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Middle to Late Eocene polycystine radiolarians from the Site 1172, Leg 189, Southwest Pacific

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Abstract

Mid to late Eocene radiolarian faunas in the >61 μm fraction from ca 70 samples of Southwest Pacific ODP Site 1172 were surveyed. All encountered morphotypes were classified when possible to species level. 158 species level morphotypes were determined: 84 have been previously described and the remaining 57 are in open nomenclature. A mixed assemblage of tropical and Antarctic indicators was concordant with current paleoceanographic models for Southwest Pacific area in Late Eocene. All the encountered morphotypes are illustrated and are provided with short descriptions of distinguishing features.

Key words: Radiolaria, Tasmania, Late Eocene, Southwest Pacific, taxonomy

Introduction

Eocene radiolarians have been reported from southern oceans in many papers (e.g. Funakawa and Nishi, 2005), but only a few papers report faunal composition (e.g. Kozlova, 1999). Many radiolarians were illustrated from Kerguelen Plateau (Apel et al., 2002), Macquarie Ridge (Petrushevskaya, 1975), Australian–Antarctic Basin (Chen, 1975), Mahurangi Limestone in Northland, New Zealand (O'Connor, 1999b), Oarmaru Diatome in Southland, New Zealand (O'Connor, 1999a), but not all of the fauna were reported. Our paper aims to illustrate all the encountered morphotypes, including described and undescribed species from the Middle to Upper Eocene of Site 1172, and briefly describe their distinguishing features. Detailed paleontological and biostratigraphic studies will be published in separate papers. It is noted that the application of taxonomic names in this paper is trying to use so rigid that many name usages may still be in conflict against "traditional" usage.

Sample and materials

Site 1172 was drilled at a water depth of 2622 m (43°57.58'S, 149°55.69'E) west of the East Tasman Plateau, east of Cascade Seamount (Figure 1). The lithology of this site consists primarily of upper Maestrichtian to Upper Eocene diatomaceous claystone and claystone to clayey siltstone (Unit 3, 361-766 mbsf), Upper Eocene to Oligocene silty diatomaceous claystone to glauconitic diatomaceous clayey siltstone (Unit 2, 356-361 mbsf), and Oligocene to Pleistocene foraminifer-nannofossil

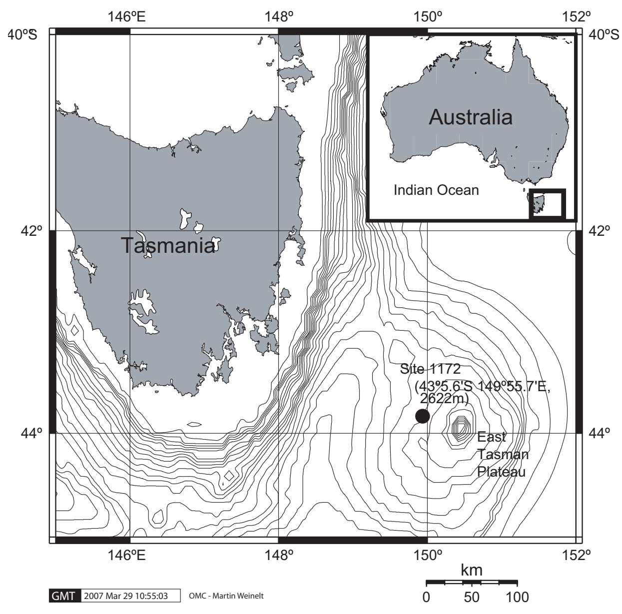
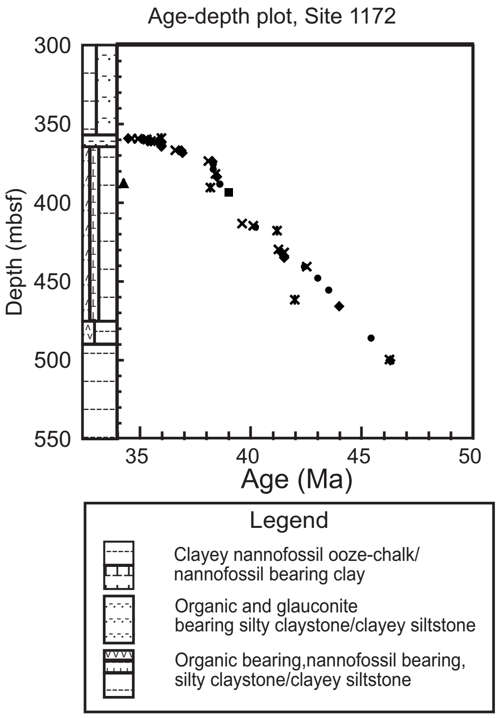


Fig. 1. Location of Ocean Drilling Program Site 1172 at the present.



Sample information			Core recovery	
Sample	Average depth (mbsf)	inffered age (Ma)	Core	%
39X-CC	364.15	34.84	39X	102.1
40X-CC	373.75	38.05	40X	102.6
41X-CC	383.35	38.47	41X	101
43X-CC	402.55	39.2	43X	102.9
44X-CC	412.15	39.57	44X	103.3
46X-CC	431.35	41.47	46X	103.8
47X-CC	440.95	42.55	47X	103.5
48X-CC	450.55	43.14	48X	103.1
49X-CC	460.15	43.74	49X	103.1
50X-CC	469.75	44.35	50X	0.8
51X-CC	476.19	44.75	51X	67.6
52X-CC	488.7	45.55	52X	96.9
53X-CC	498.8	46.17	53X	102.6

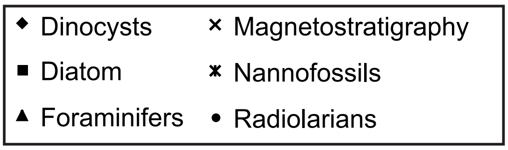


Fig. 2. Age-depth model for Site 1172 with estimated depositional age of the selected samples.

to nannofossil ooze/chalk (Unit 1, 0-356 mbsf). The interval examined in our study is correlated to the uppermost part of Unit 3 (498.7 mbsf) and the basal part of Unit 1 (335.0 mbsf). These two units are dated as 46.3 Ma to 19.1 Ma (Stickley et al, 2004). The Upper Eocene interval of Site 1172 was sampled at an interval of one per section from Cores 189-1172-53X-CC to 39X-CC. The depositional age of each sample was estimated from the age-depth model of Stickley et al (2004) (Fig. 2).

Samples were treated with standard methods to isolate radiolarian individuals, by removal of calcareous matter by HCl, organic matter by H_2O_2, and clay minerals by Calgon. The collected dried residues on a 63-μm screen mesh were evenly divided into several aliquots for future studies, and one portion of one aliquot, generally with more than 500 radiolarian individuals, was embedded in UV-curative material or Entellan Neu (R) as mount media. The completed slides were thoroughly scanned under a light-transmitted microscope of 100 – 600 magnifications. Suzuki mainly identified spherical Actinommoidea and other spherical Polycystina, Ogane Spongodiscoidea and other flat-shaped Polycystina, and Chiba did the remaining polycystines.

Results and concluding remarks

A total of 158 morphotypes were identified from the Middle to Late Eocene. Of these, 84 species were already described in previous studies and 57 morphotypes remain open nomenclature. Referred to Lazarus and Caulet (1993), the radiolarian assemblages at Site 1172 includes ten tropical taxa (*Artobotrys biauritus*, *Axoprunum minor*, *Eurystomoskevos petrushevskayae*, *Lithomelissa ehrenbergi*, *Lithomelissa haeckeli*, *Lychnocanoma bellum*, *Siphocampe imbricata*, *Siphocampe quadrata*, *Spongodiscus rhabdosytla*, *Stylosphaera coronata*), three cosmopolitan taxa (*Artobotrys auriculaleporis*, *Lychnocanoma* (?) *conica*, *Lychnocanoma* (?) *amphitrite*), six antarctic taxa (*Cymaetron* aff. *sinolampas*, *Eucyrtidium antiquum*, *Larcopyle haysei haysei*, *Lophocyrtis* (*Paralampterium* (?)) *longiventer*, *Lophocyrtis* (*Paralampterium*) *dumitricai*, *Spongodiscus osculosa*), and one boreal taxon (*Ceratocyrtis* aff. *stigi*). The depositional site of Site 1172 in Late Eocene was located at about 45°S and 150-160°E, east of Tasmania (Cande and Stock, 2004) where the southwardly flowing subtropical surface water mixed with Antarctic surface water (Kennett and Exon, 2004). Mixed assemblages with tropical and antarctic taxa support this paleoceanographic interpretation.

According to Kennett and Exon (2004), the influence of subtropical water weakened between the Late Eocene and Early Oligocene, due to the opening of the Tasmanian Gateway. This process would have been reflected in fauna changes in this transitional period. Our taxonomic work provides the framework for collecting data on precise faunal composition and its change in future studies.

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Systematic paleontology

Supra-generic taxonomy mainly follows De Wever et al (2001). Synonymy is limited to the papers with the first description, important remarks, good illustrations, and undoubted conspecific morphotypes even if it was identified as different species. Morphological terminology follows Ogane and Suzuki (2006) for disk shaped polycystines, Suzuki (2006) for spherical polycystines, and Petrushevskaya (1984) for other polycystines.

Order Entactinaria Kozur and Mostler 1982

Remarks: De Wever et al (2001) moved many spumellarian genera and families into Order Entactinaria. This taxonomic decision has not been verified by stratigraphic direct connections between these forms and the type genus of Entactinaria, *Stigmosphaerostylus* (a senior synonym of *Entactinia*). We herein only tentatively follow De Wever et al (2001)'s classification.

Family Axoprunidae Dumitrica 1985

Remarks: Dumitrica, 1985 treated this family as a subfamily of Saturnalidae, but we tentatively raise it into family-level because the phylogenetic relationship between *Axoprunum*, the type genus of this "subfamily" and *Saturnalis*, the type genus of Saturnalidae are unknown.

Genus *Axoprunum* Haeckel 1887

Type species: *Axoprunum stauraxonium* Haeckel 1887

Axoprunum Haeckel 1887

Stylacontarium Popofsky 1912

Remarks: As noted in Sugiyama et al (1992), *Stylacontarium* is probably a junior synonym of *Axoprunum*. A Miocene radiolarian *"Axoprunum" angelinum* (Campbell and Clark 1944) has long been treated as a member of the genus *Axoprunum*, but this species should be excluded from the representative genus as Sugiyama et al (1992) mentioned.

Axoprunum venustum (Borisenko 1959)

pl. 1, figs. 1a-b

Dorylonchidium (?) *venustus* n. sp. Borisenko, 1959, p. 35, pl. 1, fig. 11.

Stylotractus pictus n. sp. Mamedov, 1969, p. 99-100, pl. 2, fig. 4, 4a.

Axoprunum venustum (Borisenko). Kozlova, 1999, p. 70-71, pl. 33, fig. 10, pl. 38, fig. 2.

Remarks: This species is characterized by angular cortical shell

Axoprunum aff. *venustum* (Borisenko 1959)

pl. 1, figs. 2a-b

Remarks: This morphotype is same as *A. venustum*, except for spongy layers covering the cortical shell. Polar spines of this morphotype tend to be shorter than that of a typical *A. venustum*.

Axoprunum bispiculum (Popofsky 1912)

pl. 1, figs. 3a-4b

Stylacontarium bispiculum n. sp. Popofsky, p. 91, pl. 2, fig. 2.

Axoprunum minor (Clark and Campbell 1942)

pl. 1, figs. 5a-6c

Stylosphaera (*Stylosphaerantha*) *minor minor* n. sp. et n. subsp. Clark and Campbell, 1942, p. 27, pl. 5, figs. 1, 2, 2a.

[?] *Stylosphaera isoporata* n. sp. Carnevale, 1908, p. 13, pl. 2, fig. 3

Remarks: The illustrated specimen in our plate appears to have the same internal structure of the genus *Axoprunum*, although no information is available whether the type specimens of *A. minor* have the same internal structure. Differing from other *Axoprunum*-species, the cortical shell is always spherical.

Axoprunum sp. C

pl. 4, figs. 12a-b

Genus *Xiphosphaerantha* Haeckel 1887

Type species: *Xiphosphaera* (*Xiphosphaerella*) *pallas* Haeckel 1887

Remarks: As note in Sugiyama et al (1992), *Axoprunum angelinum* has a same structure as the genus *Xiphosphaerantha*. Although Haeckel (1887) did not show the internal structure of this species, Dumitrica (1985) described the internal structure of the genus *Xiphosphaerantha* by a probably closely related species, *Xiphosphaerantha venus* Haeckel.

Xiphosphaerantha pallas Haeckel 1887

pl. 1, figs. 7a-b

Xiphosphaera (*Xiphosphaerella*) *pallas* n. sp. Haeckel, 1887, p. 124-125, pl. 14, fig. 4.

Stylosphaera fornasinii n. sp. Vinassa de Regny, 1900, p. 569, pl. 1, fig. 15.
Amphisphaera spinosa n. sp. Carnevale, 1908, p. 14, pl. 2, fig. 6.
Remarks: This morphotype is characterized by completely spherical cortical with two cylindrical slender polar spines. This species is rather similar to *Axoprunum minor*, but differs from the latter by having short secondary spines which reflects the different internal structure between the genus *Axoprunum* and *Xiphosphaerantha*.

Family Centrocubidae Hollande and Enjumet 1960, sensu emend. Dumitrica 1994

Genus *Pessagnulus* Dumitrica 1983

Type species: *Pessagnulus fiskensis* Dumitrica 1983
Remarks: Only one species, *P. fiskensis*, has been formally described in this genus from Cenomanian-Campanian material.

***Pessagnulus* sp. 1**

pl. 2, figs. 11a-c

Remarks: Although the exact number of radial spines of this morphotype is not known, it closely resembles the genus *Pessagnulus* by having a cubic microsphere and eight microsphere beams.

Family Hexalonchidae Haeckel 1882 sensu De Wever et al. 2001

Genus *Hexalonchetta* Haeckel 1882

Type: *Hexalonche* (*Hexalonchetta*) *amphisiphon* Haeckel 1887
Remarks: We include herein '*Hexalonche'* forms with two concentric shells and six radial spines. The internal shell is a characteristic initial tetrapetaloid structure with four wide pores. This essential information on the internal structure of the type species, *Hexalonche amphisiphon*, has not been illustrated by Haeckel (1887). Instead, the type species of *Hexalonchetta*, *Hexalonche amphisiphon* fits the distinguishing features of '*Hexalonche'* by the original illustration and description of Haeckel (1887): "medullary shell octahedral, with irregular polygonal meshes and very thin bars between them, connected with the outer (six to eight times larger) shell by six very thin radial beams." (p. 182, Haeckel, 1887). The traditional usage of *Hexalonche* includes not only the forms with a characteristic initial tetrapetaloid microsphere but also the forms with a spherical inner microsphere. The former is *Hexalonchetta* and the latter *Hexancistra*.

***Hexalonchetta* sp. 1**

pl. 2, figs. 10a-b

Genus *Hexacontium* Haeckel 1887, sensu emend. Hollande and Enjumet 1960

Type species: *Hexacontium* (*Hexacontannta*) *phaenaxonium* Haeckel 1887.
Remarks: This genus is possibly nomen dubium because Haeckel (1887) did not illustrate the type species, *H. phaenaxonium*, and gave only short, simple descriptions. However, we follow the traditional usage of *Hexacontium* as having three concentric shells with six radial spines. The innermost shell is generally a characteristic initial terapetaloid structure with four wide pores.

***Hexacontium rosetta* (Haeckel 1887)**

pl. 2, figs. 4a-6b

Hexalonche (*Hexalonchara*) *rosetta* n. sp. Haeckel, 1887. p. 180, pl. 25, figs. 3, 3a, 3b.
Hexalonche drymodes Haeckel. De Wever et al, 2001, fig. 133.1.
Remarks: This species is characterized by having a complete spherical cortical shell with small to moderate-sized, circular to elliptical pores, rough surface, and six radial spines whose distal part is robust. *H. rosetta* is similar to *Hexacontium drymodes amphispina* Dumitrica 1978 in having spines with distally robust tips, but is distinguished from the latter by having a complete spherical cortical shell. This species differs from *Hexacontium papillosum* Haeckel and *Hexacontium floridum* Haeckel by having smaller pores on the cortical shell.

***Hexacontium* (?) sp. 2**

pl. 2, figs. 7a-b

Description: Three concentric shells with six radial spines. Concentric shells consisting of spherical double medullary shells and a spherical cortical shell. The ratio of diameters of inner microsphere, outer microsphere and exosphere is 1:3:9. Microsphere beams radially arising from the inner microsphere, connect between medullary shells. Radial beams also radially arising from the outer microsphere to connect with the cortical shell. Six primary radial spines extend from the microsphere; triradiate, tapering distally.
Remarks: This species differs from other *Hexacontium*-species by having many radial beams between the outer microsphere and exosphere. Some radial beams penetrate the exosphere to form short by-spines.

***Nanina* Kozur and Mostler 1982**

Type species: *Melittosphaera* (*Melittosphaera*) *hokurikuensis* Nakaseko 1954.

***Nanina* sp. 1**

pl. 3, figs. 2a-c

Remarks: This morphotype is different from *Nanina hokurikuensis* (Nakaseko 1954) by having a thinner cortical shell with many pores.

Genus *Hexadendron* Haeckel 1882

Type: *Hexadendron quadricuspis* Haeckel 1887

Remarks: This genus is tentatively included in the family Hexalonchidae although the internal structure has not been described in detail.

