOTT, 1886, p. 89 [**L. zitteli;* OD] [=*Tuponia* WALCOTT, 1920, p. 271, *partim* (type, *T. lineata* WALCOTT, 1920, p. 272), *non* REUTER, 1875]. Elongate, tubular, very thin-walled sponges with double-layered skeleton; coarse, moderately widely spaced, en echelon oxeas are dominant elements that combine to produce parallel rods that extend virtually entire length of sponge; space between rods filled with thatch of smaller, vertical oxeas that combine with coarse rods to produce striped-appearing, outer, skeletal layer; inner layer a thatch of tiny, horizontal, monaxial spicules; neither vertical nor horizontal, small spicules occur in bundles; walls without parietal gaps and major ostia or canals. *Lower Cambrian–Middle Cambrian:* Canada (British Columbia), Greenland, USA (Georgia, Vermont, Virginia, Pennsylvania, Utah), China (Yunnan).——FIG. 1*a–c. L. lineata* (WALCOTT), Stephen Formation, Burgess Shale, Albertan, Burgess quarry, Mount Field, British Columbia; *a,* generalized restoration, ×1; *b,* idealized segment of wall showing outer layer of monaxial thatch subdivided by coarse oxeas and inner, horizontal thatch of irregularly spaced, small oxeas, not to scale (Rigby, 1986c); *c,* lower part of lectotype showing general shape and skeletal structure, USNM 66448, ×2 (Walcott, 1920).

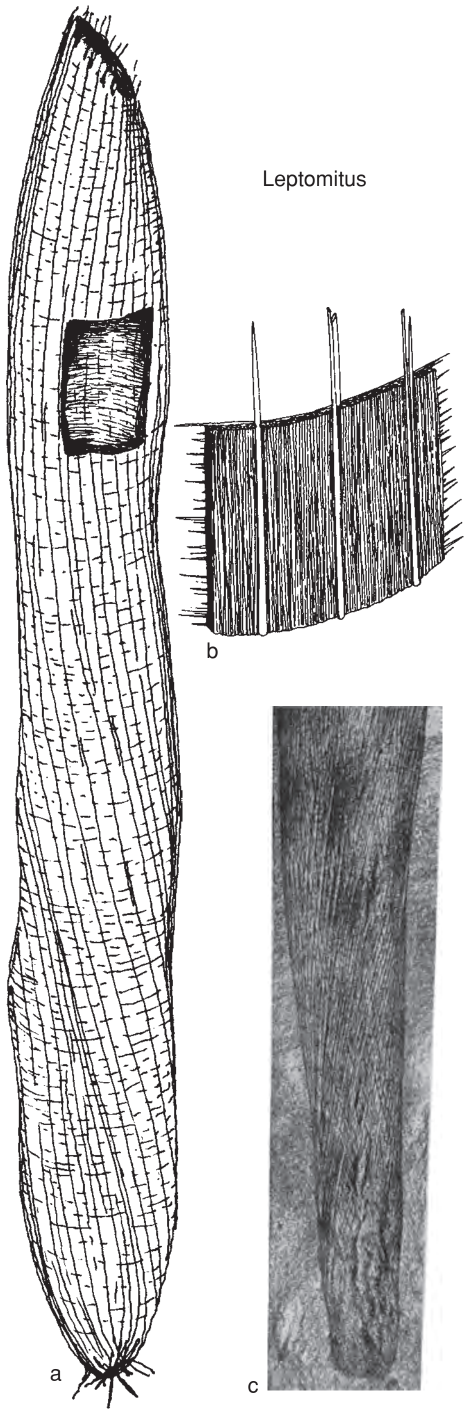

FIG. 1. Leptomitidae (p. 9).

Leptomitella RIGBY, 1986a, p. 24 [**Leptomitus metta* RIGBY, 1983a, p. 243; OD]. Cylindrical to steeply conical, thin-walled, smooth with walls of monaxons in two layers, outer layer of fine, vertical thatch with inserted, vertical rods of en echelon oxeas; inner layer of horizontal monaxons in bundles that spiral; two layers produce reticulated-appearing wall. *Lower Cambrian–Middle Cambrian:* China (Yunnan), *Lower Cambrian;* USA (Utah), *Middle Cambrian:*——FIG. 2*a–d.* **L. metta* (RIGBY), Marjum Formation, Albertan, House Range, Utah; *a,* holotype showing prominent, pigmented, horizontal bands of monaxons that are interior to long, vertical spicules of outer layer preserved in bas-relief, ×1; *b,* photomicrograph of skeletal net showing both spicules in horizontal bands and vertical structure of outer layer in holotype, BYU 1564, ×10 (Rigby, 1983a); *c,* generalized restoration showing form and nature of skeletal structure, ×1; *d,* idealized segment of wall showing outer, monaxial thatch and inner, distinct bundles of monaxons, not to scale (Rigby, 1986a).

Paraleptomitella CHEN, HOU, & LU, 1989, p. 23 [29] [**P. dictyodroma;* OD]. Tubular to globose, thin-walled sponges with double-layered skeleton of monaxons; outer layer of coarse, slightly curved oxeas that are interlocked with one another to form vertically elongate net in which openings are filled with smaller, vertically arranged, fine monaxons; inner layer of monaxons in horizontal bundles. [*Leptomitella* is similar in having a double-layered skeleton with an inner layer of bundled spicules, but it has an outer layer of straight, coarse and fine, vertical spicules.] *Lower Cambrian:* China (Yunnan).——FIG. 3,*1a–c.* **P. dictyodroma,* Chiungchussu Formation, Chengjiang; *a,* holotype, generalized form, 1108492, ×1.2; *b,* photomicrograph of skeletal structure of holotype showing curved, subvertical spicules, and less distinct, irregular, inner, horizontal spicule bundles, ×4; *c,* generalized restoration of skeletal segment showing relationships between coarse and fine, outer spicules and inner spicule bundles, ×20 (Chen, Hou, & Lu, 1989).

Wareiella RIGBY & HARRIS, 1979, p. 977 [**W. typicala* RIGBY & HARRIS, 1979, p. 978; OD]. Small, conicocylindrical to subcylindrical sponge with deep, simple spongocoel; thin walled with simple, skeletal net principally a thin thatch of vertical, short diactines with minor, horizontal or diagonal diactines, or perhaps more complex spicules; osculum armored with prostalia; marginalia absent; base rounded to round-pointed with root tuft of a few long spicules. *Silurian (Llandovery–Wenlock):* Canada (British Columbia).——FIG. 3,*2. W. typicala,* unnamed Silurian siltstone, north-central British Columbia; iron-oxide-stained, argillaceous impression of holotype with vertical prostalia showing at oscular margin, GSC 60643, ×2 (Rigby & Harris, 1979).

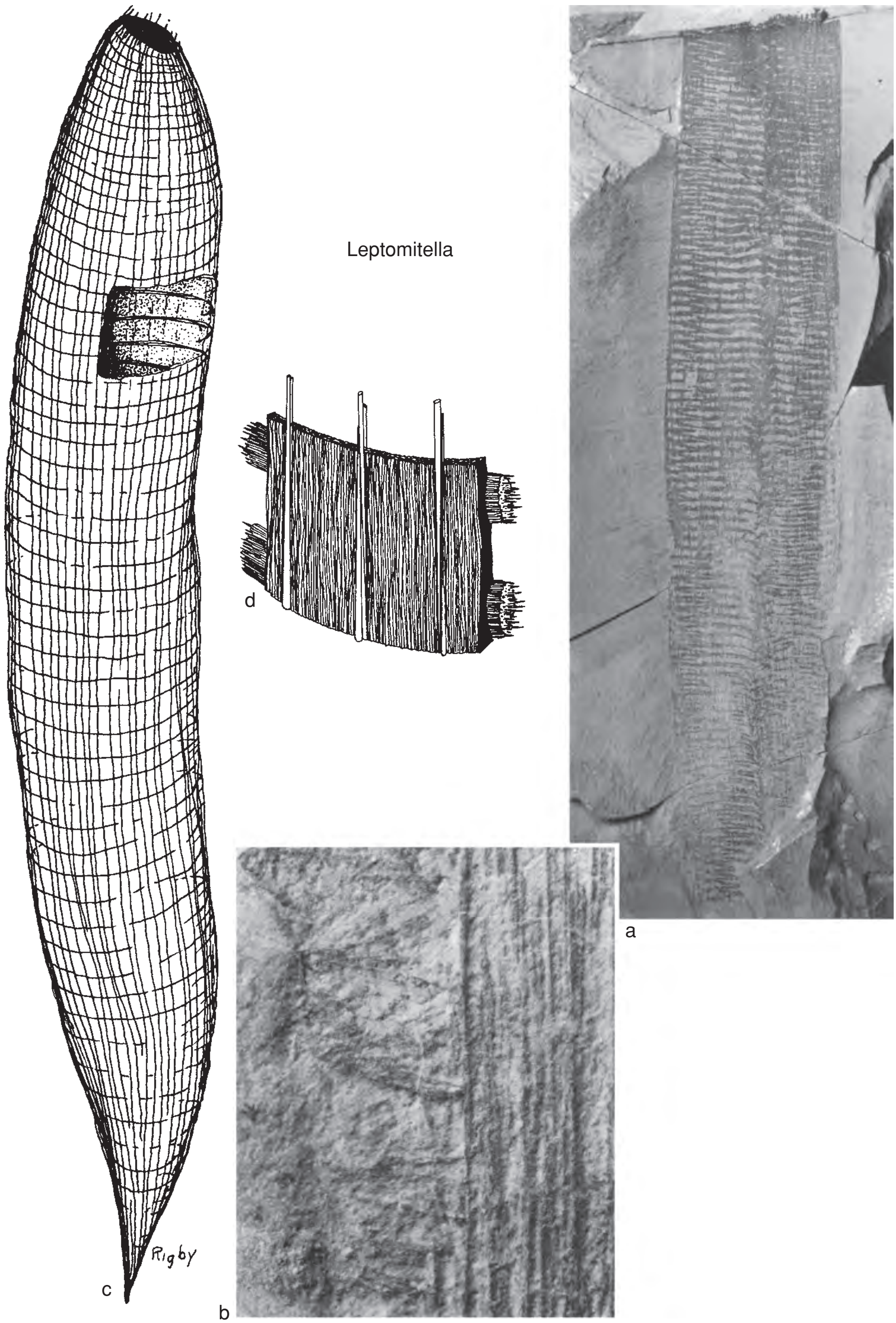

FIG. 2. Leptomitidae (p. 10).

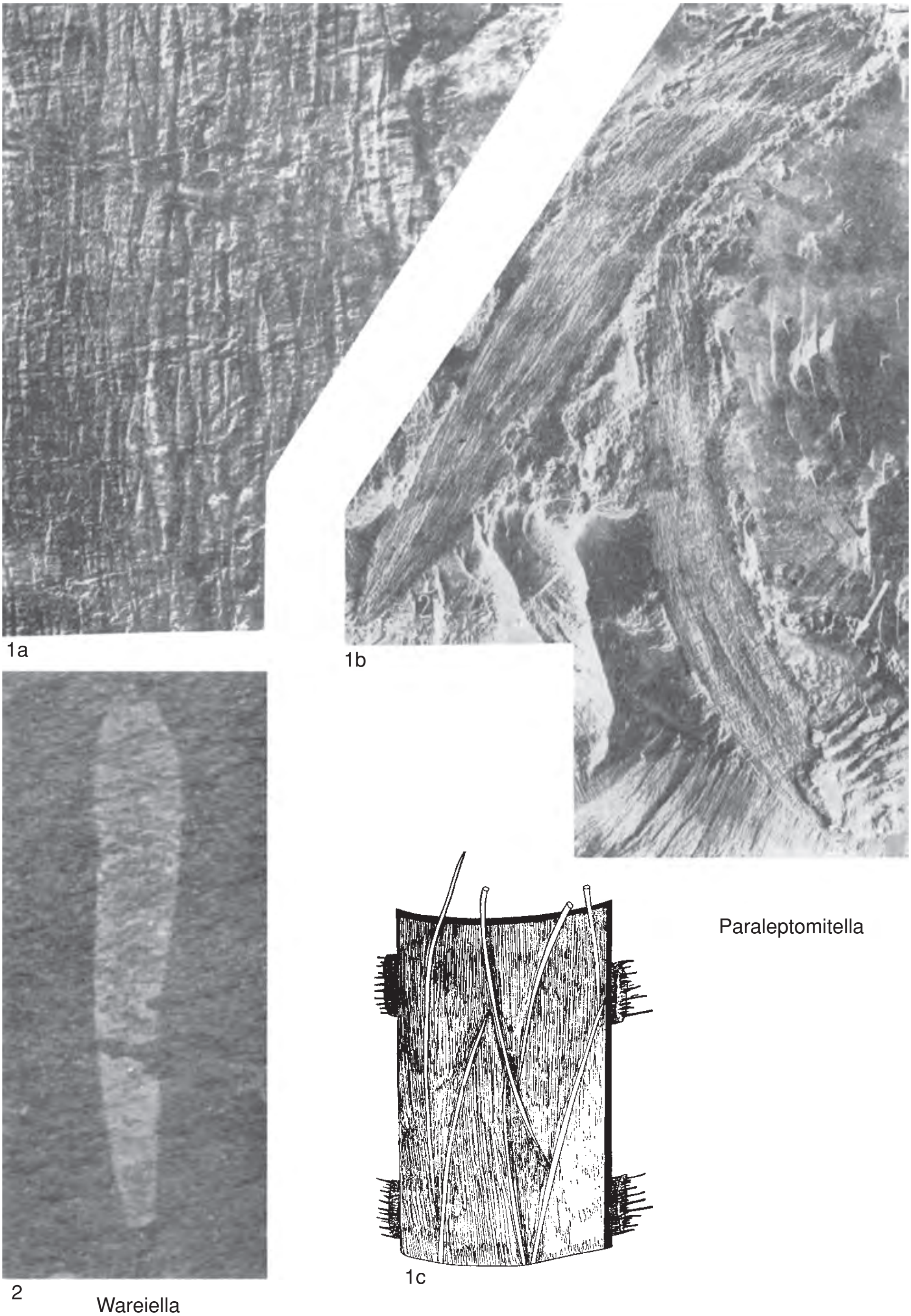

FIG. 3. Leptomitidae (p. 10).

Family SINOSPONGIIDAE new family

[Sinospongiidae FINKS & RIGBY, herein] [type genus, *Sinospongia* CHEN in CHEN & XIAO, 1992, p. 518]

Supposed sponges with thin walls characterized by coarse, curved, monaxial spicules that are more or less horizontal; smaller monaxial spicules may be present. *Cryogenian–Ediacaran.*

Sinospongia CHEN in CHEN & XIAO, 1992, p. 518 [526] [**S. chenjunyuani;* OD] [=*Niuganmafeia* CHEN in CHEN & XIAO, 1992, p. 520, *nom. nud.* (type, *N. obesa,* OD); *Xilinxiaella* LI in DING & others, 1996, p. 106 (type, *X. bella,* OD]. Supposed sponge, tall and sausage shaped, skeleton a single layer of rods or spicules curved and more or less horizontal tangential to surface, sometimes forming rounded, rhombic openings, or elsewhere with only a few scattered elements; small spicules may occur between larger elements. [Although the sponge origin of the fossils is not certain (XIAO & others, 2002), they appear similar to Cambrian protomonaxonids and are tentatively placed here.] *Cryogenian–Ediacaran:* China (Hubei).——FIG. 4*a–b*. **S. chenjunyuani,* Doushantuo Formation, Ediacaran, Miaohe Village, Zigui County; *a,* general view of holotype showing form and skeletal structure, ×2; *b,* photomicrograph of part of skeletal net showing curved, mainly horizontal spicules, ×10 (Chen & Xiao, 1992).

Family HAMPTONIIDAE de Laubenfels, 1955

[Hamptoniidae DE LAUBENFELS, 1955, p. 39]

Massive, globose, or frondescent sponges with skeletons of two series of spicules; large, moderately smooth monaxons, either isolated or clumped, separated by tracts of smooth, smaller, monaxial spicules; generally lacking cross-bracing, horizontal elements; larger spicules do not develop coronal fringe. *Middle Cambrian–Middle Ordovician.*

Hamptonia WALCOTT, 1920, p. 296 [**H. bowerbanki* WALCOTT, 1920, p. 297; M]. Globose, bladderlike, or frondescent sponges, subparallel, large monaxons either singly or in small bundles or bands are separated by tracts of small, thatched, possibly monaxial spicules radiating from center or central axis of sponge to meet periphery at right angles; bundles may be crossed at high angles or by inosculation in outer part of sponge. *Middle Cambrian:* Canada (British Columbia).——FIG. 5*a–b*. **H. bowerbanki,* Stephen Shale, Burgess Shale, Mount Field; *a,* flattened lectotype showing generally circular sponge with radiating, skeletal structure, ×0.5; *b,* enlarged part of upper skeleton showing monaxial structure and coarse, principal oxeas grouped into crude tufts, USNM 66493, ×5 (Walcott, 1920).

Hamptoniella RIGBY & COLLINS, 2004, p. 35 [**H. foliata;* OD]. Obconical to turbinate or goblet shaped with three-dimensional skeleton; largely without a spongocoel but with axial region with moderately coarse, subvertical canals and a marginal region of endosome where canals diverge upwardly and outwardly from axial zone; skeleton of clustered to unclustered, long oxeas, arranged generally parallel to canals in interior but somewhat less clustered in exterior. Locally spicules may diverge to produce echinating-appearing tracts that may inosculate or have some cross bracing; oxeas generally straight. *Middle Cambrian:* Canada (British Columbia).——FIG. 6,*1a–b*. **H. foliata,* Burgess Shale, Albertan, Mount Stephen; *a,* side view of holotype with moderately compact, endosomal skeleton of upwardly and outwardly expanding tracts and with central, open canal zone obscured behind dense skeleton, ROM 43816, ×2; *b,* vertically flattened paratype with radiating skeleton of oxeas in anastomosing tracts that grade outwardly to straight tracts, ROM 44283, ×4 (Rigby & Collins, 2004).——FIG. 6,*1c*. *H. hirsuta* RIGBY & COLLINS; side view of holotype showing somewhat annulate, obconical form with coarse canals between ragged, coarse tracts of echinated, long oxeas, ROM 44285, ×2 (Rigby & Collins, 2004).

Lasiothrix HINDE in DAWSON & HINDE, 1889, p. 50 [**L. curvicostata* HINDE in DAWSON & HINDE, 1889, p. 51; OD]. Small, cup-shaped sponge with root tuft; meridional bundles of diactines (oxeas or rhabdodiactines) are underlain by transverse diactines or stauractines; fringe of crowded diactines surrounding upper edge of cup. [*L. flabellata* DAWSON & HINDE, 1889, comprises plumose masses of diactines diverging from a root tuft; it may not be congeneric with the type species.] *Upper Cambrian:* Canada (Quebec).——FIG. 6,*2a–b*. **L. curvicostata,* Metis shale, Metis Bay; *a,* drawing of holotype, side view of lower part, ×1; *b,* enlarged, upper part showing curved spicules and cross-connecting, transverse spicules in main net with prostalia above, PRM, approximately ×15 (Dawson & Hinde, 1889).

Offela ROGERS, JACKSON, & MCKINNEY, 1964, p. 135 [**O. spondeum;* M]. Small, ovoid, vasiform sponge with thin body wall and somewhat collared osculum smaller than cloacal diameter; root tuft present at base; spicules long and short diactines (oxeas or rhabdodiactines) crossing one another (possibly at low angles); longer spicules more abundant on exterior, near osculum, and near and in root tuft. *Middle Ordovician:* USA (Virginia, Alabama).——FIG. 6,*3a–b*. **O. spondeum,* Lenoir Limestone, Chazyan, Cahaba Valley, Alabama; *a,* side view of small holotype showing globose form and osculum of shallow spongocoel, ODC 2511;

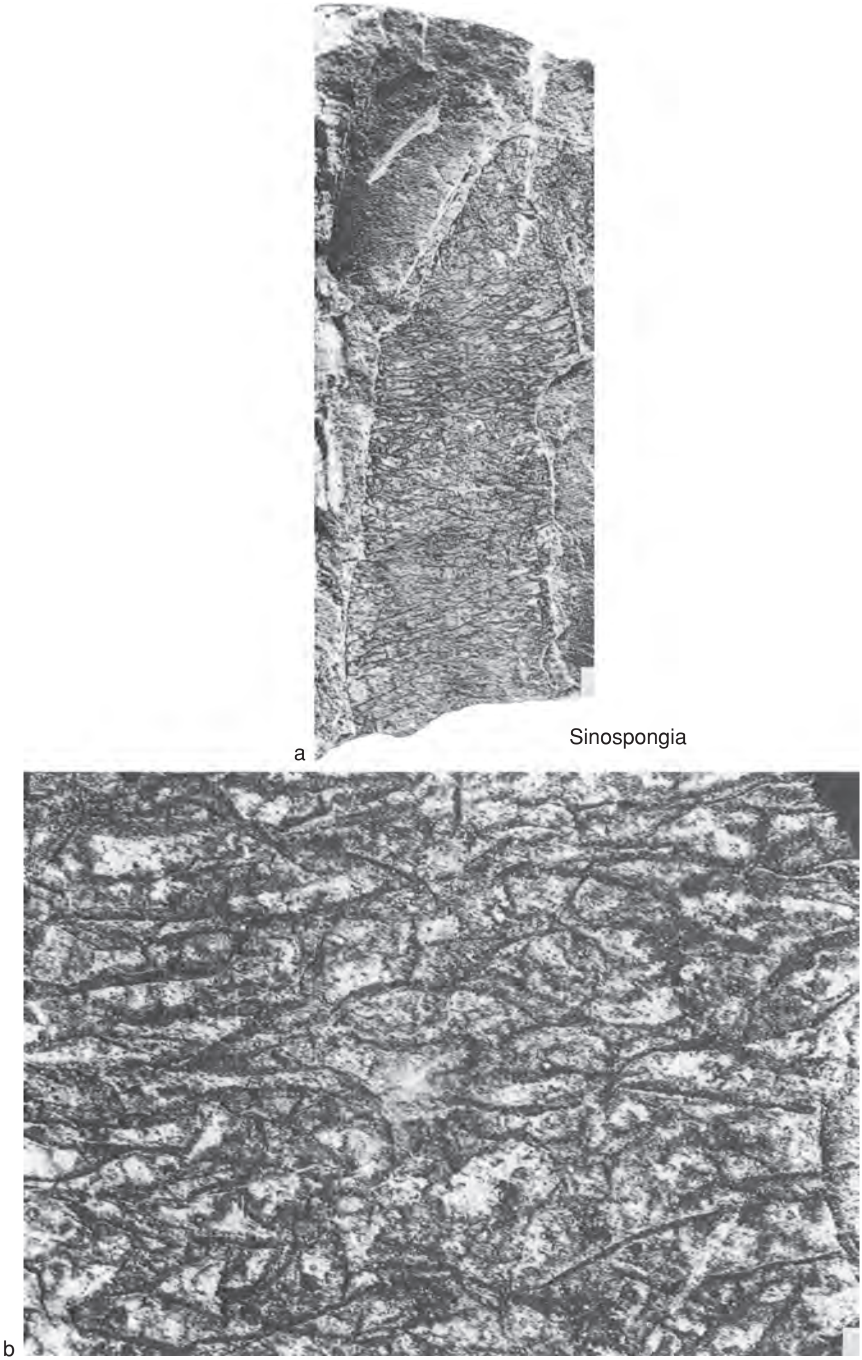

FIG. 4. Sinospongiidae (p. 13).

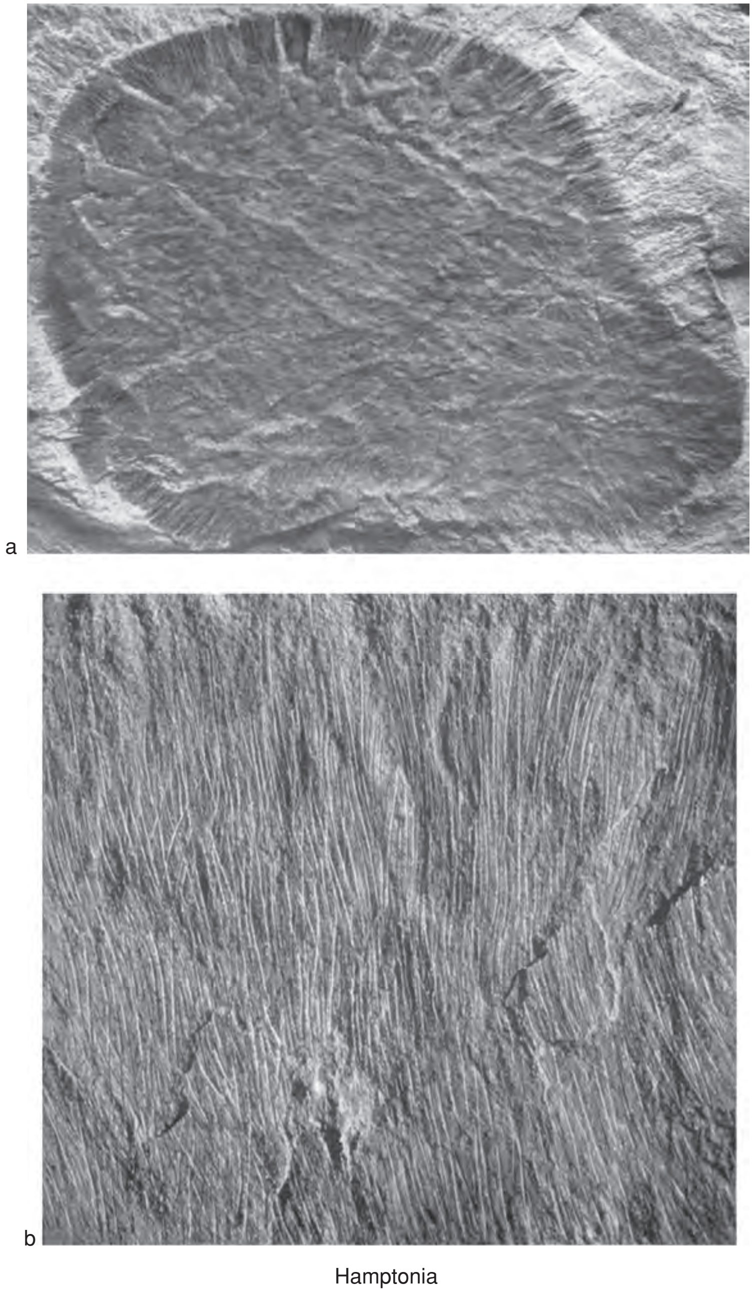

FIG. 5. Hamptoniidae (p. 13).

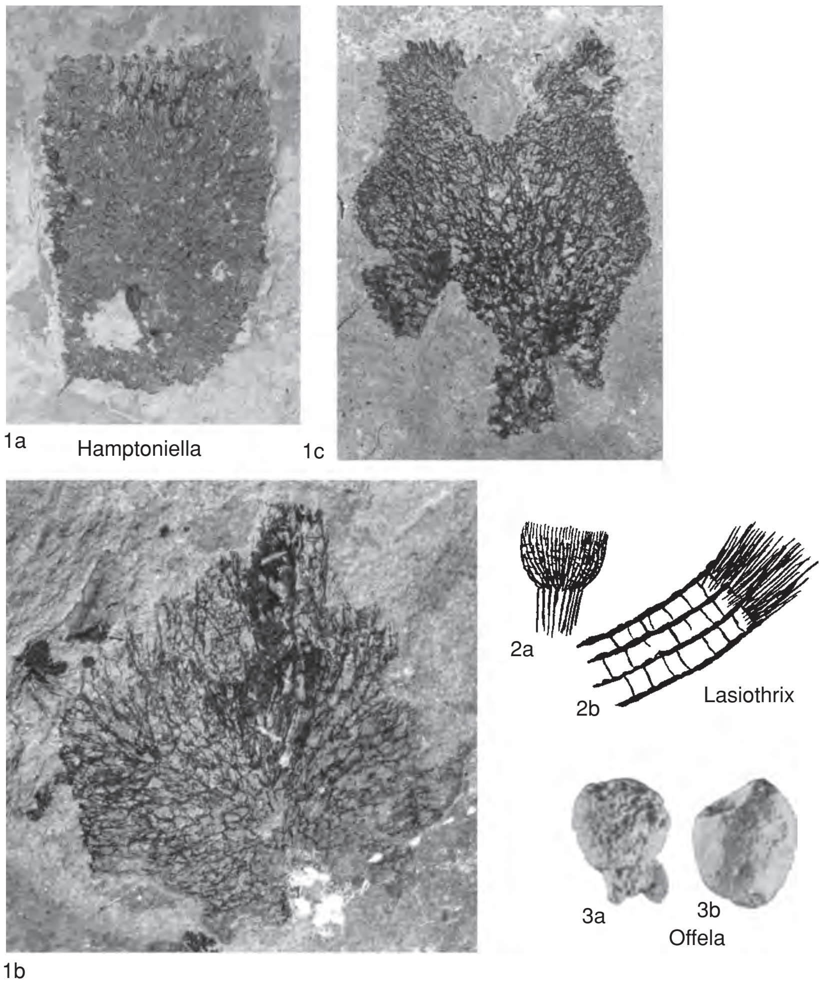

FIG. 6. Hamptoniidae (p. 13–16).

b, side view of globose paratype with a prominent root tuft, ODC 2512, ×1.5 (Rogers, Jackson, & McKinney, 1964).

Family ULOSPONGIELLIDAE Rigby & Collins, 2004

[Ulospongiellidae RIGBY & COLLINS, 2004, p. 38] [type genus, *Ulospongiella* RIGBY & COLLINS, 2004, p. 39]

Sponges whose skeletons are made of strongly curved to sigmoidal or gently serpentine oxeas or strongyles arranged in irregular felt or in upwardly echinating tracts, at least in interior of sponge; tracts, when present, parallel to large, subvertical to upwardly and outwardly directed canals. *Middle Cambrian.*

Ulospongiella RIGBY & COLLINS, 2004, p. 39 [**U. ancyla;* OD]. Moderately small, conicocylindrical, obconical, or subcylindrical sponges whose relatively massive, felted-appearing skeleton is made of moderately large, curved oxeas or strongyles that are commonly sigmoidal, undulating, curved or hooked to locally straight; moderately open-textured skeleton not in tracts; canals ill defined; coarse marginalia may include oxeas or strongyles as isolated spicules; spongocoel not developed. *Middle Cambrian:* Canada (British Columbia).——FIG. 7,*1a–b.* **U. ancyla,* Burgess Shale; *a,* side view of holotype showing generalized growth form, with felted skeleton that includes upwardly and outwardly radiating, coarse marginalia, ROM 43830, ×3; *b,* photomicrograph of upper left part of holotype with endosomal skeleton of curved spicules and coarse tylostyle and oxea marginalia, ×5 (Rigby & Collins, 2004).

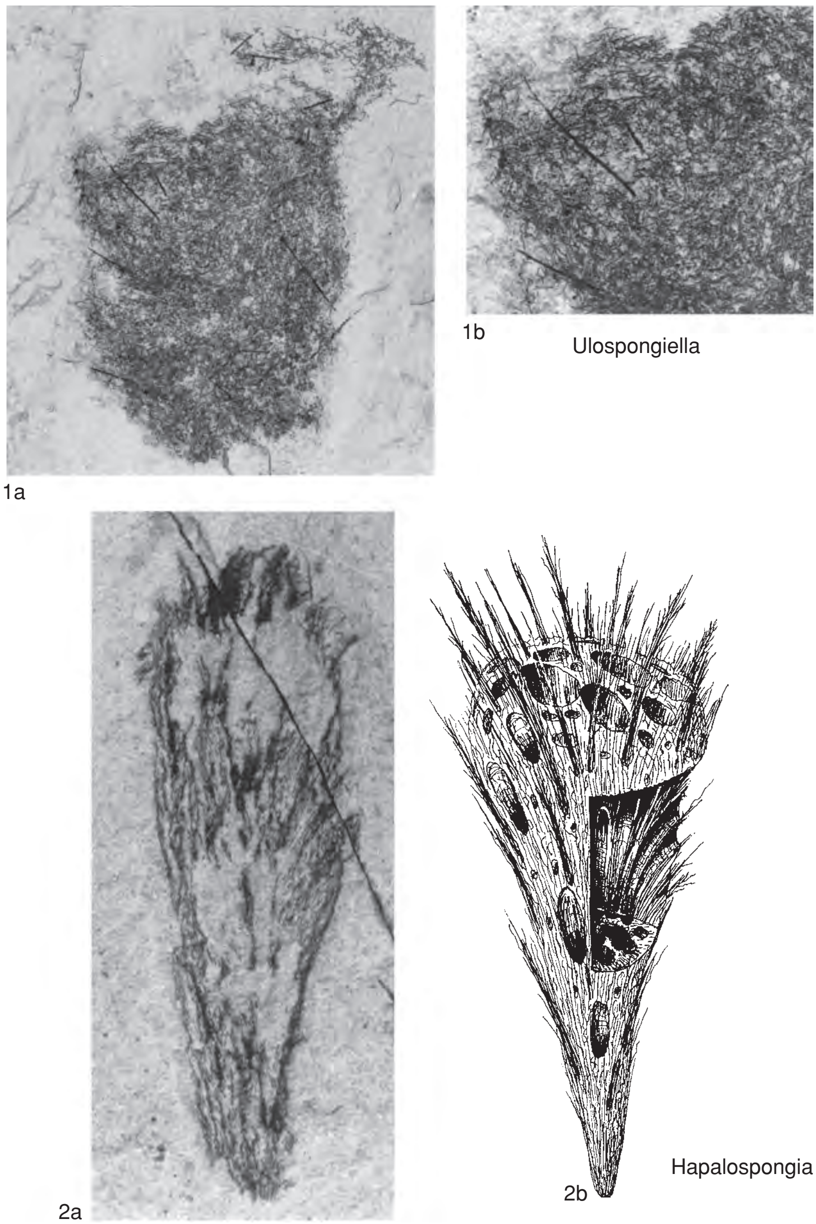

FIG. 7. Ulospongiellidae (p. 16–18).

Hapalospongia RIGBY & COLLINS, 2004, p. 41 [**H. flexuosa;* OD]. Steeply obconical to flaring sponges without spongocoel; interior perforated by large, subvertical canals that branch upwardly and outwardly and are paralleled by smaller canals; skeleton delicate, made of fine tracts or unclustered, aligned, small, curved oxeas or strongyles that range from straight to sigmoidal or gently serpentine; spicules echinating in tracts. *Middle Cambrian:* Canada (British Columbia).——FIG. 7,*2a–b*. **H. flexuosa,* Middle Cambrian trilobite beds, Mount Stephen; *a,* side view of steeply obconical holotype with loose-textured skeleton of curved to straight oxeas or strongyles, in tracts between upwardly divergent, coarse canals, ROM 43819, ×4; *b,* restoration showing general relationships of spicule tracts to canals of various size in upwardly divergent skeletal structure of steeply obconical sponge, ×2.5 (Rigby & Collins, 2004).

Family CHOIIDAE de Laubenfels, 1955

[Choiidae DE LAUBENFELS, 1955, p. 42]

Unattached forms consisting of a thin, circular to elliptical, central disc from which radiate long, coronal spicules that are inserted at various levels within thatch of central disc; both small spicules and large coronal spicules are probably oxeas. *Lower Cambrian–Middle Cambrian.*

Choia WALCOTT, 1920, p. 291 [**C. carteri* WALCOTT, 1920, p. 292; OD]. Small to medium-sized, low, conical, oval to elliptical sponges with thatched, central disc surrounded by corona with relatively large diameter, long spicules that extend beyond and radiate from central disc; central disc composed of fine, radiating monaxial spicules (probably oxeas) with interspersed, large, monaxial, coronal spicules, which may be oxeas or styles. *Lower Cambrian–Middle Cambrian:* China (Anhui), *Lower Cambrian;* Canada (British Columbia, Quebec), USA (Utah), Wales, *Middle Cambrian.*——FIG. 8,*1.* **C. carteri,* Stephen Formation, Burgess Shale, Albertan, Mount Field, British Columbia; flattened lectotype showing compact, circular, central disc and longer, radiating, coronal oxeas or styles, USNM 66482, ×2 (Walcott, 1920).

Allantospongia RIGBY & HOU, 1995, p. 1015 [**A. mica;* OD]. Small, elongate, ovate to sausagelike sponges with skeleton of small, monaxial, radiating to somewhat irregular monaxons, with longer, coarser spicules in distinct tufts that extend beyond central, thatched part of skeleton. *Lower Cambrian:* China (Yunnan).——FIG. 8,*3a–b.* **A. mica,* Chungchussu Formation, Xiaolantian, Chengjiang County; *a,* small, sausagelike holotype with skeleton a radiating thatch of possible oxeas, NIGPAS 115322, ×2; *b,* enlarged lower part of holotype showing dense, outer, radiating fringe and irregularly oriented spicules in skeletal interior, ×10 (Rigby & Hou, 1995).

Choiaella RIGBY & HOU, 1995, p. 1,014 [**C. radiata;* OD]. Small, discoidal to broad obconical sponges with skeleton of radiating thatch of small monaxons of one size that may be locally bundled but do not extend beyond margin of disc, other than as limited fringe; coarse coronal spicules absent. [These small sponges do not have the coronal spicules of *Choia* and the distinctly bundled skeleton of *Belemnospongia.*] *Lower Cambrian:* China (Yunnan).——FIG. 8,*2a–b.* **C. radiata,* Chiungchussu Formation, Xiaolantian, Chenjiang County; *a,* small, discoidal holotype with radiate skeleton of oxeas, ×4; *b,* enlargement of part of disc showing radiating oxeas but without large, coronal spicules, NIGPAS 115325, ×10 (Rigby & Hou, 1995).

Lenica GORYANSKY, 1977, p. 275 [**L. unica;* OD]. Wide, funnel- or fan-shaped sponges with radiating skeleton of long, thin bundles of diactine spicules, perhaps joined by spongin during life; large spicules up to 70 mm long, with broad, axial canals and very thin walls covered with spiraled wrinkles; smaller spicules up to 35 mm long. [*Corralia* WALCOTT, 1920, to which *Lenica* was considered to be related by GORYANSKY, was placed in the new genus *Capsospongia* by RIGBY (1986a) and included in the Anthaspidellidae because it has a skeleton of dendroclones. *Lenica* is included here in the family Choiidae because of its radiate structure and relatively simple skeleton.] *Lower Cambrian:* Russia (eastern Siberia).——FIG. 9. **L. unica,* Lena layer, Lena River; flattened holotype with radiate, fanlike skeletal structure, Ts NIGRM 12/10833, ×1 (Goryansky, 1977).

Family WAPKIIDAE de Laubenfels, 1995

[Wapkiidae DE LAUBENFELS, 1955, p. 37]

Elongate, oval or flattened sponges whose endodermal skeleton is principally of oxeas arranged in upwardly plumose tracts that outline cellular canals that are particularly pronounced in exterior; rows of canals produce uniformly wrinkled pattern in exterior skeleton; dermal layer as a thin sheet of differentiated coarse and fine spicules, as in *Leptomitus,* may be present. *Middle Cambrian:* Canada (British Columbia).

Wapkia WALCOTT, 1920, p. 279 [**W. grandis;* M]. Elongate oval or flattened fronds; slender, parallel spiculofibers have a plumose pattern centered on longitudinal axis of sponge; they are crossed by outer layer of parallel, long, vertical oxeas; fibers made of parallel, elongate oxeas and possible styles and outline outer layer with cellular canals in upwardly and outwardly flaring pattern. *Middle Cambrian:* Canada (British Columbia).——FIG. 10*a–b.* **W. grandis,* Stephen Formation, Burgess Shale, Mount Field; *a,* flattened, elongate holotype with radiating to plumose, clumped, spicule structure, ×1 (Walcott, 1920); *b,* generalized three-dimensional restoration of wall showing bundled spicules separated by canals in outer part of sponge and outer layer of vertical oxeas, not to scale (Rigby, 1986a).——FIG. 11. **W. grandis;* Stephen Formation, Burgess Shale, Mount Field; enlarged upper left part of holotype showing upward divergence of spicules in flattened skeleton, USNM 66458, ×4 (Walcott, 1920);

Family HALICHONDRITIDAE Rigby, 1986

[Halichondritidae RIGBY, 1986a, p. 30]

Conicotubular to steeply obconical sponges in which principal skeleton is made

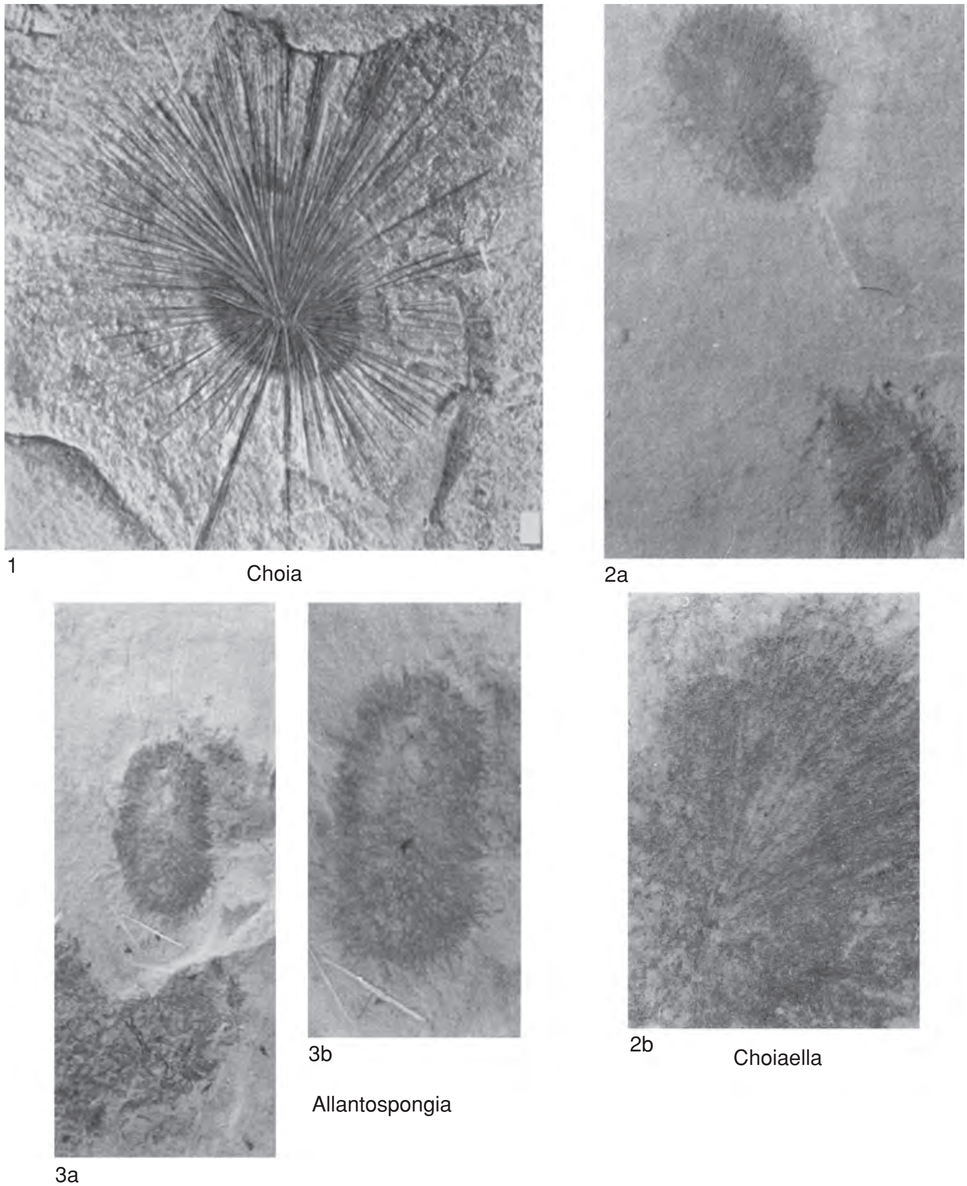

FIG. 8. Choiidae (p. 18).

of long, upwardly plumescent, monaxial spicules; main endosomal net is coarse thatch of generally vertically oriented oxeas; with prominent, coarse marginalia and prostalia. *?Middle Cambrian, Upper Cambrian–Carboniferous (Serpukhovian).*

Halichondrites DAWSON in DAWSON & HINDE, 1889, p. 52 [**H. confusus;* M]. Oval or irregular masses of oxeas (or possible rhabdodiactines) organized in two parallel series crossing one another at low angle; very much smaller spicules may have formed a dermal layer. [*H. elissa* WALCOTT, 1920, may be a hexactinellid, with rectangular crossings of spicules (possible stauractines) and may not belong to this genus. WALCOTT's action in designating it as the type was invalid.] *?Middle Cambrian, Upper Cambrian:* Canada (Quebec, ?British Columbia).——FIG. 12*a*. **H. confusus,* Metis shale, Upper Cambrian, Metis, Quebec; irregular cluster of enlarged spicules from oval or irregular masses in drawing by

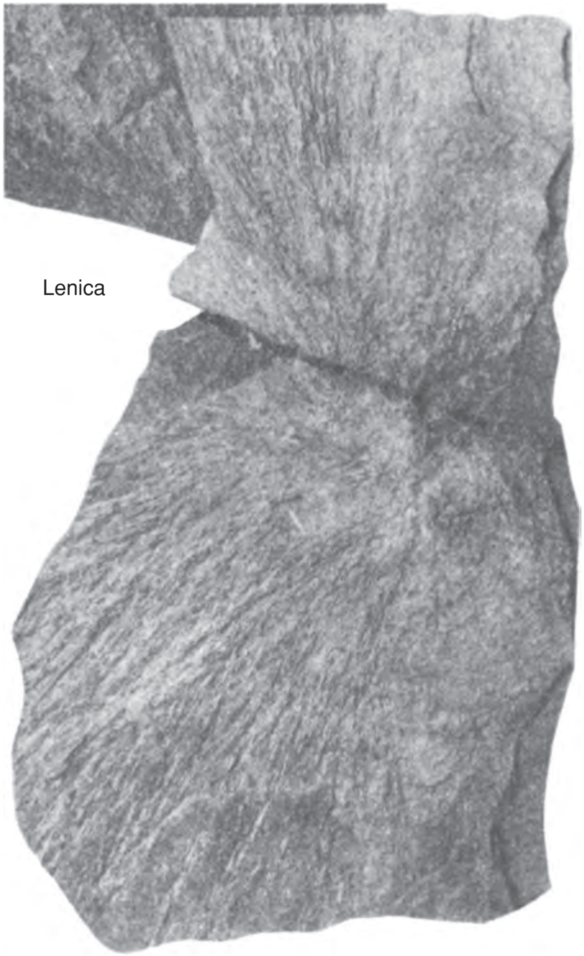

FIG. 9. Choiidae (p. 18).

DAWSON, scale unknown (Dawson & Hinde, 1889).——FIG. 12*b. H. elissa* WALCOTT, Stephen Formation, Burgess Shale, Albertan, Mount Field, British Columbia; generalized restoration showing general form of species and its coarse spiculature, not to scale (Rigby, 1986a).——FIG. 13. *H. elissa* WALCOTT, Stephen Formation, Burgess Shale, Albertan, Mount Field, British Columbia; flattened holotype showing steep, obconical form and coarse, vertical oxeas of skeletal thatch and as pronounced prostalia, USNM 66447, ×1 (Walcott, 1920).

Arborispongia RIGBY, 1986c, p. 446 [**A. delicatula;* OD]. Tall, arborescent sponge with dichotomous branches, without spongocoel or dermal layer; skeleton composed of bundles of long, upwardly divergent monaxons, which produce a bristly, dermal surface to relatively smooth branches, and spinose, frayed-appearing terminations to branches; circular canals parallel skeletal bundles in upwardly and outwardly divergent pattern and produce elongate-oval ostia where they emerge dermally. [This genus is placed in the family with some question.] *Carboniferous (Serpukhovian):* USA (Montana).——FIG. 14*a–b.* **A. delicatula,* Heath Formation, Fergus County; *a,* photomicrograph of brushlike termination of branch with long, monaxial spicules, ×10; *b,* holotype with 5 or 6 dichotomous branches with smooth exteriors, UMG 5716, ×0.5 (Rigby, 1986c).

Family PIRANIIDAE de Laubenfels, 1955

[Piraniidae DE LAUBENFELS, 1955, p. 40]

Subcylindrical to obconical, branching sponges with deep spongocoel; marginalia consisting principally of tylostyles with points directed upwardly and outwardly; with principal skeleton composed of upwardly and outwardly radiating, subparallel tufts of oxeas, tufts with hexagonal placement; walls pierced by circular canals parallel to tufts. *Middle Cambrian.*

Pirania WALCOTT, 1920, p. 298 [**P. muricata;* OD]. Steeply obconical to conicocylindrical, small, moderately thick-walled, branching to complexly branching sponges with pronounced marginalia; wall composed of tufts of oxeas; individual tufts may be cored by large tylostyles that are the marginalia and prostalia; small canals parallel tufts. *Middle Cambrian:* Canada (British Columbia).——FIG. 15*a–c*. **P. muricata,* Stephen Formation, Burgess Shale, Mount Field; *a,* branching growth form of lectotype with steep, obconical branches and prominent marginalia, USNM 66549, ×2; *b,* enlargement of part of paralectotype showing small, spicule tufts of main wall and coarse, large, tylostyle marginalia, USNM 66497, ×10; *c,* restoration showing growth form of sponge and its walls composed of tufts of monaxons into which are inserted large, tylostyle marginalia, not to scale (Rigby, 1986a).

Moleculospina RIGBY, 1986a, p. 34 [**Hazelia mammillata* WALCOTT, 1920, p. 286; OD]. Moderately thick-walled sponges with skeleton of radial tufts of monaxons that converge toward tuft axis and produce low, mounded, nodes cored by one or several moderately large, possible oxeas; radial tufts cross braced by smaller tufts of similar but fewer monaxons; surface marked by elevated, mamelon-like nodes perforated by circular, excurrent ostia; general shape of genus unknown. *Middle Cambrian:* Canada (British Columbia). ——FIG. 16*a–b*. **M. mammillata* (WALCOTT), Stephen Formation, Burgess Shale, Mount Field; *a,* holotype showing four prominent, possible, excurrent openings on mamelon-like mounds, ×1; *b,* enlargement showing moderately coarsely tufted skeleton with large-diameter monaxons now largely molds, USNM 66780, ×25 (Rigby, 1986a).

Family SOLLASELLIDAE von Lendenfeld, 1887

[Sollasellidae VON LENDENFELD, 1887, p. 584]

Epipolasid sponges with radiate architecture, with dermal cortex; principal spicules oxeas and strongyles that may have swollen shafts, skeleton lacking tetraxons and spongin; microscleres absent. *Devonian (Lochkovian)–Holocene.*

Sollasella VON LENDENFELD, 1888, p. 56 (VON LENDENFELD, 1887, p. 584, *nom. nud.*) [**S. digitata;* OD]. Ramose sponges with spicules including oxeas and strongyles in plumose arrangement. [There are no fossils in this genus; included here because it is type genus of family.] *Holocene:* southwestern Pacific Ocean.

Coniculospongia RIGBY & CLEMENT, 1995, p. 215 [**C. radiata;* OD]. Broadly flaring, funnel-like to discoidal or basinlike sponges with or without small stalks, skeletons composed of radiating, smooth oxeas, unclustered and generally parallel or subparallel, may be somewhat more loosely spaced on upper, gastral surface; coronal spicules absent; spicules not interwoven but radially subparallel. *Devonian (Lochkovian):* USA (Tennessee).——FIG. 17,*2a–b*. **C. radiata,* Ross Formation, Bird Song Shale Member, western Tennessee; *a,* funnel-shaped holotype seen from above showing fine, radial skeleton, Benton Quarry, southwestern Benton County, USNM 463591, ×2; *b,* paratype skeleton of upwardly and outwardly divergent oxeas, Road cut b on Tennessee Route 69, northwestern Perry County, USNM 463592, ×5 (Rigby & Clement, 1995).

Ginkgospongia RIGBY & CLEMENT, 1995, p. 212 [**G. foliata* RIGBY & CLEMENT, 1995, p. 213; OD]. Stalked, thin-walled, lobate or crenulate palmate to funnel-like sponge, expanding upwardly from stalk as lobes, each with upwardly expanding, fibrous, brushlike arrangement of monaxons, probably oxeas, to produce leaflike, flattened form. *Devonian (Lochkovian):* USA (Tennessee).——FIG. 17,*1a–b*. **G. foliata,* Ross Formation, Birdsong Shale Member, Parsons Quarry, northwestern Perry County; *a,* leaflike, stalked, lobate to palmate holotype, ×2; *b,* photomicrograph of fine, dense, brushlike skeleton of small oxeas, USNM 463590, ×20 (Rigby & Clement, 1995).

Opetionella ZITTEL, 1878b, p. 4 (94) [**O. radians;* OD]. Globular tuberous to irregularly crustose appearing; neither oscula, pores, nor canals observed; skeleton a thick layer of closely spaced, parallel oxeas. *Jurassic:* Germany.——FIG. 17,*3a–b*. **O. radians,* Cuvieri Pläner, Upper Jurassic, Salzgitter; *a,* side view of small, irregular sponge, ×1; *b,* skeletal fabric of oxeas, ×10 (Zittel, 1878b).

Rhizopsis SCHRAMMEN, 1910, p. 132 [**R. horrida;* OD]. Elongate, rootlike or ramose, composed of thick filaments of united amphioxea and amphistrongyles. *Upper Cretaceous:* Germany.——FIG. 18,*1*. **R. horrida,* Scaphitenplaner, Turonian, Nettlingen; side view of irregular sponge with upwardly divergent spicules in filaments on right, ×0.5 (Schrammen, 1910).

Sphaeriella RIGBY & POLLARD BRYANT, 1979, p. 1,005 [**S. radiata;* OD]. Spherical or subspherical to ovoid, small sponges with radiating skeleton of unbundled, thin monaxons, principally oxeas; canals straight and radiating from center, may increase in diameter radially; microscleres and cortex unknown. [*Belemnospongia* (MILLER, 1889) has a radiate architecture but is a discoidal sponge, as is *Choia* WALCOTT, 1920. *Tethya* LAMARCK, 1815, is spheroidal but has a strongly corticate surface.

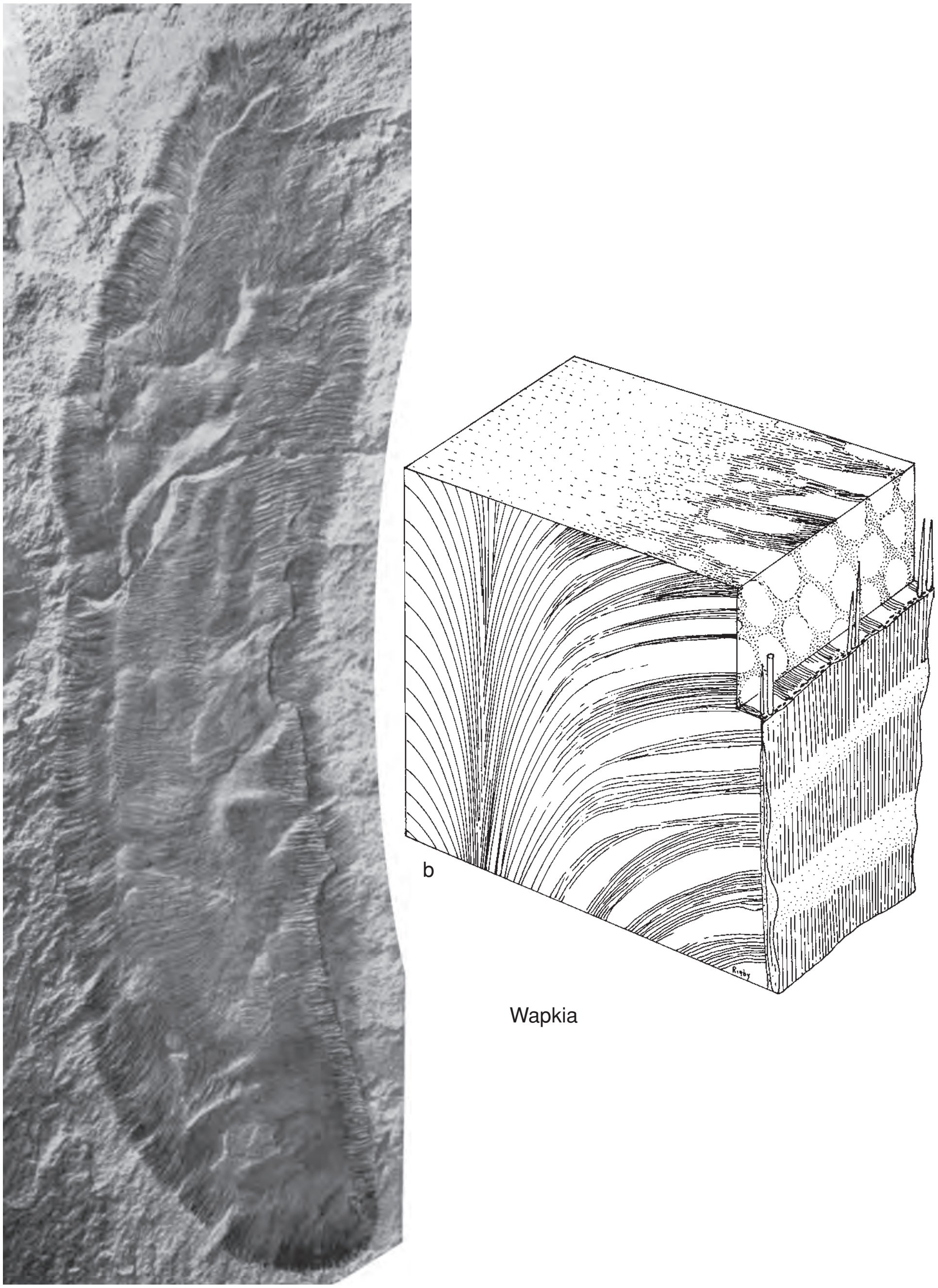

FIG. 10. Wapkiidae (p. 18).

FIG. 11. Wapkiidae (p. 18).

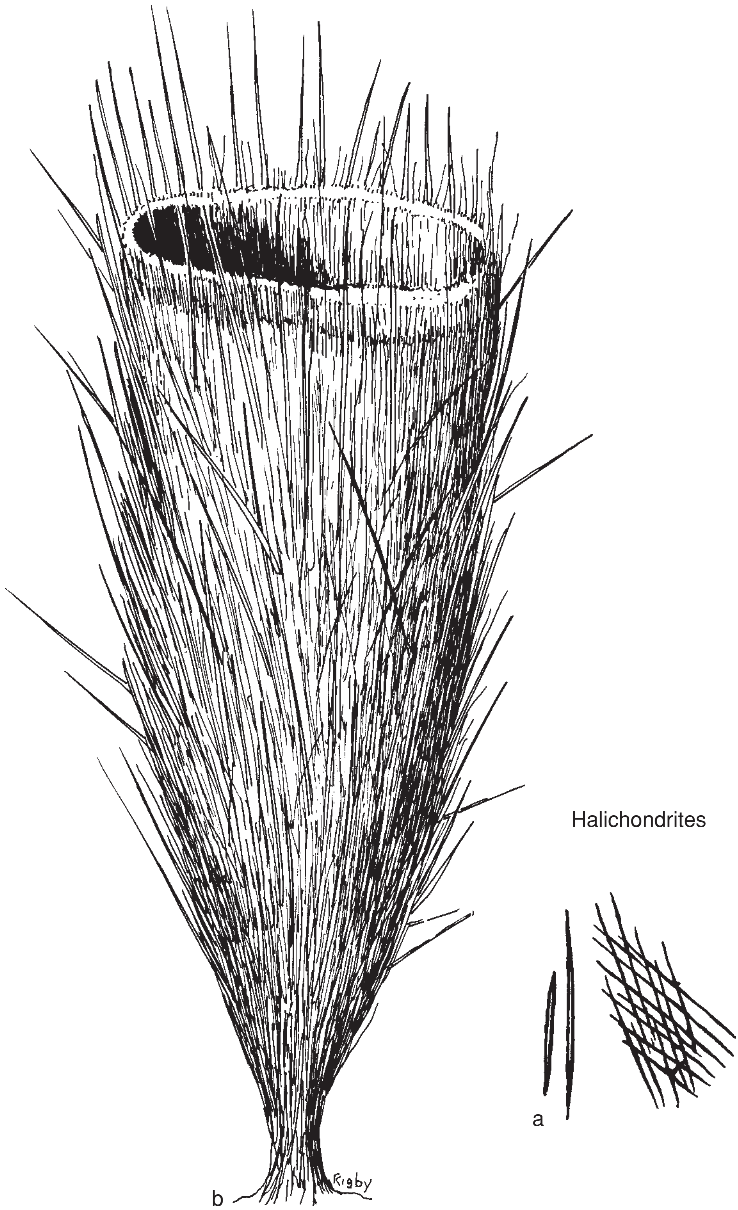

FIG. 12. Halichondritidae (p. 19–20).

This genus is placed in the family with some question.] *Carboniferous (Lower Mississippian):* USA (Alabama).——FIG. 18,*2a–b*. **S. radiata,* Fort Payne Chert, Aurora, northwestern Etowah County; *a,* spherical holotype with fine, radiating skeleton, BYU 1534, ×2; *b,* photomicrograph of paratype showing fine, hairlike, radiating spicules in interior and radial canals in outer part of vertical section, BYU 1536, ×5 (Rigby & Pollard Bryant, 1979).

Trichospongia BILLINGS, 1865, p. 357 [**T. sericea;* OD]. Hemispherical sponge with obscure, concentric structure and radiate, diactinal spicules; common branching canals occur throughout. [No

FIG. 13. Halichondritidae (p. 19–20).

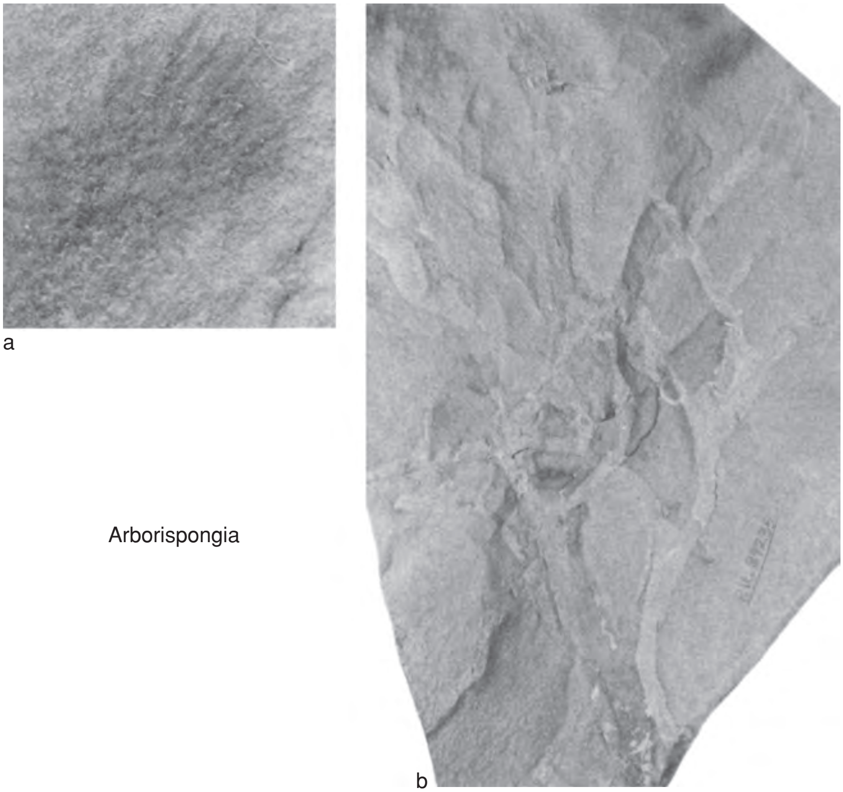

FIG. 14. Halichondritidae (p. 20).

known suitable figures.] *Ordovician (Champlainian):* Canada (Mingan Islands, Quebec).

Family TETHYIDAE Gray, 1848

[Tethyidae GRAY, 1848, p. 1] [=Donatiadae GRAY, 1872a, p. 460; Xenospongina CARTER, 1882, p. 357; Tethyidae VOSMAER, 1887, p. 326; Donatiidae BAER, 1906, p. 26]

Spheroidal sponges with strongly radiate, skeletal structure of bundles of monaxons; dermal layer prominent; microscleres include sphaerasters and euasters. [The family is commonly attributed to GRAY (1867, p. 540), but the name was used earlier by GRAY (1848).] *?Paleogene, Holocene.*

Tethya LAMARCK, 1815, p. 69, *non* GRAY, 1840, p. 148 [**Alcyonium aurantium* PALLAS, 1766, p. 357; SD TOPSENT, 1920b, p. 641]. Spherical to subspherical with two well-marked, concentric zones, an inner choanosome and an outer ectosome with strong, nodose, dermal layer; pronounced, radiate, skeletal structure produced by bundles of styles and megaster megascleres; microscleres include sphaerasters and euasters. *?Paleogene, Holocene:* Atlantic Ocean, Mediterranean Sea.——FIG. 19*a.* **T. aurantium* (PALLAS), Holocene; drawing of outer part of skeleton showing bundles of megascleres, common microscleres, and canal patterns (Sarà & Manara, 1991; courtesy of Springer-Verlag GmbH & Co.).——FIG. 19*b–c. T. cranium* LAMARCK, Holocene, Atlantic Ocean off British Isles; *b,* ovoid, complete sponge, ×1; *c,* transverse section showing radiate, skeletal structure with embedded gemmules and distinct, dermal layer, ×1 (Bowerbank, 1874a).

Family HAZELIIDAE de Laubenfels, 1955

[Hazeliidae DE LAUBENFELS, 1955, p. 37]

Fibrous skeleton; fibers composed of oxeas in either plumose or parallel arrangement; fibers anastomosing or sub-isodictyal; canals, where present, parallel fibers; dermal layer of tangential oxeas may be present. *Middle Cambrian–Lower Devonian.*

Hazelia WALCOTT, 1920, p. 281, *non* TAYLOR, 1920 [**H. palmata* WALCOTT, 1920, p. 282; OD]. Flabellate, conical, frondescent, branching or tubular, expanding upwardly from narrow base; composed

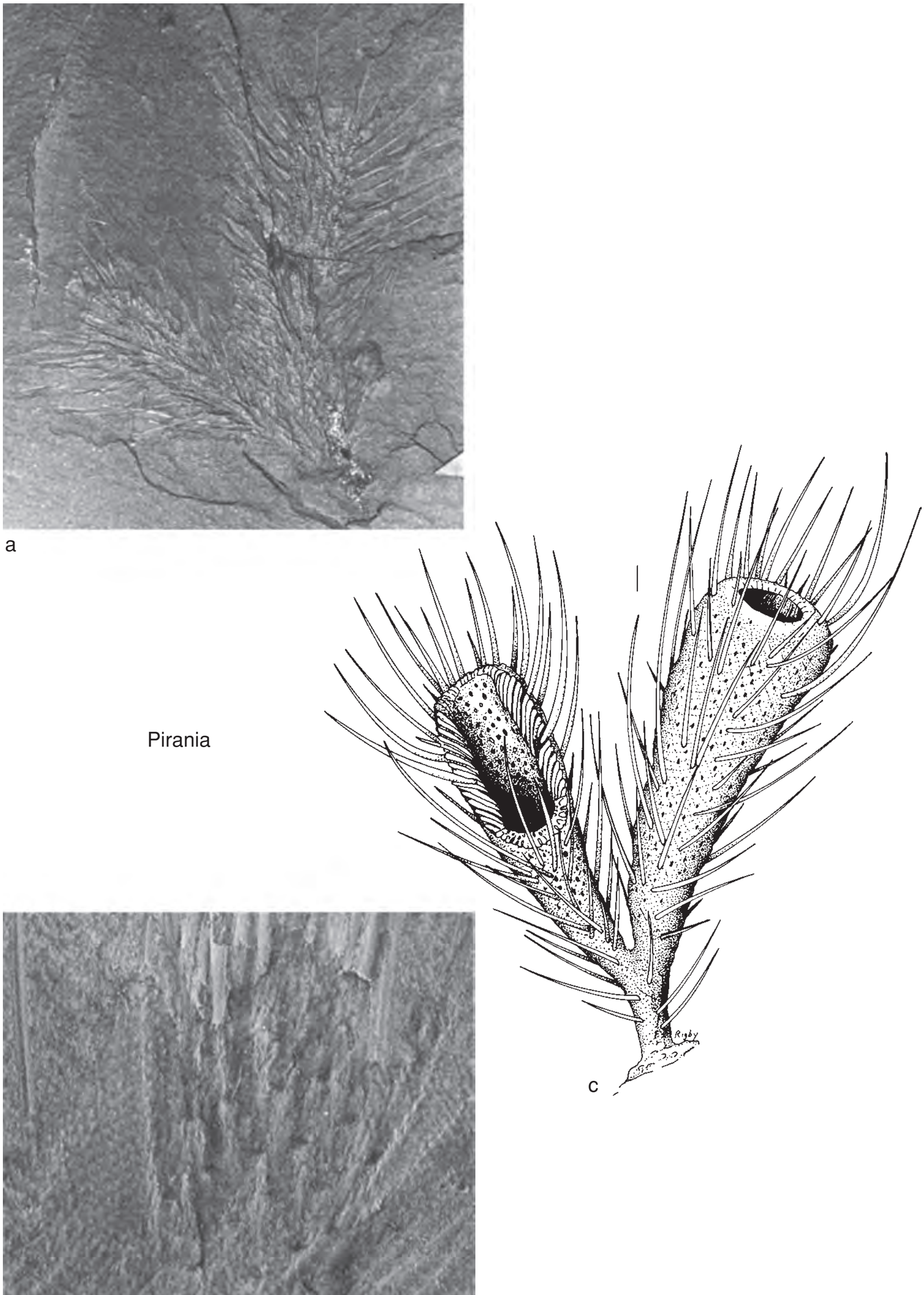

FIG. 15. Piraniidae (p. 21).

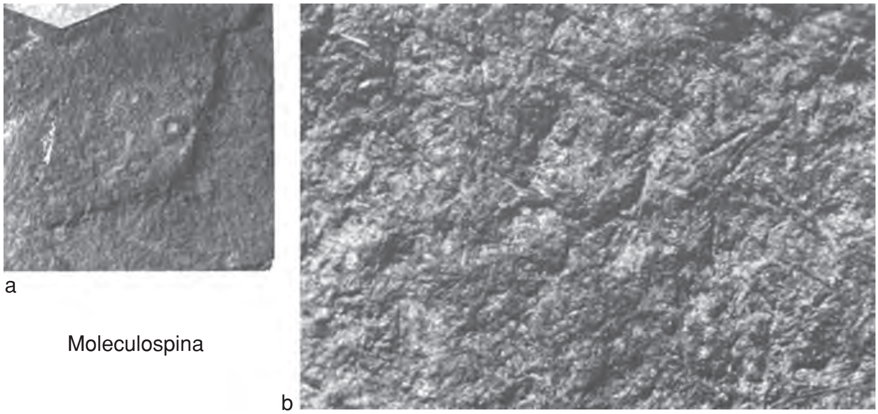

FIG. 16. Piraniidae (p. 21).

of branching and anastomosing, subparallel spiculofibers; fibers composed of plumosely arranged, smooth oxeas; canals small and parallel to fibers; a dermal layer of tangential oxeas may be present. [*H. delicatula* WALCOTT, which is tubular and branching and has a more nearly isodictyal net of bundles of parallel oxeas, perhaps should be placed in a separate, new genus.] *Middle Cambrian:* Canada (British Columbia), USA (Utah).——FIG. 20,*1a–f.* **H. palmata,* Stephen Formation, Burgess Shale, Mount Field, British Columbia; *a,* lectotype, fragment of disc with ragged, tufted margin and radiating bundles of coarse oxeas, USNM 66463, ×1; *b,* paralectotype with coarse tufts of bundled oxeas, USNM 66492, ×2; *c,* enlarged upper of paralectotype showing two diagonally oriented series of tufts of oxeas, USNM 66492, ×5; *d–f,* growth forms of various species of *Hazelia,* not to uniform scale (Rigby, 1986a).

Crumillospongia RIGBY, 1986a, p. 44 [**Morania (?) frondosa* WALCOTT, 1919, p. 231; OD]. Sack-shaped to globular or globose with thin walls of principally vertical, subparallel, monaxial spicules that form tracts around circular canals of at least two sizes; gastral layer a vertical, monaxial thatch that is less perforate; skeleton with weakly developed tufts; marginalia or prostalia absent. *Middle Cambrian:* Canada (British Columbia).——FIG. 21,*1a–c.* **C. frondosa* (WALCOTT), Stephen Formation, Burgess Shale, Mount Field; *a,* saclike holotype with rounded base and irregular, oscular margin, USNM 66779, ×2; *b,* enlargement of part of counterpart wall showing open, porous nature and two sizes of canals that interrupt vertically oriented, spicule net, USNM 66778, ×5; *c,* photomicrograph of holotype exterior showing vertical thatch of spicules interrupted by matrix clumps that fill irregular canals, USNM 66779, ×20 (Rigby, 1986a).

Falospongia RIGBY, 1986a, p. 44 [**F. falata;* OD]. Frondescent to thin-walled, obconical; composed of isolated, somewhat anastomosing, radiating tracts cross connected by abundant, horizontal or concentric tracts that produce three-dimensional, gridlike wall, tracts of clustered oxeas and possibly other monaxons. *Middle Cambrian:* Canada (British Columbia).——FIG. 20,*2.* **F. falata,* Stephen Formation, Burgess Shale, Mount Field; holotype, upper part of thin-walled, funnel-shaped sponge with anastomosing, skeletal tracts cross braced at irregular intervals by smaller tracts, both composed of oxeas, ROM 40317a, ×5 (Rigby, 1986a).

Lasiocladia HINDE, 1884a, p. 19 [**L. compressa;* OD]. Cylindrical; composed of oxeas arranged in plumose fashion about longitudinal axis of sponge; known from a single fragment. *Lower Devonian:* Belgium.——FIG. 21,*2.* **L. compressa,* Jemelle; holotype, flattened, plumose, spicule cluster, BMNH, ×1 (Hinde, 1884a).

Family TAKAKKAWIIDAE de Laubenfels, 1955

[Takakkawiidae DE LAUBENFELS, 1955, p. 38]

Slender, thin walled, conicocylindrical sponges in which dermal skeleton is made of vertically elongate, tiny oxeas; internally skeleton includes eight twisted, ribbonlike tracts that extend from base to differentiated, oscular fringe; exterior marked by vertical fins that reach from base to oscular margin where they produce a cockscomblike, oscular apparatus; entire skeleton made of clustered, monaxial spicules, except perhaps rare, triaxial spicules in twisted strands in interior (RIGBY, 1986a, p. 46). *Middle Cambrian.*

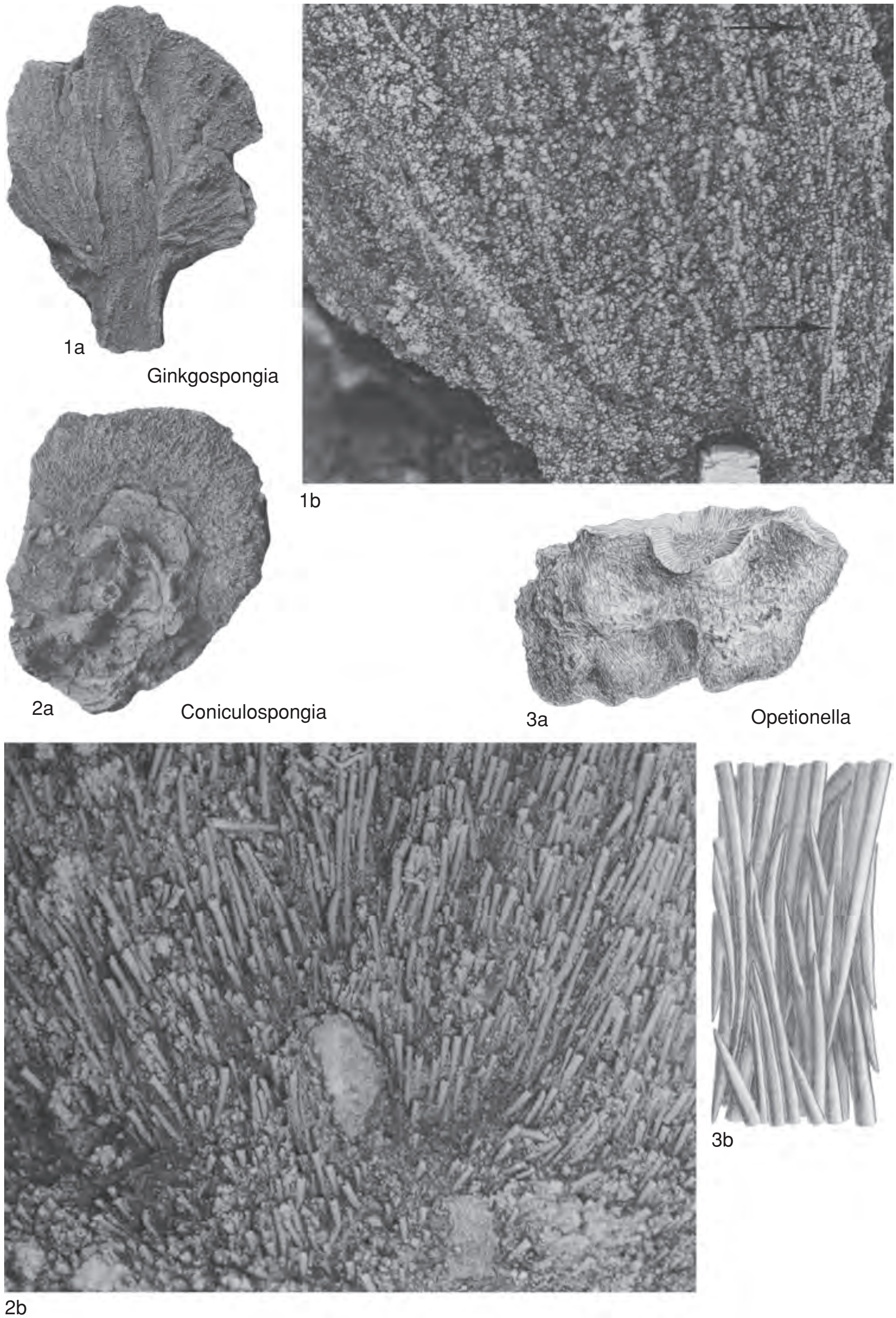

FIG. 17. Sollasellidae (p. 21).

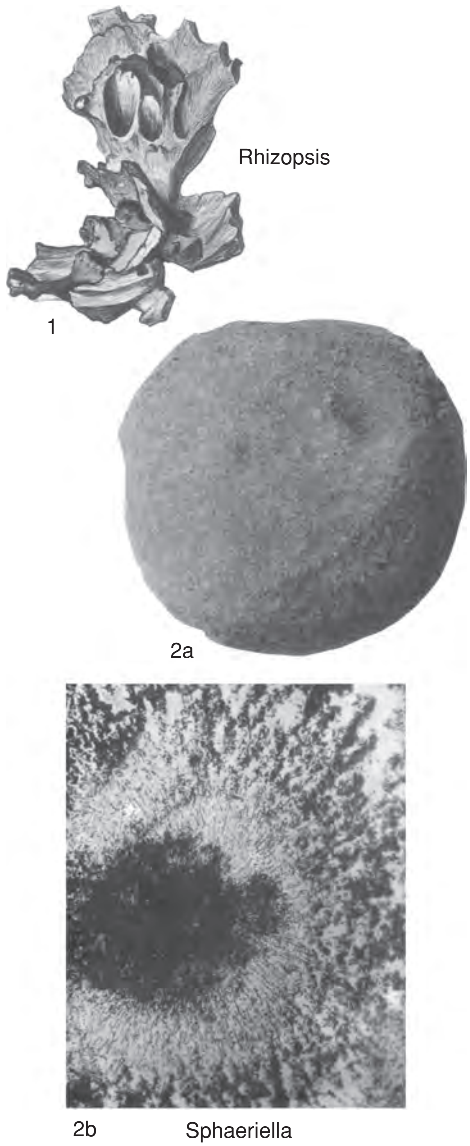

FIG. 18. Sollasellidae (p. 21–24).

Takakkawia WALCOTT, 1920, p. 277 [**T. lineata;* OD]. Conical-fusiform, with pointed base, widest part near mid-height, and slightly contracted toward broad osculum; prismatic, eight-sided, with narrow, radial, external fins at interfacial angles; vertical bundles of spicules at interfacial angles show spirally twisted structure (RIGBY, 1986a, p. 47–48) and splay out at oscular end (oscular apparatus of RIGBY, 1986a); spicules possibly rhabdodiactines, tauactines, or stauractines; horizontal spicule rays extend across space between bundles; there is a suggestion of a finer quadrate mesh of possible stauractines between bundles. *Middle Cambrian:* Canada (British Columbia).——FIG. 22*a–c*. **T. lineata,* Stephen Formation, Burgess Shale, Field, British Columbia; *a,* flattened lectotype showing general form, oscular apparatus, and twisted, spiral strands characteristic of genus, ×2 (Walcott, 1920); *b,* photomicrograph of upper part of lectotype showing twisted, ribbonlike strands and their upper, frayed ends associated with radiating fins of oscular apparatus, horizontal elements cross connect between spiral tracts in main part of sponge, ×10; *c,* lower part of lectotype showing traces of eight spiral tracts and associated radial fins; rates of spiraling are relatively constant within a tract, but vary between tracts, USNM 66539, ×5 (Rigby, 1986a).——FIG. 23. **T. lineata,* Stephen Formation, Burgess Shale, Field, British Columbia; restoration showing relationships between spiral tracts, radiating fins, and their rounded tips in oscular apparatus, ×4 (Rigby, 1986a).

Family MAHALOSPONGIIDAE Rigby & Stuart, 1988

[Mahalospongiidae RIGBY & STUART, 1988, p. 130]

Small, simple, monaxonid sponges with thin walls composed mainly of tangential, diagonal to horizontal, curved to serpentine ophirhabds; prostalia may form dense, oscular fringe. *Silurian–Devonian.*

Mahalospongia RIGBY & STUART, 1988, p. 130 [**M. floweri;* OD]. Small, conicocylindrical to subcylindrical sponges with thin wall and deep, simple spongocoel; walls smooth and unornamented; skeletal net composed principally of irregularly subhorizontal to diagonal, curved to sinuous monaxons, mainly ophirhabds; oscular fringe a dense prostalia of diactines, principally oxeas, of several sizes; skeletal structure becoming more nearly vertical near base; root tuft unknown. *Silurian–Devonian:* USA (Nevada).——FIG. 24*a–b*. **M. floweri,* Roberts Mountains Formation, Silurian, Independence Mountains; *a,* flattened holotype and associated paratypes, with sharp, pointed base and distinct, oscular fringe, USNM 415777, ×2; *b,* enlargement of central part of paratype showing dominantly subhorizontal monaxons (possible ophirhabds) in moderately loose, open, skeletal net, USNM 415778, ×10 (Rigby & Stuart, 1988).

Family HELIOSPONGIIDAE Finks, 1960

[Heliospongiidae FINKS, 1960, p. 40]

Skeletal net a radial-reticulate mesh of spiculofibers composed of thick bundles of smooth, slightly curved oxeas closely packed parallel to length of fiber; dense, dermal

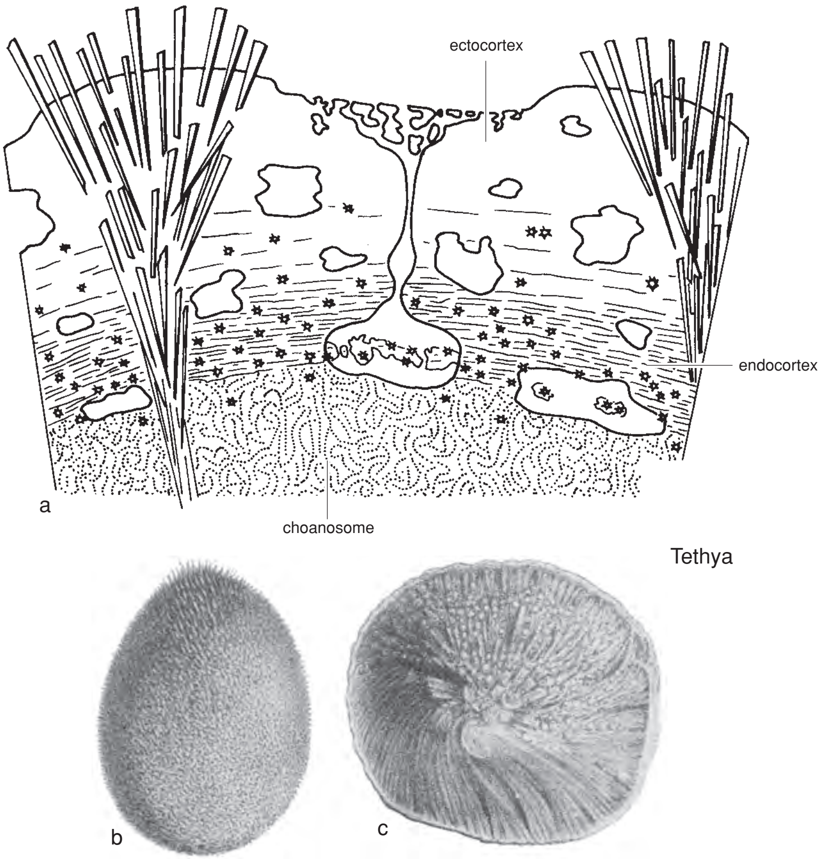

FIG. 19. Tethyidae (p. 26).

layer may be present, composed of similar oxeas closely packed, tangential to surface and arranged concentrically about pores; vertical fibers perpendicular to growing surface, horizontal fibers parallel to it. *Carboniferous (Middle Pennsylvanian)–Permian (Changhsingian).*

Heliospongia GIRTY, 1908, p. 288 [**H. ramosa* GIRTY, 1908, p. 289; OD] [=*Corynospongia* DENG, 1990, p. 317 (type, *C. tubuliforma* DENG, 1990, p. 319, OD)]. Tubular and branching with deep cloaca, or flabellate and solid with shallow, lateral, multiple, cloacal depressions; horizontal spiculofibers form upwardly arched layers parallel to top surface of sponge; vertical spiculofibers at right angles to these, diverging upwardly and outwardly from axial region or cloaca of sponge; larger, exhalant canals parallel to horizontal spiculofibers and open as circular pores on cloacal surface, arranged in vertical and horizontal rows and forming surface grooves about osculum on sponge exterior; somewhat smaller, circular to stellate, inhalant pores on outer surface lead into inhalant canals that follow vertical fibers inwardly and downwardly; lower part of cloaca filled in secondarily with less regular mass of spiculofibers pierced by vertical, exhalant canals; juvenile stage solid, hemispherical, and encrusting. *Upper Carboniferous–Permian (Sakmarian):* southwestern North America, USA (Kansas, Ohio, Texas), Tunisia, Spain, China (Ziangsu, Guizhou, Sichuan).——FIG. 25*a–b*. **H. ramosa,* Plattsburg (Allen) Limestone, Missourian, Chanute, Kansas; *a,* holotype block, ×0.25, and *b,* part showing branching habit, axial spongocoel, and regular arrangement of spicules in skeleton, USNM 53472, ×1 (Girty, 1908).——FIG. 25*c*. *H. excavata* KING, 1933, Graford Formation, Missourian, Lake Bridgeport Dam, Texas; median section of topotype showing general pattern of skeleton, USNM 127582f, ×1 (Finks, 1960).——FIG. 25*d*. *H. vokesi* KING, Leonard Formation, Leonardian, Glass Mountains, Texas; weathered longitudinal section showing thick walls around axial spongocoel and

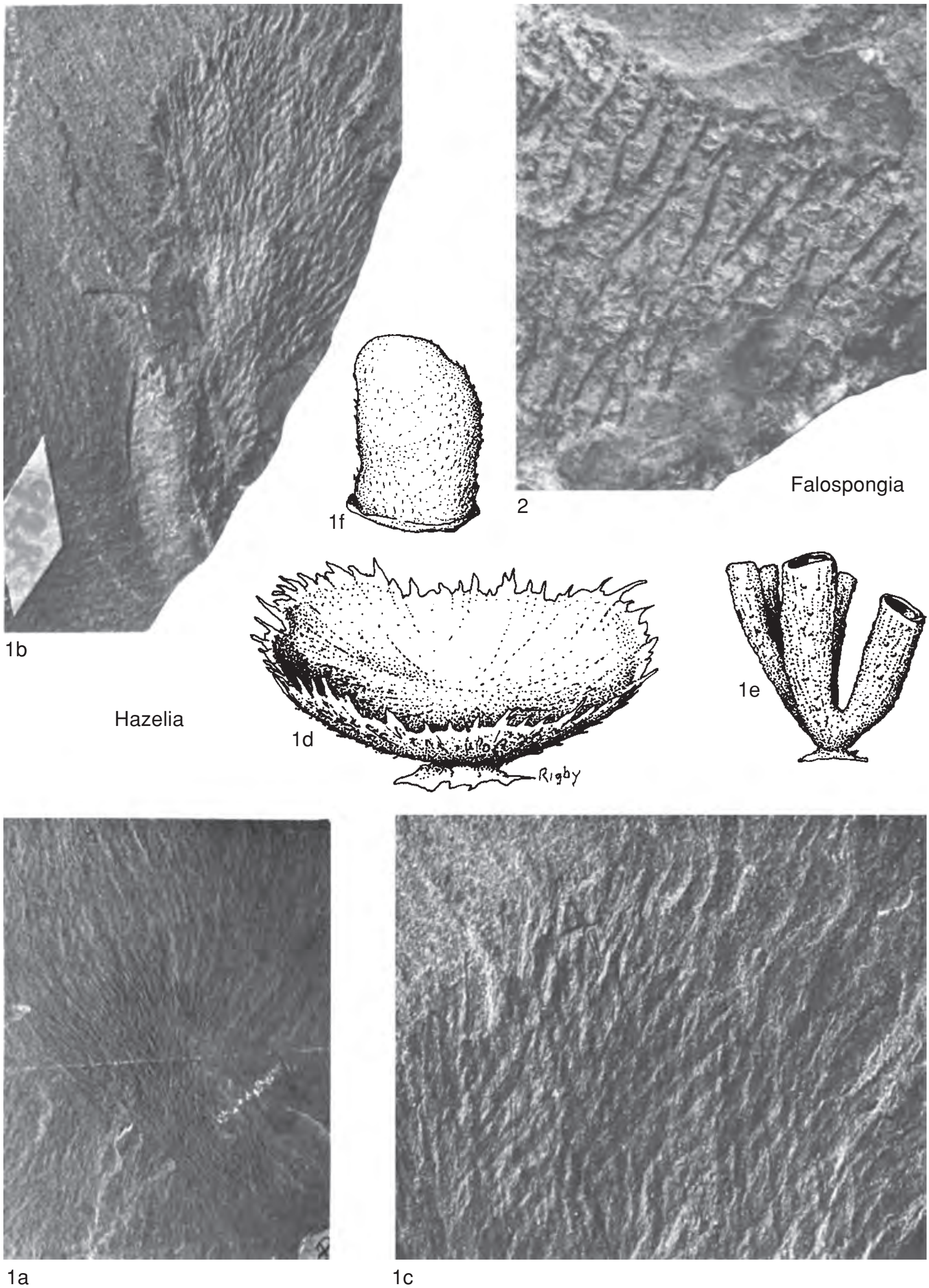

Fig. 20. Hazeliidae (p. 26–28).

upwardly arched, skeletal structure pierced by aligned apochetes, USNM 127588d, ×1 (Finks, 1960; courtesy of The American Museum of Natural History).