***Hexadendron* (?) aff. *octahedrum* (Haeckel 1887)**

pl. 3, figs. 13a-b

Hexacromyum octahedrum n. sp. Haeckel, 1887. p. 202, pl. 23, fig. 2

Remarks: The illustration of the species in the original paper showed a very artificially symmetric form. This species was found from a probably mixed sample of recent and Eocene-Oligocene radiolarians at H.M.S. Challenger Station 263 (17°33'N, 153°36'W). Similar morphotypes to this species have never been found from recent and living radiolarian assemblages worldwide, suggesting that it is an Eocene-Oligocene species. This species was originally included in the genus *Hexacromyum*, but the type species of this genus, *Hexacromyum elegans* Haeckel, 1887, has an identical skeletal structure to the genus *Hexacontium*. The relatively octahedral shape of the shell however suggests a closer relationship to the genus *Hexadendron*. Our specimens slightly differ from *H. octahedrum* by having more irregularly shaped cortical shells and more robust radial spines.

Hexalonchidae gen A

Reference species: Hexalonchidae gen A et sp. 2

Description: This group consists of forms with three or more concentric shells. The innermost shell is a tetrapetaloid microsphere identical to that of *Hexalonche*. The second shell is large (> 50μm in diameter), spherical, with circular to elliptical pores. The outermost shell is also large (ca 150 μm in diameter) without radial spines. Cylindrical microsphere beams arising from the tetrapetaloid microsphere connect with the second shell. The radial beams between the second and outermost shell are generally three-bladed.

Remarks: This group is probably a new genus.

Hexalonchidae gen. A et sp. 1

pl. 4, figs. 3a-c

Remarks: This morphotype differs from similar morphotypes by having many secondary radial beams between the second and outermost shells. The total number of concentric shells is three.

Hexalonchidae gen. A et sp. 2

pl. 4, figs. 5a-c

Remarks: Differing from Hexalonchidae gen. A et sp. 1, this morphotype generally lack secondary radial beams between the second and outermost shells.

Hexalonchidae gen. A et sp. 3

pl. 4, figs. 6a-b

Remarks: This morphotype consists of four concentric shells. The outermost shell is spherical.

Hexalonchidae gen. A et sp. 4

Pl. 4, figs. 4a-b

Remarks: Differingpfrom Hexalonchidae gen. A et sp. 3, the outermost shell has a rough surface.

Family Rhizosphaeridae Hollande and Enjumet 1960

Genus *Styptosphaera* Haeckel 1882

Type species: *Styptosphaera spumacea* Haeckel 1887

***Styptosphaera* (?) sp. 1**

pl. 4, figs. 8a-b

Remarks: This species is similar to *Spongoplegma variabile* Nakaseko 1972 in having a spongoise internal structure and cortical outer exosphere, suggesting that both belong to the same genus.

Family incertae sedis

Entactinaria? gen. et sp. indet 1

pl. 3, figs. 1a-c

Remarks: This morphotype is characterized by a spherical cortical shell and pentagonal internal structure. Owing to ambiguous image under transmitted light microscopy, the internal structure of this morphotype cannot be described in detail.

Order Spumellaria Ehrenberg 1876, sensu emend. De Wever et al. 2001

Superfamily Actinommoidea Haeckel 1862, sensu emend. De Wever et al. 2001

Family Actinommidae Haeckel 1862

Genus *Actinomma* Haeckel 1860a

Type species: *Actinomma trinacrium* Haeckel 1860a

***Actinomma kuznetsovi* (Gorbunov 1979)**

pl. 2, figs. 2a-b

Hexacontium kuzunetsovi n. sp. Gorbunov, 1979, p. 99-101, pl. 4, figs. 1a, 1v.

Remarks: Gorbunov (1979) treated this species a member of *Hexacontium*, but it has apparently more than six radial spines.

***Actinomma* sp. 1**

pl. 2, figs. 1a-b

Remarks: This morphotype differs from *Actinomma kuzunetsovi* by having a relatively larger outer microsphere in comparison with the size of the first cortical shell.

Family Astrosphaeridae Haeckel 1882 sensu Hollande and Enjumet 1960

Genus *Cladococcus* Müller 1858

***Cladococcus eocenica* (Petrushevskaya in Petrushevskaya and Kozlova 1979)**

pl. 2, fig. 9

Anomalocantha dentata eocenica Petrushevskya n. sp. Petrushevskaya and Kozlova, 1979, p. 90, figs. 220, 221.

Family Liosphaeridae Haeckel 1882

Genus *Liosphaera* Haeckel 1887

Type species: *Liosphaera* (*Melitomma*) *hexagonia* Haeckel 1887.

Remarks: The genus *Liosphaera* was originally defined as an Actinommoidea with two cortical shells and absence of internal structures. The type species of the genus, *Liosphaera hexagonia* possesses large inner cortical (120 μm in diameter) and outer (160 μm) cortical shells. The outer cortical shell appears to develop in ontogeny after the inner cortical shell. Thus a single shelled morphotype like the genus *Cenosphaera* might be included in this genus. The type species of *Cenosphaera*, *Cenosphaera plutonis* Ehrenberg 1854b, however posseses some internal structures by preliminary examination of the type specimen (Suzuki, unpubl. obs.), so that this generic name is not applicable for our specimens. The next available name for a single-shelled actinommoid without internal structure is *Cyrtidosphaera*, but the type species of *Cyrtidosphaera*, *Cyrtidosphaera reticulata* Haeckel 1860a, differs from *Liosphaera* by having a rather perforated cortical shell. Although we have not found two-shelled morphotypes like the type species of *Liosphaera* in our samples, the phylogenetically related genus is assumed to be *Liosphaera* for the listed species here because the morphological feature of our species is concordant with that of *Liosphaera hexagonia*, except in the latter having the defining two cortical shells.

***Liosphaera* (?) sp. 1**

pl. 4, figs. 7a-b

Remarks: The exact internal structure is unknown although the examined species is hollow inside the cortical shell.

Family Stylosphaeridae Haeckel 1882

Genus *Stylosphaera* Ehrenberg 1846

Type species: *Stylosphaera hispida* Ehrenberg 1854b

Remarks: The type species of this genus has an elliptical internal shell with two polar beams and several radial beams.

***Stylosphaera coronata* Ehrenberg 1873**

pl. 1, fig. 13

Stylosphaera coronata n. sp. Ehrenberg, 1873, p. 258.

Stylosphaera coronata Ehrenberg. Ehrenberg, 1876, p. 84-85, pl. 25, fig. 4

Remarks: This species is distinguishable from *Stylosphaera* ex. gr. *radiosa* Ehrenberg by having a thick walled cortical shell with smaller pores. One radial spine is always longer than the other. This longer spine is variable in length and on the position.

***Stylosphaera* ex. gr. *radiosa* Ehrenberg 1876**

pl. 1, figs. 8a-b

Stylosphaera radiosa n. sp. Ehrenberg, 1876, p. 84-85, pl. 24, fig. 5

Remarks: This species is characterized by an elliptical cortical shell, one longer polar spine, and the occasional appearance of short secondary spines around the cortical shell.

***Stylosphaera gigantea* (Haeckel 1887)**

pl. 1, figs. 9a-b

Stylatractus (*Stylatractylis*) *giganteus* n. sp. Haeckel, 1887, p. 329, pl. 17, fig. 1.

Remarks: This species differs from *Amphisphaera ostracion* by having a more elliptical outer shell with a smooth surface and smaller pores. Differing from *S. radiosa*, *S. gigantea* possesses a larger cortical shell and longer polar spines, and lacks secondary spines.

Genus *Sphaeractis* Brandt in Wetzel 1936 sensu emend.

Type species: *Sphaeractis triacantha* Brandt in Wetzel 1936

Description: One or two concentric shells with three radial spines. These three radial spines lie in the same plane. The inner shell is pear-shaped, and the outer one spherical with framed pores. Three radial spines are distributed not complete symmetrically, e.g. not always at 120 degrees between radial spines.

Remarks: This genus was initially introduced by Wetzel (1936). Wetzel (1936) noted that the vertical axis of the pear-shaped inner shell is oblique to the main axis of the test. The taxonomic relationship between two-spine bearing *Stylosphaera* and three-spine bearing *Sphaeractis* should be revised because it seems many intermediate forms between both types exist within samples.

Sphaeractis sp. 1

pl. 4, figs. 10a-b

Remarks: This morphotype is easily distinguished from *Sphaeractis triacantha* by having larger pores on the thick-walled, spherical outer shell, and differs from *Sphaeractis trochilus* (Haeckel) by having three radial spines of the same length, a smaller outer cortical shell with more small, irregularly arranged pores.

Sphaeractis trochilus (Haeckel 1887), sensu emend. herein.

pl. 10, figs. 10a-b

Xiphostylus (*Xiphostyletta*) *trochilus* n. sp. Haeckel, 1887, p. 129, pl. 13, fig. 10

Description: Two concentric shells with one long polar spine and two shorter polar spines. Internal shell pear-shaped with many radial beams. One spine always arising from the tip of the pear-shaped internal shell. In this species, the longer polar spine is extended from one oblique radial beam on the lower hemisphere of the pear-shaped internal shell. The bottom short beam extends in the opposite direction of the polar radial beams from the tip of the pear-shaped internal shell, but does not connect with any radial spines. The other polar spines arise from the oblique radial beams on the upper hemisphere of the pear-shaped internal shell. The length of polar spines and orientation of the pear-shaped internal shell is variable within a species. The outer cortical shell is spherical to elliptical with circular to subcircular pores; 5-6 pores on a hemisphere. All polar spines triradiate, not tapering.

Remarks: The original illustration of this species seems to be exaggerated about the shorter polar spine, but the arrangement of polar spines and the number of pores on the outer cortical shell are identical to our species. *S. trochilus* is easily distinguished from any other known *Stylosphaera*-species by having an eccentric distribution of polar spines, the orientation of the pear-shaped internal shell, and triradiate polar spines.

Genus *Amphisphaera* Haeckel 1882 sensu emend.

Type species: *Amphisphaera* (*Amphisphaerantha*) *neptunus* Haeckel 1887

Amphisphaera Haeckel 1882

Stylatractus Haeckel 1887

Description: Three concentric shells with two polar spines. The innermost shell porous, spherical; numerous primary radial beams arising from the surface. All these radial beams connect with the secondary radial beams which arise from the second internal shell. The second internal shell is large in comparison with the size of the outer shell; elliptical but not pear-shaped with many radial beams. These radial beams connect with the second internal shell and outer shell. Two radial beams arise from the both ends of the ellipsoidal internal shell, connecting with polar spines. The outer shell is spherical to elliptical; thick walled; has numerous elliptical pores.

Remarks: The type species of *Amphisphaera*, *Amphisphaera* (*Amphisphaerantha*) *neptunus* Haeckel 1887 was distinguished from the type species of *Stylatractus* (*Stylatractona*) *neptunus* Haeckel 1887 by the number of concentric shells, thus they are synonyms. The earliest genus, *Amphisphaera*, is a valid name. Sanfilippo and Riedel (1973) synonymized *Stuermeria* Deflandre, 1964, with *Amphisphaera*, but these two genera have different internal structures. Petrushevskaya (1975) synonymized the genus having bi-polar spines with *Amphisphaera* without phylogenetic evidences or comparison with internal structures so that we don't follow her synonymy. Most of the species previously assigned to *Amphisphaera* have apparently different internal structures than the type species of *Amphisphaera*. The following species could be included in this genus: *Amphisphaera aotea* Hollis 1993, *Stylatractus compactus* Haeckel 1887, *Amphisphaera cronos* Haeckel 1887, *Xiphatractus brevispina* Carnevale 1908, *Lithatractus fragilis* Haeckel 1887, *Stylosphaera goruna* Sanfilippo and Riedel 1973, *Amphisphaera kina* Hollis 1993, *Stylosphaera lithatractus* Haeckel 1887, *Stylatractus neptunus* Haeckel 1887, *Druppatractus ostracion* Haeckel 1887, *Ellipsoxiphus privus* Foreman 1978, *Sphaerostylus rosetta* Blueford 1982, *Stylosphaera sabaca* Sanfilippo and Riedel 1973, *Lithatractus santaennae* Campbell and Clark 1944, *Stylatractus sethoporus* Haeckel 1887, *Xiphatractus spumeus* Dumitrica 1973, *Xiphatractus stahlii* Dreyer 1889 and *Protoxiphotractus wilsoni* Hollis 1997.

***Amphisphaera* sp. 1**
pl. 1, figs. 11a-b

Description: Three spherical concentric shells with irregularly arranged pores.

Remarks: This morphotype is distinguished from any other *Amphisphaera*-species by absence of strong, stout polar spines.

***Amphisphaera* sp. 2**
pl. 1, figs. 12a-b.

Remarks: This morphotype is similar to *Amphisphaera stahlii* (Dreyer), but differs from the latter by having a rough surface with more stout triradiate spines. This morphotype differs from *Amphisphaera compacta* (Haeckel 1887) by having a rough surface and differs from *Amphisphaera cronos* Haeckel (1887) and *Amphisphaera fragilis* (Haeckel 1887) by having smaller pores on the outermost shell. Differing from *Amphisphaera* sp. 1, *Amphisphaera* sp. 2 has three concentric shells with two polar spines which arise completely from the opposite sides of the outermost cortical shell. Secondary spines of similar or shorter length to the polar spines appear in this morphotype.

Family Entapiidae Dumitrica in De Wever et al. 2001
Genus *Entapium* Sanfilippo and Riedel 1973
Type species: *Entapium regulare* Sanfilippo and Riedel 1973

***Entapium veneris* (Clark and Campbell 1942)**
pl. 3, fig. 7, pl. 5 figs. 1a-4b

Cenosphaera (*Circulosphaera*) *veneris* n. sp. Clark and Campbell, 1942, p. 20, pl. 4, figs. 6, 11, 13.

Cenosphaera veneris Clark and Campbell, 1942 (?).Funakawa and Nishi, 2005, pl. 1, fig. 7.

Remarks: Most the individuals examined in our samples have not lost the internal structure and this is still visible despite the thick cortical shell A few specimens have a large microsphere which is similar to that of the genus *Entapium*.

Family Coccodiscidae Haeckel 1862
Subfamily Coccodiscinae Haeckel 1862
Genus *Phacodiscus* Haeckel 1882
Type species: *Phacodiscus* (*Phacodiscinus*) *rotula* Haeckel 1887

***Phacodiscus subsphaericus* Lipman 1972**
pl. 3, figs. 9a-b

Phacodiscus subsphaericus n. sp. Lipman, 1972, p. 49-50, pl. 9, figs. 9, 10, text-fig. 14.

Remarks: The illustrated specimen is shown from the lateral side of the test. This morphotype is similar to *Phacodiscus planatus* (Moksyakova 1961) in the robust lateral profile of the cortical shell. This species is also similar to *Phacodiscus phacoides* Haeckel 1887 in the number of pores on the cortical shell, but differs from the latter by the more robust outline.

Genus *Heterosestrum* Clark et Campbell 1945
Type species: *Stylodictya* (*Stylodictyon* ?) *sexispinata* Clark et Campbell 1942

***Heterosestrum rotundum* Clark and Campbell 1945**
pl. 3, fig. 12

Heterosestrum sexipinatum rotundum n. subsp. Clark and Campbell, 1945, p. 21-22, pl. 3, fig. 9.

Remarks: This species was originally described as a subspecies of *Heterosestrum sexipinatum* (Clark and Campbell 1942), but differs from the latter by having a lower number of concentric shells.

Family Heliodiscidae Haeckel 1887, sensu De Wever et al. 2001
Genus *Heliodiscus* Haeckel 1862
Type species: *Haliomma phacodiscus* Haeckel 1860a

Remarks: This genus name was first applied for four *Haliomma*-species by Haeckel (1862). Campbell (1954) erroneously designated the type species for this genus as *Heliodiscus inchoatus* Rüst 1885 but the valid type species for *Heliodiscus* is *Haliomma phacodiscus* Haeckel 1860a which was designated by Strelkov and Reshetnyak (1959).

The species belonging to *Heliodiscus* are presumed to have a wide variation in the number of equatorial radial spines, the size of equatorial radial spines, the development state of peripheral plate, and the number of pores on the cortical shell. However, the range of these morphologic variations has never been estimated, and thus we tentatively apply Haeckel's artificial classification with only minor revision.

***Heliodiscus pertsus* Haeckel 1887**
pl. 3, fig. 10

Heliodiscus (*Heliodiscilla*) *pertusus* n. sp. Haeckel, 1887, p. 448, pl. 35, fig. 1.

Heliodiscus (*Heliodiscetta*) *polymorphus* n. sp. Haeckel, 1887, p. 447, pl. 34, figs. 11, 12.

Heliodiscus (*Heliodiscetta*) *pentasteriscus* n. sp. Clark and Campbell, 1942, p. 39, pl. 3, fig. 8.

Remarks: The original illustration of *H. pertusus* shows perforate radial spines, but this structure due to dissolution.

H. polymorphus is probably a morphologic variation which possesses regularity in the length of the spine.

Heliodiscus perplexus Clark and Campbell 1942
pl. 3, fig. 11

Heliodiscus (*Heliodiscomma*) *perplexus* n. sp. Clark and Campbell, 1942, p. 40-41, pl. 3, fig. 12.
Heliodiscus (*Heliodiscomma*) *charlestonensis* n. sp. Clark and Campbell, 1945, p. 22-23, pl. 3, fig. 10.

Remarks: This species seems to be different from *Heliodiscus pertsus* by having cylindrical equatorial radial spines.