Coelocladia Girty, 1908, p. 287 [**C. spinosa* Girty, 1908, p. 288; OD]. Tubular and branching with deep cloaca (not continuous between branches), or funnel shaped and frondose; sponge smaller,

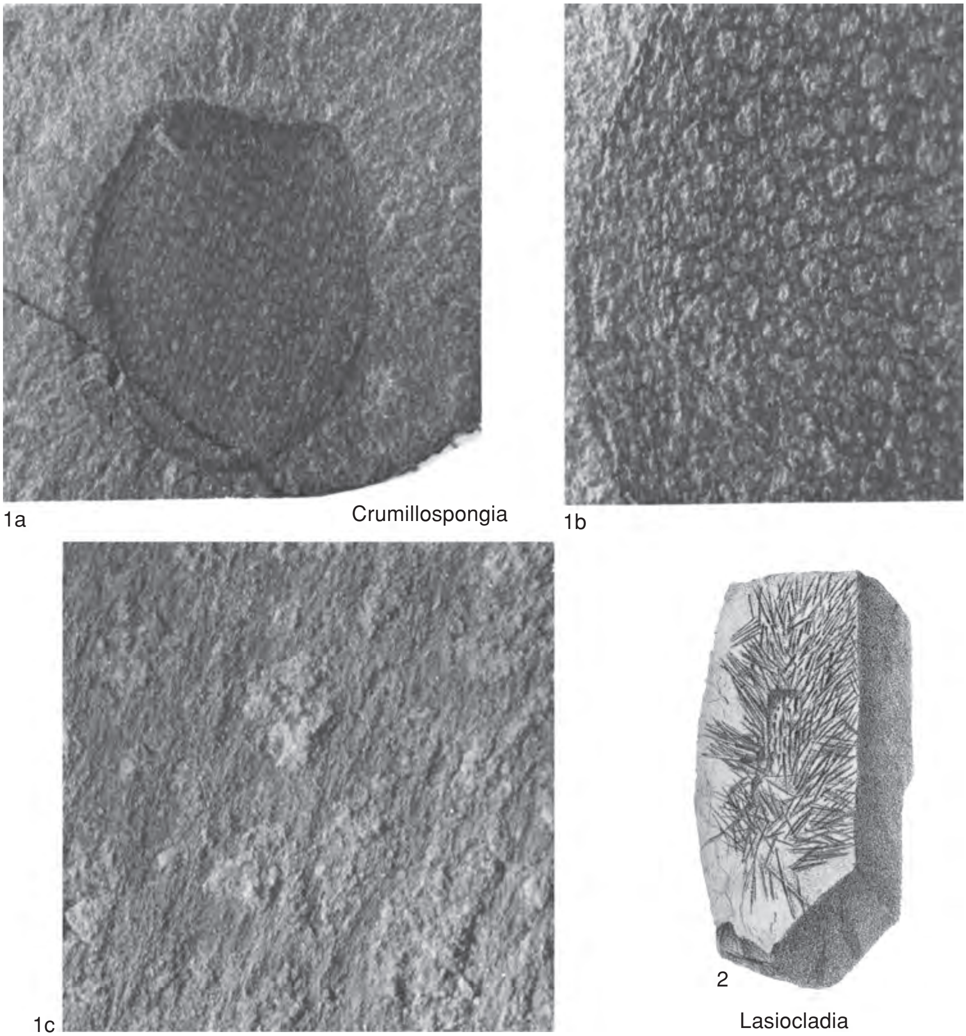

FIG. 21. Hazeliidae (p. 28).

spiculofibers thinner and more closely spaced, and somewhat less regularly arranged than in *Heliospongia;* horizontal fibers forming convex-up layers parallel to top of sponge or growing edge of frond; vertical fibers subparallel to exhalant (cloacal) surface and diverging upwardly and outwardly to inhalant (exterior) surface; exhalant surface bearing rows of irregular, exhalant pores parallel to growing edge; inhalant surface covered with a dense, imperforate layer that forms collars about circular, evenly distributed, inhalant pores; adjacent collars may unite to form meandriform ridges; exhalant canals parallel to horizontal spiculofibers; inhalant canals parallel to vertical fibers. *Carboniferous (Middle Pennsylvanian–Upper Pennsylvanian):* North America, Spain.——FIG. 26,*1a–e.* **C. spinosa,* Plattsburg Limestone, Chanute, Kansas, USA; *a,* lectotype, cylindrical fragment with nodose prosopores and osculum of axial spongocoel at summit, USNM 53469a, ×1 (Girty, 1908); *b,* longitudinal section of paratype showing upwardly divergent, trabecular, skeletal net in thick walls around axial spongocoel, USNM 53469c, ×5; *c,* transverse section of same paratype showing radial, excurrent, canal system in trabecular, skeletal net, USNM 53469c, ×5; *d,* side view of figured specimen showing lower stem and upper, funnel-shaped parts with nodose or lipped prosopores in dermal layer, USNM 127591a, ×1; *e,* opposite side view showing thin walls and broad

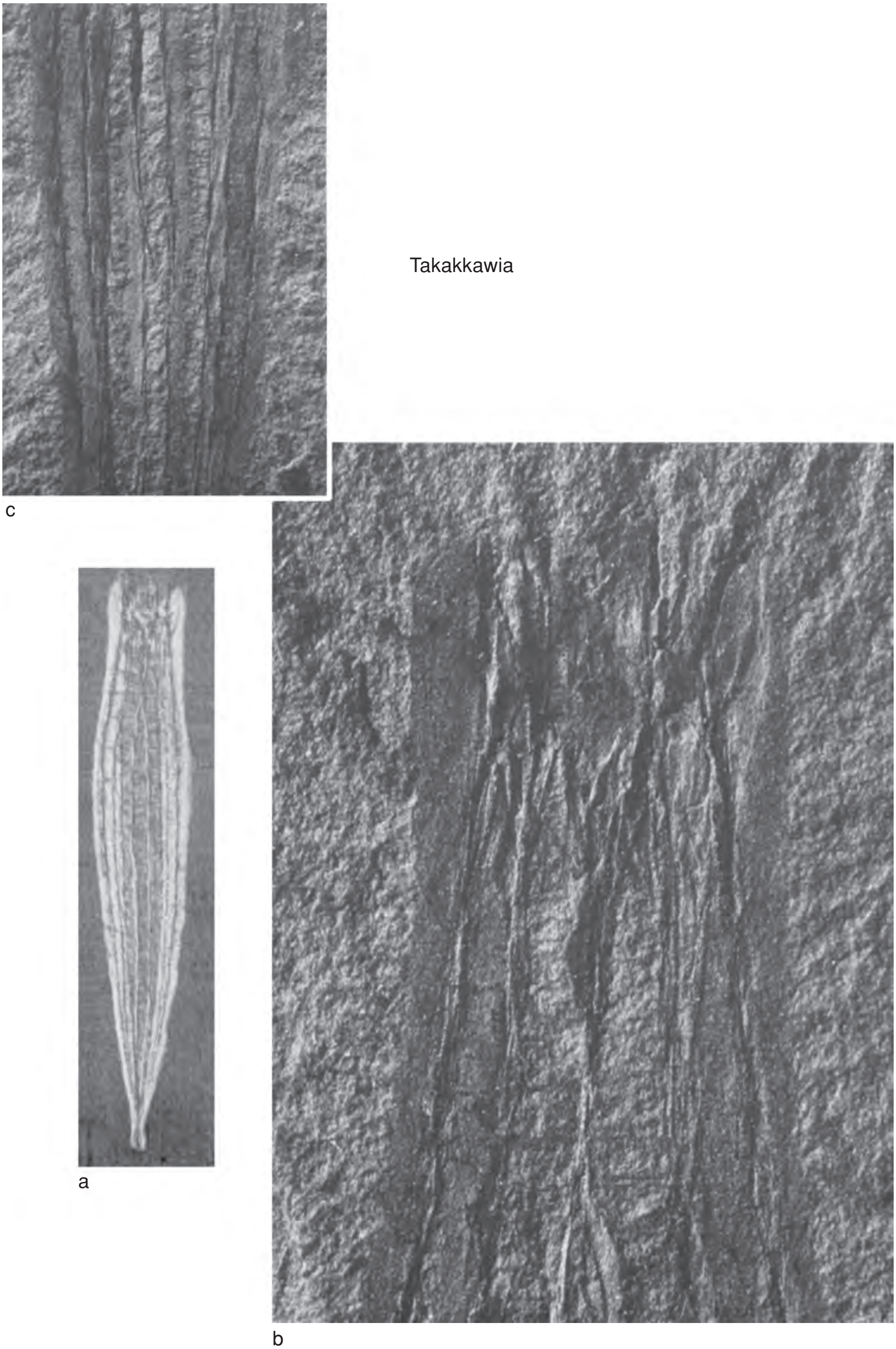

FIG. 22. Takakkawiidae (p. 30).

spongocoel with apopores, USNM 127591a, ×1 (Finks, 1960; courtesy of The American Museum of Natural History).

Coelocladiella FINKS, 1960, p. 52 [**C. lissa* FINKS, 1960, p. 53; OD]. Tubular and thin walled with broad cloaca; resembles *Coelocladia* but differs in that dense, external layer, with collars about inhalant pores, is absent, and skeletal net less regular and more open; no spicules have been observed. *Upper Carboniferous–Permian (Lopingian):* USA (Texas, ?Missouri), *Upper Carboniferous–Permian (Sakmarian);* China (Guangxi), *Permian (Lopingian).*——FIG. 26,*2a–c.* **C. lissa,* Gaptank Formation, Missourian–Wolfcampian, Brewster County, Texas; *a,* holotype from side, ×1; *b,* vertical section showing upwardly divergent, skeletal structure, USNM 127595, ×5; *c,* side view of silicified specimen showing deep, simple spongocoel and pores of canal system, USNM 127594, ×1 (Finks, 1960; courtesy of The American Museum of Natural History).

Neoheliospongia DENG, 1981, p. 426 [**N. typica;* OD]. Branching, cylindrical sponge lacking axial spongocoel, with relatively dense skeleton of thick, upwardly divergent, ascending tracts interconnected by convex layers of thick, concentric horizontal tracts that turn down sharply around periphery; spicule structure unknown; canal system well developed with canals partially parallel to ascending tracts and to horizontal tracts with ascending canals connecting to horizontal ones; surface with irregular to distinctly aligned pores. [*Neoheliospongia* is structurally similar to *Heliospongia* GIRTY, 1908, but without characteristic large, axial spongocoel of the latter. *Heliospongia* has skeletal tracts composed of bundled, smooth oxeas and until skeletal details of *Neoheliospongia* can be obtained, comparisons depend on larger, structural relationships.] *Permian (Changhsingian):* China (Guangxi).——FIG. 27,*2a–b.* **N. typica,* Changhsing Formation; *a,* longitudinal section of holotype showing upwardly divergent, vertical tracts connected by arched, horizontal tracts in regular skeletal structure, NIGPAS 59971, ×2.5; *b,* transverse section of cylindrical holotype showing uniform skeletal structure and lacking spongocoel, NIGPAS 59972, ×2.5 (Deng, 1981).

Spitsbergenia HURCEWICZ, 1983, p. 90 [**S. patella;* OD]. Plate- or bowl-shaped sponges without differentiated canal system within skeleton; reticulate skeleton of numerous smooth, straight to slightly bent, sharply terminated diactines. *Permian:* Spitzbergen.——FIG. 27,*1a–c.* **S. patella,* Kapp Starostin Formation, Hornsund, Treskellen; *a,* holotype, transverse section showing dense, skeletal structure and absence of major canals, IPPAS AI-69-66, ×3; *b,* transverse section of reference specimen with laterally divergent, skeletal structure, below, overgrown by coarser *Haplistion skinneri* (KING, 1943), IPPAS AI-69-31, ×2; *c,* drawings of diactine spicules from reference thin section, IPPAS AI-69/66, ×50 (Hurcewicz, 1983; courtesy of *Acta Palaeontographica Polonica,* Polska Akademia Nauk).

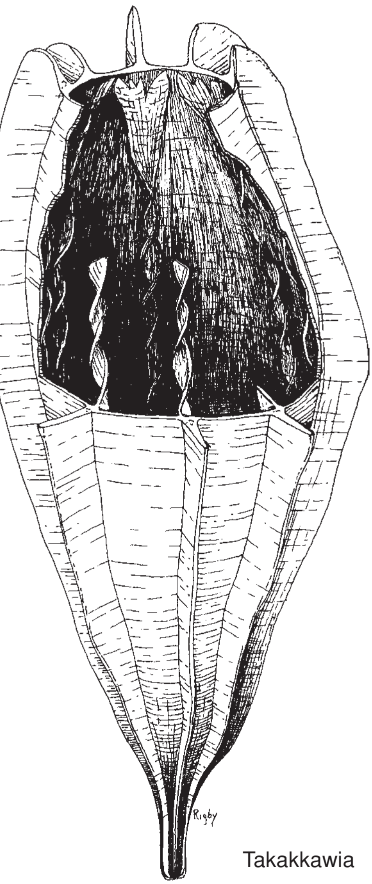

FIG. 23. Takakkawiidae (p. 30).

Order CLAVULINA Vosmaer, 1887

[*nom. transl.* FINKS & RIGBY, herein, *ex* tribus Clavulina VOSMAER, 1887, p. 328] [=suborder Hadromerina TOPSENT, 1898, p. 93]

Diagnostic microscleres are spinispires; megascleres characteristically tylostyles that may be accompanied by oxeas and styles. *Ordovician–Holocene.*

Family CLIONAIDAE d'Orbigny, 1851

[*nom. correct.* BOUCHET & RÜTZLER, 2003, p. 99, *pro* Clionidae D'ORBIGNY, 1851, p. 209; *emend.,* BOUCHET & RÜTZLER, 2003, p. 99] [=Clioniadae GRAY, 1867, p. 524, *non* RAFINESQUE, 1815, gastropod]

Clavulinid sponges that excavate ramifying and usually anastomosing galleries in calcareous shells; numerous openings to surface occur along length of galleries, diameter being about same as that

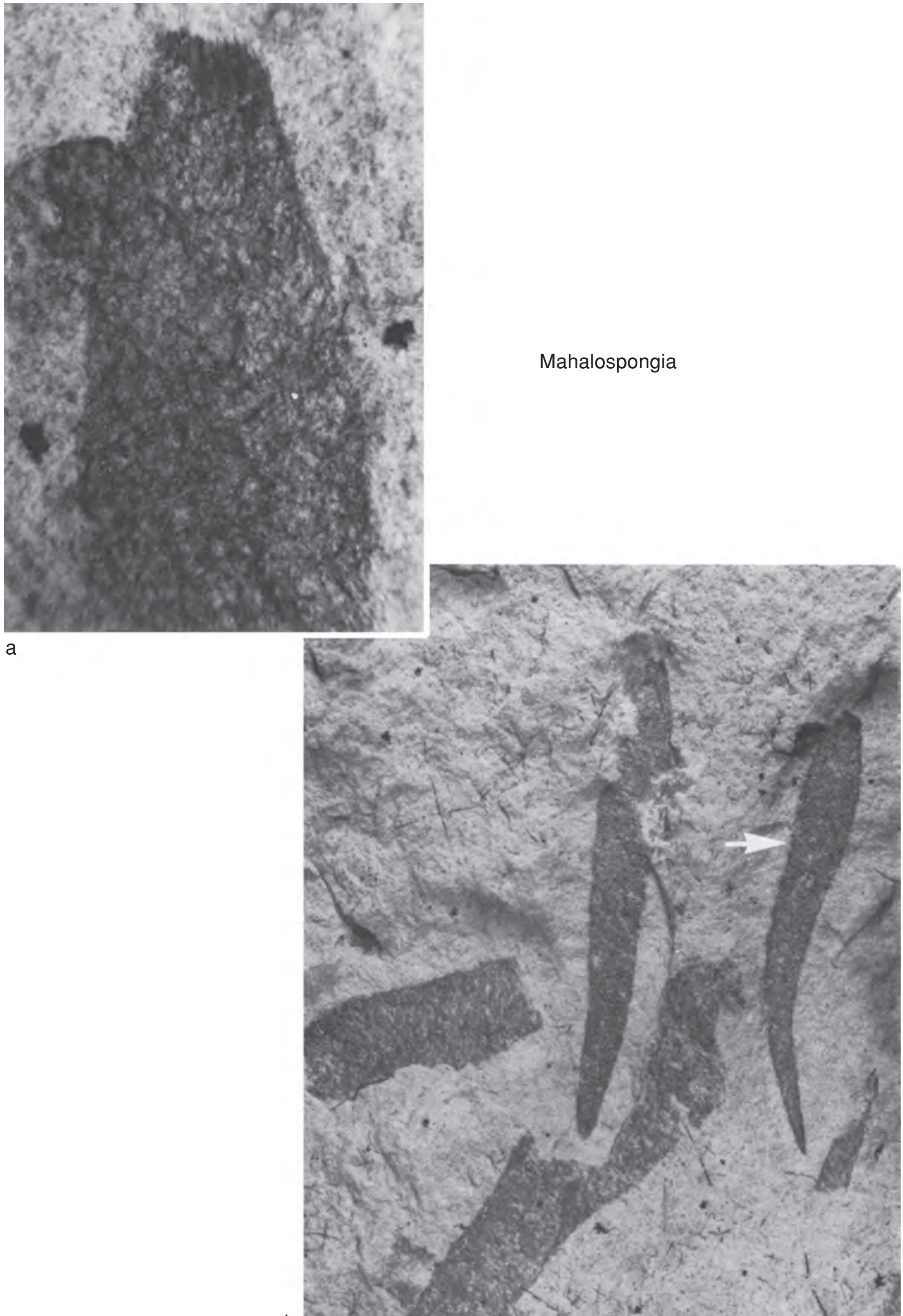

FIG. 24. Mahalospongiidae (p. 30).

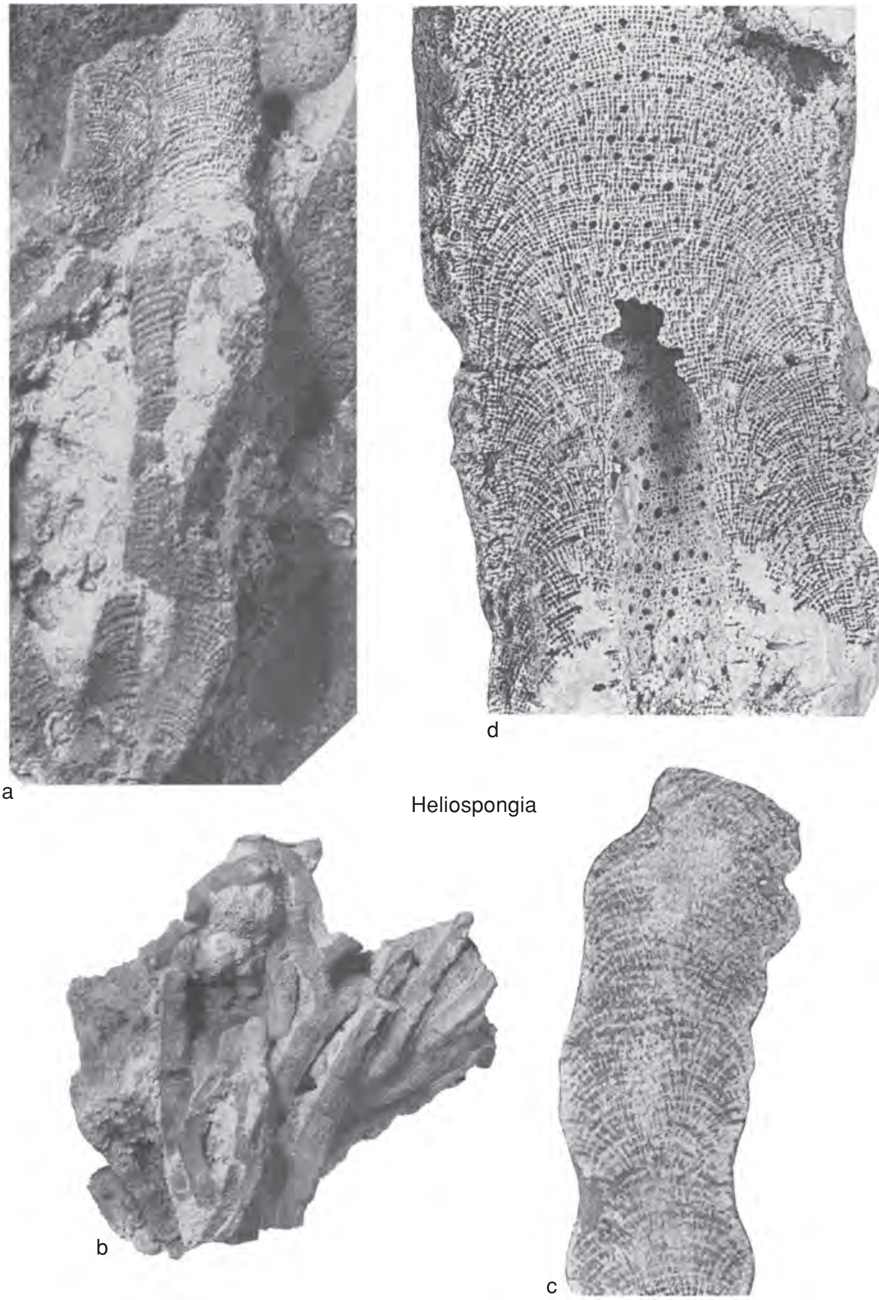

FIG. 25. Heliospongiidae (p. 31–32).

of galleries; abundant tylostyles may remain in well-preserved borings, but are unknown from Paleozoic forms. *Ordovician–Holocene.*

Cliona GRANT, 1826a, p. 79 [**C. celata;* OD]. Shallow, sponge borings as meandering impressions in calcareous shells or other substrates; spicules mainly tylostyles but may include spirasters and less commonly oxeas. *Devonian–Holocene:* cosmopolitan.

FIG. 26. Heliospongiidae (p. 32–35).

——FIG. 28,*4a–b. C. cretacica* FENTON & FENTON, Navesink Formation, Upper Cretaceous, New Egypt, New Jersey, USA; *a,* shell of *Exogyra* with perforations of boring sponge, ×0.5; *b,* etched shell of *Gryphaea* showing casts of sponge borings, ×1 (Fenton & Fenton, 1932b).

Alectona CARTER, 1879, p. 497 [**A. millari;* SD DE LAUBENFELS, 1936, p. 156]. Membranous like *Thoosa,* but not certainly burrowing, and larva seem to be choristid; some megascleres peculiarly lumpy. *Paleogene–Holocene:* New Zealand, *Paleogene–Neogene;* cosmopolitan, *Holocene.*——FIG.

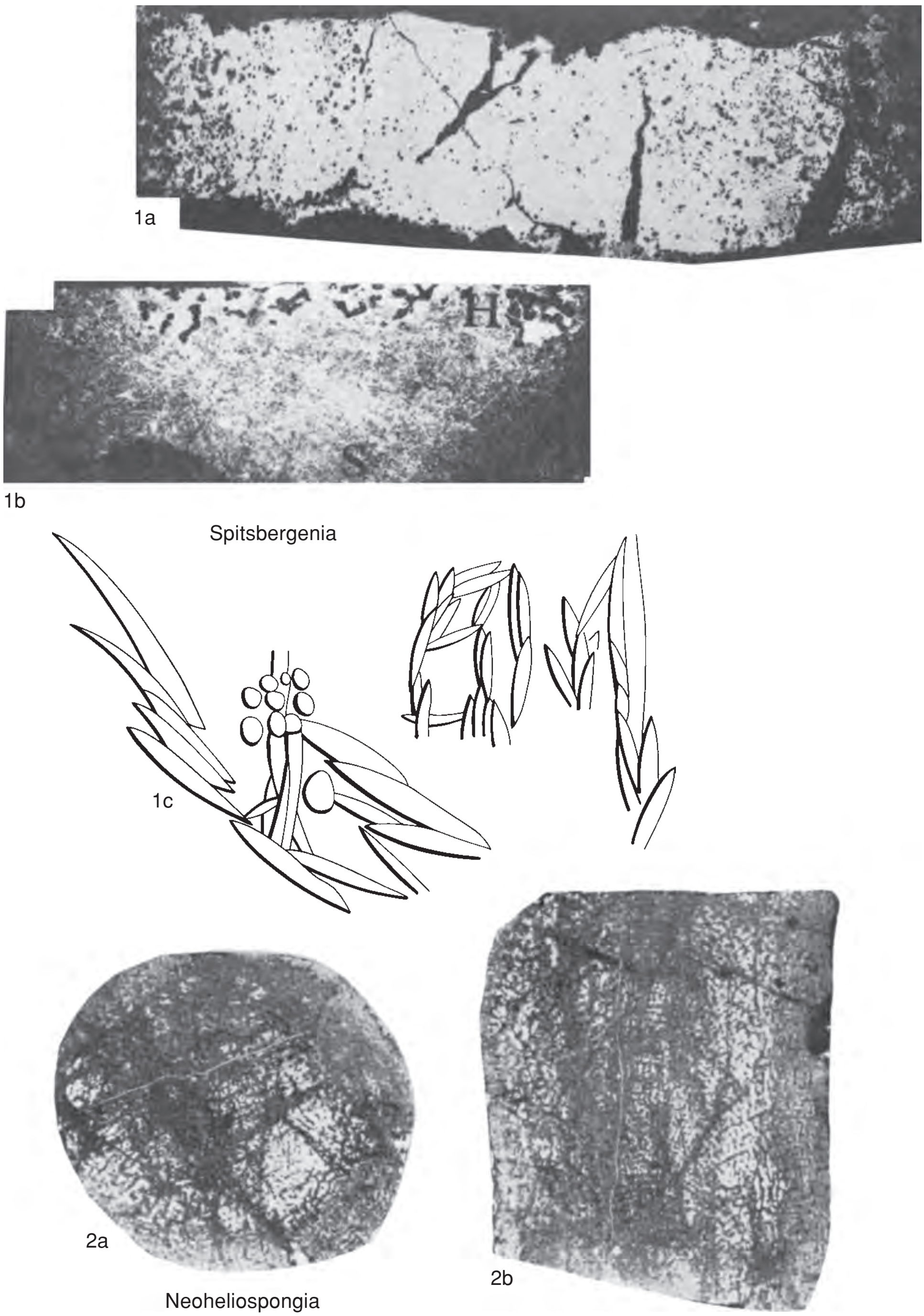

FIG. 27. Heliospongiidae (p. 35).

29,*1a–c.* **A. millari,* Holocene, North Atlantic Ocean; *a–b,* microscleres, ×400 (de Laubenfels, 1955); *c,* nodose megascleres, ×100 (Carter, 1879).

Clionoides FENTON & FENTON, 1932a, p. 47 [**C. thomasi* FENTON & FENTON, 1932a, p. 48; OD]. Borings in shells consist of long, rather straight tubes that may branch once or twice; they communicate to exterior by series of closely spaced openings along length of each tube. [This last characteristic makes an assignment to the sponges more likely than is the case with the other borings described here, although it must still be considered doubtful. See also HÄNTSCHEL, 1962, p. 230.] *Middle Devonian:* North America.——FIG. 28,*2.* **C. thomasi,* Cedar Valley Limestone, Waterloo, Iowa, USA; holotype boring in brachiopod valve, USNM 184641a, ×1 (Fenton & Fenton, 1932a).

?Clionolithes CLARKE, 1908, p. 168 [**C. radicans;* SD FENTON & FENTON, 1932a, p. 43] [=*Olkenbachia* SOLLE, 1938, p. 156 (type, *O. hirsuta* SOLLE, 1938, p. 157, OD)]. Borings in shells; from central cavity, opening to exterior, and radiating in one plane with numerous branching tubes that each taper to point. [This may not be a sponge. See also HÄNTZSCHEL, 1962, p. 230.] *Ordovician–Carboniferous:* Europe, *Ordovician;* Europe, USA, China, *Devonian–Carboniferous.*——FIG. 28,*3. C. irregularis* FENTON & FENTON, Cedar Valley Limestone, Upper Devonian, Blackhawk County, Iowa, USA; holotype as ramifying borings in an *Atrypa* shell, USNM 84693, ×1 (Fenton & Fenton, 1932a).

Entobia BRÖNN, 1838 in 1837–1838, p. 691 [**E. cretacea* PORTLOCK, 1843, p. 360; SD HÄNTZSCHEL, 1962, p. 230]. Borings in calcareous substrates as small, chambered impressions with short apophyses that widen at base; chambers not spherical but irregularly nodular and commonly occurring in closely adjacent rows; apertures variable but up to several millimeters wide; large canals connecting with these apertures and may have half chambers on their sides. *?Silurian, Upper Cretaceous–Holocene:* Ireland, *?Silurian;* England, Ireland, *Upper Cretaceous;* Greece, *Pliocene;* Italy, *Holocene.*——FIG. 28,*1a–b. E. goniodes* BROMLEY & ASGAARD, upper Pliocene occupation of Jurassic Elaphokampos Cherty Limestone, Tsampika Bay, Island of Rhodes, Greece; *a,* counterpart to holotype pebble with entobian borings in interior, MGUH 20743b, ×1; *b,* enlarged view of holotype with chambers and aporhyses, ×5 (Bromley & Asgaard, 1993; courtesy of Gordon and Breach Publishers).

?Filuroda SOLLE, 1938, p. 158 [**Clionolithes reptans* CLARKE, 1908, p. 168; OD]. Threadlike, serpentine, irregularly branching borings in shells, ramifying just beneath surface. [This may not be a sponge. See also HÄNTZSCHEL, 1962, p. 230.] *Lower Devonian–Carboniferous (Pennsylvanian):* North America, Europe, *Lower Devonian–Middle Devonian;* North America, *Pennsylvanian.*——FIG. 28,*5.* **F. reptans* (CLARKE), Oriskany Sandstone, Lower Devonian, Becraft Mountain, New York, USA; holotype, threadlike boring, ×30 (Solle, 1938; courtesy of *Senckenberg Naturforschende Gesellschaft*).

?Palaeosabella CLARKE, 1921, p. 91, *nom. nov. pro Vioa* M'COY, 1855, p. 260, *non* NARDO, 1833 [**Vioa prisca* M'COY, 1855, p. 260; OD] [=*Palaeosabella* CLARKE, 1921, p. 91, *nom. null.; Paläosabella* SOLLE, 1938, p. 157, *nom. null.; Topsentopsis* DE LAUBENFELS, 1955, p. 41, *nom. nov. pro Topsentia* CLARKE, 1921, p. 88, *non* BERG, 1899]. Borings in shells and stromatoporoids, consisting of straight, occasionally branching tubes, often enlarged at end, that may radiate from central cavity or open directly to shell surface. [This may not be a sponge, but it shows some resemblance to *Clionoides* FENTON & FENTON, 1932a, with which it occurs.] *?Silurian, Devonian:* England, *?Silurian;* North America, *?Silurian, Devonian.*——FIG. 29,*2.* **P. prisca* (M'COY), upper Silurian, Malverns, England; central cavities from which radiate relatively straight tubes, all as fillings, ×1 (Fenton & Fenton, 1932a).

Runia MAREK, 1984, p. 402 [**R. runica;* OD]. Horizontal series of borings, each of which consists of short, vertical, almost straight, nodular to cylindrical, narrow tunnels that have circular cross sections and appear like short, dotted line in early stages; later stages have two or three branches in forklike structure, and later stages may have secondary branches; tunnels in single series more or less alike, but may differ from those above and below in branched development; series of borings follow growth lines in host shells. *Silurian (Ludlow):* Czech Republic, Slovakia.——FIG. 29,*4a–b.* **R. runica,* Kopanina Formation, central Bohemia, Barrandian area; *a,* holotype series of borings in *Orthoceras* shell, Lejskov hill, near Zdice, PDMNH-P NM L 20273, ×1; *b,* enlargement of one series of borings from holotype showing beaded form of borings, ×8 (Marek, 1984).

Thoosa HANCOCK, 1849, p. 345 [**T. cactoides;* SD DE LAUBENFELS, 1936, p. 156]. Sponges branched or lobed, buried in calcareous bodies; interior with anastomosing tubes without spicules; surficial megascleres typically conjoined spheres with one or more radiating shafts; microscleres commonly with verticillate spines as in *Ditriaenella. Paleogene–Holocene:* New Zealand, *Paleogene–Neogene;* cosmopolitan, *Holocene.*——FIG. 29,*3a–b.* **T. cactoides,* Holocene, Indo-Pacific Ocean; *a,* part of branched individual with terminal, twiglike tips, ×1; *b,* highly enlarged spicule from surface of same specimen as in *a,* approximately ×2,000 (Hancock, 1849).——FIG. 29,*3c. T. bulbosa* HANCOCK, Holocene, Indo-Pacific Ocean; triradiate, surficial megascleres, approximately ×200 (Hancock, 1849).

Family ADOCIIDAE de Laubenfels, 1936

[Adociidae DE LAUBENFELS, 1936, p. 65]

Boring sponges with oxeas in bundles or brushes; spicules of inner sponge with

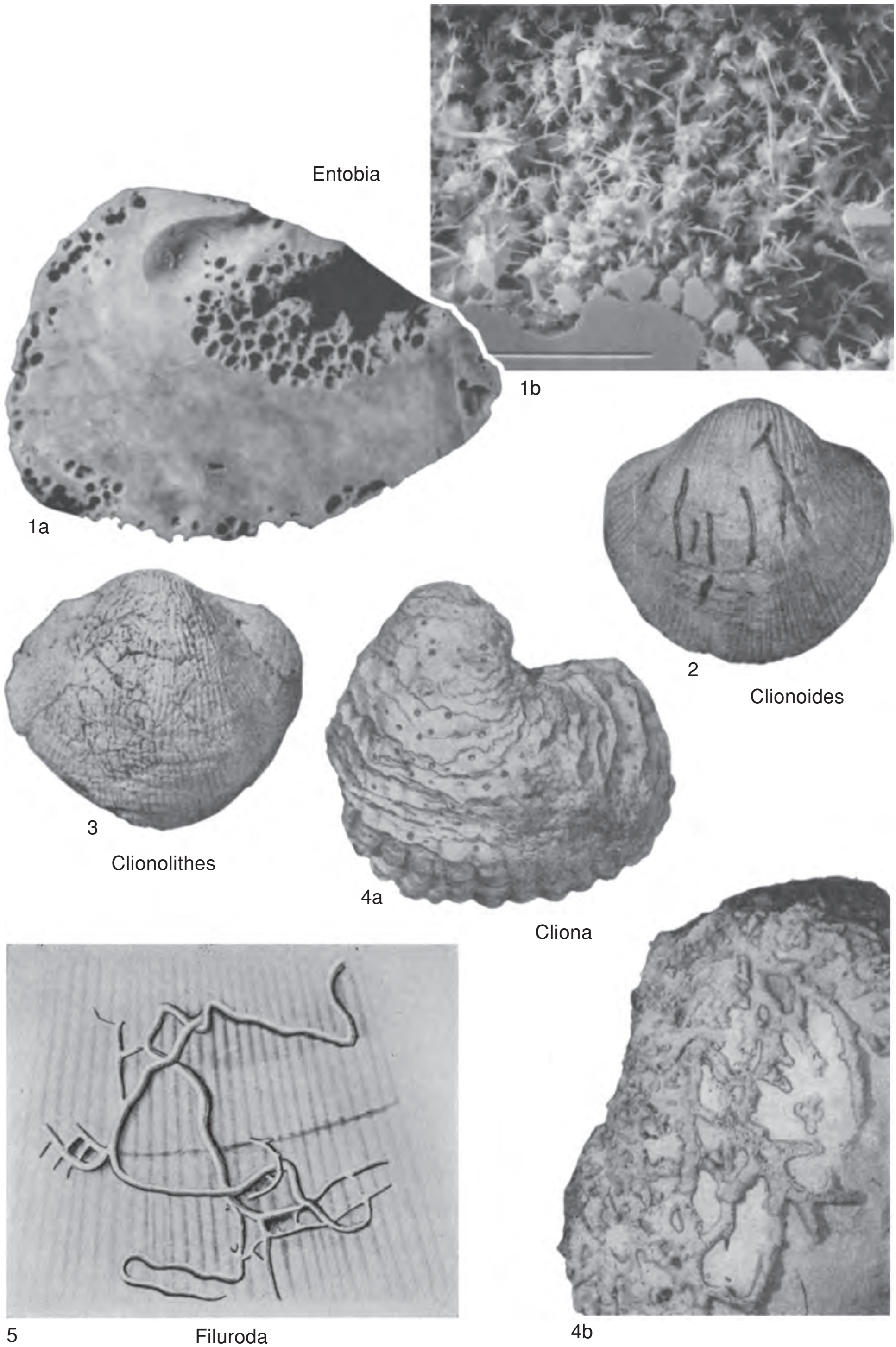

Fig. 28. Clionaidae (p. 37–40).

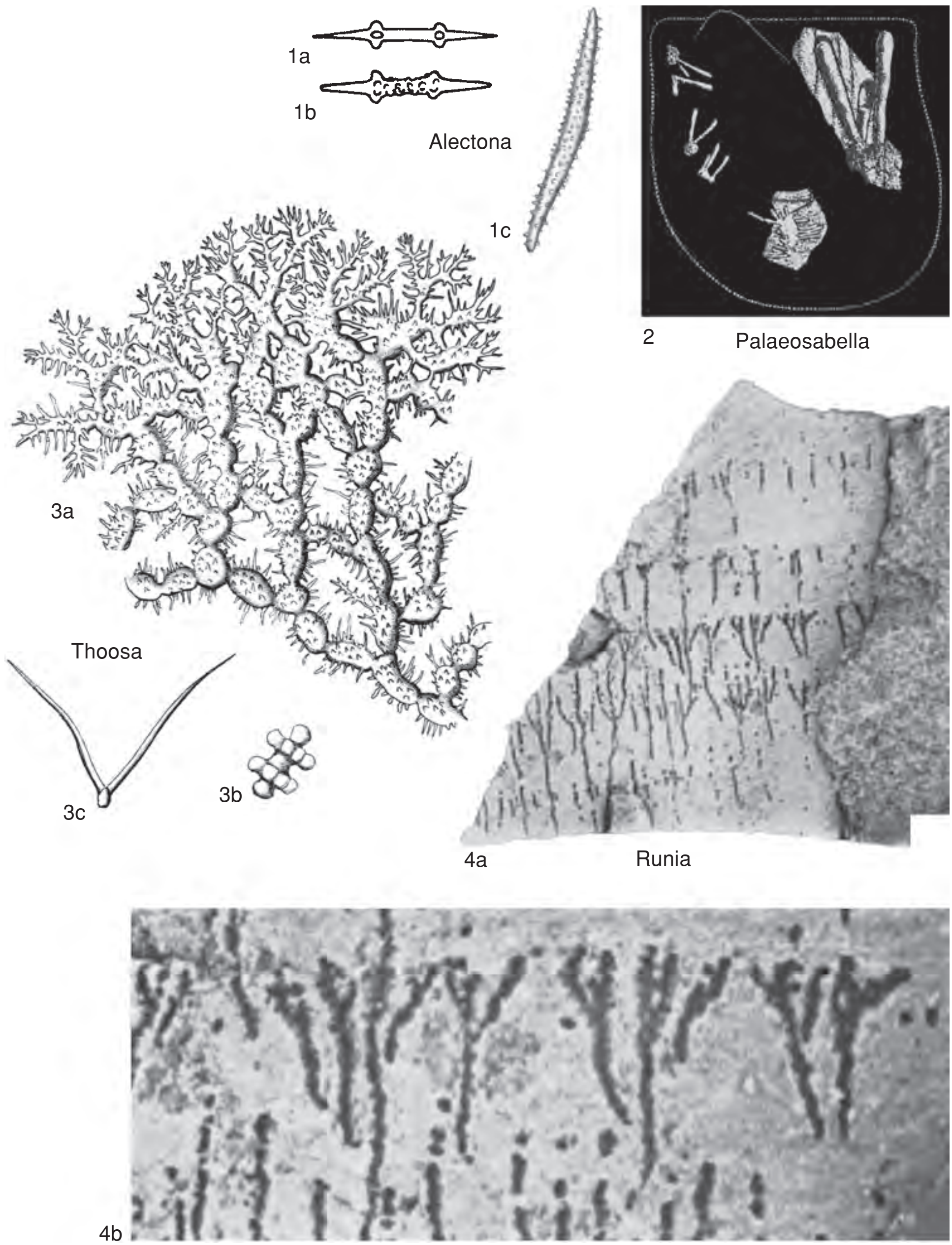

FIG. 29. Clionaidae (p. 38–40).

cortical, spicule tracts perpendicular to central, spicule bundles; prominent chimneys with apertures protruding from burrowed surfaces. *Triassic (Carnian)–Holocene.*

Aka DE LAUBENFELS, 1936, p. 155, *nom. nov. pro Acca* JOHNSON, 1899, p. 461, *non* HUEBNER, [1819], p. 49, Lepidoptera [**Acca insidiosa* JOHNSON, 1899, p. 461; OD] [=*Siphonodictyon* BERGQUIST, 1965, p. 158 (type, *S. mucosa,* OD)]. Excavating sponges with elongate to sack-shaped borings in calcareous substrates, spicules are oxeas in bundles or brushes, with cortical, spicule tracts perpendicular to more central spicule tracts; prominent chimneys with apertures protruding from burrowed surfaces.

[Specimen for type species lost.] *Triassic (Carnian)–Holocene:* Italy, *Carnian;* Germany, Spain, *Jurassic;* Spain, *Cretaceous;* Spain, *Eocene;* Mediterranean and Caribbean Seas, *Holocene.*——FIG. 30,*1a. A. muelleri* REITNER & KEUPP, Kimmeridge sponge mounds, Upper Jurassic, Rossbach, Germany; holotype, photomicrograph of spicule tracts including coarse oxeas, in burrow, IPFUB, JR6/89, ×10 (Reitner & Keupp, 1991).——FIG. 30,*1b. A. coralliphaga* (RÜTZLER), Holocene, Playa Kalki, Curacao, Caribbean Sea; spicule bundle of central part of exterior chimney, scale bar indicates magnification (Reitner & Keupp, 1991).

Family SPIRASTRELLIDAE Ridley & Dendy, 1886

[Spirastrellidae RIDLEY & DENDY, 1886, p. 490] [=Choanitidae DE LAUBENFELS, 1936, p. 140]

Sponges having astrose microscleres, not boring. *Paleogene–Holocene.*

Spirastrella SCHMIDT, 1868, p. 17 [**S. cunctatrix;* OD]. Megascleres comprise tylostyles only and microscleres spirasters only. *Holocene:* cosmopolitan.——FIG. 30,*3.* **S. cunctatrix,* Cyprus; tylostyle megasclere and associated spiraster microscleres, approximately ×500 (Schmidt, 1868).

Ditriaenella HINDE & HOLMES, 1892, p. 232 [**D. oamaruensis;* OD] [=*Ditraenella* DE LAUBENFELS, 1955, p. 40, *nom. null.*]. Verticillate spined microrhabds, similar to some in *Latrunculia,* which seem to be immature chessman spicules. *Paleogene–Neogene:* New Zealand.——FIG. 30,*5.* **D. oamaruensis;* spined microsclere, ×400 (de Laubenfels, 1955).

Family SUBERITIDAE Ridley & Dendy, 1886

[Suberitidae RIDLEY & DENDY, 1886, p. 484]

Similar to Spirastrellidae but lacking microscleres other than microrhabds, spicules commonly styles or tylostyles, not boring. *Cretaceous–Holocene.*

Suberites NARDO, 1833, p. 523 [**Alcyonium domunculum* OLIVI, 1792, p. 241; OD]. Architecture radiate with small tylostyles in cortex and large ones in endosome; microscleres absent. *?Paleogene–?Neogene, Holocene.*——FIG. 30,*6. S.* sp.; isolated tylostyle, ×50 (de Laubenfels, 1955).

Calcisuberites REITNER & SCHLAGINTWEIT, 1990, p. 249 [**C. stromatoporoides;* OD]. Coralline, hadromerid sponge with a magnesium-calcite, basal skeleton in stromatoporoid organization; spicular skeleton consisting of typical hadromerid tylostyles, in dermal layer arranged in plumose, bushlike patterns. *Lower Cretaceous (Coniacian):* Germany.——FIG. 30,*2a–b.***C. stromatoporoides,* Gosau Formation, Chiemgau; *a,* drawing of spicule development in vertical section of outer part of wall, vertical scale, 200 µm long, approximately ×50; *b,* photomicrograph showing tylostyles in outer part of wall and calcareous, basal skeleton below, with horizontal tabulae indicated by *arrow points,* IPFUB/ JR 90, ×100 (Reitner & Schlagintweit, 1990).

Rhopaloconus SOLLAS, 1880d, p. 392 [**R. tuberculatus;* OD]. Tylostyles extremely thick, with heads covered with many small, tentlike tubercles. *Cretaceous:* England.——FIG. 30,*4.* **R. tuberculatus,* Trimmingham Chalk, Maastrichtian, Norfolk; isolated, type tylostyle with conical tubercules on rounded head, scale uncertain (Sollas, 1880d).

Subclass CERACTINOMORPHA Lévi, 1953

[*nom. correct.* BERGQUIST, 1967, p. 167, *pro* Céractinomorphes LÉVI, 1953, p. 855]

Spicules when present are exclusively monaxonic, without triaenes; megascleres generally sigmoid or chelate, never astrose; microscleres when present are usually sigmas or derivatives thereof or microrhabds and never astrose; spongin usually abundant and may form entire skeleton with or without foreign particles; living sponges viviparous with parenchymella larva. *Cambrian–Holocene.*

Order DICTYOCERATIDA Minchin, 1900

[*nom. correct.* BERGQUIST, 1978, p. 176, *pro* Dictyoceratina MINCHIN, 1900, p. 153]

Ceractinomorph sponges without mineralized, spicule skeleton, but with skeleton of spongin fibers, often of great complexity, constructed in anastomosing patterns involving differentiated, primary and secondary fibers. *Jurassic–Holocene.*

Family SPONGIIDAE Gray, 1867

[*nom. correct.* DE LAUBENFELS, 1936, p. 7, *pro* Spongiadae GRAY, 1867, p. 508]

Dictyoceratid sponges with small, flagellated chambers, not preserved as fossils, and fibers uniform in cross section and without diffuse, central pith. *Holocene.*

Spongia LINNÉ, 1759, p. 1,348 [**S. officinalis;* SD BOWERBANK, 1862, p. 1119]. Sponges with fibers spongy, even when dry; chiefly clear, but a few

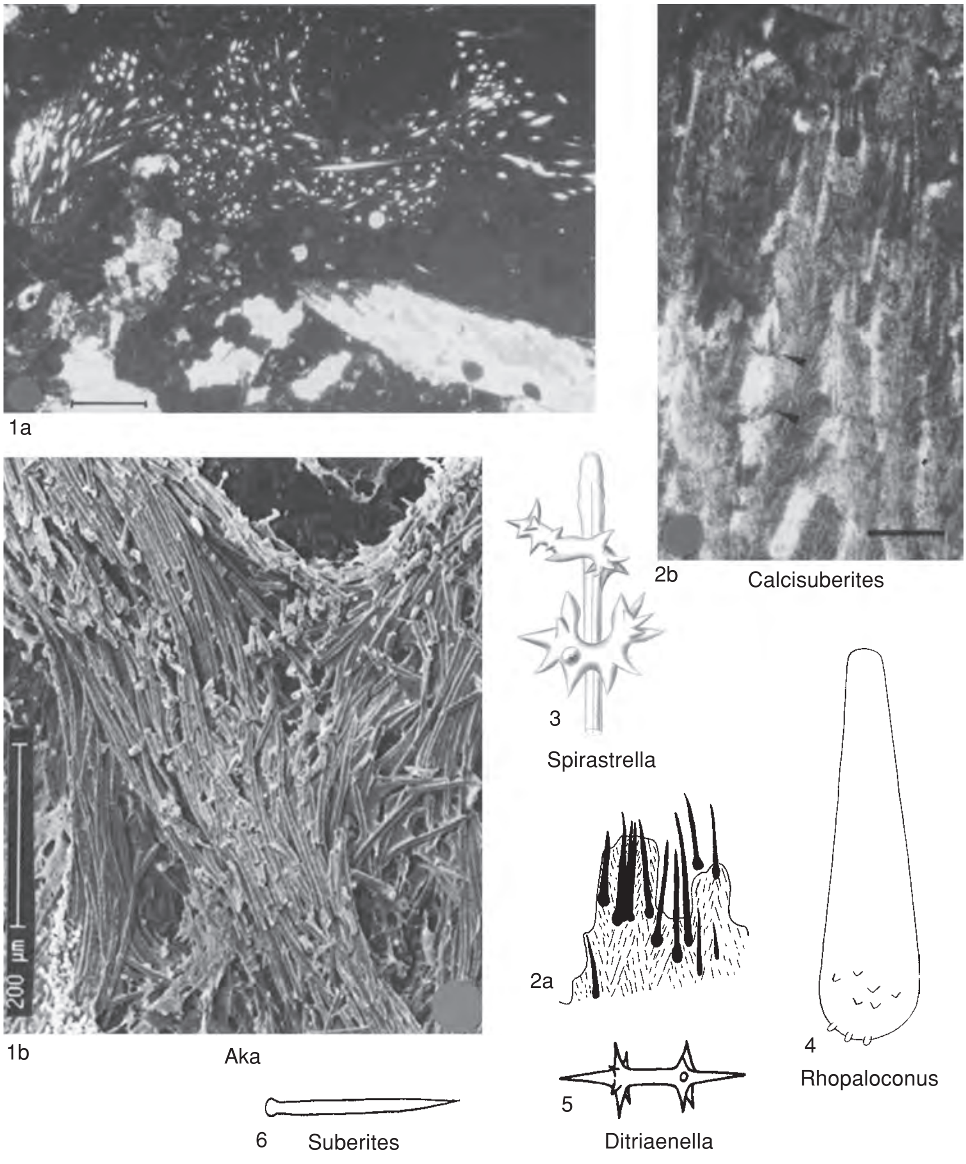

FIG. 30. Adociidae, Spirastrellidae, and Suberitidae (p. 42–43).

ascending fibers that may contain debris. *Holocene:* cosmopolitan.

Family DYSIDEIDAE Gray, 1867

[Dysideidae GRAY, 1867, p. 511]

Large, sac-shaped (eurypylous), flagellate chambers (not visible in fossils) with skeleton of fibers usually containing much foreign debris. *Lower Jurassic–Holocene.*

Dysidea JOHNSTON, 1842, p. 251 [**Spongia fragilis* MONTAGU, 1818, p. 114; SD DE LAUBENFELS, 1936, p. 27] [=*Spongelia* NARDO, 1847, p. 3 (type, *S. elegans,* M]. Fragile sponges with all fibers cored with foreign debris and many appearing rugose, as though covered by sand. *Paleogene (Eocene)–Holocene:* Belgium, *Eocene;* cosmopolitan, *Holocene.*——FIG. 31,*1.* **D. fragilis* (MONTAGU), Holocene, Devon coast, United Kingdom; side view of small, coarsely reticulated sponge, ×1 (Montagu, 1818).

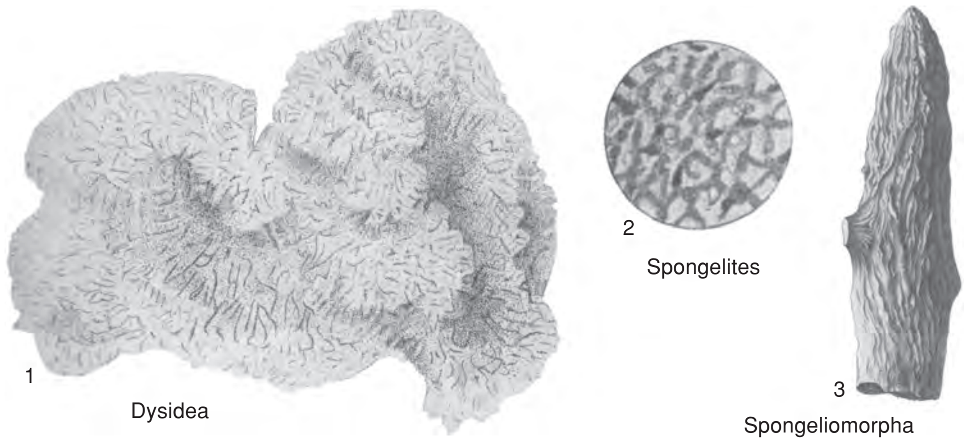

FIG. 31. Dysideidae (p. 44–45).

Spongelites ROTHPLETZ, 1900, p. 154 [**S. fellenbergi;* OD]. Bladelike sponges with anastomosing, not sharply defined, brown strings that are reticulate to anastomosing, sand-filled fibers that form dark network with light, mesh spaces. *Lower Jurassic:* Switzerland.——FIG. 31,*2.* **S. fellenbergi,* upper Lias, Bern; photomicrograph of thin section with dark fibers and light, matrix-filled meshes, ×40 (Rothpletz, 1900).

Spongeliomorpha DE SAPORTA, 1887, p. 298 [**S. iberica* DE SAPORTA, 1887, p. 299; OD]. Resembles *Spongelites* with skeleton of more or less sinuous, interconnected, anastomosing, longitudinal tracts with long, ridgelike impressions of spicules; lateral oscules occurring on low nodes that may have been small branches on side of generally cylindrical-appearing sponge. *Neogene (Miocene):* Spain.——FIG. 31,*3.* **S. iberica,* Alocoy; broken, cylindrical fragment showing skeletal structure and lateral nodes in natural mold, ×0.5 (De Saporta, 1887).

Family UNCERTAIN

Felixium DE LAUBENFELS, 1955, p. 36 [**Rhizocorallium glaseli* FELIX, 1913, p. 19; OD]. Elaborately sculptured cylinder 5 cm in diameter and 29 cm high. [No suitable figures available for illustration.] *Cretaceous:* Germany.

Order VERONGIDA Bergquist, 1978

[Verongida BERGQUIST, 1978, p. 178]

Ceractinomorpha without mineralized skeleton and with reduced, spongin, fibrous skeleton; fibers with pith, and in some forms pith alone where outer bark lost. *Middle Cambrian–Holocene.*

Family VERONGIIDAE de Laubenfels, 1936

[*nom. transl.* FINKS & RIGBY, herein, *ex* Verongiinae DE LAUBENFELS, 1936, p. 21]

Fibers not homogenous throughout, but with laminated, concentric, cylindrical layers, and divided into a peripheral, semitransparent region and a more or less opaque pith within. *Middle Carboniferous–Holocene.*

Verongia BOWERBANK, 1845, p. 403 [**Spongia fistularis* PALLAS, 1766, p. 385; OD]. Fibers peculiarly pithed. *Holocene:* cosmopolitan.——FIG. 32,*1.* **V. fistularis* (PALLAS), Hamilton Harbor, Bermuda Islands; skeletal fiber cored with pith, ×100 (de Laubenfels, 1955).

Aplysinofibria BOLKHOVITINOVA, 1923, p. 69 [**A. carbonicola;* OD]. Looped, interlaced, slender, secondary calcareous fibers that sometimes spread out fanwise; fibroid structures similar to those of *Verongia,* for such have often been called aplysinoid fibers where several species of *Verongia* have been incorrectly identified as *Aplysina. Middle Carboniferous:* Russia.——FIG. 32,*2.* **A. carbonicola,* Moscow region; fibrous skeletal structure of holotype, ×1 (Rezvoi, Zhuravleva, & Koltun, 1962).

Family VAUXIIDAE Walcott, 1920

[*nom. transl.* DE LAUBENFELS, 1955, p. 77, *ex* Vauxininae WALCOTT, 1920, p. 316]

Thin-walled, tubular, keratose sponges, branched or unbranched, with double-layered skeleton; inner layer of fused, cored fibers united in single-layered, open net with cellular, hexagonal or polygonal openings;

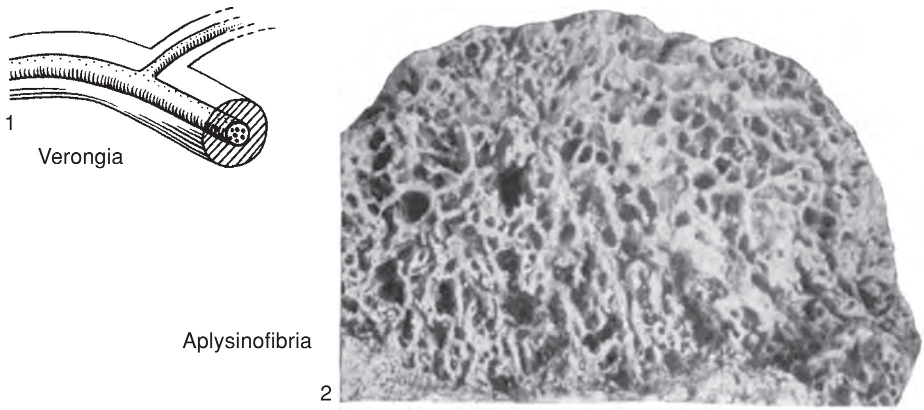

FIG. 32. Verongiidae (p. 45).

outer or dermal layer thin and generally irregular, supported by radial fibers. *Middle Cambrian.*

Vauxia WALCOTT, 1920, p. 317 [**V. gracilenta;* OD]. Low, obconical, conicocylindrical to branched, keratose sponges with entire double-layered skeleton a continuously fused framework without spicules; outer layer ranging from irregularly anastomosing or arborescent to moderately regular and delicate (see Fig. 33). *Middle Cambrian:* Canada (British Columbia), USA (Utah).——FIG. 34*a–f.* **V. gracilenta,* Stephen Formation, Burgess Shale, Mount Field, British Columbia; *a,* small, branching form with secondary branches, USNM 66511, ×1; *b,* small form with long branches, USNM 66510, ×1 (Walcott, 1920); *c,* photomicrograph of upper end of branch on holotype showing regular, fused, endosomal layer of skeleton below, flattened, irregular, dermal layer in upper part of impression, and laterally flattened, outer layer along complete edges of stem, USNM 66515, ×10; *d,* camera lucida drawing of part of endosomal layer of holotype showing rectangular net of fibers with irregularly flattened, radial rays extending into cells, ×25; *e,* camera lucida drawing of laterally flattened margin of holotype showing arborescent, radial fibers extending out from endosomal layer and supporting fine-textured, irregular, outer layer, above, ×25; *f,* camera lucida drawing of inner part of dermal layer of holotype where primary and secondary fibers form moderately uniform ostia, ×25 (Rigby, 1986a).——FIG. 34*g. V. bellula* WALCOTT, Stephen Formation, Burgess Shale, Albertan, Mount Field, British Columbia; camera lucida drawing of part of endosomal net of lectotype showing nonspiculate fibers of skeleton cored by what is interpreted to be pithy elements inside a cortex, somewhat similar to living *Verongia,* USNM 66508, ×25 (Rigby, 1986a).

Order HALICHONDRIDA Topsent, 1898

[Halichondrida TOPSENT, 1898, p. 93]

Ceractinomorph sponges in which megascleres are oxeas, styles, or strongyles in many combinations, and microscleres absent; skeleton lacking organization except for dermal layer of tangential spicules; sometimes supported by brushes of endosomal spicules; endosomal spicules commonly in confused arrangement. *Paleogene (Oligocene)–Holocene.*

Family HALICHONDRIIDAE Gray, 1867

[*nom. transl.* DE LAUBENFELS, 1936, p. 133, *ex* Halichondriadae GRAY, 1867, p. 518] [=Halichondridae VOSMAER, 1887, p. 335; Stylotellinae LENDENFELD, 1888, p. 185; Ciocalyptidae HENTSCHEL, 1923 in 1923–1924, p. 408; Spongosoritidae TOPSENT, 1928b, p. 35; ?Hymeniacidonidae DE LAUBENFELS, 1936, p. 136]

Principal megascleres diactines, principally oxeas, although minor styles may be present; marked system of subdermal spaces developed and separating dermal layer from endosomal part of sponge. *Holocene.*

Halichondria FLEMING, 1828, p. 520 [**Spongia panicea* PALLAS, 1766, p. 388; OD]. Sponges of great variety of forms from tubular to irregular nodular with numerous oscular tubes; spicules only oxeas with great range in size and scattered throughout sponge; definite dermal layer of tangential spicules over large, subdermal spaces, without microscleres. *Holocene:* cosmopolitan.——FIG. 35,*2a–b.* **H. panicea* (PALLAS), Atlantic Ocean around British Isles; *a,*

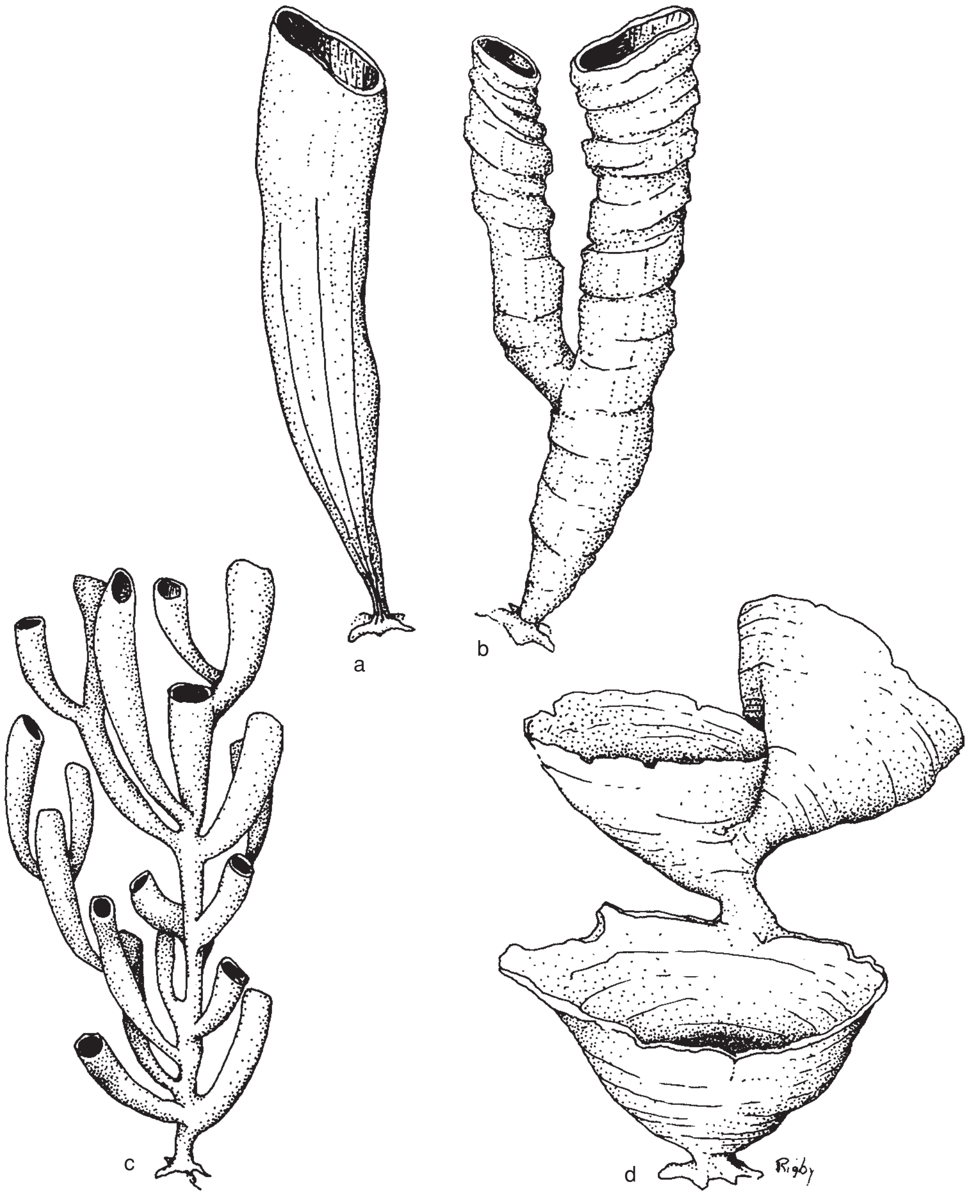

FIG. 33*a–d*. Growth forms of species of *Vauxia; a, V. bellula* WALCOTT, 1920; *b, V. densa* WALCOTT, 1920; *c, V. gracilenta* WALCOTT, 1920; *d, V. venata* WALCOTT, 1920 (Rigby, 1986b).

tubular form of species, ×0.25; *b,* fistulose form with numerous oscular tubes, ×1 (Bowerbank, 1874a).

Family ?HYMENIACIDONIDAE de Laubenfels, 1936

[?Hymeniacidonidae DE LAUBENFELS, 1936, p. 136]

Fleshy ectosome not profusely echinated with erect spicules; endosomal structure varying from plumose to confused, and often more or less gelatinous; dermalia skinlike, often with few, if any, spicules and those present, commonly styles, are tangential; microscleres largely absent. *Paleogene (Oligocene)–Holocene.*

Roepella VAN KEMPEN, 1977, p. 114 [**R. solanensis;* OD]. Cylindrical, unbranched sponge with deep

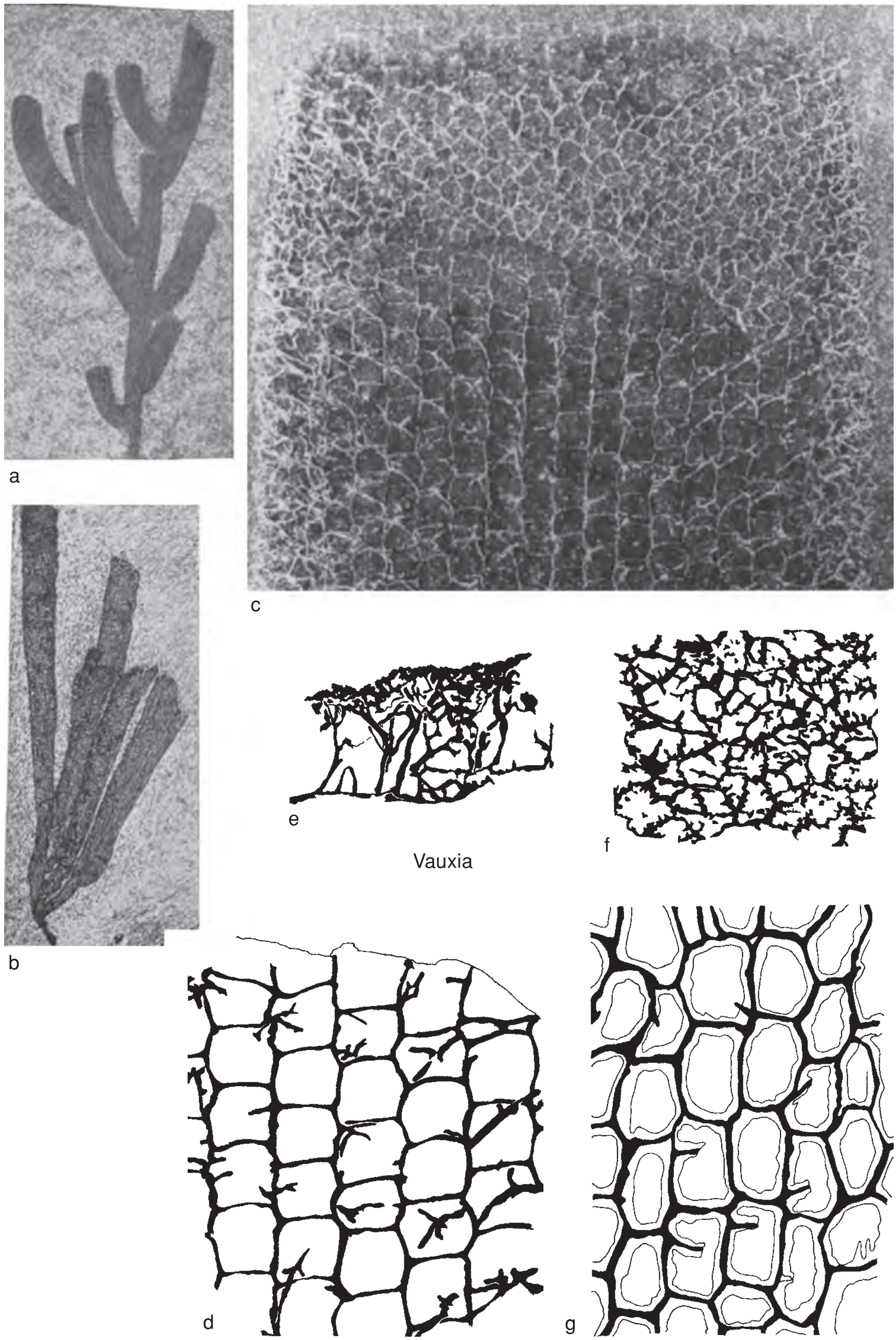

FIG. 34. Vauxiidae (p. 46).

spongocoel with walls of varying thickness and more or less horizontally folded to form irregular, horizontal, annular swellings and constrictions; walls without parietal openings; canal system obscure, apparently fine textured with oscules at summit of tubules; skeleton nonreticulate, confused feltwork of irregularly strewn but loosely vertical, monaxial spicules in vaguely defined tracts with overall tendency to diverge upwardly; skeleton without defined ectosomal or endosomal specialization; megascleres smooth, monactinal and diactinal monaxons including styles, oxeas, subtylostyles, and strongyles; microscleres unknown. *Paleogene (Oligocene)–Neogene (Miocene):* Spain.——FIG. 35, *1a–e.* **R. solanensis,* Solana Formation, Velez Rubio area, southeastern Spain; *a,* side view of small, tubular sponge with irregular annulations, PA 8677, ×2; *b,* transverse section showing irregular spicule orientation, PA 8684, ×30; *c,* part of transverse section showing irregular, loose bundles of monaxial spicules, PA 8684 (II), ×100; *d,* cluster of tylostyles, PA 8684, approximately ×100; *e,* style, PA 8684, approximately ×100 (van Kempen, 1977).

Order POECILOSCLERIDA Topsent, 1928

[*nom. correct.* DE LAUBENFELS, 1955, p. 38, *pro* Poecilosclerina TOPSENT, 1928b, p. 41] [=Poecilospleridae TOPSENT, 1894, p. 5]

Demosponges with dermal specialization or other complexities of spicules but no radiate structure or astrose microscleres; spiny spicules, spongin, or both commonly present. *Cretaceous–Holocene.*

Family MYXILLIDAE Hentschel, 1923

[Myxillidae HENTSCHEL, 1923 in 1923–1924, p. 406]

Megascleres diactinal, smooth in ectosome, and monactinal, chiefly spined, in endosome. *Paleogene–Holocene.*

Myxilla SCHMIDT, 1862, p. 71 [**Halichondria rosacea* LIEBERKÜHN, 1859, p. 520; SD DE LAUBENFELS, 1936, p. 85]. Sponges fragile with nodes or spinose projections; megascleres including tylotes and acanthostyles; microscleres consisting of sigmas and anchorate isochelas. *?Paleogene–?Neogene, Holocene:* New Zealand; *Holocene:* Adriatic Sea.——FIG. 36,*2a–f.* **M. rosacea* (LIEBERKÜHN), ?Paleogene–?Neogene, New Zealand; *a–b,* monaxon megascleres including tylote and acanthostyle, ×100; *c–f,* microscleres including sigmas and anchorate isochela in two views, ×500 (de Laubenfels, 1955).

Iophon GRAY, 1867, p. 534 [**Halichondria scandens* BOWERBANK, 1866, p. 259; SD DENDY, 1924a, p. 347]. Sponges soft and crumbling, with main skeleton a reticulation of loose, spicule fibers or single spicules, usually acanthostyles but sometimes smooth. Microscleres usually palmate anisochelae and bipocilla, including deformed isochelas. *Paleogene–Holocene:* New Zealand, *Paleogene–Neogene;* cosmopolitan, *Holocene.*——FIG. 36,*3a–c.* **I. scandens* (BOWERBANK), Paleogene–Neogene, New Zealand; deformed isochelas, ×500 (de Laubenfels, 1955).

Iophonopsis DENDY, 1924a, p. 348 [**Halichondria nigricans* BOWERBANK, 1866, p. 266; SD DENDY, 1924a, p. 348]. Soft sponge, perhaps lobose, with rounded margin that has rows of oscula of cylindrical tubes; main skeleton a reticulation of loose fibers or single spicules, usually acanthostyles but sometimes smooth styles; not echinated by accessory acanthostyles; weak, dermal skeleton of secondary diacts, including tylotes; microscleres palmate isochelae in which small end is spurred, and bipocilla. *Holocene:* New Zealand (Spirits Bay near North Cape), British Isles.——FIG. 36,*1a–c.* **I. nigricans* (BOWERBANK), British Isles; *a,* strongyle with spinose terminations, from dermal layer; *b,* larger, endosomal, spinose acanthostyle, ×250; *c,* anisochela microsclere from dermal layer, ×500 (Bowerbank, 1874b).

Family TEDANIIDAE Ridley & Dendy, 1886

[*nom. transl. et correct.* DE LAUBENFELS, 1955, p. 38, *ex* subfamily Tedaniina RIDLEY & DENDY, 1886, p. 335]

Megascleres chiefly smooth monaxons in endosome; without chelae or sigmas. *Paleogene–Holocene.*

Tedania GRAY, 1867, p. 520 [**Halichondria anhelans* LIEBERKÜHN, 1859, p. 521; SD DE LAUBENFELS, 1936, p. 90]. Sponge lobed, crested, with lateral tube ending in osculum, spicules needle shaped clavate or slender fusiform to cylindrical with blunt ends; microscleres solely faintly spined raphids. *Holocene:* cosmopolitan.——FIG. 37,*1.* **T. anhelans* (LIEBERKÜHN), Adriatic Sea, near Trieste; gently curved, smooth, needle-shaped style with crepidal canal, ×250 (Lieberkühn, 1859).

Acarnus GRAY, 1867, p. 544 [**A. innominatus;* OD]. Sponge reticulate, spicules including cylindrical, fasciculated monaxons forming radiating group and peculiar anatetraenes with four short, recurved rays. [No suitable figures available for illustration.] *?Paleogene–?Neogene, Holocene:* New Zealand, *?Paleogene–?Neogene;* cosmopolitan, *Holocene.*——FIG. 37,*6.* **A. innominatus;* idealized reconstruction of skeleton (Hooper, 2002).

Forcepia CARTER, 1874, p. 248 [**F. colonensis;* OD]. Microscleres including forceps. *Paleogene–Holocene:* New Zealand, *Paleogene–Neogene;* cosmopolitan, *Holocene.*——FIG. 37,*5.* **F. colonensis,* Holocene, Atlantic Ocean, off Colon, Panama; typical, spinose, forceps microsclere, with spines not shown on one side, ×100 (Carter, 1874).

Melonanchora CARTER, 1874, p. 212 [**M. elliptica;* OD]. General form globular to corrugated with projecting tubercules in upper two-thirds, lower

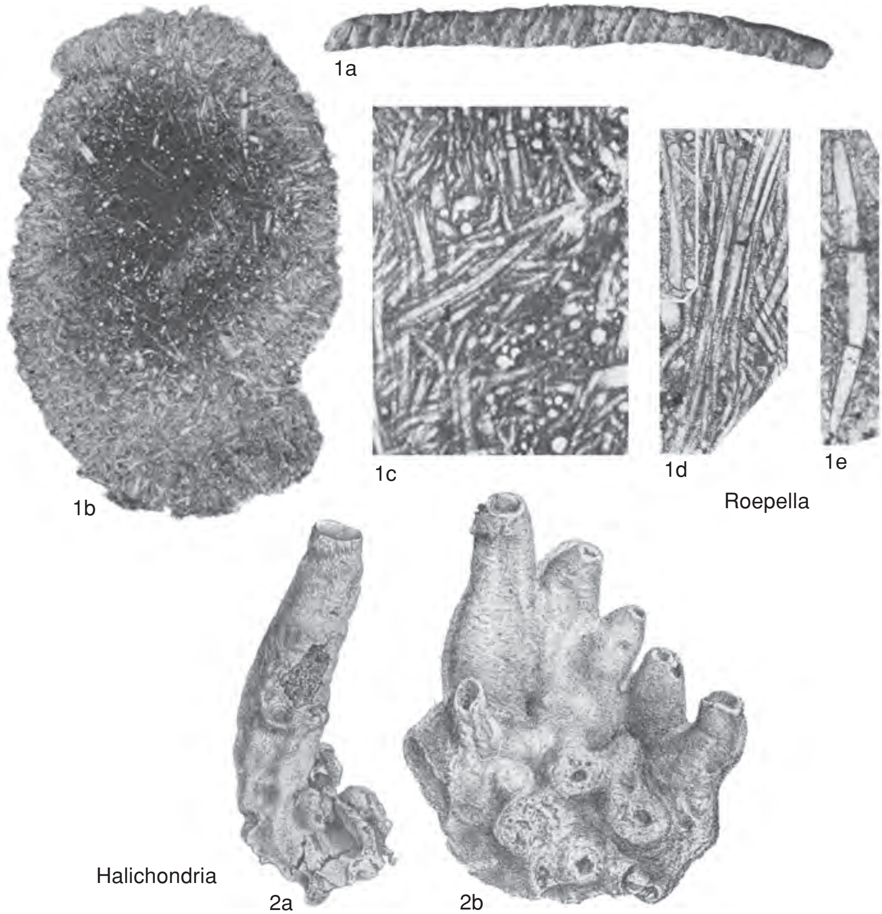

FIG. 35. Halichondriidae and Hymeniacidonidae (p. 46–49).

part smooth; megascleres styles and oxeas; microscleres including equianchorate clavidiscs. *?Paleogene–?Neogene, Holocene:* New Zealand, *?Paleogene–?Neogene;* cosmopolitan, *Holocene.*——FIG. 37,*11a–b.* **M. elliptica,* Holocene, North Atlantic Ocean; clavidiscs, ×400 (de Laubenfels, 1955).

Family CLADORHIZIDAE Dendy, 1922

[*nom. correct.* DE LAUBENFELS, 1936, p. 122, *pro* Cladorhizeae DENDY, 1922, p. 58]

Bizarre-shaped, commonly small, deep-sea sponges with axial skeleton of monoactinal and diactinal megascleres, from which tracts diverge to ectosome; microscleres including peculiar chelas, sigmas, forceps, and spear-shaped microstyles. *Paleogene–Holocene.*

Cladorhiza SARS, 1872, p. 65 [**C. abyssicola;* OD]. Branched sponge with main growth form appearing like a rooted conifer branch, axes of branches formed by long oxeas and with isochelas of several types in outer, organic layer; microscleres swollen anisochelas. *Paleogene–Holocene:* New Zealand, *Paleogene–Neogene;* cosmopolitan, *Holocene.*——FIG. 37,*2a–g.* **C. abyssicola,* Holocene, Lofoten, Norway; *a,* branched form of genus, slightly magnified; *b,* isochela megasclere, ×200; *c,* anisochela megasclere, ×250; *d–g,* anisochela microscleres, ×300 (Sars, 1872).

Chondrocladia C. W. THOMSON, 1873a, p. 188 [**C. virgata;* OD]. General form long, narrow, rarely branching stem; megascleres long styles; microscleres peculiar, anchorate isochelas. *Paleogene–Holocene:* New Zealand, *Paleogene–Neogene;* cosmopolitan, *Holocene.*——FIG. 37,*8a–b.* **C. virgata,* Holocene, Atlantic Ocean between Scotland and Faroe Islands, anchorate isochela; lateral and dorsal view, ×480 (Carter, 1874).

Family AMPHILECTIDAE de Laubenfels, 1936

[Amphilectidae de Laubenfels, 1936, p. 123]

Monactinal spicules throughout in both ectosome and endosome, none spinose. *Paleogene–Holocene.*

Amphilectus Vosmaer, 1880, p. 109 [**Isodictya gracilis* Bowerbank, 1866, p. 331; SD Dendy, 1922, p. 58]. Ramose with slender branches dichotomous or trichotomous, terminations attenuated; oscula inconspicuous; microscleres all palmate isochelas. *?Paleogene–?Neogene, Holocene:* New Zealand, *?Paleogene–?Neogene;* cosmopolitan, *Holocene.*——Fig. 37,*10a–b.* **A. gracilis* (Bowerbank), Holocene, North Atlantic Ocean; *a,* front side of palmate isochela; *b,* reverse side of same, ×500 (de Laubenfels, 1955).

Hamacantha Gray, 1867, p. 538 [**Hymedesmia johnsoni* Bowerbank, 1864, p. 35; M]. Microscleres include diancistras. *Paleogene–Holocene:* New Zealand, *Paleogene–Neogene;* cosmopolitan, *Holocene.*——Fig. 37,*4.* **H. johnsoni* (Bowerbank), Holocene; diancistra, ×500 (de Laubenfels, 1955).

Family LATRUNCULIIDAE Topsent, 1922

[Latrunculiidae Topsent, 1922, p. 1]

Sponges with wide-meshed, reticulate, choanosomal skeletons of anisostyles or strongyles that are closely spaced in ectosomal skeleton; microscleres acanthodiscorhabds or chessman spicules forming outer layer on ectosome. *Paleogene–Holocene.*

Latrunculia Barboza du Bocage, 1869, p. 161 [**L. cratera;* OD]. Form of sponge is irregular, attached, with low mounds, most of which have distinct oscules; megascleres smooth, greatly curved oxeas, microscleres peculiar, spinose, chessman elements. *Paleogene–Holocene:* New Zealand, *Paleogene–Neogene;* Atlantic Ocean, *Holocene.*——Fig. 37,*3a–c.* **L. cratera,* Holocene, North Atlantic Ocean; *a,* side view of attached sponge with low mounds and oscules, ×1; *b,* tissue of interior with coarse oxeas and associated, small, chessman microscleres, ×200; *c,* chessman microsclere, ×400 (Barboza du Bocage, 1869).

Family ACARNIIDAE de Laubenfels, 1936

[Acarniidae de Laubenfels, 1936, p. 79]

Spicules all spinose, mostly with confused arrangements. *Cretaceous–Holocene.*

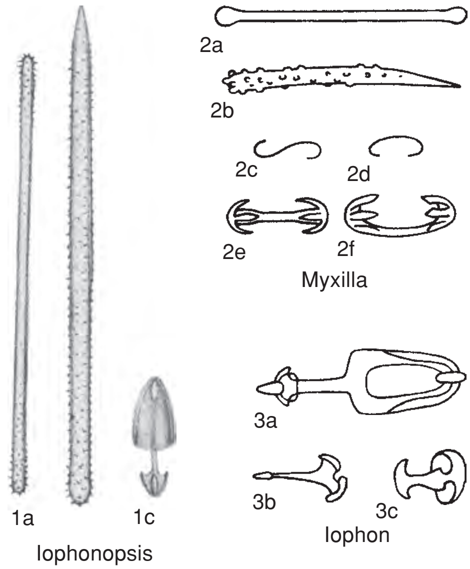

Fig. 36. Myxillidae (p. 49).

Acarnia Gray, 1867, p. 515 [**Hymeniacidon cliftoni* Bowerbank, 1864, p. 276; OD]. Sponges epizoic, membranous, with clavate, spinose spicules, ends blunt, covered with spines; acanthostrongyles and acanthotylotes present. *Holocene:* southwestern Pacific Ocean.——Fig. 37,*7a–b.* **A. cliftoni* (Bowerbank), Freemantle, Australia; *a,* fragment of epizoic sponge overgrowing branches of a *Fucus* and having numerous irregularly oriented and spaced acanthostrongyles, ×108; *b,* isolated, spinose acanthostrongyle from interior part of sponge, ×260 (Bowerbank, 1864).

Acanthoraphis Hinde, 1884a, p. 20 [**A. intertextus;* OD]. All spicules are similar spinose oxeas. *Cretaceous:* England.——Fig. 37,*9.* **A. intertextus,* Upper Chalk, Upper Cretaceous, Kent; spinose oxeas and their distribution in fragment of dermal layer of sponge, ×10 (Hinde, 1884a).