Heliodiscus contiguum (Ehrenberg 1873)
pl. 3, figs. 8a-b

Haliomma contiguum n. sp. Ehrenberg, 1873, p. 234.
Haliomma umbonatum n. sp. Ehrenberg, 1873, p. 236-237.
Haliomma contiguum Ehrenberg. Ehrenberg, 1876, p. 74-75, pl. 26, fig. 5.
Haliomma umbonatum Ehrenberg Ehrenberg, 1876, p. 74-75, pl. 27, fig. 4.

Remarks: This species is characterized by the small number of radial equatorial spines.

Genus _Excentrosphaerella_ Dumitrica 1978

Type species: *Excentrosphaerella sphaeroconcha* Dumitrica 1978

Excentrosphaerella aff. _sphaeroconcha_ Dumitrica 1978
pl. 3, figs. 4a-5b

[aff.] *Excentrosphaerella sphaeroconcha* n. sp. Dumitrica, 1978, p. 238, pl. 5, figs. 17, 18, 22.

Remarks: This morphotype is similar to *E. sphaeroconcha* but differs from the latter in having a more spherical, thick first exosphere and robust radial beams between outer microsphere and exosphere.

Excentrosphaerella spinulosa (Lipman 1972)
pl. 5, figs. 5a-b

Cromyomma spinulosa n. sp. Lipman, 1972, p. 45-46, pl. 9, fig. 3, text-fig. 9.

Superfamily Sponguroidea Haeckel 1862
Family Sponguridae Haeckel 1862
Genus _Spongurus_ Haeckel 1860a

Type species: *Spongurus cylindricus* Haeckel 1860a

Synonymy: *Ommatogramma* Ehrenberg 1860
Spongocore Haeckel 1887
Amphicarydiscus Lipman 1972

Remarks: *Amphicarydiscus* appears to differ from *Spongurus* in having a more concentric structure and a very robust polar end, but is synonymized herein with the latter because the skeletal structures are identical with each other.

Spongurus bilobatus Clark and Campbell 1942
pl. 6, figs. 13-19

Spongurus (*Spongurantha*) *bilobatus* n. sp. Clark and Campbell, 1942, p. 36, pl. 1, figs. 7, 9.
Spongurus (*Spongurantha*) *spathulaeformis* n. sp. Clark and Campbell, 1942, p. 36, pl. 1, fig. 15.
[?] *Spongurus* (*Spongurantha*) *smithi* n. sp. Campbell and Clark, 1944, p. 21, pl. 3, fig. 4.
Spongurus biconstricus n. sp. Lipman, 1953, p. 140, pl. 7, fig. 5.
Spongurus elongatus n. sp. Borisenko, 1958, p. 89-90, pl. 3, figs. 6, 7.

Remarks: This species has a wide variation from slender forms to robust forms. These differences have been applied for species distinction in previous studies, but here we treat these variations as a single species because we found many intermediate forms. *Spongurus bilobatus* is very similar to *Spongurus cylindricus* Haeckel 1860a. Discrete definitions for distinguishing both species is not well understood, but *Spongurus bilobatus* tends to have a more inflated bar-like part and rarely develops a gown around the bar-like part.

Spongurus saxeus Krasheninnikov 1960
pl. 6, figs. 1-8b

Spongurus saxeus n. sp. Krasheninnikov, 1960, p. 282-283, pl. 2, fig. 1.
Amphicarydiscus fusoidus n. sp. Lipman, 1972, p. 10, figs. 3, 4, text-figs. 17, 18.
Amphicarydiscus ovoides n. sp. Lipman, 1972, p. 51-52, pl. 10, figs. 1, 2, text-figs. 15, 16.
Amphicarydiscus tshelkarensis n. sp. Lipman, 1972, p. 54, pl. 10, figs. 5, 6.
Spongurus biconstricus triangulatus n. subsp. Gorbunov, 1979, p. 113-115, pl. 10, fig. 3.
Amphibrachium mugodscharicum acerosum n. subsp. Gorbunov, 1979, p. 134-137, pl. 7, figs. 1a, 1b.
Amphibrachium mugodscharicum carinatum n. subsp. Gorbunov, 1979, p. 132-134, pl. 8, figs. 1a, 1v.

Description: Test consists of a larger, spherical to inflated spindle central part and two opposite lobes. The central part consists of an inner, spherical, sparsely concentric part and outer tubular 3-4 concentric shells. Both ends of the outer tubular concentric shells attach with the proximal part of the two opposite lobes. The surface of the outer tubular concentric shells is smooth with medium-sized pores. Opposite lobes are flat-bottom flask-shaped with a necked distal part; radial structures from the central part are visible; one of the opposite lobes having a narrow funnel-form tunnel with or without peripheral spines. The stricture between lobes and attached outer tubular concentric shells is distinct. The width of opposite lobes is 1/2 to 2/3 the width of the central part.

Remarks: This species has varies broadly from relatively slender, smaller forms to robust, larger forms. Many previous studies proposed many species or subspecies, but we include them into a single species due to presence of many intermediate forms.

***Spongurus illepidus* Krasheninnikov 1960**
pl. 5, figs. 11-16

Spongurus illepidus Krasheninnikov, 1960, p. 283, pl. 2, fig. 2.

Remarks: This species differs from *Spongurus saxeus* Krasheninnikov in having a more globular end of the opposite lobes which consists of spongy material. *S. illepidus* has however a relatively longer, cylindrical central part with spongy layers. A pylome has not been recognized in our material.

***Spongurus* sp. A**
pl. 5, figs. 18a-b

Description: This morphotype consists of a spherical larger central part and two opposite lobes. The central part consists of an inner, 3/4 invisible part, and three thin concentric shells in the outer, visible part; 13 - 20 relatively larger pores on a half-hemisphere of the central part; straight, thick radial beams widely distributed among the outer concentric shells. Opposite lobes a chunky dome shape, consisting of 3 or 4 dividers; pores as large as those on the central part.

Remarks: This morphotype is easily distinguished from other *Spongurus* species by having thin sparse concentric shells and larger pores. The spherical central part of this morphotype is similar to *Prunopyle hayesi* Chen 1974 but the former differs from the latter in having two opposite lobes and absence of pylomate outermost cortical shell.

Family Litheliidae Haeckel 1862

Remarks: As note by Lazarus et al. (2005), so-called *Lithelius* and *Larcopyle* have identical skeletal structures in having spiral structures from the central microsphere. De Wever et al. (2001) assigned the genus *Larcopyle* to family Pyloniidae and subfamily Pylodiscinae, but we disagree with this interpretation because the internal structure of *Larcopyle buetschli* Dreyer 1889, the type species of this genus, is completely different from *Pylodiscus triangularis* Haeckel 1887, the type species of the genus *Pylodiscus*, and *Tetrapyle octacantha* Müller 1858, the type species of *Tetrapyle* which is the senior synonym of the genus *Pylonium*, the type genus of the family Pyloniidae.

We captured digital images of all the prunoid and lithelid individuals encountered in the samples 189-1172A-51X-CC, 189-1172A-45X-CC and 189-1172A-40X-CC in order to assign them into species-level categories,based on morphological variation, ontogenetic changes and evolutionary criteria. Our efforts, however, are still not fully satisfactory. In particular, most of the lithelid species are fundamentally indistinguishable from incomplete prunoid and lithelids individual or neotenic species.

Adult forms of *Amphicarydiscus* Lipman 1972 (type species: *Amphicarydiscus ovoides* Lipman) are characterized by a spherical or elongated ellipsoidal central part which has concentric structures with inflated balloon-like both ends, as in a dumbbell. Specimens without these inflated ends are morphologically identical to the concentric structure of *Lithelius spiralis* Haeckel, the type species of the genus *Lithelius*. Adult forms of *Middourium* Kozlova 1999 (type species: *Cromyodruppa regularia* Borisenko) as well as *Monobrachium* Kozlova 1999 (type species: *Spongurus irregularis* Nishimura) are distinguishable from *Lithelius* species by having a thick outer cortical shell, but the specimens without this cortical shell are like *Lithelius*. *Larcopyle* is characterized by a well-developed cortical shell typically of ellipsoidal or flattened ellipsoidal shape, and a pylome at one pole (Lazarus et al., 2005). This genus possesses spongy, spiral or pylonid internal structures, which are indistinguishable from *Lithelius* species with loosely-spiral forms (e.g. *Lithelius nautiloides* Popofsky). Although the taxonomic classification of *Amphicarydiscus*, *Larcopyle*, *Lithelius*, *Middourium*, *Monobrachium* has been ill understood, *Amphicarydiscus* species have not been found in the Neogene so far known, suggesting that these genera include more or less phylogenetically separated groups. Furthermore, these genera are thought to be belong to a different higher taxonomic rank: *Amphicarydiscus* in Coccodiscidae Haeckel, 1882 (Lipman, 1972) or Spongodiscoidea (Kozlova, 1999), *Larcopyle* in Larcariidae Haeckel 1884 (e.g. Campbell, 1954) or Pyloniidae Haeckel 1882 (De Wever et al, 2001), *Lithelius* in Litheliidae Haeckel 1860b (De Wever et al, 2001; Haeckel, 1860b), and *Middourium* and *Monobrachium* in Sponguridae Haeckel 1862 (Kozlova, 1999). We tentatively classify our material into the family Lithelidae, although biostratigraphic distributions, skeletal structures and phylogeny of the type species for these families have not been well understood so far. In addition, the type species of *Lithelius*, *Lithelius spiralis* Haeckel, seems to have a similar concentric structure to a flat-shaped group, *Spongodiscus,* and shows apparently different internal structures from a loosely-coiled *Lithelius* such as *Lithelius nautiloides*. We cannot place these groups into a phylogenetically coherent scheme without comprehensive studies so that we artificially separated our individuals into several genera.

Genus *Larcopyle* Dreyer 1889 sensu emend. Lazarus et al. 2005

Type species: *Larcopyle buetschlii* Dreyer 1889

Remarks: We followed the sense of Lazarus et al. (2005) for adult forms. Indistinguishable juvenile or incomplete *Larcopyle* individuals have no distinguishing characteristics and questionably fall into *Lithelius*. *Middourium* and *Monobrachium* seem to be different from *Larcopyle* by having a tightly concentric structure, but both genera are tentatively synonymized with *Larcopyle* until taxonomic issues are solved.

***Larcopyle* sp. A**

pl. 7, figs. 1-5b

Description: Test spherical to elliptical in juvenile forms (pl. 7, figs. 1-3) and sub-elliptical in mature forms (pl. 7, figs. 4a-5b); consisting of 2-3 innermost spherical shells, 1 to 2 opposite caps with a pylomate cortical shell; weak constrictions visible between the innermost spherical shells and opposite caps. Innermost spherical shells loosely evolute. In juvenile forms, incomplete spherical shells appearing as opposite caps.

Remarks: Although the innermost spherical shells of the juvenile form of *Larcopyle* sp. A are loosely wound in comparison to those of *Larcopyle* sp. B, it is impossible to distinguish between juvenile forms of *Larcopyle* sp. A and those of *Larcopyle* sp. B.

***Larcopyle* sp. B**

pl. 7, figs. 6-9b, 12a-15b

Description: Test spherical to subspherical in juvenile forms (pl. 7 figs. 6-9b) and elliptical in mature forms (pl. 7, figs. 12a-12b); consisting of 3 innermost spherical shells, 1 to 2 opposite caps with a pylomate cortical shell; a relatively smooth surface on the cortical shell. Innermost shells normally revolved with moderately spaced whorls. In juvenile forms, the incomplete spherical shell appears as opposite caps. In mature forms, short spines appear around the pylome.

Remarks: *Larcopyle* sp. B differs from *Larcopyle* sp. A by having more tightly wound innermost shells and a more globular cortical shell with a smooth surface. In our material, *Larcopyle* sp. B tends to be smaller than *Larcopyle* sp. A.

***Larcopyle* sp. C**

pl. 7, figs. 10-11, 16-22b

Description: Test spherical to thickly fusiform in juvenile forms (pl. 7 fig. 16, 19a-20b) and thickly fusiform in mature forms (pl. 7 figs. 17a-18b, 21a-22b); consisting of 3-4 spherical to thickly fusiform innermost shells, 1 to 2 opposite caps with a pylomate cortical shell; smooth surface on the coverage. Innermost shells tightly - wound and very slightly loosening outward. The inner opposite caps from the last ones barely covering the equator portion of the innermost shells; very narrow along the equatorial portion. The last opposite caps small and narrow. A pylomate cortical shell thick. Pylome is relatively narrow and in some specimens develops a tube-like periphery.

Remarks: *Larcopyle* sp. C is characterized by a thick-walled, thickly fusiform pylomate cortical shell and a thin pylome. Juvenile forms of *Larcopyle* sp. C are distinguishable from those of *Larcopyle* sp. A and *Larcopyle* sp. B by having more tightly revolved wrapped innermost shells. Differing from *Lithelius* sp. A, *Larcopyle* sp. C has more loosely revolved wound innermost shells and its shape is not completely spherical.

***Larcopyle occidentalis* (Clark and Campbell 1942)**

pl. 8, figs. 1a-3, pl. 9, figs. 1a-13b

Prunopyle occidentalis n. sp. Clark and Campbell, 1942, p. 35-36, pl. 5, fig. 27, 27a.

Description: Test spherical to spiral shape in juvenile forms (inside structure shown in pl. 8 figs. 1a-1b) and ellipsoidal to globular in mature forms (pl. 8 figs. 1a-3); consisting of 3 to 4 spherical to spiral innermost shells, 1 to 2 opposite caps; smooth surface on the cortical shell. Innermost shells very loosely revolved wound except for the first chamber; larger pores visible. The opposite caps have the same height as the innermost shells. The outermost opposite caps in many specimens develop only around the peripheral equatorial portions and are incomplete at the polar ends; in this case, the specimen appears to have two pylomes of both ends of the test. A pylomate cortical shell very thick. Pylome in mature specimens varies from narrow (pl. 9 figs. 1a-1b, 3a-3b, 11a-11b) to having a very wide opening (pl. 9 figs. 4a-4b, 7a-7b, 12-13b); a few spines extend from the periphery of the pylome.

Remarks: *Larcopyle occidentalis* appears spherical in polar view and elliptical in tangential view. The mature form of *Larcopyle occidentalis* is easily distinguished from other *Larcopyle*-morphotypes by having larger shells with larger innermost shells. The mature forms of *Larcopyle occidentalis* were not encountered with *Larcopyle* sp. E in Sample 1172A-51X-CC, thus both morphotypes are considered to be different species. However, the specimens identified as *Larcopyle* sp. E (pl. 8 figs. 4-19) may include juvenile forms of *Larcopyle occidetantalis*, but we are unable to separate these from *Larcopyle* sp. E.

Larcopyle sp. D is similar to *Larcopyle frakesi* (Chen), *Larcopyle hayesi* (Chen) and *Larcopyle monikae* (Petrushevskaya 1975), *Larcopyle ovata* (Kozlova in Kozlova and Gorbovets 1966), and *Larcopyle titan* (Campbell and Clark 1944) by having a larger thicker pylomate cortical shell, but is easily distinguished from the latter species by having loosely wound innermost shells.

***Larcopyle* sp. E**
pl. 8, figs. 4-40b

Description: Test is spherical to spiral in shape in both juvenile and mature forms; consists of 3 to 4 spiral shells; tightly wrapped inside and gradually loosening outward; rough on the surface.

Remarks: *Larcopyle* sp. E is distinguishable from juvenile forms of *Larcopyle* sp. A, *Larcopyle* sp. B and *Larcopyle* sp. C by having more loosely wound shells.

***Larcopyle compositus* (Mamedov 1973)**
pl. 5, fig. 17, pl. 10, figs. 1a-7b

Azerbaidjanicus compositus n. sp. Mamedov, 1973, p. 61-62, pl. 1, figs. 3, 4

Remarks: This species differs from *Larcopyle hayesi hayesi* by having more tightly wound concentric shells and the presence of radial spines. *L. compositus* replaced *Larcopyle hayesi hayesi* in the uppermost Eocene at Site 1172. *Larcopyle compositus* is distinguishable from *Larcopyle adelstoma* (Kozlova in Kozlova and Gorbovets 1966) and *Larcopyle ovata* (Kozlova in Kozlova and Gorbovets 1966) by the former's lack of a pylome and its spherical form. This species is very similar to *Larcopyle echinatus* (Mamedov 1970) in spherical shape, presence of radial spines and concentric structures. We tentatively separated *Larcopyle compositus* from *Larcopyle echinatus* in that the latter possesses more robust radial spines.

***Larcopyle hayesi hayesi* (Chen 1974)**
pl. 10, figs. 8a-18b

Prunopyle hayesi n. sp. Chen, 1974, p. 482, pl. 1, fig. 7, 8, pl. 2, figs. 1, 2.

Larcopyle hayesi variety *'hayesi*'. Lazarus et al, 2005, p. 119-120, pl. 11, figs. 1-8, 18-20.

Remarks: Lazarus et al. (2005) treated it as a morphotype of *Larcopyle hayesi* (s.l.) stock by examination of Neogene Antarctic sediments. We have not encountered *Larcopyle hayesi* variety *"irregularis*", despite the common occurrence of *Larcopyle hayesi* variety "*hayesi"*, and consequently we raised it to subspecies status herein.

***Larcopyle* sp. H**
pl. 7, figs. 23a-30

Remarks: This morphotype differs from *Larcopyle labyrinthusa* Lazarus et al. (2005) by a more slender shape and absence of spines around the pylome.

***Larcopyle eccentricum* Lazarus et al. 2005**
pl. 7, figs. 31a-b

Larcopyle eccentricum n. sp. Lazarus et al, 2005, p. 111, pl. 6, figs. 1-15

Genus *Lithelius* Haeckel 1862
Type species: *Lithelius spiralis* Haeckel, 1860b

Remarks: This genus includes spumellarians with concentric or spirally-concentric structures without the thick cortical shell or the pylome that it bears. This genus is also potentially confused with juvenile or incomplete *Amphicarydiscus*, *Larcopyle*, *Middourium* and *Monobrachium*.

***Lithelius* (?) *octoxyphophora* (Clark and Campbell 1942)**
pl. 4, figs. 2a-b

Stylosphaera (*Stylosphaerella*) *hexaxyphophora octoxyphophora* n. subsp. Clark and Campbell, 1942, p. 29, pl. 6, fig. 12

Remarks: Sanfilippo and Riedel (1973) synonymized this subspecies with *Lithelius hexaxyphophora* (Clark and Campbell 1942), but we have never encountered a morphotype with very long radial spines like *L. hexaxyphora*. We therefore tentatively separate this morphotype from *L. hexaxyphora*.

***Lithelius* sp. A**
pl. 5, figs. 6-10

Remarks: This morphotype is characterized by very tightly wound concentric spherical spiral shells and is distinguished from *Lithelius spiralis* Haeckel 1860 by absence of radial spines. Incomplete shells are formed on the opposite side of the other incomplete shell (Pl. 5 fig. 9).

***Lithelius* (?) sp. B**
pl. 6, figs. 20a-20b

Remarks: This morphotype is characterized by three or four large concentric spherical shells. The superficial features of this morphotype appear to be similar to actinommids, but this morphotype differs from the latter on formative patterns of concentric shells. The precise taxonomic position of this morphotype needs to be fixed by examination of the internal structures.

***Lithelius* sp. F**
pl. 11, figs. 1-6, 8a-8b

Description: Test large, spherical spiral form; consisting of 3-5 spiral concentric shells with incomplete caps; very tightly evolved wrapped. Open gates occasionally visible in tangential views (pl. 16, figs. 3a-3b). Radial beams arise from inner shells, thick, straight, extending outward to connect to radial spines. Radial spines thick, triradiate, straight and short. Pores relatively large, except for the ontogenetically last chamber. No cortical shell present.

Remarks: This morphotype is similar to *Lithelius haliomma*

(Ehrenberg 1861), but the former is rather tightly evolved wound in comparison with the latter. This species bears morphologically similarity to *Lithelius nautiloides* Popofsky, 1908, and *Lithelius nerites* Tan and Su 1982, but differs from these latter two taxa by having more robust, straight, triradiate radial beams and a thicker wall. *Lithelius* sp. F is similar to *Lithelius primordalis* Hertwig 1879, and *Lithelius riedeli* Petrushevskaya 1967 but differs from them by having more irregularly evolved wound concentric shells and triradiate robust spines.

Lithelius sp. G
pl. 11, figs. 7a-7b, 9a-9b

Superfamily Spongodiscoidea Haeckel 1862

Remarks: Flat-type Polycystina have such complex internal structures (e.g. Ogane and Suzuki, 2006, 2007) that detailed examination of their internal structure is needed for more comprehensive description. Morphologic terms for this groups are from Ogane and Suzuki (2006) because previous papers have never clearly defined the terms to describe precise structure of flat-type Polycysitna. We note definition of some terms defined in Ogane and Suzuki (2006):

Biconvex: a shape consisting of two curved surfaces akin to a biconvex lens.
Crust: thick spherical shell enclosing a margarita.
Coinlike: a flat disk consisting of two flat or slightly concave planar sides enclosed within a flat margin
Face: the flat planes on either side of a coinlike disk.
Gown: a porous delicate plate covering the disk; pores are generally irregularly arranged.
Hoop: annular shells having circular equatorial sections but whose crescents distned outwards in polar section. Each hoop possesses a smooth surface with regularly arranged subcircular pores. They are joined directly to one another.

Following two terms are used in this manuscript, but they were not defined in Ogane and Suzuki (2006). Therefore, these two terms are defined here in.
Mantle: The thin hollow plate-like skeleton surrounding the disk.
Ring: The concentric or spiral structure in the disk observed under optical microscopy. Rings can be divided into palea, hoop, and biretta according to their three-dimensional structure (Ogane & Suzuki 2006), but it is sometimes difficult to distinguish them using optical microscopy. In such cases we use the simpler term “ring”.

Family Spongodiscidae Haeckel 1862
Genus _Spongodiscus_ Haeckel 1862
Type species: *Spongodiscus resurgens* **Ehrenberg 1854b**

Remarks: This genus is characterized by a spongy disk. The disk is composed of a margarita, or margarita and spongy brim. Some species have spines, mantles, or gowns.

Spongodiscus osculosa (Dreyer 1889)
pl. 12, figs. 12a-14b

Spongopyle osculosa Dreyer, 1889, p. 118-119, figs. 99, 100.

Diagnosis: Disk spongy, biconvex in equatorial view and circular in face view. Pylome with a porous tube; tube connected to the lining of pylome.

Remarks: This species is similar to *Spongodiscus resurgens*, but *S. osculosa* can be distinguished from *S. resurgens* by having a pylome with lining and tube. The lining is difficult to observe under the light microscopy, but can be observed under the transmitted illumination as a dark line along the pylome.

Spongodiscus resurgens Ehrenberg,1854b
pl. 12, figs. 8a-9b

Spongodiscus resurgens Ehrenberg, 1854b, p. 246.

Diagnosis: Biconvex spongy disk without spines and pylome.

Remarks: This species is similar to *S. osculosa*, but *S. resurgens* is different in the absence of a tube and lining.

Spongodiscus festivus (Clark and Campbell 1942)
pl. 13, figs. 4a-7b

Spongotrochus (*Stylotrochiscus*) *festivus* Clark and Campbell. Clark and Campbell, 1942, p. 99, pl. 2, fig. 3, 5, 8.
Spongotrochus (*Stylotrochiscus*) *festivus* Clark and Campbell. Clark and Campbell, 1945, p. 57, pl. 4, fig. 8, 9.

Diagnosis: Test consists of a spongy disk with numerous needle-like radial spines. Disk coin-like in equatorial view and circular in face view. Radial spines 4 to 8. Gown developing in some individuals.

Remarks: Radial spines are occasionally broken off, but are countable by observation of preserved proximal part. This species is similar to *Spongodiscus rhabdostyla* in having spines, but differs from the latter by having more slender spines.

Spongodiscus rhabdostyla (Ehrenberg 1873)
pl. 13, figs. 1a-3c

Spongosphaera rhabdostyla Ehrenberg, 1873, p. 256.

Diagnosis: Disk spongy, coin-like in equatorial view and circular in face view. Four to 8 radial spines ; spines are broad in their proximal part, showing triangular side view; long.

Remarks: This species is characterized by possessing a spongy disk and robust radial spines. This species rarely has fine radial spines as like *Spongodiscus festivus*, but is easily distinguished from the latter by having triangular spines with wide proximal part. Radial spines are occasionally broken off.

***Spongodiscus communis* Clark and Campbell 1942**
pl. 13, figs. 9a-12b

Spongodiscus (Spongocyclia) communis Clark and Campbell. Clark and Campbell, 1942, p. 99, pl. 2, fig. 11.

Schizodiscus disymmetricus (Dogiel) group. Petrushevskaya, 1975, pl. 5, fig. 1-2.

Spongodiscus craticulatus (Stöhr). Petrushevskaya, 1975, pl. 5, fig. 10.

Diagnosis: Test consisting of spongy disk and wrapped crust. Crust biconvex in equatorial view and circular in face view; possessing a vent-like pylome: crescent-shaped depressions on central portion of the surface., A few small pores are arranged in the crescent-shaped depressions. A space is visible between the crust and the periphery of disk.

***Spongodiscus* sp. D**
pl. 12, figs. 10a-11b

Diagnosis: Disk spongy without any particular ornament; coin-like shape with weakly concave face structure on its center in equatorial view and circular in face view.

Remarks: This morphotype can be distinguished from any other similar species of *Spongodiscus* by absence of ornaments and concave shape.

***Spongodiscus cruciferus* (Clark and Campbell 1942)**
pl. 14, figs. 1a-5b

Spongasteriscus (*Spongasteriscinus*) *cruciferus* Clark and Campbell. Clark and Campbell, 1942, p. 98, pl. 1, fig. 1-2, 4-5, 6, 8, 10, 17.

Spongasteriscus (*Spongasteriscinus*) *cruciferus* Clark and Campbell. Clark and Campbell, 1945, p. 57, pl. 4, fig. 4, 6, 7.

Diagnosis: Disk possessing a margarita in the central portion. Brim elliptical in shape, spongy; characterized by two ridges along the elongate axis in face view. Elongate ridges are drop-shaped, bulging distally, appearing like an arm.

Remarks: Elliptical disk with elongate ridges are very significant characters for distinguishing this species from any other *Spongodiscus*-species. Small individuals of *Spongaster berminghami* are similar to *Spg. cruciferus* but they have a margarita with four arms in two opposite crossed pairs. Two arms of one pair longer than the other two arms, and the shape of entire shell is elliptical. The two longer arms of *Spr. berminghami* are similar to two ridges on the brim of *Spg. cruciferus*. However, the ridges of *Spg. cruciferus* can be recognized from the arms of *S. berminghami* in drop-shap. The longer arms of *S. berminghami* have spatula-like shape.

Genus *Flustrella* Ehrenberg 1839
Type species: *Flustrella concentrica* Ehrenberg 1839

Diagnosis: Disk generally consisting of a margarita and surrounding concentric brims. Mantle or spines appearing in some species.

***Flustrella parva* (Clark and Campbell 1942)**
pl. 12, figs. 1-5

Porodiscus (Trematodiscus) parvus Clark and Campbell. Clark and Campbell, 1942, p. 99, pl. 2, fig. 12.

Spongotrochus (?) sp. Petrushevskaya and Kozlova, 1972, p. 567, pl. 5, fig. 12.

Diagnosis: Disk concentric, coin-like shape, weakly convex on its center. Central chamber and rings circular.

Remarks: This species is characterized by presence of circular concentric disks and absence of ornament. This species can be distinguished from *Flustrella* sp. B by having wider rings. This species differs from *Flustrella* sp. D, *Flustrella* sp. G and *Flustrella* sp. F, respectively, by absence of ornaments.

***Flustrella* sp. A**
pl. 12, figs. 6a-7b

Diagnosis: Test consisting of simple concentric disk. Disk biconvex or coin-like shape with a substantial convex dome in its central portion.

Remarks: This species can be distinguished from any other *Flustrella* species by the large convex dome.

***Flustrella* sp. B**
pl. 15, figs. 1a-6b

Spongotrochus (?) sp. Petrushevskaya and Kozlova, 1972, p. 567, pl. 5, fig. 12.

Diagnosis: Disk concentric without any ornaments; coin-like shape with concave center. Central chamber and rings elliptical or concentric circular outline. The width between the rings is narrow.

Remarks: This species can be distinguished from any other *Flustrella* species by having narrow rings.

***Flustrella* sp. D**
pl. 15, figs. 9a-c

Diagnosis: Disk concentric with radial spines; biconvex in equatorial view and circular in face view. Spines cylindrical, long, needle-like in equatorial view. Rings of the central portion generally obscured by thick surface of the test

Remarks: This morphotype is distinguishable from other *Flustrella*-species by possessing long, needle-like radial spines. *Flustrella* sp. G appears to be similar to *Flustrella* sp.

D by presence of long spines, but the spines in *Flustrella* sp. G can be distinguished from the latter in that they are bladed.

***Flustrella* sp. G**
pl. 14, figs. 12-13b

Diagnosis: Test consists of a concentric squared disk and four radial spines. Disk concentric, biconvex in equatorial view, and having a roundish square outline in polar view. Radial spines long, relatively robust, and bladed.
Remarks: This morphotype is different from other *Flustrella* by having bladed spines and a square shaped outline.

***Flustrella* sp. H**
pl. 15, figs. 7a-8b

Diagnosis: Test consisting of concentric disk with a pylome. No other ornamentation present. Disk coin-like shape in equatorial view and circular in face view. Pylome possessing a tube. Rings circular outline, very tightly spaced.
Remarks: This morphotype can be distinguished from any other species in our material by having a pylome with tube.

Genus *Histiastrum* Ehrenberg 1846
Type species: *Histiastrum quaternarium* Ehrenberg 1873

Remarks: This genus is characterized by four arms. Disk is chambered with concentric rings, or spongy.

***Histiastrum* sp. A**
pl. 13, figs. 8a-c

Diagnosis: Test consists of a disk chambered with concentric rings and four arms. Disk has an elliptical central chamber and tightly spaced elliptical rings. Arm oblanceolate in shape; arranged at right angles on the equatorial plane.
Remarks: This morphotype is similar to *Histiastrum quaternarium*, but is different from the latter in absence of spines.

Genus *Ommatodiscus* Stöhr 1880
Type species: *Ommatodiscus haeckeli* Stöhr 1880

Diagnosis: Test is characterized by crust which covers the margarita. Crust has generally one vent-like pylome. Lazarus et al. (2005) suggested not to use any of taxa in Stöhr (1880) because the original description and material are very poor. Stöhr's specimens are missing at this point. We aware these problems for many species in Stöhr (1880), but ICZN strongly requests to designate neotype but not discards such "nomen dubium" without ruling by the ICZN commission. It is also appropriate to use the taxa in Stöhr (1880) with exact descriptions and accurate drawings.

***Ommatodiscus* sp. A**
pl. 14, figs. 6a-11b

Diagnosis: Disk elliptical in face view and convex in equatorial view; covered with porous crust. Crust having one vent-like conical pylome; with crescent-shaped depressions. A few pores are arranged within the crescent-shaped depressions. Many spines arise from the mouth of the pylome.

***Ommatodiscus* sp. B**
pl. 16, figs. 8a-11b

Diagnosis: Test consists of a concentric-ringed disk and porous crust. Crust is elliptical to circular in face view and biconvex in equatorial view; with one pylome; with crescent-shaped depressions. A few pores are arranged within the crescent-shaped depressions. Spines are present around the mouth of the pylome. Rings of disk are rather indistinct.

Genus *Amphymenium* Haeckel 1882
Type species: *Amphymenium* (*Ommatogramma*) *zygartus* Haeckel 1887

***Amphymenium splendiarmatum* Clark and Campbell 1942**
pl. 6, figs. 9-12

Amphymenium (*Ommathymenium*) *splendiarmatum* n. sp. Clark and Campbell, 1942, p. 46, pl. 1, figs. 12, 14.

Family Stylodictyidae Haeckel 1882
Genus *Stylodictya* Ehrenberg 1846
Type species: *Stylodictya gracilis* Ehrenberg 1854a

Remarks: This genus is characterized by the decussate disk. Some species have several radial spines.

***Stylodictya* sp. A**
pl. 16, figs. 5-7

Stylodictya gracilis Ehrenberg. Haeckel, 1887, p. 611, pl. 7, fig. 12.
Diagnosis: Test consists of a decussate disk with eight radial spines. Microsphere, circular in face view, possesses four primary radial beams. Biretta with four to eight secondary radial beams. Primary and secondary radial beams penetrate through hoops, and connect to radial spines. Double or triple lines of pores on each hoop.
Remarks: Radial spines are tend to be broken in most specimens.

***Stylodictya rosella* Kozlova**
in Petrushevskaya and Kozlova 1972
pl. 16, figs. 1a-4

Stylodictya rosella Kozlova n. sp. Petrushevskaya and Kozlova, 1972, p. 526, pl. 18, fig. 9.

Stylodictya targaeformis (Clark et Campbell). Petrushevskaya, 1975, p. 576, pl. 6, fig. 7-8.

Diagnosis: Test consists of a decussate disk without any ornaments. Rings are narrow in width, and there are double lines of pores on each ring. Microsphere has four primary radial beams.

Remarks: This species can be distinguished from *Stylodictya* sp. A by having narrower rings.

Superfamily Pylonioidea Haeckel 1882
Family Larnacillidae Haeckel 1884
Genus *Larnacalpis* Haeckel 1887
Type species: *Larnacalpis lentellipsis* Haeckel 1887

***Larnacalpis* sp. A**
pl. 11, figs. 10a-27b

Genus *Circodiscus* Petrushevskaya and Kozlova 1972
Type species: *Circodiscus microporus* **(Stöhr 1880)**

Remarks: This genus is characterized by a larcoidal structure in the central portion of the disk.

***Circodiscus circularis* (Clark and Campbell 1942)**
pl. 16, figs. 12-13b

Circodiscus circularis (Clark and Campbell). Petrushevskaya and Kozlova, 1972, p. 595, pl. 19, fig. 9, 12.

Circospyris ellipticus (Stöhr). Petrushevskaya, 1975, p. 609, pl. 6, fig. 1-3, 5, 6.

Diagnosis: Test consists of a concentric-ringed disk without ornaments. Disk elliptical in face view and biconvex in equatorial view. Central chamber elliptical, and characterized by a larcoidal structure in the central chamber. Rings The shell has two to four rings.

Remarks: This species is similar to *Circodiscus* sp. C, but can be distinguished from *C.* sp. C in having more regular,wider rings and no spongy mantle.

***Circodiscus* sp. A**
pl. 17, figs. 1a-3b

Perichlamidium limbatum Ehrenberg. Petrushevskaya, 1975, p. 609, pl. 6, fig. 11.