Family UNCERTAIN

Makiyama de Laubenfels, 1955, p. 39, *nom. nov. pro Sagarites* Makiyama, 1931, p. 5, *non* Ashmead, 1900 [**Sagarites chitanii* Makiyama, 1931, p. 5; OD]. Tubular, rarely branching with echinated spicules that may have been reticulated on exterior; spicules mainly bent oxeas and strongyles. *Paleogene–Neogene:* Japan.——Fig. 37,*12a–b.* **M. chitanii* (Makiyama), Sagara Mudstone, Pliocene, Tôtômi Province; *a,* restoration of several sponges, each with small osculum at summit and spiculated, dermal surface, attached to plant fragment, ×1; *b,* oxeas from skeleton, ×200 (Makiyama, 1931).

Oppligera de Laubenfels, 1955, p. 39, *nom. nov. pro Subularia* Oppliger, 1921a, p. 205, *non*

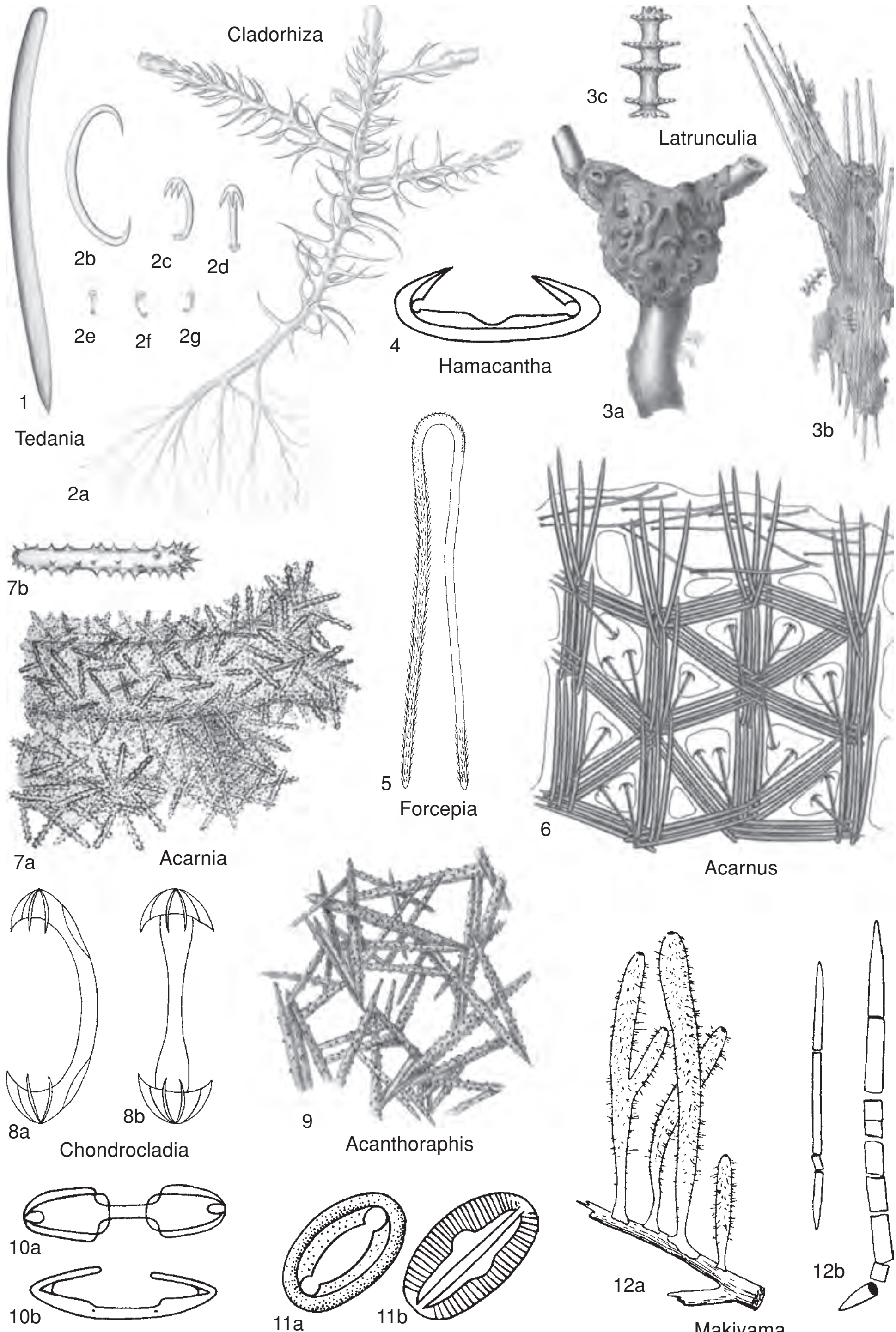

FIG. 37. Tedaniidae, Cladorhizidae, Amphilectidae, Latrunculiidae, Acarniidae, and Uncertain (p. 49–51).

MONTEROSATO, 1884 [**Subularia clavaeformis* OPPLIGER, 1921a, p. 205; OD]. Small, club-shaped sponge with spongocoel; spicules are styles to 2 mm long. [No known suitable figures.] *Jurassic:* Europe.

Order HAPLOSCLERIDA Topsent, 1898

[*nom. correct.* DE LAUBENFELS, 1955, p. 37, *pro* Haplosclerina TOPSENT, 1898, p. 93]

Sponges with almost no dermal specialization and megascleres generally of one simple type, normally oxeas or strongyles of uniform length within species; skeleton generally reticulate with much spongin and isodictyal with rectangular or triangular meshes; microscleres sigmas and toxas, when present. *Jurassic–Holocene.*

Family SPONGILLIDAE Gray, 1867

[Spongillidae GRAY, 1867, p. 550]

Freshwater sponges (a few ranging into brackish water) with gemmules; some genera with microscleres as in many hyalosponges. *Jurassic–Holocene.*

Spongilla LAMARCK, 1816b, p. 98 [**Spongia lacustris* LINNÉ, 1759, p. 1348; SD POTTS, 1881, p. 388]. Megascleres simple, invariably slender to stout amphioxea; microscleres present in dermal membrane, usually slender amphioxea and generally spined throughout; gemmules also contain spiny oxeas (acanthoxeas). *Jurassic–Holocene:* cosmopolitan.——FIG. 38,*5a–b.* **S. lacustris* (LINNÉ), Holocene; *a,* spinose microsclere, ×100; *b,* gemmosclere, ×125 (Penny & Racek, 1968).——FIG. 38,*5c. S. alba* CARTER, Holocene, Australia or South America; smooth megasclere, ×125 (Penny & Racek, 1968).

Eospongilla DUNAGAN, 1999, p. 390 [**E. morrisonensis;* OD]. Small, low, domical to cylindrical sponges; megascleres diactinal, monaxon strongyles and oxeas, spicules straight or slightly curved, without ornamentation; microscleres unknown or absent. [Fossil sponges occur in freshwater lacustrine carbonates.] *Upper Jurassic:* USA (Colorado).——FIG. 39,*1a–b.* **E. morrisonensis,* Morrison Formation, possibly uppermost Oxfordian to Kimmeridgian, Fort Collins, USNM 496326; *a,* circular mass of megascleres outlined by *small, black arrows,* ×20; *b,* cluster of straight oxeas and slightly curved strongyles, ×50 (Dunagan, 1999).

Ephydatia LAMOUROUX, 1816, p. 2 [**Spongia fluviatilis* LINNÉ, 1759, p. 1348, SD PENNY & RACEK, 1968, p. 82] [=*Ephidatia* LAMOUROUX, 1816, p. 6, obj.]. Gemmoscleres amphidiscs, smooth to spinose; cylindrical shaft with serrated discs at both ends; megascleres fusiform, amphioxea, smooth or spinose but all smooth at tips; microscleres absent. *Neogene (Miocene)–Holocene:* cosmopolitan.——FIG. 38,*3a–b. E. mülleri* (LIEBERKÜHN), Katata Formation, Pleistocene, Otsu City, Japan; isolated, smooth and spinose, amphioxea megascleres, ×1,000 (Matsuoka, 1983).

Eunapius GRAY, 1867, p. 552 [**A. carteri* BOWERBANK, 1858, p. 315; SD ANNANDALE, 1911, p. 97]. Gemmoscleres amphistrongyles or amphioxea, stout and nearly straight to curved, spines sparse but usually more common at spicule tips; megascleres slender, fusiform, smooth amphioxea straight to gently curved; microscleres absent. *Neogene (Miocene)–Holocene:* cosmopolitan.——FIG. 38,*2a–d. E. fragilis* (LEIDY), Katata Formation, Pleistocene, Otsu City, Japan; *a–b,* megascleres including thick and thin types; *c–d,* gemmoscleres including curved and straight forms, ×1,000 (Matsuoka, 1983).

Heteromeyenia POTTS, 1881, p. 150 [**A. baileyi* BOWERBANK, 1863, p. 451; SD DE LAUBENFELS, 1936, p. 36; =*S. repens* POTTS, 1880, p. 357]. Similar to *Myenia,* with megascleres usually slender and fusiform amphioxea covered with minute, irregular spines; microscleres long, thin, sharply pointed, fusiform amphioxea, with amphidiscs of two distinct types. *Neogene (Pleistocene)–Holocene:* cosmopolitan.——FIG. 38,*4a–b.* **H. baileyi* (BOWERBANK), Holocene, USA; *a,* characteristic, irregularly spined megasclere, ×150; *b,* spined, amphioxea microsclere, ×250 (Penny & Racek, 1968).——FIG. 38,*4c–d. H. repens* POTTS, Holocene, USA; two amphidisc gemmoscleres, ×250 (Penny & Racek, 1968).

Lutetia RICHTER & WUTTKE, 1999, p. 184 [**L. heili;* OD]. Sponges possibly relatively thin with megascleres as thin, straight to weakly curved, smooth amphioxeas, or with fine spines evenly developed over entire surface of spicules; microscleres unknown; gemmoscleres of two types: larger ones amphistrongyles of unusually variable size and shape and may be straight or slightly bent, their outer surfaces strongly spinose and most spinose on swollen, club-shaped ends; smaller ones short, thin to stocky amphistrongyles or pseudoamphioxeas of very irregular appearance with club-shaped to discoidal ends. *Paleogene (Eocene):* Germany.——FIG. 38,*1a–c.* **L. heili,* Lutetian, Messel; *a,* holotype fragment with cluster of gemmules, SMF ME 1 5143a, ×10; *b,* wall of gemmule from holotype with irregularly arranged, tangential megascleres, ×100; *c,* wall of gemmule with large and fine gemmoscleres, ×200 (Richter & Wuttke, 1999).

Meyenia CARTER, 1881a, p. 90 [**M. fluviatilis;* SD DE LAUBENFELS, 1936, p. 36]. Gemmules containing amphidisc microscleres; commonly reported erroneously as *Ephidatia* (=*Tupha*). *Neogene (Pleistocene)–Holocene:* cosmopolitan.——FIG. 38,*7a–b.* **M. fluviatilis,* Holocene; birotulate spicule seen from side and end, ×500 (Carter, 1881a).

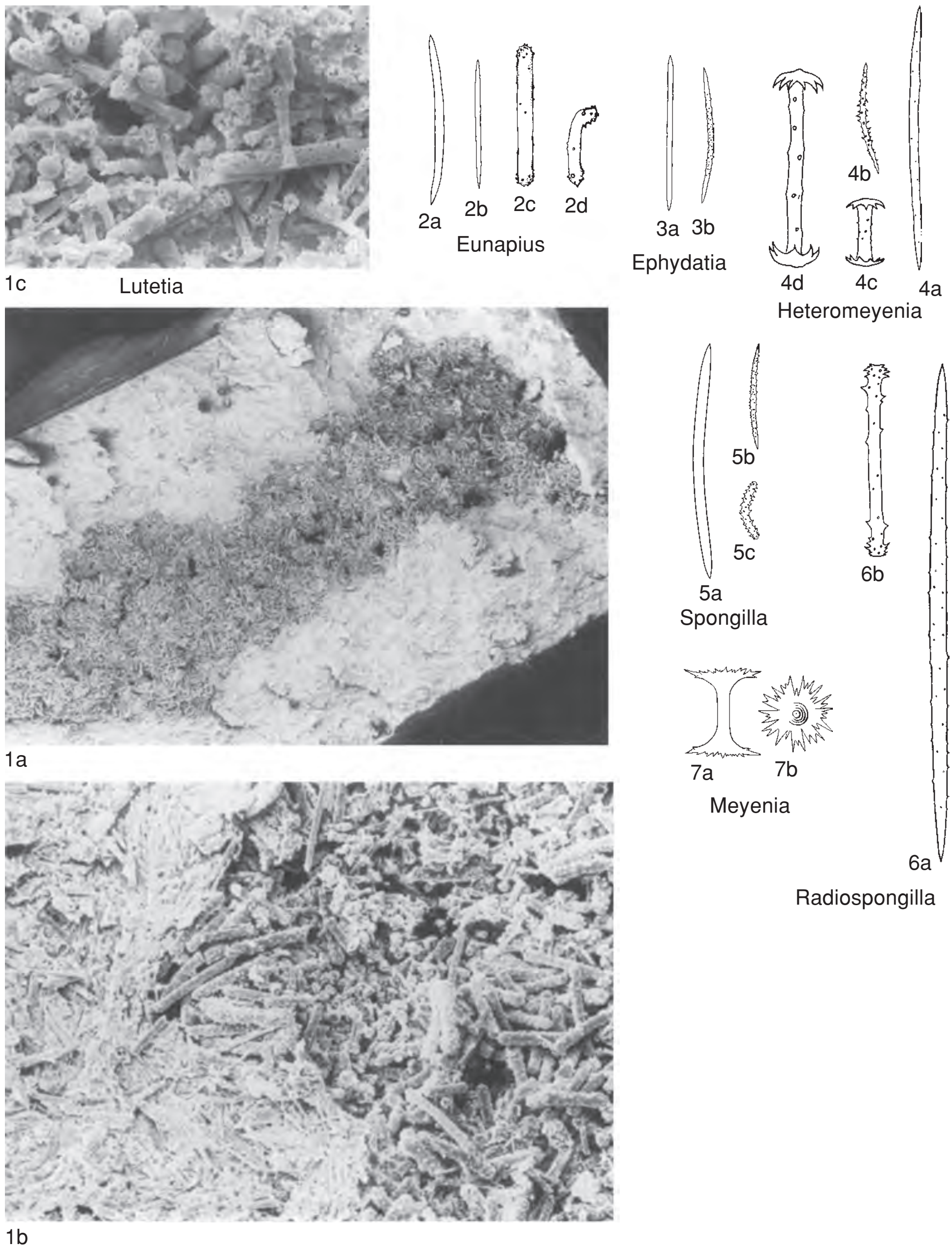

FIG. 38. Spongillidae (p. 53–56).

Oncosclera VOLKMER-RIBEIRO, 1970, p. 435 [**Spongilla jewelli* VOLKMER, 1963, p. 271; OD]. Megascleres amphioxeas to amphistrongyles that are slightly curved, robust, and may have small spines; microscleres not present; gemnoscleres variable amphistrongyles and amphioxeas that are short, robust, commonly curved, and expanded at midlength, usually with spines, which are more common on swollen spicule tips. [Taxonomic position of the genus is in question. It was originally included in the family Spongillidae by VOLKMER-RIBEIRO (1970) but has been included later by others in the family Potamolepidae of BRIEN (1967).] *Neogene (Miocene)–Holocene:* Japan, South

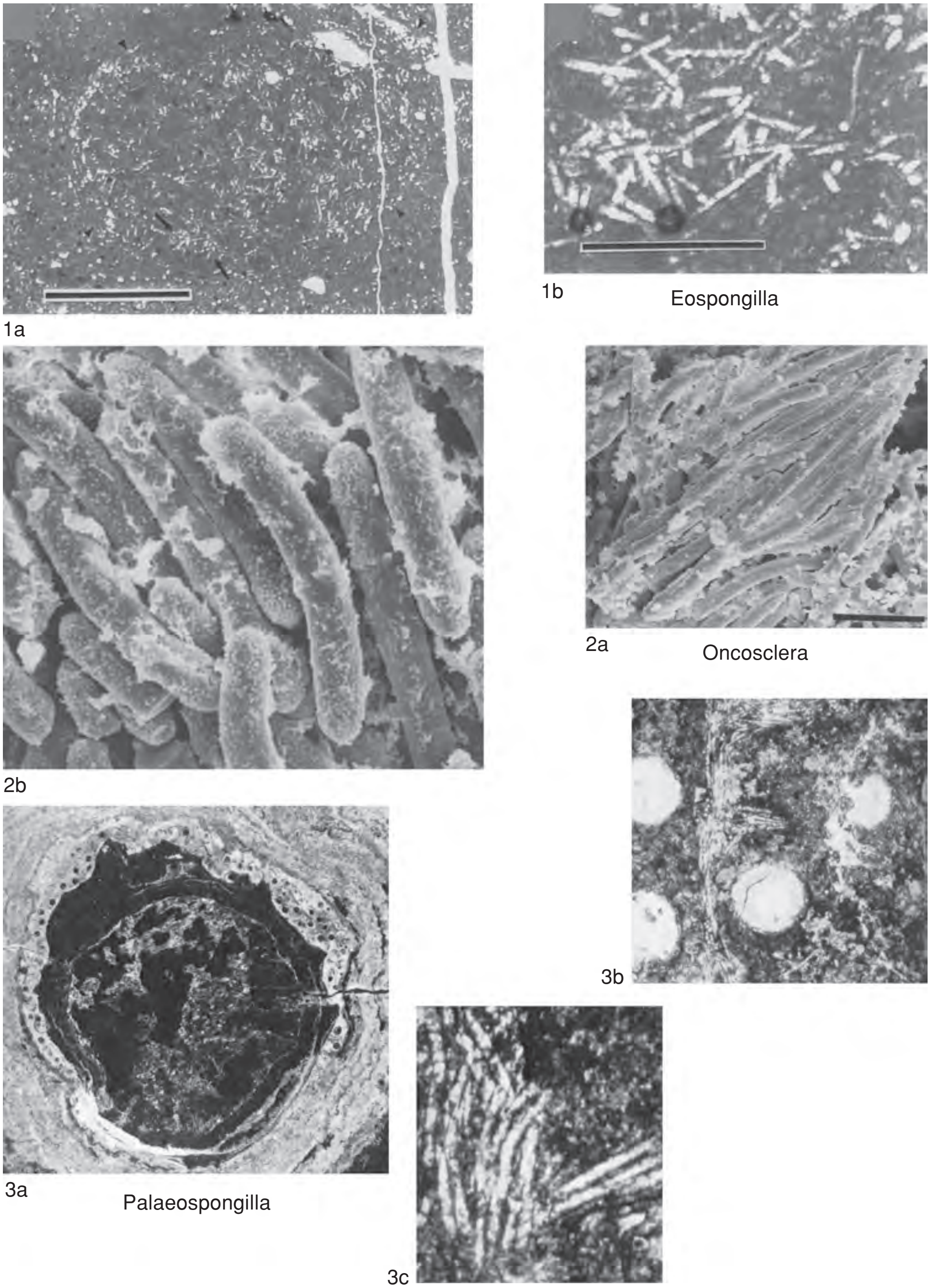

FIG. 39. Spongillidae (p. 53–56).

America, Africa, Asia.——FIG. 39,*2a–b*. *O. kaniensis* MATSUOKA & MASUDA, Miocene, Nakamura Formation, central Japan; *a,* amphioxea megascleres with minutely spinose, rounded or sharp, ray tips, ×250; *b,* curved gemnoscleres with spinose, rounded tips, ×100 (Matsuoka & Masuda, 2000).

Palaeospongilla OTT & VOLKHEIMER, 1972, p. 53 [**P. chubutensis;* OD]. Skeleton composed of bundles of smooth, monaxial megascleres that descend steeply at various angles; cavities within framework containing spherical gemmules with small, spinose, needlelike microscleres. [This is one of only a few known gemmule-bearing, fossil, freshwater sponges.] *Cretaceous (Coniacian–Maastrichtian):* Argentina.——FIG. 39,*3a–c*. **P. chubutensis,* Chabut Group, lacustrine, freshwater, tuffaceous sandstone and marl, Rio Chabut, Patagonia; *a,* transverse section of gemmule-bearing, encrusting sponge as thin, basal layer on plant stem, which is in turn overgrown by algal crusts, ×2; *b,* photomicrograph of spicule bundles around spherical gemmules, ×25; *c,* photomicrograph of tangential section with bundles of megascleres, ×100 (Ott & Volkheimer, 1972; courtesy of *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*).

Radiospongilla PENNY & RACEK, 1968, p. 61 [**Spongilla sceptroides* HASWELL, 1882, p. 209; OD]. Flat crusts or cushion-shaped sponges that may have rare, small branches; megascleres moderately stout to slender amphioxeas and, rarely, amphistrongyles commonly covered with variable, minute to conspicuous spines, but rarely may be smooth; microscleres absent; gemmules with gemnoscleres slender amphioxeas or amphistrongyles invariable, strongly spinose and may be curved to straight and range to very long elements; spines often aggregated and larger on tips of spicules, forming clublike terminations. *Neogene (?Pleistocene), Holocene:* widespread in tropical to subtropical, freshwater environments.——FIG. 38,*6a–b*. **R. sceptroides* (HASWELL), Holocene; *a,* amphioxea megasclere with widespread, small spines; *b,* amphistrongyle gemnoscleres with small spines, most concentrated on rounded, clublike tips, ×280 (Penny & Racek, 1968).

Family HALICLONIDAE de Laubenfels, 1932

[Haliclonidae DE LAUBENFELS, 1932a, p. 111]

Extremely simple skeletons without dermal or ectosomal specialization; spicules almost exclusively simple diactines; microscleres absent; most typical family of order. *Paleogene (?Eocene), Holocene.*

Haliclona GRANT, 1841 in 1835–1841, p. 6 [**Spongia oculata* LINNÉ, 1759, p. 1348; OD] [=*Chalina* BOWERBANK, 1864, p. 209, *nom. nud.* (type, *C. occulata,* OD), *non* GRANT, 1861, p. 76]. Incrusting to ramose sponges. *Paleogene (?Eocene), Holocene:* cosmopolitan.——FIG. 40,*3a–b*. **H. oculata* (LINNÉ), Holocene; branched sponge, suspended from digitate base, with lines at pores showing inhalant flow at *a,* and exhalant flow at *b,* at pores within fibrous skeleton, scale unknown (Grant, 1835–1841).

Reniera NARDO, 1847b, p. 3, *nom. nov. pro Rayneria* NARDO, 1833, p. 519, *non* GIRARD, 1848 [**R. aqueductus* SCHMIDT, 1862, p. 73; SD SCHMIDT, 1862, p. 73]. Similar to *Haliclona* but a hollow cylinder to weakly branched sponge with small, inhalant ostia and terminal osculum; spicules simple oxeas. [Many Ordovician to Eocene fossils erroneously assigned to this genus based on presence of oxeas.] *Holocene.*——FIG. 40,*1a–c*. **R. aqueductus* (SCHMIDT), Sebenico, Adriatic Sea; *a,* side view of small sponge showing general growth form, ×1; *b–c,* oxeas of skeleton, ×100 (Schmidt, 1862).

Family PETROSIIDAE van Soest, 1980

[Petrosiidae VAN SOEST, 1980, p. 66]

Sponges with multispicular tracts in reticulate pattern with rounded mesh spaces in choanosomal skeleton and mostly tangential, multilayered crust of spicules in irregular to circular patterns in ectosomal skeleton; several kinds of monaxial spicules. *Paleogene–Holocene.*

Petrosia VOSMAER, 1887, p. 338 [**Reniera dura* SCHMIDT, 1862, p. 76; SD DE LAUBENFELS, 1932a, p. 116]. Sponges hard and stony with numerous well-defined, large ostia; skeleton more or less confused mass of oxeas and strongyles that are usually short and closely packed in tracts. Differs from *Haliclona* in having four kinds of monaxons. *?Paleogene–?Neogene, Holocene:* cosmopolitan.——FIG. 40,*7a–f*. **P. dura* (SCHMIDT), Holocene, Zara and Quarnero, Adriatic Sea; *a,* side view of sponge with ostia on several node summits, ×0.5; *b–f,* oxeas of various sizes and large strongyle from type specimen, ×125 (Schmidt, 1862).

Propetrosia PISERA & BUSQUETS, 2002, p. 343 [**P. pristina;* OD]. Petrosiid sponge with only one size of oxea in thick, tangential, multispicular ectosome, and in choanosomal skeleton that is a more or less regular reticulation of multispicular fibers of oxeas of one general size. [This is the first reported, undoubted body fossil of a petrosiid sponge in the geologic record. Other problematic references are to isolated spicules.] *Paleogene–Neogene:* Spain.——FIG. 40,*2a–b*. **P. pristina,* Eocene, Bartonia, Catalonia; *a,* etched holotype fragment showing spicule fibers of ectosome, ×1; *b,* photomicrograph of skeletal fiber in holotype composed largely of subparallel oxeas, ZPAL Pf.X/52, ×50 (Pisera & Busquets, 2002).

Family DESMACIDONIDAE Gray, 1867

[Desmacidonidae GRAY, 1867, p. 536; *non* Desmacidonidae DENDY, 1924a, p. 334] [=Desmacidontidae GRAY, 1967, p. 536, *nom. correct.* DE LAUBENFELS, 1955, p. 37 *pro* Desmacidonidae GRAY, 1867, p. 536; Desmacididae SCHMIDT, 1870, p. 52, *partim, nom. correct.* WIEDENMEYER, 1977a, p. 79, *pro* Desmacidinae SCHMIDT, 1870, p. 52]

Similar to Haliclonidae but having microscleres; flesh commonly slimy. *Paleogene–Holocene.*

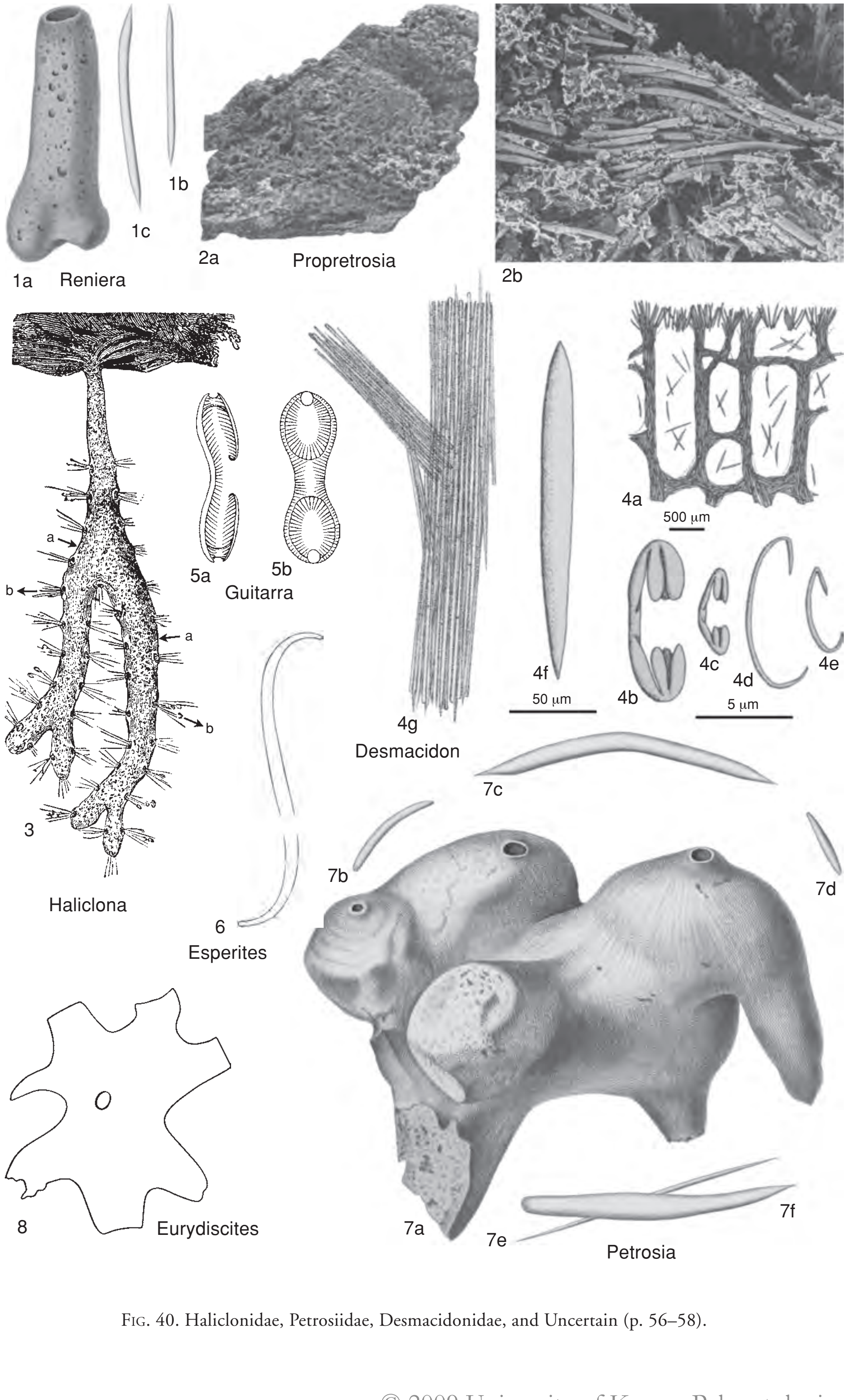

FIG. 40. Haliclonidae, Petrosiidae, Desmacidonidae, and Uncertain (p. 56–58).

Desmacidon BOWERBANK, 1861, p. 372 [**Spongia fruticosa* MONTAGU, 1818, p. 112; SD DE LAUBENFELS, 1936, p. 53]. Skeleton fibrous and irregularly reticulated, with fibers composed entirely of parallel spicules that are cemented together and coated with spongin; megascleres all oxeas; microscleres sigmas and arcuate isochelas; flesh very slimy. *?Paleogene–?Neogene, Holocene:* Europe.——FIG. 40,*4a–f.* **D. fruticosa* (MONTAGU), HOLOCENE, ROSCOFF, FRANCE; drawing of skeleton and spicules made from a slide of specimen (Van Soest, 2002).——FIG. 40,*4g. D. aegagropila* (JOHNSTON), Holocene, United Kingdom; keratose fiber fragment showing its spiculate nature, ×100 (Bowerbank, 1862).

Guitarra CARTER, 1874, p. 210 [**G. fimbriata;* SD DE LAUBENFELS, 1932a, p. 63]. Sponge form generally conical, surface with fingerlike to hairlike villi; megascleres oxeas; microscleres include placochelas. *Paleogene–Holocene:* New Zealand, *Paleogene–Neogene;* cosmopolitan, *Holocene.*——FIG. 40,*5a–b.* **G. fimbriata,* Atlantic Ocean, off northwestern coast of British Isles; characteristic placochela microscleres, lateral and anterior view, ×500 (Carter, 1874).

Family UNCERTAIN

Eurydiscites SOLLAS, 1880d, p. 387 [**E. irregularis;* OD]. Only a few loose spicules distinguished by their large size and coalescence of arms to produce an irregular, lobate disc. *Cretaceous:* England.——FIG. 40,*8.* **E. irregularis,* Trimmingham Chalk, Maastrichtian, Norfolk; isolated, large, lobate, irregular, discoidal spicule, scale uncertain (Sollas, 1880d).

Esperites CARTER, 1871, p. 131 [**E. giganteus;* OD]. Isolated sigma. *Lower Cretaceous:* Europe.——FIG. 40,*6.* **E. giganteus,* Upper Greensand, Haldon Hill, Exeter, England; large, isolated, sigmoidal spicule, ×30 (Carter, 1871).

Order SIGMATOSCLEROPHORIDA Burton, 1956

[*nom. correct.* FINKS & RIGBY, herein, *pro* Sigmatosclerophora BURTON, 1956, p. 114]

Microscleres, when present, include sigmas, chelae, or their derivatives; asters absent, but microrhabds may be present; megascleres are styles, strongyles, oxeas, or any combination of these; tylostyles, if present, accompanied by styles; tetraxons absent; skeleton often composed of spiculofibers; different types of megascleres often localized in different parts of skeleton; sublithistid forms occur, but not lithistids. *Lower Ordovician–Holocene.*

Family DYSTACTOSPONGIIDAE Miller, 1889

[Dystactospongiidae MILLER, 1889, p. 153]

Sublithistid; fibrous skeleton; principal fibers subparallel, connected by smaller fibers and by anastomosis; spicules styles, possible oxeas, and heloclonid desmoids that form spiculofibers either together or separately; when together desmoids forming coating on surface of spiculofiber; styles arranged in fibers either plumosely (axinellid structure) or as coring and echinating elements (ectyonine structure), oxeas arranged tangent to fiber surface. *Lower Ordovician–Upper Ordovician.*

Dystactospongia MILLER, 1882, p. 42 [**D. insolens* MILLER, 1882, p. 43; OD]. Massive, tuberose or subdigitate; no cloaca; sponge surface variably hispid and covered with circular, polygonal, or submeandriform pores of varying size; larger, osculelike pores with tributary canals may be present; spiculofibers porous; principal spiculofibers subparallel, radiating from base and perpendicular to outer surface; connected by thin, tangential spicule; spiculofibers seemingly composed solely of subparallel, heloclonid desmoids. [*Heterospongia* ULRICH, 1889, is very similar, if not identical to this genus. *Dystactospongia radicosa* RUEDEMANN appears to be the burrow *Rauffella* ULRICH, 1889.] *Upper Ordovician:* USA (Illinois, Ohio, Indiana).——FIG. 41*a.* **D. insolens,* Fairview Formation, Maysvillian, Cincinnati, Ohio; holotype fragment with radial canals around several oscula on gastral surface, ×1 (Miller, 1882).——FIG. 41*b–d. D. madisonense* FOERSTE, Saluda Formation, Upper Ordovician, Versailles, Indiana; *b,* side view of reference specimen with two sizes of canal openings, ×1; *c,* transverse section of fragment base with dark matrix in canals and beaded-appearing, skeletal tracts, ×5; *d,* photomicrograph of spicules, mainly irregular heloclones in dense structure, OSU 14618, ×250 (Rigby, 1966b).

Heterospongia ULRICH, 1889, p. 239 [**H. subramosa* ULRICH, 1889, p. 240; OD]. Ramose to lobate, without cloaca; surface smooth or hispid, covered by circular to polygonal or elongate, skeletal pores of variable size and distribution; larger, osculelike pores with tributary surface grooves present in one species (*H. knotti*) that is not type; spiculofibers porous; principal spiculofibers longitudinal in axial region but curving perpendicular to outer surface, connected by tangential spiculofibers; fibers seemingly coated with, and probably composed of, heloclonid desmoids and smooth monaxons, parallel to fiber surface. [It is not clear whether the monaxons are oxeas or styles. Their presence is the only significant difference between this genus and the senior *Dystactospongia* MILLER,

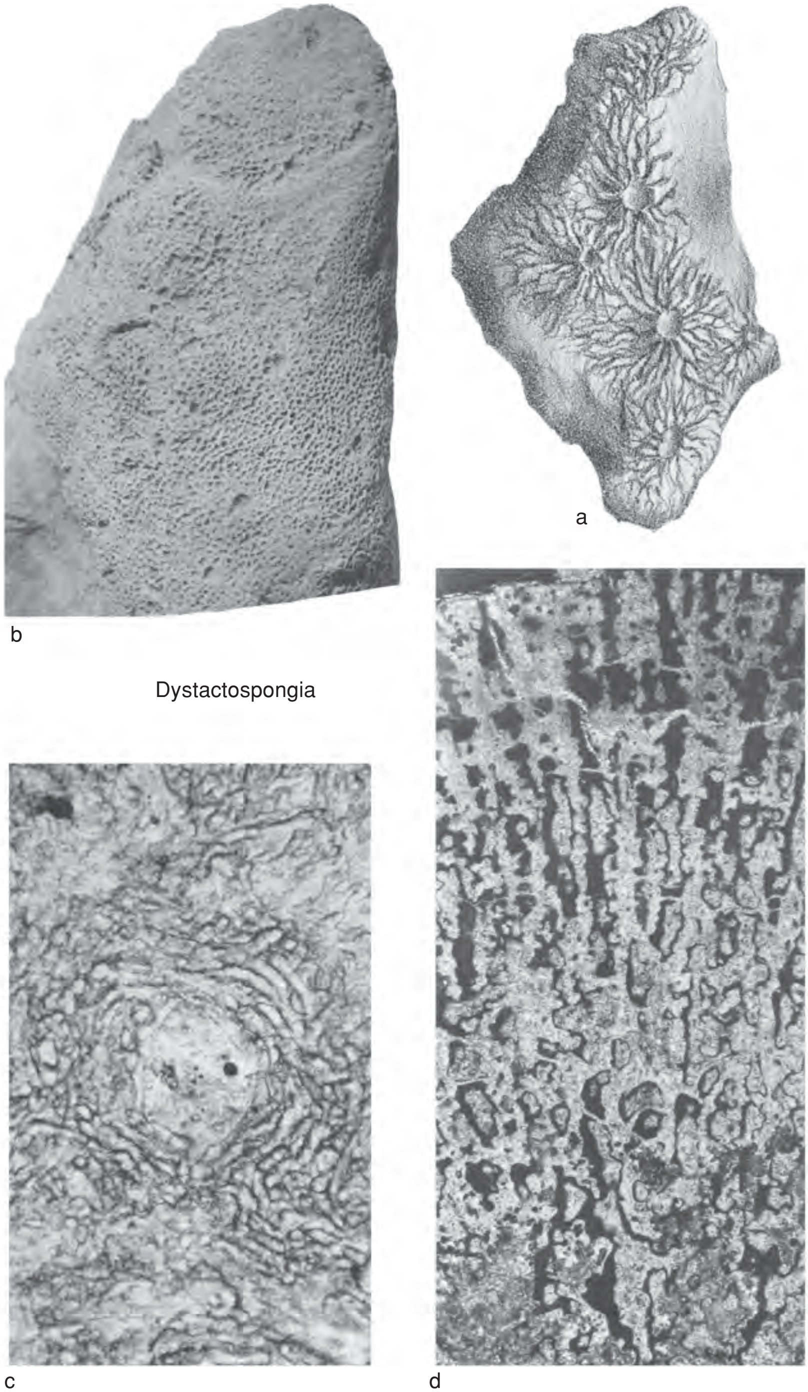

FIG. 41. Dystactospongiidae (p. 58).

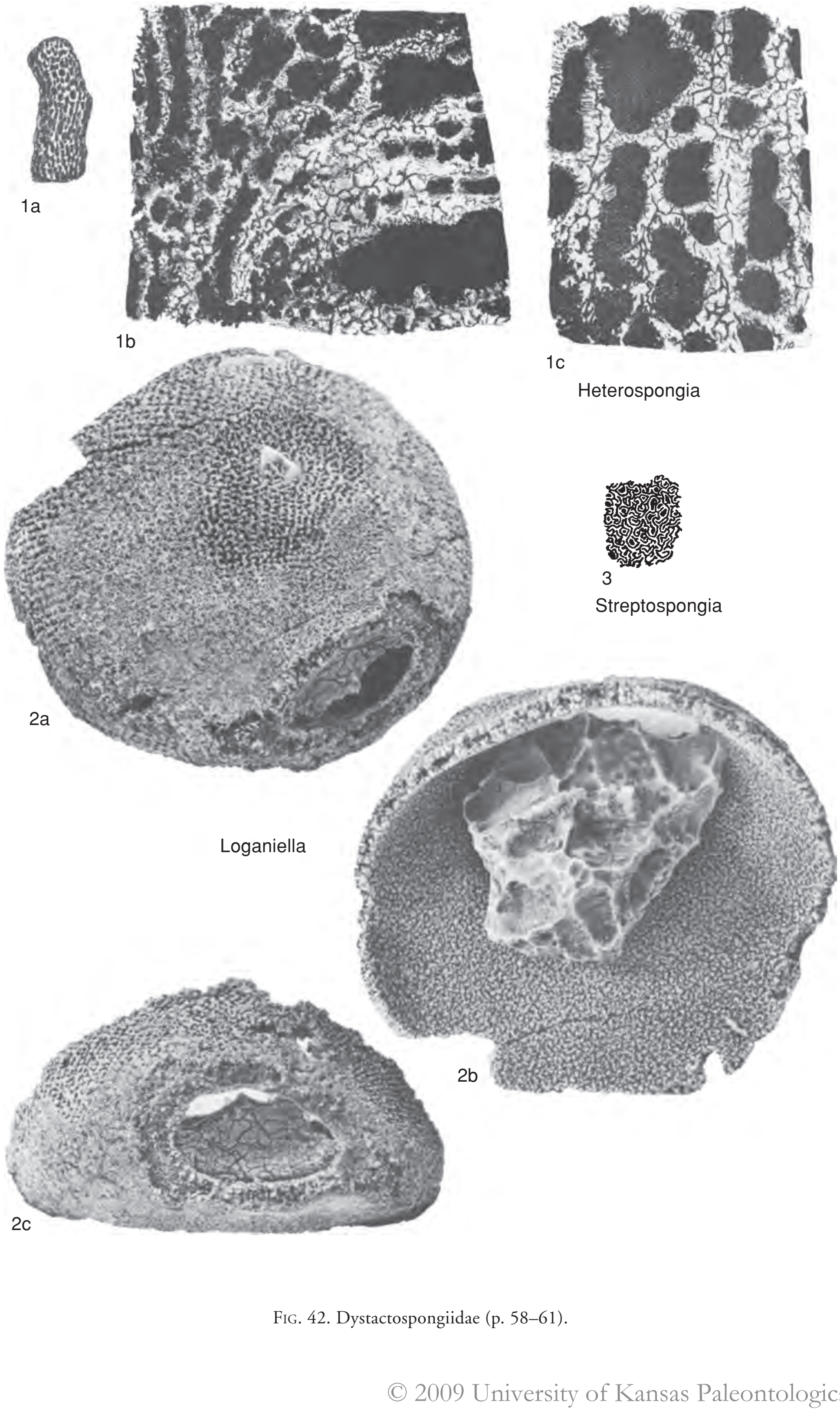

FIG. 42. Dystactospongiidae (p. 58–61).

1882.] *Upper Ordovician:* USA (Kentucky, Ohio, Minnesota).——FIG. 42,*1a–c.* **H. subramosa,* Hudson River Group, Upper Ordovician, Spring Valley, Minnesota; *a,* side view of small, subcylindrical sponge with ostia of small canals, ×1; *b,* vertical section of recrystallized, upwardly and outwardly diverging, skeletal tracts, with dark matrix in canals, ×10; *c,* tangential section with vertically aligned, matrix-filled canals and light, skeletal tracts, specimens in collections of E. O. Ulrich, ×10 (Winchell & Schuchert, 1893).

Loganiella RIGBY & GILLAND, 1977, p. 476 [**L. johnsoni;* OD]. Cylindrical to subcylindrical or bowl-shaped sponges with flat base; broad spongocoel surrounded by relatively thin walls through which four sizes of generally radial canals penetrate into spongocoel; canals may have regular, quadrangular spacing or occur in linear series; skeletal net composed of curved, possible oxeas combined into relatively thick tracts or spiculofibers in reticulate pattern on sponge surfaces, but radial orientation in wall interiors. [The sponges are associated with conodonts of trilobite zones J–L, so they may have come from upper Lower or lower Middle Ordovician beds. The spicules are known only as impressions on the silicified tract surfaces, so placement in the family is questioned, but the sponge appears similar to *Dystactospongia.*] *Lower Ordovician:* USA (Idaho).——FIG. 42,*2a–c.* **L. johnsoni,* Garden City Limestone, Logan River; *a,* flat base of holotype with rectangularly arranged, spicule tracts; *b,* view into spongocoel to flat bottom, partially obscured by matrix, with thin wall in section above; *c,* side view of preserved, partial, lower wall showing moderately regular canal spacing on upper part of wall, above flat base, BYU 1091, ×0.85 (Rigby & Gilland, 1977).

Streptospongia ULRICH, 1889, p. 244 [**S. labyrinthica;* OD]. Fragment with anastomosed, subparallel trabeculae that may be coated with heloclonid desmoids. [This may be a coarsely silicified fragment of *Saccospongia* or *Dystactospongia.*] *?Upper Ordovician:* USA (Kentucky). ——FIG. 42,*3.* **S. labyrinthica,* float from Arnheim Formation, Richmondian, Lebanon; drawing of small part of transverse fracture on holotype showing labyrinthic, skeletal structure, ×1 (Ulrich, 1889).

Subclass LITHISTIDA Schmidt, 1870

[*nom. transl.* ZITTEL, 1878a, p. 96, *ex* group Lithistida SOLLAS, 1887, p. 421, *nom. correct. pro* group Lithistina CARTER, 1875, p. 185, *nom. correct. pro* group Lithistidae SCHMIDT, 1870, p. 21]

Demospongea whose principal megascleres are desmas that are normally united by articulation (zygosis) to form coherent, skeletal framework; some also with types of megascleres that may be monaxons (e.g., oxeas), triaenes, or both, or with accessory (supplemental) desmas in addition to main ones; principal desmas tetraxial, tripodal, monaxial, or anaxial in those whose character is known; some with tetraxial desmas intergrading with triodal or monaxial forms; articulatory features (zygomes) sometimes simple facets only, but typically twig, root, or clawlike, or forming tongue, cup, or handlike expansions; few forms with zygosis only weakly developed or absent; skeletal framework uncanalized, or with ostia, postica, or both, or with additional epirhyses, aporhyses, or both, or with skeletal pores or canals of unknown character; triaenes arranged typically at surfaces when present, with shafts running inwardly into meshes of internal framework when long enough, and their cladi in ectosome in living forms; shafts of triaenes never normally incorporated into primary, skeletal meshwork, although sometimes imbedded in secondary meshwork formed by supplemental desmas; supplemental monaxons usually loose in skeletal meshes or lying tangentially at surfaces, but sometimes grasped by zygomes of desmas or incorporated into composite, skeletal fibers; supplemental desmas usually small, rhizoclone-like bodies found in internal meshes, at surface or both, and sometimes intergrading with primary desmas; examples found at surface may form a supplemental cortex that coats skeletal framework, and may then cover ostia or postica, or be pierced by intracortical pores or canals; microscleres present or absent in life in living examples, in which they may be microrhabds, streptoscleres (intergrading plesiasters, metasters, and spirasters), unidentified spirasters or amphiasters, or sigmaspires when present; soft parts as in normal Demospongea, with the ectosome usually a dermis. *Cambrian–Holocene.*

Order ORCHOCLADINA Rauff, 1895

[*nom. transl.* REID, 1963e, p. 93, *ex* subtribe Orchocladinae RAUFF, 1895, p. 242]

Principal spicules are dendroclones organized parallel to one another in rows or chiastoclones with less regular arrangement;

principal skeletal canals radial and paratangential. *Middle Cambrian–Permian (Lopingian).*

Family ANTHASPIDELLIDAE Miller, 1889

[Anthaspidellidae MILLER, 1889, p. 153] [=Anthaspidellidae ULRICH, 1890a, p. 221; Archaeoscyphiidae RAUFF, 1894, p. 238; Aulocopiidae RAUFF, 1895, p. 247; Eospongiidae DE LAUBENFELS, 1955, p. 64, *partim*]

Dendroclones arranged with long axes paratangential to upper or outer growing surface of sponge, forming an isodictyal net with mainly triangular interspaces; ladderlike rows of dendroclones radiating upwardly and outwardly approximately perpendicular to growing surface; interlocking zygoses of contratangent rows of spicules often forming conspicuous, columnlike structures or trabs that may be cored by smooth monaxons; principal skeletal canals both parallel to dendroclone rows and to dendroclone layers, in latter instance they tend to persist in same place at successive levels to form vertical rows of pores, or frequently by coalescence, vertical, slitlike passages; sponges vasiform, fungiform, or massive; apparently attached to substrate basally but not by root tuft; imperforate, concentrically wrinkled, basal layer common. [MILLER (1889) had seen ULRICH's proofs (1890a) or ms and used ULRICH's new family name without giving him credit, although he did use ULRICH's name for the new type genus.] *Middle Cambrian–Permian (Changhsingian).*

Anthaspidella ULRICH & EVERETT in MILLER, 1889, p. 153 [**A. mammulata;* OD]. Broadly funnel or saucer shaped, attached to substrate by short, central stalk; upper surface covered by numerous oscules more or less evenly distributed; each oscule with radially arranged, exhalant canals converging upon it; dendroclone rows arranged radially with respect to center of sponge and diverging upwardly and downwardly toward upper and lower surfaces. *Lower Ordovician–Devonian (Frasnian):* USA (Texas, New Mexico), Argentina, China (Hubei), *Ibexian;* widespread Canada and USA, and northern Europe, *Middle Ordovician*; Western Australia, *Frasnian.*——FIG. 43*a–b*. **A. mammulata,* Platteville Limestone, Chazyan, Dixon, Illinois, USA; *a,* vertical view of holotype with shallow, gastral depression marked by multiple, low, mounded, exhalant oscula, ×1; *b,* vertical section showing trabs and cross-connecting dendroclones, ISM, ×18 (Ulrich & Everett, 1890).——FIG. 43*c*. *A. amplia* RIGBY & DESROCHERS, Mingan Formation, Chazyan, Mingan Islands, Canada; view from above of paratype showing numerous moderately coarse clusters of exhalant canals in shallow depression, surrounded by convergent, essentially horizontal, exhalant canals, GSC 111098, ×1 (Rigby & Desrochers, 1995).

Amplaspongia RIGBY & WEBBY, 1988, p. 41 [**A. bulba;* OD]. Large, hemispherical to globular sponges lacking a spongocoel; anthaspidellid skeleton of uniform, upwardly and outwardly radiating trabs; two major canal series with two different diameters are parallel trabs, canals may be crudely clustered; minor, subhorizontal canals moderately rare and discontinuous; trabs dense, coring spicules largely absent, and dendroclones simple with long shafts; dense, basal dermal layer may be present, pores absent. *Upper Ordovician*: Australia (New South Wales).——FIG. 44*a–b*. **A. bulba,* Malongulli Formation, Cliefden Caves area; *a,* vertical view of gastral, upper surface of holotype showing separated clusters of coarse, excurrent canals in otherwise uniform skeleton pierced by smaller, isolated canals, ×0.5; *b,* photomicrograph of broken surface of paratype showing ladderlike skeleton including vertical trabs produced by union of ray tips of horizontal, runglike dendroclones, small canals parallel trabs, AMu. F66820, ×8 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).——FIG. 45*a–b*. **A. bulba,* Malongulli Formation, Cliefden Caves area; *a,* enlargement of gastral surface of holotype showing a prominent cluster of excurrent canals, on left, and abundant, smaller, circular canals in surrounding uniform skeleton where tiny, rodlike, horizontal dendroclones connect between vertical, rodlike trabs, seen here in transverse sections as small dots, AMu. F66819, ×2; *b,* side view of paratype where upwardly expanding skeleton of vertical trabs and horizontal dendroclone spicules interrupted locally by vertical canals, ×1 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Annulospongia LIU, RIGBY, & ZHU, 2003, p. 438 [**A. tarimensis;* OD]. Ringlike or tirelike, short, large sponge with broad, deep spongocoel extending upwardly from near base; skeleton anthaspidellid with vertical trabs of dendroclones in double rows nearly parallel to each other so surface of pinnation weak or present only near base; horizontal canals radial, straight to slightly curved and vertically stacked. *Ordovician (Darriwilian):* China (Xinjiang).——FIG. 46,*1a–b*. **A. tarimensis,* Yijianfang Formation, Bachu County; *a,* tirelike holotype from above with large spongocoel largely filled with matrix, ×0.4; *b,* transverse, horizontal section with radial canals between ladderlike, double rows of trabs of dendroclone, ×2 (Liu, Rigby, & Zhu, 2003).

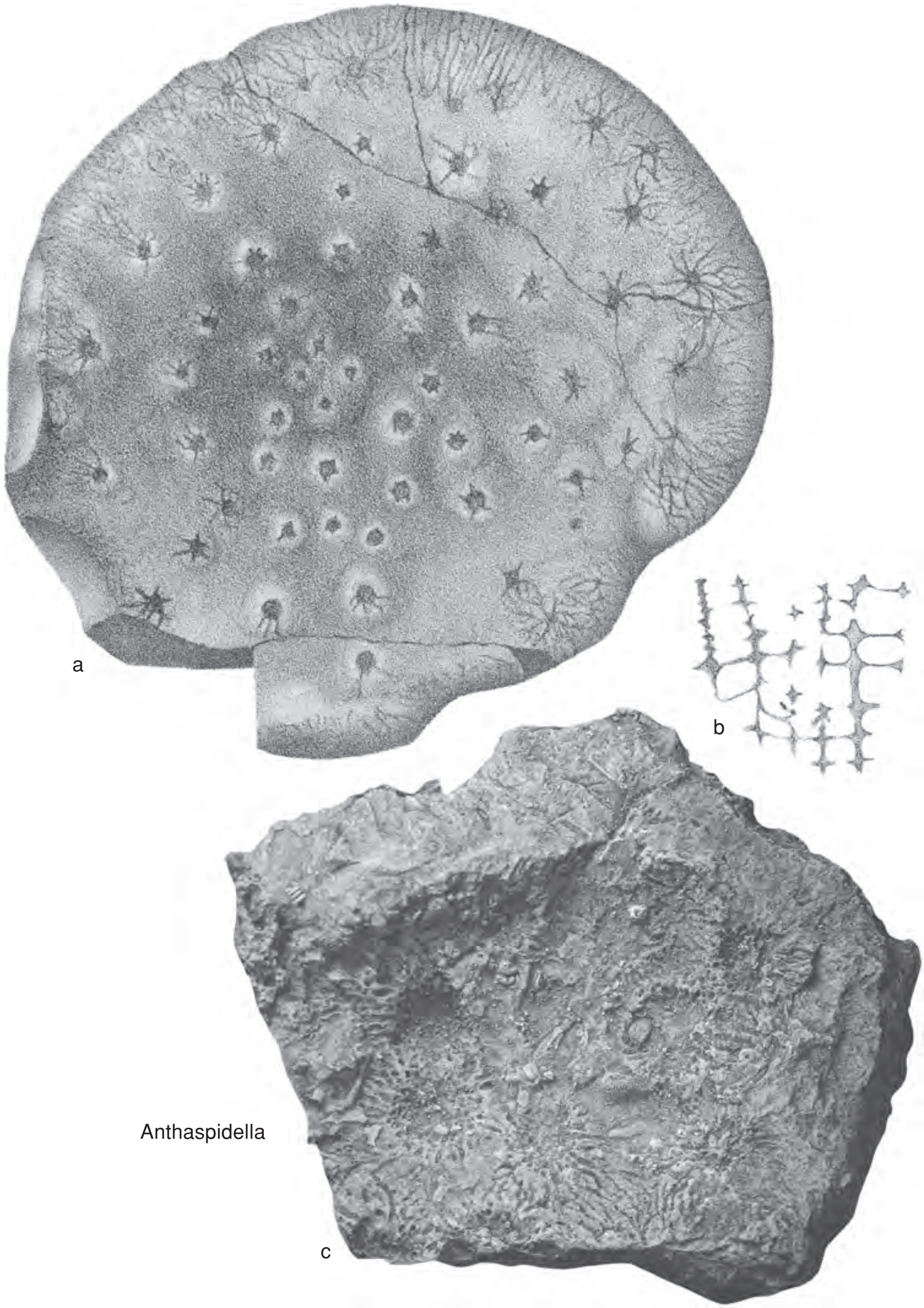

FIG. 43. Anthaspidellidae (p. 62).

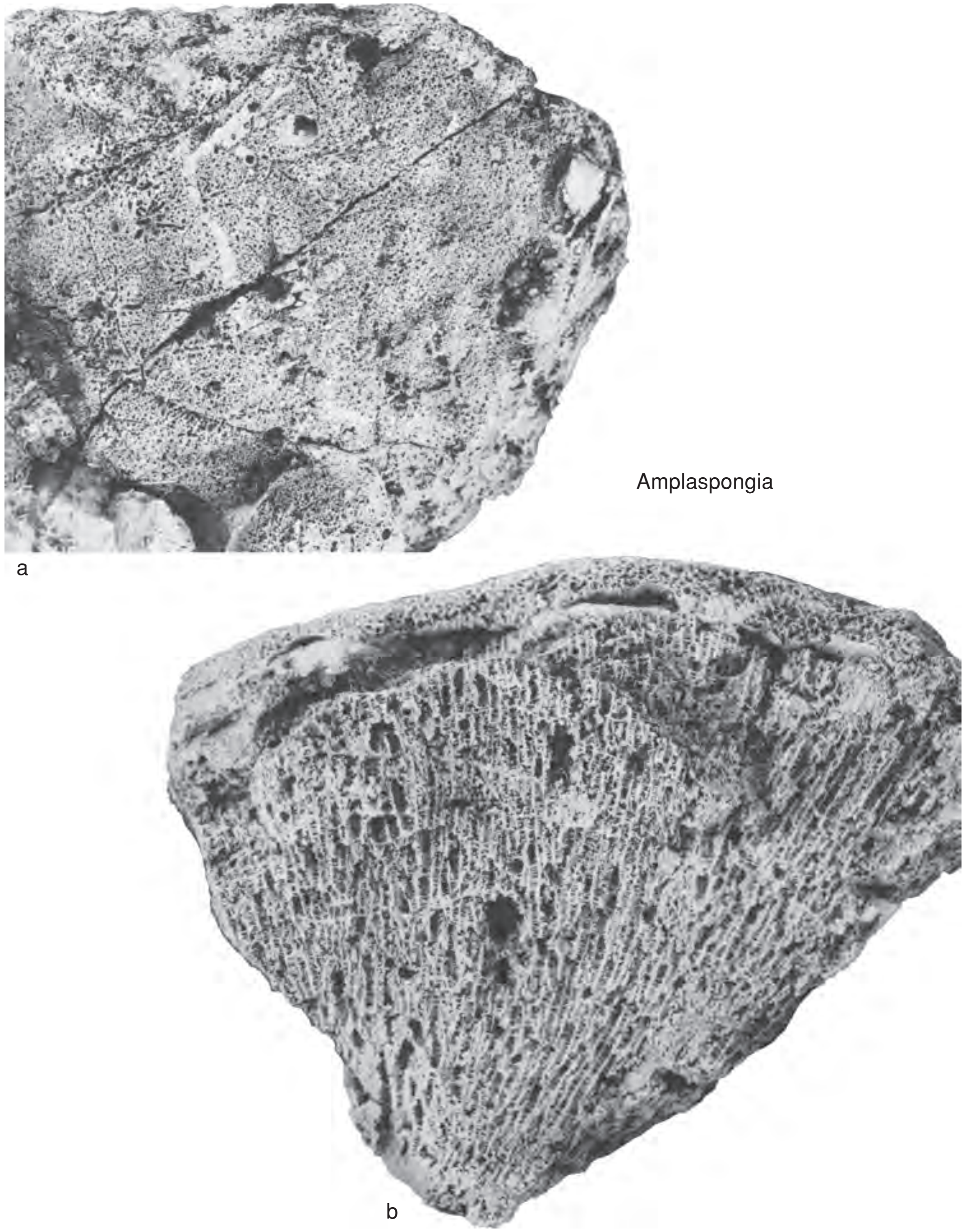

FIG. 44. Anthaspidellidae (p. 62).

Archaeoscyphia HINDE, 1889b, p. 141 [**Petraia minganensis* BILLINGS, 1859, p. 346; OD] [=*Costaspongia* BARTHOLOMAUS & LANGE, 1998, p. 398 (type, *C. nansoedi,* OD)]. Conical with flangelike, horizontal, annular outgrowths encircling exterior at regular intervals; cloaca relatively broad, smooth walled; body wall relatively thin, containing closely spaced, vertically stacked, radially arranged, upwardly arched to horizontal canals that extend from exterior to cloacal surface; spicules principally dendroclones with a minority of rhizoclones and tetraclone-like desmas; may have thin, dermal layer of flattened, dendroclone tips. [Synonym *Costaspongia* BARTHOLOMAUS & LANGE, 1998, p. 398 is differentiated because of its laterally flattened form that is probably a diage-

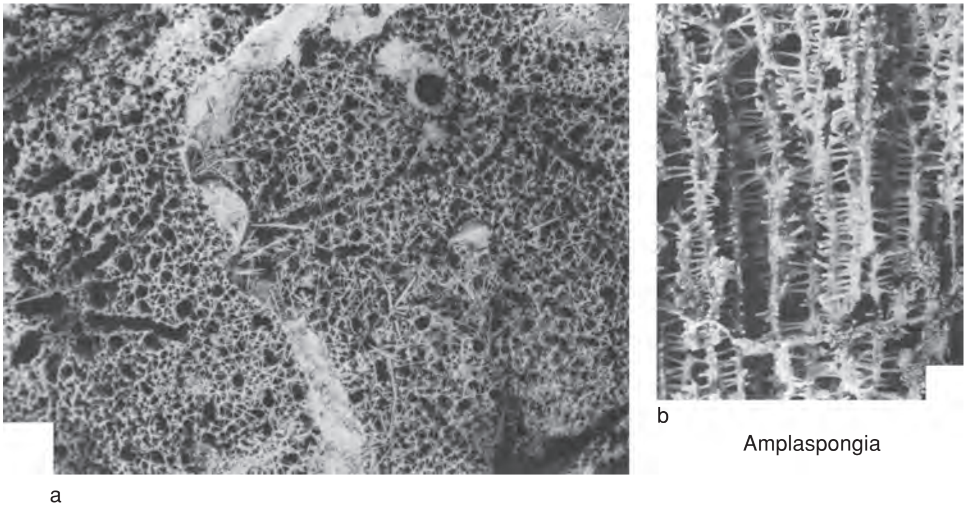

FIG. 45. Anthaspidellidae (p. 62).

netic effect.] *Lower Ordovician–Silurian:* cosmopolitan.——FIG. 47,*1*. **A. minganensis* (BILLINGS), Romaine Formation, Canadian, La Grosse Romaine Island, Mingan Islands, Quebec, Canada; side view of characteristic, steeply obconical sponge, GSC 111103, ×1 (Rigby & Desrochers, 1995).

Aulacospongia GERTH, 1927, p. 117 [**A. hanieli* GERTH, 1927, p. 118; OD]. Ellipsoid with major axis vertical; surface grooves running vertically up sides and converging on top of sponge; interior with scattered, vertical canals corresponding to such surface grooves at earlier stages of growth; dendroclone rows perpendicular to outer surface and radiating from attachment point within base of sponge. *Permian (Lopingian):* Timor.——FIG. 46,*2a–b*. **A. hanieli,* Permian Limestone, Besleo; *a,* side view of type specimen showing growth form with prominent canals converging from sides to summit, ×1; *b,* transverse section showing radial, skeletal and canal structure in dense skeleton, ×1.5 (Gerth, 1929; courtesy of E. Schweizerbart'sche Verlagsbuchhandlung).

Aulocopina BILLINGS, 1875, p. 230 [**A. granti* BILLINGS, 1875, p. 231; OD]. Ovoid or pyriform, with deep, central cloaca; principal canals parallel to upper and outer surface, branched to sinuous and converging on cloaca; canals forming surface grooves that cover entire, outer surface; dendroclone rows presumably perpendicular to surface. *Silurian (Wenlock–Ludlow):* Canada.——FIG. 47,*3a–b*. **A. granti,* Niagara Formation, Hamilton, Ontario; *a,* side view of lectotype, with osculum of axial spongocoel on summit and grooves of canals on osculum and exterior; *b,* summit view of larger specimen with radial canals and small spongocoel, ×1 (Billings, 1875).

Australospongia HOWELL, 1952, p. 1 [**A. turbinata;* OD]. Small, cylindrical to conical with deep spongocoel and thin walls perforated by two radial, small, canal series regularly spaced although not uniform; ill-defined trabs radiating upwardly and possibly outwardly from gastral surface, skeletal details unknown but dermal layer evident. [May be a poorly preserved *Playfordiella* RIGBY, 1986b, and if so then *Playfordiella* is a junior synonym.] *Devonian (Famennian):* Western Australia.——FIG. 48,*1a*. **A. turbinata,* Virgin Hills Formation, Mount Pierre; side view of small, steeply obconical sponges, PU 57873, ×1 (Rigby, 1986b).——FIG. 48,*1b–c*. *A. cylindrica* HOWELL, Virgin Hills Formation, Mount Pierre; *b,* side view of cylindrical, small sponge, ×1; *c,* oscular view showing tubular form with round spongocoel and thin walls, PU 57872, ×2 (Rigby, 1986b).

Brianispongia PICKETT & RIGBY, 1983, p. 727 [**B. quadratipora;* OD]. Slender, branching, without spongocoel or axial excurrent canals but with scattered ostia and numerous inhalant pores on smooth surface; skeleton of dendroclones and trabs, which arch upwardly and outwardly from axial region. *Lower Devonian:* Australia (New South Wales).——FIG. 46,*3a–c*. **B. quadratipora,* Garra Formation, Lochkovian–Pragian, Wellington; *a,* transverse, weathered surface showing canal pattern and absence of spongocoel in holotype, ×4; *b,* side view of subcylindrical holotype with four-sided, inhalant ostia and small, skeletal pores, ×4; *c,* photomicrograph showing trabs and cross-connecting dendroclones of anthaspidellid, skeletal net, MMF 22570, ×20 (Pickett & Rigby, 1983).

Calycocoelia BASSLER, 1927, p. 392 [**C. typicalis;* OD]. Conical and tubular to somewhat club shaped with smoothly convex, upper surface descending into narrow, central cloaca; exterior surface smooth; small (possibly inhalant) pores arranged on outer surface in vertical rows and on

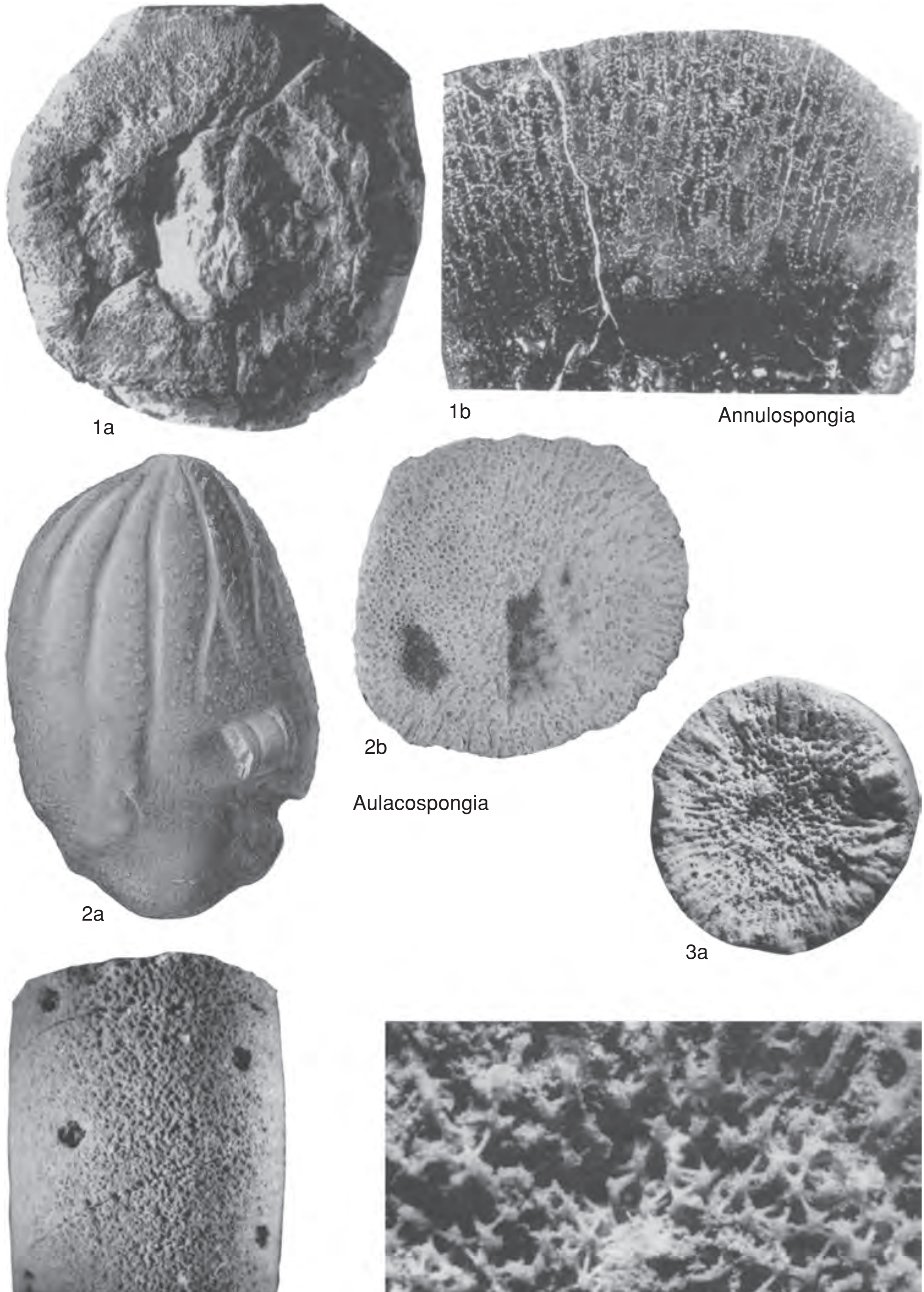

FIG. 46. Anthaspidellidae (p. 62–65).

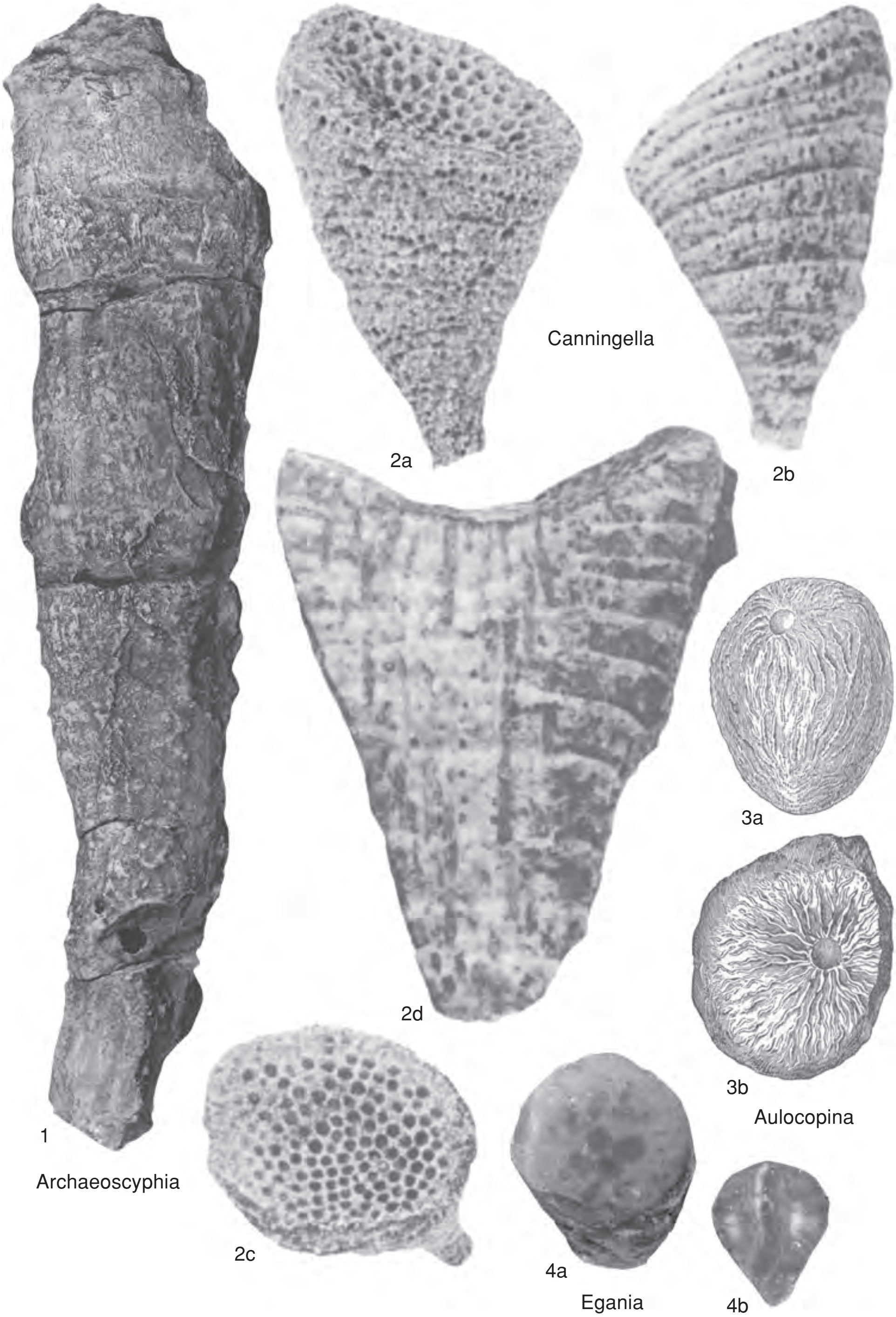

FIG. 47. Anthaspidellidae (p. 64–73).

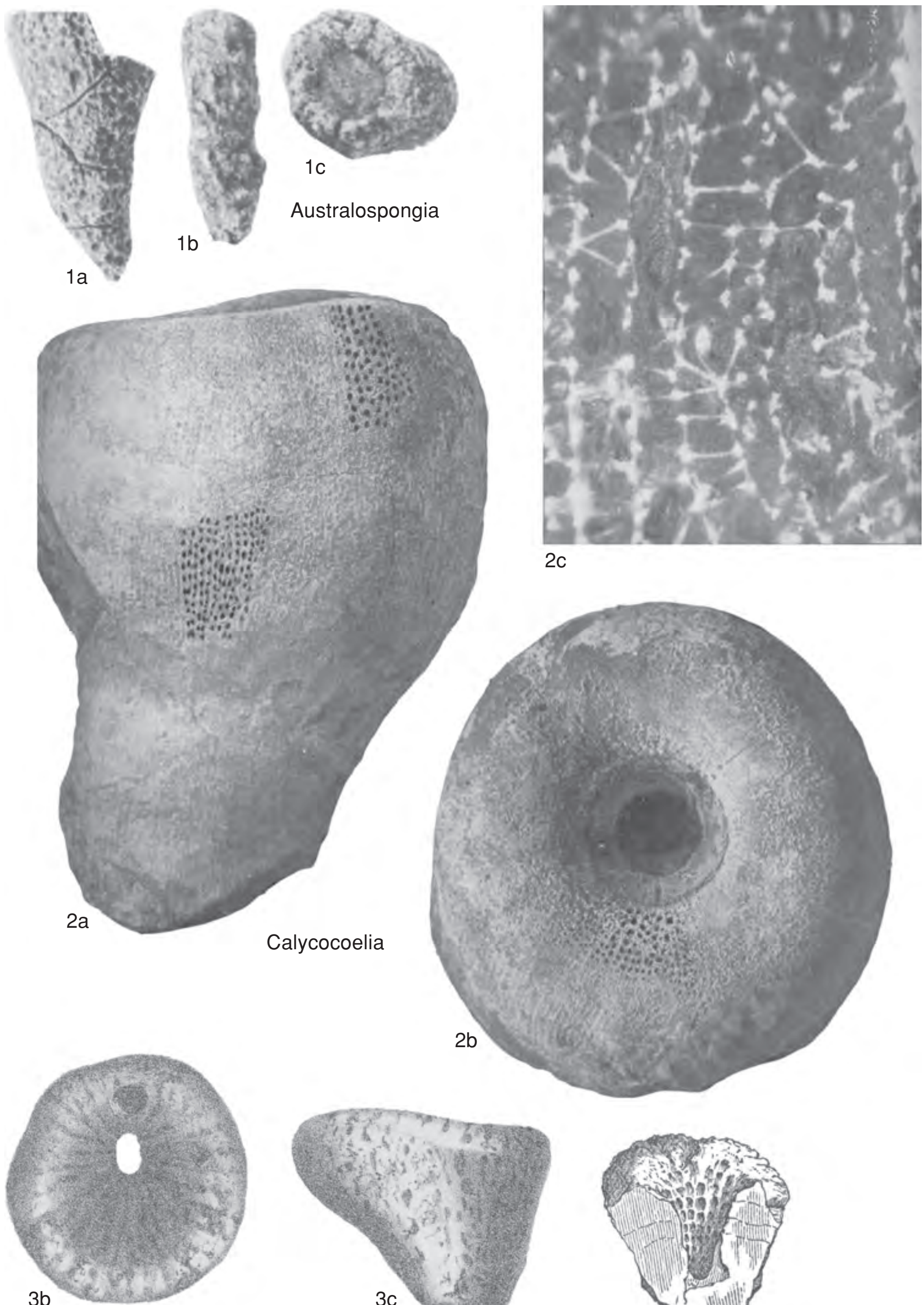

FIG. 48. Anthaspidellidae (p. 65–76).

upper surface in radial rows; dendroclones relatively long for family and arranged in usual, upwardly diverging rows. *Lower Ordovician–Silurian:* USA (Texas, Colorado), Argentina, China (Xinjiang), *Ibexian;* USA (Nevada, California), Canada (Quebec, Northwest Territories, Cornwallis Island), China (Sichuan), Germany (Island of Sylt and at other localities across northern Europe, as glacial erratics, presumably from Baltic region), *Middle Ordovician–Silurian.*——FIG. 48,*2a–c.* **C. typicalis,* Antelope Valley Formation, Whiterockian, Ikes Canyon, Toquima Range, Nevada; *a,* side view of goblet-shaped holotype with several inhalant ostia darkened to emphasize their distribution, ×1; *b,* view from above of rounded, oscular margin, marked by radial series of canals, and central, deep spongocoel, USNM 79637, ×1; *c,* photomicrograph of transverse section showing radial canals and parallel series of trabs interconnected with runglike dendroclones, ×9 (Bassler, 1941).

Canningella RIGBY, 1986b, p. 22 [**C. obconica* RIGBY, 1986b, p. 23; OD]. Small to medium-sized, cylindrical-conical or funnel-shaped sponges with major, deep spongocoel or numerous large, excurrent canals; skeletal net with alternating open and dense layers, latter with swollen spicules marking former dermal surfaces of sponge; skeleton anthaspidellid with trabs composed of dendroclones and possible other spicules, but well organized and generally upwardly plumose or expanding. *Devonian (Frasnian–Famennian):* Australia (Western Australia).——FIG. 47,*2a–d.* **C. obconica,* Virgin Hills Formation, Lawford Range; *a,* side view of weathered holotype with numerous exhalant ostia in shallow spongocoel at top, ×1; *b,* opposite side view showing alternating layers of dense and open skeleton, both with abundant, inhalant canals, ×1; *c,* view into shallow spongocoel showing numerous uniformly spaced, exhalant ostia, GSWA F7198, ×1; *d,* natural vertical section through paratype showing alternating, skeletal layers, particularly in outer part, and vertical, exhalant canals in interior, GSWA F7199, ×1 (Rigby, 1986b).

Capsospongia RIGBY, 1986a, p. 51 [**Corralia undulata* WALCOTT, 1920, p. 288; OD]. Annulate, conicocylindrical, thin walled; skeleton with irregular, vertical trabs formed by combined tips of horizontal dendroclones to produce septate-appearing wall; major canals parallel upwardly divergent skeleton. *Middle Cambrian:* Canada (British Columbia).——FIG. 49,*2a–b.* **C undulata* (WALCOTT), Stephen Formation, Burgess Shale, Mount Field; *a,* annulate holotype with vertical, skeletal tracts moderately well preserved in calcareous replacement; USNM 66479, ×1; *b,* detail of tip of small lectotype showing small trabs of skeleton near filled fracture, USNM 66480, ×20 (Rigby, 1986a).

Cauliculospongia RIGBY & CHATTERTON, 1989, p. 20 [**C. solida;* OD]. Small, twiglike, branched or unbranched without spongocoel; ladderlike series of dendroclones and trabs arching upwardly and outwardly from axis to meet dermal surface at high angles; may have discontinuous, vertical canals irregularly throughout. *Silurian (Ludlow):* Canada (Northwest Territories, Cornwallis Island).——FIG. 49,*1a–b.* **C. solida,* Cape Phillips Formation, Baillie-Hamilton Island; *a,* side view of holotype showing small, ramose form, ×1; *b,* photomicrograph showing center of stem of sponge lacking spongocoel and with upwardly pinnate trabs in uniform skeleton, with canals essentially normal to trabs, UA 7706, ×10 (Rigby & Chatterton, 1989; courtesy of Minister of Public Works and Government Services, 2000, and the Geological Survey of Canada).

Climacospongia HINDE, 1884a, p. 18 [**C. radiata;* OD]. Spheroidal; dendroclone rows radiating from base and perpendicular to surface; columns of interlocking zygoses cored by smooth oxeas; principal skeletal canals radial. *Silurian (Wenlock–Ludlow):* USA (Tennessee), *Wenlock–Ludlow;* Canada (Cornwallis Island), *Ludlow.*——FIG. 50,*1a–b.* **C. radiata,* Brownsport Formation, Niagaran, Perry County, Tennessee; *a,* upwardly divergent skeletal and canal structure in vertical section of type sponge, ×1; *b,* enlarged view of part of fractured surface showing radiating monaxons and transverse dendroclones in skeleton, BMNH, ×10 (Hinde, 1884b).

Cockbainia RIGBY, 1986b, p. 15 [**C. palmata;* OD]. Upright, bladed to palmate, anthaspidellid sponges with distal, fingerlike digitations; spongocoel absent but with moderately developed, radiating canals in centers of digitations; trabs originating near base of sponge or near basal parts of digitations and then diverging upwardly and outwardly; trabs composed of fused tips of smooth-shafted dendroclones and cored by one or two monaxons in any section. *Devonian (Frasnian):* Australia (Western Australia).——FIG. 50,*3a–d.* **C. palmata,* Sadler Formation, Sadler Ridge; *a,* side view of holotype showing wrinkled, palmate growth form and partial, dermal layer, ×1; *b,* view from above showing radiating canals in each of branches, ×1; *c,* photomicrograph of skeletal structure from above, with dendroclones radiating from rodlike trabs, WAGS F7192, ×25; *d,* camera lucida drawing of spicule relationships in fragment with coring oxeas of trabs and attached, dendroclone spicules, ×30 (Rigby, 1986b).

Colinispongia JOHNS, 1994, p. 60 [**C. regularis* JOHNS, 1994, p. 61; OD]. Palmate with relatively thin wall, surface smooth to slightly undulose; straight, radial canals vertically stacked and commonly discontinuous with one to three trabs between canals; exhalant openings quadrate and regular, producing checkerboard pattern; skeletal net ladderlike, of amphiarborescent dendroclones with surface of pinnation one-third to one-half wall thickness from gastral surface; ectosomal layers well developed over exterior, but open textured

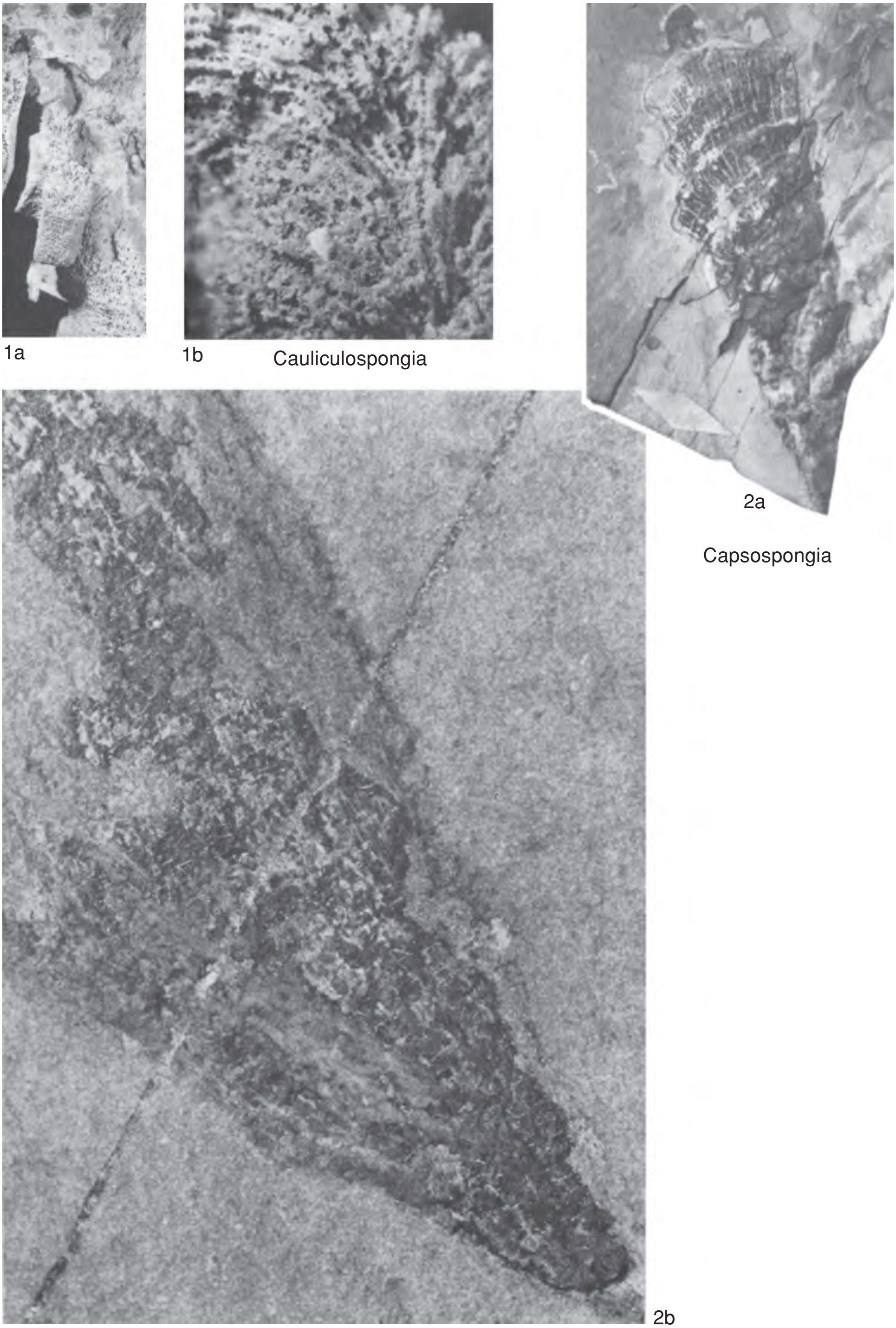

FIG. 49. Anthaspidellidae (p. 69).

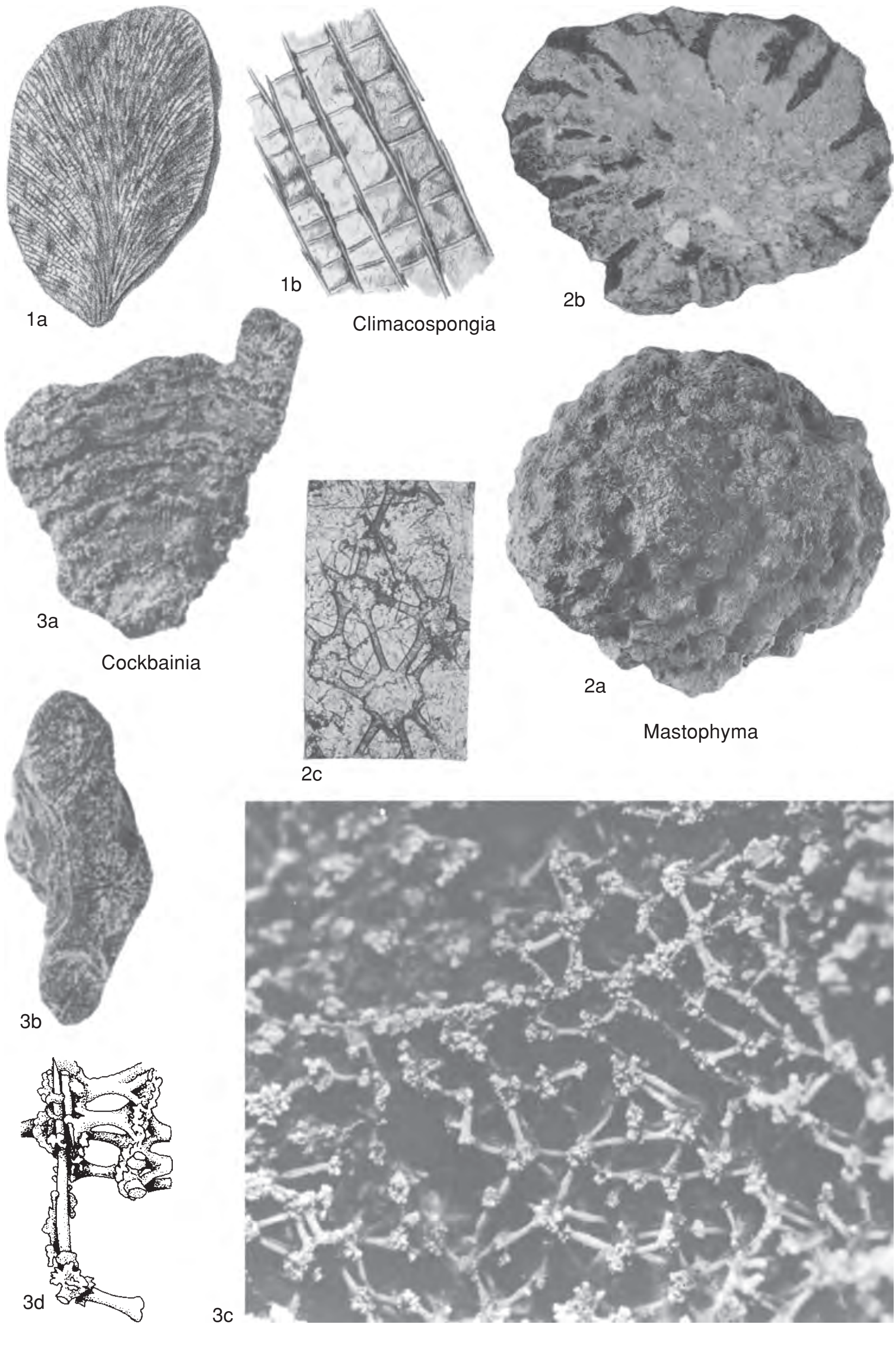

FIG. 50. Anthaspidellidae (p. 69–85).

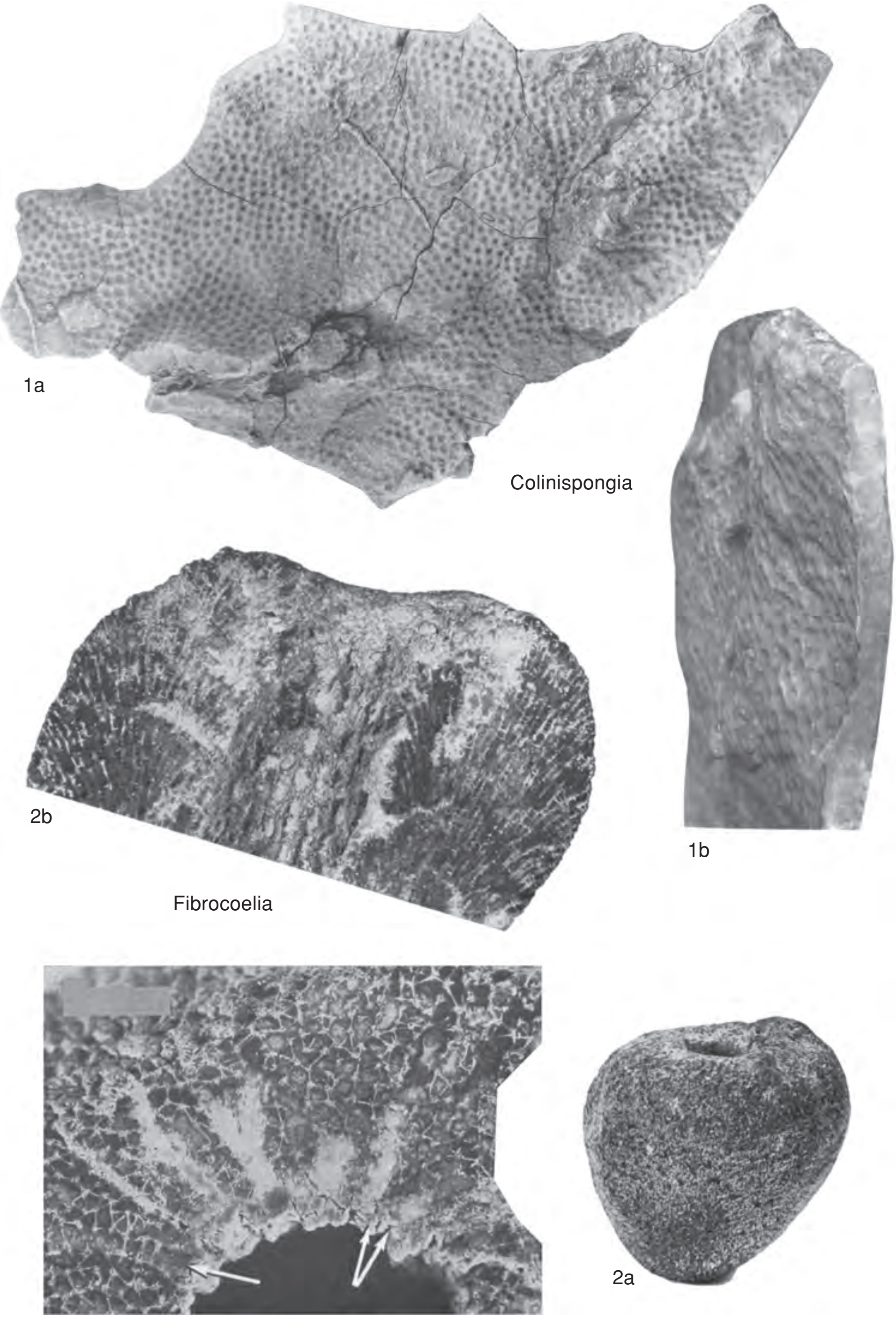

FIG. 51. Anthaspidellidae (p. 69–76).

and thin. *Lower Ordovician:* USA (western states).——FIG. 51,*1a–b*. **C. regularis,* Shingle Limestone, Ibexian, Egan Range, Nevada; *a,* gastral view of holotype with regular dimensions and spacing of exhalant ostia; *b,* vertical section showing horizontal, radial canals and pinnation of skeletal trabs, UT 1787TX1, ×0.8 (Johns, 1994; courtesy of Nevada Bureau of Mines and Geology).

Diotricheum VAN KEMPEN, 1989, p. 133 [**D. vonhachti;* OD]. Medium-sized, thick-walled, obconical sponges with narrow, pointed base, upper part probably subhemispherical; lateral walls smooth, dense, and differentiated from inner skeleton, marked with upwardly fanning folds or ribs and rhythmic, concentric growth increments; spongocoel moderately deep and narrow; subhorizontal, radial canals merging into clustered, vertical, axial, exhalant canals; irregularly disposed ostia on summit from upwardly divergent canals that originate near base; skeleton anthaspidellid with less regularly arranged, ladderlike spicule series with trabs cored by small monaxons; principal, runglike spicules are branched dendroclones. [The sponges are glacial erratics, presumably derived from the Baltic region to the northeast of Sylt. The genus is similar to several anthaspidellids but is differentiated by its external appearance with smooth, dense outer walls that are marked by vertical creases and horizontal growth rings and by conspicuous ostia randomly distributed over entire summit. These canals are separable into those of coarse, axial, exhalant cluster and those more peripheral ones that may be inhalant canals and are separate from the exhalant system.] *Upper Ordovician:* Germany (Island of Sylt), across northern Europe.——FIG. 52,*2a–f*. **D. vonhachti,* glacial erratic, Island of Sylt; *a,* holotype, side view with smooth surface and growth marks, ×0.9; *b,* side view of holotype with fractured surface showing growth increments and inner structure, GPIMH/S1, ×0.9; *c,* vertical section of paratype showing canal pattern and spongocoel with stacked apopores, GPIMH/S27, ×1; *d,* transverse section of paratype showing distribution of coarse, exhalant canals with converging, smaller canals, GPIMH/S2, ×2; *e,* photomicrograph of vertical section of paratype showing dendroclones of endosomal skeleton, GPIMH/S3, ×25; *f,* photomicrograph of cortical spicules in paratype, dermal layer, VK/S30, ×44 (van Kempen, 1989).

Dunhillia RIGBY & WEBBY, 1988, p. 47 [**D. tubula* RIGBY & WEBBY, 1988, p. 48; OD]. Minute, tubular to conicocylindrical anthaspidellids with cylindrical spongocoel; trabs vertical and only slightly divergent, without surface of pinnation; principal spicules dendroclones; incurrent canals with outer, short tubes or rims, connecting to discontinuous, horizontal, ringlike canals at midwall that connect to horizontal, radial, excurrent canals and to axial spongocoel; dermal layer of small, tilelike, flattened rhizoclones. *Upper Ordovician–Silurian (Ludlow):* Australia (New South Wales), *Upper Ordovician;* Canada (Northwest Territories, Baillie-Hamilton and Cornwallis Islands), *Ludlow.*——FIG. 53,*1a–d*. **D. tubula,* Malongulli Formation, Caradoc–Ashgill, Cleifden Caves area, New South Wales; *a,* side view of holotype showing cylindrical form with separated, incurrent canals, each with a low, labropore rim or short, exaulos-like tube, ×4; *b,* enlarged side view showing small, rectangular, tilelike rhizoclones of dermal layer in regular rows that deflect around bases of incurrent openings, ×15; *c,* diagonal view of upper, oscular end with an axial spongocoel and uniform, spicular structure of skeleton, AMu. F66824, ×15; *d,* vertical section of paratype showing marked regularity of endosomal skeleton of parallel trabs and runglike dendroclones, shelflike rings on gastral surface composed largely of rhizoclones, horizontal ring canals occurring at midwall, AMu. F66825, ×15 (Rigby & Webby, 1988).——FIG. 53,*1e*. *D. cribrata* RIGBY & WEBBY, Malongulli Formation, Caradoc–Ashgill, Cliefden Caves area, New South Wales; side view of holotype showing dense, dermal wall and clustered, incurrent canals, AMu. F66845, ×4 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).——FIG. 53,*1f*. *D. multiporata* RIGBY & WEBBY, Malongulli Formation, Caradoc–Ashgill, Cliefden Caves area, New South Wales; side view of holotype showing numerous fairly uniformly spread, incurrent ostia, each with a minor rim, in dense, dermal layer, AMu. F66850, ×5 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Egania JOHNS, 1994, p. 63 [**E. typicalis;* OD]. Obconical to massive, usually with hemispherical, upper surface commonly without spongocoel; exterior unornamented and smooth; several large, vertical, excurrent canals loosely clustered around axis; radial canals subhorizontal and moderately straight, in more-or-less vertical series; skeletal net with surface of trab pinnation midway between exterior surface and axis of sponge; spicules dominantly polyclonid and less commonly amphiarborescent dendroclones, often not in horizontal orientation. *Lower Ordovician:* USA (western states).——FIG. 47,*4a–b*. **E. typicalis,* Shingle Limestone, Ibexian, Egan Range, Nevada; *a,* transverse section of holotype with scattered, vertical, exhalant canals, UT 1784TX38, ×1; *b,* vertical section of paratype with fine, radial, inhalant canals and coarse, vertical, exhalant canals, UT 1784TX41, ×1 (Johns, 1994; courtesy of Nevada Bureau of Mines and Geology).

Exochopora RAYMOND & OKULITCH, 1940, p. 208 [**Calathium canadense* BILLINGS, 1865, p. 377; OD]. Conical, thick walled, with deep, central cloaca into which radial, exhalant canals open, their openings being superposed so as to form vertical rows on cloacal wall; exhalant canals parallel

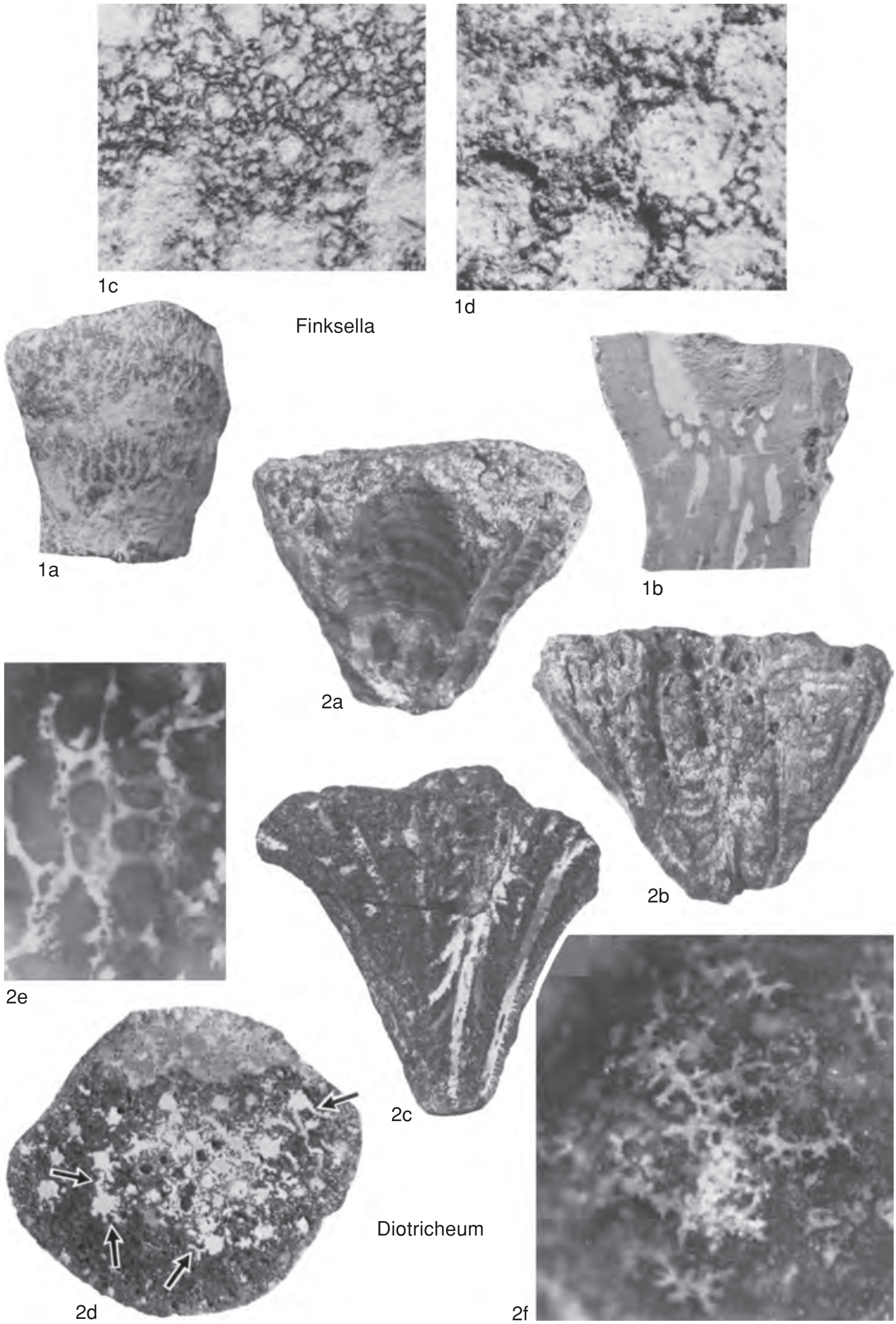

FIG. 52. Anthaspidellidae (p. 73–76).

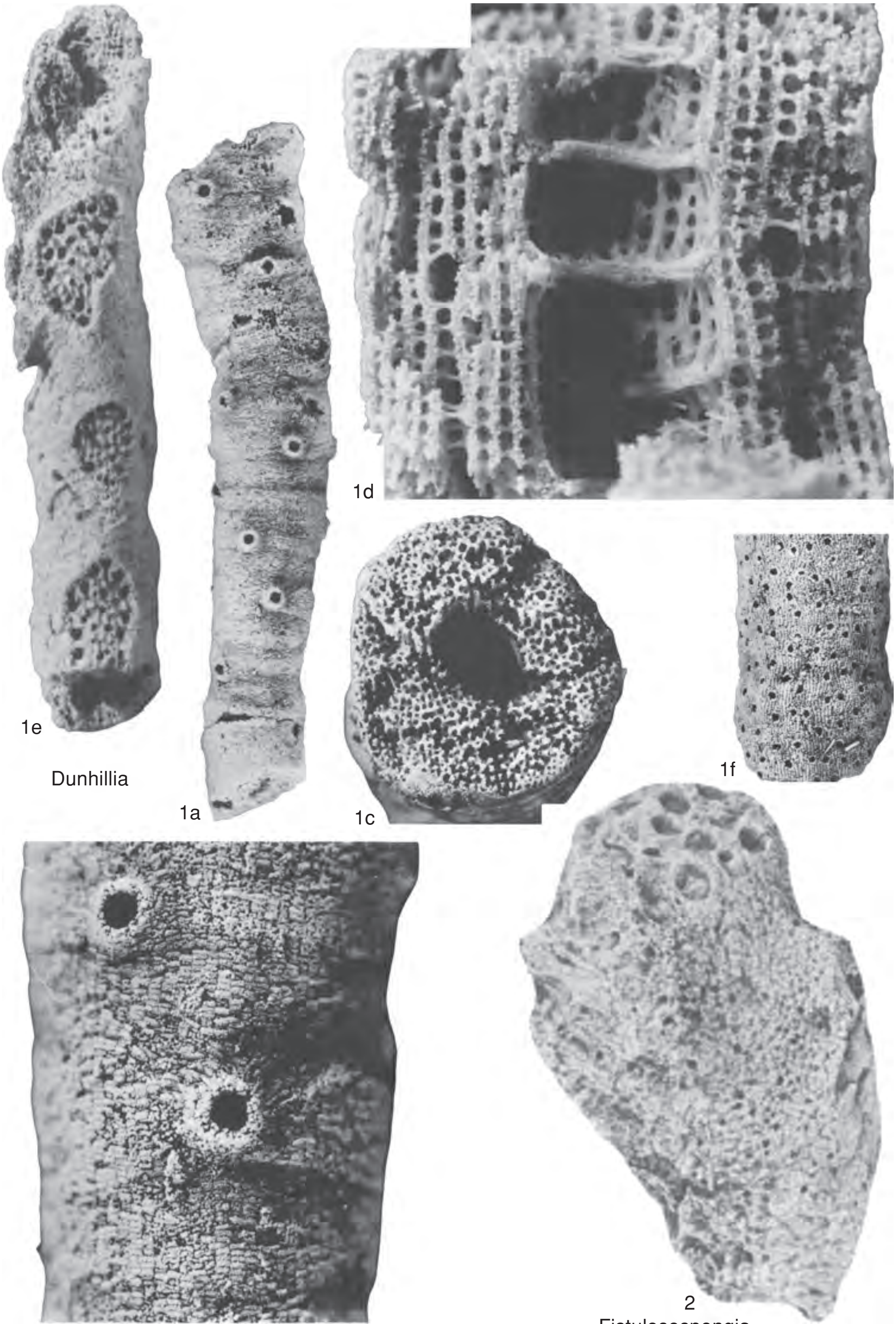

FIG. 53. Anthaspidellidae (p. 73–76).

to upper surface that is broadly convex; internal rows of dendroclones perpendicular to this surface thus radiating upwardly and outwardly. [Genus is similar to *Eospongia.*] *Middle Ordovician:* North America.——FIG. 48,*3a.* **E. canadense* (BILLINGS), Mingan Formation, Chazyan, Mingan Islands, Canada; vertical section of small holotype showing interior of sponge and coarse, aligned, exhalant ostia in walls of spongocoel, ×1 (Billings, 1965).——FIG. 48,*3b–c. E. infelix* (ULRICH & EVERETT), Platteville Limestone, Chazyan, Dixon, Illinois, USA; *b,* view down into spongocoel of abraded holotype; *c,* holotype, side view, ISM, ×1 (Ulrich & Everett, 1890).

Fibrocoelia VAN KEMPEN, 1978, p. 321 [**F. tubantiensis;* OD]. Rounded, steeply obconical sponge with tubular, deep spongocoel; walls thick, with smooth, dermal surface; main canals radial, arched upwardly, and in regular, ascending series; canals may bifurcate laterally, opening into spongocoel in conspicuous, vertical rows; skeleton anthaspidellid and radially or plumosely reticulate with trabs; spicules dendroclones, irregular, moncrepid desmas, rhizoclones, and smooth styles; a few oxeas may be present; trabs formed by union of dendroclone tips and cored with overlapping styles, with discontinuous coating of generally elongated, branchlike, monocrepid desmas; rhizoclones generally occurring in conjunction with dendroclones rather than with trabs; no dermal nor gastral specialization apparent. *Upper Ordovician:* Netherlands (glacial erratics, presumably derived from the Baltic region).——FIG. 51,*2a–c.* **F. tubantiensis,* glacial erratic from Baltic region, Westerhaar; *a,* side view of holotype with deep, cylindrical spongocoel in thick-walled, obconical sponge, ×1; *b,* median section with exhalant ostia in gastral margin of cylindrical spongocoel and upwardly divergent trabs in thick walls, ×1; *c,* transverse section with light gray, radial canals to black spongocoel and thin dendroclones and rodlike trabs of skeletal net, *arrows* indicate canals filled by chalcedony, GIA PA 86980, ×4 (van Kempen, 1978; courtesy of *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*).

Fieldospongia RIGBY, 1986a, p. 50 [**Tuponia bellilineata* WALCOTT, 1920, p. 274; OD]. Moderately thin walled, conical to cylindrical with deep spongocoel; smooth walls of ladderlike, anthaspidellid, skeletal structure of possible dendroclones that cross connect vertical strands; walls without canals; strands may be arranged in bladelike elements. *Middle Cambrian:* Canada (British Columbia).——FIG. 54,*1a–b.* **F. bellilineata* (WALCOTT), Mount Whyte Formation, Mount Stephen; *a,* thick-walled, steeply obconical holotype, ×1; *b,* photomicrograph of vertical, trablike structures cross connected with short, horizontal elements (possible dendroclones) in moderately preserved skeleton, USNM 66454, ×5 (Rigby, 1986a).

Finksella RIGBY & DIXON, 1979, p. 620 [**F. turbinata;* OD]. Turbinate to low, conical sponges with a broad, simple, open spongocoel at crest, into which empty numerous large, circular, excurrent canals from stalked base; circular canals separated by skeleton, so without prismatic packing; wall pierced by canals that rise from exterior toward spongocoel; skeletal net of dendroclones united in characteristic anthaspidellid net with trabs upwardly pinnate from close to dermal margins; well-differentiated dermal layer with considerably less regularity than internal skeleton, but with spicules of similar size and shape. *Silurian (Ludlow–Pridoli):* Canada (District of Franklin, Arctic Islands).——FIG. 52,*1a–d.* **F. turbinata,* Read Bay Formation, Somerset Island; *a,* holotype, side view with irregular, surficial canals, ×1; *b,* vertical section showing coarse, exhalant canals in lower part and matrix-filled spongocoel with thick walls in upper part, ×1; *c,* photomicrograph of irregular spiculation in dermal layer that contrasts with regular structure of interior, ×40; *d,* photomicrograph of skeletal net and large, exhalant canals in floor of spongocoel, GSC 54843, ×10 (Rigby & Dixon, 1979).

Fistulosospongia RIGBY, 1986b, p. 17 [**F. parallela;* OD]. Massive to conical sponge; without spongocoel but with several widely separated, vertical, coarse, excurrent canals; incurrent openings subhorizontal and locally in crudely stacked series; skeletal net anthaspidellid, trabs radiating upwardly and outwardly from near base without prominent zone of pinnation; skeleton more or less uniformly textured, without alternation of open and dense layers, except for denser, dermal layer. *Devonian (Frasnian–Famennian):* Australia (Western Australia).——FIG. 53,*2.* **F. parallela,* Virgin Hills Formation, Lawford Range; holotype, side view showing irregular, obconical form and large, exhalant oscula on summit, GSWA F17248, ×1 (Rigby, 1986b).

Gleesonia RIGBY & WEBBY, 1988, p. 57 [**G. porosa* RIGBY & WEBBY, 1988, p. 58; OD]. Obconical, coarse-textured anthaspidellid composed of upwardly and outwardly radiating, webbed beams in interior that become simple trabs in outer part; webbed, compound beams of several trabs characteristic of interior, separated by large, axial, excurrent canals and by upwardly and inwardly convergent canals approximately normal to trabs. *Upper Ordovician:* Australia (New South Wales).——FIG. 55,*1a–e.* **G. porosa,* Malongulli Formation, Cliefden Caves area; *a,* vertical view into oscular pit showing axial canals and general, radiate structure of skeleton composed of compound elements of dendroclones and associated rhizoclones, ×2; *b,* diagonal view showing upwardly and outwardly divergent beams of endosomal part of skeleton with coarse dendroclones and dense, outer, dermal layer, shallow spongocoel pit showing in upper left, ×2; *c,* photomicrograph of skeletal elements of rhizoclone spicules around large, central, axial canals, AMu. F66858, ×6; *d,* photomicrograph of vertical section of paratype showing upwardly and outwardly radiating, compound beams composed

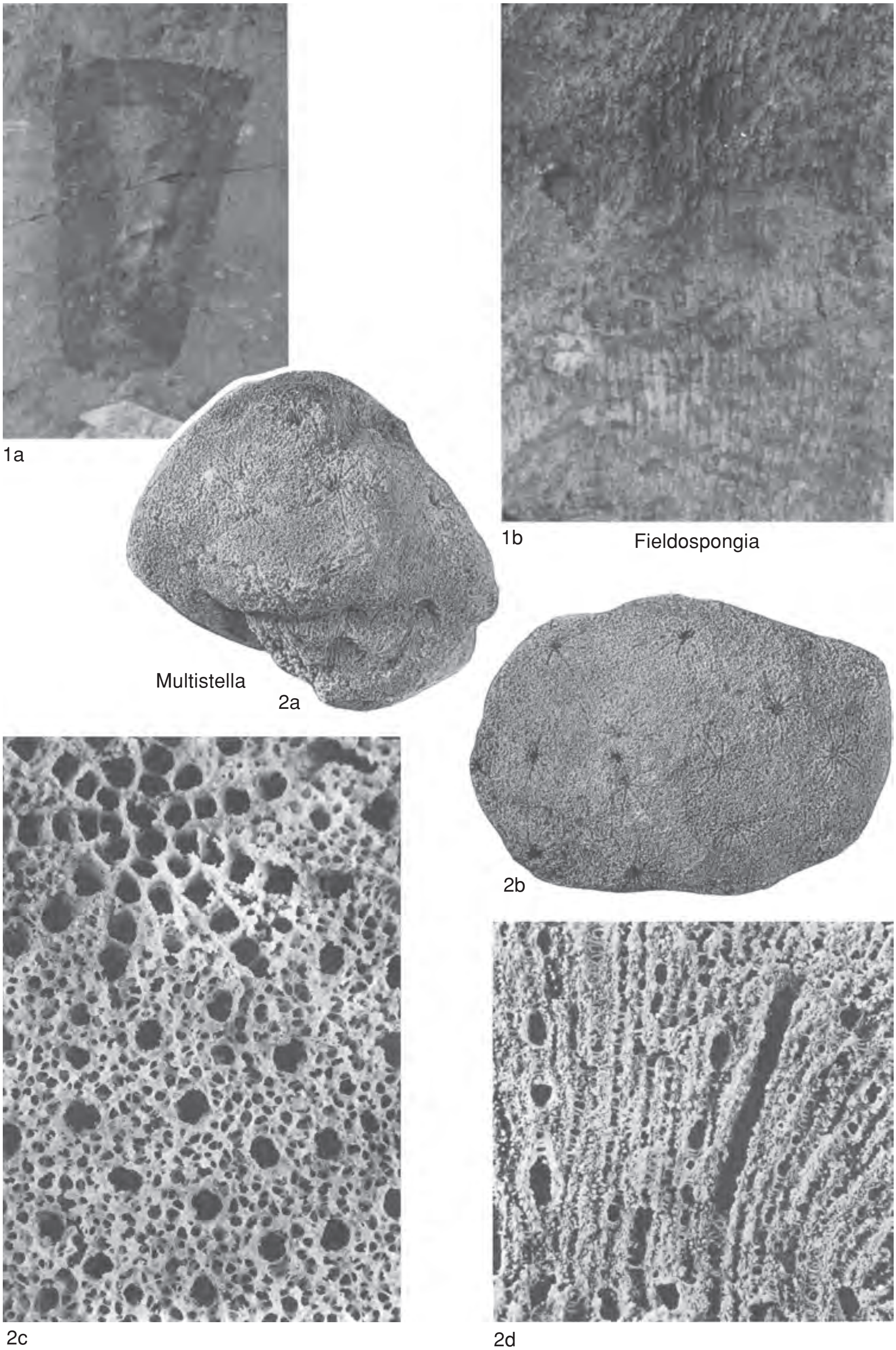

FIG. 54. Anthaspidellidae (p. 76–85).

of clusters of trabs formed by cross webbing and ray tips of large, H-shaped dendroclones, beams separated by parallel, coarse canals, AMu. F66859, ×6; *e,* photomicrograph of nodose, dermal layer, made of laterally fused ray tips of dendroclones, perforated by tiny, circular ostia and small pores, AMu. F66860, ×15 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Incrassospongia Rigby, 1977a, p. 122 [**I. rhipidos;* OD]. Subcylindrical, club shaped to distinctly fan shaped, without spongocoel, spicules dendroclones in upwardly fanning, ladderlike pattern cross connected by less continuous, horizontal fibers; only openings are parallel to skeletal structure; such structures enlarged in older parts where horizontal fibers, cored by spicule shafts, and vertical trabs, composed of united, spicule tips, are of nearly equal diameter. *Ordovician:* Canada (District of Franklin, Arctic Islands); Argentina, *Lower Ordovician.*——Fig. 56,*2a–b.* **I. rhipidos,* unnamed formation, Middle Ordovician, Amadjuak Lake, Baffin Island, District of Franklin, Canada; *a,* holotype, side view, steeply obconical to fan shaped with vertically and horizontally concentric fibers, GSC 43570, ×1; *b,* paratype, photomicrograph of upper part showing simple dendroclones in upper, outer part of skeleton and increasing in diameter of fibers in older, interior part of sponge, GSC 43576b, ×10 (Rigby, 1977a).

Incrustospongiella Rigby & Boyd, 2004, p. 73 [**I. superficiala;* OD]. Thin, sheetlike incrusting sponge with skeleton of unbundled, X-shaped dendroclones, and rarely I-shaped dendroclones, all fused at mutual contacts of digitate ray tips to produce indistinctly layered skeleton; isolated monaxial spicules locally common as erect armoring elements; larger exhalant canals extending through approximately half of sponge thickness to end on dermal surface as isolated openings or small clusters of exopores; smaller inhalant canals occurring between rays of dendroclones and also extending irregularly inward from dermal surface to midthickness. *Permian (Wordian):* USA (Wyoming).——Fig. 57,*2a–c.* **I. superficiala,* Park City Formation, Bull Lake area, eastern Wind River Mountains; *a,* view of thin film of sponge holotype (*arrow*) encrusting concave surface of productid brachiopod, on right, and part of hinge area and outer surface of valve on left, UW4026, ×2; *b,* SEM photomicrograph of dermal surface of holotype showing dominance of X-shaped dendroclones in uniform skeletal structure, with small inhalant ostia and somewhat larger, more rare, exhalant ostia, scale bar, 200 µm; *c,* SEM image of paratype with uniform dendroclones of encrusting sponge (*S*) coating central brachiopod spine (*B*), with prominent, armoring, monaxial spicules radiating from dermal surface, UW4027, scale bar, 500 µm (Rigby & Boyd, 2004).

Isispongia Pickett, 1969, p. 16 [**I. paradoxa;* OD]. Massive, rounded to irregular; surface bearing large to small, more or less evenly distributed pores; some adjacent pores may be laterally confluent; principal canals and dendroclone rows radial, perpendicular to surface, with connecting canals parallel to surface; similar to *Phacellopegma* but without well-developed grooves. *Middle Devonian:* Australia (New South Wales).——Fig. 58. **I. paradoxa,* Timor Limestone, ?Eifelian, County Brisbane; side view of weathered holotype with prominent, aligned ostia of canals in uniform skeleton, AM F12903, ×1 (Pickett, 1969).

Jereina Finks, 1960, p. 74 [**J. cylindrica;* OD]. Cylindrical, with or without branching; large, exhalant canals occupying axial region, parallel to its length, and opening on end or sides of sponge; inhalant canals radial, perpendicular to sides; spicules chiastoclones and dendroclones without regular arrangement, and meeting in noticeably inflated junctions. *Middle Devonian–Permian (Artinskian):* Australia (New South Wales), *Middle Devonian;* USA (Texas), *Artinskian.*——Fig. 59,*2a–d.* **J. cylindrica,* Bone Spring Formation, Sierra Diablo; *a,* holotype, side view, steeply obconical with dense, outer skeleton, ×0.5; *b,* holotype, cross section showing coarse, axial apochetes and smaller, nearly horizontal, cross-connecting canals, PU 78875, ×1; *c,* paratype, longitudinal section showing axial apochetes and dense, outer layer of sponge, ×1; *d,* horizontal section of same specimen showing porous interior of sponge and dense, outer layer with smaller, horizontal prosochetes, PU 78876, ×1 (Finks, 1960; courtesy of The American Museum of Natural History).

Jianghania Liu & others, 1997, p. 198 [**J. yichangensis;* OD]. Moderately large, annulate, conicocylindrical sponges with deep, annulate spongocoel; thick walls composed of upwardly and outwardly diverging, radially arranged trabs of ladderlike series of dendroclones; pinnation surface one-fourth wall thickness in from gastral margin; outer trabs arching strongly to meet dermal surface at right angles between annulations, but rising to meet upper edges of annulations at 60 to 70 degrees and lower edges less steeply; coarse, horizontal, radial canals arranged in distinct, separated layers around spongocoel at level of middle of annular ridges; individual, horizontal canals may arch upwardly distally. [*Jianghania* is similar to *Archaeoscyphia* in its annulate form, but differs from the latter in having the principal, horizontal canals concentrated at one distinct level in the middle of each annular ridge.] *Lower Ordovician:* China (Hubei).——Fig. 60*a–d.* **J. yichangensis,* Honghuayuan Formation, Tremadocian–Arenig, Yichang; *a,* transverse section through wall and spongocoel between annular ridges on holotype, JPI YH-1-a, ×2; *b,* longitudinal section of annulate walls with trabs diverging upwardly and outwardly from gastral surface of subcylindrical spongocoel, JPI YH-1-d, ×2; *c,* transverse section through annular ridge with prominent, convergent, horizontal, excurrent canals, JPI YH-1b, ×2;

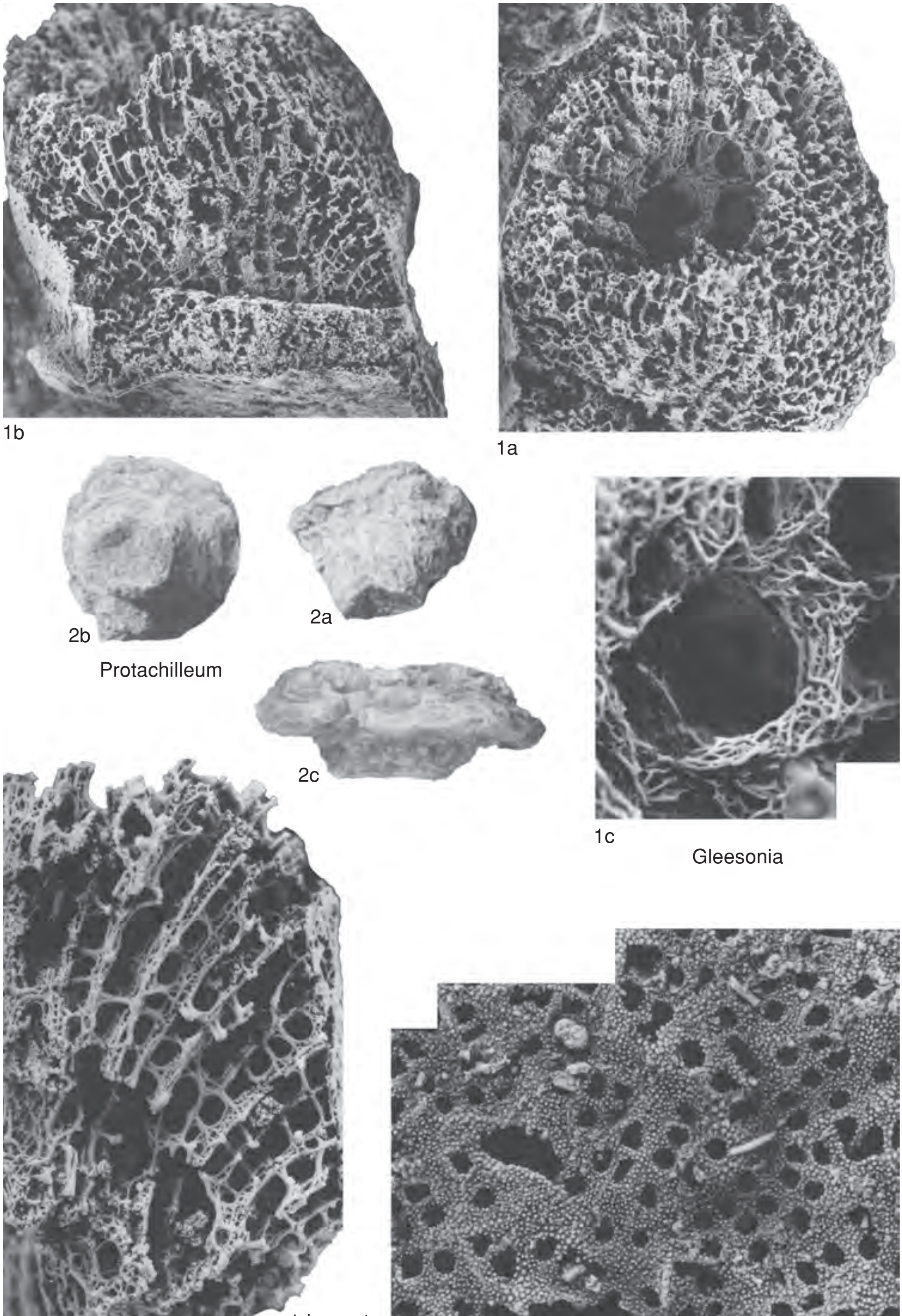

FIG. 55. Anthaspidellidae (p. 76–89).

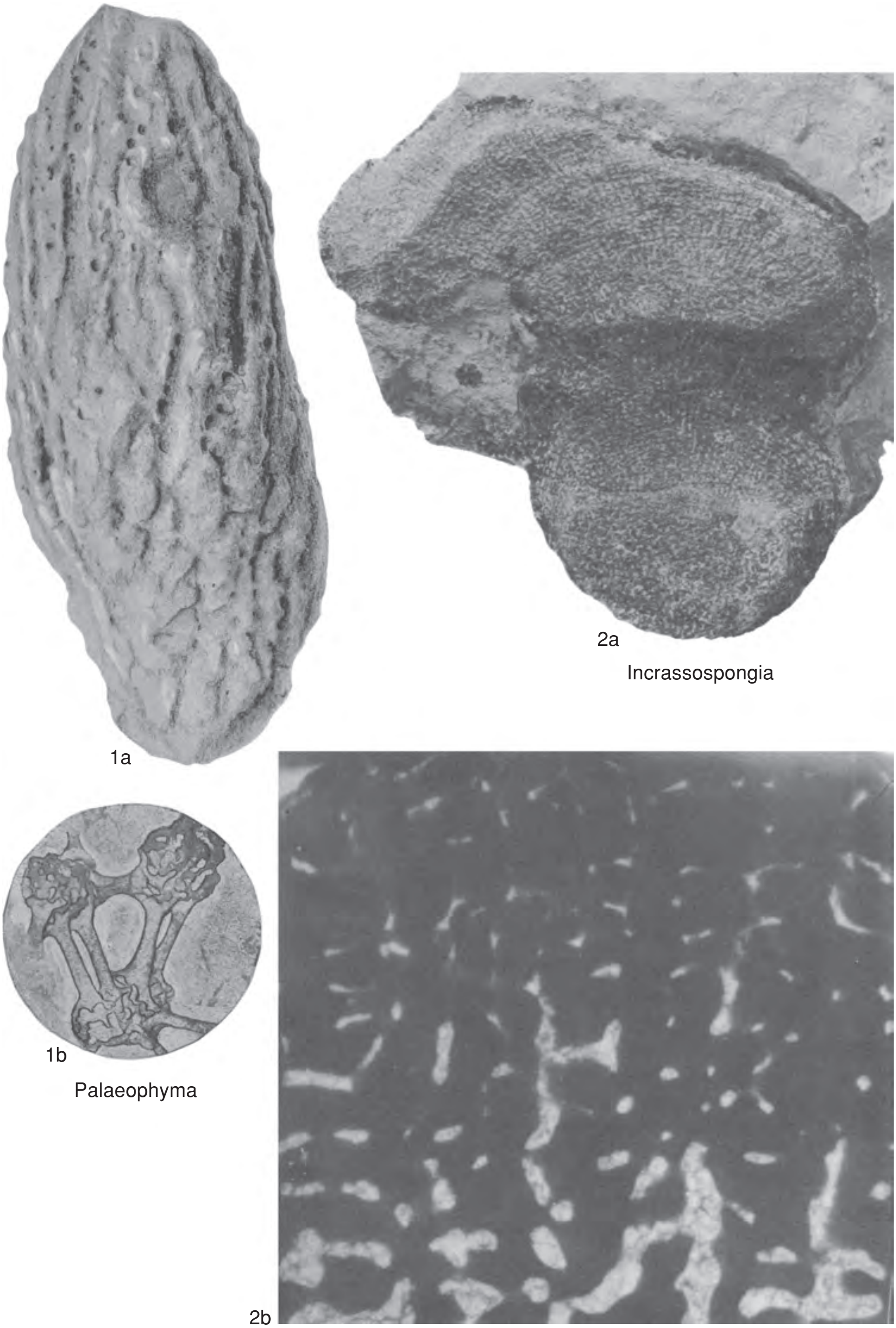

FIG. 56. Anthaspidellidae (p. 78–88).

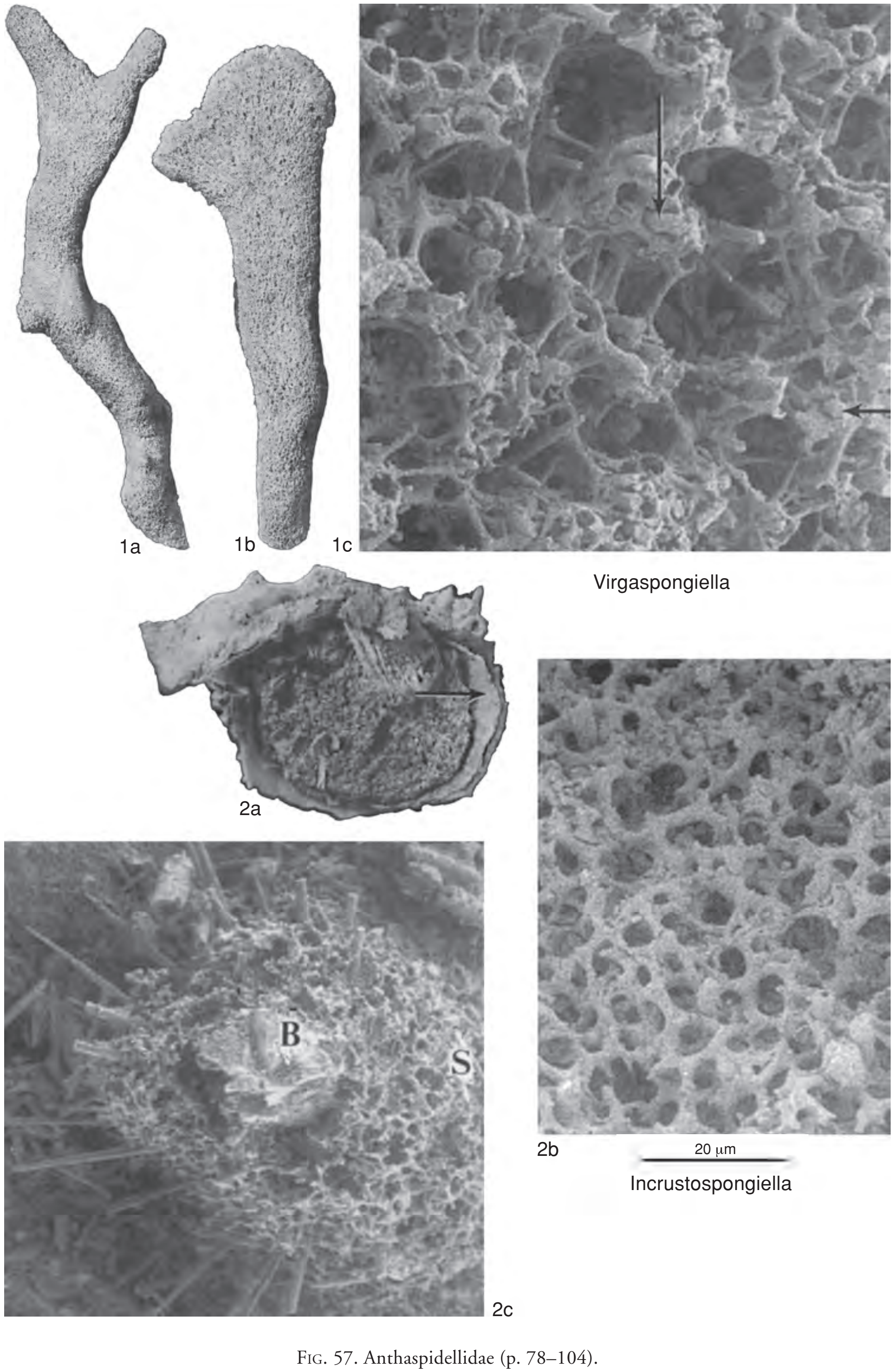

FIG. 57. Anthaspidellidae (p. 78–104).

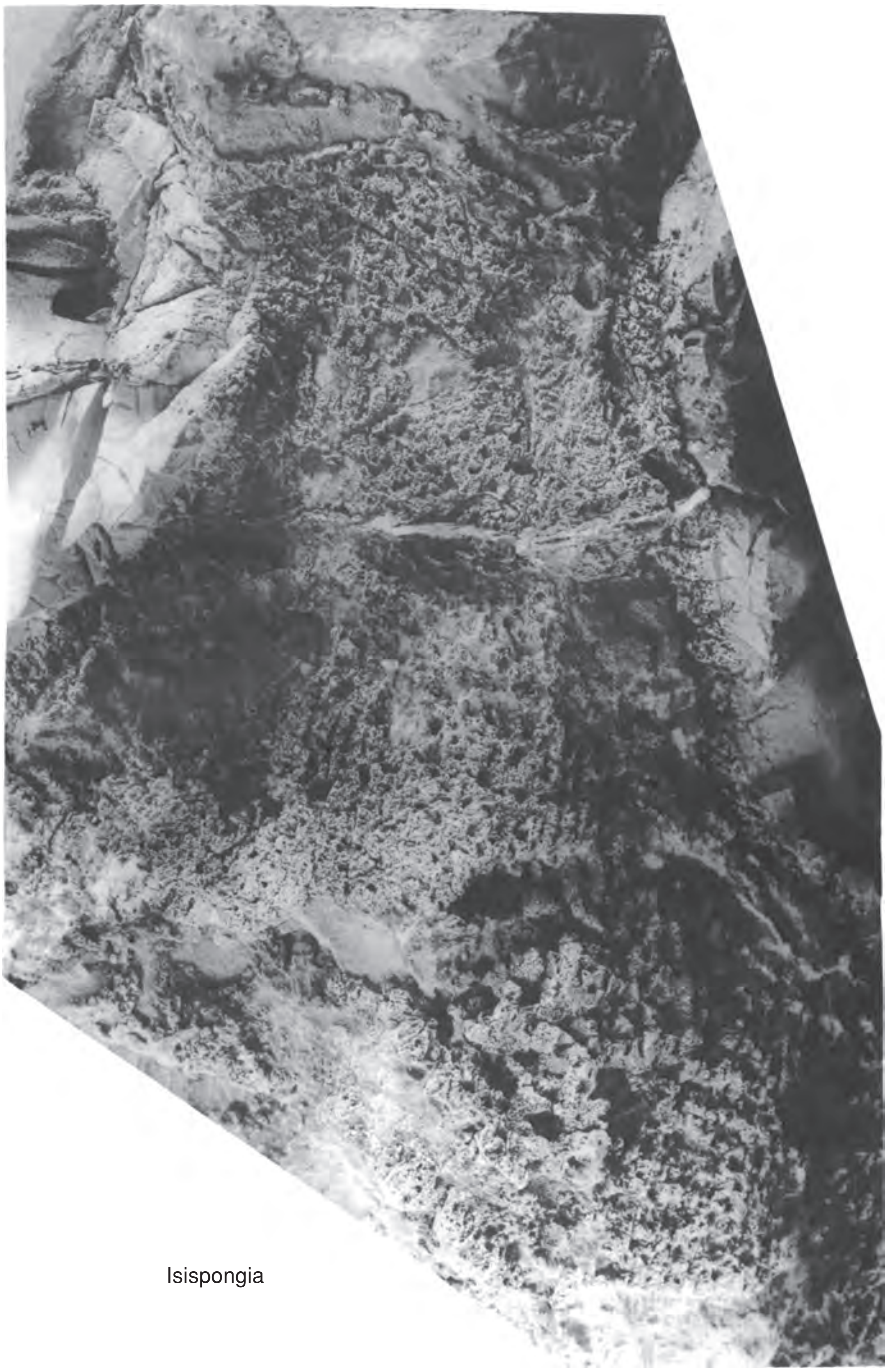

FIG. 58. Anthaspidellidae (p. 78).

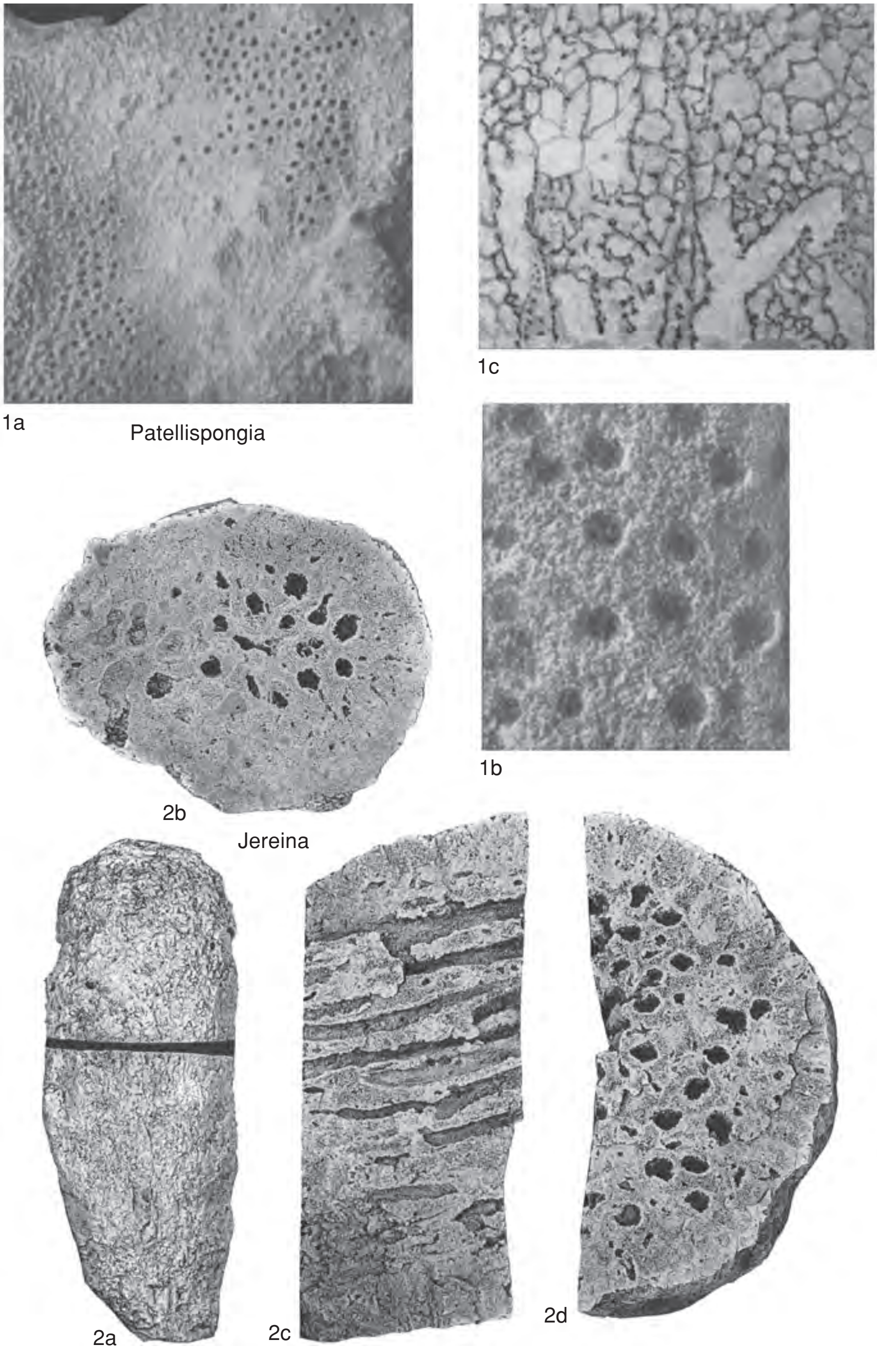

FIG. 59. Anthaspidellidae (p. 78–88).

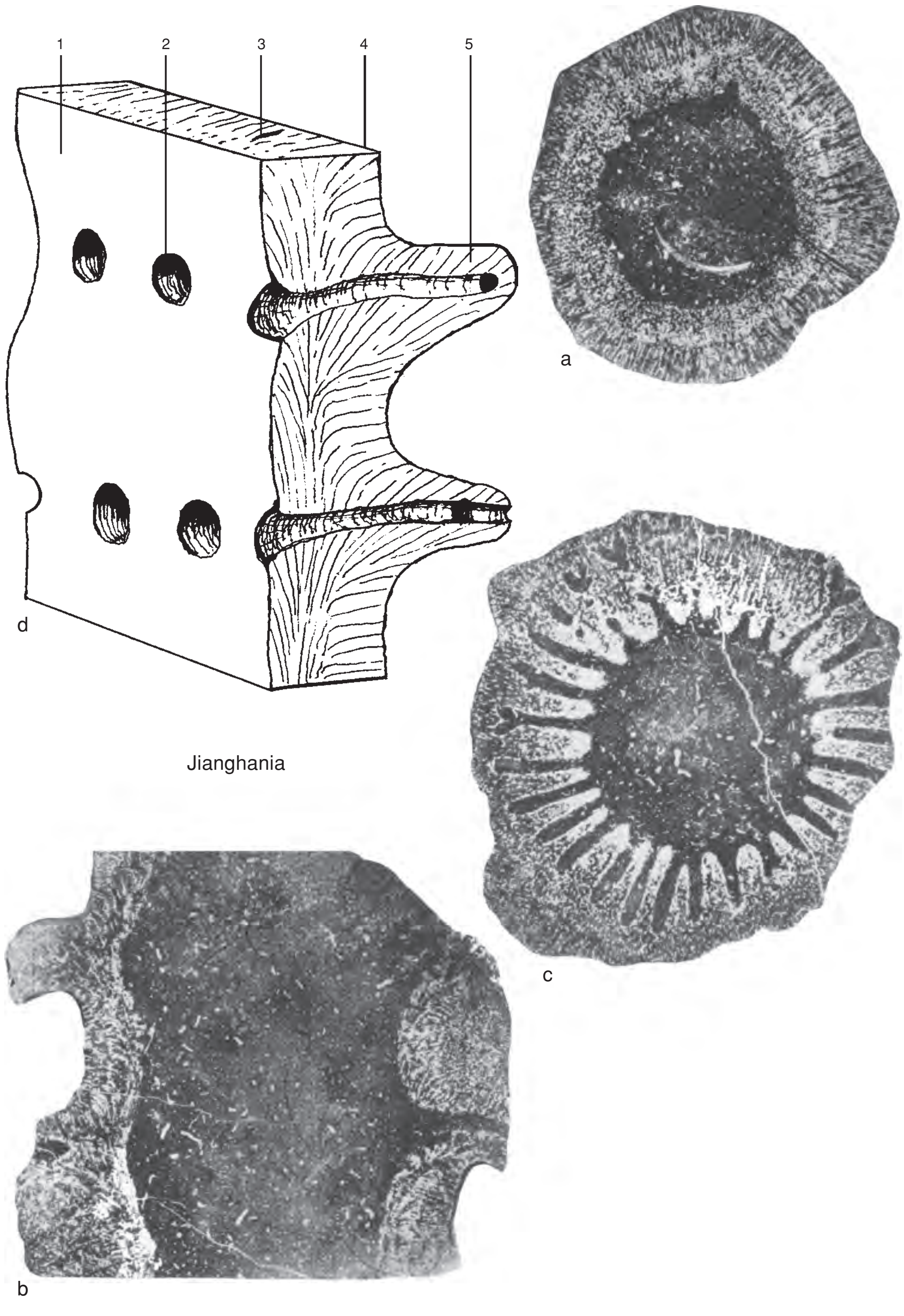

FIG. 60. Anthaspidellidae (p. 78–85).

d, diagram of skeletal and canal structure of genus; *1,* gastral surface; *2,* ostium of horizontal canal; *3,* section of trab; *4,* dermal surface; *5,* annulation in outer wall, not to scale (Liu & others, 1997).

Malongullospongia RIGBY & WEBBY, 1988, p. 44 [**M. delicatula;* OD]. Massive to subhemispherical anthaspidellid without spongocoel but with large, subhorizontal canals in stacks and parallel to gastral surfaces, normal to trabs, which radiate from center of sponge; vertical canals in tracts between stacked canals producing rectangular, interconnected system of canals; skeleton of delicate, long-rayed dendroclones combined with numerous oxeas to produce thin trabs; dendroclones may be vertical, from dendroclone shaft to shaft, rather than horizontal in normal, ladderlike pattern. *Upper Ordovician:* Australia (New South Wales).——FIG. 61*a–e.* **M. delicatula,* Malongulli Formation, Cliefden Caves area; *a,* side view of holotype showing dense, dermal layer on left, over more open, canalled skeleton of interior, ×1; *b,* view down onto gastral surface, which is marked with irregular, horizontal canals with vertical ostia of vertical canals on ridges between, ×1; *c,* vertical section through porous interior showing coarse, horizontal canals that interrupt upwardly expanding, skeletal system, ×1; *d,* photomicrograph of vertical section through interior of holotype showing curved trabs and ladderlike series of dendroclones curving around some horizontal canals, but interrupted by others, ×5; *e,* SEM photomicrograph showing prominent, vertical trabs cored by oxeas, and horizontal X- and Y-shaped dendroclones whose branching ray tips grasp oxeas, AMu. F66822, ×200 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Mastophyma GERTH, 1927, p. 109 [**M. jonkeri* GERTH, 1927, p. 110; OD]. Spheroidal; surface covered with conical protuberances alternating with deep depressions into which radially arranged, exhalant canals open; dendroclone rows or trabs are perpendicular to outer surface, radiating from central, presumed initial, attachment point. *Permian (Lopingian):* Timor.——FIG. 50,*2a–c.* **M. jonkeri,* Upper Permian Limestone, Nifoetassi; *a,* side view of nodose, hemispherical, type specimen with large ostia of radial canals; *b,* transverse section with coarse, radial canals filled with dark matrix, ×1; *c,* photomicrograph of skeletal structure showing coarse trabs connected by runglike dendroclones, ×30 (Gerth, 1929; courtesy of E. Schweizerbart'sche Verlagsbuchhandlung).

Multistella FINKS, 1960, p. 61 [**M. porosa* FINKS, 1960, p. 62; OD]. Spheroidal to fungiform, with concentrically wrinkled, conical base covered with dense, dermal layer and upper surface strongly convex and smooth; upper surface bearing numerous stellate clusters of exhalant pores; dendroclone rows perpendicular to upper surface, radiating from attachment point within basal region; canals are dominantly perpendicular to surface. *Permian (Guadalupian):* USA (Texas).——FIG. 54,*2a–d.* **M. porosa,* Cherry Canyon Formation, Guadalupe Mountains; *a,* side view of silicified holotype showing multiple clusters of apopores in upper part of hemispherical, stalked sponge, ×1; *b,* top view of holotype showing widespread, apopore clusters surrounded by short, convergent canals, ×1; *c,* photomicrograph of part of upper surface including stellate cluster of apopores and isolated pores in skeleton where dendroclones form spokes around rodlike trabs, ×10; *d,* vertical section of side of sponge showing dark, vertical and horizontal canals interrupting upwardly divergent, skeletal structure of rodlike trabs and runglike dendroclones, USNM 12760, ×10 (Finks, 1960; courtesy of The American Museum of Natural History).

Nevadocoelia BASSLER, 1927, p. 392 [**N. wistae;* OD]. Conical to conicocylindrical with deep cloaca; exterior with irregular, horizontal ridges that do not encircle sponge (*N. wistae*), or evenly spaced, conical protuberances (*M. traini*), or broad, flangelike annulations (*N. pulchra*); large ostia of horizontal canals tend to form vertical rows on exterior, canals cross connected by ascending one parallel to rows of dendroclones. [Similar to *Archaeoscyphia* but differs in having a thicker body wall; in lack of regular, vertical, slitlike spaces in body wall; and in having generally more subdued, external outgrowths (except for *N. pulchra*). It also resembles the slightly later and still less regular *Rhopalocoelia.*] *Middle Ordovician–Upper Ordovician:* USA (Nevada, California, Alabama), *Middle Ordovician;* northern Europe, *Upper Ordovician.*——FIG. 62,*1a–b.* **N. wistae,* Antelope Valley Formation, Whiterockian, Ikes Canyon, Toquima Range, Nevada; *a,* side view of obconical holotype with transverse, ridged, dermal surface, USNM 79632, ×1; *b,* photomicrograph of vertical section showing outwardly curving trabs of skeleton interrupted by a dark, matrix-filled canal, ×9 (Bassler, 1941).

Okulitchina WILSON, 1948, p. 21 [**O. magna* WILSON, 1948, p. 22; OD]. Broadly conical or discoidal sponge with convex, upper surface; central cloaca present into which empty radial, exhalant passages in form of vertical slits, some of which branch; vertical canals of circular cross section also present, arranged in radial rows as in *Psarodictyum. Upper Ordovician:* Canada (Ontario).——FIG. 62,*3a–c.* **O. magna,* ?Cobourg beds, Ottawa; *a,* side view of paratype with faint, upper depression, GSC 9307d, ×1; *b,* transverse section of holotype showing large, radial canals and spongocoel, GSC 9307b, ×1; *c,* photomicrograph of holotype showing skeleton composed of dendroclones cross-connecting rodlike trabs, GSC 9307b, ×8 (Wilson, 1948; courtesy of Minister of Public Works and Government Services Canada, 2002, and Geological Survey of Canada).

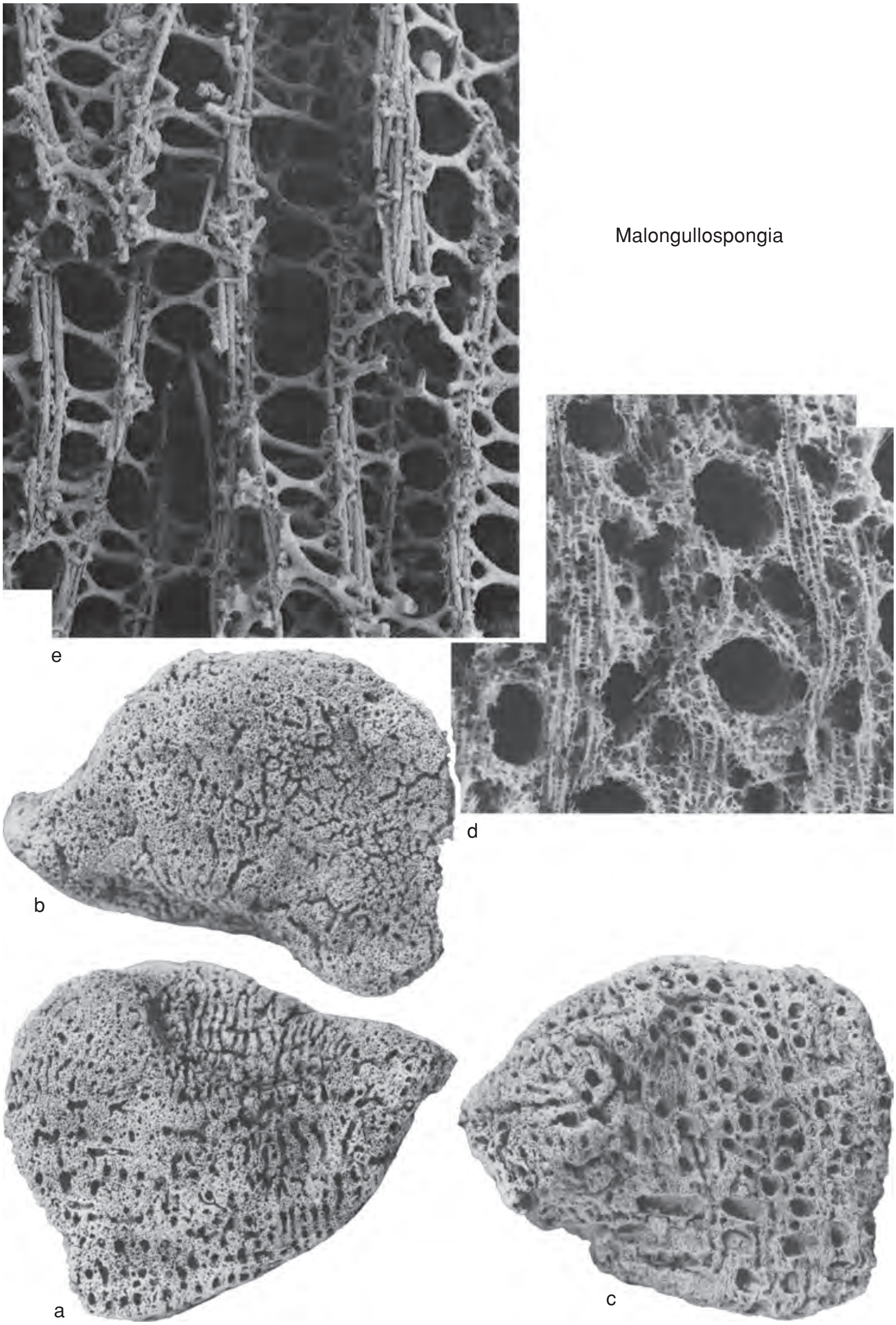

FIG. 61. Anthaspidellidae (p. 85).

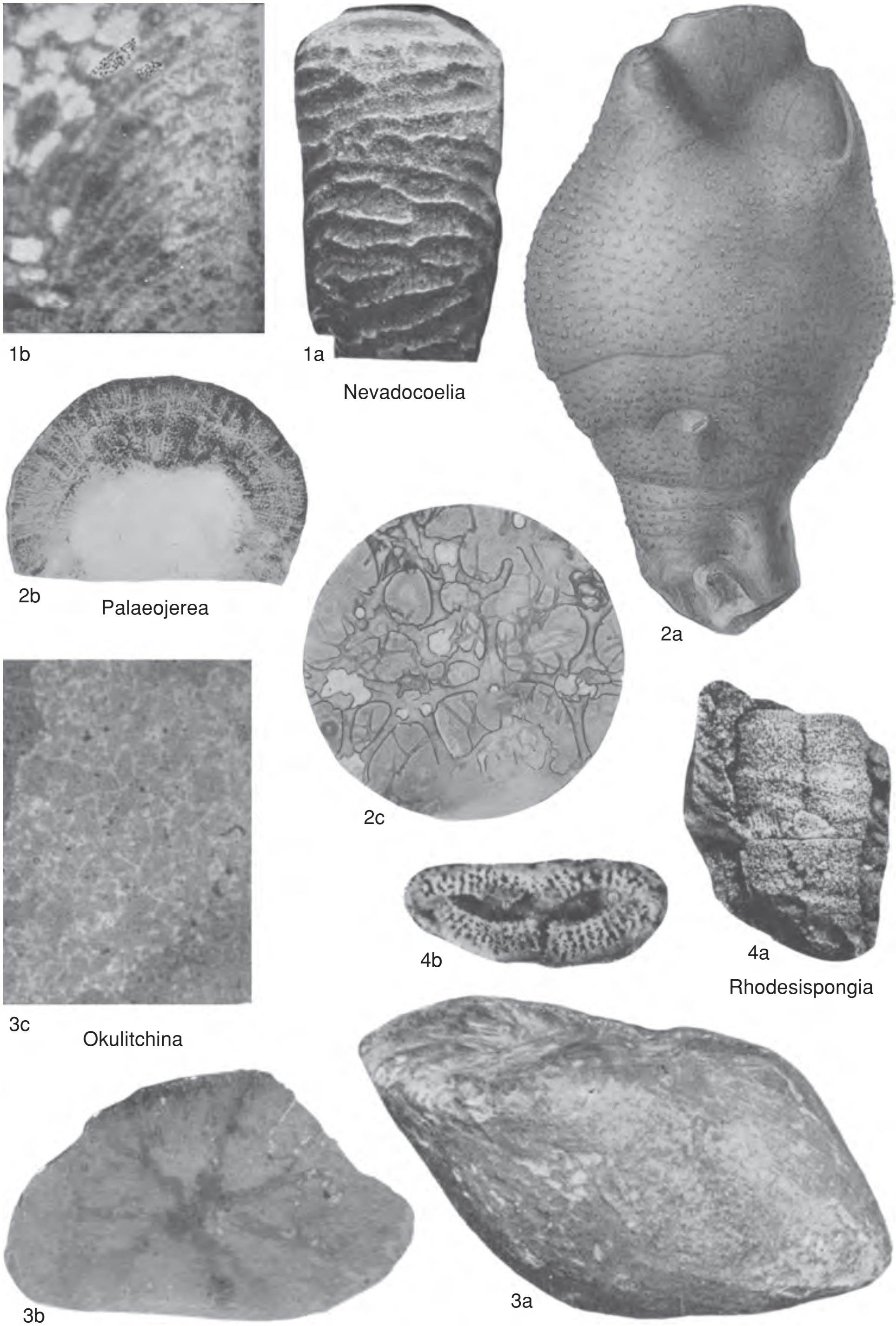

FIG. 62. Anthaspidellidae (p. 85–96).

Palaeojerea GERTH, 1927, p. 111 [**P. molengraaffi* GERTH, 1927, p. 112; OD] [=*Gerthiella* ZHURAVLEVA in REZVOI, ZHURAVLEVA, & KOLTUN, 1962, p. 54, obj.]. Ficiform, stipitate; surface hispid or papillose owing to projecting ends of trabs produced by dendroclone zygoses; entire surface covered with dense, dermal layer; dendroclone rows and skeletal canals perpendicular to outer surface; structures of axial region (including top surface) obliterated by silicification according to author so his assumption of vertical canals here would appear entirely putative. [The name is not a homonyn of *Palaeoierea* LAUBE, 1864, so *nom. subst. Gerthiella* ZHURAVLEVA, 1962, is not necessary. The GERTH, 1927, paper was essentially reprinted in 1929 as part of a volume on the paleontology of Timor.] *Permian (Lopingian):* Timor.——FIG. 62,*2a–c*. **P. molengraaffi,* Upper Permian limestone, Besleo; *a,* side view of holotype with micronodose, dermal surface, ×1; *b,* transverse section showing radial, skeletal structure in outer part, but with structure destroyed in central, silicified region, ×1; *c,* photomicrograph showing X- and I-shaped dendroclones of skeleton, ×25 (Gerth, 1929; courtesy of E. Schweizerbart'sche Verlagsbuchhandlung).

Palaeophyma GERTH, 1927, p. 106 [**P. cucumeriformis;* OD]. Cucumeriform, with anastomosing, vertical, surface grooves on sides convergent on summit; dendroclone rows and principal canals perpendicular to surface, canals opening into bottoms of surface grooves; smooth monaxons scattered in mesh spaces are also reported. *Permian (Lopingian):* Timor.——FIG. 56,*1a–b*. **P. cucumeriformis,* Upper Permian limestone, Nifoetassi; *a,* side view of type specimen with grooves of surficial canals, ×1; *b,* photomicrograph showing trabs, normal to section, interconnected by I-shaped dendroclones whose ray tips interdigitate to produce trabs, ×50 (Gerth, 1929; courtesy of E. Schweizerbart'sche Verlagsbuchhandlung).

Patellispongia BASSLER, 1927, p. 393 [**P. oculata;* OD]. Explanate fronds, possibly originally saucer-shaped as in *Anthaspidella;* upper surface bearing numerous radial rows of small, closely spaced, exhalant pores without conspicuous, exhalant canals convergent on them, thus differing from *Anthaspidella;* lower surface with dense, dermal layer; internal spicular net well organized in regular, radial rows of dendroclones, may include some rhizoclones. *Lower Ordovician–Silurian (Wenlock):* USA (Texas, Colorado), Argentina, *Lower Ordovician;* USA (Nevada, California), *Middle Ordovician;* Australia (New South Wales), northern Europe, *Upper Ordovician;* Canada (Northwest Territories, Baillie-Hamilton Island, District of Mackenzie), *Wenlock*.——FIG. 59,*1a–c*. **P. oculata,* Antelope Valley Limestone, Whiterockian, Ikes Canyon, Toquima Range, Nevada; *a,* dermal surface of holotype with regularly spaced, exhalant ostia, ×1; *b,* enlarged, dermal surface with pores and dense, dermal layer, USNM 79638, ×5; *c,* photomicrograph of vertical section with distinct, lined canals in open, skeletal net of long dendroclones, ×9 (Bassler, 1941).

Phacellopegma GERTH, 1927, p. 103 [**P. campana* GERTH, 1927, p. 104; OD]. Massive without cloaca; surface covered with anastomosing grooves into which open principal canals from interior of sponge; dendroclone rows and principal canals perpendicular to surface of sponge. *Carboniferous (Middle Pennsylvanian)–Permian (Lopingian):* North America, Timor.——FIG. 63,*2a–d*. **P. campana,* Upper Permian limestone, Lopingian, Besleo, Timor; *a,* side view of holotype, ×0.5; *b,* enlarged dermal surface with tips of rodlike trabs and cross-connecting dendroclones shown on ridges between surficial grooves of canals, ×3; *c,* photomicrograph of section transverse to trabs that are cross connected with dendroclones, best shown on left, surrounded by dark matrix, ×9; *d,* cross section showing radial rows of dendroclones and parallel canals filled with dark matrix, ×1.2 (Gerth, 1929; courtesy of E. Schweizerbart'sche Verlagsbuchhandlung).

Playfordiella RIGBY, 1986b, p. 10 [**P. cylindrata* RIGBY, 1986b, p. 11; OD]. Obconical to conicocylindrical, moderately thin-walled, weakly annulate, anthaspidellid sponges with deep simple spongocoel; canals in vertically stacked series and roughly horizontal; surface of pinnation of trabs at midwall to outer one-third; trabs composed of normal and triclonid dendroclones and cored with smooth monaxons; thin dermal and gastral layers dense, of thickened dendroclones, and more chiastoclones than in main skeleton. *Devonian (Frasnian–Famennian):* Australia (Western Australia).——FIG. 63,*1a–c*. **P. cylindrata,* Sadler Limestone, Sadler Ridge; *a,* side view of holotype, GSWA F7186, ×1; *b,* diagonal view of paratype showing open spongocoel, wall thickness, and wrinkled, dermal layer, GSWA F7190, ×1; *c,* camera lucida drawing of skeletal fragment showing trabs with coring, monaxial spicules and associated dendroclones, GSWA F7191, ×25 (Rigby, 1986b).

Protachilleum ZITTEL, 1877c, p. 22 [**P. kayseri;* OD]. Mushroom-shaped sponge with broad, short stalk and overhanging, flat to arched, platterlike, upper part, lacking spongocoel; basal part smooth to weakly annulate; dermal ostia prominent, inhalant canals rising sharply upward to produce porous, lower stalk and scattered, vertical canals throughout central part of sponge; skeleton anthaspidellid with trabs diverging from near-basal radiante; surface of pinnation nearly horizontal in thin, upper plate, spicules mainly Y- and X-shaped dendroclones in fine-textured skeleton. *Lower Ordovician:* Argentina (San Juan Province).——FIG. 55,*2a–c*. **P. kayseri,* San Juan Formation, Arenig, Precordillera Oriental; *a,* side view of steeply obconical, reference specimen showing flaring upper part, ×1; *b,* view from below showing circular base but without spongocoel in lower part of sponge; CRICYT H-43, ×1; *c,* side view of more stalked, flaring sponge, CRICYT H-42, ×1 (Beresi & Rigby, 1993).

Psarodictyum Raymond & Okulitch, 1940, p. 212 [**P. magnificum;* OD]. Large, open, saucer or funnel shaped, with sublobate outline; principal, skeletal canals parallel to outer, growing edge and thus perpendicular to upper and lower surfaces; canals open on both upper and lower surfaces in radial rows. [This genus may be thought of an as everted *Exochopora* in which the cloacal surface has become the upper surface.] *Lower Ordovician–Silurian (Ludlow):* Argentina, *Lower Ordovician;* USA (New York), Canada (Quebec), *Middle Ordovician;* Canada (Northwest Territories, Baillie-Hamilton Island), *Ludlow.*——Fig. 64*a–d.* **P. magnificum,* Chazyan; *a,* vertical view of lobate holotype with shallow, central depression, Chazy Formation, Valcour Island, New York, MCZ 9330, ×0.125; *b,* photomicrograph of thin section showing radial and concentric, skeletal elements, Chazy Formation, Valcour Island, New York, MCZ ?9555, ×10 (Raymond & Okulitch, 1940); *c,* dermal view of weathered, funnel-like sponge showing radial, skeletal structure, Mingan Formation, Mingan Islands, Canada, GSC 111161, ×1; *d,* vertical section near outer, rounded margin showing divergent, rodlike trabs and runglike, small dendroclones of skeleton interrupted by dark, matrix-filled canals, Mingan Formation, Mingan Islands, Canada, GSC 111158, ×10 (Rigby & Desrochers, 1995).

Pseudomultistella Deng, 1981, p. 422 [425] [**S. decipiens;* OD]. Ramose sponges without spongocoel, but with canals diverging upwardly toward surface, connected by horizontal canals; skeleton of horizontal dendroclones superposed in ladder-like series either vertically or radially arranged in spokelike groups around common, axial area; surface porous but lacking astrorhizae. [*Pseudomultistella* has an internal structure like *Multistella* but is a polelike sponge without astrorhizae on the exterior.] *Permian (Changhsingian):* China (Guangxi).——Fig. 65,*1a–c.* **P. decipiens,* Heshan Formation; *a,* longitudinal section of holotype showing upwardly radial canals piercing anthaspidellid skeleton of upwardly divergent trabs, NIGPAS 59983, ×4; *b,* transverse section showing radially arranged canals and skeleton, NIGPAS 59984, ×4; *c,* transverse section of paratype showing lack of central spongocoel in dense skeleton with radiating, tract structure and canals, NIGPAS 59985, ×2.5 (Deng, 1981).

Pseudopalmatohindia Rigby & Webby, 1988, p. 46 [**P. digitata;* OD]. Large, undulating, vertically palmate to buttressed or anastomosing, digitate anthaspidellids with coarse, parallel, excurrent canals in linear series at midblade or midwall; trabs formed of dendroclones tips and cored by monaxons, trabs diverging upwardly and outwardly from general, mid-wall canal area. *Lower Ordovician–Upper Ordovician:* China (Xinjiang), *Lower Ordovician;* Australia (New South Wales), *Upper Ordovician.*——Fig. 66*a–d.* **P. digitata,* Malongulli Formation, Caradoc–Ashgill, Cliefden Caves area, New South Wales; *a,* irregular, broken surface of digitate holotype showing large, excurrent canals along axes of digitation of palmate blades, direction of growth toward bottom as indicated by downwardly expanding, trab-based skeleton, fragments of other demosponges showing above dark, V-shaped matrix fill between digitations, ×1; *b,* tip of digitation showing relatively dense, dermal layer on right and more open, endosomal skeleton in interior, with thin, dense, gastral layer around axial canals, ×3.5; *c,* enlargement of upper part of view *b* showing three layers of skeleton where dendroclones and trabs show in more open, intermediate layer, ×9; *d,* photomicrograph showing relatively coarse but smooth dendroclones and trabs that arch outwardly toward left, AMu. F66823, ×10 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Pycnospongia Gerth, 1927, p. 113 [**P. timorensis;* OD]. Somewhat fungiform with pointed top and horizontal, overhanging bulges on sides; surface reported to be covered with finely perforate, dermal layer without larger pores; principal canals perpendicular to surface but do not penetrate outer layer; dendroclone rows also perpendicular to surface, spicules may include anomoclones and didymoclones. *Permian (Lopingian):* Timor.——Fig. 67,*1a–b.* **P. timorensis,* Upper Permian limestone, Nifoetassi; *a,* side view of holotype showing dense, lobate, dermal layer with ostia of exhalant canals and pear shape, ×1; *b,* enlarged, dermal surface showing dense, skeletal net, poorly preserved, cut by arcuate, calcite veinlets, ×3 (Gerth, 1929).

Rankenella Kruse, 1983, p. 51, *nom. nov. pro Arborella* Gatehouse, 1968, p. 61, *non* Osborn, 1914 [**Arborella mors* Gatehouse, 1968, p. 61; OD]. Smooth-walled, explanate or conicocylindrical, digitate sponges with deep, cylindrical spongocoel; skeletal structure anthaspidellid with dendroclones forming trabs that are parallel to gastral surface and diverge upwardly and outwardly toward dermal surface; differentiated canal system not developed; some spicules modified in dermal layer. [The lack of a differentiated canal system separates *Rankenella* from related genera.] *Middle Cambrian:* Australia (Northern Territory).——Fig. 67,*3a–b.* **R. mors* (Gatehouse), Ranken Limestone, Ordian, Soudan; *a,* longitudinal section of conicocylindrical, possibly branched, reference specimen with longitudinal and transverse sections of axial spongocoel, trabs diverging from gastral to dermal surface, CPC 21238, ×5; *b,* dendroclones and rhizoclones from associated limestone, SUP 78108, ×50 (Kruse, 1983).

Rhodesispongia de Freitas, 1991, p. 2056 [**R. simplex;* OD]. Obconical to subcylindrical, thin-walled sponge with deep, broad spongocoel; skeleton simple with thick, vertical trabs that parallel dermal and gastral surfaces and are formed by regular union of ray tips of slender, runglike,

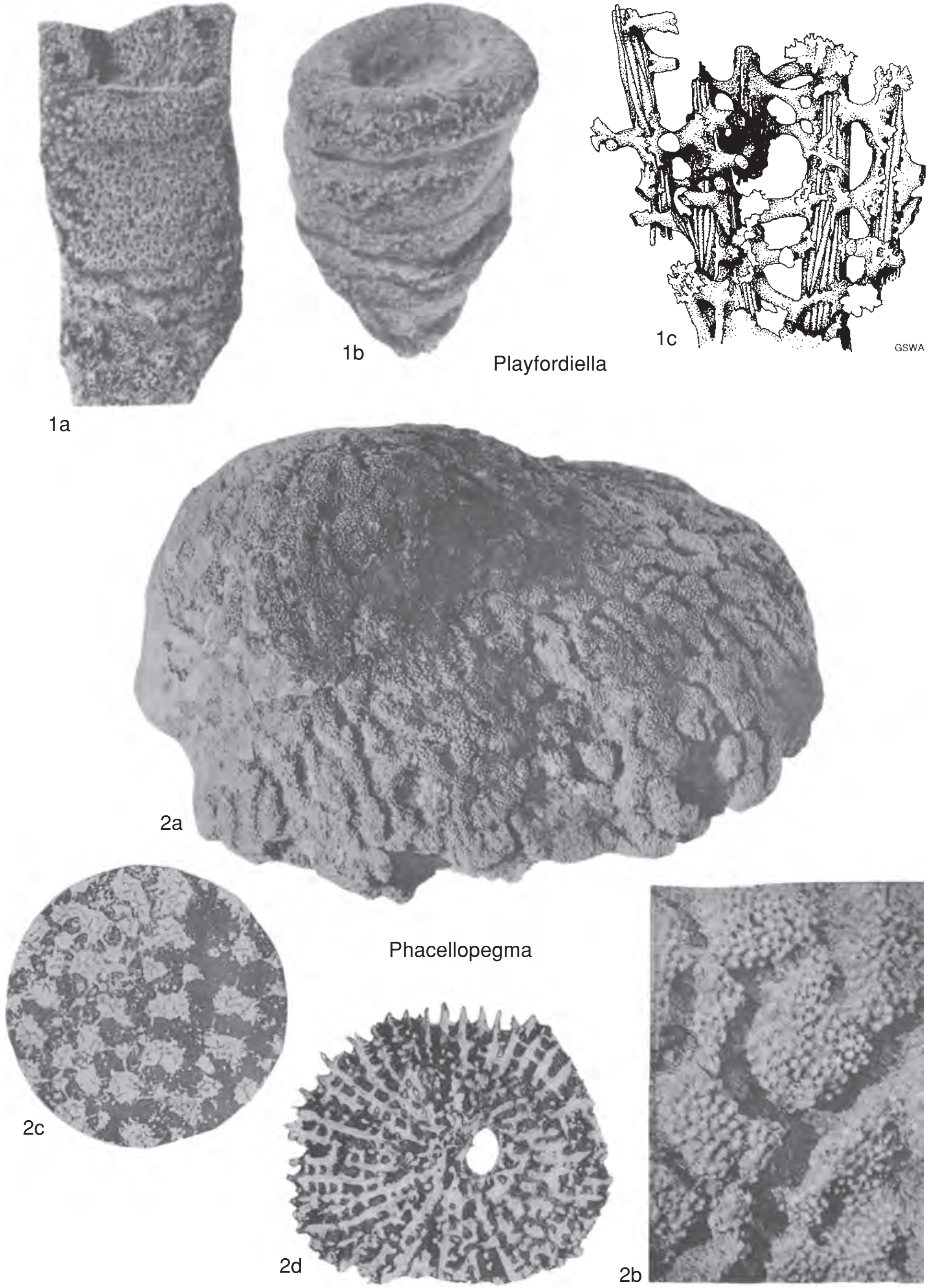

FIG. 63. Anthaspidellidae (p. 88).