Diagnosis: Test consists of a concentric-ringed disk with mantle. Disk circular to elliptical in face view and biconvex in equatorial view. Central chamber elliptical. Ring elliptical or circular. Mantle porous, significantly larger in radius than the ringed disk, and possessing one pylome. Space between mantle and disk filled with spongy meshwork.

Remarks: This species is different from any other circodiscid species by having wide mantle and narrow rings. *Circodiscus* sp. C also has a mantle, but the mantle of *C.* sp. A is more than two times as wide as *C.* sp. C.

***Circodiscus* sp. C**
pl. 17, figs. 4a-9

Diagnosis: Test consists of a concentric, two to four ringed disk with mantle. Disk is elliptical in face view and biconvex in equatorial view. Central chamber is elliptical, with a larcoidal structure in the central chamber. Mantle surrounds the disk. The development state of the mantle is variable.

Remarks: Mantle in some specimens is broken off or missing. This species is similar to *C. circularis*, but can be distinguished from *C.* sp. A in having narrower irregular rings and a spongy mantle.

Spumellaria, Superfamily et family Incertae sedis

Genus *Hexancistra* Haeckel 1879 sensu Kozlova and Gorbovets 1966
Type species: *Hexancistra quadricuspis* Haeckel 1879.

Hexalonche [sensu emend]: Kozlova and Gorbovets, 1966, p. 58.

Remarks: Differing from *Hexalonche*, the innermost shell of *Hexancistra* is a spherical microsphere. Kozlova and Gorbovets (1966) emended the definition of *Hexalonche* as having two concentric spherical shells and six radial spines which are arranged vertically to each other. This definition does not fit with the definition of *Hexalonche* that has a characteristic initial tetrapetaloid structure with wide pores (De Wever et al., 2001). All the *Hexalonche*-species with two concentric spherical shells in previous papers should be moved into this genus.

***Hexancistra orientalis* (Kozlova 1983)**
pl. 2, figs. 8a-b

Hexalonche orientalis n. sp. Kozlova, 1983, p. 91, pl. 1, figs. 2, 2a.

***Hexancistra* (?) sp. 2**
pl. 3, figs. 3a-b

Genus: *Stauroxiphos* Haeckel 1887
Type species: *Stauroxiphos gladius* Haeckel 1887

Remarks: Kozur and Mostler (1979) synonymized *Staurancistra*, *Staurolonchidium* and *Stauroxiphos* with *Staurolonche* as all possessing two concentric shells with four radial spines, but they provided no stratigraphic or phylogenetic data for their type species. The type species of *Staurolonchidium* was designated by Campbell (1954) as *Haliomma perspicuum* Ehrenberg 1873 and that of *Stauroxiphos* as *Stauroxiphos gladius*, both of which are Eocene-Oligocene species. However, the type species of *Staurolonche* is *Staurolonche robusta* Rüst 1885, a Jurassic radiolarian, thus *Staurolonche* is not a synonym of both *Staurolonchidium* and *Stauroxiphos*. Although the exact structure of both type species have not been examined, the type species of *Staurlonchidium* has a very small microsphere, while that of *Stauroxiphos* possesses a larger, spherical inner shell. We tentatively separate *Stauroxiphos* and *Staurolonchidium* in analogy with the case of *Hexastylus* and *Hexalonche*. We regard *Staurancistra* as nomen dubium because the skeletal structures of the type species of this genus, *Staurancistra quadricuspis* Haeckel 1887 cannot be evaluated its owing to there being no illustrations in the original paper and no designated type material.

Stauroxiphos (?) sp. 1
pl. 4, figs. 9a-b

Remarks: This morphotype is similar to *Stylosphaera* and *Sphaeractis* except for the presence of four radial spines.

Genus _Spongopylidium_ Dreyer 1889

Type species: *Spongopyle* (*Spongopylidium*) *ovata* Dreyer, 1889

Remarks: Although the internal skeletal structure of *Spongopylidium ovata*, the type species of *Spongopylidium* is not detailed yet, we include here forms with a spongy internal structure, a latticed-cortical shell and a pylome. an identical species with the distinguishing features of *Sponopylidium* has been described from the Jurassic as *"Archicapsa pachyderma* Tan" (Tan, 1927), but the exact relationship between the Mesozoic and Cenozoic forms are unknown. Included species in *Spongopylidium* are *Collosphaera elliptica* Chen and Tan 1989, *Collosphaera pyloma* Reynolds 1980, *Haliomma ovatum* Ehrenberg 1840, *Spongopyle* (*Spongopylidium*) *ovata* Dreyer 1889, and *Spongopyle* (*Spongopylidium*) *variabilis* Dreyer 1889. The type species of *Spongopylidium*, *Spongopylidium ovatum* Dreyer 1889, is a secondary junior homonym of *Spongopylidium ovatum* (Ehrenberg 1840). The subsequent valid junior synonym for Dreyer's *"Spongopylidium ovatum*" is *Spongopylidium variabile* Dreyer 1889.

Spongopylidium ovatum (Ehrenberg 1840)
pl. 2, figs. 3a-b

Haliomma ovatum n. sp. Ehrenberg, 1840, p. 200.
Haliomma ovatum Ehrenberg form α. Ehrenberg, 1854a, pl. 19, fig. 48, not fig. 49).

Spumellaria gen. et sp. indet. 1
pl. 4, fig. 11

Remarks: This morphotype is characterized by a pentagonal flat-shaped shell with five multi-bladed spines, one from each corner. the internal structure is unknown due to our specimens being filled with opaque matter.

Spumellaria ? gen. et sp. indet 2
pl. 4, figs. 1a-c

Remarks: The taxonomic position of this morphotype is unknown owing to ambiguous images of the internal structure.

Order Nassellaria Ehrenberg 1876, sensu De Wever et al. 2001.
Superfamily Plagiacanthoidea Hertwig 1879
Family Lophophaenidae Haeckel 1882, sensu emend. Petrushevskaya 1971
Genus _Ceratocyrtis_ Bütschli1882, sensu Petrushevskaya 1971

Type species: *Cornutella cucullaris* Ehrenberg 1873

Ceratocyrtis rhabdophora (Clark and Campbell 1945)
pl. 20, figs. 12a-b

Bathrocalpis rhabdophora rhabodphora n. sp. et. n. var. Clark and Campbell, 1945, p. 34-35, pl. 7, figs. 37-41.

Ceratocyrtis aff. _stigi_ (Bjørklund 1976)
pl. 20, figs. 10a-b

[aff] *Lithomelissa stigi* n. sp. Bjørklund, 1976, p. 1125, pl. 15, figs. 15, 16 (only)

Remarks: This species was moved into the genus *Ceratospyris* by Petrushevskaya and Kozlova (1979). The holotype was a specimen from a Miocene sample (ODP 38-338-Core 8), so that this morphotype from the Eocene is tentatively included in the this species.

Ceratocyrtis aff. _cornutus_ (Brandt in Wetzel 1936)
pl. 20, figs. 11a-b

[aff.] *Helotholus cornutus* n. sp. Brandt in Wetzel, 1936, p. 55, pl. 9, figs. 10, 11.

Remarks: This morphotype differs from *Ceratospyris cornutus* in the former having a spinose surface.

***Ceratocyrtis* (?) sp. 1**

pl. 22, figs. 2a-b

Remarks: The exact classification of this morphotype is unknown.

Genus *Archiperidium* Haeckel 1882 sensu Funakawa 1995

Type species: *Peridium* (*Archiperidium*) *spinipes* Haeckel, 1887

Remarks: Funakawa (1995) erroneously cited *Peridium spinipes* as the type species of the genus *Peridium* Haeckel, 1882, and the first designation of the type species for *Peridium* as *Peridium* (*Peridarium*) *lasanum* Haeckel 1887 by Campbell (1954). *P. spinipes* was selected only as the type species of a subgenus *Archiperidium* of the genus *Peridium* by Campbell (1954). We raise *Archiperidium* to a generic level because the type species of *Peridium* – *P. lasanum* is a nomen dubium owing to no illustration and indefinite description by the original author (Haeckel, 1887).

***Archiperidium sphaerum* (Funakawa 1995)**

pl. 22, figs. 3a-b

Peridium sphaerum n. sp. Funakawa, 1995, p. 21-22, pl. 2, figs. 1a-4.

(?) Plagoniid, gen. et sp. indet. Takemura, 1992, p. 744, pl. 1, fig. 10.

Remarks: (?) Plagoniid, gen. et sp. indet. of Takemura (1992) is slightly different from the holotype of the this species in that it has a more spherical cephalis with a thick wall, although morphological variations and chronologic variations of this species are unknown.

Genus *Lithomelissa* Bütschli 1882

Type species: *Lithomelissa tartari* Ehrenberg 1854b

***Lithomelissa ehrenbergi* Bütschli 1882**

pl. 20, figs. 1a-b

Lithomelissa ehrenbergi n. sp. Bütschli, 1882, pl. 33, fig. 21.

***Lithomelissa haeckeli* Bütschli 1882**

pl. 20, figs. 2a-b

Lithomelissa haeckeli Bütschli, 1882, pl. 33, fig. 23.

***Lithomelissa macroptera* Ehrenberg 1873**

pl. 20, figs. 5a-b

Lithomelissa macroptera n.sp. Ehrenberg, 1873, p. 241.

Lithomelissa macroptera Ehrenberg. Ehrenberg, 1876, p. 78-79, pl. 3, figs. 9-10.

***Lithomelissa hertwigi* Bütschli 1882**

pl. 20, figs. 6a-b

Lithomelissa hertwigi n. sp. Bütschli, 1882, pl. 33, fig. 22.

***Lithomelissa* sp. 4**

pl. 20, figs. 8a-b

***Lithomelissa* sp. 5**

Pl. 20, figs. 9a-b

***Lithomelissa lautouri* O'Connor 1999a**

pl. 21, figs. 10a-b

Lithomelissa lautouri O'Connor, 1999a, p. 16-18, pl. 2, figs. 23-27, pl. 6, figs. 11a-15.

***Lithomelissa* aff. *mitra* Bütschli 1882**

pl. 21, figs. 11a-b

Lithomelissa mitra n. sp. Bütschli, 1882, pl. 33, fig. 24.

***Lithomelissa* (?) aff. *bifurcata* Clark and Campbell 1942**

pl. 21, figs. 12a-b

Lithomelissa (*Micromelissa* ?) *bifurcata* n. sp. Clark and Campbell, 1942, p. 70, pl. 9, fig. 22.

Remarks: The illustrated specimen has a wider thorax and more porous surface than *L. bifurcata*.

Genus *Spongomelissa* Haeckel 1887

Type species: *Lithomelissa spongiosa* Bütschli 1882

***Spongomelissa spongiosa* (Bütschli 1882)**

pl. 20, figs. 3a-b

Lithomelissa spongiosa n. sp. Bütschli, 1882, pl. 33, fig. 25.

***Spongomelissa* sp. 1**

pl. 22, figs. 1a-b

Remarks: This morphotype consists of two segments (cephalis and thorax) with an internal spicular system with **MB,** spine ***A***, ***D*** and ***L***, and probably arch **AL**. The skeletal structure of this morphotype is similar to *Spongomelissa spongiosa* (Bütschli) as illustrated in fig. 25c of Bütschli (1882), and thus this species is tentatively included in the genus *Spongomelissa*. This morphotype appears to have complex initial spicular system below **MB**.

Genus *Arachnocalpis* Haeckel,1882, sensu Petrushevskaya 1981

Remarks: Petrushevskaya (1981) synonymized the genus *Mitrocalpis* Haeckel 1882 with this genus in the subfamily Sethopiliinae of the family Plagiacanthidae. Furthermore, she synonymized the genus *Sethopilium* with *Peromelissa*, a member of the family "Lophophaeninae", and subsequently all the members of Sethopiliinae automatically moved into

Lophophaninae. De Wever et al. (2001) raised this subfamily to family level, and thus the genus *Archnocalpis* is included in the family Lophophaenidae.

***Arachnocalpis* (?) sp. 1**
pl. 22, figs. 17a-b

Description: A large, elongate, mango-shaped cephalis with very narrow aperture and apertural wall. No internal structure has been found so far.

Remarks: *Arachnocalpis* has previously only been known from living plankton samples because this taxon has a very fine skeleton. As no other appropriate taxon names have been proposed for this morphotype, we (probably artificially) apply this genus name. Overall the shape is similar to *Cyrtocalpis* (?) *gromia* Haeckel, 1887, but the size of our specimens is five times larger than the original description of *C. gromia*.

Family Stephaniidae Haeckel 1887
Genus *Zygocircus* Bütschli 1882
Type species: *Lithocircus productus* Hertwig, 1879

***Zygocircus triangularis* (Clark and Campbell 1945)**
pl. 22, fig. 15

Semantis triangularis n. sp. Clark and Campbell, 1945, p. 29, pl. 5, fig. 7.

Zygocircus sp. Petrushevskaya and Kozlova, 1972, p. 534, pl. 41, figs. 8-11.

Zygocircus büetschlii Haeckel [sic]. Funakawa and Nishi, 2005, pl. 3, fig. 9.

Description: Triangular to elongated triangular D-shaped ring with long **D** and **L**. **D** long, nearly parallel to Arch **AV**. The distal part of **D** becoming larger than its proximal part. **MB** short. **L** triangular in shape; bifurcated in its very proximal part, forming a pore; small spinules present on its distal part; the angle and shape of **L** variable. Spine **A** indistinguishable from other appendages on D-shaped ring. **V** short like other appendages on the upper portion of Arch **AV**. Very short ***l*** extending vertical to the plane of D-shaped ring. Two or three short appendages arising on the middle to upper part of Arch **AD**, three or four appendages on Arch **AD-AV**, and one to two appendages on Arch **AV**.

Remarks: This species is easily distinguished from other *Zygocircus* species by having a triangular **L** with a pore, and the distribution patterns of short appendages on the D-shaped ring, indistinguishable **A** and **V**. The shape of the D-shaped ring is variable.

Family Sethoperidae Haeckel 1882, sensu emend. Petrushevskaya 1971
Genus *Tripocyrtis* Haeckel 1887
Type species: *Tripocyrtis plagoniscus* Haeckel 1887

Remarks: The taxonomy of genera for dicyrtid nassellarians with well-developed spines **A**, **D** and **L** and arch **AD** and **AL** should be revised because Haeckel's artificial geometric classification has not been reevaluated in accordance with stratigraphic or phylogenetic evidence.

***Tripocyrtis* aff. *plectaniscus* Haeckel 1887**
pl. 20, figs. 4a-b

Tripocyrtis plectaniscus n. sp. Haeckel, 1887, p. 1020, pl. 60, fig. 9.

Remarks: This morphotype is slightly different from *Tripocyrtis plectaniscus* Haeckel by the absence of thorns on the apical horn and the wider angle of the feet. Furthermore, the original specimens for *T. plectaniscus* were obtained from much younger materials- a plankton sample towed at H.M.S. Challenger Station 264 (Haeckel, 1887).

Family incertae sedis

Genus *Amphicentria* Ehrenberg 1861
Type species: *Amphicentria salpa* Ehrenberg 1861

Remarks: The exact phylogenetic position of this genus cannot be determined due to poor illustrations of the type specimens in Ehrenberg (1872b). Based on our possible *Amphicentria* specimens, the distinctive large cephalis lacking Arch *AV* in the internal cephalic structure suggests that its taxonomic position is within the Tripedurnulidae Dumitrica, 1991, although this family has been only reported in Anisian (Middle Triassic) to Albian (mid-Cretaceous).

***Amphicentria* sp. 1**
pl. 22, fig. 4

Remarks: This morphotype is characterized by a large cephalis with large open area on its top.

Superfamily Acanthodesmoidea Hertwig 1879
Family Tripospyridae Haeckel 1882
Genus *Desmospyris* Haeckel 1882
Type species: *Desmopyris mammillata* Haeckel 1887

***Desmospyris* cf. *haysi* (Chen 1974)**
pl. 19, figs. 15a-b

Dendrospyris haysi n. sp. Chen, 1974, p. 482-483, pl. 2, fig. 3-5.

Desmospyris rhodospyroides n. sp. Petrushevskaya, 1975 (synonymized by Weaver, 1976)

[non] *Desmospyris* (?) *haysi* n. sp. Petrushevskaya, 1975, p. 593, pl. 8, figs. 3, 4, pl. 27, figs. 4-6 (a secondary junior homonym).

Remarks: This morphotype is slightly different from *Desmospyris haysi* (Chen) (not Petrushevskaya!) in having a small apical spine from the central sagittal ring. This morphotype is easily distinguished from *Desmospyris stabilis* (Goll 1968) by having more rounded cephalis.

Genus *Giraffospyris* Haeckel 1882 sensu Goll 1969

Type species: *Ceratospyris heptaceros* Ehrenberg 1873

***Giraffospyris incertecoronata* (Clark and Campbell 1942)**

pl. 19, figs. 12a-b

Aegospyris (?) *inertecoronata* n. sp. Clark and Campbell, 1942, p. 58, pl. 9, fig. 14

Genus *Liriospyris* Haeckel 1882

Type species: *Liriospyris hexapoda* Haeckel 1887

***Liriospyris* (?) sp. B**

pl. 22, fig. 19

Remarks: The precise generic position is unknown.

Genus *Petalospyris* Ehrenberg 1846

Type species: *Petalospyris foveolata* Ehrenberg 1854a.

***Petalospyris* cf. *eupetala* Ehrenberg 1873**

pl. 19, fig. 13

Petalospyris eupetala n. sp. Ehrenberg, 1873, p. 247.

Petalospyris eupetala Ehrneberg. Ehrenberg, 1876, p. 80-81, pl. 22, fig. 4.

Remarks: The illustrated specimen in our material appears to be similar to *Petalospyris eupetala* Ehrenberg by having plate-like feet around the aperture, a nut-shaped cephalis with small pores and relatively rough shape. However, our specimen cannot be precisely identified as this species because the upper part of the cephalis is not seen.

Genus *Triceraspyris* Haeckel 1882

Type species: *Triceraspyris* (*Triospyridium*) *giraffa* Haeckel, 1887.

***Triceraspyris palmipodiscus* Petrushevskaya in Petrushevskaya and Kozlova 1979**

pl. 19, figs. 14a-b

Triceraspyris palmipodiscus Petrushevskaya n. sp. Petrushevskaya and Kozlova, 1979, p. 157, figs. 249, 483.

Remarks: The illustrated specimen has a longer apical horn than the holotype.

Superfamily Cannobotryoidea Haeckel 1882

Family Cannobotryidae Haeckel 1882

Genus *Glycobotrys* Campbell 1951

Type species: *Lithobotrys geminata* Ehrenberg 1873

***Glycobotrys geminata* (Ehrenberg 1873)**

pl. 18, figs. 1a-b

Lithobotrys geminata n. sp. Ehrenberg, 1873, p. 238

Lithobotrys geminate Ehrenberg. Ehrenberg, 1876, p. 76-77, pl. 3, fig. 19; Petrushevskaya and Kozlova, 1972, figs. 273-275.

Superfamily Eucyrtidioidea Ehrenberg 1846, sensu De Wever et al. 2001

Family Carpocaniidae Haeckel 1882, sensu emend. Riedel 1967

Genus *Artobotrys* Petrushevskaya 1971

Type species: *Theocorys borealis* Cleve 1899

***Artobotrys auriculaleporis* (Clark and Campbell 1942)**

pl. 21, figs. 1a-b

Lophophaena (*Lophophaenula*) *auriculaleporis* n. sp. Clark and Campbell, 1942, p. 76-77, pl. 8, figs. 20, 27-29.

***Artobotrys biauritus* (Ehrenberg 1873)**

pl. 21, figs. 2a-b

Eucyrtidium biauritum n. sp. Ehrenberg, 1873, p. 266.

Eucyrtidium bicorne n. sp. Ehrenberg, 1873, p. 226-227. (Synonymized by Foreman, 1973)

Eucyrtidium biauritum Ehrenberg. Ehrenberg, 1876, p. 70-71, pl. 10, figs. 7, 8.

Eucyrtidium bicorne Ehrenberg. Ehrenberg, 1876, p. 70-71, pl. 11, fig. 7.

Remarks: The illustrated specimen is an endemic morphotype having numerous pores on the thorax, identical to *"Eucyrtidium bicorne*" form. Our examined samples yield many intermediate forms between numerous pores to few pores on the thorax.

***Artobotrys norvegiensis* (Bjørklund and Kellogg 1972)**

pl. 21, figs. 3a-3b

Lophocyrtis norvegiensis n. sp. Bjørklund and Kellogg, 1972, p. 388-389, pl. 1, figs. 2, 7, text-figs. 8, 9.

Artobotrys titanothericeraos (Clark and Campbell 1942)
pl. 21, figs. 4a-5b

Lophoconus titanothericeraos n. sp. Clark and Campbell, 1942, p. 89-90, pl. 8, figs. 24-26, 30-38.

Remarks: *A. titanothericeraos* is similar to *Artobotrys kryschotofovichi* (Lipman), but is distinguished from the latter by having a more conical thorax.

Artobotrys kryschotofovichi (Lipman 1953)
pl. 21, figs. 6a-b

Theocorys kryschotofovichi n. sp. Lipman, 1953, p. 183-184, pl. 8, fig. 8.

Family Eucyrtidiidae Ehrenberg 1846
Genus _Eucyrtidium_ Ehrenberg 1846
Type species: *Lithocampe acuminata* Ehrenberg 1844

Remarks: Two species, *Eucyrtidium antiquum* Caulet and *Eucyrtidium nishimurae* Takemura et Ling, are tentatively included in this genus, although there are no phylogenetic studies in support of this assignment.

Eucyrtidium antiquum Caulet 1991
pl. 21, figs. 14a-b

Eucyrtidium antiquum n. sp. Caulet, 1991, p. 535-536, pl. 4, figs. 1-2.

Eucyrtidium nishimurae Takemura and Ling 1997
pl. 21, figs. 15a-b

Eucyrtidium nishimurae n. sp. Takemura and Ling, 1997, p. 113, pl. 2, figs. 1-6.

Genus _Cymaetron_ Caulet 1991
Type species: *Cymaetron sinolampas* Caulet, 1991

Cymaetron aff. _sinolampas_ Caulet 1991
pl. 19, figs. 10a-b

[aff.] *Cymaetron sinolampas* n. sp. Caulet, 1991, p. 536-537, pl. 4, figs. 10-12.

Cymaetron sp. 1
pl. 19, figs. 11a-b

Remarks: This morphotype is characterized by the presence of a flower-cluster like apical horn and spongy meshwork on the surface. This morphotype is also distinguished from *Cymaetron* aff. *sinolampas* by the former having a smaller, slender test.

Genus _Lithostrobus_ Bütschli 1882
Type species: *Eucyrtidium argus* Ehrenberg 1873

Lithostrobus cyrtoceras Haeckel 1887
pl. 21, fig. 16

Lithostrobus (*Cornustrobus*) *cyrtoceras* n. sp. Haeckel, 1887, p. 1470-1471, pl. 80, fig. 2.

Remarks: This species is easily distinguished from *Cornustrobus calceros* by having small pores.

This species possesses more longitudinal pores than *Lithostrobus acuminatus* Haeckel 1887.

Genus _Theocotyle_ Riedel and Sanfilippo 1970
Type species: *Theocotyle venezuelensis* Riedel and Sanfilippo 1970

Theocotyle (?) _alta_ (Moksyakova 1970)
pl. 21, figs. 13a-b

Theocampe altus Moksyakova, 1970, p. 152, pl. 2, fig. 1 (non viso).

Cyrtophormis sp. Ch of Petrushevskaya and Kozlova (1972). Dzhinoridze et al, 1978, pl. 28, fig. 3

Cyrtophormis (?) *alta* (Moksjakova). Kozlova, 1999, p. 155, pl. 20, figs. 7, 9, pl. 46, fig. 4.

Remarks: The superficial features of *Theocotyle* (?) *alta* (Moksjakova) are very similar to *Theocotyle cryptocephala* (Ehrenberg 1873), but the former is easily distinguishable from the latter by the absence of a hyaline peristome around the abdominal aperture. The taxonomic position of this species at the genus-level is unknown.

Family Lophocyrtiidae Sanfilippo and Caulet 1998
Genus _Lophocyrtis_ Haeckel 1887 sensu Sanfilippo 1990
Type species: *Eucyrtidium stephanophorum* Ehrenberg 1873

Remarks: All the species belonging to *Theocorys* in the sense of Takemura and Ling 1998 (*T. kerguelensis*, *T. minuta*, *T. robusta*, *T. saginata* and *T. semiplita*) should be included in the genus *Lophocyrtis*. Takemura and Ling (1998) erroneously cited the type species of *Theocyrtis* as *Theocorys morchellula* Rüst 1885 (subsequent designation by Campbell, 1954). The valid first designated type species for *Theocorys* is *Eucyrtidium turgidulum* Ehrenberg 1872a by Frizzell and Middour (1951). This species was originally found from the surface sediments in the Philippine Sea, and presumably is a recent species.

Subgenus _Paralampterium_ Sanfilippo 1990
Type species: *Lophocyrtis (Paralampterium) dumitricai* Sanfilippo 1990

Lophocyrtis (Paralampterium) (?) *longiventer* (Chen 1975)
pl. 19, figs. 7a-b

Cyclampterium (?) *longiventer* n. sp. Chen, 1975, p. 459-460, pl. 10, fig. 7.

Lophocyrtis (*Paralampterium*) (?) *longiventer* Chen. Sanfilippo, 1990, p. 309-310, pl. 3, figs. 1-5.

***Lophocyrtis* (*Paralampterium*) *dumitricai* Sanfilippo 1990**
pl. 19, figs. 8a-b

Lophocyrtis (*Paralampterium*) *dumitricai* n. sp. Sanfilippo, 1990, p. 308, pl. 3, figs. 7-13.

Subgenus *Apoplanius* Sanfilippo and Caulet 1998

Type species: *Lophocyrtis* (*Apoplanius*) *klydus* Sanfilippo and Caulet, 1998

***Lophocyrtis* (*Apoplanius*) *keraspera* Sanfilippo and Caulet 1998**
pl. 18, figs. 18a-b

Lophocyrtis (*Apoplanius*) *keraspera* n. sp. Sanfilippo and Caulet, 1998

Remarks: According to Sanfilippo and Caulet (1998), the subgenus *Apoplanius* differs from the subgenus *Lophocyrtis*, in having a shorter apical horn without three proximal arches. However, *Lophocyrtis* (*Apoplanius*) *keraspera* Sanfilippo and Caulet 1998 is very similar to *Lophocyrtis* (*Lophocyrtis* (?)) *semipolita* (Clark and Campbell 1942), sensu emend. Sanfilippo and Caulet (1998) because both species possesses a long apical horn. This species is distinguishable from *Lophocyrtis* (*Lophocyrtis* (?)) *semipolita* (Clark and Campbell 1942), sensu emend. Sanfilippo and Caulet (1998) by having a thin-walled cylindrical thorax with smaller, irregularly arranged thoracic pores.

***Lophocyrtis* (*Apoplanius*) sp. A**
pl. 18, figs. 19a-c

Remarks: This morphotype is different from *Lophocyrtis* (*Apoplanius*) *keraspera* by having lateral spinules on the distal part of the apical horn and small wings from the thorax. This species is similar to *Lophocyrtis* (*Lophocyrtis*) *haywardi* O'Connor 2000 but differs from the latter by having wings from the thorax but not the abdomen.

Genus *Aphetocyrtis* Sanfilippo and Caulet 1998

Type species: *Aphetocyrtis gnomabax* Sanfilippo and Caulet 1998

Remarks: *Aphetocyrtis*-species are easily distinguished from the species belonging to *Lophocyrtis* by not having a significant apical horn. Sanfilippo and Caulet (1998) further separated a closely related genus to *Aphetocyrtis*, namely *Clinorhabdus*, but it is very difficult to distinguish these from each other without detailed observation of the initial spicular systems within the cephalo-thorax. Sanfilippo and Caulet (1998), the original author of *Aphetocyrtis* and *Clinorhabdus* did not depict distinguishing features between both genera. However, except for *Clinorhabdus longithorax* (Petrushevskaya 1975), *Clinorhabdus*-species can be distinguished from *Aphetocyrtis* by having a more or less "neck-like" shape on upper part of the thorax. This "neck-like" shape is related to obliquely prolonged spines ***L*** and ***D*** which are freely extended from **MB** in thorax. The descendant two *Clinorhadus*-species, *C. longithorax* and *Clinorhabdus robusta* (Abelmann 1990), sensu emend. Sanfilippo and Caulet (1998), appear to be similar to *Cyrtocapsella tetrapera* Haeckel. *Aphetocyrtis*-species always show open aperture and lack a pronounced "neck-like" shape on the upper part of the thorax because the initial spicular system components downwardly prolonged from MB are considered to be embedded in thoracic wall.

***Aphetocyrtis* cf. *rossi* Sanfilippo and Caulet 1998**
pl. 18, figs. 17a-b

Calocyclas (*Calocycletta*) *semipolita semipolita* n. sp. et n. subsp. [not lectotype] Clark and Campbell, 1942, p. 83-84, pl. 8, fig. 12 (only).

Aphetocyrtis rossi n. sp. Sanfilippo and Caulet, 1998, p. 18, pl. 2, figs. 8, 9, 12, 13, pl. 7, figs. 1-9.

Theocorys semipolita (Clark et Campbell). Takemura and Ling, 1998, p. 166-167, figs. 4.15-4.21, 5.11, 5.12.

Remarks: This species appears to be similar to *"Theocorys semipolita* Clark and Campbell 1942" of Takemura and Ling (1998) because they included the morphotype without an apical horn. However, prior to their publication, Sanfilippo and Caulet (1998) already emended the definition of *"Theocorys semipolita*" as having a stout apical horn under the genus *Lophocyrtis*.

A. rossi is only distinguishable from its ancestor, *Aphetocyrtis gnomabax* Sanfilippo and Caulet 1998, by having embedded mitra-arches within the cephalic wall and absence of three ribs in the thoracic wall originating from spines ***L*** and ***D***. *A. rossi* differs from the descendant, *Aphetocyrtis catalexis* Sanfilippo and Caulet 1998, by not having a small apical horn with holes or dimples at the base. *A. rossi* also seems to have smaller test and more conical thorax with pronounced suture between thorax and abdomen, compared with *A. catalexis*. *A. rossi* is easily distinguished from *Lophocyrtis* by absence of a pronounced apical horn. *A. rossi* differs from *Clinorhabdus robusta* by not having a constricted or closed aperture, *Clinorhabdus ocymora*

Sanfilippo and Caulet 1998 by having more spherical thorax without "neck-like" shape on its upper part.

***Aphetocyrtis bianulus* (O'Connor 1997)**
pl. 18, figs. 16a-b

Theocorys bianulus n. sp. O'Connor, 1997, p. 84, 86, pl. 4, figs. 1-4, pl. 10, figs. 1-4, pl. 11, fig. 5.

Theocorys bianulus O'Connor. Sanfilippo and Fourtanier, 2003, pl. P2, figs. 8, 9, 13.

Remarks: This species posses an identical initial spicular system in the cephalo-thorax, and thus it falls into the genus *Aphetocyrtis*. Differing from the typical *A. bianulus* (e.g. pl. 4, figs. 1, 2 of O'Connor, 1997, the holotype), our illustrated specimen shows weak undulation in the abdomen, which is wider than thorax.

Genus *Clinorhabdus* Sanfilippo and Caulet 1998
Type species: *Clinorhabdus anatomus* Sanfilippo and Caulet 1998

***Clinorhabdus ocymora* Sanfilippo and Caulet 1998**
pl. 18, figs. 15a-b

Clinorhabdus ocymora n. sp. Sanfilippo and Caulet, 1998, p. 20-22, pl. 1, figs. 11-13, pl. 8, figs. 4-6.

Remarks: This species is easily distinguished from *Aphetocyrtis rossi* Sanfilippo et Caulet by having a more conical thorax, which is a distinguishing feature between *Aphetocyrtis* and *Clinorhabdus*.

Genus *Calocyclas* Ehrenberg 1847
Type species: *Calocyclas turris* Ehrenberg 1873

***Calocyclas* (?) *multiplicatus* (Lipman in Lipman et al. 1960) sensu Takemura and Ling 1998**
pl. 21, figs. 7a-b

Sethocyrtis multiplicatus Lipman in Lipman et al, 1960, p. 93-94, pl. 12, fig. 9.

Calocyclas (?) *nakasekoi* n. sp. Takemura and Ling, 1998, p. 160, figs. 3.1-7, 5.1, 5.2.

Remarks: The definition of this species follows Takemura and Ling (1998) for a junior synonym of *C.*(?) *multiplicatus*, *C.* (?) *nakasekoi*, because the original description and illustration were not adequate for understanding its skeletal features.

Family Lychnocaniidae Haeckel 1882
Genus *Dictyophimus* Ehrenberg 1846, sensu emend. Nigrini 1967
Type species: *Dictyophimus crisiae* Ehrenberg 1854b

***Dictyophimus* sp. 1**
pl. 22, figs. 7a-b

Genus *Lychnocanoma* Haeckel 1887
Type species: *Lychnocanium* (*Lychnocanoma*) *clavigerum* Haeckel 1887

Remarks: Although the actual specimen of the type species has not been illustrated since Haeckel (1887) described it, the illustration shows no connection between the feet and the internal spicular system. This is different from the genus *Pterocanium*. The taxonomic criteria that distinguish between *Lychnocanium* and *Lychnocanoma* have been confused (e.g. Morley and Nigrini, 1995; O'Connor, 1997; O'Connor, 1999a), and then in this paper, the lychnocanomid forms which have an rod embedded in the thorax between the feet and internal spicular systems are questionably assigned as *Lychnocanoma*.

***Lychnocanoma amphitrite* Foreman 1973**
pl. 19, figs. 5a-6b

Lychnocanoma amphitrite n. sp. Foreman, 1973, p. 437, pl. 11, fig. 10.

***Lychnocanoma bellum* (Clark and Campbell 1942)**
pl. 19, figs. 1a-b

Lychnocanium (*Lychnocanissa*) *bellum* n. sp. Clark and Campbell, 1942, p. 72, pl. 9, figs. 35, 39.

Lychnocanoma bellum (Clark and Campbell). Foreman, 1973, p. 437, pl. 1, fig. 17, pl. 11, fig. 9.

***Lychnocanoma* (?) *conica* (Clark and Campbell 1942)**
pl. 19, figs. 2a-b

Lychnocanium (*Lychnocanella*) *conicum* n. sp. Clark and Campbell, 1942. p. 71, pl. 9, fig. 38.

Lychnocanium obscurum n. sp. Moksyakova, 1965, p. 252, pl. 1, figs. 9, 9a.