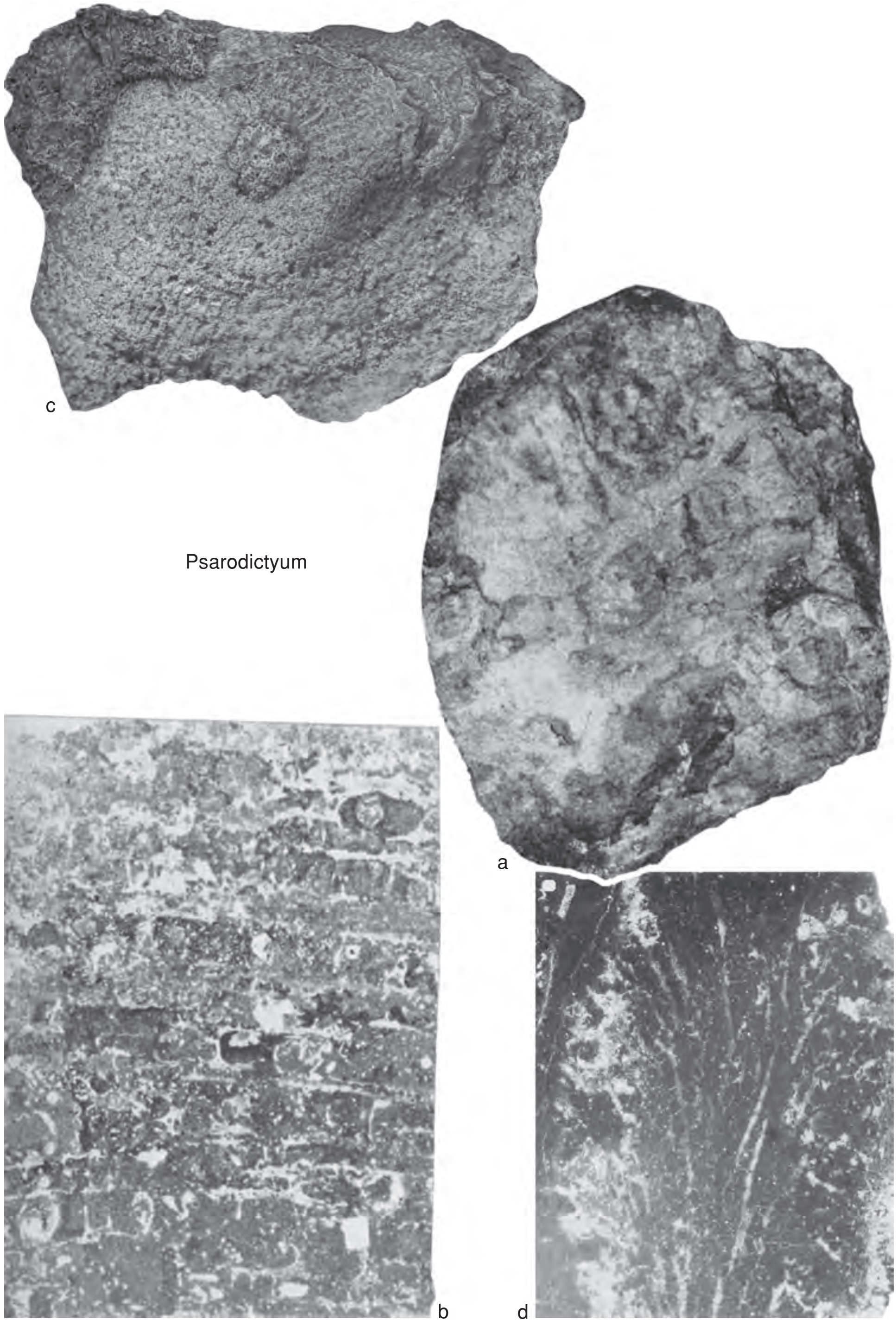

FIG. 64. Anthaspidellidae (p. 89).

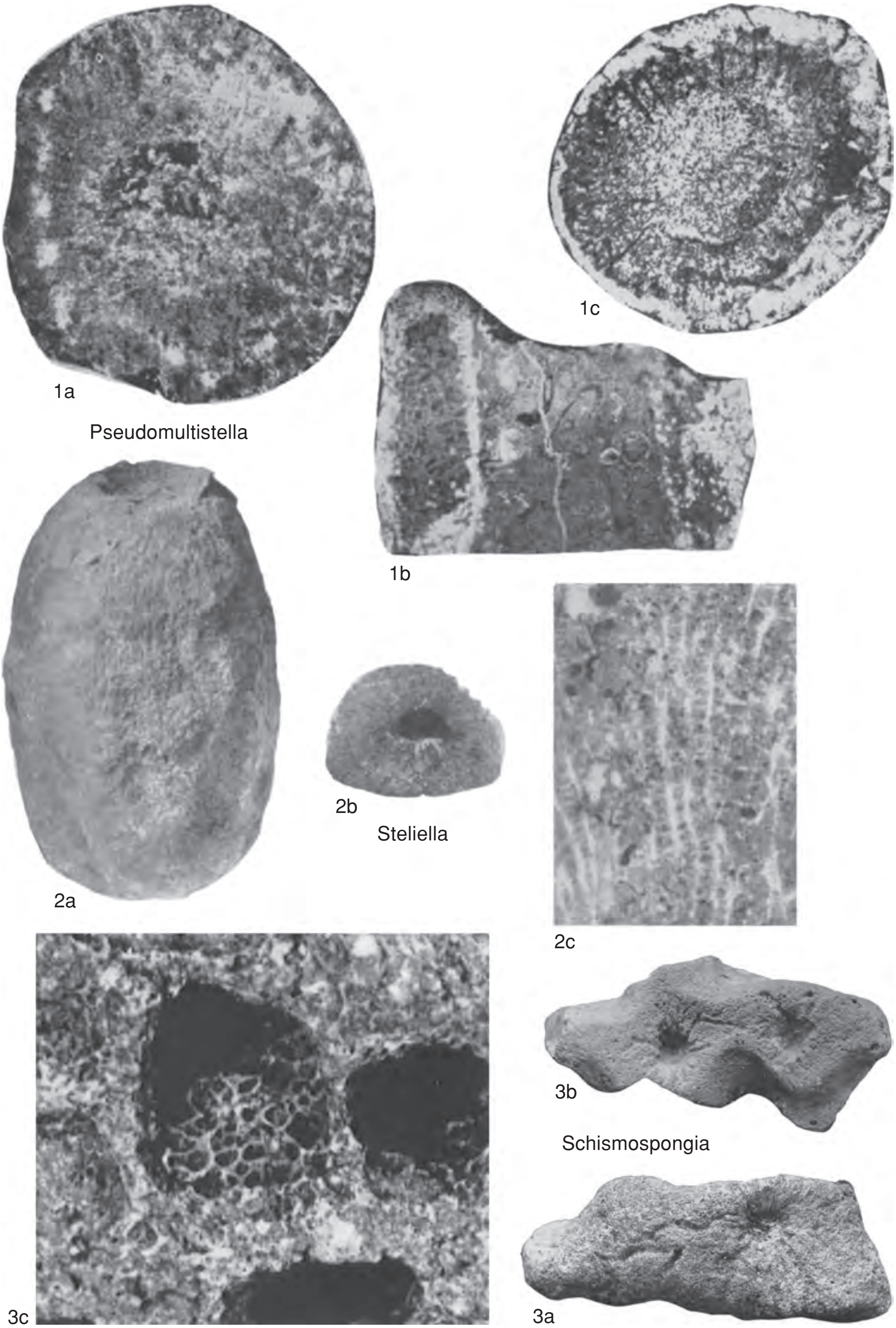

FIG. 65. Anthaspidellidae (p. 89–98).

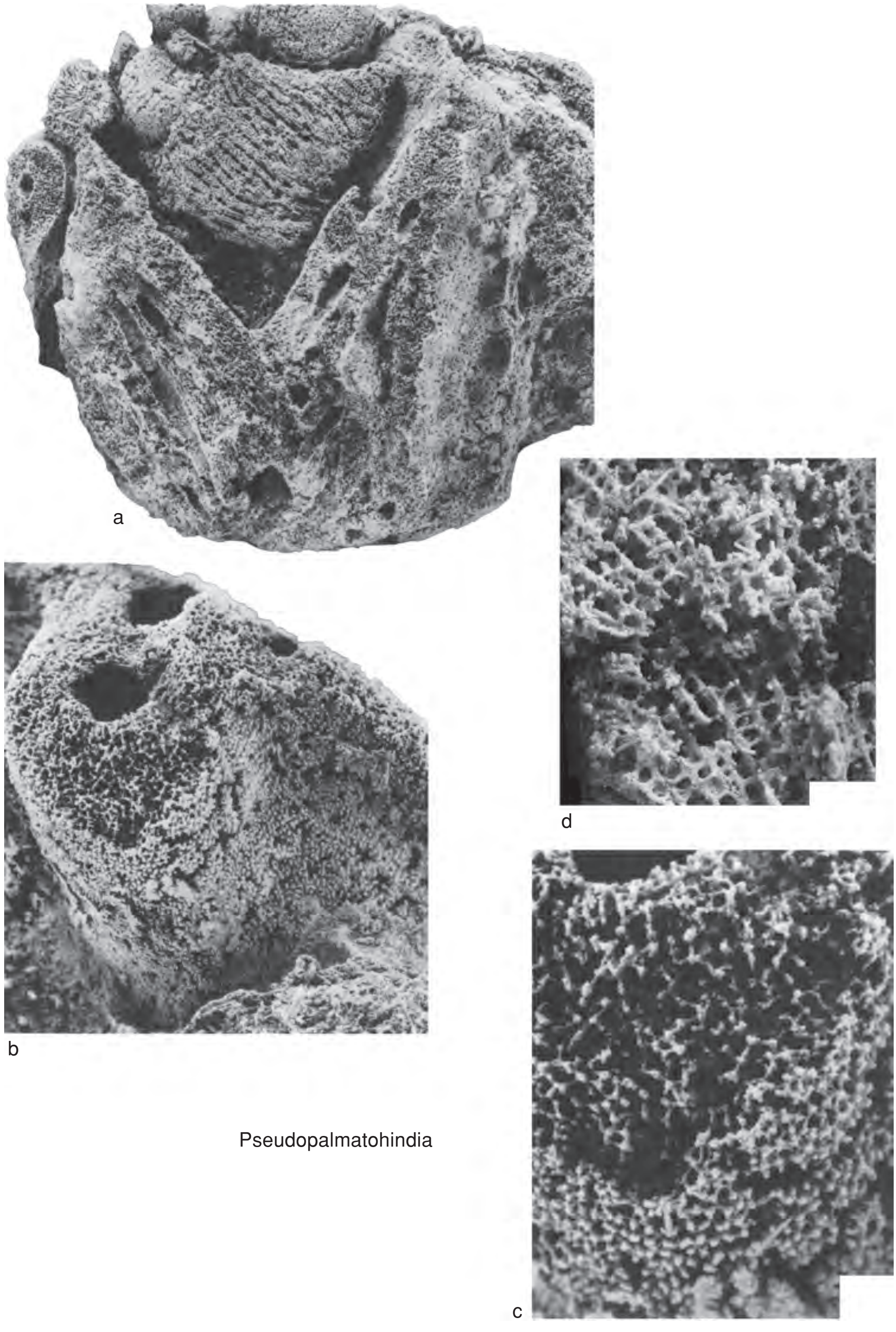

FIG. 66. Anthaspidellidae (p. 89).

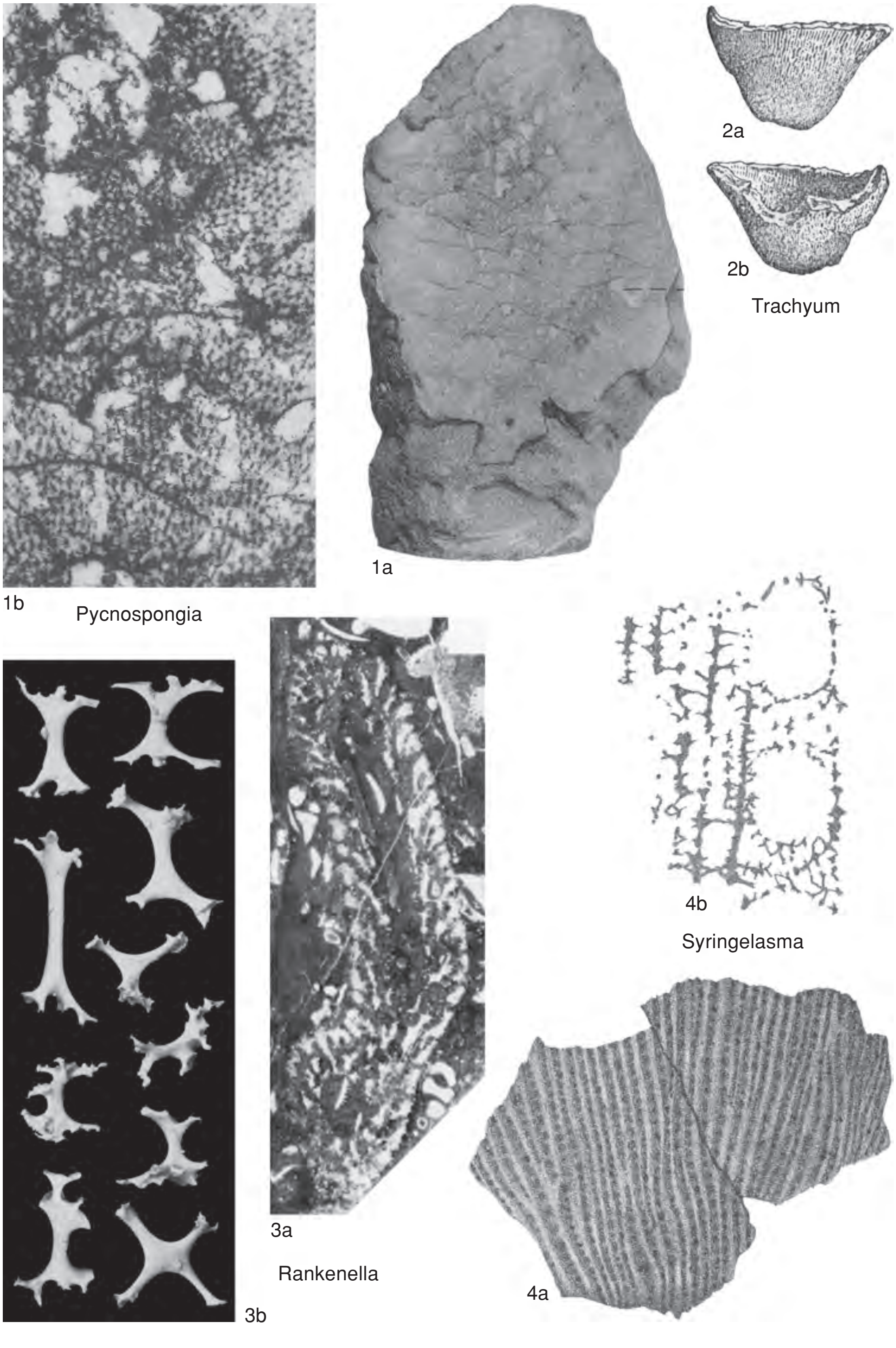

FIG. 67. Anthaspidellidae (p. 89–98).

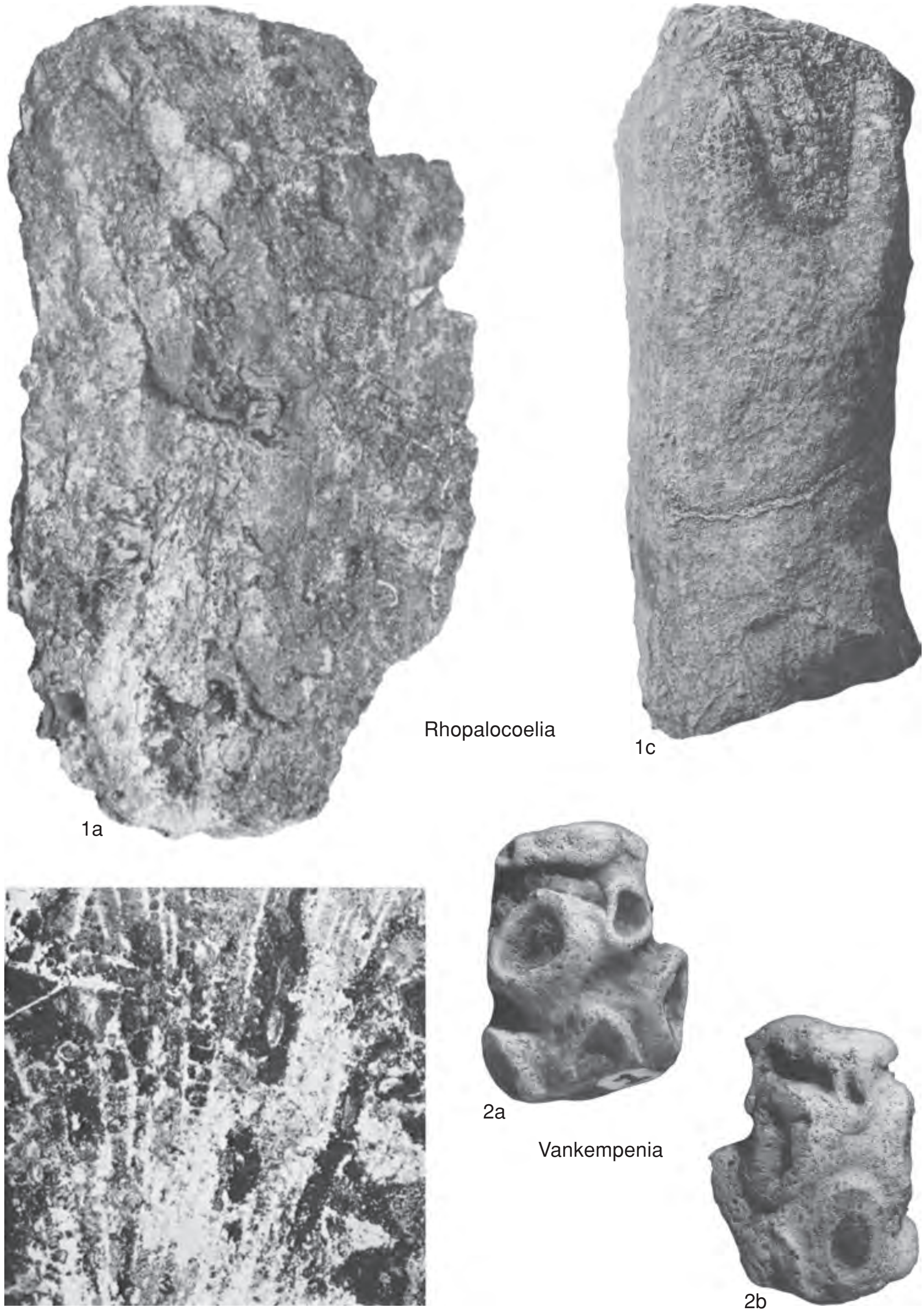

FIG. 68. Anthaspidellidae (p. 96–102).

I-shaped dendroclones; skeletal structure open and coarse; differentiated canals not developed. *Silurian (Ludlow):* Canada (Northwest Territories, Cornwallis Island).——FIG. 62,*4a–b.* **R. simplex,* Cape Phillips Formation, Cornwallis Island; *a,* side view of thin-walled holotype with fine-textured, dermal surface, ×1; *b* , cross section of laterally flattened holotype with a central spongocoel and thin walls with coarse trabs cross connected by I-shaped dendroclones, GSC 102174, ×2.5 (de Freitas, 1991; courtesy of *Canadian Journal of Earth Sciences*).

Rhopalocoelia RAYMOND & OKULITCH, 1940, p. 210 [**R. clarkii;* OD]. Cylindrical with deep cloaca into which radial, subhorizontal, branching, exhalant canals open; exterior with broad, irregular swellings; dendroclone rows radiating upwardly and outwardly from base, apparently perpendicular to upper surface. [Similar to the contemporaneous *Exochopora* and *Eospongia,* as well as to the earlier *Nevadocoelia.*] *Lower Ordovician–Middle Ordovician:* Argentina, China (Hubei, Xinjiang), *Ibexian;* USA (New York), Canada (Quebec), *Middle Ordovician.*——FIG. 68,*1a–c.* **R. clarkii,* Chazyan; *a,* side view of holotype showing large, central spongocoel in cylindrical sponge, Chazy Limestone, Valcour Island, New York, MCZ 9352, ×0.66; *b,* longitudinal section of paratype showing upwardly divergent, rodlike trabs and cross-connecting dendroclones, Chazy Limestone, Valcour Island, New York, MCZ 9354, ×8 (Raymond & Okulitch, 1940); *c,* upper end of cylindrical sponge showing thin walls and large, matrix-filled spongocoel, Mingan Formation, Mingan Islands, Canada, GSC 111127, ×1 (Rigby & Desrochers, 1995).

Rugocoelia JOHNS, 1994, p. 84 [**R. eganensis;* OD]. Lamellate to funnel-shaped with regular, concentric ribbing; radial canals straight, normal to exterior, and vertically stacked; vertical canals rare; surface of pinnation of trabs along gastral margin; ladderlike, skeletal net of small, amphiarborescent dendroclones; dermal layer well developed, particularly on rib crests; gastral layer may be present. *Lower Ordovician:* USA (Nevada).——FIG. 69,*2a–b.* **R. eganensis,* Shingle Limestone, Ibexian, Egan Range; *a,* regularly wrinkled, dermal surface of holotype, ×1; *b,* enlargement of dermal surface showing anthaspidellid, skeletal structure and ectosomal thickening along ridge, UT 1784TX1, ×2 (Johns, 1994; courtesy of Nevada Bureau of Mines and Geology).

Schismospongia RHEBERGEN & VON HACHT, 2000, p. 798 [**S. syltensis;* OD]. Relatively small but massive sponges with triangular to irregularly rectangular, transverse sections and one or two shallow spongocoels on upper surface; distal, exhalant canals curved, but converging toward walls of upper part of spongocoel as straight, nearly parallel, stacked canals 0.7 to 1.5 mm in diameter; inhalant canals 0.4 to 1.2 mm in diameter in outer walls, with obscure ostia in lower half of dermal surface. Spicules are dendroclones typical of family, but not well preserved in type material. [*Schismospongia* was interpreted to have been a natural cleft or small, cavern dweller. *Archaeoscyphia attenuata* DE FREITAS, 1989 is a small, bladed form with spongocoels located on the edge of the frond. *Hesperocoelia* BASSLER, 1927 is also bladelike with numerous elliptical oscula on the upper edge. Known only as Plio-Pleistocene glacial erratics recovered from the Island of Sylt.] *Middle Ordovician–Upper Ordovician:* northwestern Germany (Island of Sylt).——FIG. 65,*3a–c.* **S. syltensis,* glacial erratic; *a,* view of holotype from above with shallow spongocoel on right and curved canals in more massive part of skeleton on left, collection U. von Hacht S3, ×1; *b,* view from above of paratype 2 with two small spongocoels surrounded by convergent, exhalant canals, collection U. von Hacht S1, ×1; *c,* dendroclone spicules exposed in section of exhalant canal in silicified paratype 4, collection U. von Hacht, S4, ×15 (Rhebergen & von Hacht, 2000).

Somersetella RIGBY & DIXON, 1979, p. 614 [**S. conicula* RIGBY & DIXON, 1979, p. 615; OD]. High obconical to digitate, smooth-walled to weakly and irregularly annulate sponges with deep, simple spongocoel; vertically stacked, relatively small, straight, radial canals piercing walls; skeleton anthaspidellid with trabs of dendroclones that are cored by oxeas; surface of pinnation near gastral surface; coarse, vertical cluster of short, exhalant canals in base above radiante of skeleton; thin, dermal layer of irregularly oriented dendroclones, with irregular openings of ostia smaller than canals of walls. *Silurian (?Wenlock, Ludlow, ?Pridoli):* Canada (Northwest Territories, Baillie-Hamilton Island), *?Wenlock*; Canada (Northwest Territories, Somerset Island), *Ludlow, ?Pridoli.* ——FIG. 70,*2a–b.* **S. conicula,* Read Bay Formation, Ludlow, ?Pridoli, Somerset Island; *a,* annulate, obconical holotype, GSC 54836, ×1; *b,* photomicrograph of cellulose peel of paratype showing vertical trabs and cross-connecting shafts of dendroclones, GSC 54837, ×20 (Rigby & Dixon, 1979).——FIG. 70,*2c. S. digitata* RIGBY & DIXON, Read Bay Formation, Somerset Island, Canada; side view of digitate holotype with faint ribbing produced by stacked canals exposed where thin, dermal layer removed, GSC 54828, ×1 (Rigby & Dixon, 1979).

Steliella HINDE, 1889a, p. 395 [**S. billingsi* HINDE, 1889a, p. 396; SD DE LAUBENFELS, 1955, p. 61]. Club shaped with deep cloaca; principal, skeletal canals arching across from exterior to cloacal surface to form vertical rows of ostia on exterior and probably on cloacal wall, and appear as radial rows of canal intersections in horizontal, cross sections of sponge. [This is poorly known but may be a synonym of *Exochopora* (possibly a decorticated specimen).] *Upper Ordovician:* Canada (Ontario).——FIG. 65,*2a–c.* **S. billingsi,* ?Cobourg Formation, Ottawa; *a,* side view of ribbed, subcylindrical holotype with rounded, oscular margin to spongocoel, GSC 982, ×1; *b,*

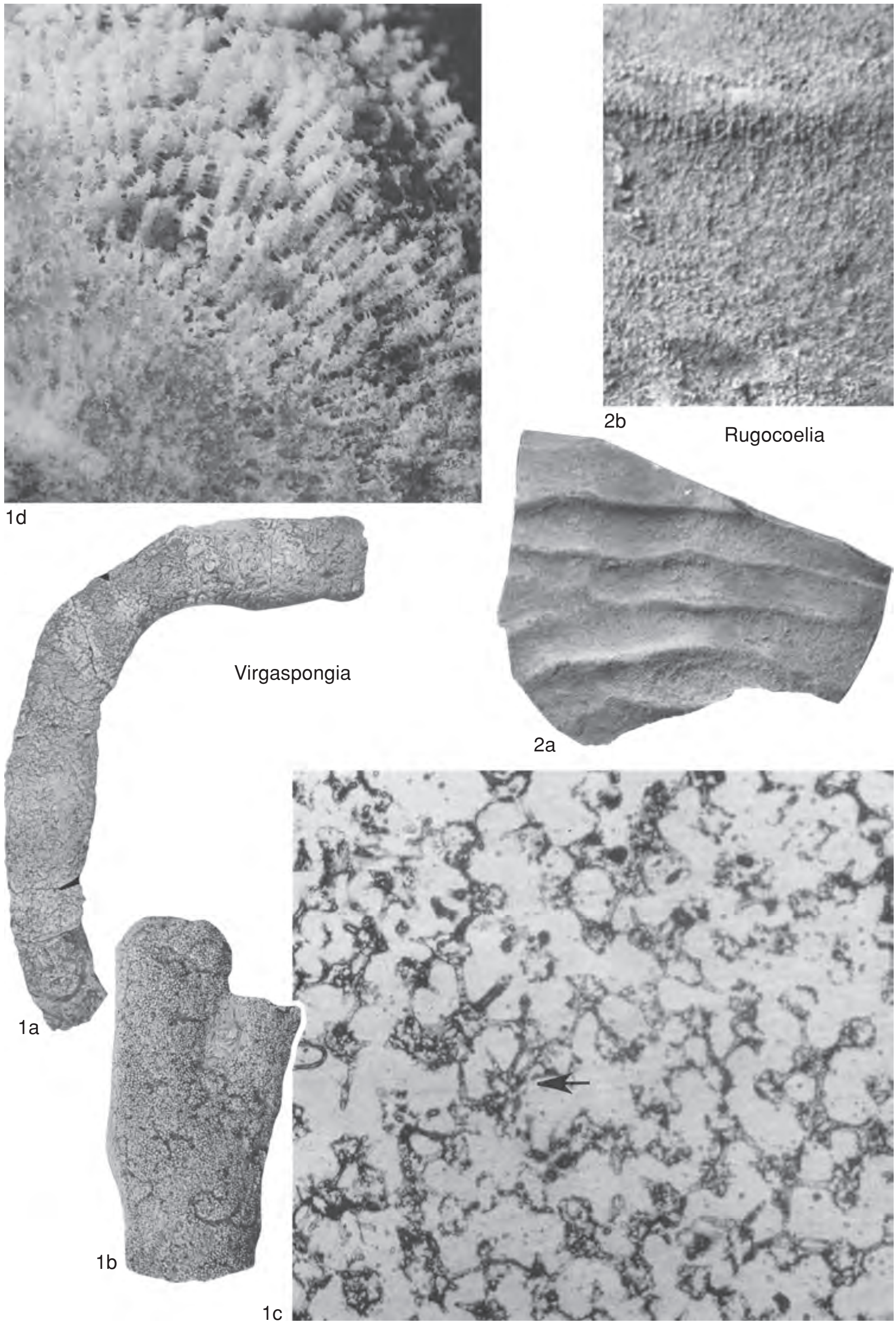

FIG. 69. Anthaspidellidae (p. 96–102).

transverse section of cotype with central spongocoel and radial, canal pattern, GSC 982e, ×1; *c,* photomicrograph of vertical section with vertical trabs and runglike dendroclones, GSC 982d, ×8 (Wilson, 1948; courtesy of the Minister of Public Works and Government Services Canada, 2002, and Geological Survey of Canada).

Strotospongia ULRICH & EVERETT in MILLER, 1889, p. 166 [**S. maculosa;* OD]. Externally identical to *Anthaspidella,* with which it is sympatric, but internal canals irregularly anastomosing and spicular arrangement obscure. [This may be an aberrant or poorly preserved *Anthaspidella;* MILLER (1889) used proofs of ULRICH and EVERETT (1890) and cited the genus and species as in press in his book.] *Upper Ordovician:* USA (Illinois).——FIG. 71,*1a–c.* **S. maculosa,* Platteville Limestone, Chazyan, Dixon; *a,* side view of holotype showing funnel-like form with aligned, inhalant ostia in dermal layer, ×1; *b,* view from above of shallow, gastral depression and several oscula surrounded by radial, exhalant canals, ×1; *c,* vertical section showing general skeletal and canal patterns in endosome of holotype, ISM, ×1 (Ulrich & Everett, 1890).

Syringelasma ULRICH, 1890b, pl. 8, *nom. nov. pro Syringophyllum* ULRICH in MILLER, 1889, p. 166, *non* MILNE-EDWARDS & HAIME, 1850, p. 242 [**Syringophyllum wortheni* ULRICH, 1890b, p. 250; M]. Flabellate fronds, possibly broken portions of a saucer-shaped sponge, bearing subparallel channels radiating from base of sponge on both flat surfaces; canals perpendicular to surfaces completely penetrate sponge and open into bottoms of radial channels; dendroclone rows radiate from base of sponge and diverge toward both upper and lower surfaces as in *Anthaspidella. Middle Devonian:* USA (Michigan).——FIG. 67,*4a–b.* **S. wortheni* (ULRICH), Hamilton Group, Hamiltonian, Thunder Bay; *a,* surface of platelike fragment with prominent, radial series of ostia separated by ridges of trabs, ×1; *b,* photomicrograph of thin section showing rodlike trabs with runglike dendroclones between, large ostia are openings on right, ×18 (Ulrich, 1890b).

Talacastonia BERESI & RIGBY, 1993, p. 56 [**T. chela;* OD]. Cylindrical to conicocylindrical sponges with coarse, dendroclone-based skeleton; coarse trabs anastomose or wander and with irregular, almost spinose-appearing surfaces; trab structure complex and cored by oxeas grasped by complex cladomes and other dendroclone, ray tips; skeleton also includes other irregular, vertical elements; canals moderately coarse and essentially horizontal through walls into spongocoel, dermal ostia in crude, vertical rows. *Lower Ordovician:* Argentina.——FIG. 70,*1a–c.* **T. chela,* San Juan Formation, Precordillera Central; *a,* horizontal section through elliptical holotype with thin walls around spongocoel(s), ×1; *b,* side view showing relatively robust, medium-gray trabs with light gray matrix in canals in smooth walls, ×1; *c,* photomicrograph of transverse section of holotype showing coarse canals separated by compound trabs cored by oxeas and cross connected by I-shaped dendroclones (*d*), CRICYT T-53, ×20 (Beresi & Rigby, 1993).

Timidella DE LAUBENFELS, 1955, p. 65, *nom. nov. pro Timorella* GERTH, 1909, p. 695, *non* BERGH, 1905 [**Timorella permica* GERTH, 1909, p. 695; OD]. Spheroidal; upper part of sponge surface bearing conical protuberances and surface grooves that converge on a small, shallow depression at summit; dendroclone rows and principal canals perpendicular to surface and radiating from a point well in interior of sponge. [The genus is similar to *Mastophyma.*] *Permian:* Timor.——FIG. 72,*1a–c.* **T. permica* (GERTH), Permian limestone; *a,* side view of type specimen showing globose form and complex canal pattern radiating out from small, oscular depression on summit, ×0.5; *b,* transverse section through sponge with thin, convergent, inhalant canals and thick, irregular, exhalant canals shown in black, ×1; *c,* drawing of skeletal structure with vertical, coarse trabs cross connected by horizontal dendroclones, all recrystallized, ×20 (Gerth, 1909).

Trachyum BILLINGS, 1865, p. 211 [**T. cyathiforme;* OD]. Broad, open, thin-walled cup with obtusely rounded base; closely spaced, parallel, slitlike openings running vertically up both surfaces of cup; skeleton of thin, parallel fibers radial from base, spicules not known but probably dendroclones. [This genus is known poorly, but the structure of the wall is like that of *Patellispongia.*] *Lower Ordovician:* Canada (Newfoundland), USA (?Alabama).——FIG. 67,*2a–b.* **T. cyathiforme,* Unit G, Canadian, Cape Norman, Newfoundland; side views of holotype showing broad, funnel-like form, approximately ×1 (Billings, 1865).

Trochospongia ROEMER, 1887, p. 174 [**T. cyathophylloides* ROEMER, 1887, p. 176; OD]. Conical with concave, upper surface; fine, subparallel, radial canals converging upon axial region of upper surface from its periphery; corresponding, horizontal, radial canals in interior, axial region of sponge occupied by large, vertical canals so closely packed as to have a polygonal outline; dendroclone rows probably perpendicular to upper surface and seemingly outlining radial canals. [This may be a senior synonym of *Zittelella.*] *?Silurian:* Germany (glacial drift).——FIG. 72,*2a–c.* **T. cyathophylloides,* Pleistocene glacial drift; *a,* side view of obconical sponge with vertically aligned, skeletal structure suggested by sections of trabs, ×1; *b,* view into spongocoel from above showing thick walls with radial canals between dotted rows of trabs, ×1; *c,* enlarged skeletal structure showing rodlike dendroclones connecting trabs that are aligned dots of transverse sections, approximately ×10 (Roemer, 1887).

Tschernyschevostuckenbergia ZHURAVLEVA, 1962, p. 63, *nom. nov. pro Stuckenbergia* TSCHERNYSCHEV, 1898, p. 24, *non* TSERVINSKII, 1898 [**Kazania*

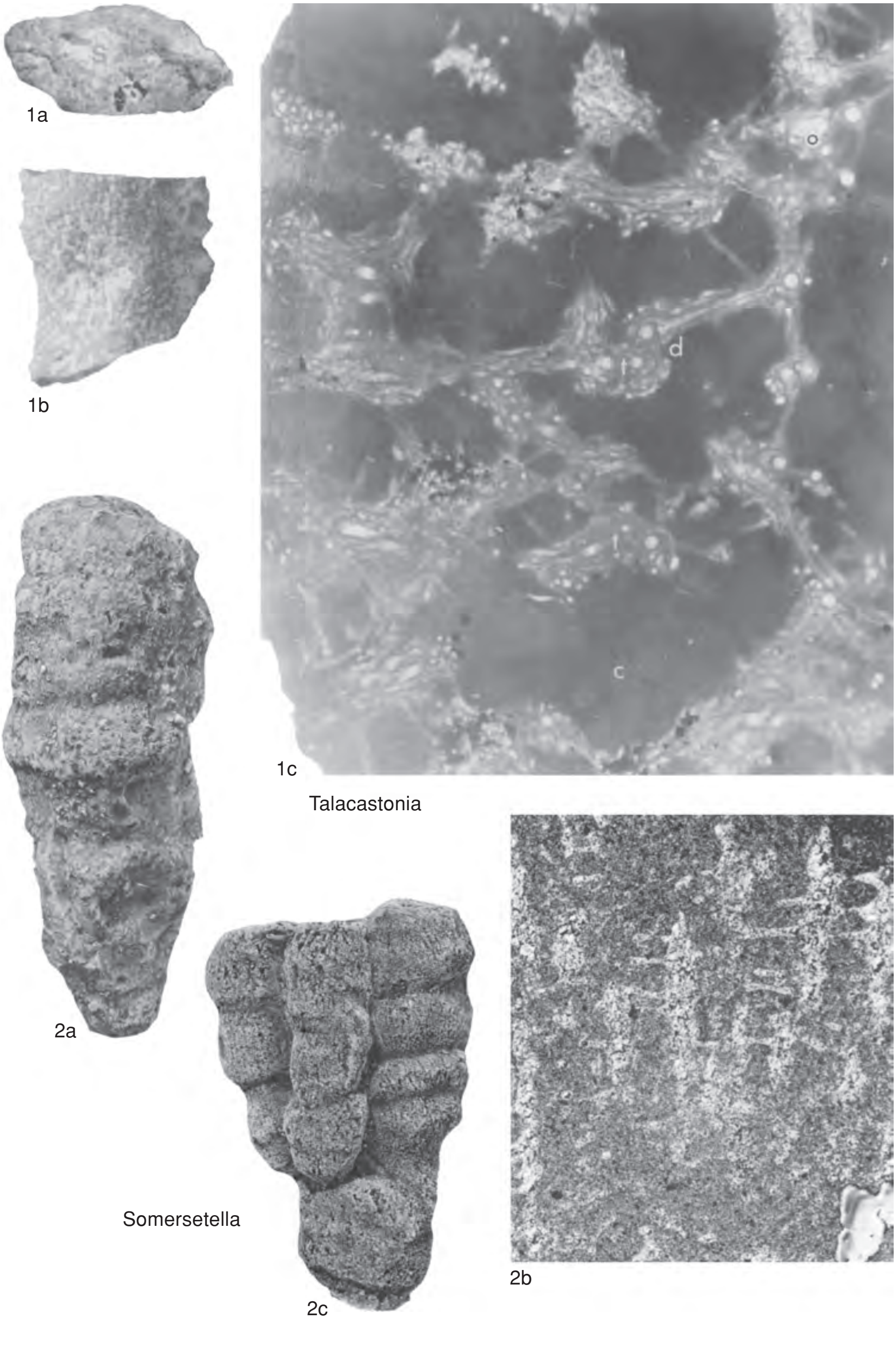

FIG. 70. Anthaspidellidae (p. 96–98).

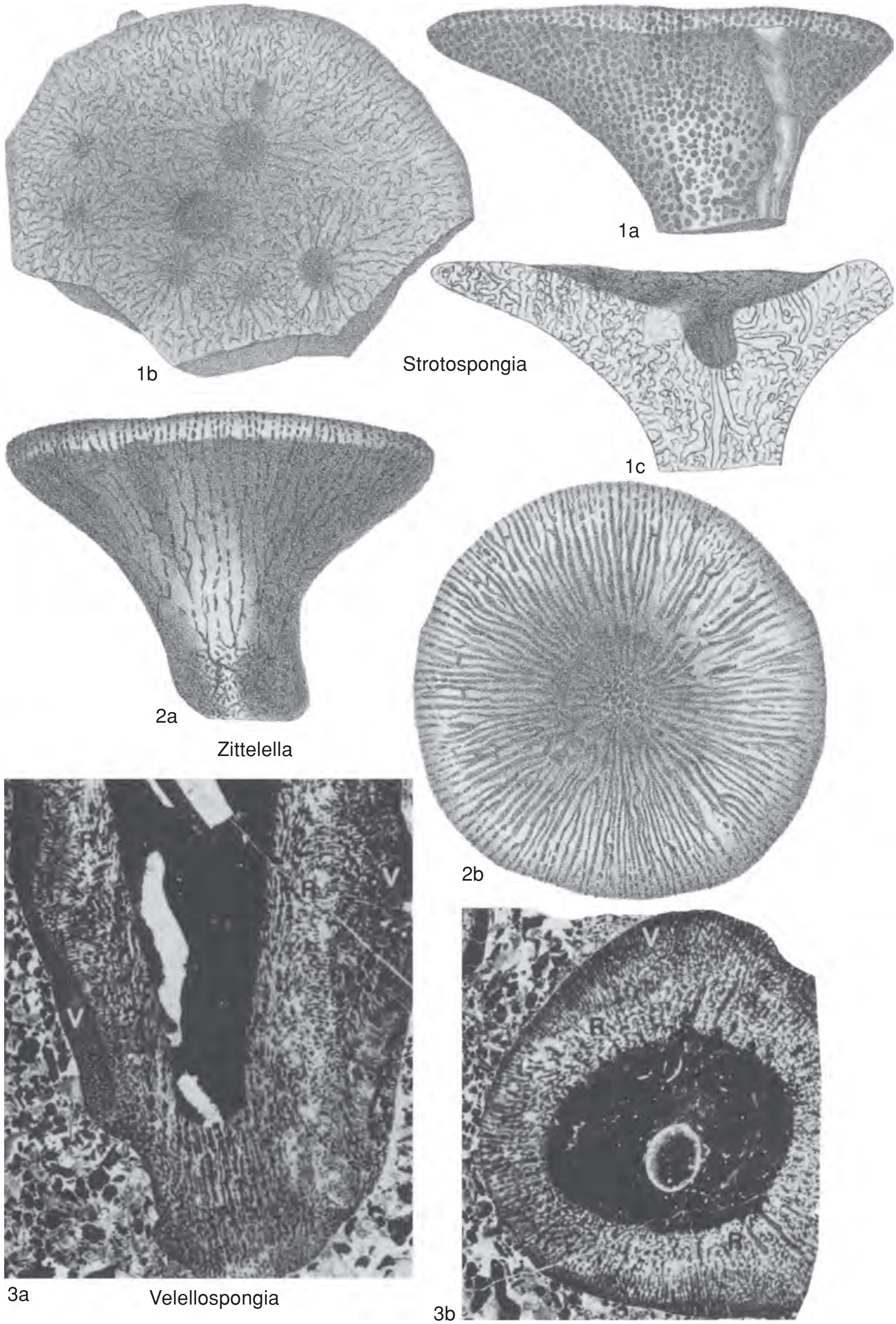

FIG. 71. Anthaspidellidae (p. 98–104).

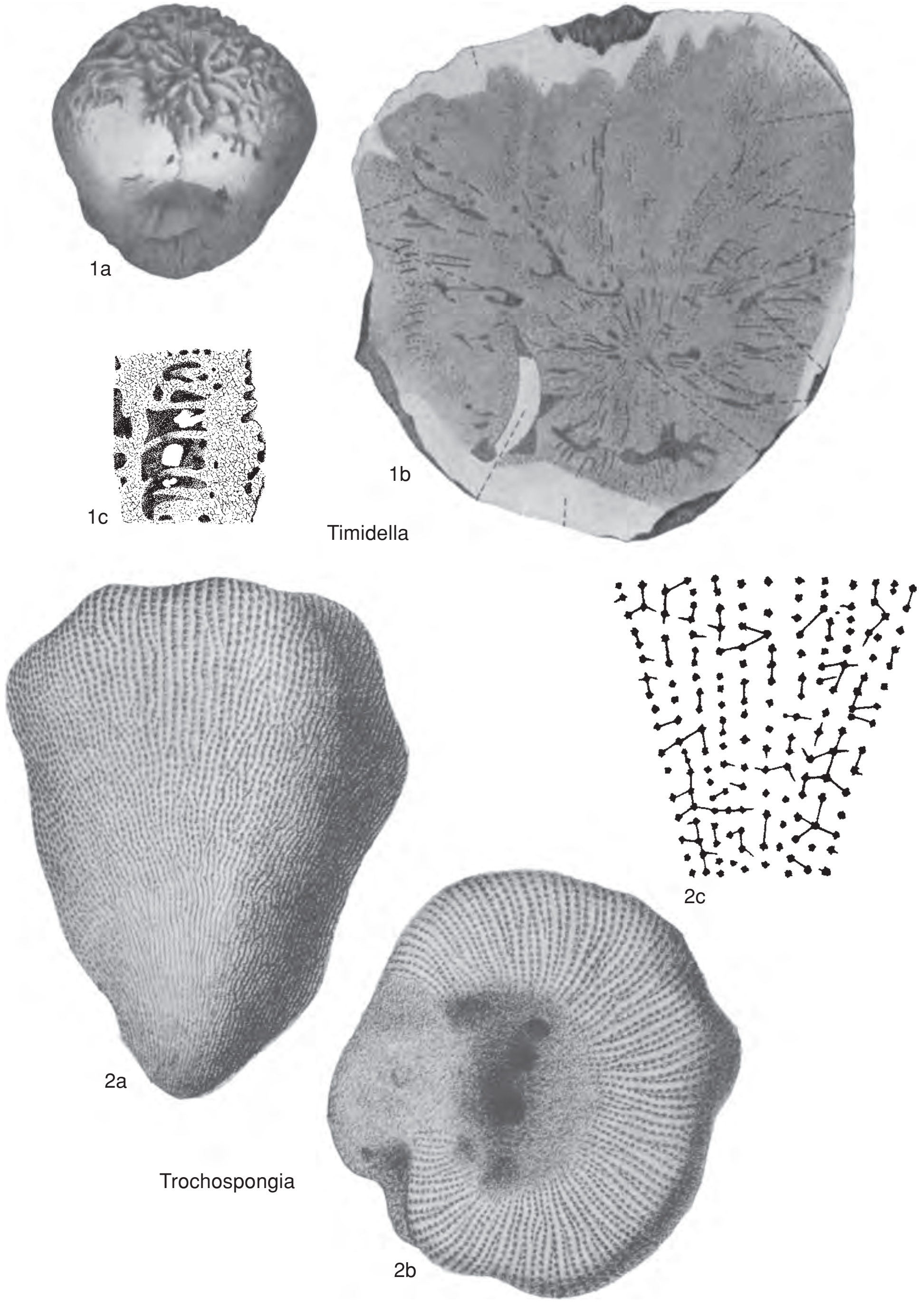

FIG. 72. Anthaspidellidae (p. 98).

ufimiana Stuckenberg, 1895, p. 22; OD]. Massive; dendroclone rows and principal canals perpendicular to outer surface and radiating from a point at or near base; no pore clusters or surface grooves; spicules resemble those of *Pemmatites,* but smaller. *Permian:* Russia (South Ural Mountains).——Fig. 73,*2.* **T. ufimiana* (Stuckenberg), Artinskian beds; part of exposed surface showing canals and skeletal structure, ×5 (Rezvoi, Zhuravleva, & Koltun, 1962; courtesy of Russian Academy of Science).

Vandonia Rigby & Webby, 1988, p. 59 [**V. clathrata* Rigby & Webby, 1988, p. 60; OD]. Cavernous, obconical to massive, subhemispherical sponges with very regular, coarse trabs produced by unusually large dendroclones spaced uniformly to produce almost laminate, stromatoporoid-looking, regular skeleton; canal system of large, medial, excurrent, and smaller, nearly vertical canals subparallel to upwardly and outwardly radiating trabs; vertical webs of cladome origin may connect trabs but do not produce compound beams; dendroclones large for family. *Upper Ordovician:* Australia (New South Wales).——Fig. 73,*1a–c.* **V. clathrata,* Malongulli Formation, Cliefden Caves area; *a,* vertical section of holotype showing regular, coarse skeleton with trabs produced by large dendroclones and finer webs, with dendroclones spaced uniformly to produce reticulate structure, large canals radiating upwardly, parallel to skeletal elements, ×4; *b,* photomicrograph of vertical section showing coarse dendroclones in rectangular structure and whose extended ray tips produce principal, discontinuous, webbed, vertical elements, ×8; *c,* vertical view of upper surface of holotype showing weblike, skeletal elements cross connected by coarse dendroclones, and pierced by vertical canals of several sizes, AMu. F66861, ×4 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Vankempenia von Hacht, 1994, p. 76 [**V. erratica;* OD]. Sponge cylindrical with broad, central spongocoel and irregularly spaced, thick-walled, craterlike, lateral oscula, or tubular branched with thickened walls; moderately large, more or less horizontal and winding canals pierce principal walls; other canals parallel ladderlike trabs of skeletal system that diverge upwardly and outwardly from near gastral surface to terminate at dermal surface; trabs formed by union of dendroclone tips and cored by long monaxons; upper surfaces of some craterlike oscula may be covered with closely spaced monaxons. *Ordovician:* Germany and northern Europe.——Fig. 68,*2a–b.* **V. erratica,* Ordovician glacial erratics, Braderup, Island of Sylt, Germany; *a,* side view of holotype with several craterlike oscula, ×1; *b,* opposite side of same showing more tubular, basic form, ×1 (von Hacht, 1994; courtesy of *Nederlandse Geologische Vereniging*).

Velellospongia Liu & others, 1997, p. 205 [**V. adnata;* OD]. Encrusting, sheetlike anthaspidellid, assuming general contours of substrate but with separated, low shield, volcano-like mounds; internal, horizontal-radial, exhalant canals converging toward mounds and arching upwardly or outwardly to produce exhalant clusters with dense walls; inhalant canals also walled but perforate and downwardly divergent into lower part of skeleton, either as isolated openings or limited clusters on flanks of mounds; skeleton of I-shaped dendroclones that form trabs generally parallel to encrusting base, but may arch upwardly to meet dermal surface approximately at right angles in mounds and intervening areas; trabs apparently radiate out from mound areas into thin, sheetlike, intervening areas, where skeleton interrupted by convergent, exhalant canals. [*Velellospongia* is the only distinctly encrusting sponge known in the family.] *Lower Ordovician:* China (Hubei).——Fig. 71,*3a–b.* **V. adnata,* Honghuayuan Formation, Xintan; *a,* oblique, longitudinal section of holotype of *Velellospongia* (*V*) overgrowing cylindrical *Rhopalocoelia* (*R*) and separated from it by an abrupt discontinuity between trab-based skeletons, with cluster of convergent, exhalant canals in mound on right, JPI XLOH-3-c, ×2; *b,* transverse section of holotype showing encrusting habit of genus, JPI XLOH-3-a, ×2 (Liu & others, 1997).

Virgaspongia Rigby & Manger, 1994, p. 735 [**V. ichnata* Rigby & Manger, 1994, p. 736; OD]. Irregularly curved, subcylindrical to conicocylindrical, branched to unbranched sponges without spongocoel; skeleton typically anthaspidellid, made of dendroclones whose united ray tips form trabs that diverge upwardly and outwardly from sponge axis, with steeply ascending trabs in axial area that become horizontal in outer two-thirds of stem; most observable spicules I-shaped dendroclones, although Y-shaped dendroclones also occur; canals subparallel to trabs. *Carboniferous (Lower Pennsylvanian):* USA (Arkansas).——Fig. 69,*1a–d.* **V. ichnata,* Bloyd Formation, Ozark Mountains; *a,* side view of large, cylindrical holotype with tips of outwardly divergent trabs forming minute, stippled surface, USNM 463444, ×0.5; *b,* side view of branched paratype with minute, stippled exterior produced by trab tips, USNM 4673449, ×1; *c,* photomicrograph of transverse section of paratype showing cross sections of cylindrical trabs (*arrow*) formed by union of tips of cross-connecting, rodlike dendroclones, USNM 463454, ×20; *d,* diagonal photomicrograph of paratype showing silicified, skeletal structure with rodlike trabs and runglike dendroclones, USNM 46342, ×5 (Rigby & Manger, 1994).

Virgaspongiella Rigby & Boyd, 2004, p. 72 [**V. ramosa;* OD]. Small, branching, twig-like to palmate sponges without a distinct spongocoel, although axial exhalant canals may be developed; skeleton of ladderlike elements that diverge upwardly and composed of prominent trabs cross connected by runglike, I- and X-shaped dendroclones whose branching tips unite to form trabs; trabs may be cored with one or more axial oxeas at any level and those spicules project outwardly as spines

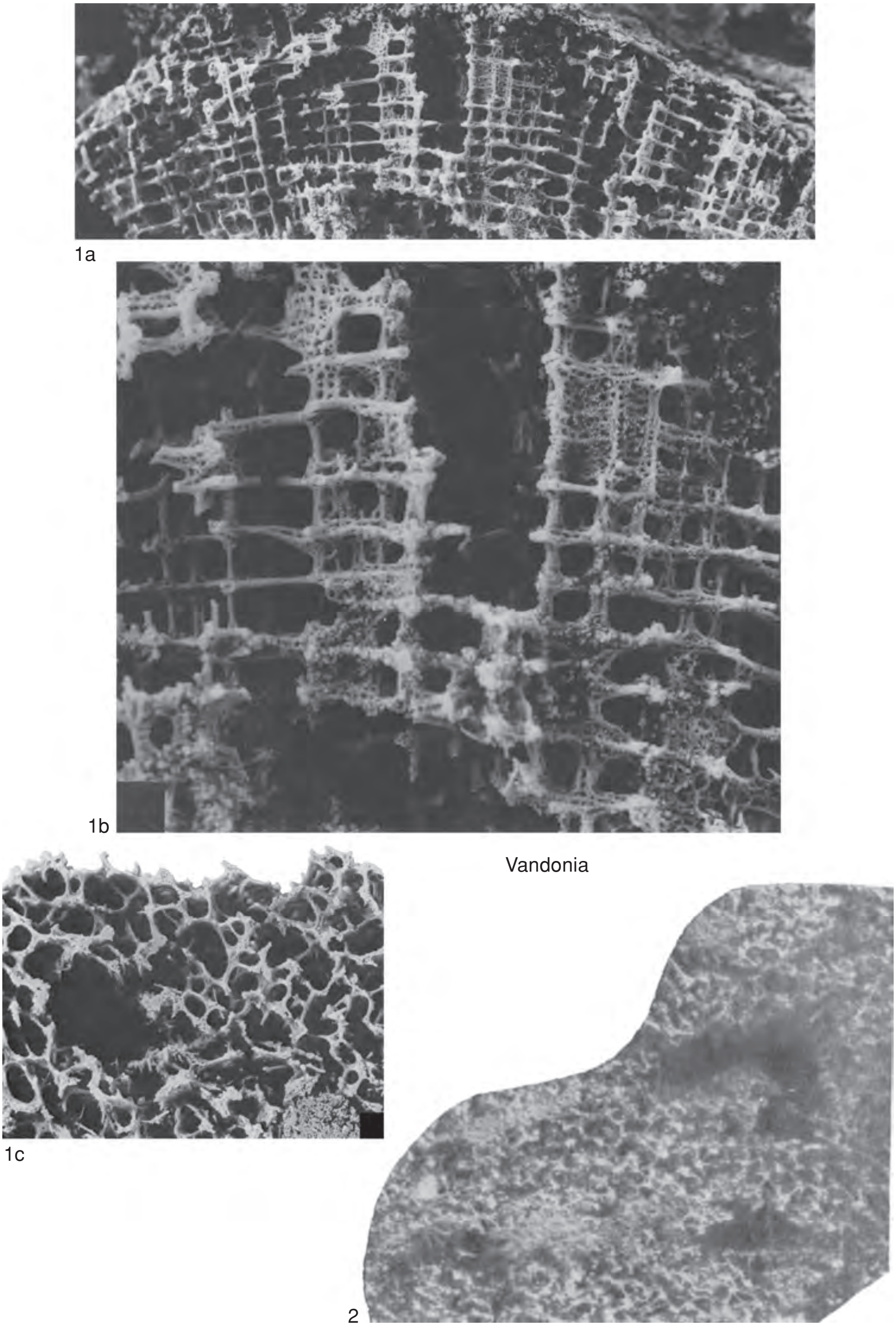

FIG. 73. Anthaspidellidae (p. 98–102).

beyond trab tips on dermal surfaces. *Permian (Wordian):* USA (Wyoming).——FIG. 57,*1a–c.* **V. ramosa,* Park City Formation, Bull Lake area, eastern Wind River Mountains; *a,* side view of twiglike, branching holotype, UW4022, ×2; *b,* side view of twiggy to palmate paratype with exhalant ostia more prominent in upper part, UW4024, ×2; *c,* SEM photomicrograph of holotype showing prominent, large exhalant pores and smaller inhalant pores, between I-shaped dendroclones with terminal rays combining to form subcylindrical trabs that are cored by larger monaxons (*arrow*), now commonly broken, UW4022, scale bar, 200 µm (Rigby & Boyd, 2004).

Yarrowigahia RIGBY & WEBBY, 1988, p. 56 [**Y. brassicata;* OD]. Laminated, globose to massive anthaspidellid in which smooth to wrinkled laminae curve downwardly from a central core but then sweep upwardly to become subparallel, like leaves of a cabbage, in upper part; main canals concentrated in layers between laminar sets and generally parallel to trabs; trabs of long-shafted dendroclones radiate upwardly and outwardly, generally parallel to curving laminae, although skeletal structure irregular and ladderlike dendroclone series not as clearly defined as in related sponges; trabs cored by oxeas. *Upper Ordovician:* Australia (New South Wales).——FIG. 74*a–b.* **Y. brassicata,* Malongulli Formation, Cliefden Caves area; *a,* natural, vertical section through interior showing uparched laminae of central core in lower part and curved laminae in outer, lower part, that sweep up like cabbage leaves to produce upper part of sponge, where they are separated by canals; *arrow* indicates top of sponge to right, ×1; *b,* photomicrograph of prominent trabs produced by coring oxeas and fused ray tips of widely spaced, X- and Y-shaped dendroclones, AMu. F66857, ×20 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Zittelella ULRICH & EVERETT in MILLER, 1889, p. 167 [**Cnemidium? trentonense* WORTHEN, 1875, p. 491; M]. Broadly conical to pedunculate and ficiform with broadly concave to deeply cloacate, upper surface; cluster of vertical, exhalant canals along axis; numerous, radially disposed, exhalant canals converging upon axial cluster and cloaca from periphery of sponge; upper surface marked by grooves of convergent, horizontal canals; radial incurrent-excurrent canals of interior tend to be superposed and may coalesce to form vertical, radial slits; dendroclone rows nearly vertical above surface of pinnation, which is near outer, lower margin; imperforate outer layer may be present on base. *Lower Ordovician–Middle Ordovician:* USA (?Texas, ?Colorado), China (Xinjiang), *Ibexian;* North America, *Middle Ordovician.*——FIG. 71,*2a–b.* **Z. trentonense* (WORTHEN), Platteville Limestone, Chazyan, Dixon, Illinois, USA; *a,* side view of funnel-shaped holotype with stalk marked by aligned, inhalant ostia, ×1; *b,* view from above of regular radial skeletal and canal structure, with several vertical, exhalant canals in center, ISM, ×1 (Ulrich & Everett, 1890).

Family STREPTOSOLENIDAE Johns, 1994

[Streptosolenidae JOHNS, 1994, p. 87]

Sponges ranging from discoidal or palmate to funnel shaped and branched; skeleton of irregularly oriented dendroclones fused at ends to form trabs that may be cored by oxeas, spicules of endosome and ectosome of comparable size; dermal and gastral layers variably developed; canal systems commonly complex and intertwining; exhalant canals may empty into spongocoel or as individual openings in clustered oscula; surface usually smooth but surficial ridges and nodes may be present. *Upper Cambrian–Silurian.*

Streptosolen ULRICH & EVERETT in MILLER, 1889, p. 165 [**S. obconicus;* OD]. Broadly conical with shallowly concave upper surface; skeleton of irregularly oriented, small dendroclones that produce only short, discontinuous, and irregular trabs; axial cluster of vertical, exhalant canals joined by sinuous and branching, subhorizontal tributary canals, some of which are subradial, branched, and visible on upper surface, irregularly convergent on central cluster of exhalant openings; outer surface is covered with similar sinuous, branching canals without clear orientation. [This genus differs from *Zittelella* in the irregular skeleton and pattern of the canal system. MILLER (1889) used proofs of ULRICH and EVERETT (1890) and cited the genus and species as in press in his book.] *Middle Ordovician–Upper Ordovician:* USA (Illinois, California); northern Europe, *Upper Ordovician.*——FIG. 75,*1a–c.* **S. obconicus,* Platteville Limestone, Chazyan, Illinois; *a,* side view of steeply obconical holotype marked by irregular canals on dermal surface, ×1; *b,* view from above into shallow spongocoel with irregular canals around cluster of vertical, exhalant canals near center, ×1; *c,* vertical, medial section with central cluster of vertical, exhalant canals and other, more irregular, lateral canals, ISM, ×1 (Ulrich & Everett, 1890).

Allosaccus RAYMOND & OKULITCH, 1940, p. 208 [**A. prolixus* RAYMOND & OKULITCH, 1940, p. 209; OD]. Discoidal to irregularly hemispherical, with convex, upper surface and concave, lower surface; lower surface covered by imperforate layer; central depression on upper surface containing openings of exhalant canals, and branching, sinuous, radial canals converging upon it across upper surface; skeleton irregular. *Lower Ordovician–Middle Ordovician:* Argentina (Precordillera), *Lower Ordovician;* USA (?California, Virginia, Tennessee),

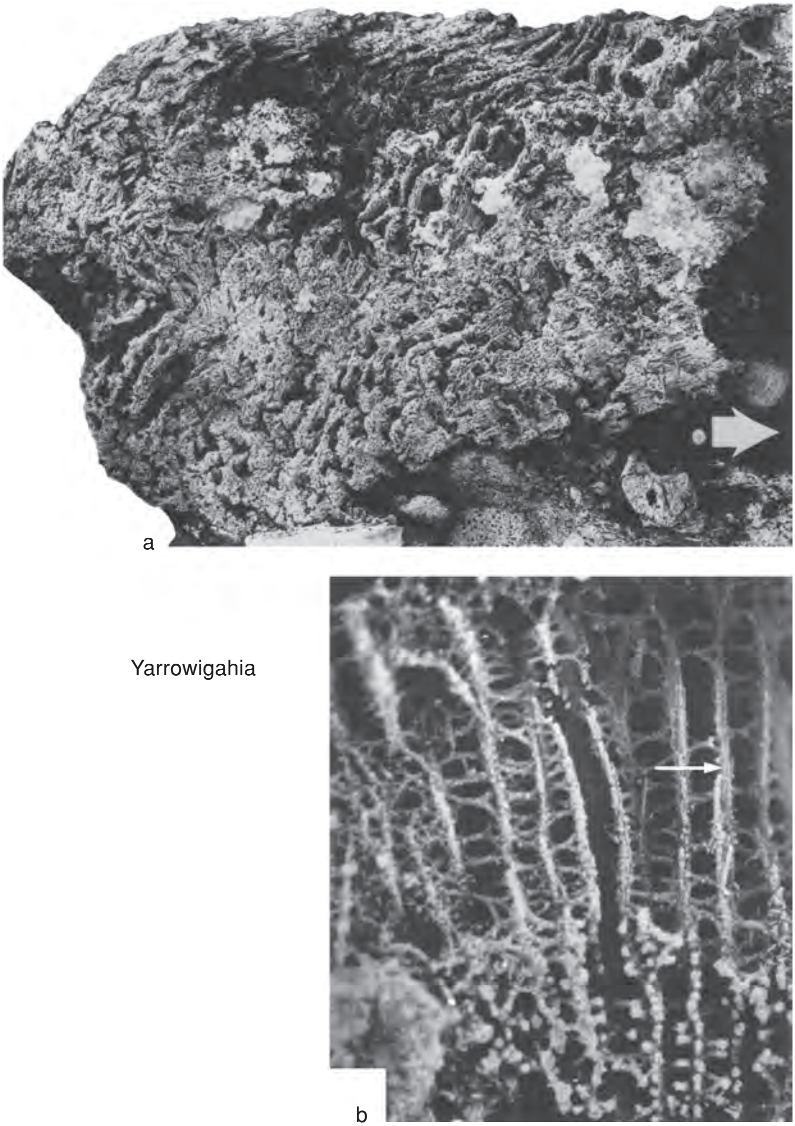

FIG. 74. Anthaspidellidae (p. 104).

Middle Ordovician.——FIG. 75,*2a–b.* **A. prolixus,* Lenoir Limestone, Arenig–Llanvirn, Knoxville, Tennessee; *a,* view of holotype from above showing coarse, exhalant ostia in center and radiating canals on surface, MCZ 9351, ×1; *b,* paratype from above with convergent canals to shallow, exhalant depression, MCZ 9352, ×1 (Raymond & Okulitch, 1940).

Antrospongia RIGBY & CHATTERTON, 1989, p. 15 [**A. aberrans* RIGBY & CHATTERTON, 1989, p. 16; OD]. Thin-walled, obconical with deep, simple spongocoel, gastral surface with large, conical pits into which exhalant canals empty; inhalant system with large, conical openings bridged with irregular screen in dermal area; skeleton in midwall with moderately well-oriented trabs, but outer and inner part of wall irregular; trabs commonly connected by clusters of subparallel dendroclones that produce irregular dermal and gastral layers. *Silurian (Ludlow):* Canada (Northwest Territories, Baillie-Hamilton Island).——FIG. 76,*1a–c.* **A. aberrans,* Cape Phillips Formation, Baillie-

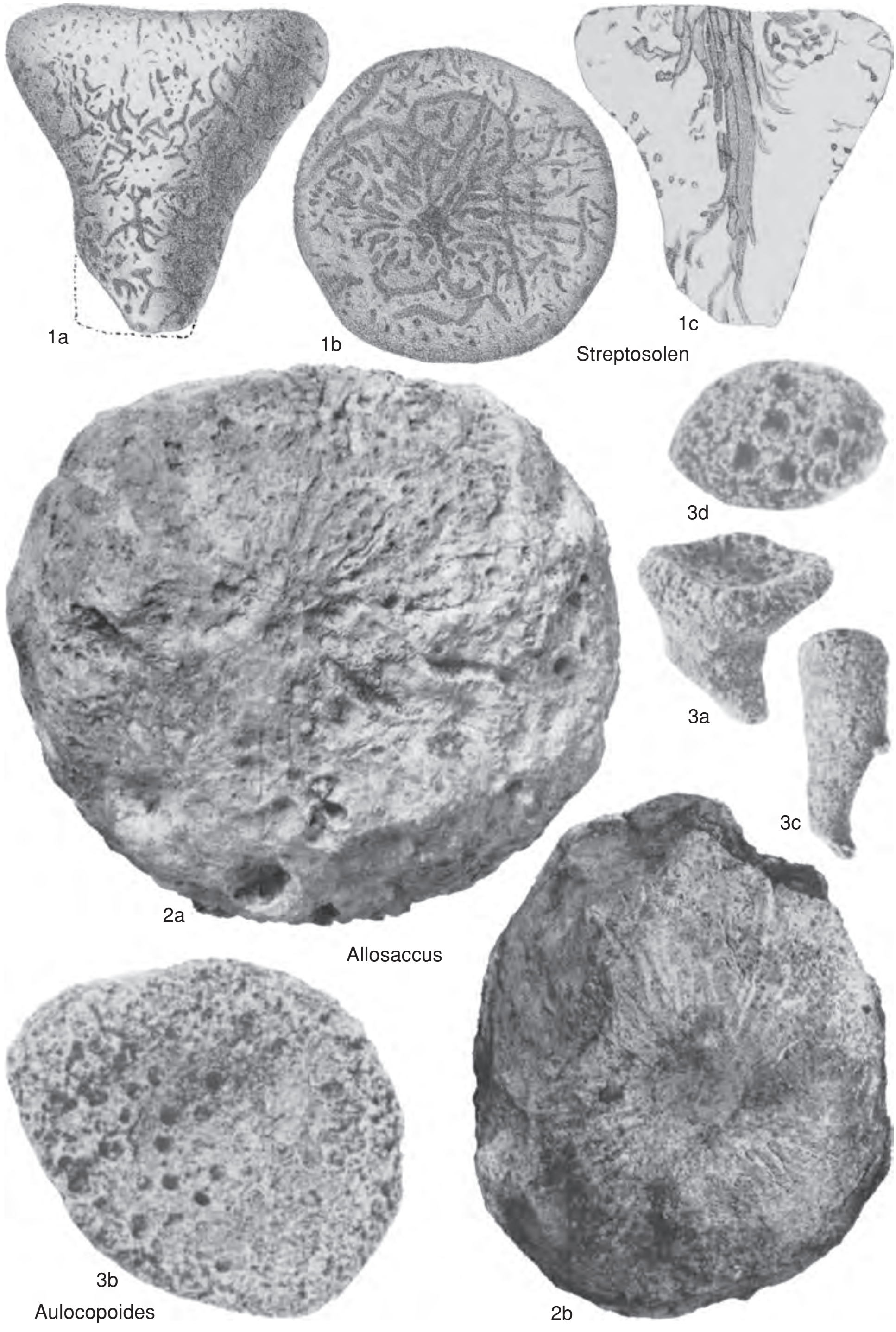

FIG. 75. Streptosolenidae (p. 104–108).

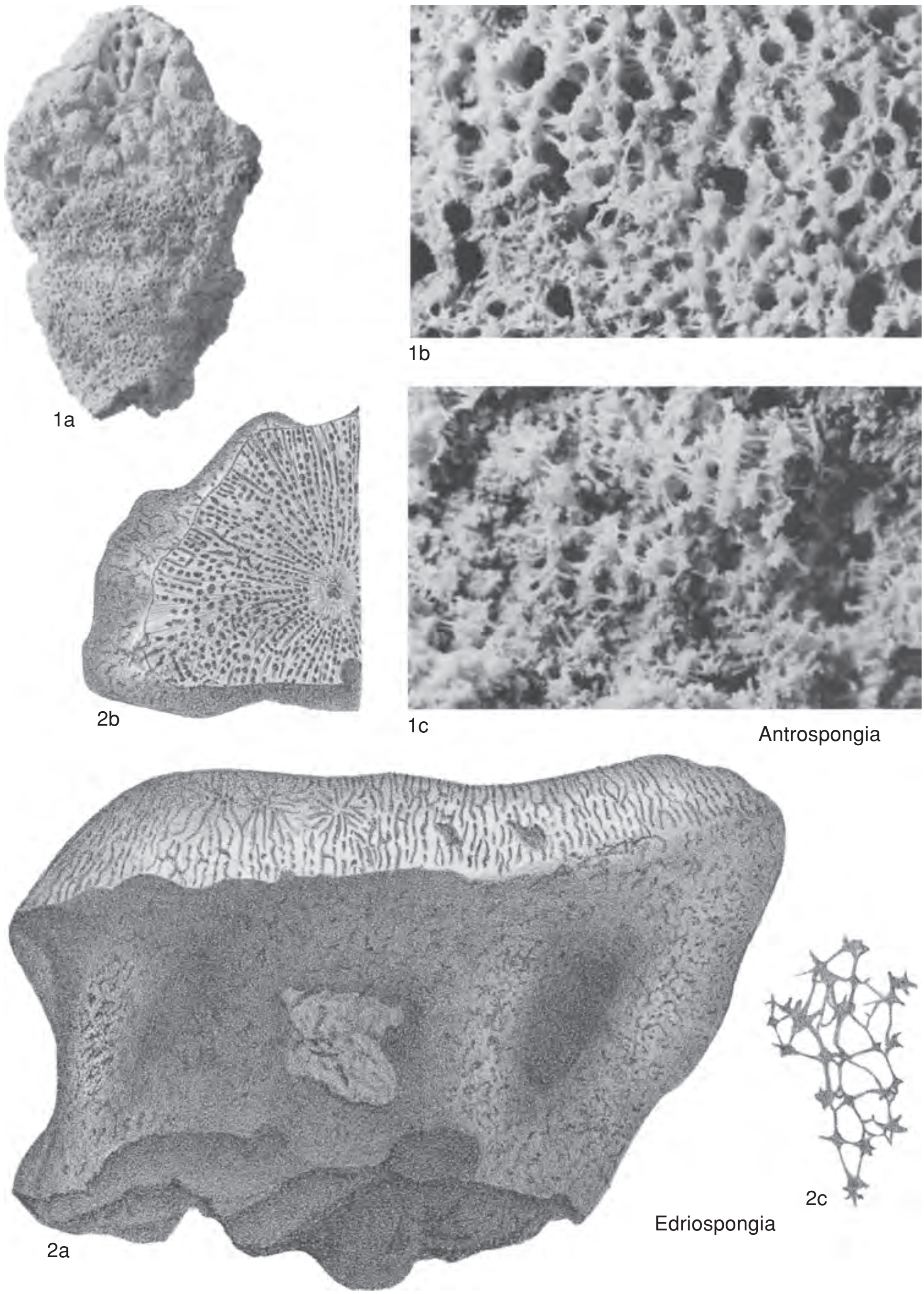

FIG. 76. Streptosolenidae (p. 105–108).

Hamilton Island; *a,* side view of flattened, thin-walled holotype showing dense, dermal layer in lower part and into gastral surface of spongocoel, with coarse, exhalant ostia in crude, vertical rows in upper part, ×1; *b,* photomicrograph of part of irregular dermal net, ×10; *c,* photomicrograph of natural cross section through middle part of wall showing regular, short trabs cross connected with other trabs and dendroclones, UA 7703, ×10 (Rigby & Chatterton, 1989; courtesy of Minister of Public Works and Government Services, 2000, and the Geological Survey of Canada).

Aulocopella Rauff, 1895, p. 268 [**A. winnipegensis* Rauff, 1895, p. 269; OD]. Depressed spheroidal, radially lobate, with deep, central cloaca; principal canals strongly arched parallel to upper and outer surface, in stacked series, opening into cloaca; dendroclone rows perpendicular to outer surface and radiating from a point within basal part of sponge, beneath cloaca. *Ordovician:* North America, Europe.——Fig. 77,*1a–c.* **A. winnipegensis,* Red River Formation, Cat Head Member, Caradoc–Ashgill, Lake Winnipeg, Manitoba, Canada; *a,* holotype from above showing central, matrix-filled spongocoel and radiating, gearlike fins with prominent, exhalant canals, GSC 6863, ×0.6 (Rauff, 1895); *b,* nearly complete specimen of species from above showing bladed form and open spongocoel with aligned, exhalant ostia in gastral surface, ×0.67; *c,* side view of upper, lateral slope of fin with aligned, outwardly divergent trabs interrupted by upwardly and inwardly arched, exhalant canals, MMMN I-7986, ×0.67 (Rigby & Leith, 1989).

Aulocopium Oswald, 1847, p. 58 [**A. aurantium* Oswald, 1850, p. 83; SD Rauff, 1895, p. 257]. Pyriform; base conical and covered by concentrically wrinkled, imperforate layer; central cloaca present and of variable depth; principal canals entering cloaca vertically from below and horizontally from sides, latter being parallel to upper and outer surfaces of sponge; dendroclone rows perpendicular to upper and outer surfaces. [Genus is similar to *Eospongia.*] *Ordovician–Silurian:* worldwide.——Fig. 78,*1a–c.* **A. aurantium* Oswald; *a,* side view of typical specimen with wrinkled, dermal layer below and canalled, upper part around spongocoel, Silurian strata, near Berlin, Germany, Berlin Museum, ×1; *b,* vertical, median section with deep spongocoel and upwardly converging, exhalant canals with ostia in gastral surface, crossed by upwardly diverging, skeletal tracts and downwardly converging, smaller, exhalant, skeletal tracts, Silurian strata, Gaarden by Kiel, Germany, Kiel Museum, ×2; *c,* silicified sponge, photomicrograph of skeletal structure of small, typical specimen with tips of runglike dendroclones forming trabs, Silurian, Gotland, Bonner Museum, ×35 (Rauff, 1895).

Aulocopoides Howell, 1952, p. 2 [**A. patulum;* OD]. Funnel-like to conicocylindrical, unbranched with or without spongocoel into which empty several large, widely spaced, vertical, cylindrical, excurrent canals but with convergent lower parts; numerous inhalant canals approximately radial and at right angles to dermal surface; skeleton irregular with moderately regular trabs approximately parallel to dermal surface in upper, funnel-like part but irregular below; surface of pinnation near dermal margin. *Devonian (Famennian):* Australia (Western Australia).——Fig. 75,*3a–b.* **A. patulum,* Virgin Hills Formation, Mount Pierre; *a,* side view of funnel-shaped sponge with shallow spongocoel and minor, exhalant ostia, ×1; *b,* view from above with minor, exhalant ostia in saucer-shaped spongocoel, PU 57875, ×2 (Rigby, 1986b).——Fig. 75,*3c–d.* *A. teicherti* Howell, Virgin Hills Formation, Mount Pierre, Western Australia; *c,* side view showing steeply obconical form of small sponge, ×1; *d,* view from above of rounded summit with separated, exhalant ostia, PU 57877, ×2 (Rigby, 1986b).

Dendroclonella Rauff, 1895, p. 252 [**D. rugosa;* OD]. Cushion-shaped or low, biconical sponge without cloaca or dermal layer; principal canals and dendroclone rows perpendicular to surface. *Silurian (Wenlock–Ludlow):* USA (Tennessee).——Fig. 79,*2a–c.* **D. rugosa,* Brownsport Formation, Perry County; *a* side view of holotype with wrinkled exterior without coarse ostia or canals, ×1; *b,* vertical section of holotype showing upwardly diverging trabs of skeletal structure and absence of coarse, internal canals, Munich Museum, ×1; *c,* photomicrograph of coarse trabs and dendroclones in silicified holotype, ×25 (Rauff, 1895).

Edriospongia Ulrich & Everett in Miller, 1889, p. 159 [**E. basalis;* OD]. Massive, irregular; skeletal canals partly radial, following dendroclone rows, partly irregular; poorly known and probably an aberrant *Anthaspidella* or *Streptosolen. Middle Ordovician–Upper Ordovician:* USA (Illinois).——Fig. 76,*2a–c.* **E. basalis,* Platteville Limestone, Chazyan, Dixon; *a,* side view of irregularly massive, columnar-appearing holotype, below overgrowing *Anthaspidella,* ×1; *b,* polished surface through smaller specimen showing its radial skeleton and canal structure, ×1; *c,* thin section of skeleton made of thin dendroclones that unite to form coarser, rodlike trabs, ×18 (Ulrich & Everett, 1890).

Eospongia Billings, 1861, p. 18 [**E. roemeri* Billings, 1861, p. 19; SD S. A. Miller, 1889, p. 159]. Pear- or club-shaped sponge; upper surface convex with central depression about one-third diameter of sponge into which vertical, exhalant canals open; inhalant canals regular to irregular for family, connecting to axial, exhalant cluster or emptying horizontally into cloaca; *E. varians,* second of two original species, broadly conical with sinuous, branching, horizontal, exhalant canals convergent upon central depression. [Differs from *Exochopora,* if at all, in the absence of a deep cloaca, it being

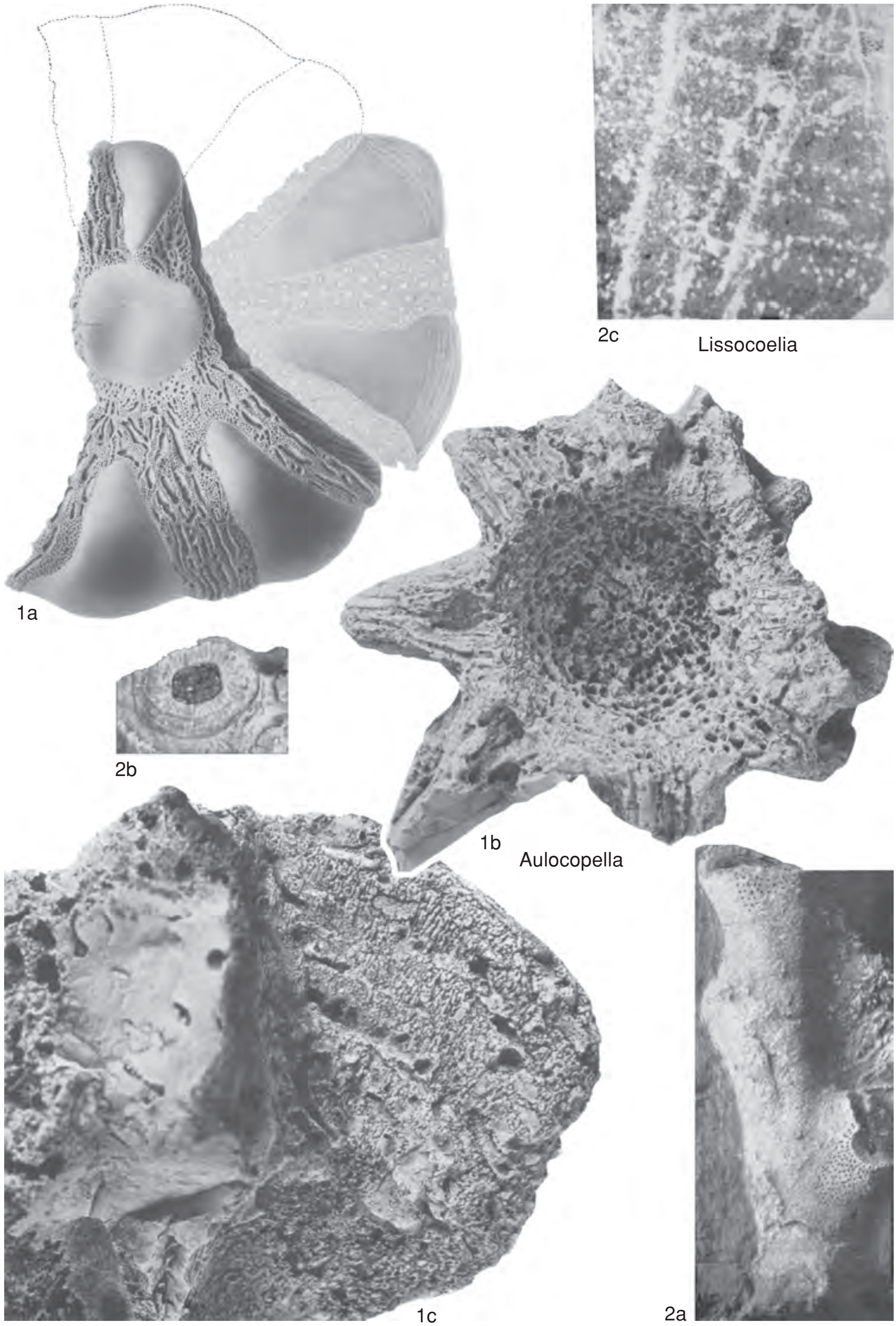

FIG. 77. Streptosolenidae (p. 108–112).

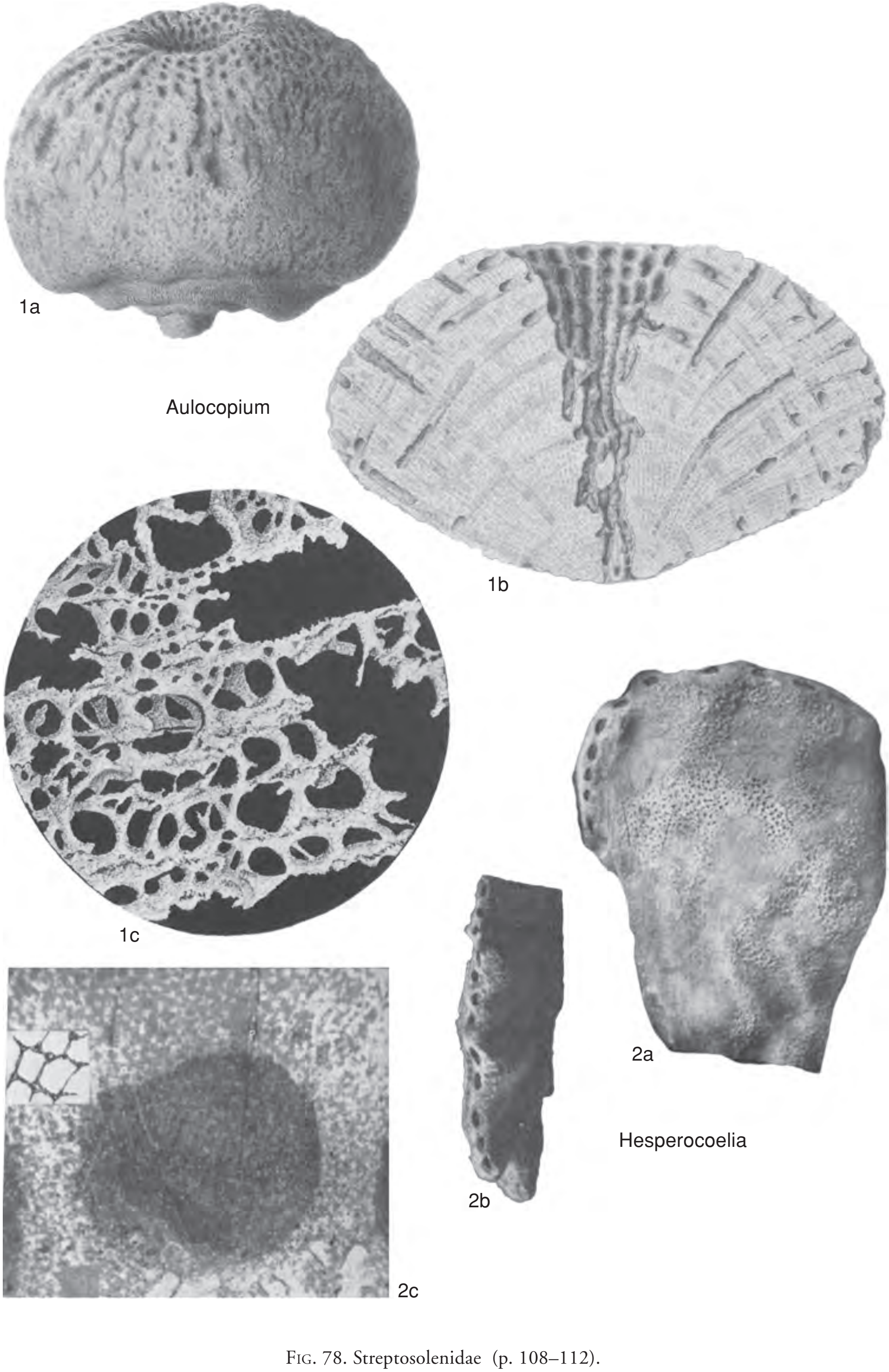

FIG. 78. Streptosolenidae (p. 108–112).