[non] *Lychnocanium conicum* n. sp. Mamedov, 1970, p. 67-68, pl. 2, figs. 3, 4. [a primary junior homonym]

***Lychnocanoma* (?) ex. gr. *trichopus* (Ehrenberg 1876)**
pl. 19, fig. 3

Lychnocanium trichopus n. sp. Ehrenberg, 1873, p. 244.

Lychnocanium trichopus Ehrenberg. Ehrenberg, 1876, p. 80-81, pl. 7, fig. 5.

***Lychnocanoma* (?) *ventricosa* (Ehrenberg 1873)**
pl. 19, figs. 4a-b

Lychnocanium ventricosum n. sp. Ehrenberg, 1873, p. 245.

Lychnocanium ventricosum Ehrenberg. Ehrenberg, 1876, p.

80-81, pl. 7, fig. 12.
Lychnocanium exilis n. sp. Gorbovets, 1972, p. 157-158, fig. 1a, 1b.

Family Theoperidae Haeckel 1882
Genus *Eusyringium* Haeckel 1882
Type species: *Eusyringium* (*Eusyringartus*) *conosiphon* Haeckel, 1887

***Eusyringium fistuligerum* (Ehrenberg 1873)**
pl. 22, figs. 14a-b
Eucyrtidium fistuligerum n. sp. Ehrenberg, 1873, p. 229.
Eucyrtidium fistigerum Ehrenberg. Ehrenberg, 1876, p. 70-71, pl. 9, fig. 3
Eusyringium (*Eusyringartus*) *fistuligerum* (Ehrenberg). Haeckel, 1887, p. 1498.

Genus *Pterocyrtidium* Bütschli 1882
Type species: *Pterocyrtidium zitteli* Bütschli 1882

***Pterocyrtidium barbadense* (Ehrenberg 1873)**
pl. 18, figs. 14a-b
Pterocanium barbadense n. sp. Ehrenberg, 1873.
Pterocanium barbadense Ehrenberg. Ehrenberg, 1873, p. 82-83, pl. 17, fig. 6.
Pterocyrtidium barbadense (Ehrenberg). Bütschli, 1882, pl. 33, fig. 29.
Pterocanium (*Pterocyrtidium*) *barbadense* (Ehrenberg). Haeckel, 1887, p. 1318.
[non] *Pterocyrtidium barbadense* (Ehrenberg). Petrushevskaya and Kozlova, 1972, p. 552, pl. 27, figs. 18, 19

Family Amphipyndacidae Riedel 1967 sensu De Wever et al. 2001
Genus *Stichophormis* Haeckel 1887
Type species: *Stichophormis* (*Stichophormium*) *pyramidalis* Haeckel 1887

***Stichophormis novena* Haeckel 1887**
pl. 18, figs. 7a-c
Stichophormis (*Stichophormiscus*) *novena* n. sp. Haeckel, 1887, p. 1455-1456, pl. 79, fig. 9.
[non] *Stichophormis novena* Haeckel. Kling, 1973, pl. 3, figs. 23, 24.
Remarks: The cephalis of this species consists of two vertically superposed chambers separated by a transverse septum resulting from a pair of horizontal branches of a cephalic initial spicular rod, suggesting a member of the family Amphipyndacidae. The illustrated specimen is characterized by straight ribs extending along the outer surface of the thorax/abdomen to the distal chambers. This species differs from *Cyrtolagena cuspidatum* (Bailey 1856) by having an amphipyndacid cephalic structure as shown in pl. 3, fig. 11c.

Superfamily Incertae sedis
Family Acropyramidae Haeckel 1882, sensu Nishimura 1990
Genus *Cinclopyramis* Haeckel 1879
Type species: *Cinclopyramis murrayana* Haeckel 1879
Bathropyramis Haeckel 1882 (type species: *Bathropyramis* (*Acropyramis*) *acephalan* Haeckel 1887)
Enneapleuris Haeckel 1887 (type species: *Plectopyramis* (*Enneapleuris*) *dodecomma* Haeckel 1887)
Peripyramis Haeckel 1882 (type species: *Peripyramis circumtexta* Haeckel 1887)
Sethopyramis Haeckel 1882 (type species: *Sethopyramis* (*Cephalopyramis*) *quadrata* Haeckel 1887)
Remarks: The generic names *Cinclopyramis, Bathropyramis* and *Peripyramis* have long been confused in previous papers because most members of these genera are within the range of variation of a single genus. The first description of *Cinclopyramis* was believed to be by Haeckel (1882) (e.g. Campbell, 1954), but Haeckel (1879) is the first author for this genus.

***Cinclopyramis quadrata* (Haeckel 1887)**
pl. 22, fig. 13
Bathropyramis (*Acropyramis*) *quadrata* n. sp. Haeckel, 1887, p. 1159, pl. 54, fig. 1.
Sethopyramis (*Cephalopyramis*) *quadrata* n. sp. Haeckel, 1887, p. 1254, pl. 54, fig. 2 [secondary junior homonym of *Bathropyramis* (*Acropyramis*) *quadrata* Haeckel, 1887, p. 1159, pl. 54, fig. 1].
Sethopyramis (*Cephalopyramis*) *magnifica* n. sp. Clark and Campbell, 1942, p. 72-73, pl. 8, figs. 1, 5, 9.
Peripyramis woodringi n. sp. Campbell and Clark, 1944, p. 39, pl. 5, figs. 21, 22.
Sethopyramis (*Cephalopyrmis*) *akanthodes leptopleura* n. subsp. Clark and Campbell, 1945, p. 40, pl. 6, fig. 4.
Plectopyramis pacifica n. sp. Nakaseko, 1963, p. 170-171, pl. 1, figs. 3a-5, text-figs. 3, 4.
Remarks: This species is characterized by 3–5 longitudinal pores on a half equator of the test without meshwork within the quadrangular pores. The overall shape is straight conical. No or very short apical horn. This species has an identical

morphology to *Cinclopyramis murrayana* Haeckel, 1879, the type species of *Cinclopyramis*, except the absence of fine meshwork within the quadrangular pores. This species differs from *Cinclopyramis quadratella* (Ehrenberg 1873) by having a more acute overall shape. This species may be a junior synonym of *C. quadratella* if development of meshwork is ontogenetic or is due to intra-species variation.

Several species previously classified into the genus *Peripyramis* are surrounded with spongy coverage on part of test (e.g. *Cinclopyramis circumtexta* Haeckel 1887). Fossil *Cinclopyramis* are sometimes dissolved but on their surfaces a spinose structure on pore frame remains as a trace of spongy coverage. If development of the spongy coverage is an ontogenetic or intra-species variation, this species is further synonymized with *C. circumtexta*, *Cinclopyramis spongiosa* (Haeckel 1887), as junior synonyms.

Genus *Polypleuris* Haeckel 1887
Type species: *Plectopyramis* (*Polypleuris*) *polypleura* Haeckel 1887

Description: Two segmented Nassellaria with a very small, thick-walled cephalis and a large conical subsequent thorax with robust, straight, longitudinal frames which is segmented with rather fine quadrangular pore frames. One or two quadrangular pores are placed between adjacent robust longitudinal frames on the upper portion of test, and two or more quadrangular pores between the frames on the lower portion of test.
Remarks: The original illustration of the type species in Haeckel (1887) shows one or two globular segment(s) and a large final segment, but Petrushevskaya (1971) illustrated an enlarged view of the proximal part of this species with two segmented structures. This genus is easily distinguished from the genus *Litharachnium* by the latter having a fragile test with very fine meshwork.

Polypleuris is very similar to *Cinclopyramis* with the exception of pore patterns. The taxonomic level of *Polypleuris* is tentative and will depend on more detailed study of the taxonomic relationships of *Polypleuris*- and *Cinclopyramis*-species.

***Polypleuris fenestrata* (Haeckel 1887)**
pl. 22, fig. 16

Plectopyramis (*Enneapleuris*) *fenestrata* n. sp. Haeckel, 1887, p. 1259.
A fenestrated pyramid, possibly a *Podocyrtis*. Bury, 1862, pl. 21, fig. 8.
Remarks: Haeckel (1887) described this species without illustration, but instead, he synonymized pl. 21, fig. 8 of Bury (1862). *P. fenestrata* differs from *Polypleuris polypleura* by the former having larger quadrangular pores.

Genus *Cornutella* Ehrenberg 1839, sensu emend. Nishimura 1990
Type species: *Cornutella clathrata* Ehrenberg 1839

***Cornutella profunda* Ehrenberg 1854b sensu Riedel 1958**
pl. 22, figs. 12a-b

Cornutella clathrata profunda n. subsp. Ehrenberg, 1854b, p. 241.
Cornutella clathrata profunda Ehrenberg. Ehrenberg, 1854a, pl. 35B-B.IV, fig. 21.
Cornutella profunda Ehrenberg. Ehrenberg, 1857, p. 549; Riedel, 1958, p. 232, pl. 3, figs. 1, 2.

Family Artostrobiidae Riedel 1967, sensu emend. O'Connor 1997, sensu emend. O'Connor 2001
Genus *Dictyoprora* Haeckel 1882, sensu emend. Nigrini 1977
Type species: *Dictyocephalus amphora* Haeckel 1887

***Dictyoprora mongolfieri* (Ehrenberg 1854a)**
pl. 18, figs. 2a-b

Eucyrtidium mongolfieri n. sp. Ehrenberg, 1854a, pl. 36, fig. 18.
Eucyrtidium gemmatum n. sp. Ehrenberg, 1872b, p. 290-291.
Sethamphora (*Dictyoprora*) *costata* n. sp. Haeckel, 1887, p. 1251.

***Dictyoprora* (?) *amyglada* (Shilov 1995)**
pl. 18, fig. 3

Dictyomitra amygdala n. sp. Shilov, 1995, p. 126, pl. 1, figs. 4-6b.

***Dictyoprora* sp. A**
pl. 18, figs. 4a-b

Remarks: This morphotype is easily distinguished from any other *Dictyoprora* and *Siphocampe* species by having a spindle form and a long abdomen with irregularly scattered pores.

Genus *Siphocampe* Haeckel 1882, sensu emend. Nigrini 1977
Type species: *Siphocampe* (*Siphocampula*) *annulosa* Haeckel 1887

***Siphocampe elegans* (Ehrenberg 1854a)**
pl. 18, fig. 10

Eucyrtidium elegans n. sp. Ehrenberg, 1854a, pl. 36, fig. 17.
Eucyrtidium pauperum n. sp. Ehrenberg, 1873, p. 231-232.
Eucyrtidium pusillum n. sp. Ehrenberg, 1873, p. 232.

***Siphocampe imbricata* (Ehrenberg 1873)**
pl. 18, fig. 12a-b

Eucyrtidium imbricatum n. sp. Ehrenberg, 1873, p. 229
Eucyrtidium imbricatum Ehrenberg. Ehrenberg, 1876, p. 72-73, pl. 11, fig. 22.

***Siphocampe minuta* (Clark and Campbell 1942)**
pl. 18, figs 5a-6b

Lithocampe (*Lithocampula*) *minuta* n. sp. Clark and Campbell, 1942, p. 93, pl. 9, fig. 17.

***Siphocampe sacculifera* (Clark and Campbell 1945)**
pl. 18, figs. 11a-b

Lithamphora sacculifera n. sp. Clark and Campbell, 1945, p. 50, pl. 7, fig. 18.

***Siphocampe quadrata* (Petrushevskaya and Kozlova 1972)**
pl. 18, fig. 9

Lithamphora sacculifera (Clark et Campbell) *quadrata* n. subsp. Petrushevskaya and Kozlova, 1972, p. 539, pl. 30, figs. 4-6.
Lithamphora quadrata Petrushevskaya et Kozlova. Petrushevskaya, 1975, p. 585, pl. 10, figs. 19, 20.

Genus *Phormocyrtis* Haeckel 1887
Type species: *Phormocyrtis longicornis* Haeckel 1887

***Phormocyrtis proxima* Clark and Campbell 1942**
pl. 22, figs. 10a-11

Phormocyrtis proxima n. sp. Clark and Campbell, 1942, p. 82-83, pl. 7, figs. 24, 26.

Family Archipilidae Haeckel 1882
Genus *Archipilium* Haeckel 1882
Type species: *Archipilium orthopterum* Haeckel 1887

***Archipilium* aff. *johannismonicae* (Deflandre 1972)**
pl. 20, figs. 7a-b

Northotripodiscinus johannismonicae n. sp. Deflandre, 1972, p. 232, text-figs. 1-3, figs. 1-9.
Remarks: This morphotype is different from the *N. johannismonicae* in having larger pores on its cephalis.

Family Neosciadiocapsidae Pessagno 1969
Genus *Lipmanium* Pessagno 1969
Type species: *Lipmanium sacramentoensis* Pessagno 1969
Remarks: Petrushevskaya (1981) synonymized the genus *Lipmanium* with *Microsciadiocapsa* Pessagno 1969 and *Scyphiforma* Pessagno 1969.

***Lipmanium* (?) sp. A**
pl. 22, fig. 18

Family Pterocoryidae Haeckel 1882
Genus *Lamprocyclas* Haeckel 1882
Type species: *Lamprocyclas* (*Lamprocyclia*) *nuptialis* Haeckel 1887

***Lamprocyclas* (?) sp. B**
pl. 18, fig. 20

Remarks: The actual generic position is unknown.

Family Sethophormididae Haeckel 1882
Subfamily Sethophormidinae Haeckel 1882
Genus *Velicucullus* Riedel and Campbell 1952
Type species: *Soreuma magnificum* Clark and Campbell 1942.

***Velicucullus oddgurneri* Bjørklund 1976**
pl. 19, fig. 9

Velicucullus oddgurneri n. sp. Bjørklund, 1976, p. 1126, pl. 19, figs. 6-9.

Family Theopiliidae Haeckel 1882
Genus *Cycladophora* Ehrenberg 1846, sensu emend. Lombari and Lazarus 1988
Type species: *Cycladophora davisiana* Ehrenberg 1861

***Cycladophora* aff. *cornuta* (Bailey 1856)**
pl. 22, figs. 9a-b

[aff] *Halicalyptra* (?) *cornuta* n. sp. Bailey, 1856, p. 5, pl. 1, figs. 13, 14.
[aff] *Halicalyptra* (?) *cornuta* Bailey. Itaki and Bjørklund, 2007, p.456-pl. 3, figs. 5-10 (lectotype as pl. 3, fig. 8a-b).
[aff] *Cycladophora davisiana* (Ehrenberg) var. *cornutoides* [sic] n.var. Petrushevskaya, 1967, p. 124, 126, text-figs. 70.1-70.3.
[aff.] *Cycladophora davisiana cornutoides* Petrushevskaya. Ling, 1974, p. 8, pl. 1, fig. 2. (nomen invalid)
Diplocyclas cornuta (Bailey). Dzinoridze et al, 1978, pl. 26, fig. 10.
Remarks: The illustrated specimen does not look like this species, and is probably not con-specific with *C. cornuta*, but this paper tentatively includes this morphotype into *C. cornuta*

(Bailey) because this specimen is similar to "*Diplocyclas cornuta* (Bailey)" which is illustrated in Dzinoridze et al. (1978). The illustrated specimen has thicker wall than the lectotype of this species which is re-illustrated in pl. 3, figs. 8a-8b in Itaki and Bjørklund, 2007). As Itaki and Bjørklund (2007) noted, *C. davisiana* var. *cornutoides* is conspecific with *C. cornuta*. Furthermore, several papers illegally treated *C. davisiana* var. *cornutoides* as a subspecies. The oldest occurrence of this species is reported from a Rupelian sample (DSDP Leg 38, Hole 338, Core 27) by Dzinoridze et al (1978). The continuous occurrences of *C. cornuta* seem to have started from Middle Miocene.

Genus *Eurystomoskevos* Caulet 1991, sensu emend. O'Connor 1999a

Type species: *Eurystomoskevos petrushevskaae* Caulet 1991

***Eurystomoskevos petrushevskaae* Caulet 1991**
pl. 22, figs. 5a-6

Eurystomoskevos petrushevskaae Caulet, 1991, p. 536, pl. 3, figs. 14, 15.

Diplocyclas sp. A. Petrushevskaya and Kozlova, 1972, p. 541, pl. 33, figs. 14-16; Petrushevskaya, 1975, p. 587, pl. 24, fig. 4.

Remarks: Caulet (1991) included various morphotypes with slender to broad skirts.

***Eurystomoskevos* sp. 1**
pl. 22, figs. 8a-b

Remarks: This morphotype differs from *Eurystomoskevos petrushevskayae* by having a pronounced constricted undulation. This morphotype is also similar to *Clathrocyclas* (?) *lepta* Foreman 1968, but differs from the latter by having a longer thorax.

Genus *Clathrocyclas* Haeckel, 1882

Type species: *Clathrocyclas* (*Clathrocyclia*) *principessa* Haeckel, 1887

***Clathrocyclas* ex. gr. *extensa* Clark and Campbell 1942**
pl. 21, figs. 8a-9

Calocyclas (*Calocycletta*) *extensa* n. sp. Clark and Campbell, 1942, p. 85, pl. 8, figs. 10, 11.

Remarks: This group includes morphotypes similar to *Clathrocyclas universa* Clark and Campbell 1942.

Superfamily et family incertae sedis

Remarks: This section includes the species whose genus has tentatively been assigned.

***Sethocyrtis* (?) *bicamerata* Borisenko 1958**
pl. 18, figs. 8, 13a-b

Sethocyrtis bicamerata n. sp. Borisenko, 1958, p. 99, pl. 4, fig. 9.