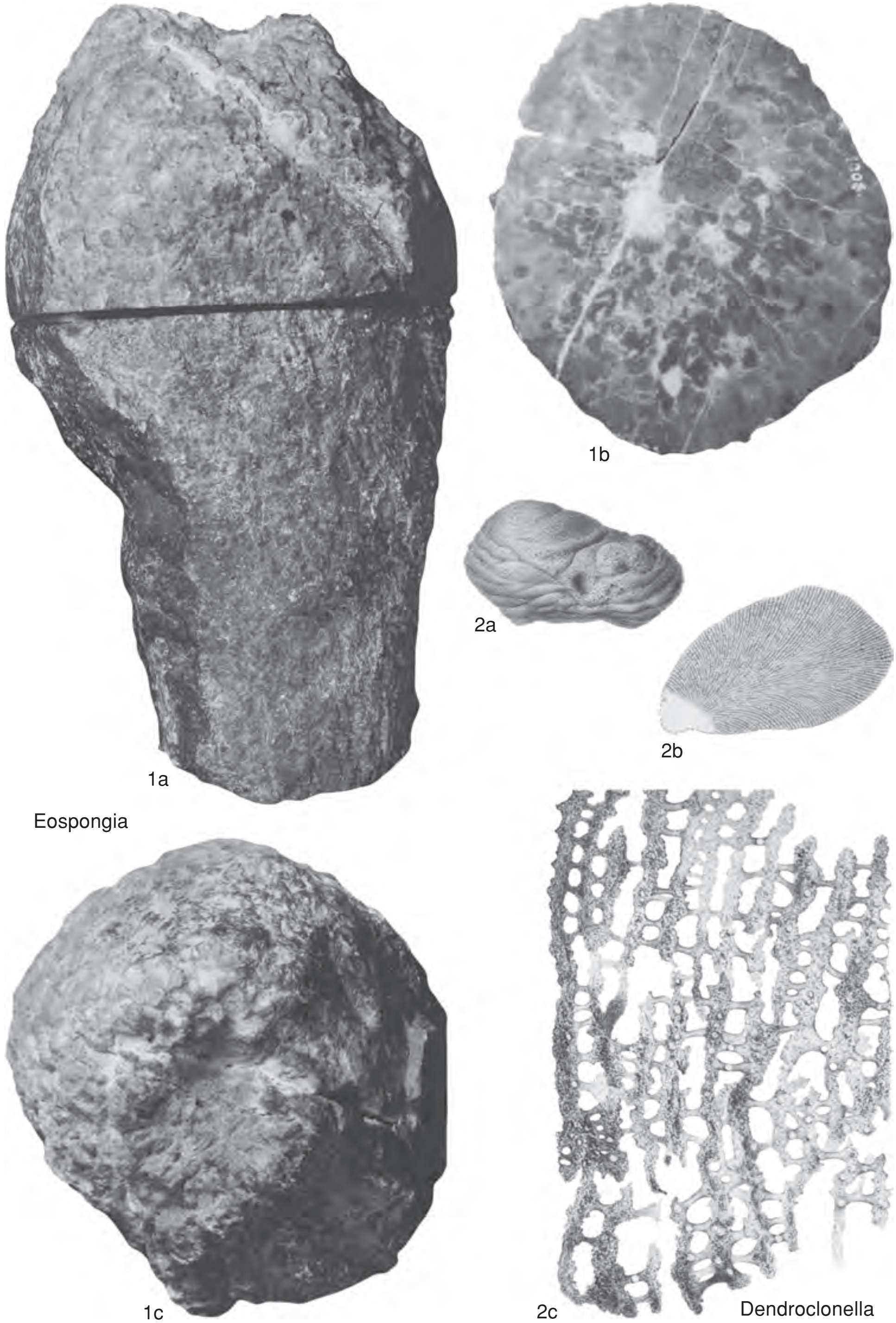

FIG. 79. Streptosolenidae (p. 108–112).

replaced by closely packed, vertical canals in the lower part of the sponge, and in absence of vertical superposition of radial canals.] *Lower Ordovician–Middle Ordovician:* Argentina, *Lower Ordovician*; North America, northern Europe, *Middle Ordovician.*——FIG. 79,*1a–c.* *E. roemeri,* Mingan Formation, Chazyan, Mingan Islands, Canada; *a,* side view of steeply obconical to club-shaped holotype in which canals show as dark, matrix fillings on side and rounded summit, ×1; *b,* polished, transverse section showing coarsely tubular, vertical, exhalant canals as dark matrix fills that interrupt medium gray skeletal net in calcareous replacement, ×1; *c,* view of rounded summit with irregular, central depression surrounded by coarse ostia of vertical, exhalant canals, GSC 11008a, b, ×1 (Rigby & Desrochers, 1995).

Gallatinospongia OKULITCH & BELL, 1955, p. 460 [**G. conica* OKULITCH & BELL, 1955, p. 461; OD]. Broad, thin-walled, open cone or cup; outer half of body wall filled with closely packed, radial canals perpendicular to outer surface, inner half of wall packed with canals of similar size that appear to bend upwardly and inwardly to cloacal surface; spicules poorly preserved but appear to be dendroclones organized into ladderlike rows that form walls of skeletal canals. [Genus is similar to *Trachyum* in gross morphology; it resembles both *Trachyum* and *Archaeoscyphia* in the thinness of the wall and in the fineness and subparallel nature of the canals but without the vertical slitlike coalescence of canals. *Orlinocyathus* KRASNOPEEVA in VOLOGDIN, 1962, p. 126, may be a poorly known synonym.] *Upper Cambrian:* USA (Wyoming, ?California).——FIG. 80,*2a–c.* **G. conica,* Gallatin Formation, Franconian, Wind River Mountains, Wyoming; *a,* longitudinal, polished section of holotype showing obconical form and canals and structure of thin walls, ×1; *b,* polished transverse section of holotype with large spongocoel and thin walls with radial canals in outer part, ×1; *c,* photomicrograph of inner part of wall of holotype with coarse, rodlike trabs connected by thin, runglike dendroclones, UBC C108, ×18 (Okulitch & Bell, 1955).

Hesperocoelia BASSLER, 1927, p. 393 [**H. typicalis;* OD]. Flabellate to frondose; both sides bearing numerous small pores; larger, presumably exhalant, medial, longitudinal canals parallel flat sides open on upper edge in row of elliptical oscula. *Middle Ordovician:* USA (Nevada, California). ——FIG. 78,*2a–c.* **H. typicalis,* Antelope Valley Limestone, Whiterockian, Ikes Canyon, Toquima Range, Nevada; *a,* bladelike holotype with ostia of several coarse, exhalant, longitudinal canals visible along margin, ×1; *b,* view down on upper end of thin sponge showing exhalant ostia, ×1; *c,* transverse section through exhalant canal and associated skeletal net (enlarged to ×30 in small sketch), ×9 (Bassler, 1941).

Hudsonospongia RAYMOND & OKULITCH, 1940, p. 203 [**H. cyclostoma* RAYMOND & OKULITCH, 1940, p. 204; OD]. Pyriform to broadly obconical, and unbranched; upper surface with a central, cloacal depression of varying depth and common, axial cluster of vertical, exhalant canals toward which converge other exhalant canals from outer part of sponge in radial structure, although regular radial partitions of *Zittelella* are absent; less common upwardly and outwardly divergent canals are parallel to divergent trabs of anthaspidellid skeleton in which I-shaped dendroclones are dominant. *Lower Ordovician–Upper Ordovician:* Argentina, China (Xinjiang), *Lower Ordovician;* North America, *Middle Ordovician;* Australia, northern Europe, USA (Tennessee, ?Utah), *Upper Ordovician.*——FIG. 81*a–b.* **H. cyclostoma,* Lenoir Limestone, Caradoc, Knoxville, Tennessee, USA; *a,* side view of steeply obconical holotype with microsculpture of vertical tracts of trabs separated by vertical stacks of inhalant ostia, MCZ 9339, ×1; *b,* transverse section showing radial canals and dendroclone-based skeleton in thick walls around central spongocoel, ×5 (Raymond & Okulitch, 1940; courtesy of Harvard University and Museum of Comparative Zoology).——FIG. 81*c. H. minganensis* RAYMOND & OKULITCH, Mingan Formation, Chazyan, Mingan Islands, Canada; side view of obconical sponge with thick walls, marked by irregular canals and shallow spongocoel, GSC 11148, ×1 (Rigby & Desrochers, 1995).——FIG. 81*d. H. irregularis* RAYMOND & OKULITCH, Mingan Formation, Chazyan, Mingan Islands, Canada; vertical view of lobate reference specimen with small, shallow spongocoel and numerous radial canals on oscular margins, GSC 11117, ×1 (Rigby & Desrochers, 1995).

Lissocoelia BASSLER, 1927, p. 392 [**L. ramosa;* OD] [?=*Ozarkocoelia* CULLISON, 1944, p. 47 (type, *O. irregularis,* OD)]. Cylindrical and branching, central cloaca extending full length of branches; outer surface smooth or with low, transverse elevations; major skeletal pores and associated radial canals relatively small, skeleton of irregularly arranged dendroclones. *Lower Ordovician–Middle Ordovician:* North America, Argentina, Netherlands (from glacial drift, presumably derived from the Baltic region).——FIG. 77,*2a–c.* **L. ramosa,* Antelope Valley Limestone, Whiterockian, Ikes Canyon, Toquima Range, Nevada, USA; *a,* side view of branched holotype with some small, inhalant ostia emphasized to show their distribution, ×1; *b,* view of upper, fractured end showing radial canals and skeletal structure in thin walls around central spongocoel, USNM 79636, ×1; *c,* photomicrograph of vertical section showing diverging, rodlike trabs cross connected by runglike dendroclones, ×20 (Bassler, 1941).

?Orlinocyathus KRASNOPEEVA in VOLOGDIN, 1962, p. 131 (KRASNOPEEVA in VOLOGDIN, 1956, p. 878, *nom. nud.*) [**O. olgae;* OD]. Thin-walled, steeply obconical, small form with broad spongocoel; skeletal elements rodlike bundles of fibers that are approximately 0.05 mm thick, bundles rising

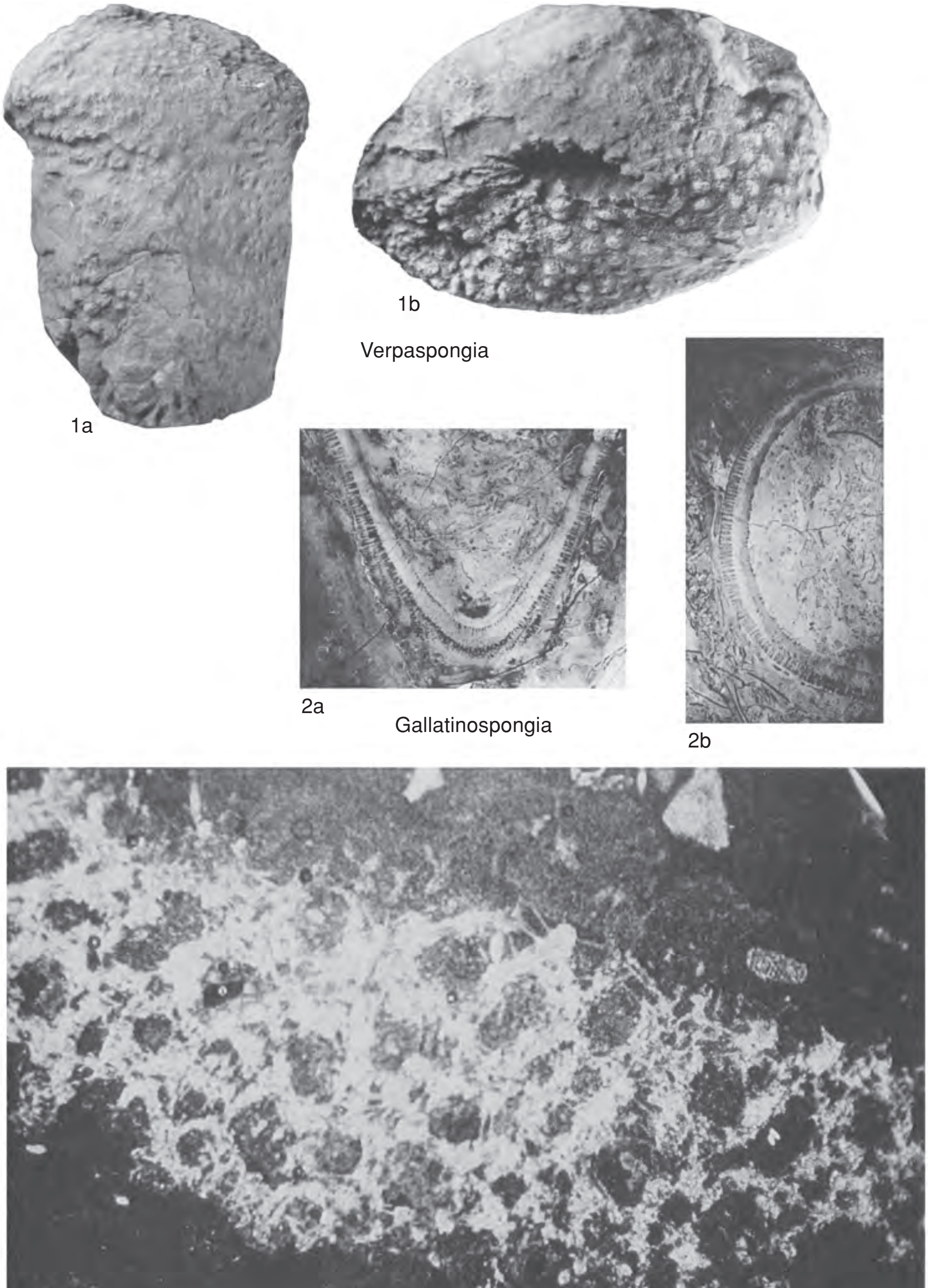

FIG. 80. Streptosolenidae (p. 112–118).

FIG. 81. Streptosolenidae (p. 112).

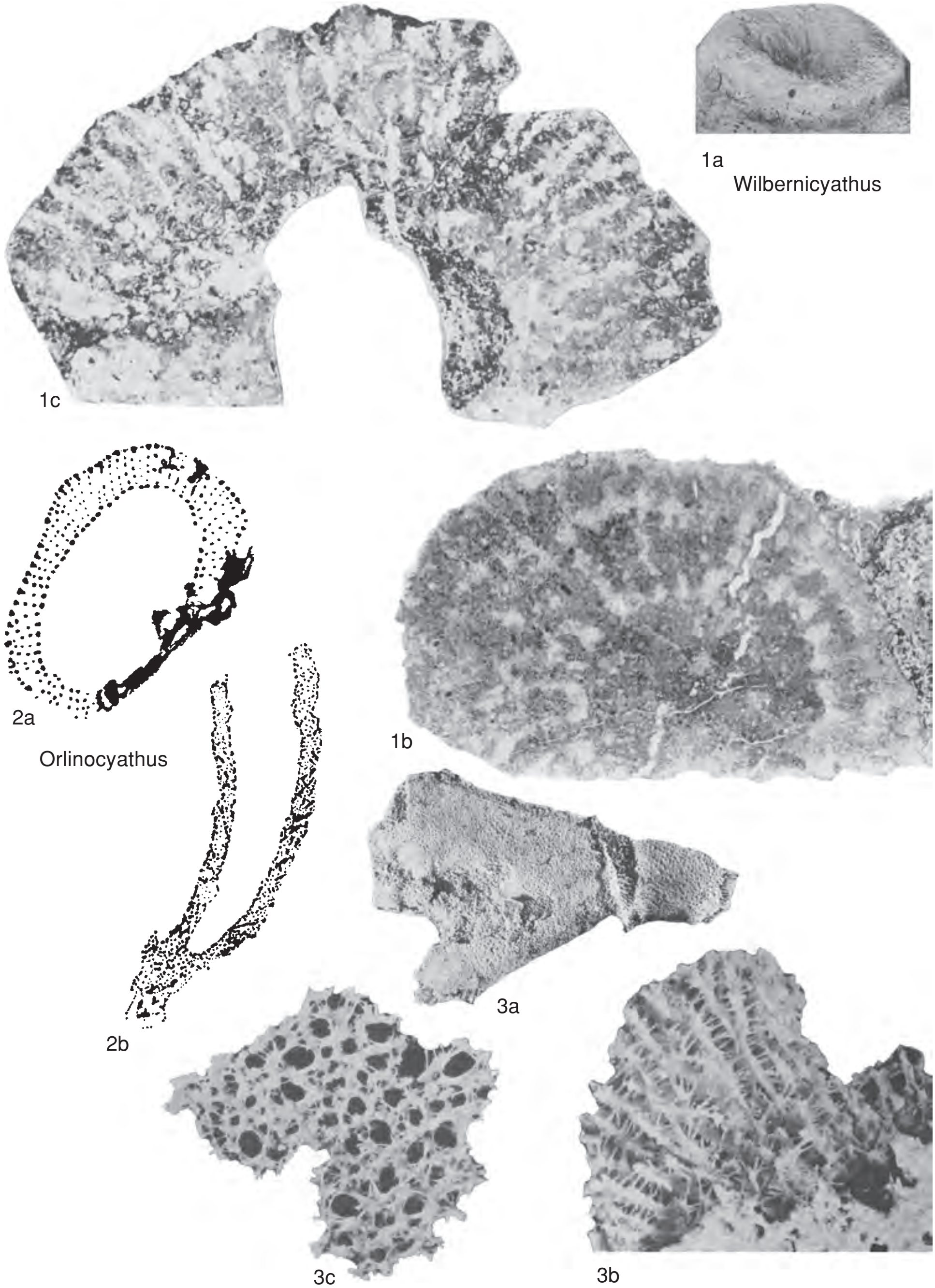

FIG. 82. Streptosolenidae (p. 112–118).

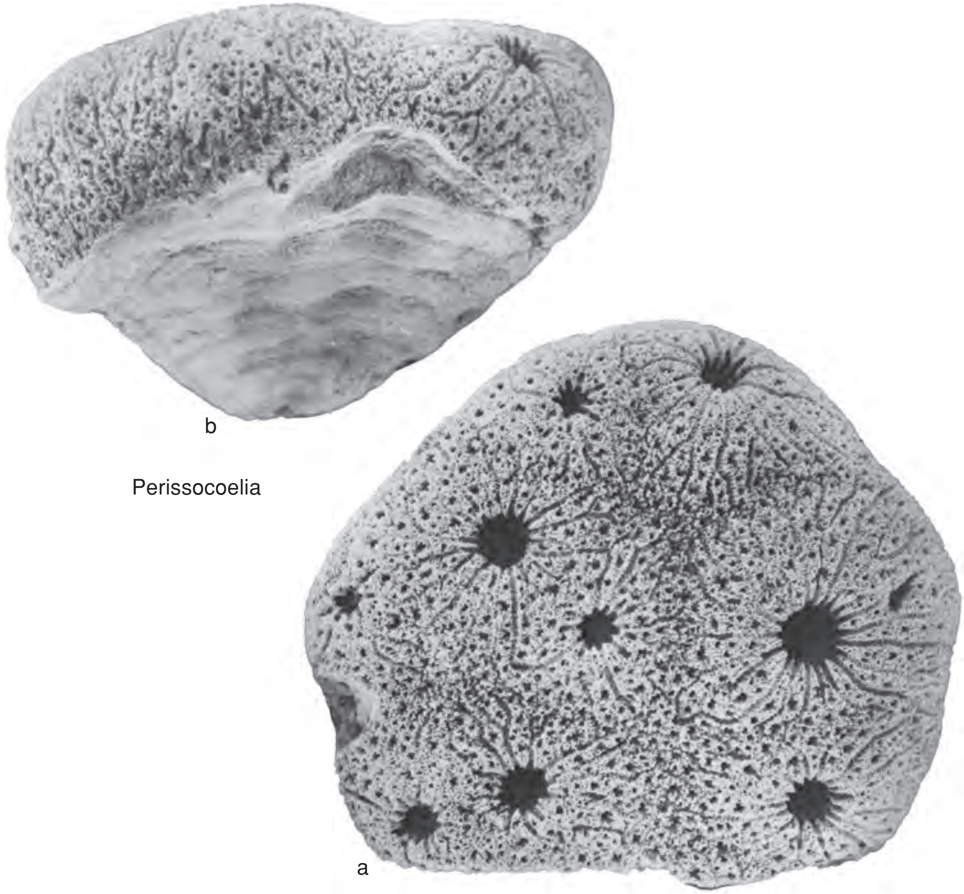

FIG. 83. Streptosolenidae (p. 116–117).

steeply in gastral part of wall and curving outwardly to become radial in dermal part of wall; walls apparently include large, reticulate pores or canals. [Classification of the genus and inclusion in the family are questionable because the skeleteal structure of the type species is uncertain, although HILL (1972, p. 142) considered it to be a probable sponge of the Archaeoscyphidae RAUFF. The genus may be a junior synonym of *Gallatinospongia* OKULITCH & BELL, 1955.] *Upper Cambrian:* Russia (Siberia, Salair).——FIG. 82,*2a–b*. **O. olgae,* Orlinaya Gora horizon, Salair, Siberia; *a,* longitudinal section showing thin walls and broad spongocoel, approximately ×2; *b,* transverse section showing radial structure of pores or canals in thin wall, ×5 (Vologdin, 1962).

?Ozarkocoelia CULLISON, 1944, p. 47 [**O. irregularis;* OD]. Differs from typical *Lissocoelia* in nondichotomous branching, in presence of small, irregularly shaped, transverse prominences on outer surface, in somewhat larger, less uniform, and less regularly distributed, skeletal pores on exterior, and in a strongly divergent, skeletal structure more regular than in smaller, related *Lissocoelia.* [These differences are questionably of generic rank.] *Lower Ordovician:* USA (Missouri, Texas, ?Colorado).——FIG. 82,*3a–c.* **O. irregularis,* Rich Fountain Formation, Phelps County, Missouri; *a,* side view of branched holotype with fine-textured, dermal layer, ×1; *b,* radiate trabs and cross-connecting dendroclones, lower right of holotype, ×10; *c,* photomicrograph of outer wall of fragment from holotype, rodlike trabs connected by thin, I-shaped dendroclones, YPM 17136, ×10 (Cullison, 1944).

Perissocoelia RIGBY & WEBBY, 1988, p. 32 [**P. habra;* OD]. Stalked to irregularly massive with numerous conical, oscular depressions on convex crest, with associated, convergent, astrorhiza-like canals on upper surface and as stacked, arcuate canals in interior, canals rising upwardly and inwardly in lower part of sponge; base of each oscular pit with

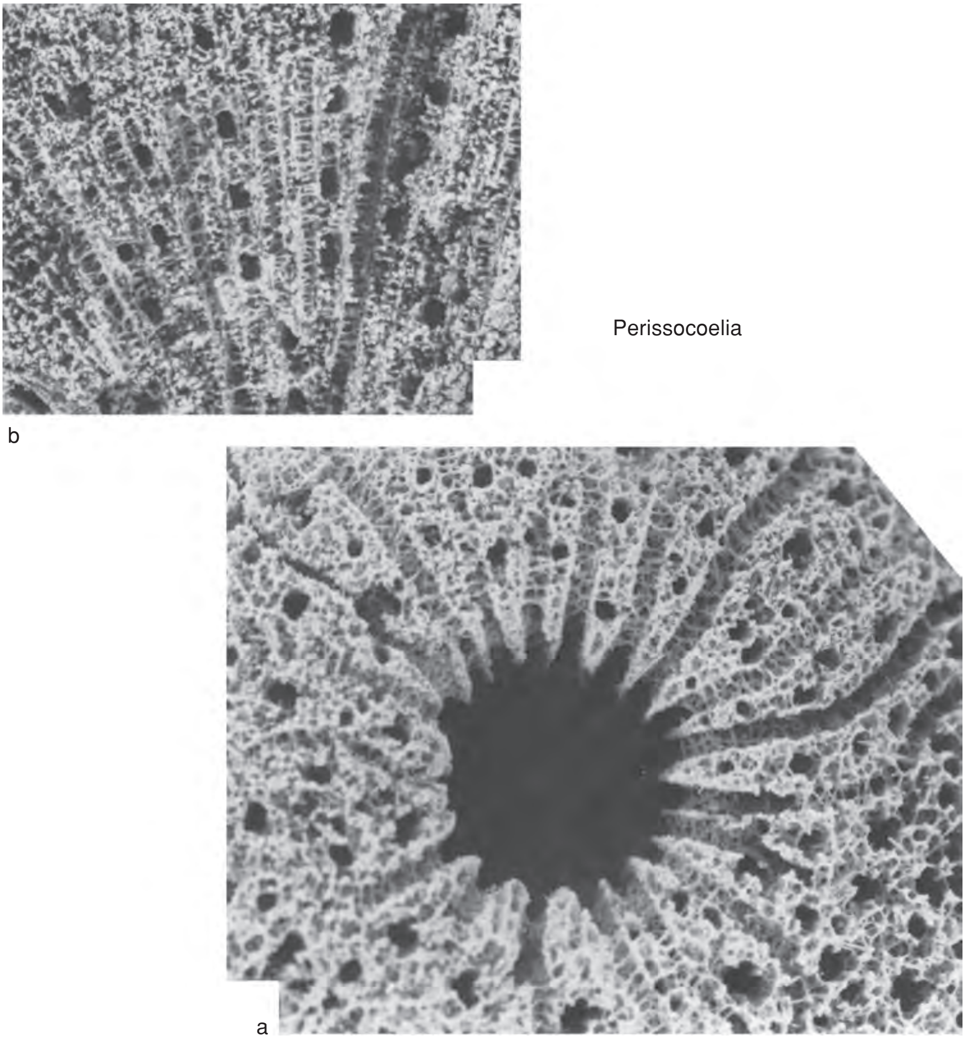

FIG. 84. Streptosolenidae (p. 116–117).

cluster of excurrent canals; discontinuous trabs radiating upwardly from near base, spicules mainly dendroclones but small rhizoclones may occur irregularly throughout; dense, basal, dermal layer. *Upper Ordovician–Silurian (Wenlock–Ludlow):* Australia (New South Wales), northern Europe, *Upper Ordovician;* Canada (Northwest Territories, Baillie-Hamilton and Cornwallis Islands), *Wenlock–Ludlow.*——FIG. 83*a–b.* **P. habra,* Malongulli Formation, Caradoc–Ashgill, Belubula River area, New South Wales, Australia; *a,* summit of hemispherical holotype with numerous deep, oscular depressions surrounded by convergent, subtangential, radial canals, smaller oscula are subvertical, inhalant canals that are parallel trabs of skeleton, ×2; *b,* side view of holotype with dense, dermal layer in lower part, ×2 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).——FIG. 84*a–b.* **P. habra,* Malongulli Formation, Caradoc–Ashgill, Belubula River area, New South Wales, Australia; *a,* photomicrograph of deep, oscular depression with almost septate-appearing margin, and surrounding convergent, tangential, exhalant canals, dendroclones of skeletal net show in some of canals and intervening skeletal tracts, which are also perforated by small, inhalant canals, ×8; *b,* photomicrograph of endosomal skeleton showing prominent, rodlike trabs and runglike dendroclones with long, smooth shafts, AMu F66808, ×6 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Verpaspongia Johns, 1994, p. 110 [**V. nodosa;* OD]. Cylindrical with nodose exterior, vertical, excurrent canals emptying into shallow spongocoel, radial canals absent but large, concentric canals irregularly present throughout; skeletal net complex with polyclonid spicules, net becoming more dense toward dermal surface. *Middle Ordovician:* USA (Nevada).——Fig. 80,*1a–b.* **V. nodosa,* Antelope Valley Limestone, Ikes Canyon, Toquima Range, holotype; *a,* side view showing subcylindrical form and nodose, dermal layer, ×1; *b,* summit with small spongocoel and nodes on oscular margins, UT 1767TX7, ×2 (Johns, 1994; courtesy of Nevada Bureau of Mines and Geology).

Wilbernicyathus Wilson, 1950, p. 591 [**W. donegani;* OD]. Possibly an open cup, small, perhaps with a concave base, wall may or may not be relatively thick (originally described as a volcano-like mound but may have been upside down), and seeming thickness of wall may have resulted from curvature of wall across plane of section); possible rows of dendroclones radial with respect to axis of sponge. [Poorly known, but may be related to *Gallatinospongia* and *Trachyum.*] *Upper Cambrian:* USA (Texas).——Fig. 82,*1a–c.* **W. donegoni,* Wilberns Formation, McCulloch County; *a,* side view of plaster cast of holotype, ×2; *b,* transverse thin section of holotype with prominent, radiating trabs cross connected by runglike dendroclones, CW-350, ×10; *c,* thin section of reference specimen showing radiating trabs connected by dendroclones, CW-351, ×5 (Wilson, 1950).

Family CHIASTOCLONELLIDAE Rauff, 1895

[Chiastoclonellidae Rauff, 1895, p. 243]

Principal spicules chiastoclones; major skeletal canals radial; sponge massive; attached to substrate basally by overgrowth; imperforate, concentrically wrinkled, basal layer often present. *Silurian (Wenlock)–Permian (Changhsingian).*

Chiastoclonella Rauff, 1894, pl. 17 [**C. headi;* OD; Rauff, 1895, p. 244] [=*Anomoclonella* Rauff, 1895, p. 226 (type, *A. zittelli,* SD de Laubenfels, 1955, p. 64); *Pycnopegma* Rauff, 1895, p. 232 (type, *P. pileum* Rauff, 1895, p. 233, SD de Laubenfels, 1955, p. 64)]. Spheroidal to fungiform, with convex, upper surface overhanging lower; surface relatively smooth, without cloaca, exhalant grooves, or notably differentiated exhalant openings; skeletal canals and obscure spicule rows radiating from a point within base of sponge and perpendicular to sponge surface; spicules chiastoclones, often quite irregular, with a minority of dendroclones. [May be related to *Dendroclonella* Rauff. Type species is figured in Rauff, 1894, but described and figured in Rauff, 1895.] *Upper Ordovician–Silurian (Ludlow):* Germany (Island of Sylt, and elsewhere in northern Europe as glacial drift, presumably from the Baltic region), *Upper Ordovician;* USA (Tennessee), *Wenlock–Ludlow.*——Fig. 85,*1a–c.* **C. headi,* Brownsport Limestone, middle Silurian, Decatur County, Tennessee; *a,* side view of characteristic specimen with wrinkled exterior, ×1; *b,* median, vertical section of smaller sponge showing radiate architecture of canals and skeleton, ×1; *c,* drawing of chiastoclones and their relationships, ×100 (Rauff, 1895).

Actinocoelia Finks, 1960, p. 70 [**A. maeandrina;* OD]. Spheroidal to flabellate or cylindroidal; large, radial canals and deep, anastomosing clefts perpendicular to surface penetrating sponge interior and reducing skeleton to narrow trabeculae between radial spaces; spicules are dendroclones to chiastoclones without clear orientation; radially oriented, smooth monaxons also present in one species. [Appears to be more closely related to *Defordia* than to other genera.] *Permian (Artinskian–Changhsingian):* USA (western states), *Artinskian–Capitanian;* China (Guangxi), *Changhsingian.*——Fig. 85,*2a–e.* **A. maeandrina,* San Andreas Formation, Leonardian–Guadalupian, Guadalupe Mountains, New Mexico; *a,* side view of holotype with coarse, skeletal tracts or trabeculae separated by coarse, divergent, anastomosing canals and less obvious, concentric, cross-connecting canals, ×1; *b–d,* outline drawings of spicules from holotype, USNM 127611, ×40; *e,* side view of smaller, cylindrical paratype showing outer terminations of both skeletal trabeculae and intervening canals, PU 78882, ×1 (Finks, 1960; courtesy of The American Museum of Natural History).

Allassospongia Rigby, 1986b, p. 26 [**A. polystromne* Rigby, 1986b, p. 27; OD]. Small, cylindrical sponges without spongocoel, but with generally axial cluster of discontinuous to continuous, excurrent canals; skeletal net of alternating, dense layers of individually thickened spicules and open layers of thin spicules; dominant spicules chiastoclones with less common dendroclones and rhizoclones; skeleton not strongly organized and without distinct linear or radiating patterns; dermal layer as dense layers of interior, where elements of individual spicules two or three times diameter of those on smaller, interior spicules. *Devonian (Frasnian):* Australia (Western Australia, Canning basin).——Fig. 86,*1a–f.* **A. polystromne,* Sadler Limestone, Sadler Ridge, Western Australia; *a,* side view of cylindrical holotype with layers of alternating density of spiculation, ×2; *b,* holotype from above with layered skeleton and small, exhalant canals in lower left; ×2; *c–f,* camera lucida drawings of isolated spicules from holotype including robust oxea, knobby strongyle, and more common chiastoclones with smooth shafts and branched terminations, GSWA F7197, ×50 (Rigby, 1986b).

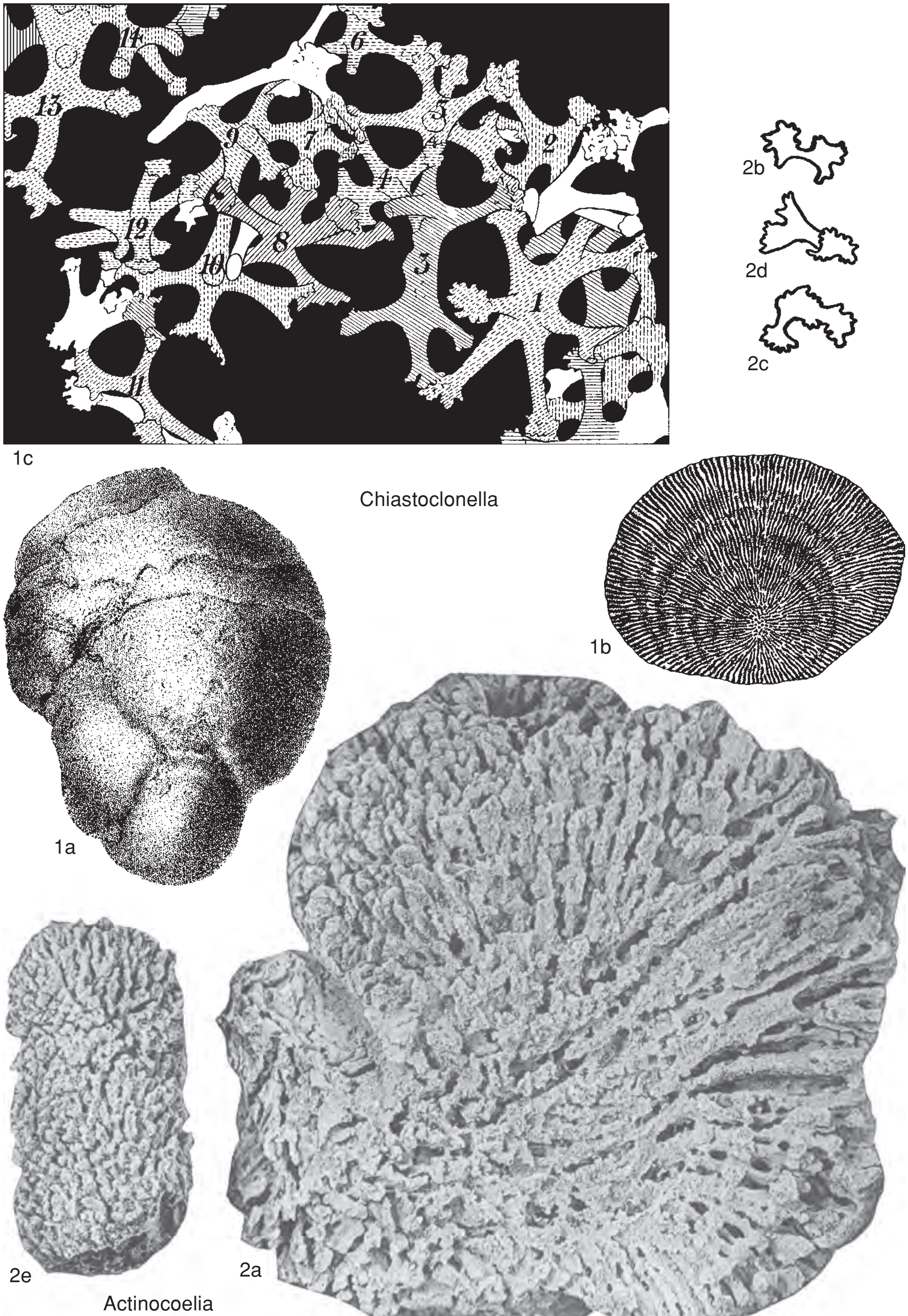

FIG. 85. Chiastoclonellidae (p. 118).

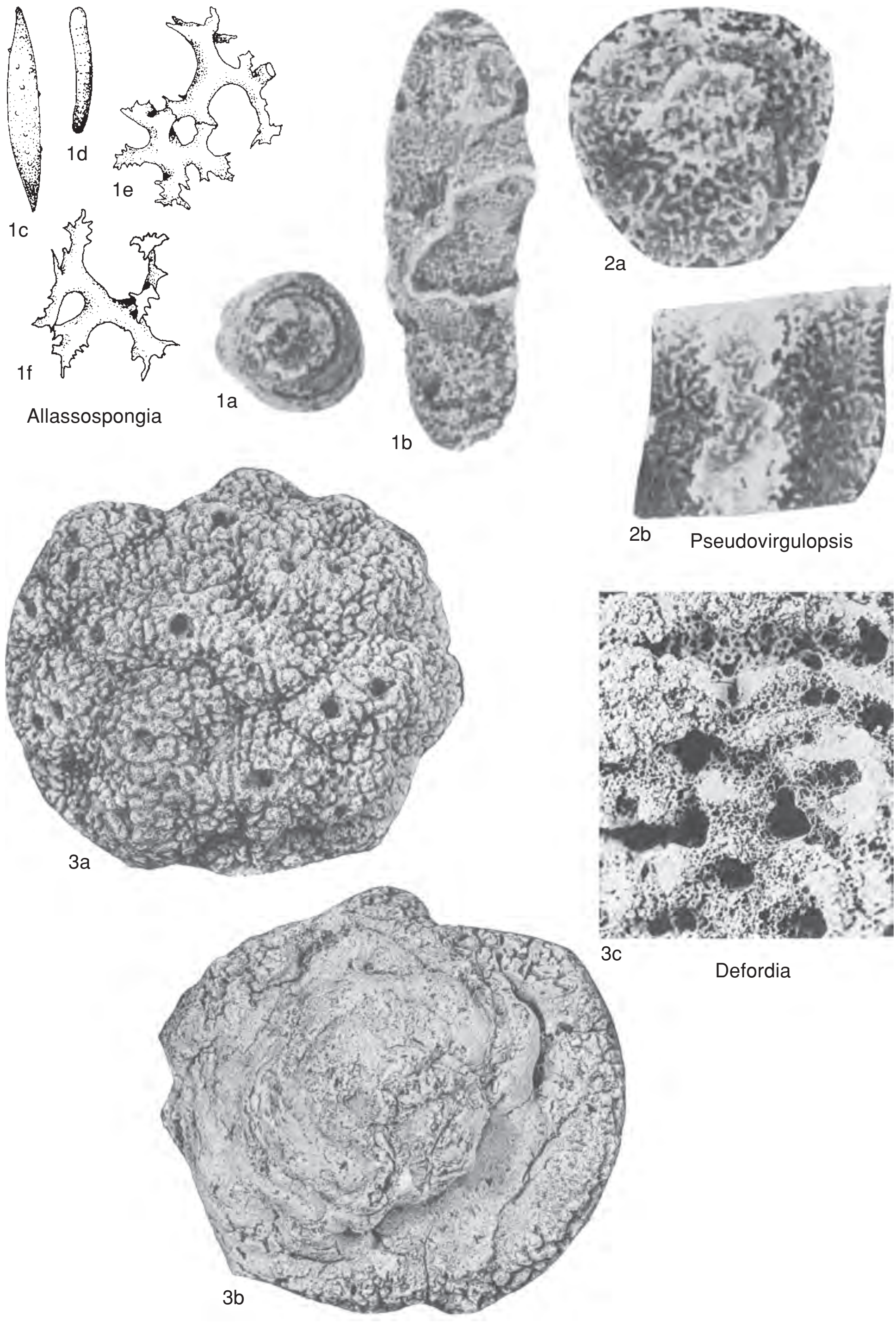

FIG. 86. Chiastoclonellidae (p. 118–123).

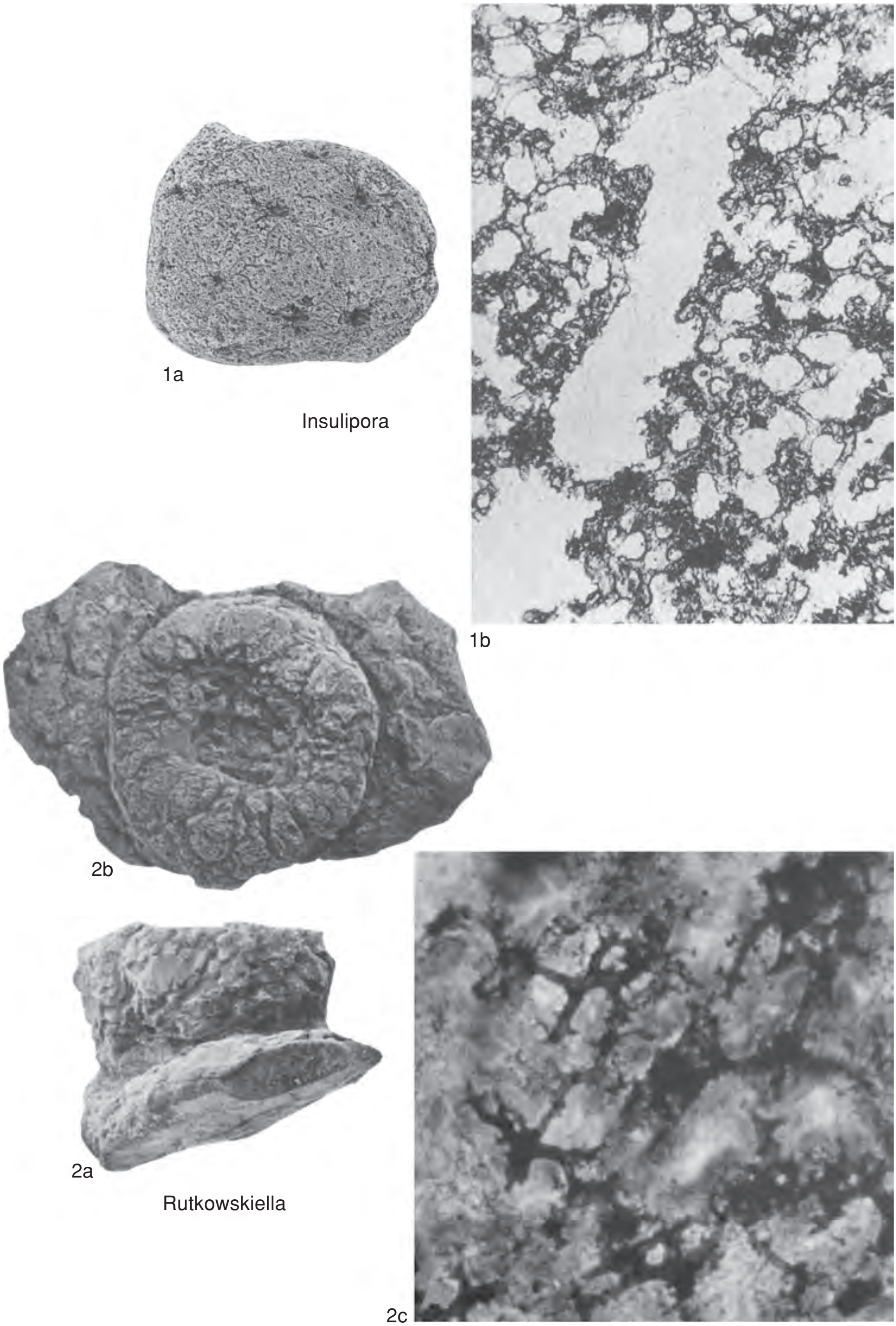

FIG. 87. Chiastoclonellidae (p. 122–124).

FIG. 88. Chiastoclonellidae (p. 124).

Defordia KING, 1943, p. 16 [*D. defuncta* KING, 1943, p. 17; OD]. Massive, spheroidal to lobate or fungiform, with convex, upper surface overhanging concentrically wrinkled, imperforate, basal surface; upper surface bearing large oscules and evenly spaced, smaller ostia, with anastomosing, sometimes deep grooves that connect ostia and converge on oscules; interior canals radial and concentric; spicules ranging from dendroclones to chiastoclones and are not clearly organized into rows. *Permian (?Asselian–?Sakmarian, Artinskian):* USA (Texas).——FIG. 86,*3a–c*. **D. defuncta*, Leonard and Hess Formation, Leonardian, Glass Mountains; *a,* top of topotype specimen with oscula on summits of mammilose nodes and with smaller ostia in deep grooves between, USNM 127604h, ×1, *b,* base of same sponge with wrinkled, imperforate, basal, dermal layer, ×1; *c,* enlarged, upper surface of topotype showing coarse, anastomosing tracts of chiastoclones and dendroclones, USNM 127604f, ×5 (Finks, 1960; courtesy of The American Museum of Natural History).

Insulipora FINKS, 1960, p. 64 [*I. elegans;* OD]. Spheroidal with convex, upper surface overhanging lower; upper surface bearing depressed oscules, evenly spaced, smaller ostia, and meandriform, anastomosing grooves that surround and isolate ostia; principal canals and obscure rows of chiastoclones perpendicular to surface. [Related to

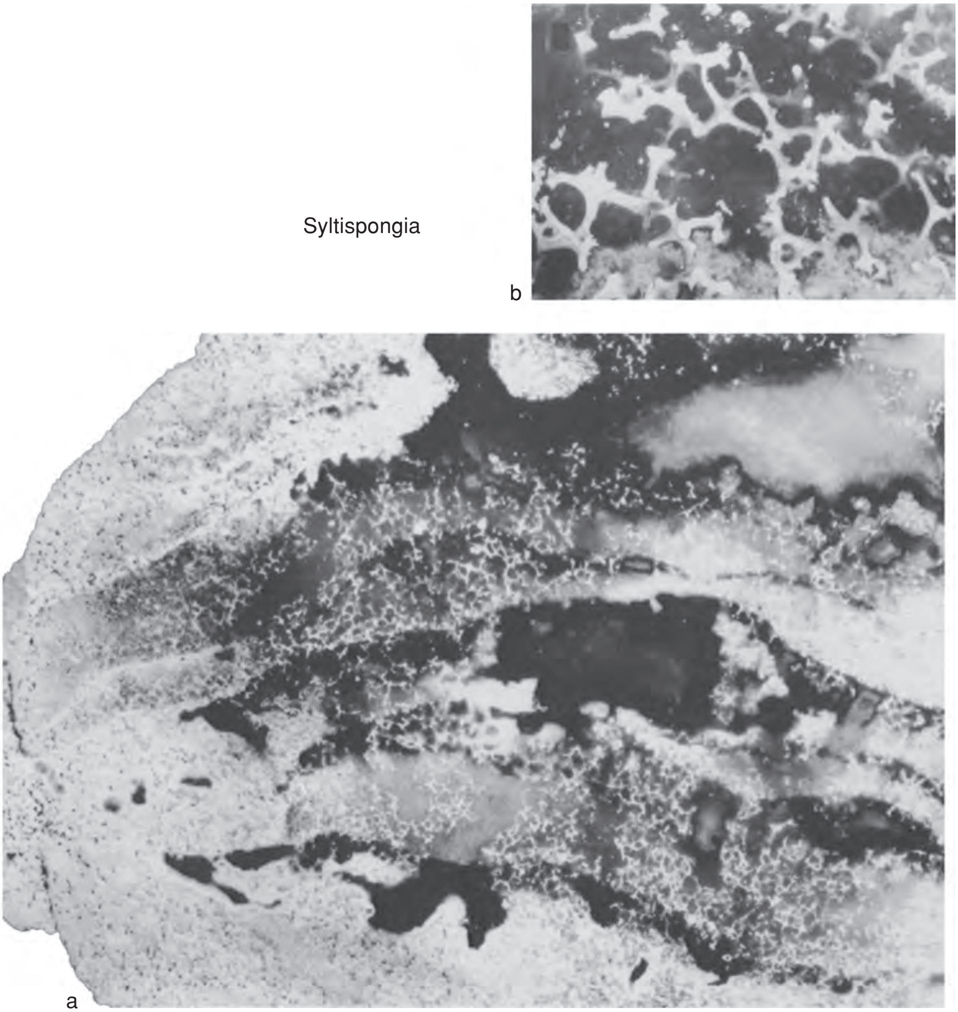

FIG. 89. Chiastoclonellidae (p. 124).

Defordia.] *Permian (Artinskian):* USA (Texas). ——FIG. 87,*1a–b.* **I. elegans,* Leonard Formation, Glass Mountains; *a,* top view of holotype showing distribution of oscula, radial canals, pores, and surface grooves, USNM 127601, ×1; *b,* photomicrograph of paratype showing skeletal net composed of chiastoclones, USNM 127602a, ×50 (Finks, 1960; courtesy of The American Museum of Natural History).

Pseudovirgulopsis DENG, 1981, p. 423 [426] [**P. solus;* OD]. Sponge branching subcylindrical with skeleton of upwardly diverging, thick tracts cross connected by transverse tracts of possible chiastoclones; canal system well defined with ascending canals commonly connected by transverse ones; skeleton of axial region more dense than in peripheral regions. *Permian (Changhsingian):* China.——FIG. 86,*2a–b.* **P. solus,* Heshan Formation, Guangxi; *a,* vertical, axial section of cylindrical holotype showing dense, axial part of skeleton, upwardly arched, skeletal tracts and small, inhalant ostia in dermal area, NIGPAS 59969, ×4; *b,* transverse sections showing differentiated, skeletal structure of axial and lateral regions, both with radially arranged, small canals, NIGPAS 59970, ×4 (Deng, 1981).

Rutkowskiella RIGBY, 1977d, p. 1,215 [**R. tumula* RIGBY, 1977d, p. 1,217; OD]. Low, conical to subcylindrical with shallow, broad spongocoel and smooth, dimpled or low-nodose exterior; intermediate-sized, radial canals subhorizontal, particularly in outer third of sponge, and connecting to larger, subvertical, excurrent canals in central part; skeleton of irregularly oriented chiastoclones, with minor rhizoclones and tetraclones; architecture only indistinctly radiating. *Devonian (Givetian):*

USA (Michigan).——FIG. 87,*2a–c.* **R. tumula,* Alpena Limestone, Alpena County; *a,* side view of holotype overgrowing tabulate coral fragment; *b,* view down into spongocoel showing large, radial canals in upper, sponge walls, ×1; *c,* photomicrograph showing irregular chiastoclones of skeletal net as limonite-stained ghosts of massive chalcedony, BYU 1480, ×50 (Rigby, 1977d).

Syltispongia VAN KEMPEN, 1990, p. 155 [**S. ingemariae;* OD]. Massive, hemispherical sponges with flattened, subcylindrical base; smooth, outer surface with a layered appearance produced by irregular layering of skeleton internally; spongocoel absent but with concentration of oscula on summit; principal canals in interior loosely organized into discontinuous, irregularly ascending canals and concentric canals; skeleton of irregularly oriented chiastoclones that in some places have a linear tendency that produces simple, discontinuous, upwardly flaring strands; monaxons occurring as minor component and form cores of sections of more complex strands; sponge without differentiated dermal layer. [The unique layering of internal skeleton and development of anthaspidellid-like, skeletal strands cored by monaxons distinguish the genus from other chiastoclonellid sponges.] *Upper Ordovician:* Germany (Island of Sylt, from glacial erratic, presumably from the Baltic region).——FIG. 88*a–b.* **S. ingemariae,* glacial erratic, ?Ordovician, Island of Sylt, the Netherlands; *a,* side view of holotype with ostia of canals between layers, AGH G 50; *b,* holotype from above without major, coarse canals and spongocoel, ×1 (van Kempen, 1990).——FIG. 89*a–b.* **S. ingemariae,* glacial erratic, ?Ordovician, Island of Sylt, the Netherlands; *a,* photomicrograph of part of polished, vertical section showing layered skeleton of irregular chiastoclones and some irregular canals, ×4; *b,* photomicrograph of light chiastoclones embedded in transparent chalcedony, ×10 (van Kempen, 1990).

Family ANTHRACOSYCONIDAE Finks, 1960

[Anthracosyconidae FINKS, 1960, p. 76]

Dendroclones arranged with their long axes perpendicular to upper or outer surface of sponge so skeleton is built of concentric or superposed layers of such spicules; in some species spicules within a layer grouped in bundles and bearing lateral zygoses; curved, rhizoclonar spicules may outline pores and canals; sponge massive, fungiform, or digitate; attached to substrate basally by encrusting or overgrowth. *Lower Devonian–Permian (Capitanian).*

Anthracosycon GIRTY, 1909, p. 72 [**A. ficus* GIRTY, 1909, p. 73; OD] [=*Laubenfelsia* KING, 1943, p. 9 (type, *L. regularis* KING, 1943, p. 10, OD)]. Conical or fungiform; relatively flat, upper surface bearing large oscules; spicule layers parallel to upper surface, their edges exposed on sides of sponge; ostia covering entire surface and most numerous on sides; surface canals most abundant at edge of upper surface; interior canals both perpendicular and parallel to spicule layers. *Permian (Artinskian–Capitanian):* USA (Texas), Australia (Western Australia).——FIG. 90,*2a–d.* **A. ficus,* Bone Spring Limestone, Leonardian, Guadalupe Mountains, Texas; *a,* enlarged side view of holotype showing prosopores and more compact skeleton of upper surface; *b,* view of summit showing large oscules and surface canals, ×2; *c,* photomicrograph of lower side of holotype with arched layers of unbundled tetraclones where skeletal pores are separated by single spicule, ×10; *d,* photomicrograph of skeletal net near top of holotype, with bundling of some rhabdomes, USNM 118127, ×10 (Finks, 1960; courtesy of The American Museum of Natural History).

Collatipora FINKS, 1960, p. 81 [**C. discreta;* OD]. Spheroidal to hemispherical and encrusting; pores grouped in one or more sievelike clusters; remainder of surface covered with deep, anastomosing, cleftlike grooves; large oscules may also be present; spicule layers concentric and parallel to surface; interior canals both perpendicular and parallel to surface. *Permian (?Asselian–?Sakmarian, Artinskian–Capitanian):* USA (Texas).——FIG. 90,*1a–b.* **C. discreta,* Bell Canyon Formation, Guadalupian, Guadalupe Mountains; *a,* ellipsoidal holotype with two pore clusters in middle and osculum toward left, ×1; *b,* enlargement of section normal to surface, showing horizontal, spicule layers in skeleton, AMNH 28094, ×5 (Finks, 1960; courtesy of The American Museum of Natural History).

Dactylites FINKS, 1960, p. 84 [**D. micropora;* OD]. Digitate with terminal oscules; ostia uniformly distributed over entire surface; few surface grooves; spicule layers parallel to outer surface. *Permian (Artinskian):* USA (Texas).——FIG. 91,*2a–e.* **D. micropora,* Bone Spring Limestone, Sierra Diablo; *a,* side view of holotype showing digitate form, terminal osculum on one branch, and small ostia uniformly distributed over surface, ×2; *b–e,* sketches of isolated spicules from holotype, PU 78881, ×40 (Finks, 1960; courtesy of The American Museum of Natural History).

Devonospongia HOWELL, 1957c, p. 14 [**Archaeocyathus? clarkei* DE KONINCK, 1877, p. 86; OD]. Branching, cylindrical or vase-shaped, conical sponge with deep cloaca; cloaca not connected between branch and parent stock; principal canals radial and vertically superposed, forming subparallel slits by their vertical coalescence; vertical slits and rows of pores prominent on both exterior and cloacal surfaces; spicules showing knots of fusion of possible chiastoclones in type species and well-defined chiastoclones and dendroclones in *D. garrae* PICKETT & RIGBY (1983, p.

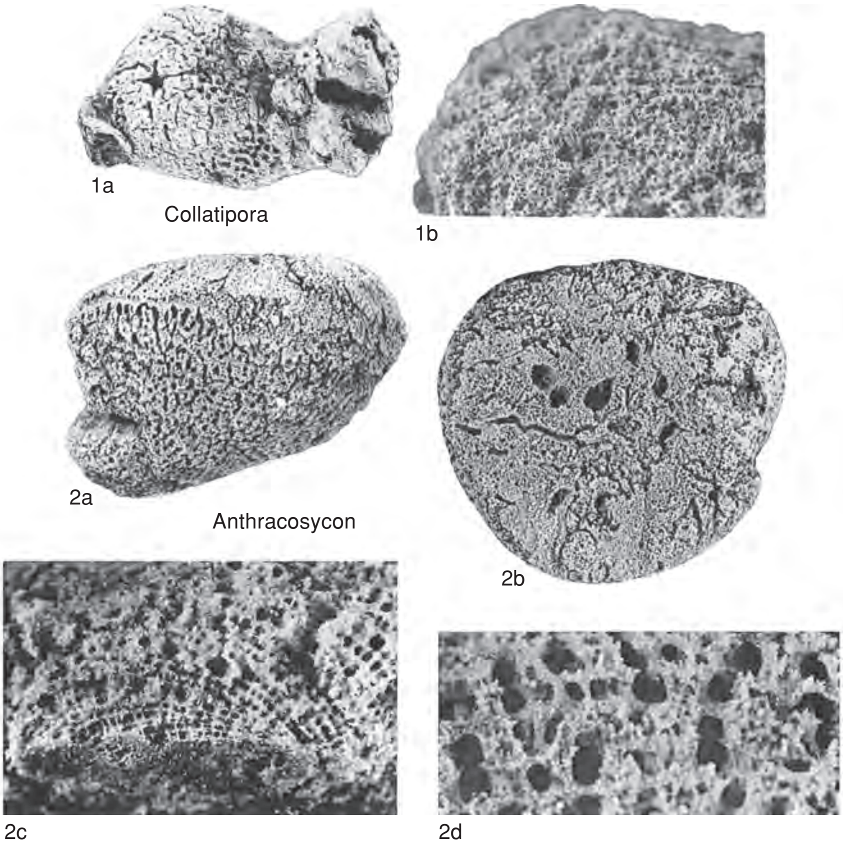

FIG. 90. Anthracosyconidae (p. 124).

726). *Lower Devonian, Middle Devonian (?Eifelian):* Australia (Western Australia, New South Wales).——FIG. 91,*1a–b.* **D. clarkei* (DE KONINCK), Sponge Limestone, ?Eifelian, Yass District, New South Wales; *a,* transverse section of lectotype showing flattened spongocoel and thin walls in dark matrix, PU 80424a, ×1 (Howell, 1957c); *b,* side view of weathered, branched, reference specimen with vertically aligned series of canals, AMu F13023, ×1 (Pickett, 1969).——FIG. 91,*1c. D. garraea* (PICKETT & RIGBY), Garra Formation, Lochkovian–Pragian, Wellington, New South Wales; electron photomicrograph of skeletal fragment in which dendroclones and a chiastoclone form knots in skeleton, MMF 25055, approximately ×100 (Pickett & Rigby, 1983).

?Laubenfelsia KING, 1943, p. 9 [**L. regularis* KING, 1943, p. 10; OD]. Differs from type of *Anthracosycon* only in absence of grouping of spicules in bundles, in larger size, and in more numerous oscules, which are no more than specific differences; here considered a junior synonym of *Anthracosycon,* and for that reason the genus is not illustrated herein. *Permian (Artinskian–Capitanian):* USA (Texas).

Family ASTYLOSPONGIIDAE Zittel, 1877

[*nom. correct.* FINKS & RIGBY, herein, *pro* Astylospongidae ZITTEL, 1877b, p. 35] [=Attungaiidae PICKETT, 1969, p. 19, *partim;* Raanespongiidae RIGBY & TERRELL, 1973, p. 1,437]

Skeleton composed of fused sphaeroclones (possible dendroclones) forming an isodictyal net with mostly triangular interspaces in all directions (ZITTEL, 1884) or by the more usual interpretation (RAUFF, 1894) of concentric layers of six-armed, anapodal spicules (dichotriders); dendroclones, or spicule arms, thin and smooth with terminal expansions for zygosis; large, smooth oxeas may lie in and parallel to radial canals; sponge shapes range from

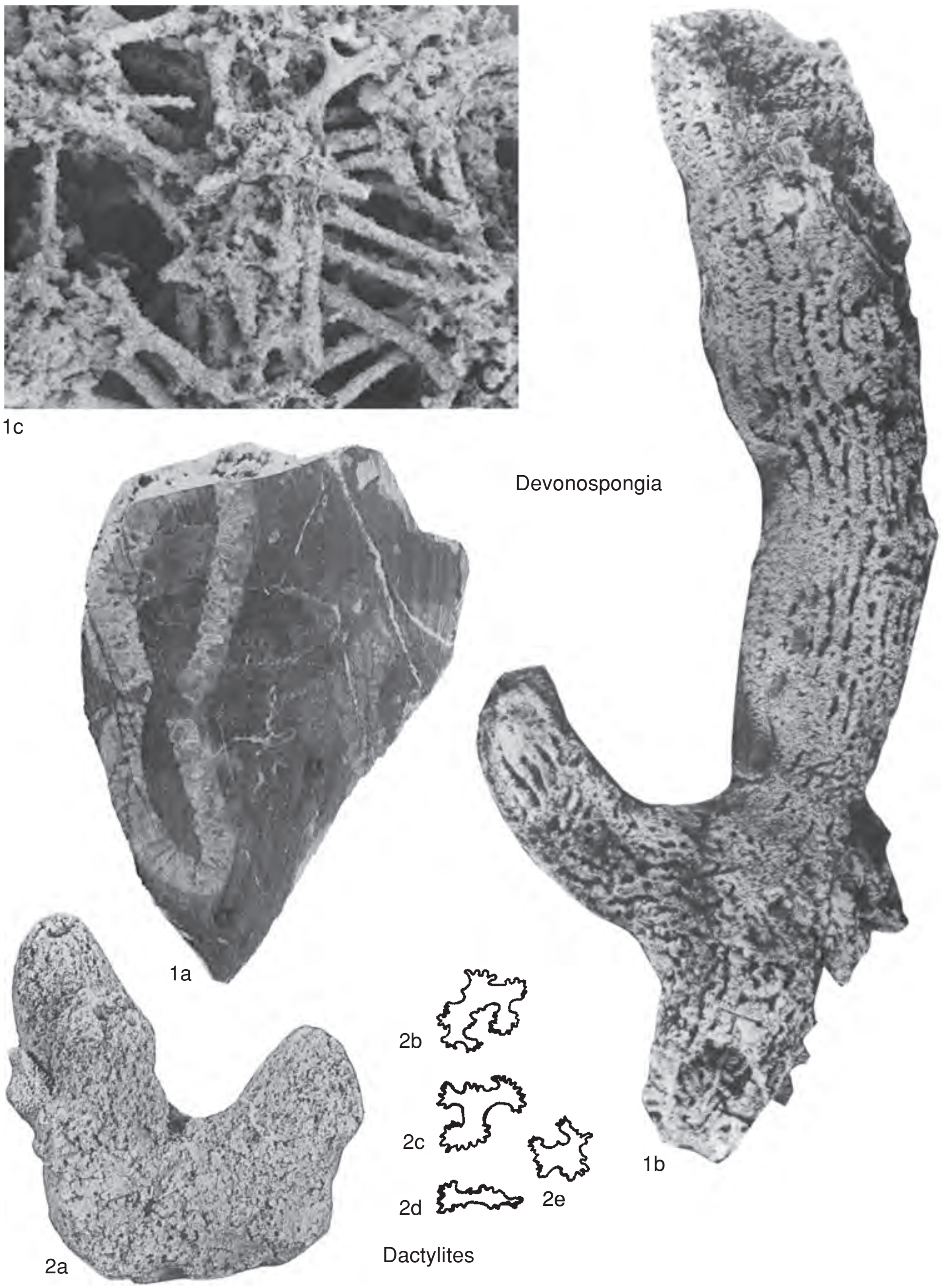

FIG. 91. Anthracosyconidae (p. 124–125).

spherical to tubular and branching. *Upper Ordovician–Permian (Roadian).*

Separation of the astylospongiids into genera was based by RAUFF (1894) on the arrangement of the canals, and the siting of the exhalant pores. This basic premise has been accepted here. The various external forms are generated by vectors of growth (see Fig. 92). Disposition of the canals results from interaction of growth with the sites of exhalant openings. Internal exhalant canals arise, in general, from the roofing over of surface grooves tributary to the exhalant pores. Thus their form is determined by the position of the surface at a given time, together with the location of their termini, the exhalant pores.

The family Attungiidae was established by Pickett (1969) for cylindrical forms with sphaeroclones. The new Devonian genera from Australia that he included in the family have spicules and a skeletal net identical to the earlier astylospongiids; and the cylindrical, tubular, or vasiform shape does not, by itself, warrant familial separation, especially as such shapes are either present or approached in many other astylospongiid genera.

Dominance of tubular forms in the Devonian seems to be a genuine phenomenon. One is also tempted to see lineages such as the Ordovician *Phialaspongia* and *Caryospongia* with their exhalant pores concentrated in meridional grooves and their strong vertical canals leading into the Devonian genus *Inglispongia.* Likewise the vasiform or cylindrical Ordovician genera *Caliculospongia* and *Camellaspongia,* with their meandriform surface grooves, may be ancestral to the Devonian *Attungaia* and *Devonoscyphia* with similar features.

The skeletal net of the astylospongiids, when viewed in transverse section, is nearly indistinguishable from that of the anthaspidellids, and indeed genera have been misassigned on the basis of single sections. The difference is that anthaspidellids have triangular interspaces only in tangential or horizontal sections, while in longitudinal and radial sections they are seen to have a ladderlike structure. The astylospongiids have triangular interspaces in all orientations. It is tempting to interpret the astylospongiid skeleton as made of separate dendroclones, as in the anthaspidellids, but attempts to demonstrate this have not been successful. Nevertheless the seemingly anapodal sphaeroclones could be the result of fusion of separate dendroclones following the deposition of each concentric, spicule layer. It would be natural for such fusion to take place about a particular center of junction of dendroclones, and the newly formed dendroclones would of necessity be on the proximal side of their junctions, assuming the underlying layer to be already fused. Thus each layer would seem to consist of anapodal spicules whose arms would be the once-separate dendroclones. It is significant that Zittel (1884) made such an interpretation of the astylospongiid skeleton, although Hinde, in discussing Zittel's view (Hinde, 1888, p. 113), believed the spicules to be polyactinal desmas, as did Rauff (1894, p. 280 ff.), who established the current interpretation of the spicule as a dichotrider or six-armed anapodal desma.

Astylospongia Roemer, 1860, p. 7 [**Siphonia praemorsa* Goldfuss, 1826, p. 17; OD]. Spheroidal with concave, exhalant depression at upper pole that meets sides of sponge in sharp rim; center of growth near center of sponge; maximum growth over entire lateral surface, which bears meridional, dendritic grooves that end at rim of exhalant depression; internal, exhalant canals are concentric and stacked in radial series, produced by roofing of surface grooves, arcuate parallel to side surface of sponge; canals open as pores in radial rows on upper, exhalant surface; internal, inhalant canals straight and radial with respect to center of growth and nearly perpendicular to outer surface; they may contain oxeas parallel their length; basal attachment absent. *Upper Ordovician–Silurian (Wenlock–Ludlow* or *Wenlock):* North America, Europe; *Lower Devonian:* Australia (New South Wales).——Fig. 93,*1a–c.* **A. praemorsa* (Goldfuss), Silurian limestone, Neustadt, Germany; *a,* side view of globular, silicified specimen with shallow spongocoel whose walls have regular, exhalant ostia of concentric canals similar to those on exterior, ×1; *b,* same specimen from above with shallow spongocoel, P-MD, ×1; *c,* vertical medial section showing concentric, exhalant canals and finer, radial, inhalant canals in alternating positions, laterally, U-SK, ×1 (Rauff, 1893).

Astyloscyphia Rigby & Pisera in Rigby & others, 2001, p. 463 [**A. irregularia;* OD]. Small, obconical to cup-shaped astylospongiids with deep spongocoel, dermal surface pierced by irregularly placed to diagonally packed canals, exhalant openings aligned in horizontal rows in diplorhysal canal pattern. Dermal and gastral layers formed of swollen sphaeroclones and interior skeleton with gentle, upward expansion; interior centra essentially same size throughout skeleton. *Upper Devonian (Frasnian):* Poland.——Fig. 93,*3a–b.*

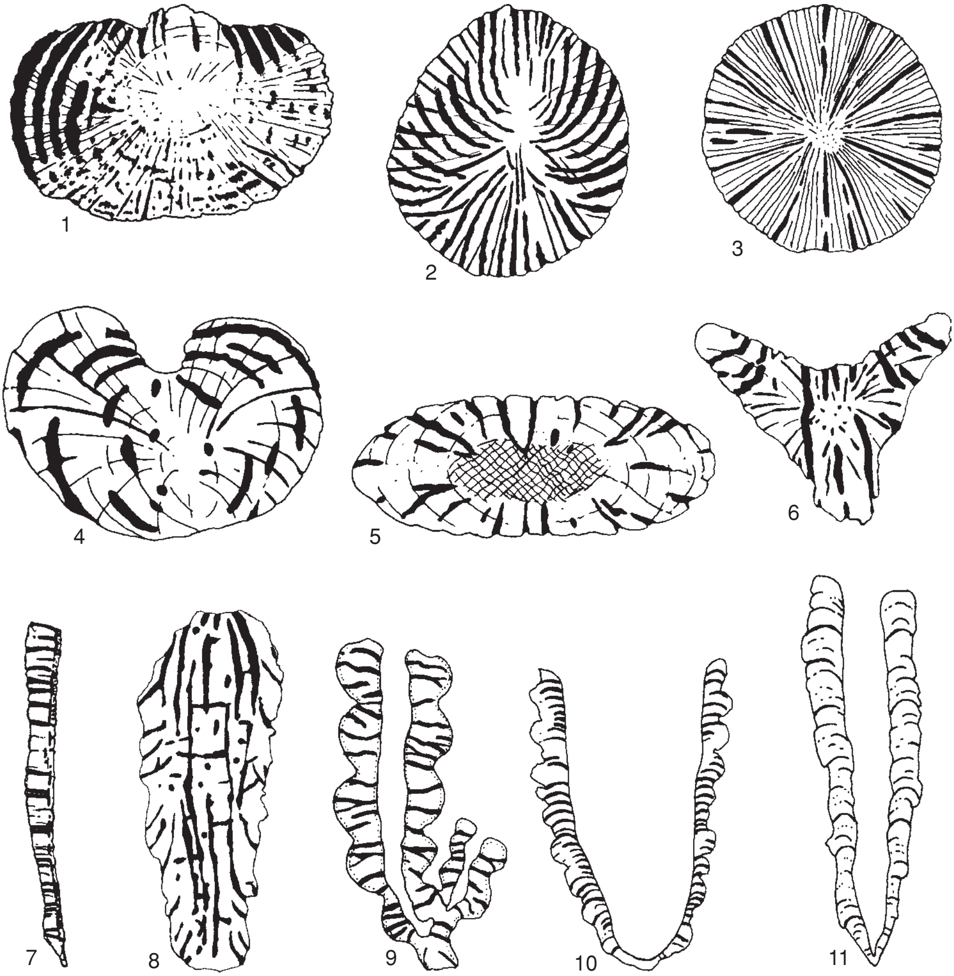

FIG. 92. Outline drawings of genera included in Astylospongiidae, showing relationships of growth forms, dermal-gastral layers, and canals; all drawings generalized; *1, Astylospongia;* major, subconcentric, large canals stacked and cross connected by radiating, intermediate, small series, ×1; *2, Caryospongia;* large canals radiating out from center but sweeping to almost vertical in stacked series; minor secondary series of radiating straight canals, ×1; *3, Carpospongia;* radiating canals of two sizes probably differentiated incurrent and excurrent openings, ×1; *4, Astylospongiella;* large, irregularly spaced canals not in vertically stacked series, nor are smaller, almost plumose ones, ×1; *5, Ellesmerespongia;* centeral area filled with matrix; branching, more or less subradial canals are large series and connected by irregularly spaced, subconcentric, intermediate canals, ×0.5; *6, Phialaspongia;* large, central canals vertical and connected by radiating, intermediate-sized ones, ×1; *7, Garraspongia;* bladed, flabellate form with differentiated dermal surface and more or less straight canals through blade; small, nearly vertical canal series occurring just below dermal surface, ×1; *8, Inglispongia;* large, vertically continuous, cylindrical canals piercing more or less through central part of body; cross connected by moderately large, subhorizontal canals and still smaller, irregular series, ×0.5; *9, Devonoscyphia;* small, sometimes branching form with irregular radial canals and differentiated dermal-gastral layer, ×3; *10, Camellaspongia;* deep, obconical sponge with regularly stacked, arcuate canals that lead directly through thin walls; stacking shows best on interior, ×1; *11, Attungaia;* conical-cyclindrical sponge with upwardly arcuate canals that lead more or less directly through walls; canals irregularly placed in outer wall but may be more regular in inner wall, ×1 (Rigby, 1986b).

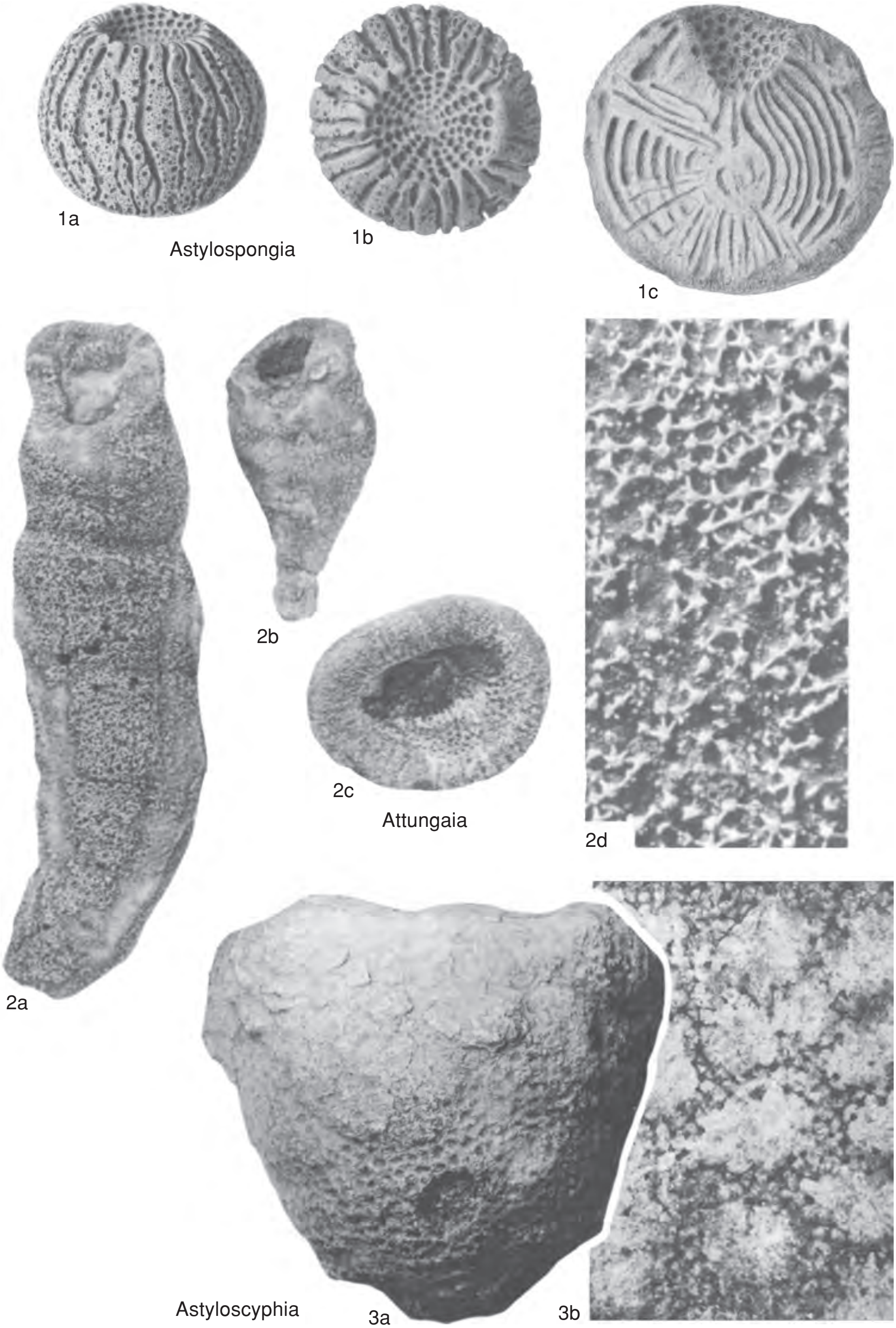

FIG. 93. Astylospongiidae (p. 127–130).

A. irregularia, Holy Cross Mountains; *a,* side view of holotype showing general form of sponge and irregular distribution of closely spaced canals, ×1; *b,* details of ostia organization and skeletal net of sphaeroclones on dermal surface, ×10 (Rigby & others, 2001).

Astylospongiella Rigby & Lenz, 1978, p. 158 [**A. megale* Rigby & Lenz, 1978, p. 159; OD]. Robust, subspherical with obconical to rounded spongocoel; largest canals with ostia on lower surface arching upwardly and inwardly, irregularly spaced and not stacked; small, cross-connecting canals radiating upwardly and outwardly, approximately normal to larger canals; sphaeroclones uniform size throughout sponge. *Silurian (Wenlock–Ludlow):* Canada (Northwest Territories, Baillie Hamilton and Cornwallis Islands).——Fig. 94,*1a–c.* **A. megale,* Cape Phillips Formation, Ludlow, Baillie-Hamilton Island; *a,* side view of holotype showing globular form and small spongocoel at summit, with shallow, convergent canals on upper slope and summit, small, circular ostia to inhalant canals showing on side, ×1; *b,* view from above into spongocoel and onto rounded, oscular summit with radial canals and small, inhalant ostia between, ×1; *c,* photomicrograph showing characteristic sphaeroclone spicules in regular, skeletal net interrupted by circular canals, GSC 54152, ×25 (Rigby & Lenz, 1978; courtesy of Canadian Journal of Earth Sciences).

Astylostroma Rigby & Webby, 1988, p. 76 [**A. micra;* OD]. Massive, laminate astylospongiid with skeleton of minute sphaeroclones, generally of uniform size throughout massive structure; laminated appearance produced by layers of dense, skeletal structure alternating with layers where up to fifty percent of space is subtangential canals; small, radial canals oriented normal to laminated layers. [*Astylostroma* is the only known genus of the family that has a massive, laminate skeleton.] *Upper Ordovician:* Australia (New South Wales). ——Fig. 95,*1a–b.* **A. micra,* Malongulli Formation, Cliefden Caves area; *a,* side view of massive, although laminated holotype, AMu. F66891, ×0.75; *b,* SEM photomicrograph of small sphaeroclones in silicified paratype, with centrum well exposed in center of figure and others uniformly distributed in fabric, tips of radiating ray fusing to adjacent centra to produce cross-braced skeleton, AMu. F66894, ×200 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Astylotuba Rigby & Pisera in Rigby & others, 2001, p. 466 [**A. modica* Rigby & Pisera in Rigby & others, 2001, p. 467; OD]. Large, tubular astylospongiids with diplorhizal, canal system in craticulariid pattern; sphaeroclones in skeleton of uniform size throughout; skeletal structure generally upwardly and outwardly divergent, pierced by coarse, inhalant and exhalant canals that end blindly within sponge wall. *Upper Devonian (Frasnian):* Poland.——Fig. 96,*1a–b.* **A. modica,* Holy Cross Mountains; *a,* longitudinal section of holotype showing wall thickness and canal distribution; *b,* detail of ostia on dermal surface, ×1 (Rigby & others, 2001).

Attungaia Pickett, 1969, p. 19 [**A. cloacata* Pickett, 1969, p. 20; OD]. Tubular and branching, thin walled with deep cloaca; cloaca of branches not connected with that of parent branch; exhalant pores somewhat aligned in vertical rows on cloacal surface; inhalant pores in meandriform, anastomosing, surface grooves on exterior of sponge; internal canals radial, exhalant canals in stacked, vertical series, sloping gently inwardly and downwardly to meet cloaca, spicules essentially same size throughout sponge. *Lower Devonian (Lochkovian)–Upper Devonian (Frasnian):* Australia (New South Wales), *Lochkovian, ?Givetian;* Australia (Western Australia), *Frasnian.*——Fig. 93,*2a–d.* **A. cloacata,* Sadler Limestone, Frasnian, Sadler Ridge, Western Australia; *a,* side view of subcylindrical sponge with matrix-filled osculum to a deep spongocoel at top, GSWA F2221; *b,* side view of smaller, obconical sponge, GSWA F7223; *c,* view down into spongocoel with ostia of exhalant canals aligned on gastral surface and radial canals in sections of rounded wall, GSWA F7250, ×1; *d,* photomicrograph of sphaeroclone skeleton with swollen centra connected by radiating rays, circular gaps are ostia of canals, GSWA 7237, ×10 (Rigby, 1986b).

Caliculospongia Foerste, 1916, p. 340 [**C. pauper;* M]. Cylindrical with shallow, cloacal depression at upper end surrounded by a flattish rim; cloacal surface bearing exhalant pores in more or less radial rows; internal canals meandriform and anastomosing, open on exterior of sponge and on upper edge of cloaca, as circular pores to meandriform slits (surface possibly decorticated); sponge surface between pores smooth and composed of apparently normal astylospongiid net (judging from coarsely silicified sole specimen) with no other skeletal pores than interspicular spaces; basally attached to shell fragments. *Upper Ordovician:* USA (Kentucky).——Fig. 94,*2a–b.* **C. pauper,* Cynthiana Formation, Lexington; *a,* side view with osculum toward top in small, globular sponge; *b,* opposite side showing irregular canals and ostia at surface, ×2 (Foerste, 1916).

Camellaspongia Rigby & Bayer, 1971, p. 619 [**C. tumula;* OD]. Conical with deep, exhalant depression or cloaca surrounded by a relatively thin body wall above pedunculate, lower portion; center of growth not known; growing surface just below rim on upper surface of cloaca, with maximum growth at outside edge; meridional surface grooves confined to this surface, and by upward growth of sponge around them forming canals running inwardly and downwardly toward cloaca, where they open as exhalant pores in vertical rows; inhalant canals perpendicular to outer surface more irregularly placed, their larger openings concentrated in depressions between irregular protuberances that

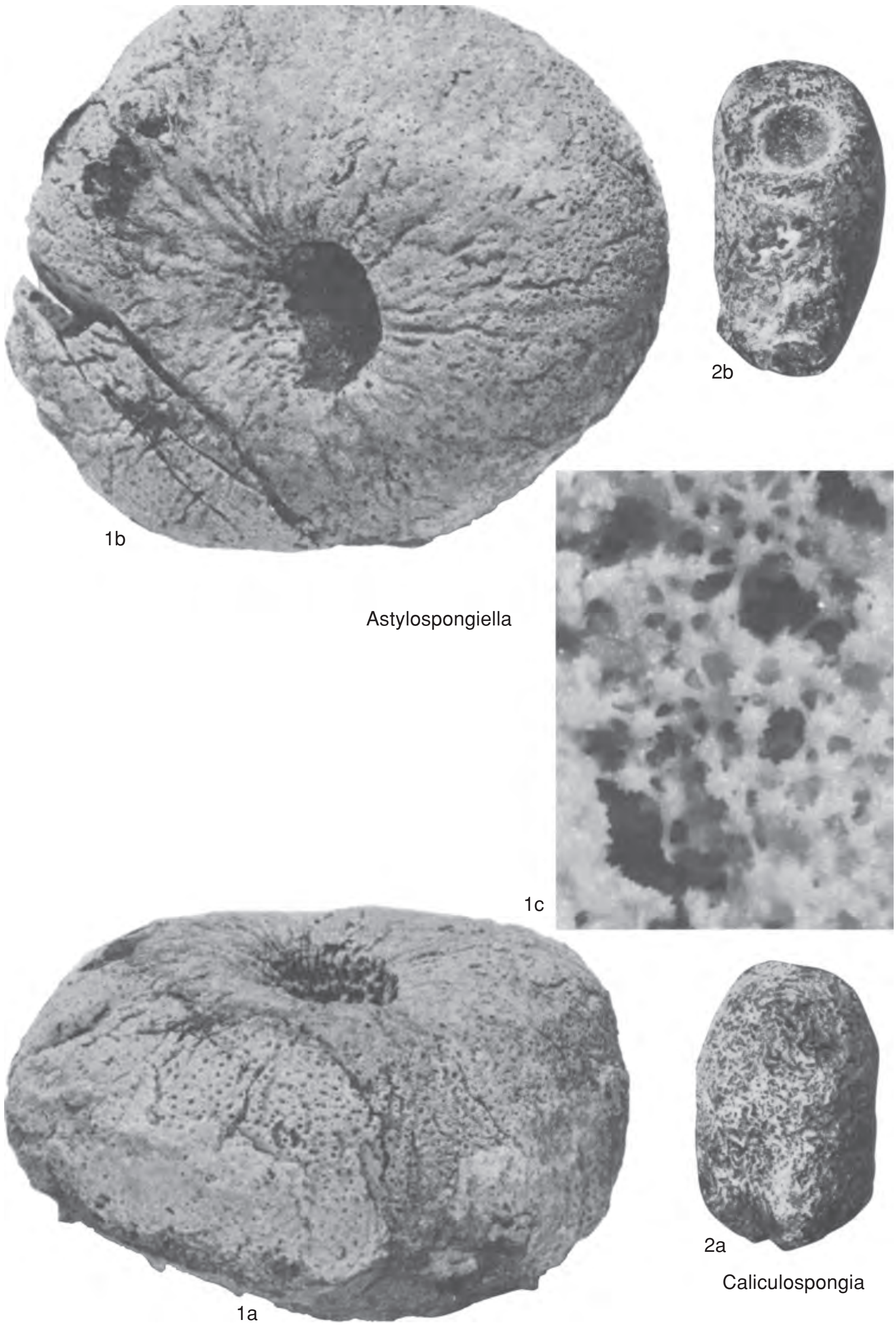

FIG. 94. Astylospongiidae (p. 130).

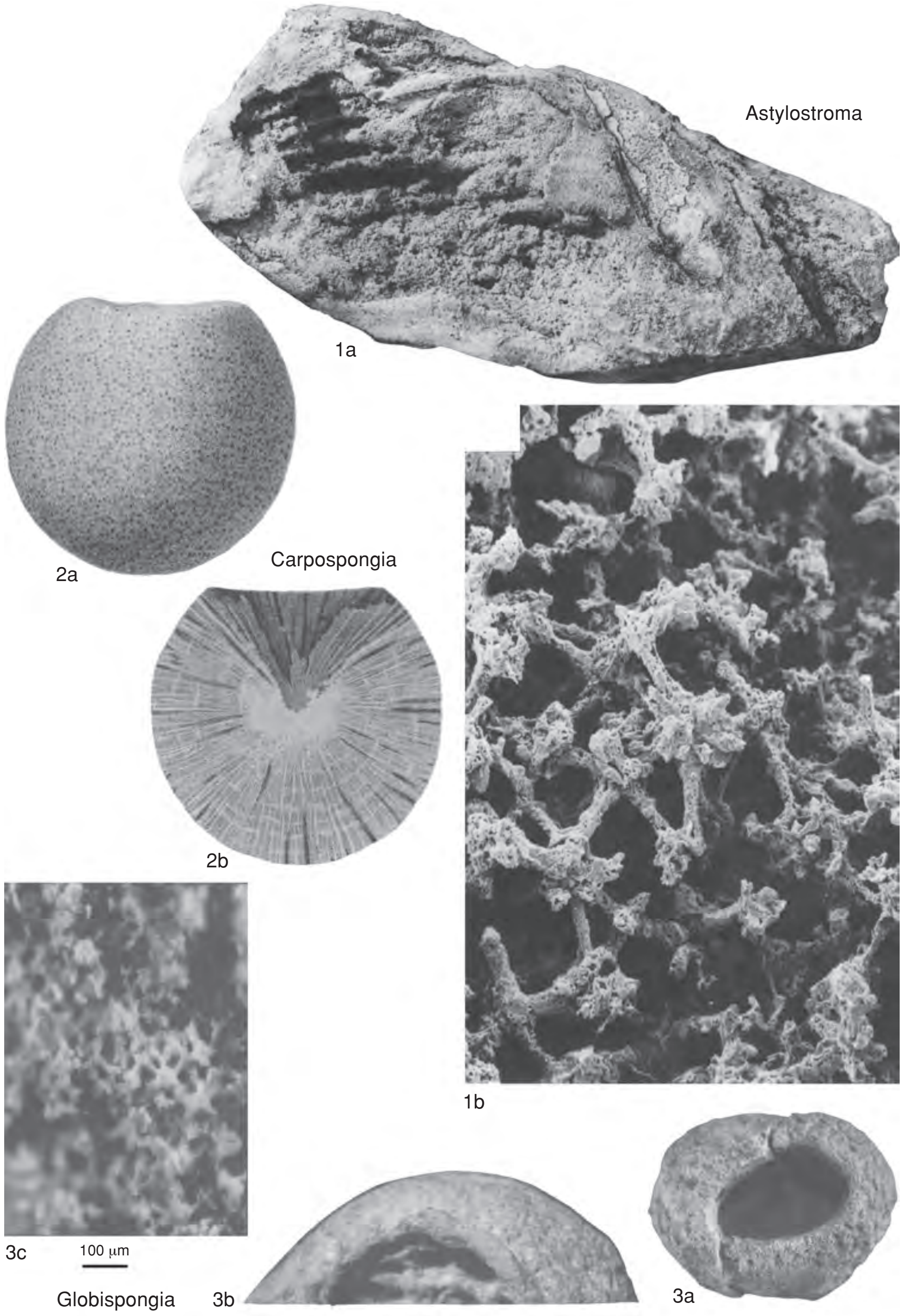

FIG. 95. Astylospongiidae (p. 130–138).

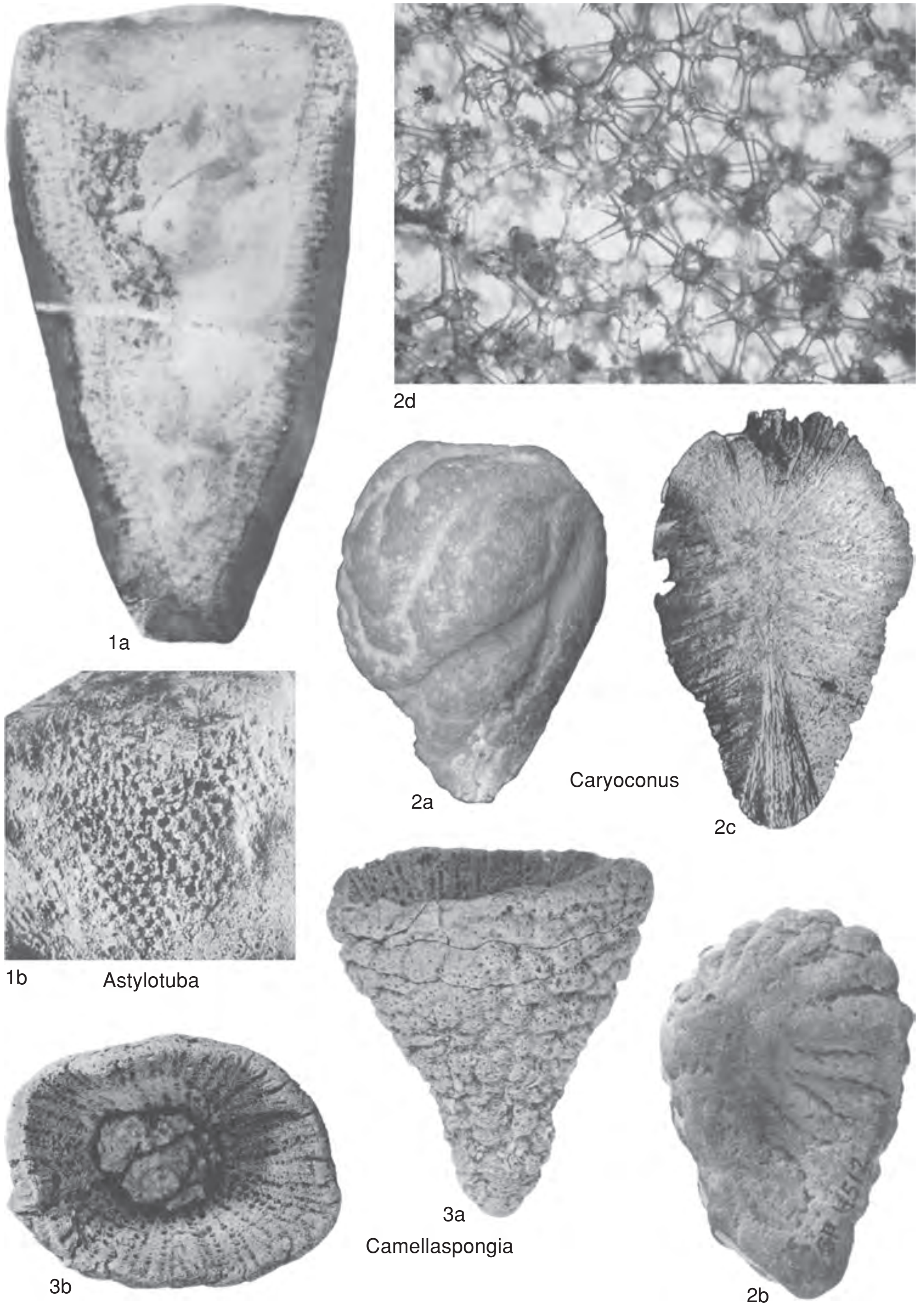

FIG. 96. Astylospongiidae (p. 130–134).

cover exterior surface; spicules increasing upwardly in size. *Upper Ordovician:* USA (Minnesota).——FIG. 96,*3a–b.* **C. tumula,* Maquoketa Formation, Granger; *a,* side view of holotype with nodose, dermal surface perforated by inhalant canal; *b,* view down into spongocoel showing thin walls and rows of exhalant ostia, UM 12039, ×1 (Rigby & Bayer, 1971).

Carpospongia RAUFF, 1894, p. 304 [**Manon globosum* EICHWALD, 1860, p. 188; SD REZVOI, ZHURAVLEVA, & KOLTUN, 1962, p. 56] [=*Carpomanon* RAUFF, 1894, p. 313, obj.]. Spheroidal, without cloaca, growing uniformly in all directions from center of growth; exhalant pores scattered over entire surface, as are stellate or anastomosing, surface grooves, when present; principal inhalant and exhalant, internal canals radial, straight, and may contain large oxeas parallel their length; no basal attachment; spicule size increasing radially from center of sponge in radiating skeleton. *Middle Ordovician–Silurian:* Europe, North America.——FIG. 95,*2a–b.* **C. globosum* (EICHWALD), Silurian limestone, Ostrowitt, West Prussia, Germany; *a,* exterior of globose sponge with smooth, dermal layer perforated by small ostia of both inhalant and exhalant canals; *b,* vertical, median section showing strongly radiate, spicule series and both inhalant and exhalant canals, P-MD, ×1 (Rauff, 1893).

Caryoconus RHEBERGEN & VAN KEMPEN, 2002, p. 188 [**Astylospongia gothlandica* SCHLÜTER, 1884, p. 79; OD]. Irregularly stalked, subspherical to subglobular to obconical or cylindrical astylospongiids without an osculum; subspherical and stalked parts generally smooth, but with irregular, anastomosing or branched, surficial furrows that radiate from lateral bulge in some specimens; lateral knob is at maximum diameter; furrows commonly extending along one side of stalk; no close connection between internal canals and surficial grooves; numerous small prosopores and fewer larger apopores are irregularly distributed over entire dermal area; more or less straight canals radiating from center of subspherical, upper part of sponge, and straight, parallel canals extending from sides of lower cone toward dermal surface; concentric canals absent; principal, choanosomal skeleton composed of interconnected, regular sphaeroclones, but sphaeroclones in conical part of sponge often irregular, with longitudinally elongate rays forming strands that diverge downwardly and outwardly toward base. *Silurian (Llandovery–upper Wenlock):* Sweden (Gotland, erratics).——FIG. 96,*2a–d.* **C. gothlandicus* (SCHLÜTER), probably Upper Högklint Formation, Wenlock, erratic on beach south of Högklint; *a,* holotype, side view showing growth form, PIUB Schlüter 134, ×1; *b,* side view of reference specimen showing lateral bulge with apical knob, NRM Sp. 4512, ×1; *c,* paratype, vertical section showing skeletal and canal structure, NRM Sp. 147, ×1; *d,* paratype, interconnected sphaeroclones of choanosomal skeleton, NRM Sp. 129, ×20 (Rhebergen & van Kempen, 2002).

Caryospongia RAUFF, 1894, p. 296 [**Siphonia juglans* QUENSTEDT, 1878 in 1877–1878, p. 555; SD DE LAUBENFELS, 1955, p. 61] [=*Caryomanon* RAUFF, 1894, p. 313, obj.]. Spheroidal, without cloaca; meridional surface grooves and maximum growth on upper hemisphere; center of growth below center of sponge; grooves may be deeply incised, rendering sponge meridionally lobate, exhalant pores concentrated in these surface grooves; internal, exhalant canals bending outwardly and upwardly from center of growth, arcuate convex toward exterior; internal, inhalant canals straight and radial with respect to center of growth; basal attachment absent; spicule size increasing radially from center of sponge in regularly radiating skeleton. *Middle Ordovician–Silurian:* Europe, North America.——FIG. 97,*1a–c.* **C. juglans* (QUENSTEDT), Magdeburg, Germany; *a,* side view of large specimen with exhalant ostia on summit and sides marked by canal segments, BM, ×1; *b,* vertical median section of large sponge showing small, straight, inhalant canals and upswept, larger, exhalant canals, defined by shaded, skeletal areas, BM, ×1; *c,* smaller sponge with clustered, exhalant ostia on summit and slopes with grooves of concentric canal series, glacial erratic, Island of Sylt, U-SK, ×1 (Rauff, 1893).

Devonoscyphia RIETSCHEL, 1968b, p. 99 [**D. sandbergeri;* OD]. Cylindrical to spheroidal with deep cloaca; principal, exhalant canals radial and branching peripherally; disposition of exhalant pores on cloacal surface not known; small, inhalant pores scattered over exterior surface that is otherwise dense and bearing only interspicular spaces; there is some suggestion of meandriform, surface grooves connecting inhalant pores; skeleton of uniform sphaeroclones. [Genus is similar to *Attungaia* PICKETT, 1969.] *Devonian (Givetian):* Germany, Belgium, Poland.——FIG. 98,*1a–b.* **D. sandbergeri,* Lahnmulde, Rheinische Schiefergebirge, Germany; *a,* etched, upper surface of silicified holotype with central, spicule-free osculum, ×4; *b,* silicified sphaeroclones from holotype, SMF XXVI 201, ×30 (Rietschel, 1968b).

Ellesmerespongia RIGBY, 1970b, p. 1,143 [**E. feildeni* RIGBY, 1970b, p. 1,145; OD]. Massive, obloid to biscuit-shaped astylospongiid without spongocoel, surface marked with impressed, round, radiating grooves; canals of three sizes: small, intraray, polygonal openings; intermediate-sized, radial and concentric canals; and large, straight canals that radiate pinnately from nearly horizontal, open-textured zone in center of sponge, latter canals opening into surficial grooves and onto surficial ridges; spicules sphaeroclones typical of family. *Permian (Cisuralian):* Canada (northern Ellesmere Island).——FIG. 99*a–c.* **E. feildeni,* unnamed limestone, Feilden Peninsula, Baffin Island; *a,* side

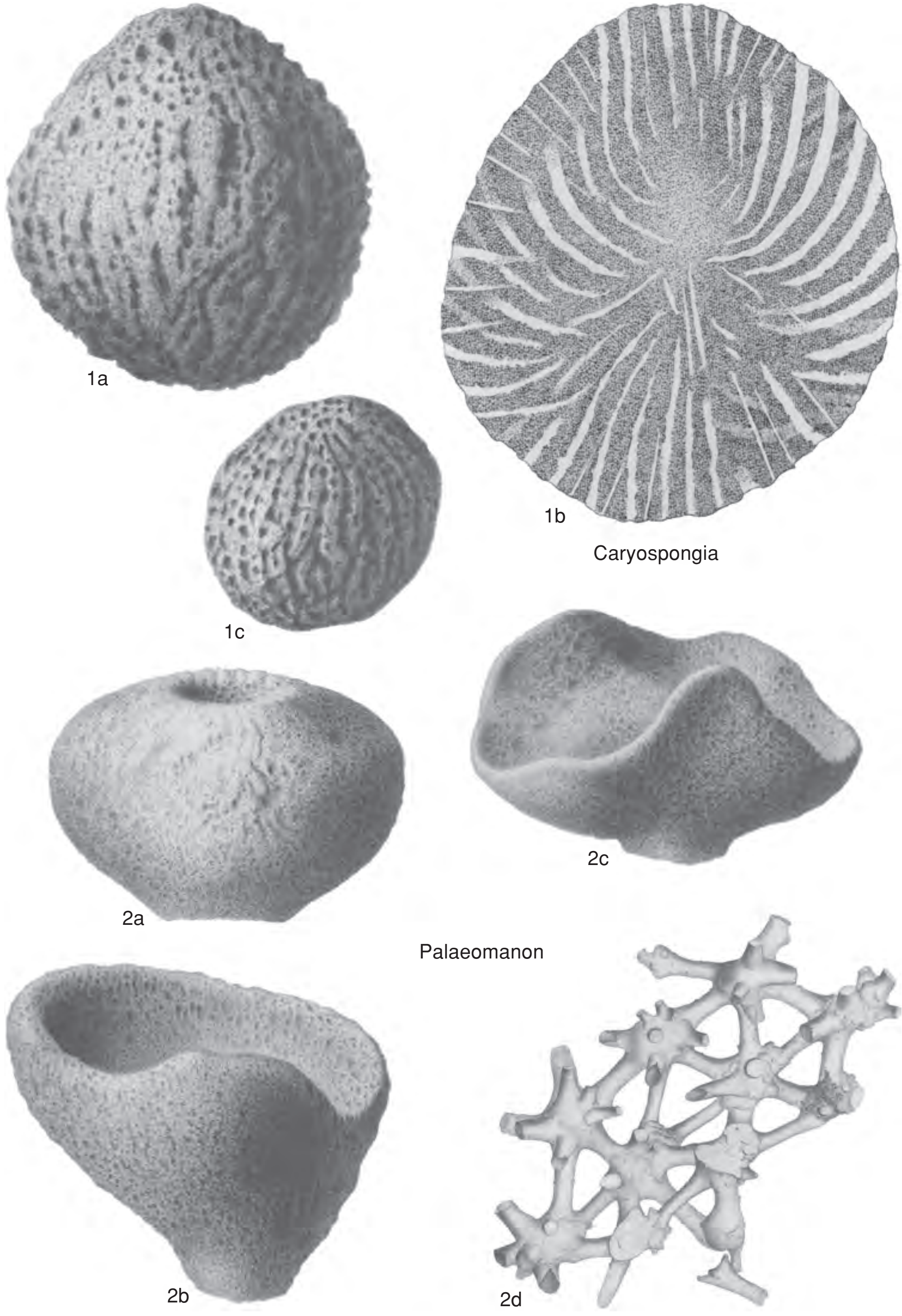

FIG. 97. Astylospongiidae (p. 134–141).

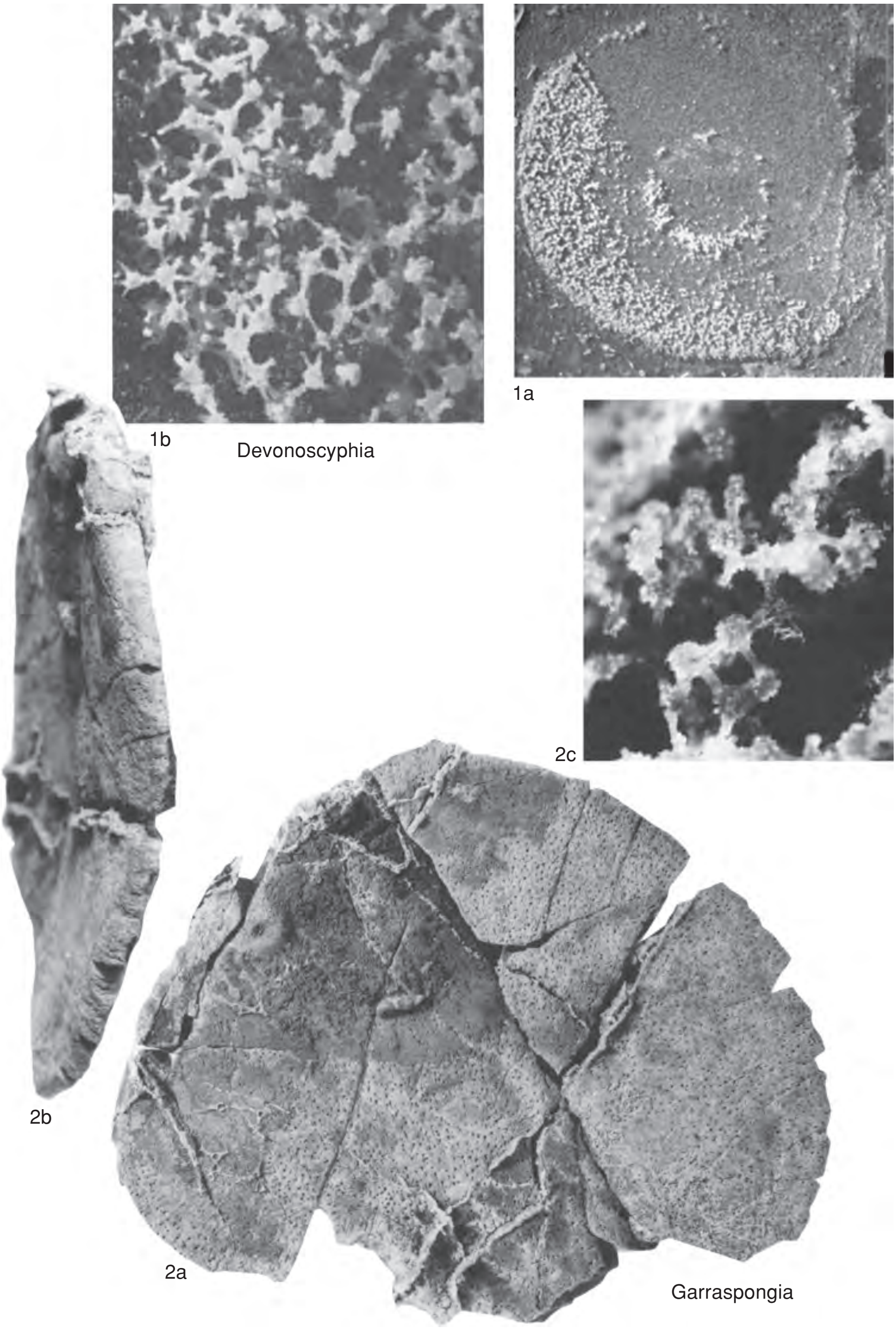

FIG. 98. Astylospongiidae (p. 134–138).

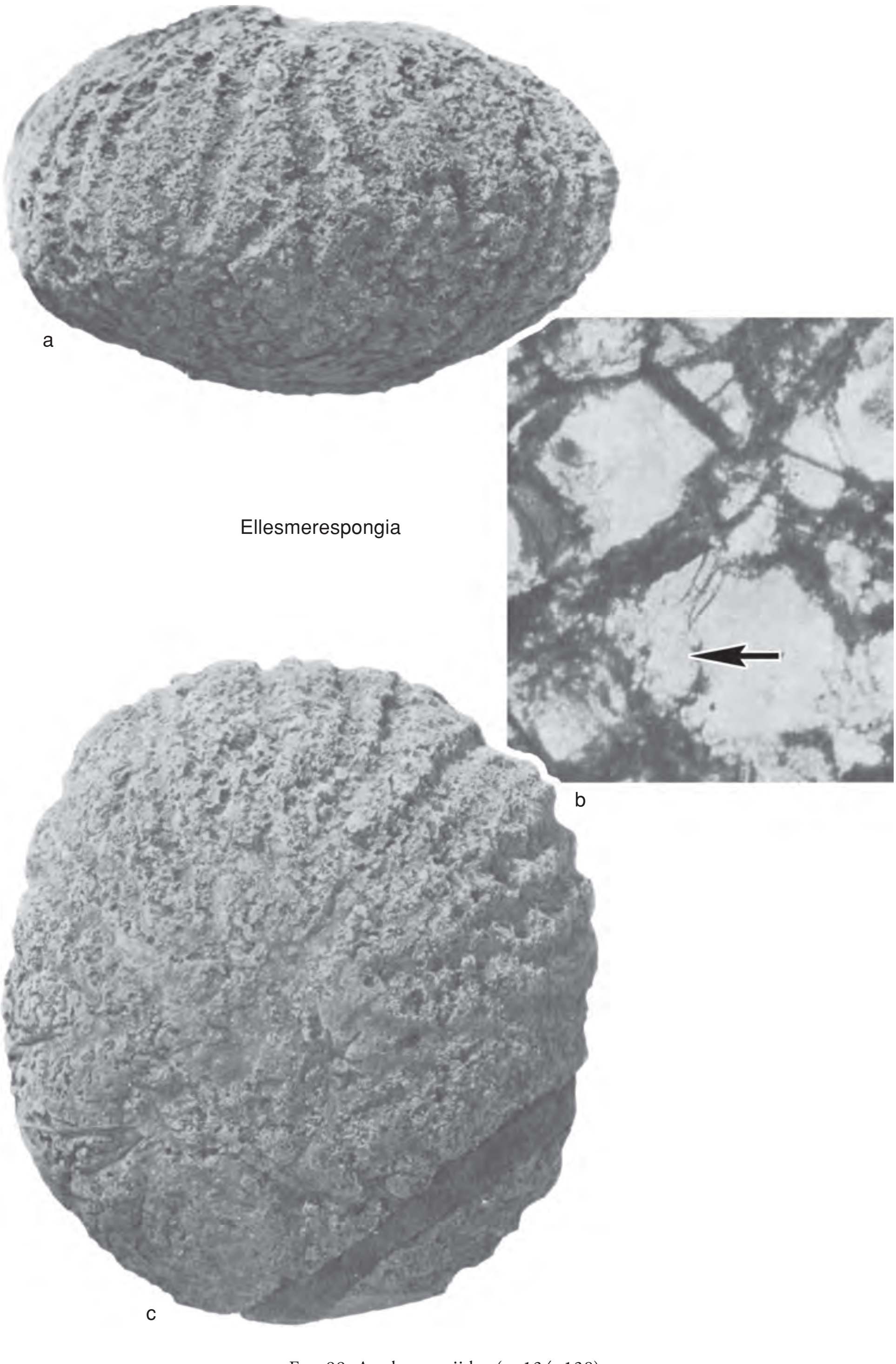

FIG. 99. Astylospongiidae (p. 134–138).

view of globose holotype with tangential grooves on margin, ×1; *b,* rounded outline from above, with broad grooves along flanks, ×1; *c,* photomicrograph showing parts of six centra and associated thin, radiating rays, GSC 81005, ×75 (Rigby, 1970b).

Garraspongia Pickett & Rigby, 1983, p. 733 [**G. vannus;* OD]. Flabellate with differentiated, incurrent and excurrent surfaces, canals normal to surfaces except upwardly plumose canals parallel to excurrent surface immediately beneath differentiated, dermal layer; skeleton of sphaeroclones with occasional, possible, accessory oxeas. *Devonian (Lochkovian–Pragian):* Australia (New South Wales).——Fig. 98,*2a–c.* **G. vannus,* Garra Formation, Wellington; *a,* side view of inhalant surface of fanlike holotype with numerous inhalant ostia, ×1; *b,* upper end of thin, bladelike holotype, MMF 23743, ×1; *c,* photomicrograph of paratype showing sphaeroclones of endosomal skeleton, MMF 23746, ×30 (Pickett & Rigby, 1983).

Globispongia Jux, 1992, p. 308 [**G. paffrathi;* OD]. Hemispherical to ovate, tuberlike sponges with flat, lower surface and deep, upper spongocoel, with irregularly arranged, inhalant ostia on mostly smooth, dermal surface, large, polygonal to horizontally elliptical apopores arranged in rings on spongocoel wall; spicules sphaeroclones as in family. *Devonian (Givetian):* Germany.——Fig. 95,*3a–c.* **G. paffrathi,* Hornstein beds, upper Givetian, Bergisches Land; *a,* view from above of paratype with ovate outline and large spongocoel and inhalant ostia in dermal surface, GIK, ×1; *b,* diagonal view of part of holotype showing oscular margin and gastral surface with large, elliptical, exhalant ostia, GIK 998, ×1; *c,* photomicrograph showing swollen centra of sphaeroclones of skeleton (Jux, 1992; courtesy of *Senckenberg Naturforschende Gesellschaft*).

Inglispongia Pickett, 1969, p. 22 [**I. scriveni;* OD]. Large, cylindrical, flabellate, or irregular massive; no cloaca; large, parallel, vertical, exhalant canals in axial region opening on upper surface; inhalant canals radial. *Devonian (?Givetian):* Australia (New South Wales).——Fig. 100,*1a–c.* **I. scriveni; a,* transverse section with large, vertical canals near axis but absent in outer parts, Moore Creek Limestone, County Inglis, AM F12864, ×1; *b,* weathered, vertical section of reference specimen with large, vertical canals and horizontal canals in dense, skeletal net, Timor Limestone, County Brisbane, AM 13296, ×1; *c,* photomicrograph of sphaeroclone spicules in reference specimen, Moore Creek Limestone, County Inglis, AM 12862, ×12 (Pickett, 1969).

Jazwicella Rigby & Pisera in Rigby & others, 2001, p. 458 [**J. media* Rigby & Pisera in Rigby & others, 2001, p. 460; OD]. Small, obconical astylospongiids with craticulariid canal pattern where canals regularly spaced in uniform rows; inhalant canals end short of gastral margin and exhalant canals do not appear in dermal layer; centra of sphaeroclone spicules of uniform size throughout skeleton. *Upper Devonian (Frasnian):* Poland.——Fig. 101,*2a–b.* **J. media,* Holy Cross Mountains; *a,* side view of holotype showing regular placement of inhalant ostia, ZPAL PfXI/24, ×2; *b,* detail of skeletal and canal pattern showing uniform size of centra of interconnected sphaeroclones around aligned ostia in holotype, ×10 (Rigby & others, 2001).

Malinowskiella Hurcewicz, 1985, p. 277 [**M. actinosum;* OD]. Cylindrical to conical, goblet-shaped sponges with deep spongocoel and broad osculum, walls moderately thick and with smooth, gastral surface, dermal skeleton, and surface rarely preserved; inhalant ostia round and in depressed, vertical rows separated by elevated, skeletal areas; principal, interior skeleton of regularly spaced and oriented sphaeroclones without layering; sphaeroclones with swollen, spinose, centrum where spines directed dermally; spicules with 3 to 4 rays oriented toward interior; ray tips fused to centra of adjacent spicules; traces of spicules in outer or dermal part of wall suggesting dichotrienes with long rays present. [Review of the original material by other workers suggests that some reported skeletal details are not easily visible.] *Devonian (Frasnian):* Poland.——Fig. 101,*3a–g.* **M. actinosum,* Kowala Formation, upper Frasnian, Holy Cross Mountains; *a,* side view of obconical holotype with broad osculum and impressed, irregular, vertical rows of inhalant ostia, MUZ IG 1501.II/3, ×1.5; *b,* transverse cross section through a cluster of individuals with open spongocoel cavities and moderately thick walls, MUZ IG 1501.II/72, ×1; *c–g,* drawings of monaxon and sphaeroclones of interior part of skeleton, ×35 (Hurcewicz, 1985; courtesy of Panstwowy Instytut Geologiczny, Warsaw).

Palaeomanon Roemer, 1860, p. 12 [**Siphonia cratera* Roemer, 1848, p. 685; OD] [=*Astylomanon* Rauff, 1894, p. 313, obj.]. Bowl shaped and pedunculate to conical; concave, exhalant surface with sharp rim at top of sponge; center of growth below center of sponge; meridional, surface grooves and site of maximum growth on outside just below rim of exhalant depression; internal, exhalant canals parallel to these grooves and formed from them by upward and outward growth of sponge around them, opening onto exhalant surface; internal, inhalant canals possibly radial, leading in from outer surface. Spicules uniform size throughout skeleton. [This genus differs from *Astylospongia* Roemer in development of a peduncle and in the concentration of growth about the upper part of the exterior, producing the bowl-like shape; the spicules and mesh spaces are also larger relative to the size of the sponge than in *Astylospongia.*] *Silurian (Wenlock–Ludlow):* USA (Tennessee), Canada (Northwest Territories).——Fig. 97,*2a–d.* **P. cratera* (Roemer), Brownsport Limestone, Niagaran, Decatur County, Tennessee; *a,* globose form of type species with small spongocoel in summit, Münchener Museum; *b,* broad, bowl-shaped representative of type species, Münchener

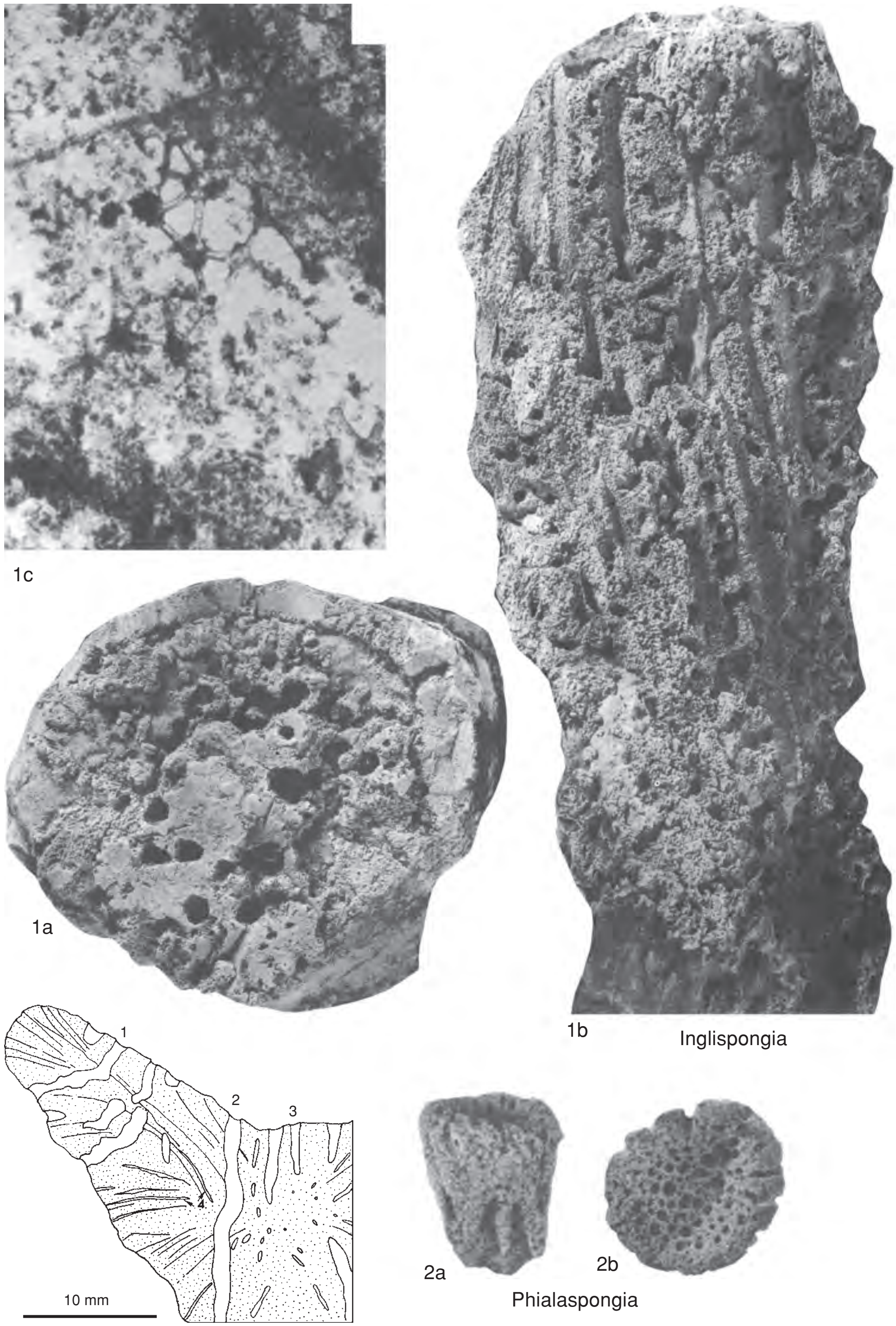

FIG. 100. Astylospongiidae (p. 138–141).

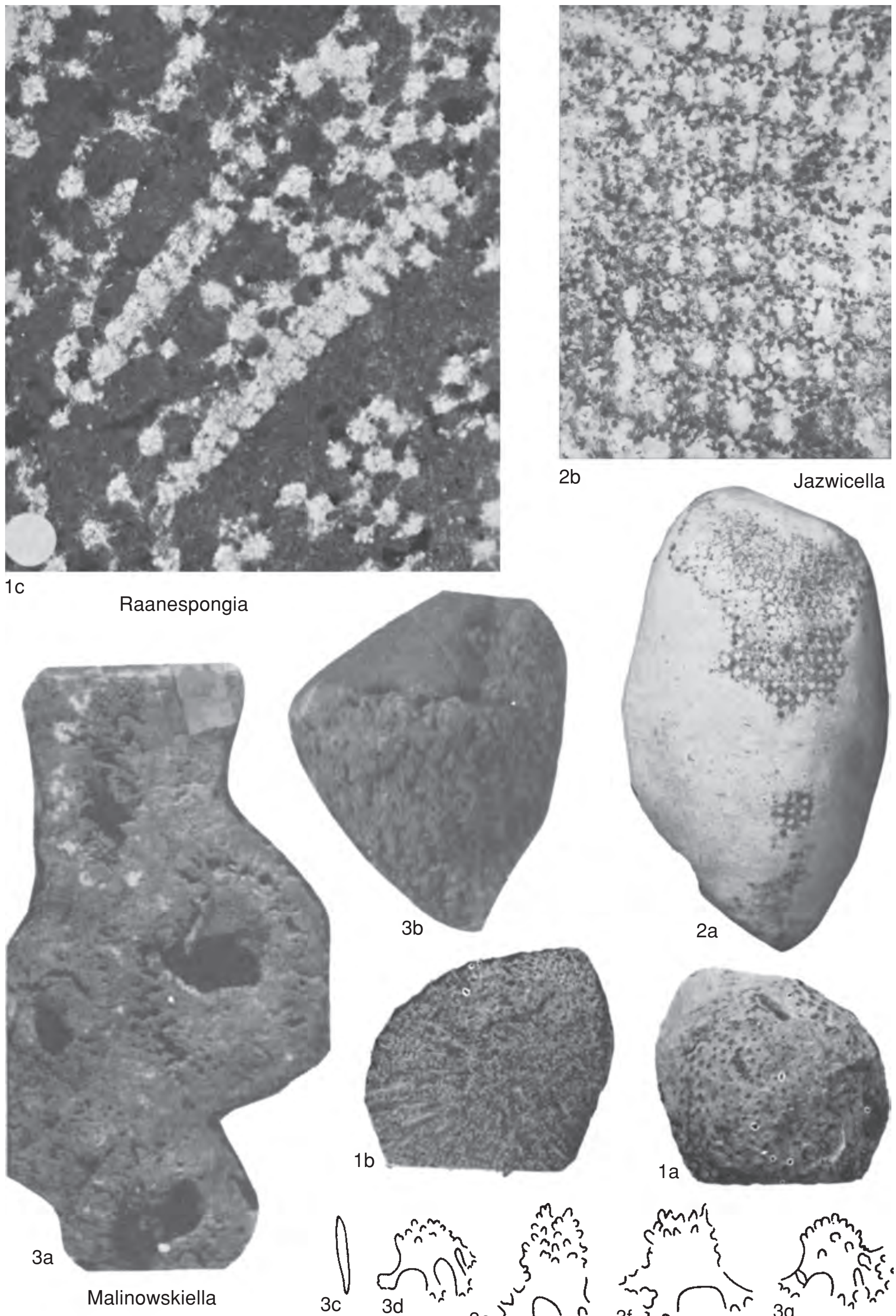

FIG. 101. Astylospongiidae (p. 138–141).

Museum; *c,* undulate, bowl-shaped representative of type species, Münchener Museum, ×1; *d,* drawing of skeletal details showing mutually attached sphaeroclones in silicified sponge, Königlich Museum für Naturkunde, Berlin, ×50 (Rauff, 1893).

Phialaspongia Rigby & Bayer, 1971, p. 622 [**P. fossa* Rigby & Bayer, 1971, p. 623; OD]. Conical with concave depression at top with rounded rim; maximum upward growth at center of this rim; prominent, meridional, surface grooves run up exterior surface, across rim, and onto upper surface; internal, exhalant canals approximately perpendicular to both exhalant and outer surfaces, being vertical at center of sponge where continuation of stalk canals arcuate and concave upward in upper part of sponge, opening into meridional grooves; internal, inhalant canals radial with respect to center of growth at center of sponge, forming pinnate pattern in upper, bowl-like part of sponge; spicule size may increase upwardly. *Upper Ordovician:* USA (Minnesota).——Fig. 100,*2a–c.* **P. fossa,* Maquoketa Formation, Fillmore County; *a,* side view of holotype showing coarse, vertical canals in lower part, ×1; *b,* vertical view showing coarse, exhalant ostia in shallow spongocoel, UM 9149, ×1; *c,* sketch of vertical section through paratype showing distribution of canals in skeleton from large ones that pierce upper walls (*1*) to larger (*2*) and smaller (*3*) ones that empty into spongocoel floor, (*4*) possible fine inhalant canals, ×15 (Rigby & Bayer, 1971).

Raanespongia Rigby & Terrell, 1973, p. 1,438 [**R. monilis;* OD]. Small to medium-sized, subspherical or oblate to spindle-shaped sponges with radiating, skeletal structure of separate to beaded or stringlike clusters of sphaeroclones with many rays; large and intermediate-sized, radial canals nearly straight, cross connected with irregularly developed, intermediate-sized, concentric canals and with small, radial canals; surface weakly hispid, marked by extended tips of beadlike rods of spicules. *Permian (Artinskian–Roadian):* Canada (Ellesmere Island).——Fig. 101,*1a–c.* **R. monilis,* Assistance Formation; *a,* side view of holotype with nodose, dermal surface produced by dark, radiating, spicule tracts, ×1; *b,* vertical section showing radial structure of skeleton as light gray separated by radial canals filled with dark matrix, ×1; *c,* photomicrograph of thin section of beaded strands of sphaeroclones, along with isolated sphaeroclones, in areas between canals filled with dark matrix, GSC 32716, ×10 (Rigby & Terrell, 1973; courtesy of *Canadian Journal of Earth Sciences*).

Order SPIROSCLEROPHORIDA Reid, 1963

[*nom. correct.* Finks & Rigby, herein, *pro* Spirosclerophora Reid, 1963d, p. 199; *emend.,* Finks & Rigby, herein]

Microscleres sigmaspires or microrhabds. *Middle Cambrian–Holocene.*

Suborder RHIZOMORINA Zittel, 1895

[Rhizomorina Zittel, 1895, p. 52]

Lithistid sponges whose principal desmas are rhizoclones and whose spicules are entirely monaxonic; microscleres, when present, are sigmaspires or microrhabds. *Middle Cambrian–Holocene.*

Family HAPLISTIIDAE de Laubenfels, 1955

[Haplistiidae de Laubenfels, 1955, p. 37] [=Columellaespongiidae Pickett, 1969, p. 11]

Principal skeleton of rhizoclones, which may be accompanied by dendroclones, chiastoclones, oxeas, and strongyles; dermal skeleton of tangential oxeas and possibly strongyles; principal skeleton made of radial spiculofibers connected by lateral or concentric fibers that are generally thinner; form of sponge spheroidal, discoidal, tubular, foliate, massive, or encrusting. *Lower Ordovician–Permian.*

Haplistion Young & Young, 1877, p. 428 [**H. armstrongi;* OD] [=*?Rhaphidhistia* Carter, 1878, p. 140 (type, *R. vermiculata,* OD); *?Pemmatites* Dunikowski, 1884, p. 13 (type, *P. verrucosa,* SD de Laubenfels, 1955, p. 49); *?Pseudopemmatites* King, 1943, p. 12 (type, *P. skinneri* King, 1943, p. 16, OD), ?*non* Fraipont, 1911; ?*Monarchopemmatites* de Laubenfels, 1947, p. 187 (type, *Pseudopemmatites skinneri* King, 1943, p. 16, OD); *?Radiatospongia* Wolfenden, 1959, p. 567 (type, *R. carbonaria,* OD)]. Spheroidal, ovoid, discoid, lobate, or irregular; no cloaca; cylindroid spiculofibers radiating from an eccentric center of growth and end as hispid projections at surface (new fibers being added by intercalation); they are connected by usually thinner fibers at right angles, forming a quadrate mesh in longitudinal section and a polygonal, mainly quadrate, mesh in surface view; rhizoclones are mainly stout and straight with warty, lateral protuberances, often on one side only, but curved forms occurring around pores and at fiber junctions; dendroclones also present in horizontal connecting fibers; abundance of smooth, curved oxeas and strongyles adherent to surfaces of many specimens suggests that these were part of sponge, probably connected with a dermal layer; larger, circular, oscule-like openings may also be present; fibers composed of rhizoclones and smooth oxeas oriented roughly parallel length of fibers. [Because of poor preservation, there is some doubt as to the presence of rhizoclones in the type specimens of *Haplistion;* originally both *Haplistion* and

Pemmatites were described as having only oxeas.] *Middle Ordovician–Permian (Capitanian, ?Changhsingian):* Australia, North America, Spitzbergen, Europe (Ural Mountains, Spain), Timor.——FIG. 102,*1a–b*. **H. armstrongi,* lower limestone series, Visean, Ayrshire, Scotland; *a,* small, spheroidal holotype (center) with tracts of rhizoclones, ×2; *b,* skeletal tracts enlarged to show rhizoclone spicules, ×40 (Finks, 1960; courtesy of The American Museum of Natural History).——FIG. 102,*1c–d*. *H. sphaericum* FINKS, Magdalena Formation, Desmoinesian, Otero County, New Mexico; *c,* section of spheroidal holotype with radiating trabeculae, ×1; *d,* enlarged part of skeletal net showing tracts of subparallel rhizoclones, USNM 127632, ×10 (Finks, 1960; courtesy of The American Museum of Natural History).

Boonderooia RIGBY & WEBBY, 1988, p. 25 [**B. spiculata;* OD]. Bladelike, flabellate or open obconical sponge with three-dimensional network of tracts made of clustered rhizoclones cored by monaxial oxeas, which project through tracts as spines at tract junctions; skeletal net irregular, without major linear structure but with tract segments mainly surrounding irregularly rectangular openings; well-defined dermal and more obscure gastral layers composed of bladelike, clustered tracts that are somewhat larger than interior ones; walls perforated by large, generally radial, discontinuous canals that commonly interconnect to ill-defined, vertical series in middle walls. *Upper Ordovician:* Australia (New South Wales).——FIG. 103,*2a–d*. **B. spiculata,* Malongulli Formation, Cliefden Caves area; *a,* gastral surface of holotype with open skeleton and larger, excurrent canals more or less uniformly distributed, ×2; *b,* side view showing ladderlike, skeletal tracts diverging upwardly toward gastral surface and outwardly toward lateral, dermal surface, ×2; *c,* dermal surface with relatively uniform, textured skeleton and absence of clearly differentiated, large canals in network of tracts, ×2; *d,* photomicrograph of dermal, skeletal structure with irregular, ropy tracts of dendroclones with tips of coring oxeas exposed at intersections and elsewhere, AMu. F66802, ×8 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Chaunactis FINKS, 1960, p. 93 [**C. foliata* FINKS, 1960, p. 94; OD]. Foliate to flabellate, skeletal net organized in porous partitions perpendicular to flat sides, originating from center of growth on attached edge and radiating toward opposite free edge; partitions connected at right angles by thinner partitions that together outline cylindrical canals that are perpendicular to flat sides and are parallel to and convex toward beveled edge; canals open as radial rows of oval pores on both flat sides; skeletal net composed of possible rhizoclones; long, smooth monaxons, parallel to flat sides locally imbedded in radial, skeletal partitions; exterior surface may bear fine, radial and concentric, rectangular, dermal mesh of bundles of parallel, smooth, small monaxons (possible oxeas); one species (not the type) showing polygonal pores on one flat side. [Genus is similar to *Mortiera* DE KONINCK, but principal spicules may be rhizoclones rather than possible dendroclones of *Mortiera,* in that the dermal mesh is composed of reticulately arranged, rather than parallel and densely crowded oxeas and in that the growth is from a lateral center of origin.] *Carboniferous (Middle Pennsylvanian)–Permian (Wordian):* USA (Colorado, Oklahoma, Texas), Mexico (Coahuila), Spitzbergen.——FIG. 104*a–c*. **C. foliata,* Gaptank Formation, Missourian, Glass Mountains, Texas; *a,* convex surface of holotype showing fine, dermal mesh in upper part and coarse, internal mesh below, USNM 127640, ×2; *b,* side view of nearly complete paratype without fine, dermal mesh but showing coarse, aligned, canal series, ×2; *c,* photomicrograph perpendicular to growing edge, at left, with monaxons parallel to radial, skeletal fibers showing in lower part of paratype, USNM 127641, ×5 (Finks, 1960; courtesy of The American Museum of Natural History).

Columellaespongia PICKETT, 1969, p. 11 [**C. woolomolensis* PICKETT, 1969, p. 12; OD]. Tubular and branching with deep cloaca; principal spiculofibers cylindroid, extending upwardly and outwardly to external surface from specialized cloacal lining; fibers connected laterally by thinner spiculofibers so as to outline polygonal to rounded, external pores and corresponding canals between principal fibers, presumably associated with inhalant canals; cloaca lined by denser net in which principal fibers are horizontal and outline horizontal, exhalant canals that open as large, round pores on cloacal surface and extend back into main net where they subdivide and branch; fibers composed of straight or somewhat curved rhizoclones parallel length of fiber. *Devonian (Eifelian–Givetian):* Australia (New South Wales).——FIG. 105*a–d*. **C. woolomolensis; a,* exterior of holotype, fragment of large, cylindrical sponge showing skeletal pores and dimensions of dermal, skeletal net, Timor Limestone, County Brisbane, ×1; *b,* vertical section through holotype showing large, cylindrical spongocoel and thick walls with skeletal tracts that diverge upwardly and outwardly, Timor Limestone, County Brisbane, AM F13723, ×1; *c,* reference specimen, drawing of transverse section showing differentiated, dermal and gastral parts of skeleton, with radial canals interrupting endosomal structure, Moore Creek Limestone, County Inglis, AM F1064, ×1; *d,* reference specimen, vertical section showing gastral layer and upwardly divergent, endosomal, skeletal tracts, Moore Creek Limestone, County Inglis, AM F10508, ×1 (Pickett, 1969).

Crawneya PICKETT, 1969, p. 13 [**C. massiva;* OD]. Massive, irregular, possibly encrusting; spiculofibers radial and normal to outer, upper surface; connected by thinner, lateral fibers; outer surface bearing polygonal, rounded to irregular,

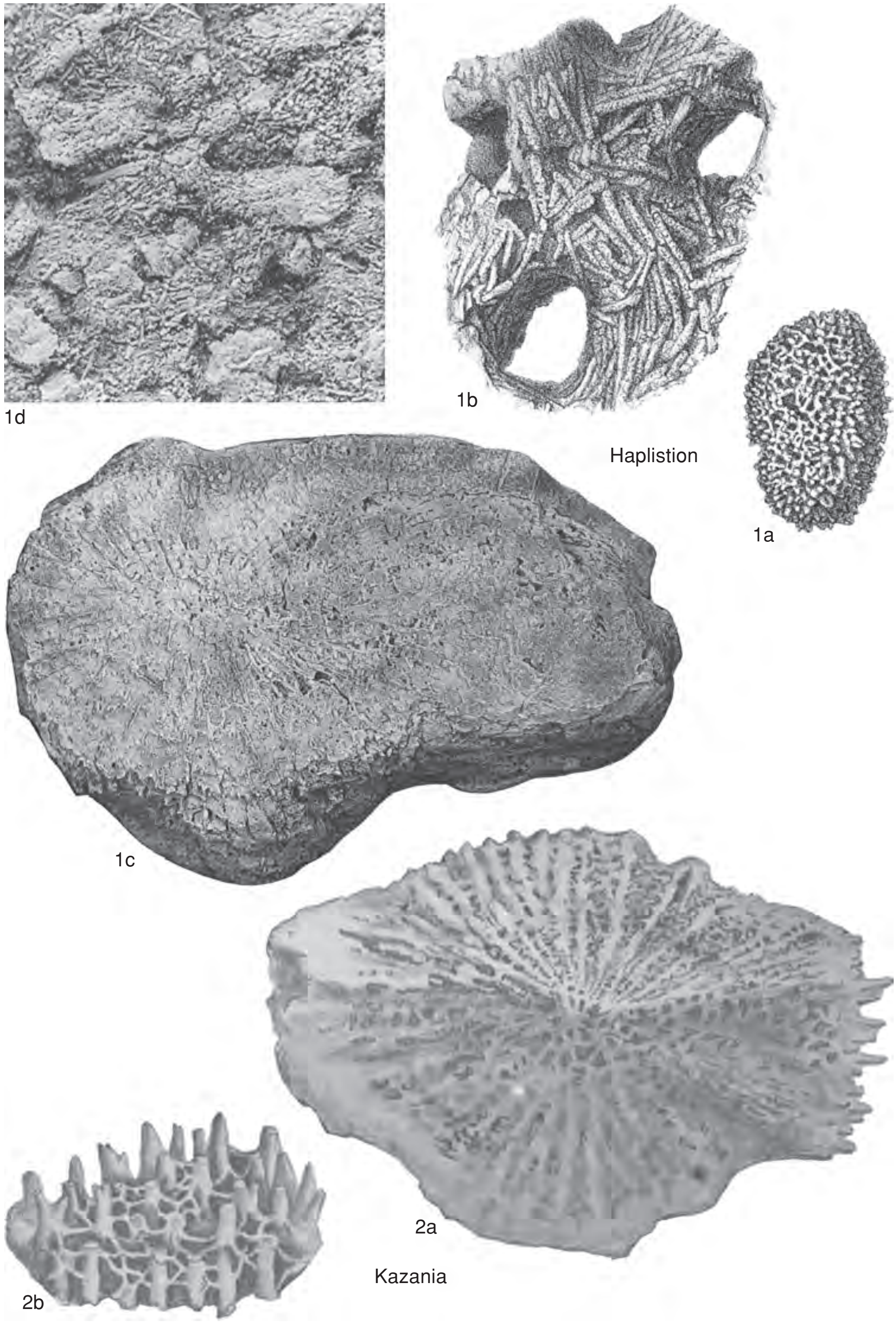

FIG. 102. Haplistiidae (p. 141–145).

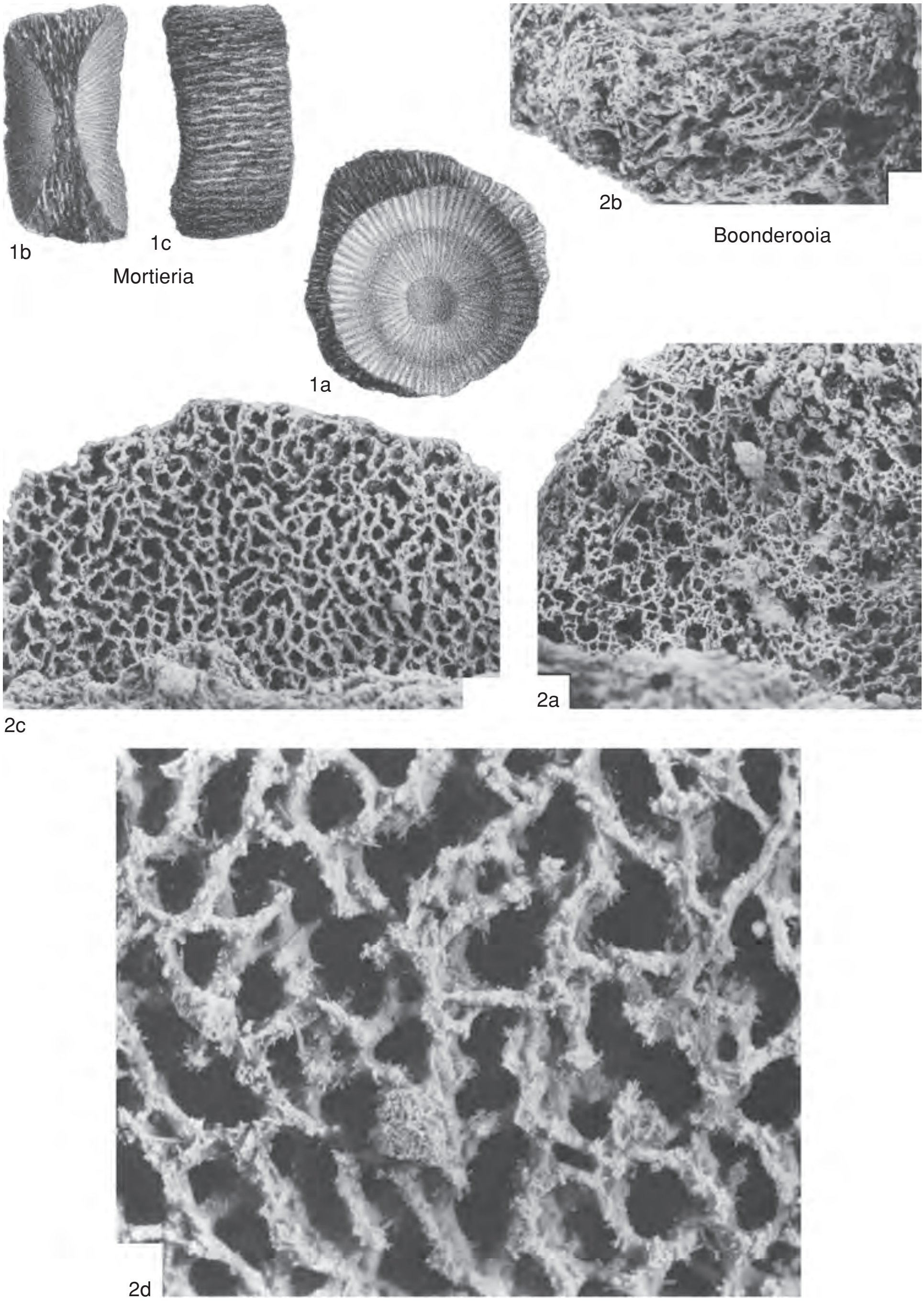

FIG. 103. Haplistiidae (p. 142–148).

submeandriform pores; large, radial canals of interior do not emerge at surface but are covered by skeletal net; fibers composed of straight to curved rhizoclones. *Devonian (?Eifelian):* Australia (New South Wales).——FIG. 106,*1a–b*. **C. massiva,* Timor Limestone, County Brisbane; *a,* fractured end of holotype showing radiate, skeletal, and canal structure in massive sponge, ×0.8; *b,* side view

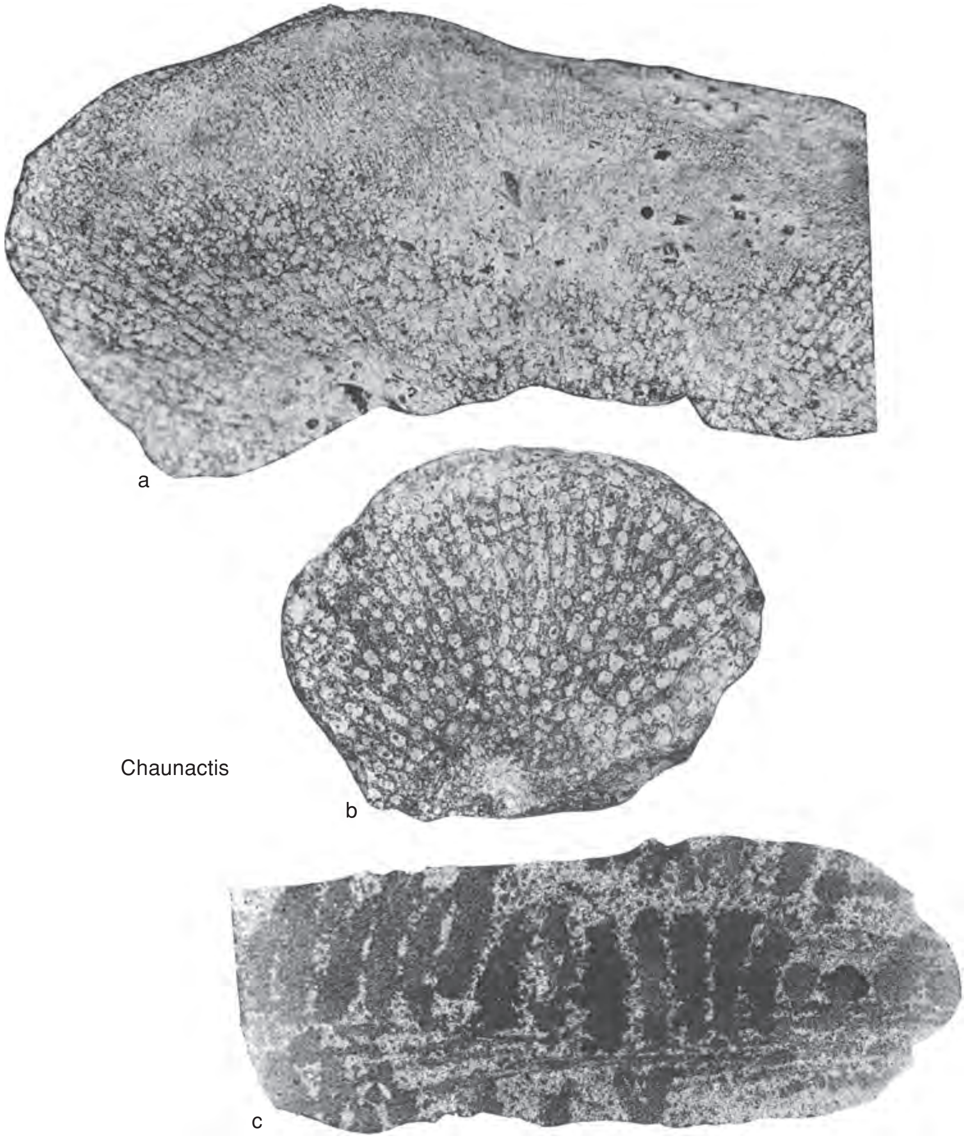

FIG. 104. Haplistiidae (p. 142).

of holotype showing variation in ostia of canals and radiate, skeletal tracts in fractured areas, AM F4896, ×0.8 (Pickett, 1969).

Kazania STUCKENBERG, 1895, p. 183 [**K. elegantissima;* SD TSCHERNYSCHEV, 1898, p. 14]. Resembles *Haplistion* but differs in that spiculofibers are cored by long, smooth oxeas, and in that tangential, connecting fibers are frequently branched or anastomosing. *Permian (Artinskian):* Russia (Ural Mountains).——FIG. 102,*2a–b.* **K. elegantissima,* upper Kohlenkalksteine; *a,* radial section of ellipsoidal holotype, ×0.5; *b,* section of skeleton showing rodlike trabeculae and cross-connecting fibers, ×1 (Stuckenberg, 1895).

Lewinia RIGBY & WEBBY, 1988, p. 22 [**L. cavernosa;* OD]. Obconical to open disclike, cavernous with skeleton dominantly of vertical rods and weblike blades in regular, upwardly and outwardly expanded, radiating pattern pierced by large, vertical canals; tracts with coring monaxons, vertical tracts cross braced by horizontal tracts or single spicules that may radiate in pincushion-like patterns; dense, dermal layer over base and sides. *Upper Ordovician:* Australia (New South Wales).——FIG.

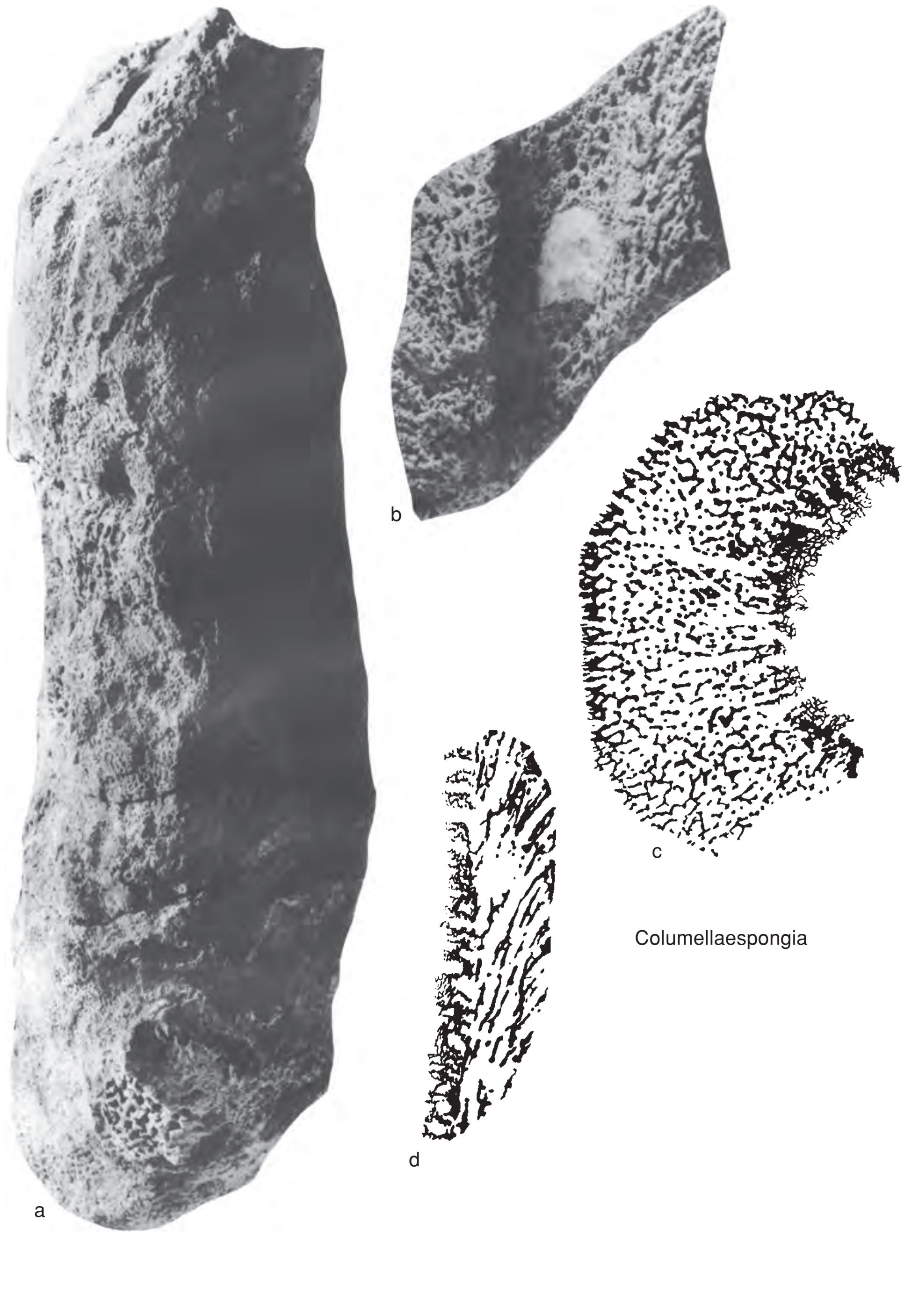

FIG. 105. Haplistiidae (p. 142).

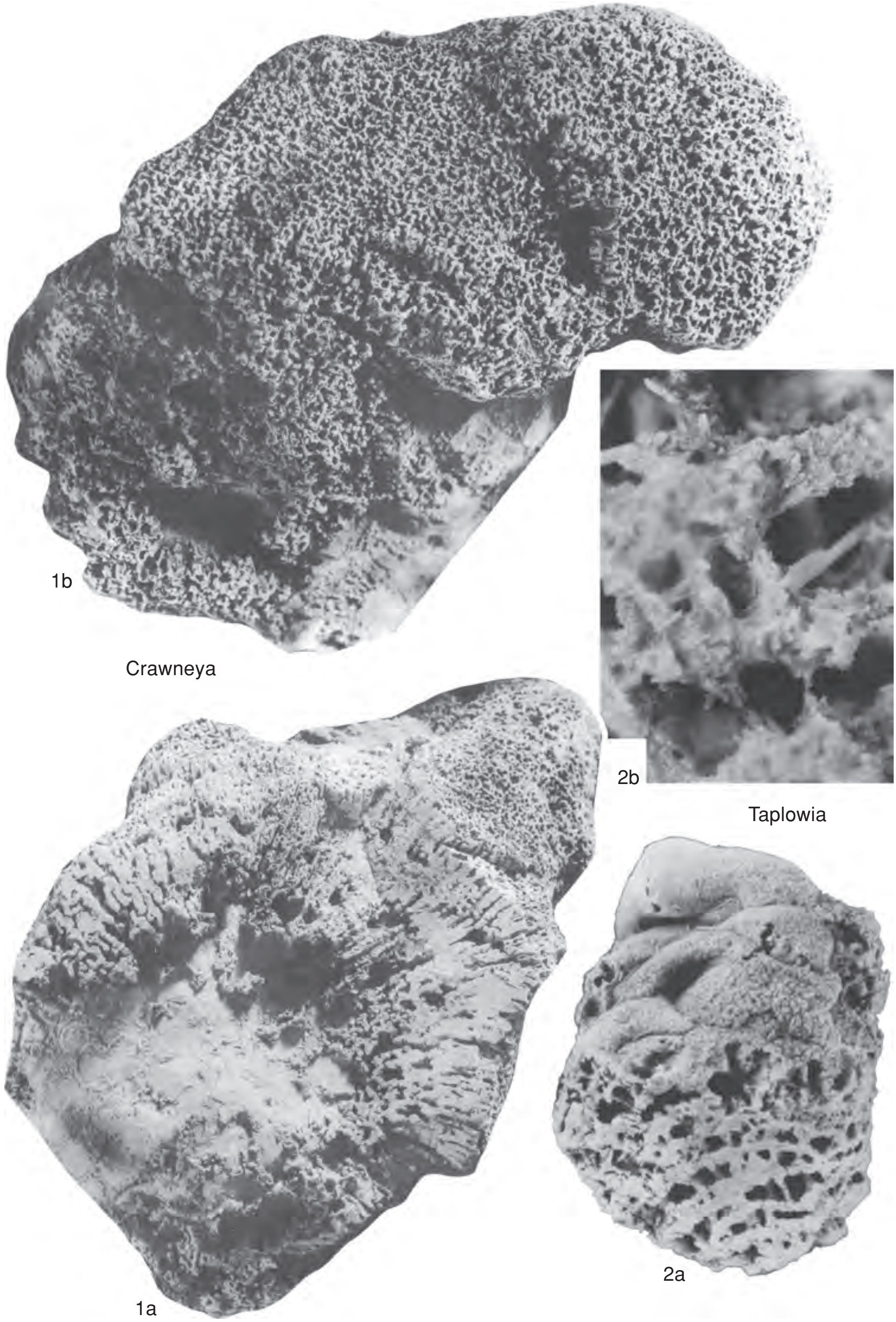

FIG. 106. Haplistiidae (p. 142–152).

107,*1a–b*. **L. cavernosa,* Malongulli Formation, Cliefden Caves area; *a,* broken base of holotype showing major canals parallel to and normal to vertical, skeletal tracts of rhizoclones interior to dense, dermal layer, AMu. F66797, ×2; *b,* photomicrograph of skeletal structure of paratype showing vertical tracts cross connected by ropy tracts or by single rhizoclones that produce weblike texture of skeleton; large, vertical canals cross connected by smaller, horizontal openings, AMu. F66798, ×10 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

?Monarchopemmatites DE LAUBENFELS, 1947, p. 187, *nom. nov. pro Pseudopemmatites* KING, 1943, p. 12, *non* FRAIPONT, 1911 [**Pseudopemmatites skinneri* KING, 1943, p. 16; OD]. Identical in external form, skeletal net, and rhizoclone spiculation to *Pemmatites* DUNIKOWSKI, 1884, p. 13, and *Haplistion* YOUNG & YOUNG, 1877, p. 428. The type species was included in *Haplistion* by FINKS (1960). [That placement is followed here, and for that reason the genus is not illustrated herein.] *Permian (Artinskian):* USA (Texas).

Mortieria DE KONINCK, 1842 in 1842–1844, p. 12 [**M. vertebralis;* OD]. Biconcave discs or short cylinders, thickening from center to maximum at cylindrical, outer edge (possibly originally growing about a now-disappeared algal stalk or similar object); vertical edge a sharp rim; outer surfaces may bear closely spaced, long, smooth oxeas, arranged radially on upper and lower surfaces and vertically on outer edge; similar spicules may be present in interior; upper and lower surfaces bearing radial rows of circular to oval pores of vertical canals subparallel to (convex toward) outer edge where canals are represented by vertical, surface grooves; internal skeleton an open meshwork of desmas organized into continuous, radial, vertical lamella between rows of canals, connected by concentric, vertical lamella that outline canals; desmas appear to be dendroclones (or dendroclone-shaped spiculofibers), chiastoclones (or chiastoclone-shaped spiculofibers), and possible rhizoclones; the so-called dendroclones may have their axes horizontal and connect radial fibers. [Genus is similar to *Chaunactis* FINKS.] *Carboniferous (Tournaisian)–Permian (Kungurian):* North America, Europe, Timor.——FIG. 103,*1a–c*. **M. vertebralis,* Europe, *a,* view from above of discoidal sponge with broad, depressed, gastral surface; *b,* vertical section showing thinned, medial part and thicker, marginal parts of specimen; *c,* side view showing vertical ribbing of dermal margin, ×1 (de Koninck, 1842).

Nipterella HINDE, 1889b, p. 144 [**Calathium paradoxicum* BILLINGS, 1865, p. 358; OD]. Cylindrical, expanded basally, upper surface shallowly concave, canals perpendicular to surface; spicules largely rhizoclones (or possibly chiastoclones); poorly known. *Lower Ordovician:* Canada.——FIG. 108,*2a–b*. **N. paradoxicum* (BILLINGS), Romaine Formation, Mingan Islands, Quebec; *a,* side view of holotype, ×1 (Billings, 1865); *b,* isolated rhizoclone spicules from holotype, ×50 (Hinde, 1889b).

Oremo PICKETT, 1969, p. 14 [**O. fibrosus;* OD]. Spheroidal to irregular; no cloaca; principal spiculofibers radial, connected by thinner, lateral fibers composed of straight or curved rhizoclones parallel to length of fibers; exterior with numerous fine, irregular pores. [Genus differs from *Crawneya* PICKETT, 1969, chiefly in absence of large, internal canals and in somewhat less regular spiculofibers. *Haplistion robustum* PICKETT, 1969, is here considered an *Oremo,* a possibility suggested by its author.] *Devonian (?Eifelian–?Givetian):* Australia (New South Wales).——FIG. 109*a–c*. **O. fibrosus,* Moore Creek Limestone, ?Eifelian, County Inglis; *a,* holotype showing dimensions of columella-like, skeletal tracts and their orientations, AM F12833, ×1; *b,* reference specimen showing lower range of dimensions of skeletal tracts in divergent, skeletal structure, AM F, ×1; *c,* photomicrograph of skeletal tracts composed of numerous rhizoclones in holotype, AM F12833, ×30 (Pickett, 1969).

Parodospongia RIGBY & CHATTERTON, 1989, p. 13 [**P. euhydra;* OD]. Thin-walled, cuplike or bowl shaped with deep spongocoel; skeleton of rhizoclone tracts, bladelike in middle and gastral parts of wall, anastomosed and upwardly oriented around canals that enter horizontally, but rise steeply to gastral margin; tracts of loosely spaced, small rhizoclones subparallel to axes, with ragged surfaces. *Silurian (Ludlow):* Canada (Northwest Territories, Baillie-Hamilton Island).——FIG. 108,*1a–c*. **P. euhydra,* Cape Phillips Formation, Baillie-Hamilton Island; *a,* side view of gastral surface of holotype with moderately coarse, irregular canals bounded by ragged tracts of rhizoclones in upwardly expanding skeleton, ×1; *b,* photomicrograph of gastral surface with ragged tracts of closely packed rhizoclones, ×10; *c,* photomicrograph of dermal surface with tracts of rhizoclones around inhalant ostia, UA 7699, ×10 (Rigby & Chatterton, 1989; courtesy of Minister of Public Works and Government Services, 2000, and the Geological Survey of Canada).

?Pemmatites DUNIKOWSKI, 1884, p. 13 [**P. verrucosa;* SD DE LAUBENFELS, 1955, p. 49]. Spheroidal, discoidal, or lobate; no cloaca; spiculofibers cylindroid and radial with tangential connections forming a polygonal, mainly quadrate mesh; fibers composed of subparallel rhizoclones and smooth oxeas. [Genus is identical to *Haplistion* YOUNG & YOUNG, unless that genus lacks rhizoclones; *Pemmatites* is here considered a junior synonym of *Haplistion,* and is therefore not illustrated herein.] *Permian:* Spitzbergen.

?Radiatospongia WOLFENDEN, 1959, p. 567 [**R. carbonaria;* OD]. Skeletal net identical in form and proportions to that of *Haplistion* YOUNG & YOUNG and *Pemmatites* DUNIKOWSKI. [In the original description the skeletal fibers were interpreted as canals. No spicules were reported, and none have been discovered in subsequent investigation

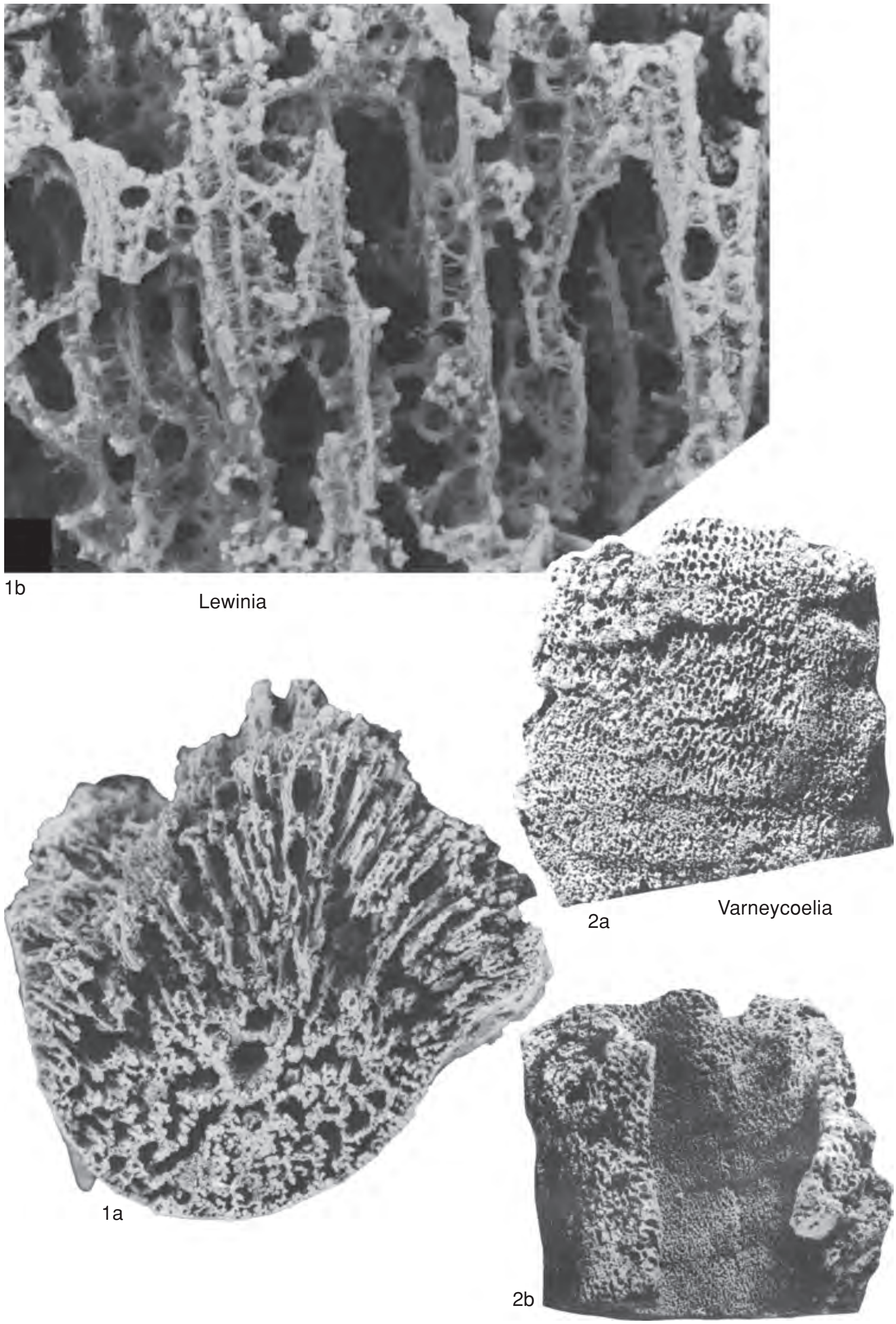

Fig. 107. Haplistiidae (p. 145–152).

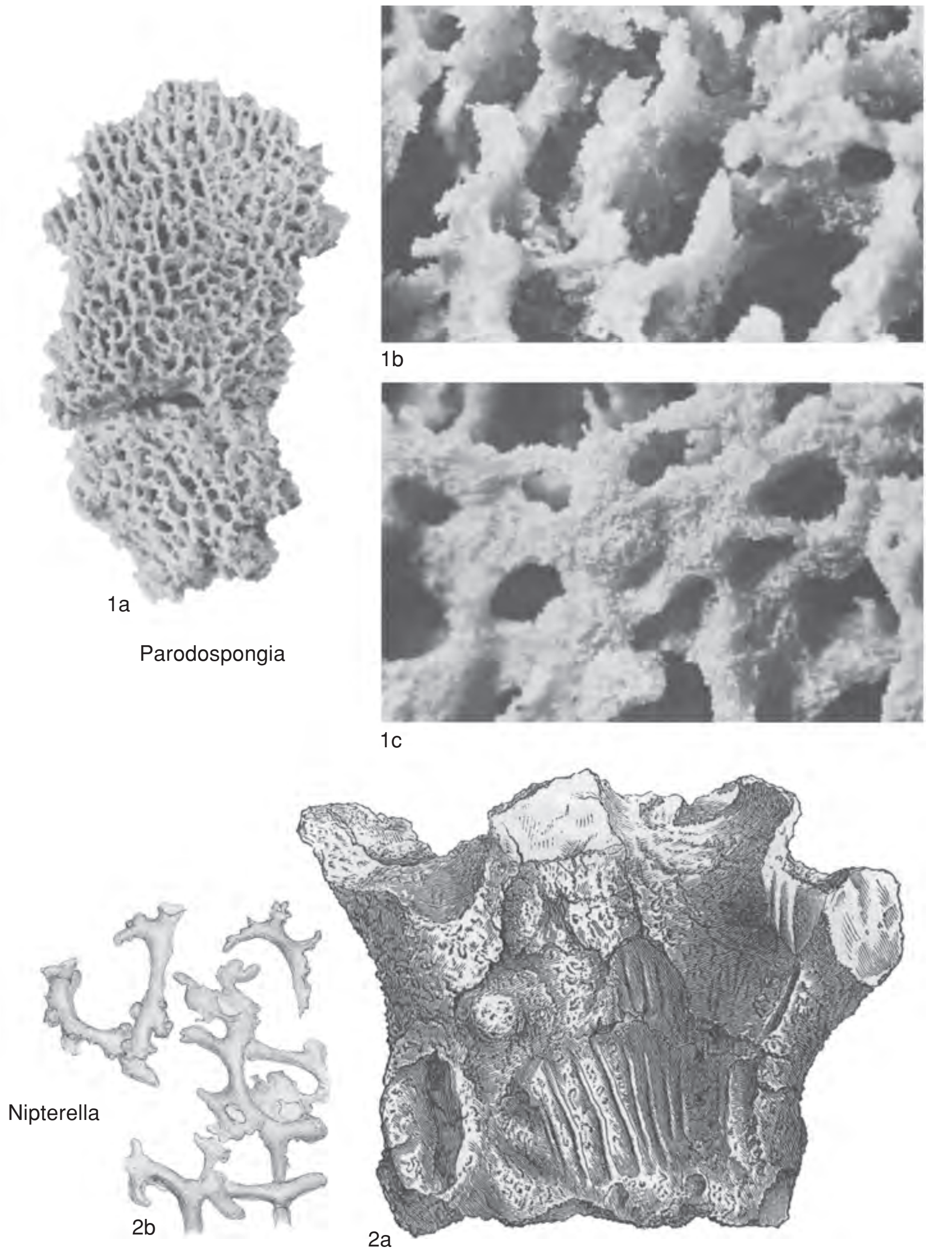

FIG. 108. Haplistiidae (p. 148).

of original material, nor in additional topotype specimens. It is herein considered a junior synonym of *Haplistion* on assumption that should spicules be found they will prove to be rhizoclones. For that reason it is not illustrated herein.] *Carboniferous (Visean):* England.

?Rhaphidhistia CARTER, 1878, p. 140 [**R. vermiculata;* OD]. The sole specimen, a small hemisphere, comes from the type locality of *Haplistion* YOUNG & YOUNG; it appears identical to *Haplistion* (see HINDE, 1887b, pl. 5,*1–2*) and, thus, is not illustrated herein. *Carboniferous (Visean):* Scotland.

Taplowia RIGBY & WEBBY, 1988, p. 21 [**T. ordinata;* OD]. Strongly obconical, regular stromatoporoid-like with pillarlike and lamina-like vertical and

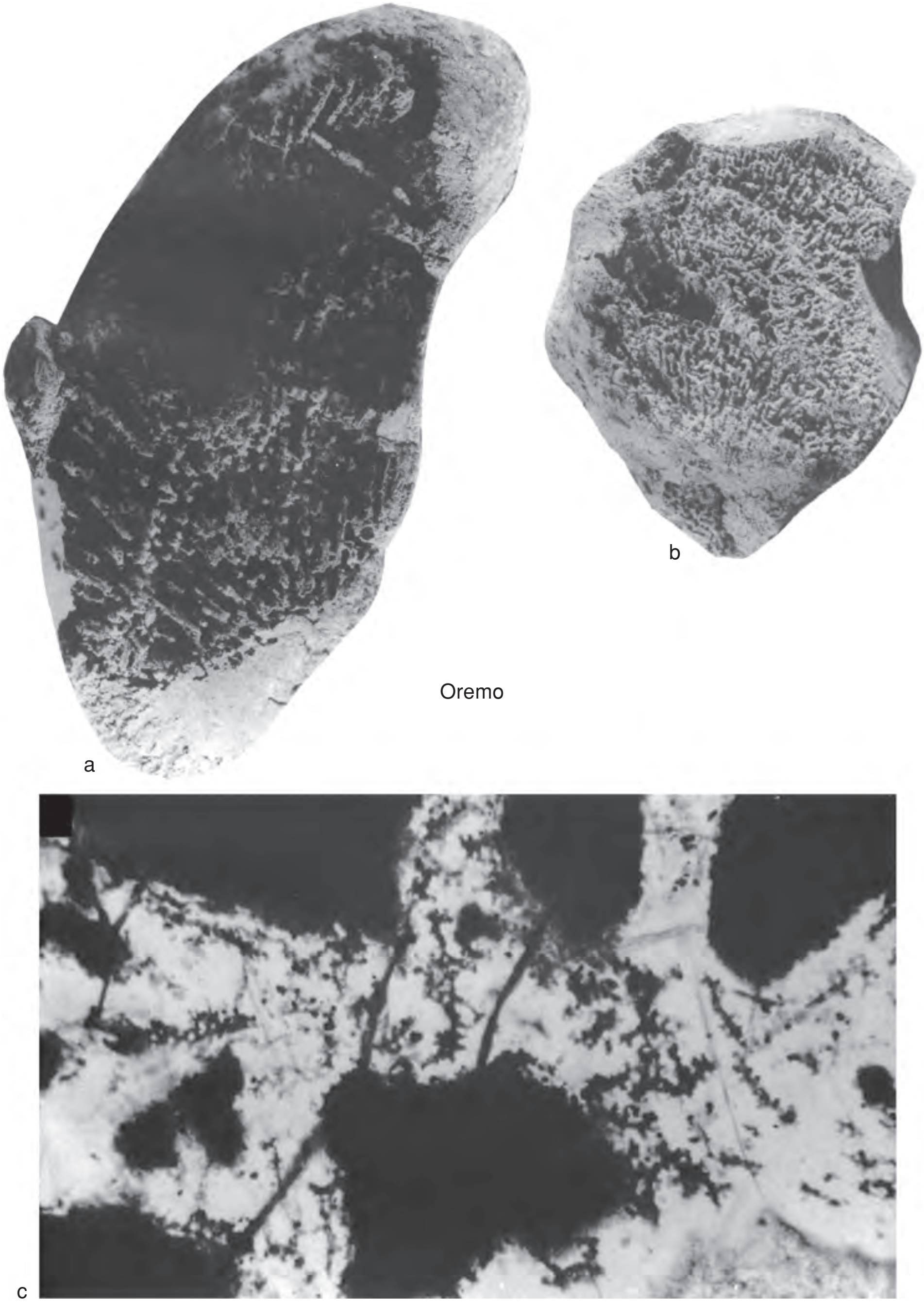

FIG. 109. Haplistiidae (p. 148).

horizontal elements of tracts of rhizoclones, tracts dividing sponge into chambers; pillarlike tracts limited between chamber floors; horizontal tracts at uniform levels; dense, dermal net of fused, tilelike, small rhizoclones. *Upper Ordovician:* Australia (New South Wales).——FIG. 106,*2a–b.* **T. ordinata,* Malongulli Formation, Cliefden Caves area; *a,* side view of holotype with irregular,

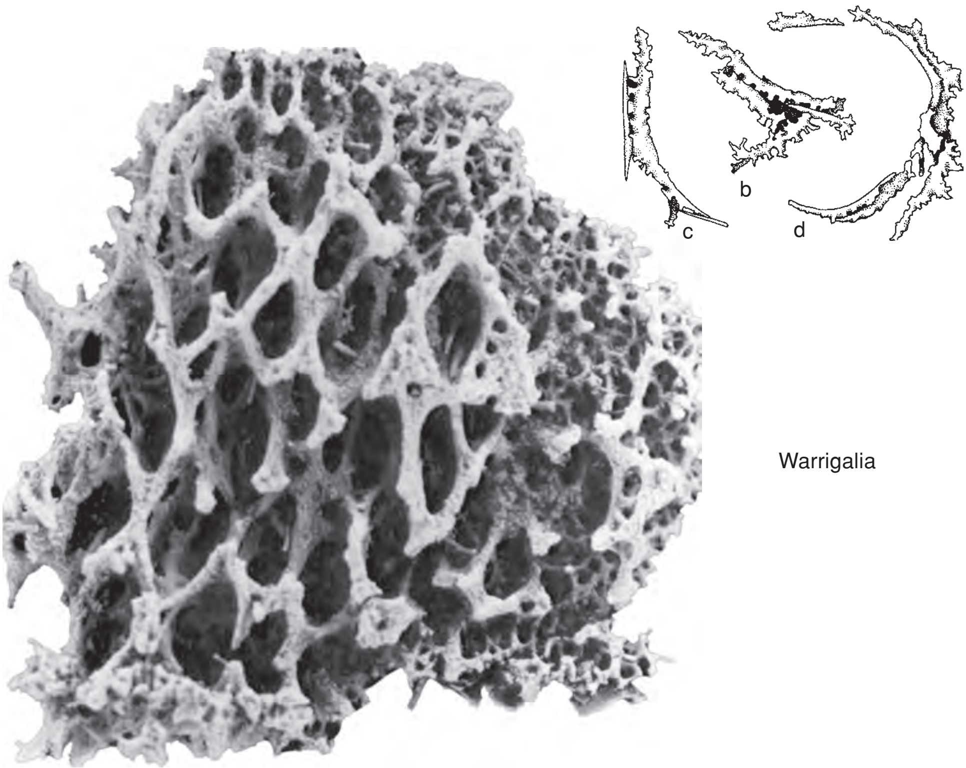

FIG. 110. Haplistiidae (p. 152).

bulbous upper part and tangential view of inner part with pillars and floors all composed of bundled rhizoclones, ×4; *b,* photomicrograph of tracts composed of small, bundled rhizoclones, AMu. F66796, ×20 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Varneycoelia PICKETT, 1969, p. 10 [**V. favosa;* OD]. Cylindrical, thin-walled, with deep, broad cloaca; exterior and cloacal surfaces bearing subdued, horizontal swellings and contractions; spicular net of straight, subparallel rhizoclones forming thin, porous walls between closely packed, radial, horizontal canals of polygonal to rounded outline; wall resembles a honeycomb in tangential section; canals open as rounded pores of somewhat smaller diameter on both cloacal and exterior surfaces. *Lower Devonian:* Australia (New South Wales).——FIG. 107,*2a–b.* **V. favosa,* Gara beds, Wellington Caves; *a,* side view of cylindrical holotype with aligned ostia of canals in uniform, skeletal mesh, ×1; *b,* vertical section of holotype with thick walls around axial spongocoel, AM F19973, ×1 (Pickett, 1969).

Warrigalia RIGBY & WEBBY, 1988, p. 18 [**W. elliptica;* OD]. Thin-walled, flabellate to massive sheetlike or obconical to bladed sponges, interior, skeletal tracts undulating or anastomosing, irregular ribbons beneath differentiated, dermal layer; tracts of long, tightly packed rhizoclones without coring monaxons, tracts locally cross braced with isolated dendroclones. *Upper Ordovician:* Australia (New South Wales).——FIG. 110*a–d.* **W. elliptica,* Malongulli Formation, Cliefden Caves area; *a,* fragment of holotype showing elliptical canals limited by tracts of bundled rhizoclones in interior and finer textured, dermal layer around right margin, AMu. F66792, ×10; *b–d,* camera lucida drawings of silicified spicules of holotype; *b,* irregular cluster of rhizoclones of several sizes; *c,* curved rhizoclone attached with zygomes to small, coring oxeas; *d,* curved rhizoclones with smooth surfaces around a pore and articulations on opposite side in interior of skeletal tract, ×50 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Family UNCERTAIN

Sentinelia WALCOTT, 1920, p. 289 [**S. draco* WALCOTT, 1920, p. 290; OD]. Flat to gently lobate or rounded, frondescent sponges marked by low, rounded tubercules to elongate mounds a few

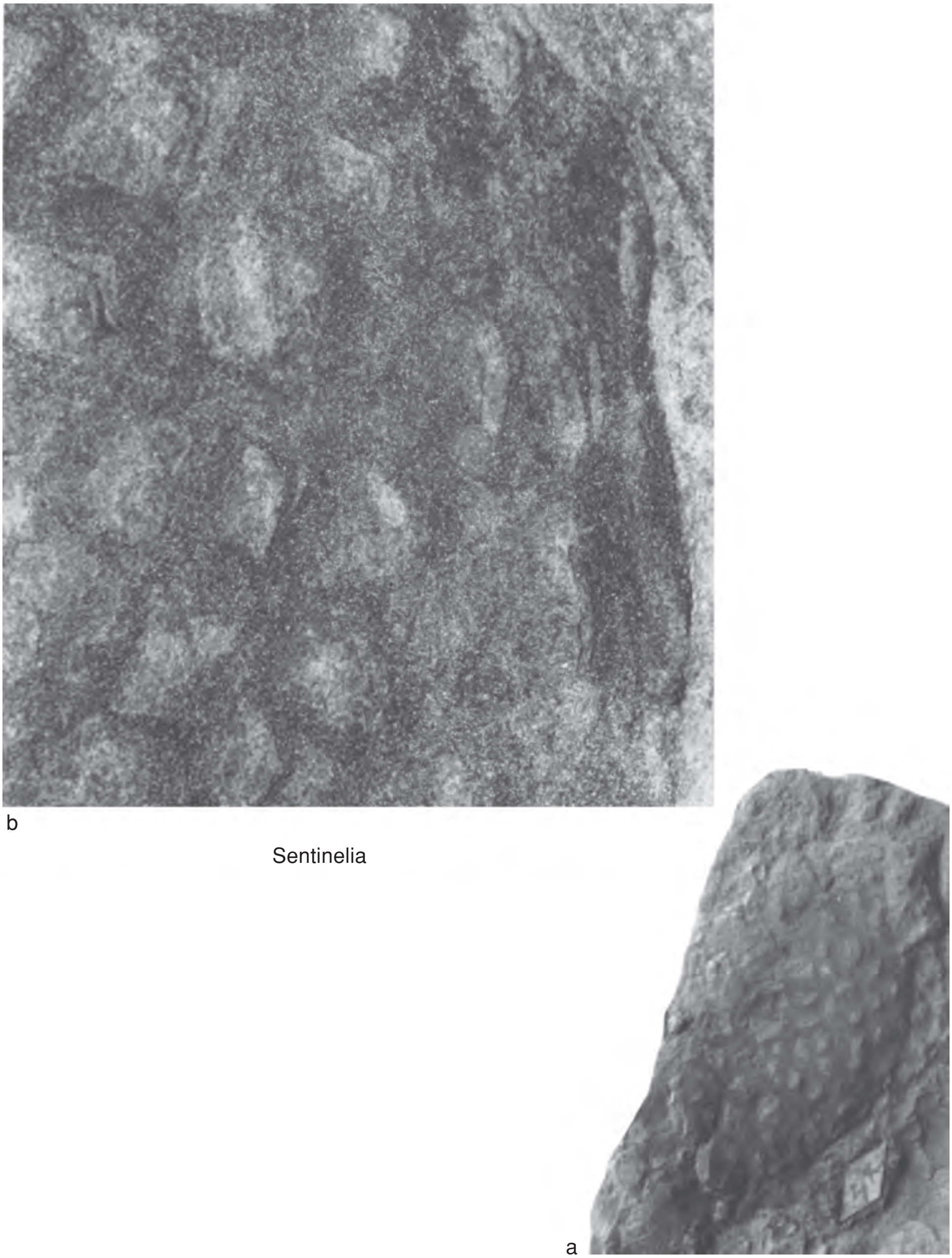

FIG. 111. Uncertain (p. 152–153).

millimeters in diameter, rising less than 1 mm above the general surface; small openings piercing tubercules and entire openings may have been parietal gaps; skeleton of irregular, monaxial spicules, perhaps with a dermal layer of even smaller, monaxial spicules. *Middle Cambrian:* USA (Utah).——FIG. 111*a–b.* **S. draco,* Wheeler Formation, House Range; *a,* nodose, holotype fragment of bun-shaped sponge, ×1; *b,* enlargement showing linear fabric of elongate, possible monaxons in tracts between canal openings, USNM 66478, ×5 (Rigby, 1986a).

Subclass TETRACTINOMORPHA Lévi, 1953

[*nom. correct.* BERGQUIST, 1967, p. 166, *pro* subclass Tétractinomorphes LÉVI, 1953, p. 855]

Principal spicules typically tetraxons, which may be accompanied by oxeas or styes; microscleres are euasters or streptoscleres, which may be accompanied by microrhabds; sigmas are not present. *Ordovician–Holocene.*

Order STREPTOSCLEROPHORIDA Dendy, 1924

[*nom. correct.* FINKS & RIGBY, herein, *pro* Streptosclerophora DENDY, 1924b, p. 249; *emend.,* FINKS & RIGBY, herein]

Living forms with streptosclere microscleres; lithistid forms built of layers of anapodal spicules, which may be accompanied by other types of desma (rhizoclones, tetraclones); dermal spicules consisting of radial dichotriaenes and derivatives in Mesozoic and later forms, radial oxeas in Paleozoic forms, and also include tangential, dermal monaxons (oxeas, strongyles) and derivatives (plates, discostrongyles). *Upper Ordovician–Permian (Changhsingian).*

Suborder EUTAXICLADINA Rauff, 1894

[*nom. transl.* ZITTEL, 1895, p. 49, *ex* tribus Eutaxicladinidae RAUFF, 1894, p. 280; *emend.,* FINKS & RIGBY, herein] [=Tricranocladina REID, 1968a, p. 24]

Principal spicules tricranoclones, which may be accompanied by megarhizoclones; dermal spicules radial, large oxeas (and possibly strongyles) and tangential, small oxeas and strongyles. *Upper Ordovician–Permian (Lopingian).*

Family HINDIIDAE Rauff, 1893

[*nom. correct.* FINKS, 1960, p. 97, *pro* Hindiadae RAUFF, 1894, p. 327] [=Microspongiidae MILLER, 1889, p. 153]

Skeleton of concentric or parallel layers of anapodal tricranoclones with approximation of hexagonal packing in each layer; spicules occupying corresponding positions in each layer so as to form radial stacks that outline radial, skeletal canals between them, opening as pores on outer surface; each tricranoclone has a short, distal arm in most early Paleozoic forms that is absent in late Paleozoic forms, and three distally convex, proximal arms (occasionally four) whose ends are terminally expanded into concave, articular facets and whose distal surfaces are generally covered with spheroidal tubercles; each proximal arm bearing articular facets of overlying tricranoclones on its distal surface near centrum; in *Scheiella* megarhizoclones occupying spaces between tricranoclones; possible dermal skeleton of radial and tangential oxeas present in some genera, with radial oxeas occupying radial canals. [MILLER (1889, p. 153) included in his family Microspongiidae both *Microspongia* and *Hindia,* which he considered to be separate genera. Because the identity of the nominal genus is doubtful (see below) and is here considered unrecognizable, the later family name Hindiidae is used instead for this taxon.] *Upper Ordovician–Permian (Changhsingian).*

Hindia DUNCAN, 1879, p. 91, *nom. conserv.,* proposed RIGBY, 2004, ICZN pending, application 3316 [**H. sphaeroidalis;* OD] [=*Sphaerolites* HINDE, 1875, p. 88 (type, *S. nicholsoni,* OD); *?Microspongia* MILLER & DYER, 1878, p. 37 (type, *M. gregaria,* OD)]. Spheroidal; three-armed tricranoclones in radially stacked series; spicules with short, crownlike brachyome and with tubercles or projections on distal surface of thin-armed cladome and on brachyome; cladi articulate at base of brachyome; radial canals and pores of two sizes (smaller inhalant and larger exhalant), but large oscules absent; radial and tangential oxeas present. [*Sphaerolites* HINDE, 1875 has priority, for it was based on the same specimens as *Hindia* DUNCAN, 1879 (*fide* HINDE, 1888, p. 115). The original description of *Microspongia* MILLER & DYER, 1878 does not correspond to that of *Hindia* DUNCAN (neither does that of *Sphaerolites*) and the types are lost (*fide* ULRICH, 1890a, p. 228–229). Retention of the more widely used name *Hindia* is recommended here (ICZN ruling pending, application 3316).] *Upper Ordovician–Lower Devonian:* North America, Europe, Australia.——FIG. 112,*2a–c.* **H. sphaeroidalis; a,* silicified, spherical sponge with flattened base, Silurian, Gotland, Sweden, ×1; *b,* median section showing radiate, canal pattern defined by radial series of stacked spicules, Silurian, near St.

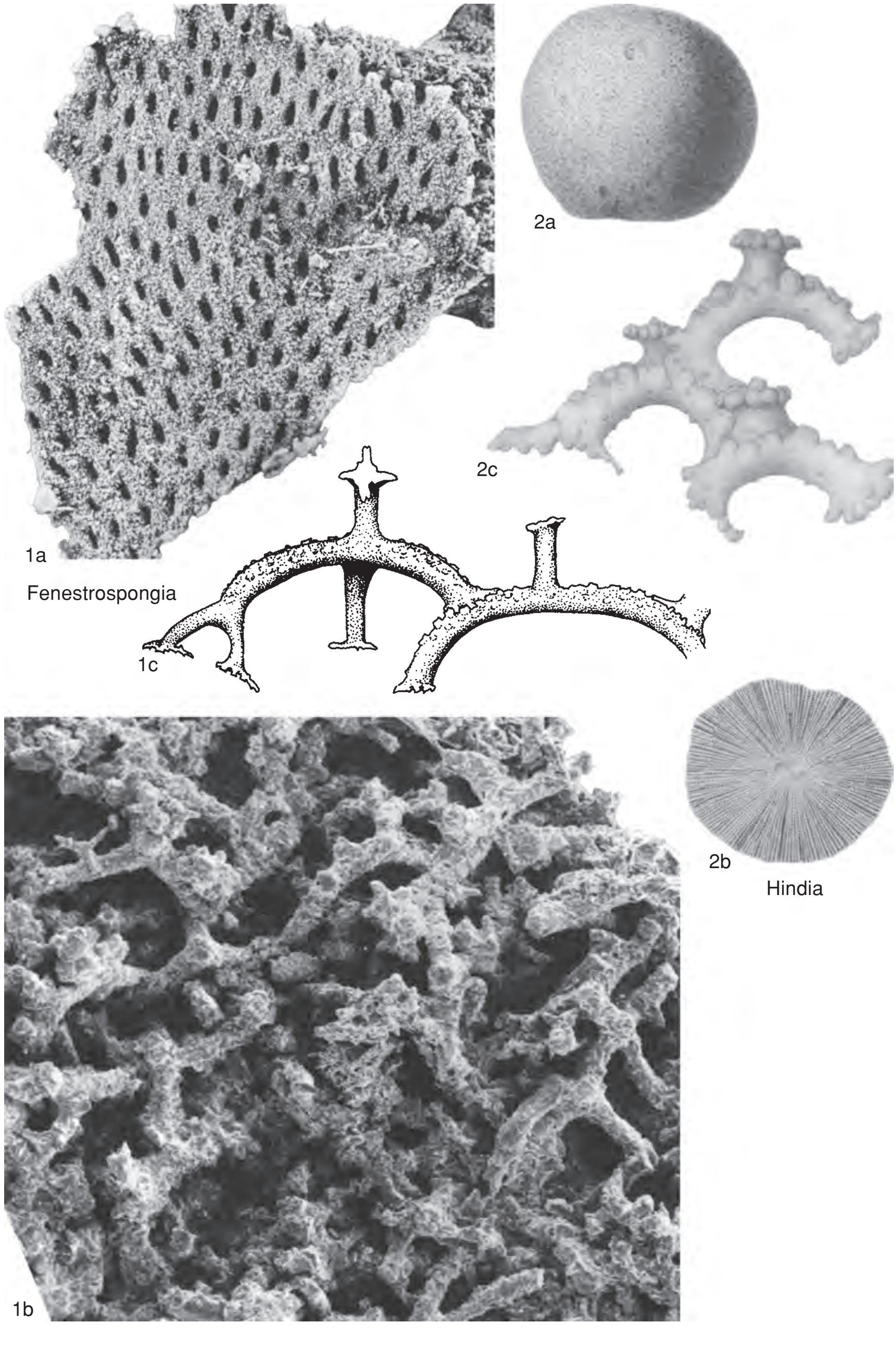

FIG. 112. Hindiidae (p. 154–158).

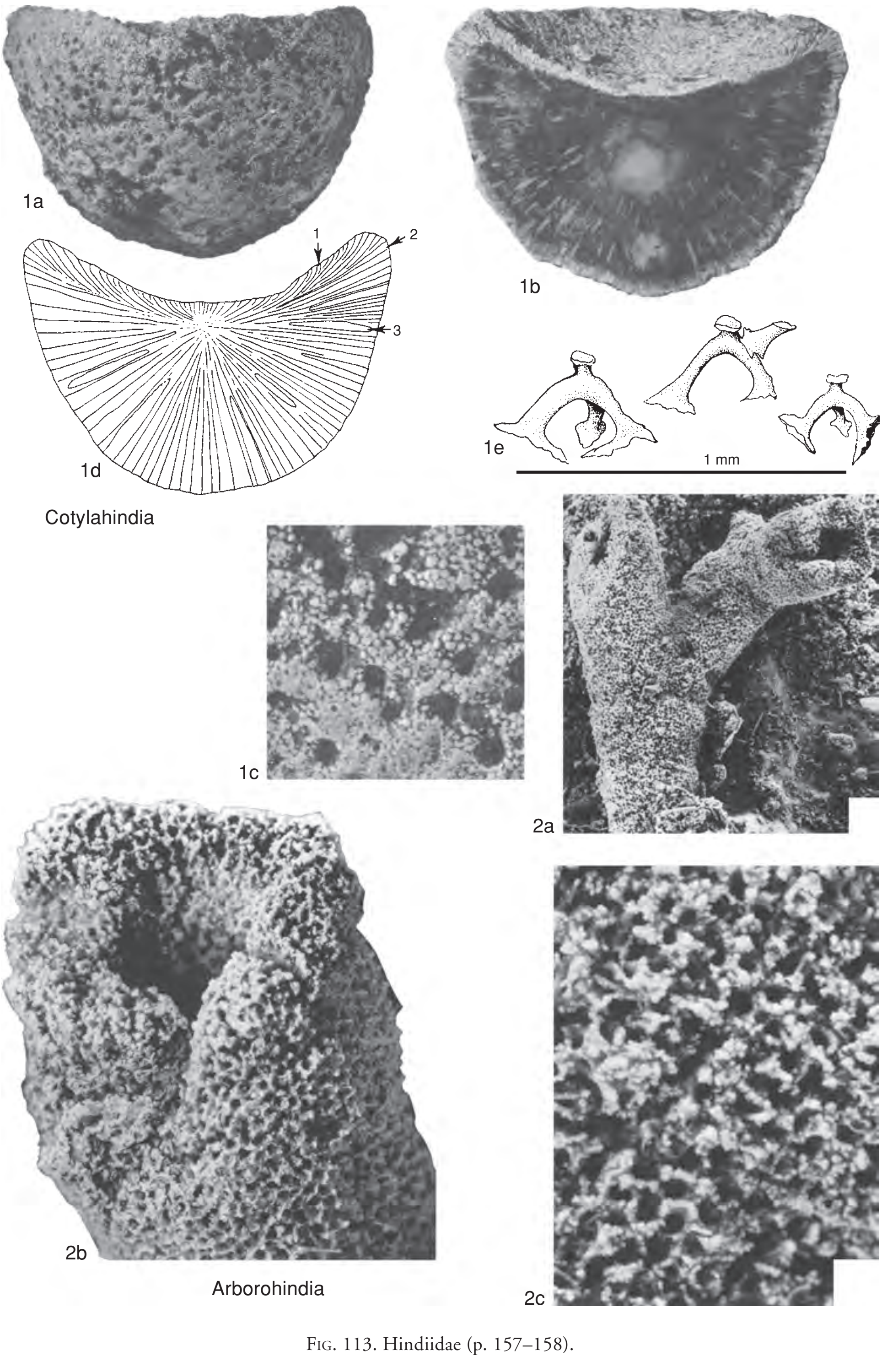

FIG. 113. Hindiidae (p. 157–158).

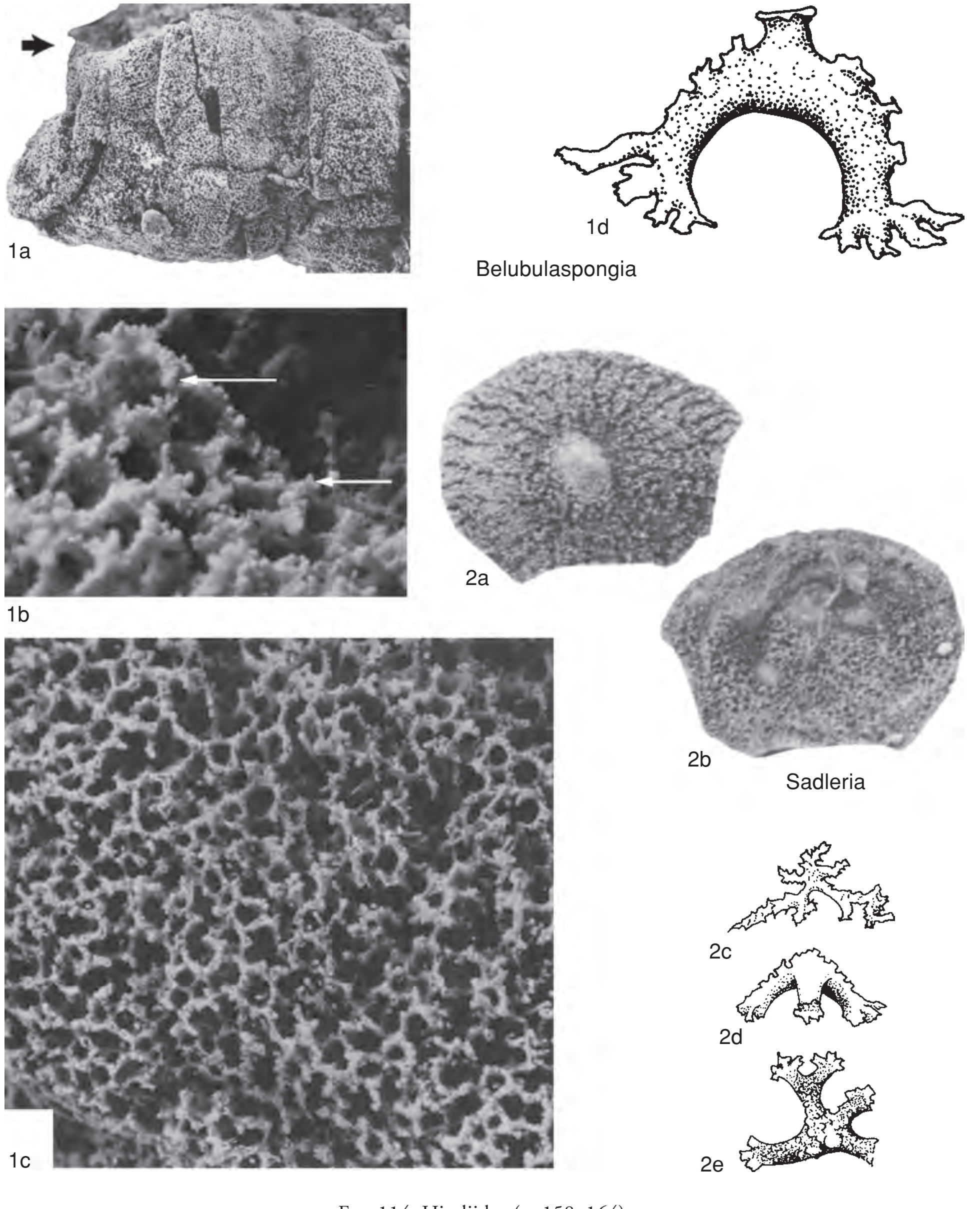

FIG. 114. Hindiidae (p. 158–164).

Petersburg, Russia, ×1; *c,* drawing of relationships of tricranoclone spicules characteristic of genus and family, Silurian, Gotland, ×120 (Rauff, 1893).

Arborohindia RIGBY & WEBBY, 1988, p. 70 [**A. uniforma;* OD]. Small, branching, subcylindrical hindiids with deep spongocoel; walls generally without canals other than uniformly spaced, skeletal pores between spicules; skeleton of normal tricranoclones with pronounced brachyomes and three sculptured, cladome rays, arranged in layers parallel to upwardly convex, growing margin of wall. [*Belubulaspongia* RIGBY & WEBBY, 1988, is a related larger, unbranched sponge, but with a similar skeletal structure.] *Upper Ordovician:* Australia (New South Wales).——FIG. 113,*2a–c.* **A. uniforma,* Malongulli Formation, Cliefden Caves area; *a,* side view of branching holotype showing upper end of tubular, axial spongocoel and uniform, skeletal structure, ×2; *b,* enlarged oscular end of branch with rounded, oscular margin and walls generally without canals other than interconnecting pores between normal tricranoclones, ×8; *c,* photomicrograph of dermal layer with dermal tricranoclones that have nodose, distal structure on cladome rays that surround circular pores, AMu. F66882, ×18 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Belubulaspongia Rigby & Webby, 1988, p. 63 [**B. gigantea;* OD]. Tubular, unbranched, relatively large, hindiid sponges with deep, central spongocoel; skeleton of stacked tricranoclones with prominent brachyome; spicules added parallel to rounded, upper edge of wall, but do not produce lamination in skeleton; canal system ill defined as crude, upwardly and outwardly radiating, skeletal pores. *Upper Ordovician:* Australia (New South Wales).——Fig. 114,*1a–d.* **B. gigantea,* Malongulli Formation, Cliefden Caves area; *a,* side view of nearly complete, conicocylindrical holotype, ×1; *b,* photomicrograph of weathered, silicified surface showing sculptured, distal surfaces of cladomes of spicules and bifid brachyomes that project distally (*arrows*), ×18; *c,* photomicrograph of dermal layer of uniform skeleton with undifferentiated tricranoclones with three cladomes tangentially around circular ostia, ×8; *d,* sketch of side view of isolated tricranoclone showing distal ornamentation on cladomes that have digitate tips and are approximately 0.5 mm long with prominent brachyome on top, AMu. F66869 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Cotylahindia Rigby & Bayer, 1971, p. 617 [**C. panaca* Rigby & Bayer, 1971, p. 618; OD]. Open, thick-walled, bowl-shaped sponge with massive base and shallow, broad spongocoel; base pierced by canals of three sizes that radiate from point within base, except in upper few millimeters where they curve abruptly upwardly into spongocoel; spicules moderately smooth tricranoclones in which clonomes weakly curved to straight and in which brachyome short but distinct. *upper Upper Ordovician:* USA (Minnesota).——Fig. 113,*1a–e.* **C. panaca,* Richmondian, Maquoketa Formation, Fillmore County; *a,* side view of exterior of holotype with dark matrix filling inhalant canals; *b,* vertical section showing radiating canals below base of broad spongocoel, ×1; *c,* photomicrograph of dermal surface showing canals and skeletal pores defined by rays of adjacent tricranoclones, ×3; *d,* sketch of vertical section showing orientation of canals that flex up into floor of spongocoel and radiate upwardly and downwardly in outer parts of skeleton, approximately ×1; *e,* camera lucida drawings of isolated tricranoclones from silicified holotype, UM 9150, ×47 (Rigby & Bayer, 1971).

Fenestrospongia Rigby & Webby, 1988, p. 74 [**F. explanata;* OD]. Fenestrate appearing, thin, saucerlike sponges with principal, round, skeletal tracts composed of compactly spaced, tiny tricranoclones, on which a prominent brachyome rises above long, thin, arcuate clonomes; two series of strong tracts cross diagonally to produce elliptical openings. *Upper Ordovician:* Australia (New South Wales).——Fig. 112,*1a–c.* **F. explanata,* Malongulli Formation, Cliefden Caves area; *a,* concave, gastral surface of holotype showing regular, round, spicule tracts and fenestrate form of sponge, ×2; *b,* SEM photomicrograph showing narrow-rayed tricranoclones in felted structure with three long, cladome rays tangential to surface and vertical, brachyome rays, ×100; *c,* sketch of articulated spicules from side showing weakly sculptured, long, cladome rays and prominent, vertical brachyomes, AMu. F66890, spicules 0.3 to 0.4 mm across (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Mamelohindia Rigby & Webby, 1988, p. 72 [**M. planata* Rigby & Webby, 1988, p. 73; OD]. Saucer-shaped to stalked, explanate hindiid in which upper, gastral surface marked with low, mamelon-like nodes, particularly above stalk; canals moderately well defined and pinnately arranged about midwall axis; skeleton of tricranoclones without brachyomes but ray junction marked with small hemisphere, nodes, and cylinders; dermal layer of thickened tricranoclones. [*Cotylahindia* Rigby & Bayer, 1971, is also a bowl-shaped hindiid, but it has a prominent, radiate skeleton and different canal pattern; *Scheiella* Finks, 1971b, and *Sadleria* Rigby, 1986b, lack the mamelon-like nodes on the gastral surface and have more complex skeletons.] *Upper Ordovician:* Australia (New South Wales).——Fig. 115*a–d.* **M. planata,* Malongulli Formation, Cliefden Caves area; *a,* vertical view of upper gastral surface of holotype with distinctive mounds in central part where spicules are particularly swollen, dark, excurrent ostia scattered across surface, ×2; *b,* lower surface of holotype showing uniform skeleton interrupted by coarse, incurrent ostia and broken stalk, ×2; *c,* side view of holotype with weakly stalked base and complete, rounded, growing margin, ×2; *d,* photomicrograph of dermal skeleton showing triangular-appearing tricranoclones with strongly nodose centra and distal parts of cladomes, largest openings are incurrent ostia, AMu. F66885, ×20 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

?Microspongia Miller & Dyer, 1878, p. 37 [**M. gregaria;* OD]. Originally described as a spheroidal, calcareous sponge with fibrous or finely porous texture, without large canals or openings on surface and with minute, needle-shaped spicules. [Genus may be the same as *Hindia* Duncan, 1879 (Miller, 1889, p. 160, expressed doubt as to such

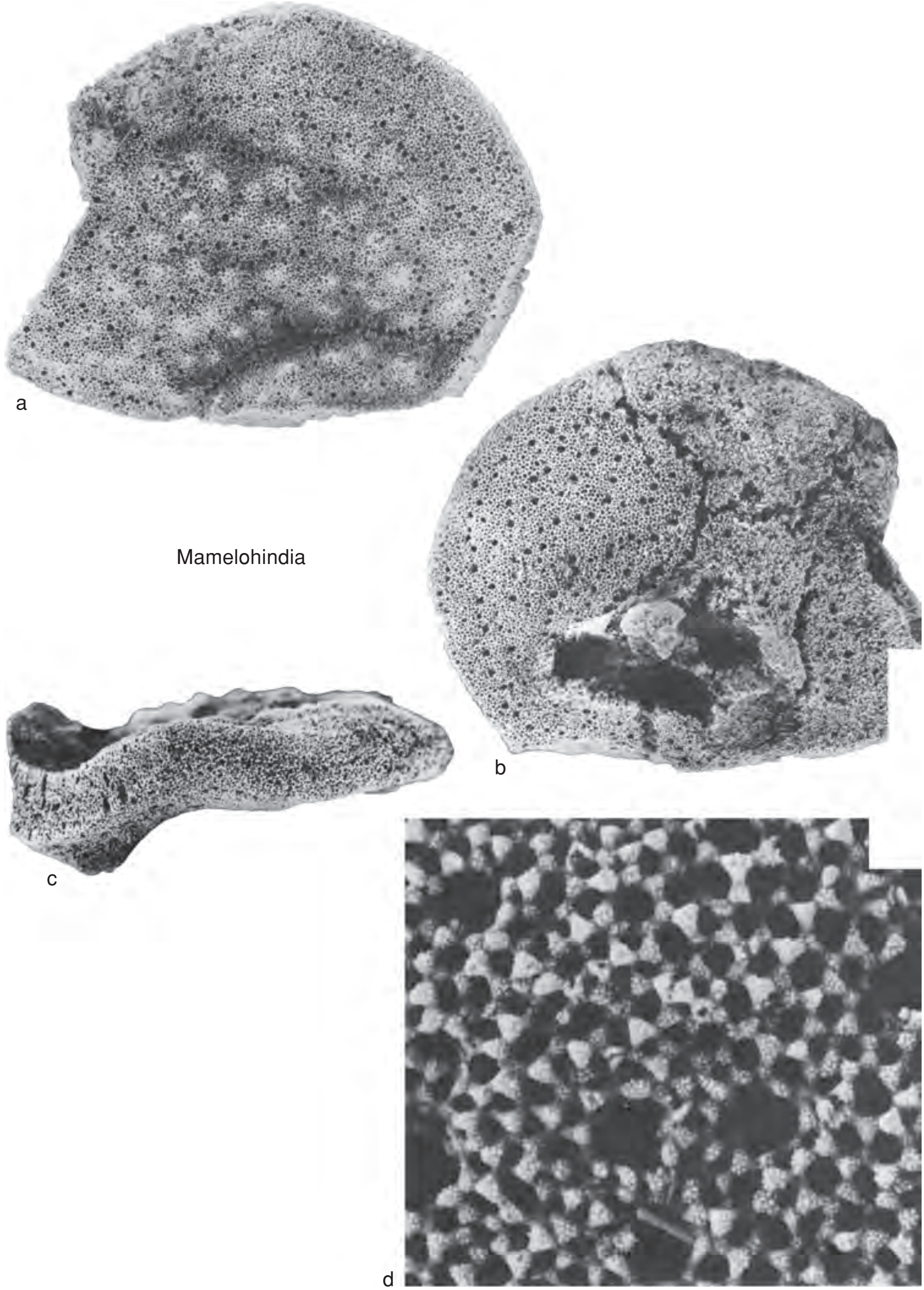

FIG. 115. Hindiidae (p. 158).

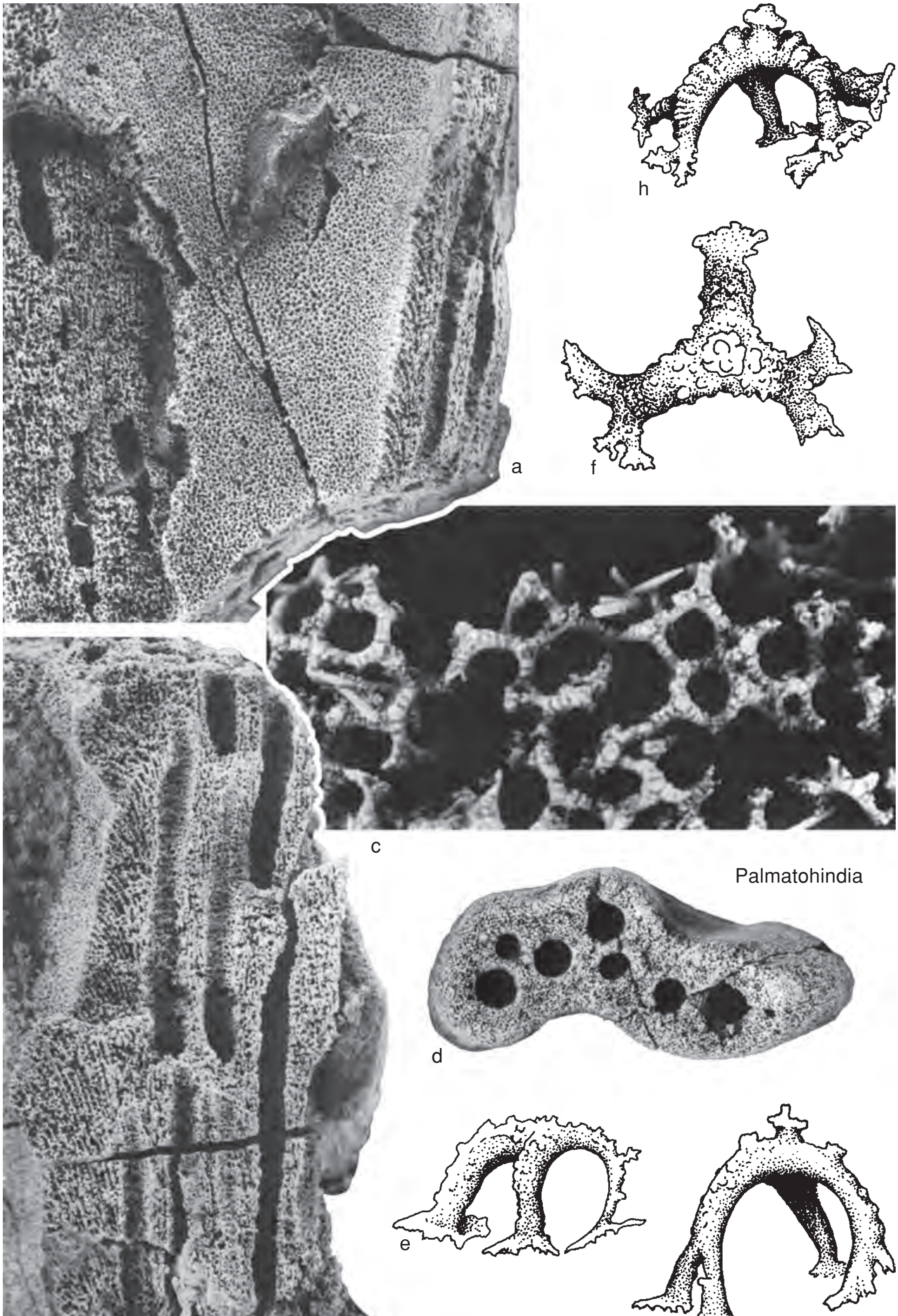

FIG. 116. Hindiidae (p. 162–163).

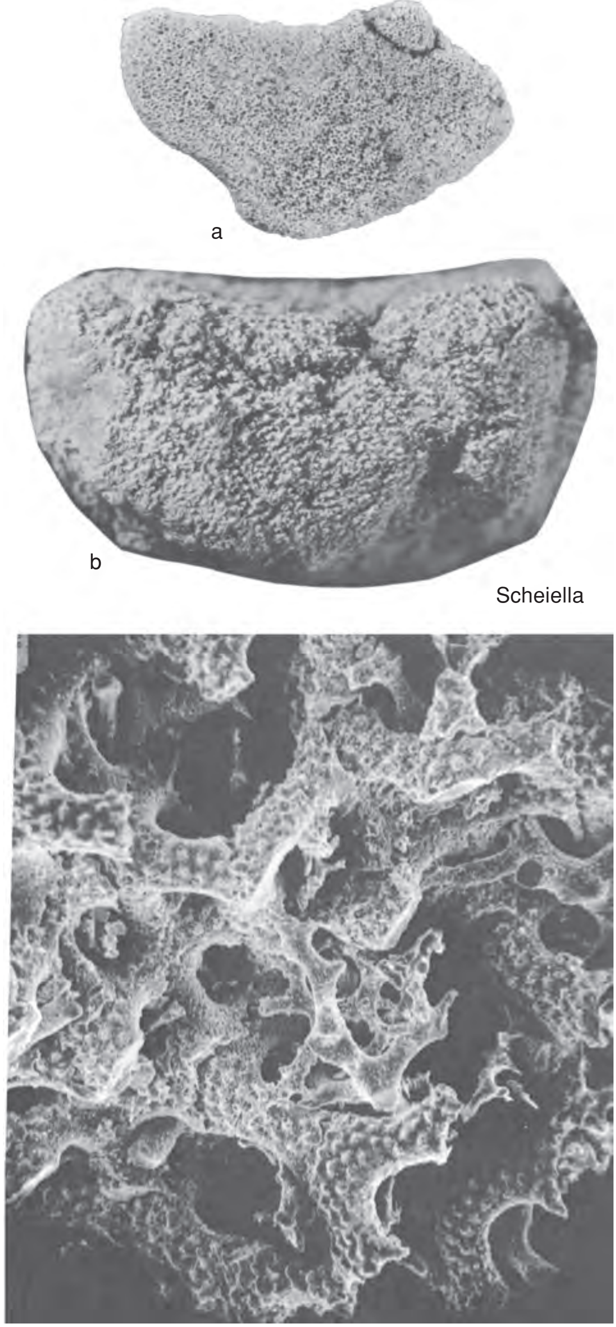

FIG. 117. Hindiidae (p. 164).

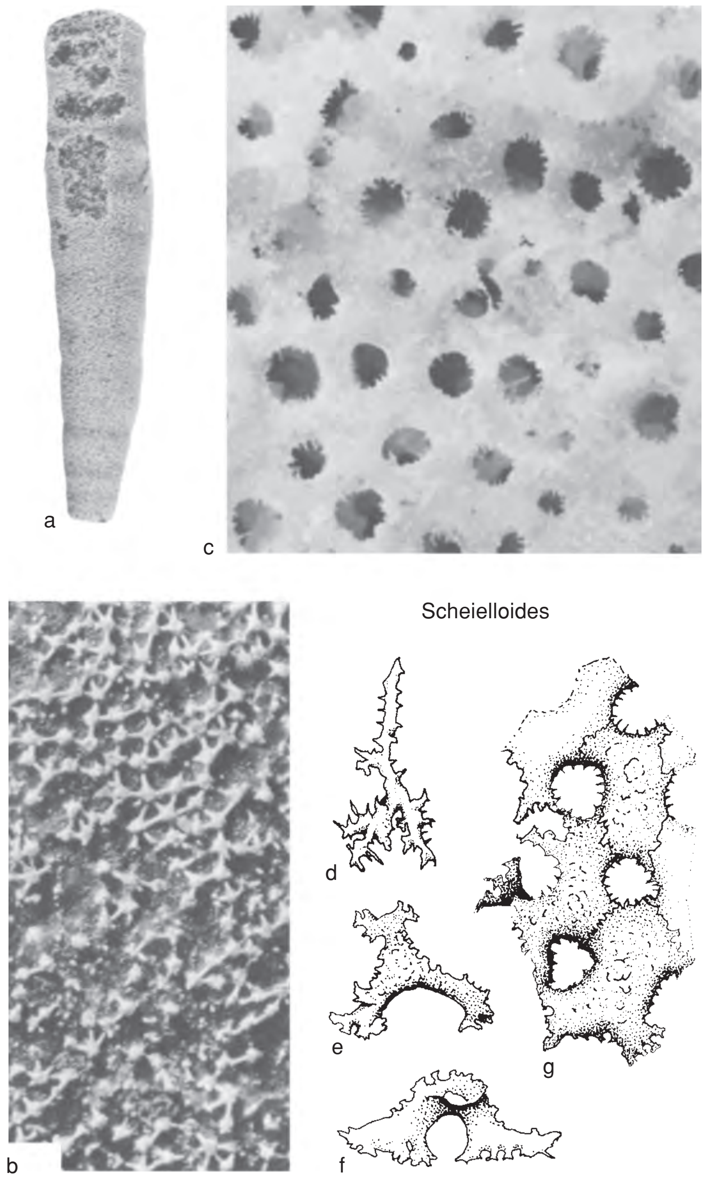

FIG. 118. Hindiidae (p. 164).

a synonymy); the types are lost (see *Hindia* above), and it must be considered unrecognizable.] *Upper Ordovician:* USA (Ohio).

Palmatohindia RIGBY & WEBBY, 1988, p. 65 [**P. multipora;* OD]. Vertically palmate to bladed hindiids with blades perforated along blade axis by numerous vertical, excurrent canals; skeleton of normal tricranoclones oriented with brachyomes vertical or normal to arcuate, growing surface; dermal layer of thickened tricranoclones. *Upper Ordovician:* Australia (New South Wales).——FIG. 116*a–h*. **P. multipora,* Malongulli Formation, Cliefden Caves area; *a,* diagonal side view of holotype showing uniform ostia in dense, dermal layer and upwardly divergent stacks of tricranoclones on broken end where two large, subparallel, excurrent canals also show, ×2; *b,* broken end showing multiple vertical, excurrent canals and upwardly diver-

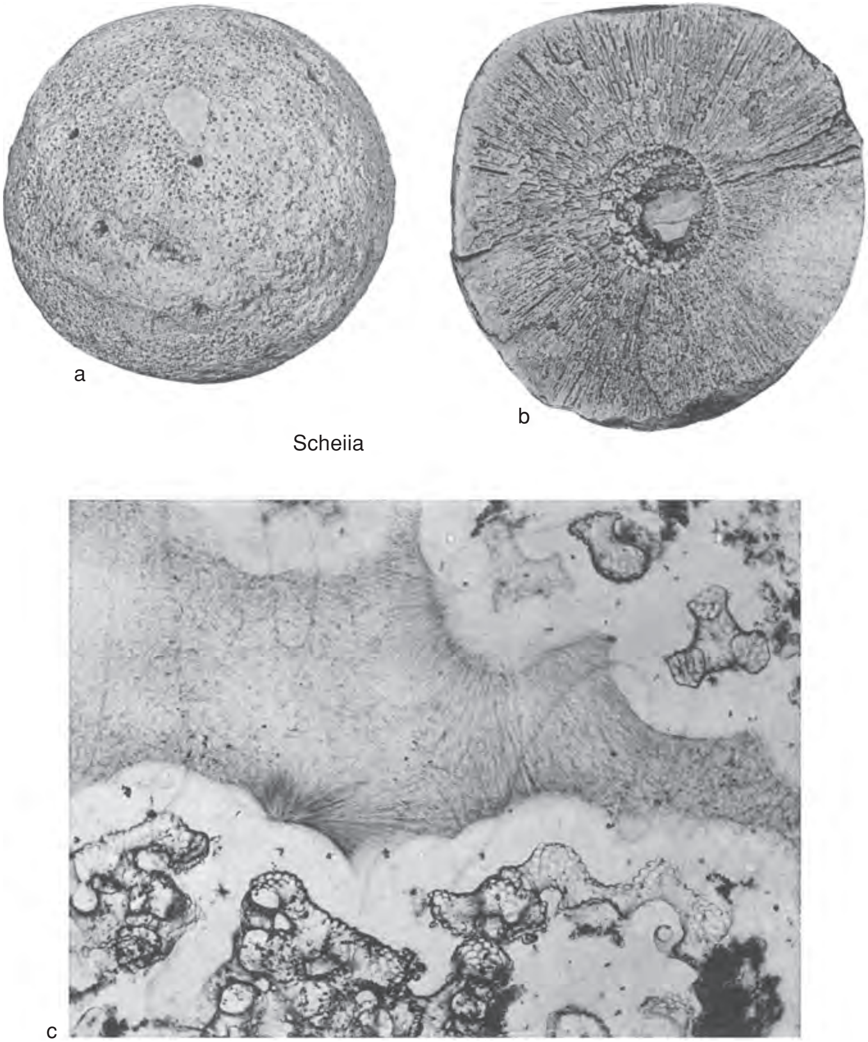

FIG. 119. Hindiidae (p. 164).

gent stacks of spicules terminating at dense, dermal layer, AMu. F66871, ×2; *c,* photomicrograph of tricranoclones with sculptured, distal surfaces of cladome rays and nodose or swollen, central brachyomes, shown in profile in upper, central part of figure, paratype, AMu. F66877, ×20; *d,* horizontal section of relatively small, undulating, bladed paratype and size and spacing of excurrent canals along midline of blade, AMu. F66873, ×2; *e–h,* camera lucida drawings of spicules from holotype, cladome rays 0.3 to 0.4 mm long (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Sadleria RIGBY, 1986b, p. 31 [**S. pansa* RIGBY, 1986b, p. 32; OD]. Small, funnel-shaped hindiid sponge in which major, irregular canals interrupt somewhat irregular skeleton composed predominantly of nodose, tripodal tricranoclones and less common, tetrapodal tricranoclones, megarhizoclones, and small, spinose rhizoclones; rare, monaxonid spicules occurring in canals; dense, dermal and gastral layers both composed of swollen spicules. *Devonian (Frasnian):* Australia (Western Australia).——FIG. 114,*2a–e.* **S. pansa,* Sadler Formation, Sadler Ridge; *a,* view from below of holotype showing prominent, tangential canals in thin walls above rounded base, ×2; *b,* view into broad, shallow spongocoel showing numerous small, exhalant ostia and thin walls, ×2; *c–e,* camera lucida drawings of isolated spicules from holotype, including a megarhizoclone and more common, sculptured tricranoclones with three and four clonomes, GSWA F7220, ×50 (Rigby, 1986b).

Scheiella FINKS, 1971b, p. 978 [**S. thesaurium* FINKS, 1971b, p. 979; OD]. Flattened and cake shaped; tricranoclones as in *Scheiia* but with a substantial minority four armed; combined in principal net with megarhizoclones, which are especially abundant on basal surface; net more open and somewhat less regular than in *Scheiia;* radial and tangential oxeas present. *Permian (Capitanian):* USA (Texas).——FIG. 117*a–c.* **S. thesaurium,* Bell Canyon Formation, Guadalupe Mountains; *a,* upper surface of cakelike holotype, coarse canals absent, ×2; *b,* broken side of holotype with vertical rows of superposed tricranoclones but no coarse canals, ×6; *c,* scanning electron photomicrograph of holotype fragment with nodose tricranoclones and smaller megarhizoclones, USNM 170273, ×100 (Finks, 1971b).

Scheielloides RIGBY, 1986b, p. 28 [**S. conica* RIGBY, 1986b, p. 29; OD]. Conicocylindrical to obconical with deep spongocoel; skeleton moderately regular, dominantly of tricranoclones but with some tetrapodal and bipodal spicules, generally arranged with clonomes toward base and knobby surfaces distally; spicules without brachyome but in armourlike, dermal layer with swollen, hemispherical knob in place of brachyome; small, spinose rhizoclones throughout; rare, radial monaxons; differentiated canals absent. *Devonian (Frasnian):* Western Australia.——FIG. 118*a–g.* **S. conica,* Sadler Limestone, Sadler Ridge; *a,* side view of small, subcylindrical holotype, GSWA F7215, ×2; *b,* vertical section through paratype showing cylindrical spongocoel, gastral surface, and nature of skeleton in walls, ×5; *c,* photomicrograph of gastral layer showing thickened tricranoclones around spinose, circular, exhalant ostia, GSWA F7217, ×50; *d–g,* camera lucida drawings of isolated spicules, including irregular megarhizoclones, more characteristic tricranoclones, and thickened tricranoclones of gastral layer, GSWA F7217, ×48 (Rigby, 1986b).

Scheiia TSCHERNYSCHEV & STEPANOV, 1916, p. 14 [**S. tuberosa;* OD]. Spheroidal, tuberose or bun shaped; three-armed tricranoclones without brachyome, with broad, triangular centrum; tricranoclones with four cladi may be present; distal surface of centrum and cladi covered by uniformly spaced, spheroidal tubercles; articulation on surface of centrum and adjacent cladi; larger oscules may be present in addition to pores of two or more sizes; radial and tangential oxeas present. *Carboniferous (Visean)–Permian (Changhsingian):* North America, USSR (Ural Mountains), Timor.——FIG. 119*a–c.* **S. tuberosa,* Leonard Formation, Leonardian, Glass Mountains, Texas, USA; *a,* spherical sponge with small, inhalant and exhalant pores and isolated, larger, exhalant oscula, USNM 127643b, ×1; *b,* median section with rows of spicules and canals radiating from central hollow, AMNH 28072, ×1; *c,* photomicrograph of tricranoclone spicules with swollen centra, rather than distal brachyomes, and with spherical tubercules on distal ray surfaces, USNM 127643c, ×50 (Finks, 1960; courtesy of The American Museum of Natural History).

Sphaerolites HINDE, 1875, p. 88 [**S. nicholsoni;* M]. Based on the same specimens as *Hindia* DUNCAN, 1879 (*fide* HINDE, 1888, p. 115) although described as a favositid coral, this is a senior objective synonym of *Hindia* DUNCAN. Retention of the more widely used name *Hindia* is recommended here (Rigby, 2004, ICZN ruling pending, application 3316). *Upper Ordovician–Lower Devonian:* North America, Europe, Australia.

Order MEGALITHISTIDA new order

[Megalithistida REID, herein] [=Megamorina ZITTEL, 1878a, p. 99; *sensu* ZITTEL, 1878a, p. 99, *non* SCHRAMMEN, 1924a, p. 61]

Lithistids that typically have dermal dichotriaenes and monaxial desmas in form of heloclones or megaclones; dermalia sometimes simple triaenes only or absent, but never phyllotriaenes, discotriaenes, or related types; rarely with additional small rhizoclonids; microscleres of modern examples microrhabds, spirasters, and amphiasters. [Definition and discussion of the order is given by REID (herein, p. 254) in treatment of Mesozoic sponges.] *Lower Ordovician–Holocene.*

Suborder MEGAMORINA Zittel, 1878

[*nom. transl.* SCHRAMMEN, 1924a, p. 38, *ex* tribus Megamorina ZITTEL, 1878a, p. 99; *emend.,* REID 1968a, p. 23] [=family Megamorinidae SCHRAMMEN, 1910, p. 32]

Principal spicules megaclones, heloclones, or ophirhabds. *Lower Ordovician–Holocene.*

Family ARCHAEODORYDERMATIDAE Reid, 1968

[Archaeodorydermatidae REID, 1968b, p. 1,253]

Presumptively sublithistid Megamorina. *Carboniferous (Visean).*

Archaeodoryderma REID, 1968b, p. 1,253 [**Doryderma dalryense* HINDE, 1884a, p. 210; M]. Isolated spicules grade from ophirhabds through heloclones to simple megaclones; presumed to be from a sublithistid sponge, although a true lithistid, some loose desmoids cannot be ruled out; form of sponge unknown. *Carboniferous (Visean):* Scot-

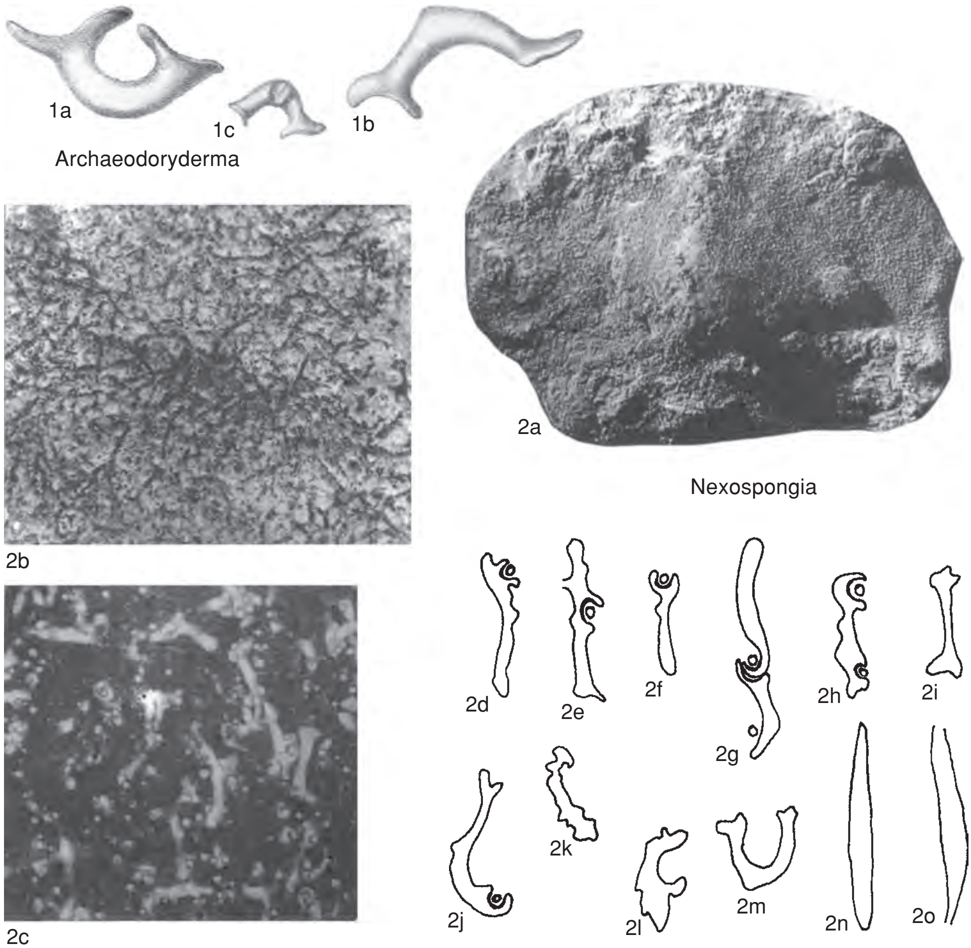

FIG. 120. Archaeodorydermatidae and Nexospongiidae (p. 164–169).

land.——FIG. 120,*1a–c.* **A. dalryense* (HINDE), Law Quarry, Dalry, Ayrshire; type suite of isolated spicules, ×28 (Hinde, 1884a).

Family SACCOSPONGIIDAE Rigby & Dixon, 1979

[Saccospongiidae RIGBY & DIXON, 1979, p. 603]

Sponges with skeletal nets of simple, radiating to branching or complexly cross-connected tracts composed dominantly of heloclones with intermixed styles and oxeas or of tracts cored with styles and blanketed with heloclones; megaclones wanting or minor; triaenes unknown. *Lower Ordovician–Silurian (Ludlow, ?Pridoli).*

Saccospongia ULRICH, 1889, p. 242 [**S. rudis;* OD]. Ramose, with well-developed, central spongocoel in each branch; sponge surface hispid with subparallel ridges and grooves; principal spiculofibers subparallel to axis of branch, intersecting outer surface obliquely; fibers composed of styles arranged both plumosely and in coring and echinating positions; fibers covered to a variable extent with a layer of heloclonid desmoids. *Upper Ordovician:* USA (Kentucky, Tennessee, Alabama).——FIG. 121,*3.* **S. rudis,* Cynthiana Formation, Lexington, Kentucky; side view of subovate holotype showing skeletal fibers and part of impervious basal layer, USNM 465781, ×1 (Ulrich, 1889).

Cliefdenospongia RIGBY & WEBBY, 1988, p. 27 [**C. lamina* RIGBY & WEBBY, 1998, p. 28; OD]. Curved, thin-walled, possibly tubular; skeleton of tracts of heloclones as principal spicules around coring oxeas, latter particularly evident in dermal

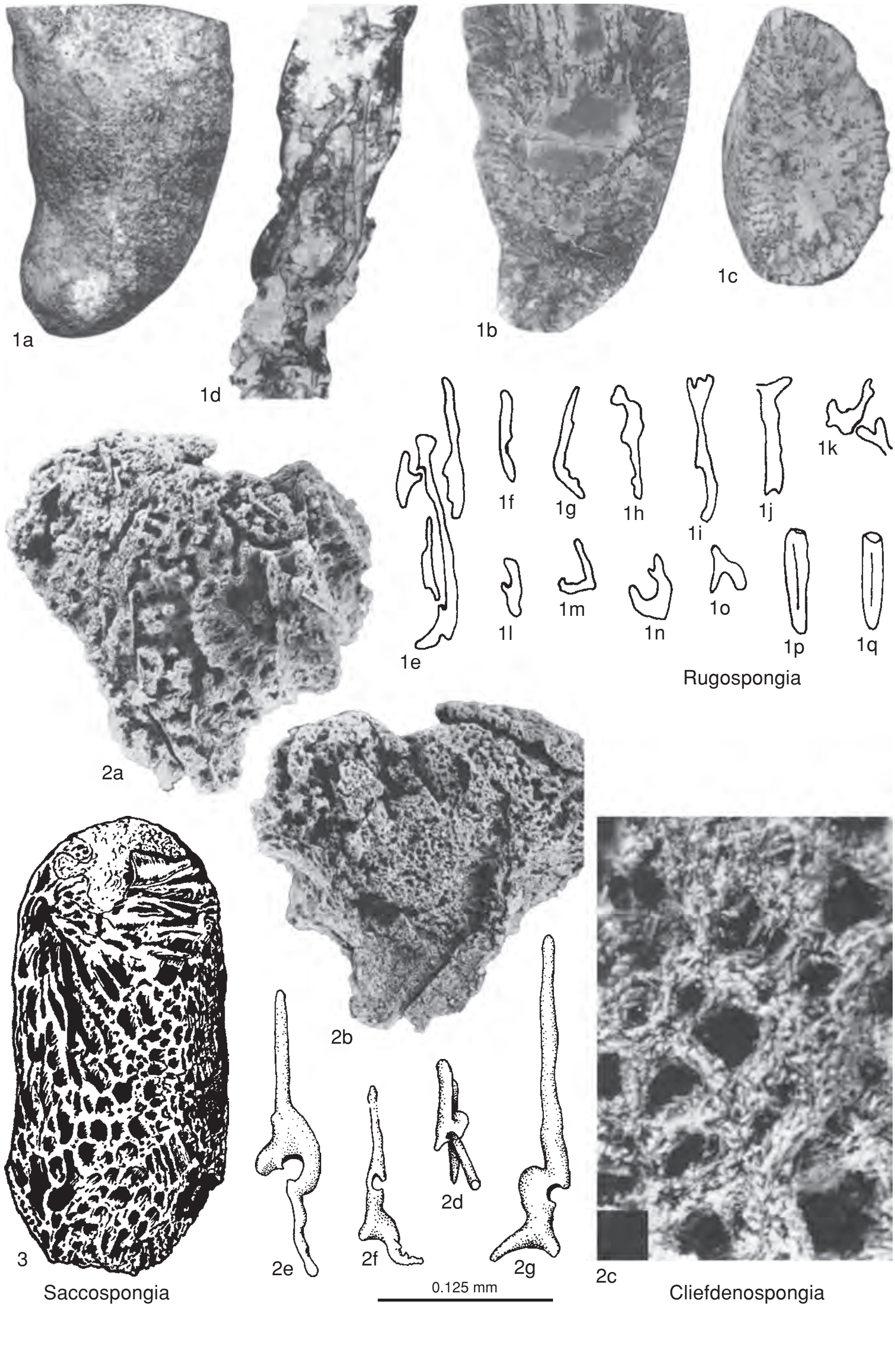

FIG. 121. Saccospongiidae (p. 165–168).

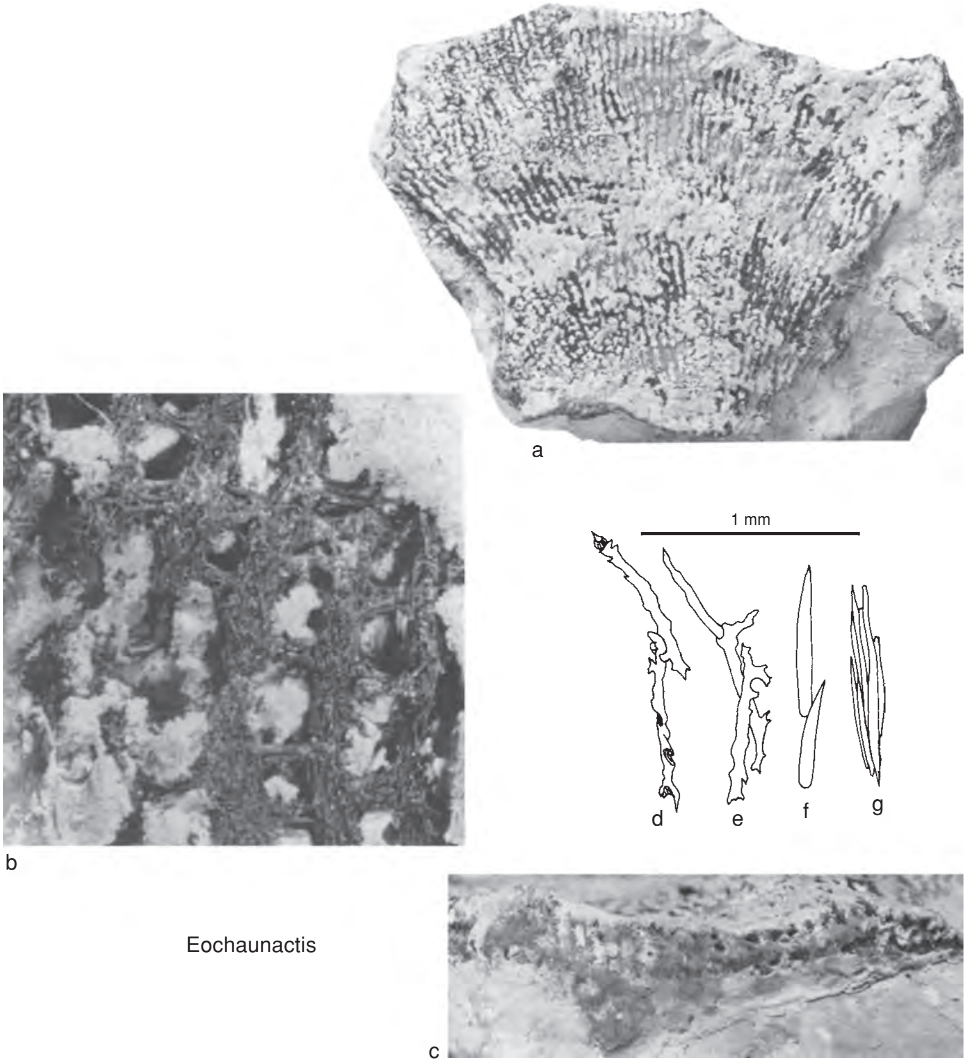

FIG. 122. Saccospongiidae (p. 167–168).

and gastral layers that are moderately thick; may include rhizoclones; tracts generally normal to dermal and gastral layers. *Upper Ordovician:* Australia (New South Wales).——FIG. 121,*2a–g*. **C. lamina,* Malongulli Formation, Cliefden Caves area; *a,* holotype from above showing coarse tracts and open canals; *b,* dermal surface of holotype from below showing thick, dermal layer, ×2; *c,* photomicrograph of stout skeletal tracts of short, robust, rhizoclones and heloclones as seen on lower surface, ×25; *d–g,* holotype, isolated heloclones with circular, grasping facets, one with an associated oxea, AMu. F66803, ×200 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Eochaunactis RIGBY & DIXON, 1979, p. 604 [**E. radiata* RIGBY & DIXON, 1979, p. 605; OD]. Flabellate, bladed to low, obconical sponges with moderately large canals normal to blade surfaces between uniformly spaced, vertical, finlike tracts of strongly radiating skeleton, radial tracts cross connected at irregular intervals by tracts of smaller diameter; spicules dominantly irregular heloclones, with less common, possible rhizoclones and possible dendroclones; moderately common styles and oxeas concentrated in central parts of strands, although all types occur throughout skeletal net; dermal and gastral layers well differentiated and with less regular, radial structure. *Silurian (Ludlow, ?Pridoli):* Canada (Northwest Territories, District of Franklin, Somerset Island).——FIG. 122*a–g*. **E. radiata,* Read Bay Formation, Somerset Island; *a,* upper surface of flabellate holotype with upwardly radiating tracts with partial, undulating dermal layer in upper part, ×1; *b,* photomicrograph of skeletal tracts composed mainly of pyritized heloclones cross connected by smaller, simpler tracts, ×10; *c,* cross section of base showing I-beam shaped tracts, with gastral surface toward top, ×2; *d–g,* camera lucida drawings of spicules; *d–e,* heloclones; *f,* styles with one hemispherical base; *g,* cluster of oxeas. ×29 (Rigby & Dixon, 1979).

Epiplastospongia RIGBY, 1977c, p. 2,663 [**E. coactilis;* OD]. Massive sponges with three-dimensional, skeletal net of diactines as cores of both ascending and concentric or horizontal fibers; central spicule core of each fiber overgrown and thickened by layered to laminated, smooth, unsculptured, monaxial spicules; canals radiating-ascending with horizontal cross connections. [Taxonomic position of the sponge is uncertain but it appears to be related to *Saccospongia,* and hence is included here with some question.] *Middle Ordovician:* Canada (Newfoundland).——FIG. 123*a–c*. **E. coactilis,* Lourdes Formation, western Newfoundland; *a,* side view of holotype with base toward lower left and with section through skeleton with ascending, spicular columns and reticulate, outer surface on right, ×1; *b,* photomicrograph of horizontal section through holotype showing canal characteristics and skeletal net near periphery of sponge; canals markedly restricted by secondary overgrowth of coring skeletal net by laminated, concentric spicules, ×10; *c,* horizontal section across a clustered series of coring spicules (*arrow*), blanketed by laminated to concentrically arranged spicules in lower center, GSC 53763, ×100 (Rigby, 1977c).

Haplistionella RIGBY & DIXON, 1979, p. 608 [**H. garnieri* RIGBY & DIXON, 1979, p. 609; OD]. Low, obconical to flabellate sponge with skeleton of robust, irregularly branching, radiating tracts cross connected by irregular mesh of considerably finer, textured tracts; major canals parallel large, radiating elements but connected laterally by numerous short canals; tracts cored by plumosely arranged, smooth monaxons and heloclones associated with moderately smooth, rare, possible rhizoclones and coated by heloclones; no well-defined dermal layer. *Silurian (Ludlow, ?Pridoli):* Canada (Northwest Territories, Somerset Island).——FIG. 124*a–f*. **H. garnieri,* Read Bay Formation, Somerset Island; *a,* vertical cross section through central part of holotype showing low, obconical form, broad, saucerlike spongocoel, and irregular base, ×1; *b,* vertical view of base showing radiating, branching, skeletal tracts in light gray matrix, ×1; *c,* photomicrograph of pyritized, radial, skeletal tract and branching, lateral tracts, both made dominantly of heloclones, ×20; *d–f,* camera lucida drawings of spicules etched from holotype, *d–e,* heloclones, and *f,* curved style with rounded, proximal base, GSC 54834, ×36 (Rigby & Dixon, 1979).

Rugospongia CARRERA, 1996, p. 644 [**R. viejoensis;* OD]. Obconical to steeply obconical sponges with a moderately deep spongocoel; skeleton of vertical and web tracts of heloclones and monaxons as principal spicules that parallel main axes of tracts, monaxons irregularly distributed along tracts; tracts may include megaclones and rhizoclones; skeletal structure expanding upwardly and outwardly and is roughly paralleled by large, vertical and horizontal canals; exterior with moderately thick, dermal layer. *Lower Ordovician:* Argentina (Precordillera).——FIG. 121,*1a–q*. **R. viejoensis,* San Juan Formation, Jáchal area; *a,* side view of obconical holotype, ×0.9; *b,* vertical, medial section of holotype with deep, broad spongocoel and upwardly arching canals in walls, ×0.9; *c,* transverse section of upper end of holotype showing irregular spongocoel and radial canals in thick walls, ×1.1; *d,* photomicrograph of vertical, spicule tract showing long heloclones, ×30; *e–q,* drawings of isolated, heloclone spicules from holotype, CEGH-UNC 9252, ×25 (Carrera, 1996; courtesy of *Geobios*).

Family NEXOSPONGIIDAE Carrera, 1996

[Nexospongiidae CARRERA, 1996, p. 648]

Low, conical, top-bladed, or laminated sponges without spongocoel; skeletal net irregular and homogenous mass of heloclones and monaxons as major spicules; rare megaclones and dendroclones may be present; spicules articulate with circular, clasping facets in heloclones or simply attaching axis to axis or zygome to zygome; some spicules appear loose or isolated in skeleton; differentiated canals absent but openings developed between spicules. *Lower Ordovician.*

Nexospongia CARRERA, 1996, p. 648 [**N. sillaensis;* OD]. Low, obconical to laminated and discoidal sponges without spongocoel or canals; skeletal net irregular, homogenous mass of heloclones and monaxons with rare megaclones and dendroclones; heloclones ranging from short-shafted, smooth spicules to ones with numerous protuberances and zygomes throughout their length; most heloclones horizontal and articulate with vertical monaxons. *Lower Ordovician:* Argentina (Precordillera).——FIG. 120,*2a–o*. **N. sillaensis,* San Juan Formation, Jáchal area; *a,* upper surface of low conical to discoidal holotype, ×1.4; *b,* detail of upper surface of holotype showing irregular net and skeletal pores, CEGH-UNC 3613, ×8; *c,* photomicrograph of thin section of paratype showing characteristic heloclones, CEGH-UNC 3602?, ×18; *d–o,* draw-

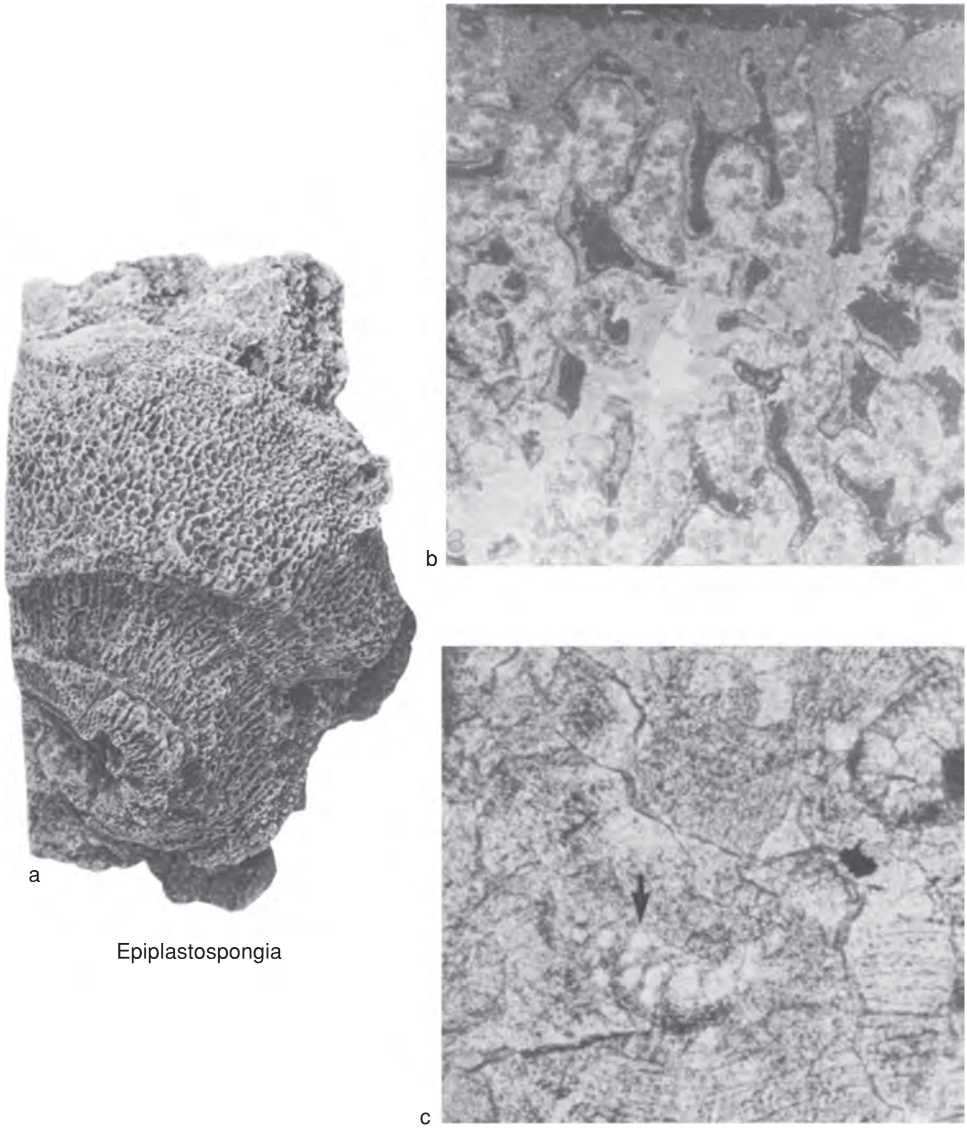

FIG. 123. Saccospongiidae (p. 168).

ing of spicules from type specimens, ×25 (Carrera, 1996; courtesy of *Geobios*).

Order AXINELLIDA Bergquist, 1967

[Axinellida BERGQUIST, 1967, p. 166]

Tetractinomorpha with a skeleton of spicules and fibers condensed into an axial region from which diverge plumose or plumoreticulate, extra-axial skeleton that may be reinforced by spongin fibers. Megascleres are monaxons, oxeas, styles, or strongyles in all combinations and often sinuous, curved, or irregular at one end. Microscleres commonly absent, but raphides and microoxeas are most common, asterose and sigmoid forms also occur; specific microscleres characterize some families. *Permian–Holocene.*

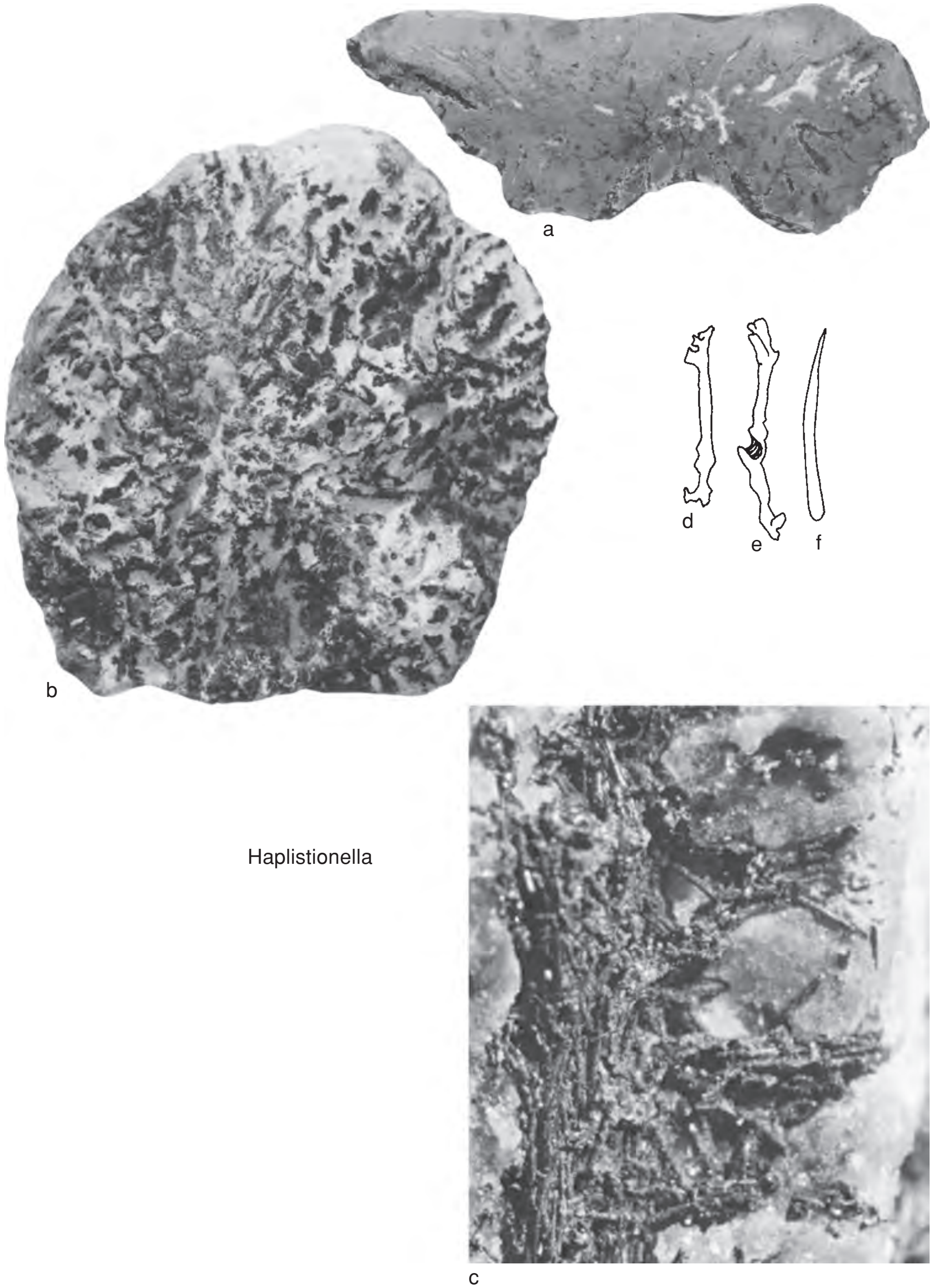

FIG. 124. Saccospongiidae (p. 168).

Family AXINELLIDAE Carter, 1875

[Axinellidae CARTER, 1875, p. 133]

Usually branched sponges with distinct, axial fibers that are plumosely branched and filled with styles, strongyles, or oxeas; spirasters or asters may be present as flesh spicules, but not chelae; microscleres usually absent. [This family, containing only recent forms, is included herein due to origin of order name.] *Holocene.*

Family AGELASIDAE Verrill, 1907

[Agelasidae VERRILL, 1907, p. 333]

Sponges with reticulate, fibrous skeleton with spongin fibers lacking primary, coring spicules, but echinated by distinctive acanthostyles with verticillate spines, or rarely smooth styles or strongyles of similar size. *Permian.*

Ropalospongia MOSTLER, 1994, p. 344 [**R. fluegeli;* OD]. Demosponges with acanthostyles ornamented with 12 to 36 horizontal rings of spines, and with an enlarged, ornamented, head end. *Permian:* USA (Texas).——FIG. 125. **R. fluegeli,* Road Canyon Formation, Roadian, Glass Mountains; holotype spicule showing characteristic spinose ornamentation, ×150 (Mostler, 1994).

FIG. 125. Agelasidae (p. 171).

Order UNCERTAIN

Family CRICCOSPONGIIDAE Mostler, 1986

[Criccospongiidae MOSTLER, 1986, p. 347]

Demosponges whose spicules have a criccomorph structure, including sponges with criccostyles and criccotriaenes. [As proposed by MOSTLER, the family included the new genera *Criccospongia* and *Criccophorina.* No species was named or described for *Criccospongia,* however, and hence it is unrecognizable. Thus, *Criccophorina* is here designated as the type genus. The family is included in the Tetractinomorpha with some question.] *Triassic.*

Criccophorina MOSTLER, 1986, p. 348 [**C. praelonga;* OD]. Sponges with very long, monactine spicules that have many pronounced, separated, surficial rings, which have granular, outer surfaces. *Triassic:* Austria.——FIG. 126,*1.* **C. praelonga,* Zlambachschichten, lower Rhaetian, St. Agatha; holotype, criccostyle spicule with clearly developed rings that have granulated, outer surfaces, and with a hemispherical upper end that has coarser, surficial granules, ×75 (Mostler, 1986).

Order and Family UNCERTAIN

Atractosella HINDE, 1888, p. 123 [**A. siluriensis;* M]. Isolated, small, fusiform oxeas in which the maximum thickness is nearer one end of the spicule than to other. [It is recommended that this taxon not be used.] *Silurian (Wenlock):* England.

Belemnospongia ULRICH in MILLER, 1889, p. 155 [**B. fascicularis;* M]. Discoidal, consisting of long oxeas radiating from single center and more or less grouped in fascicles. [Although it is possible that this is a root tuft; its consistently circular outline and apparent lack of attachment to another part of a sponge suggest that it represents the entire sponge. The lateral connections between spicules described by ULRICH may be diagenetic silica.] *Silurian (Wenlock)–Permian:* Canada (Northwest Territories), *Wenlock;* USA, Britain, *Carboniferous;* New South Wales, *Permian.*——FIG. 126, *2a–c.* **B. fascicularis,* Burlington Limestone, Osagian, Burlington, Iowa, USA; *a,* discoidal holotype with radiate, skeletal structure, ×1; *b,* bundle of spicules as exposed on surface; *c,* edge of holotype

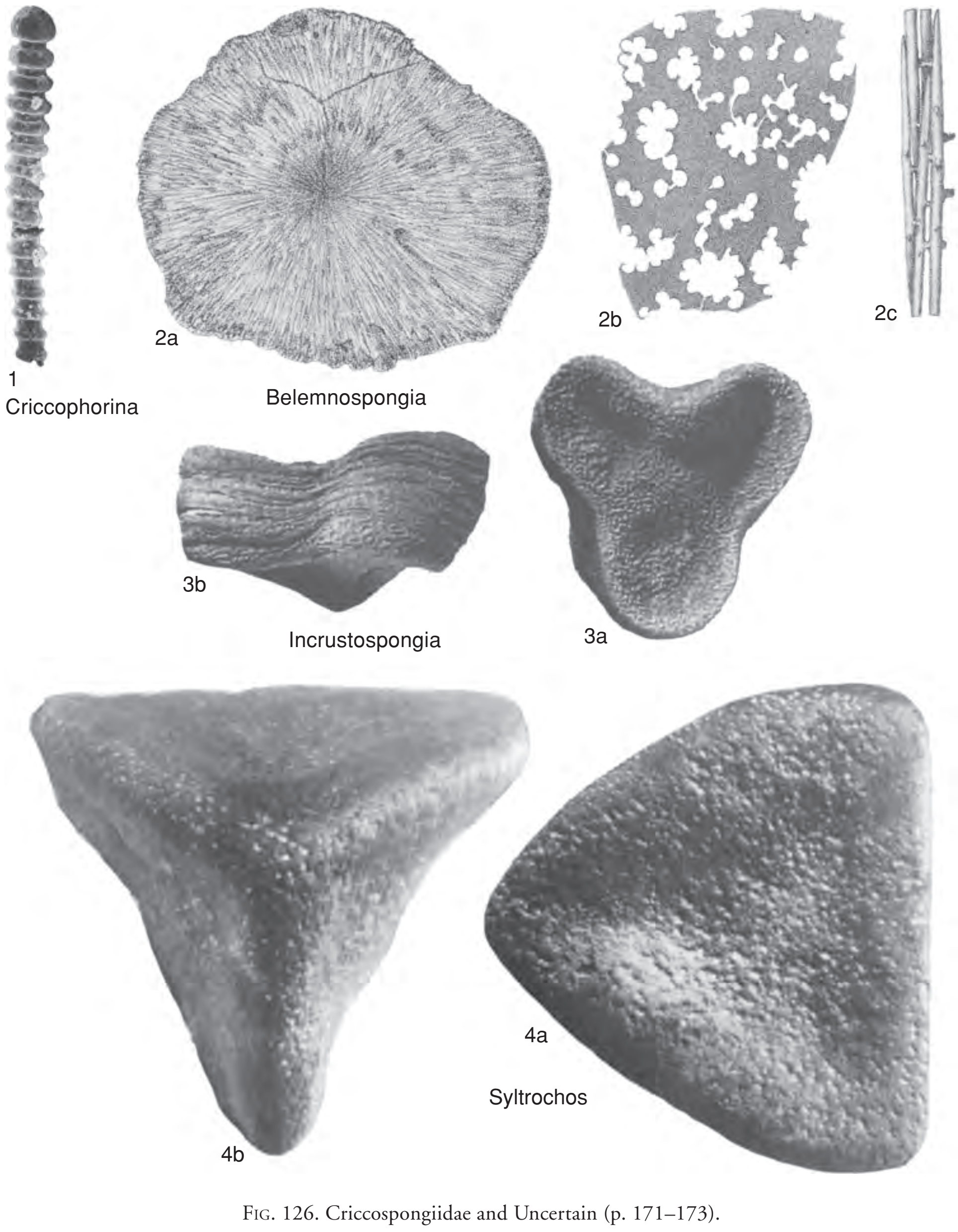

FIG. 126. Criccospongiidae and Uncertain (p. 171–173).

showing transverse sections of spicule bundles and lateral connections, ×10 (Ulrich & Everett, 1890).

Incrustospongia MOLINEAUX, 1994, p. 980 [**I. meandrica;* OD]. Small, encrusting, coralline sponges, probably originally aragonitic, currently aspiculate because too few spicule pseudomorphs show diagnostic features; surface with meandroid processes, also seen in internal layers; host organism determines initial shape, but later growth adopts unconstrained, meandroid pattern. *Carboniferous (Middle Pennsylvanian–Upper Pennsylvanian):* USA (Texas).——FIG. 126,*3a–b*. **I. meandrica,* Bluff Creek Shale, Upper Pennsylvanian, Coleman County; *a,* top view of holotype showing nodose, lobate structure, TMM 1785TX1, ×1; *b,* side view showing distinct, layered structure of holotype, ×1 (Molineaux, 1994).

?Petrosites HOWELL & LANDES, 1936, p. 58 [**P. humilis;* OD]. Isolated small, slightly curved oxeas in which ends are terminated somewhat abruptly by truncation on concave side. [It is recommended that this taxon not be used.] *Ordovician:* North America.

Syltrochos von Hacht, 1981, p. 154 [**S. pyramidoidalis;* OD]. Platter- to bowl-shaped sponge that develops a pointed, lower stem in mature stages; upper surface of complete sponge showing closely spaced, canal ostia of one to a few centers of water flow that occur under platter upper surface; canal walls are formed of and braced by closely spaced monaxons; skeletal system of sponge body is so built that a three-sided pyramid developed; open form reflecting structure system again. [Because details of the nature and relationships of the spicules are uncertain, assignment to higher taxa is questionable. Consequently the genus is listed here as of uncertain taxonomic affinity.] *Upper Ordovician:* The Netherlands (Island of Sylt, glacial erratic presumably from Baltic region).——Fig. 126,*4a–b.* **S. pyramidoidalis,* glacial debris, ?Caradoc, Ashgill, Sylt; *a,* view from above with triangular outline and small ostia on gastral surface; *b,* view from below with dense, dermal surface pierced by small, inhalant canals, ×1.02 (von Hacht, 1981).