Remarks: Two segmented Nassellaria, characterized by a spherical thorax with a constricted circular aperture. The generic assignment of this species is erroneous because the type species of the genus *Sethocyrtis* was subsequently designated as *Sethocyrtis oxycephalis* Haeckel, 1887 by Strelkov and Reshetnyak (1959) which Nigrini (1967) synonymized with *Anthocyrtidium zanguebaricum* (Ehrenberg 1872a). The superficial view of this species is similar to the type species of genera *Stylocapsa* Principi 1909 (type species: *Stylocapsa hexagona* Principi 1909) and *Plannapus* O'Connor 1997 (type species: *Dicolocapsa microcephala* Haeckel 1887), but the precise assignment needs more studies on its internal structure and phylogenetic relationships.

Order, superfamily, family et genus incertae sedis

Polycystina gen. et sp. indet.
pl. 3, figs. 6a-b

Remarks: This morphotype has a bizarre structure with spumellarian-like concentric internal structure and nassellarian-like heteropolar skeleton. This morphotype has medually shell-like concentric shell in the center of the largest test. Furthermore, an eccentric chamber-like structure is placed on the outer surface of the largest test. This paper simply illustrates it because only a single specimen was encountered.

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Explanation of plates

Plate 1

1. *Axoprunum venustum* (Borisenko)
(1172A-53X-CC)

2. *Axoprunum* aff. *venustum* (Borisenko)
(1172A-46X-CC)

3, 4. *Axoprunum bispiculum* (Popofsky)
(3: 1172A-42X-CC, 4: 1172A-50X-CC)

5, 6. *Axoprunum minor* (Clark and Campbell)
(5: 1172A-49X-CC, 6: 1172A-40X-CC)

7. *Xiphosphaerantha pallas* Haeckel
(1172A-43X-CC)

8. *Stylosphaera* ex. gr. *radiosa* Ehrenberg
(1172A-52X-CC)

9. *Stylosphaera gigantea* (Haeckel)
(1172A-47X-CC)

10. *Sphaeractis trochilus* (Haeckel)
(1172A-39X-CC)

11. *Amphisphaera* sp. 1
(1172A-52X-CC)

12. *Amphisphaera* sp. 2
(1172A-52X-CC)

13. *Stylosphaera coronata* Ehrenberg
(1172A-48X-CC)

Plate 2

1. *Actinomma* sp. 1
(1172A-51X-CC)

2. *Actinomma kuznetsovi* (Gorbunov)
(1172A-48X-CC)

3. *Spongopylidium ovatum* (Ehrenberg)
(1172A-50X-CC)

4-6. *Hexacontium rosetta* (Haeckel)
(4: 1172A-50X-CC, 5: 1172A-46X-CC, 6: 1172A-46X-CC)

7. *Hexacontium* (?) sp. 2
(1172A-49X-CC)

8. *Hexancistra orientalis* (Kozlova)
(1172A-50X-CC)

9. *Cladococcus eocenica* (Petrushevskaya)
(1172A-50X-CC)

10. *Hexalonchetta* sp. 1
(1172A-44X-CC)

11. *Pessagnulus* sp. 1
(1172A-52X-CC)

Plate 3

1. Entactinaria ? gen. et sp. indet 1
(1172A-53X-CC)

2. *Nanina* sp.1
(1172A-43X-CC)

3. *Hexancistra* (?) sp. 2
(1172A-50X-CC)

4,5. *Excentrosphaerella* aff. *sphaeroconcha* Dumitrica
(1172A-50X-CC)

6. Polycystina gen. et sp. indet.
(1172A-39X-CC)

7. *Entapium veneris* (Clark and Campbell)
(1172A-50X-CC)

8. *Heliodiscus contiguum* (Ehrenberg)
(1172A-51X-CC)

9. *Phacodiscus subsphaericus* Lipman
(1172A-51X-CC)

10. *Heliodiscus pertsus* Haeckel
(1172A-44X-CC)

11. *Heliodiscus perplexus* Clark and Campbell
(1172A-50X-CC)

12. *Heterosestrum rotundum* Clark and Campbell
(1172A-53X-CC)

13. *Hexadendron* (?) aff. *octahedrum* (Haeckel)
(1172A-53X-CC)

Plate 4

1. Spumellaria ? gen. et sp. indet 2
(1172A-44X-CC)

2. *Lithelius* (?) *octoxyphophora* (Clark and Campbell)
(1172A-50X-CC)

3. Hexalonchidae gen. A et sp. 1
(1172A-50X-CC)

4. Hexalonchidae gen. A et sp. 4
(1172A-49X-CC)

5. Hexalonchidae gen. A et sp. 2
(1172A-48X-CC)

6. Hexalonchidae gen. A et sp. 3
(1172A-49X-CC)

7. *Liosphaera* (?) sp. 1
(1172A-53X-CC)

8. *Spongoplegma* (?) sp. 1
(1172A-53X-CC)

9. *Stauroxiphos* (?) sp. 1
(1172A-48X-CC)

10. *Sphaeractis* sp. 1
(1172A-48X-CC)

11. Spumellaria gen. et sp. indet. 1
(1172A-47X-CC)

12. *Axoprunum* sp. C
(1172A-44X-CC)

Plate 5

1. *Entapium veneris* (Clark and Campbell)
Showing a large microsphere (1172A-45X-CC)

2-4. *Entapium veneris* (Clark and Campbell)
Showing the large microsphere which is broken off. (1172A-45X-CC)

5. *Excentrosphaerella spinulosa* (Lipman)
(1172A-45X-CC)

6-10. *Lithelius* sp. A
(1172A-51X-CC)

11-16. *Spongurus illepidus* Krasheninnikov
(1172A-51X-CC)

17. *Larcopyle compositus* (Mamedov)
(1172A-51X-CC)

18. *Spongurus* sp. A
(1172A-51X-CC)

Plate 6

1-8. *Spongurus saxeus* Krasheninnikov
(1172A-51X-CC)

9-12. *Amphymenium splendiarmatum* Clark and Campbell
(9, 11 and 12: 1172A-51X-CC, 10: 1172A-45X-CC)

13-19. *Spongurus bilobatus* Clark and Campbell
(13-19: 1172A-45X-CC),

20. *Lithelius* (?) sp. B
(1172A-45X-CC)

Plate 7

1-5. *Larcopyle* sp. A
(1172A-51X-CC)

6-9, 12-15. *Larcopyle* sp. B
(1172A-45X-CC)

10, 11, 16-22. *Larcopyle* sp. C
(10 and 11: 1172A-45X-CC, 16-22b: 1172A-40X-CC)

23-30. *Larcopyle* sp. H
(1172A-40X-CC)

31. *Larcopyle eccentricum* Lazarus, Faust and Popova-Goll
(1172A-40X-CC)

Plate 8

1-3. *Larcopyle occidentalis* (Clark and Campbell)
(1172A-51X-CC)

4-40. *Larcopyle* sp. E
(4-19: 1172A-51X-CC, 20-40: 1172A-45X-CC)

Plate 9

1-13. *Larcopyle occidentalis* (Clark and Campbell)
(1-7: 1172A-51X-CC, 8-13: 1172A-40X-CC)

Plate 10

1-7. *Larcopyle compositus* (Mamedov)
(1 and 2: 1172A-51X-CC, 3-7: 1172A-45X-CC)

8-18. ***Larcopyle hayesi hayesi*** **(Chen)**

(8-13. 1172A-45X-CC, 14-19: 1172A-40X-CC)

Plate 11

1-6. 8. ***Lithelius*** **sp. F**

(1-6: 1172A-45X-CC, 8: 1172A-51X-CC)

7, 9. ***Lithelius*** **sp. G**

(7 and 9: 1172A-51X-CC)

10-27. ***Larnacalpis*** **sp. A**

(1172A-40X-CC)

Plate 12

1-5. ***Flustrella parva*** **(Clark and Campbell)**

(1: 1172-49X-3, 2:1172-43X-4, 3: 1172-51X-3, 4: 1172-44X-5, 5: 1172-40X-4)

6, 7. ***Flustrella*** **sp. A**

(1172-54X-3)

8, 9. ***Spongodiscus resurgens*** **Ehrenberg**

(8: 1172-41X-1, 9: 1172-41X-2)

10, 11. ***Spongodiscus*** **sp. D**

(10: 1172-54X-3, 11: 1172-52X-3)

12-14. ***Spongodiscus osculosa*** **(Dreyer)**

(12: 1172-41X-4, 13: 1172-40X-2, 14: 1172-40X-4)

Plate 13

1-3. ***Spongodiscus rhabdostyla*** **(Ehrenberg)**

(1 and 3: 1172-45X-1, 2: 1172-44X-5)

4-7. ***Spongodiscus festivus*** **(Clark and Campbell)**

(4: 1172-46X-5, 5: 1172-42X-4, 6 and 7: 1172-41X-1)

8. ***Histiastrum*** **sp. A**

(1172-54X-3)

9-12. ***Spongodiscus communis*** **Clark and Campbell**

(9 and 11: 1172-54X-3, 10: 1172-52X-3, 12: 1172-45X-2)

Plate 14

1-5. ***Spongodiscus cruciferus*** **Clark and Campbell**

(1-3: 1172-53X-3, 4: 1172-47X-3, 5: 1172-51X-3)

6-11. ***Ommatodiscus*** **sp. A**

(6: 1172-42X-3, 7: 1172-43X-4, 8: 1172-42X-4, 9 and 11: 1172-48X-3, 10: 1172-41X-2)

12-13. ***Flustrella*** **sp. G**

(1172-45X-1)

Plate 15

1-6. ***Flustrella*** **sp. B**

(1-3: 1172-51X-3, 4 and 5: 1172-48X-3, 6: 1172-49X-3)

7, 8. ***Flustrella*** **sp. H**

(7: 1172-52X-3, 8: 1172-51X-3)

9. ***Flustrella*** **sp. D**

(1172-44X-5).

Plate 16

1-4. ***Stylodictya rosella*** **Petrushevskaya and Kozlova**

(1: 1172-42X-3, 2 and 4: 1172-49X-3, 3: 1172-41X-2)

5-7. ***Stylodictya*** **sp. A**

(5, 6: 1172-54X-3, 7: 1172-53X-3)

8-11. ***Ommatodiscus*** **sp. B**

(8: 1172-41X-2, 9 and 10: 1172-40X-2, 11: 1172-41X-4)

12-13. ***Circodiscus circulars*** **(Clark and Campbell)**

(1172-42X-5)

Plate 17

1-3. ***Circodiscus*** **sp. A**

(1172-53X-3)

4-9. ***Circodiscus*** **sp. C**

(4: 1172-47X-3, 5 and 8: 1172-49X-3, 6-7: 1172-51X-3, 9: 1172-46X-3)

Plate 18

1. *Glycobotrys geminata* (Ehrenberg)
(1172A-43X-CC)
2. *Dictyoprora mongolfieri* (Ehrenberg)
(1172A-45X-CC)
3. *Dictyoprora* (?) *amyglada* (Shilov)
(1172A-54X-CC)
4. *Dictyoprora* sp. A
(1172A-39X-CC)
5 and 6. *Siphocampe minuta* (Clark and Campbell)
(5: 1172A-47X-CC, 6: 1172A-44X-CC)
7. *Stichophormis novena* Haeckel
(1172A-49X-CC)
8,13. *Sethocyrtis* (?) *bicamerata* Borisenko
(8: 1172A-43X-CC, 13: 1172A-42X-CC)
9. *Siphocampe quadrata* (Petrushevskaya and Kozlova)
(1172A-44X-CC)
10. *Siphocampe elegans* (Ehrenberg)
(1172A-40X-CC)
11. *Siphocampe sacculifera* (Clark and Campbell)
(1172A-46X-CC)
12. *Siphocampe imbricata* (Ehrenberg)
(1172A-50X-CC)
14. *Pterocyrtidium barbadense* (Ehrenberg)
(1172A-45X-CC)
15. *Clinorhabdus ocymora* Sanfilippo and Caulet
(1172A-41X-CC)
16. *Aphetocyrtis bianulus* (O'Connor)
(1172A-40X-CC)
17. *Aphetocyrtis* cf. *rossi* Sanfilippo and Caulet
(1172A-46X-CC)
18. *Lophocyrtis* (*Apoplanius*) *keraspera* emend. Sanfilippo and Caulet
(1172A-42X-CC)
19. *Lophocyrtis* (*Apoplanius*) sp. A
(1172A- 50X-CC)
20. *Lamprocyclas* (?) sp. B
(1172A-44X-CC)

Plate 19

1. *Lychnocanoma bellum* (Clark and Campbell)
(1172A-50X-CC)
2. *Lychnocanoma* (?) *conica* (Clark and Campbell)
(1172A-52X-CC)
3. *Lychnocanoma* (?) ex. gr. *trichopus* (Ehrenberg)
(1172A-48X-CC)
4. *Lychnocanoma* (?) *ventricosa* (Ehrenberg)
(1172A-52X-CC)
5,6. *Lychnocanoma amphitrite* Foreman
(5: 189-1172A-43X-CC, 6: 189-1172A-43X-CC)
7. *Lophocyrtis* (*Paralampterium*) (?) *longiventer* (Chen)
(1172A-41X-CC)
8. *Lophocyrtis* (*Paralampterium*) *dumitricai* Sanfilippo
(1172A-43X-CC)
9. *Velicucullus oddgurneri* Bjørklund
(1172A-50X-CC)
10. *Cymaetron* aff. *sinolampas* Caulet
(1172A-48X-CC)
11. *Cymaetron* sp. 1
(1172A-48X-CC)
12. *Giraffospyris incertecoronata* (Clark and Campbell)
(1172A-50X-CC)
13. *Petalospyris* cf. *eupetala* Ehrenberg
(1172A-44X-CC)
14. *Triceraspyris palmipodiscus* Petrushevskaya in Petrushevskaya and Kozlova (1979)
(1172A-43X-CC)
15. *Desmospyris* cf. *haysi* (Chen)
(1172A-51X-CC)

Plate 20

1. *Lithomelissa ehrenbergi* Bütschli
(1172A-51X-CC)
2. *Lithomelissa haeckeli* Bütschli
(1172A-43X-CC)

3. *Spongomelissa spongiosa* (Bütschli)
(1172A-47X-CC)
4. *Tripocyrtis* aff. *plectaniscus* Haeckel
(1172A-43X-CC)
5. *Lithomelissa macroptera* Ehrenberg
(1172A-40X-CC)
6. *Lithomelissa hertwigi* Bütschli

(1172A-50X-CC)

7. *Archipilium* aff. *johannismonicae* (Deflandre)
(1172A-43X-CC)

8. *Lithomelissa* sp. 4
(1172A-42X-CC)

9. *Lithomelissa* sp. 5
(1172A-46X-CC)

10. *Ceratocyrtis* aff. *stigi* (Bjørklund)
(1172A-43X-CC)

11. *Ceratocyrtis* aff. *cornutus* (Brandt in Wetzel)
(1172A-49X-CC)

12. *Ceratocyrtis rhabdophora* (Clark and Campbell)
(1172A-41X-CC)

Plate 21

1. *Artobotrys auriculaleporis* (Clark and Campbell)
(1172A-53X-CC)

2. *Artobotrys biauritus* (Ehrenberg)
(1172A-48X-CC)

3. *Artobotrys norvegiensis* (Bjørklund and Kellogg)
(1172A-53X-CC)

4,5. *Artobotrys titanothericeraos* (Clark and Campbell)
(4,5: 1172A-48X-CC)

6. *Artobotrys kryschotofovichi* (Lipman)
(1172A-48X-CC)

7. *Calocyclas* (?) *multiplicatus* (Lipman in Lipman et al.)
(1172A-43X-CC)

8,9. *Clathrocyclas* ex. gr. *extensa* Clark and Campbell
(8: 1172A-50X-CC, 9: 1172A-40X-CC)

10. *Lithomelissa lautouri* O'Connor
(1172A-48X-CC)

11. *Lithomelissa* aff. *mitra* Bütschli
(1172A-43X-CC)

12. *Lithomelissa* (?) aff. *bifurcata* Clark and Campbell
(1172A-47X-CC)

13. *Theocotyle* (?) *alta* Moksyakova
(1172A-38X-CC)

14. *Eucyrtidium antiquum* Caulet
(1172A-43X-CC)

15. *Eucyrtidium nishimurae* Takemura and Ling
(1172A-43X-CC)

16. *Lithostrobus cyrtoceras* Haeckel
(1172A-42X-CC)

Plate 22

1. *Spongomelissa* sp. 1
(1172A-51X-CC)

2. *Ceratocyrtis* (?) sp. 1
(1172A-47X-CC)

3. *Archiperidium sphaerum* (Funakawa)
(1172A-40X-CC)

4. *Amphicentria* sp. 1
(1172A-40X-CC)

5, 6. *Eurystomoskevos petrushevskaae* Caulet
(5: 1172A-51X-CC, 6: 1172A-40X-CC)

7. *Dictyophimus* sp. 1
(1172A-50X-CC)

8. *Eurystomoskevos* sp. 1
(1172A-50X-CC)

9. *Cycladophora cornuta* (Bailey)
(1172A-53X-CC)

10, 11. *Phormocyrtis proxima* Clark and Campbell
(10: 1172A-41X-CC, 11: 1172A-41X-CC)

12. *Cornutella profunda* Ehrenberg
(1172A-48X-CC)

13. *Cinclopyramis quadrata* (Haeckel)
(1172A-49X-CC)

14. *Eusyringium fistuligerum* (Ehrenberg)
(1172A-44X-CC)

15. *Zygocircus triangularis* (Clark and Campbell)
(1172A-44X-CC)

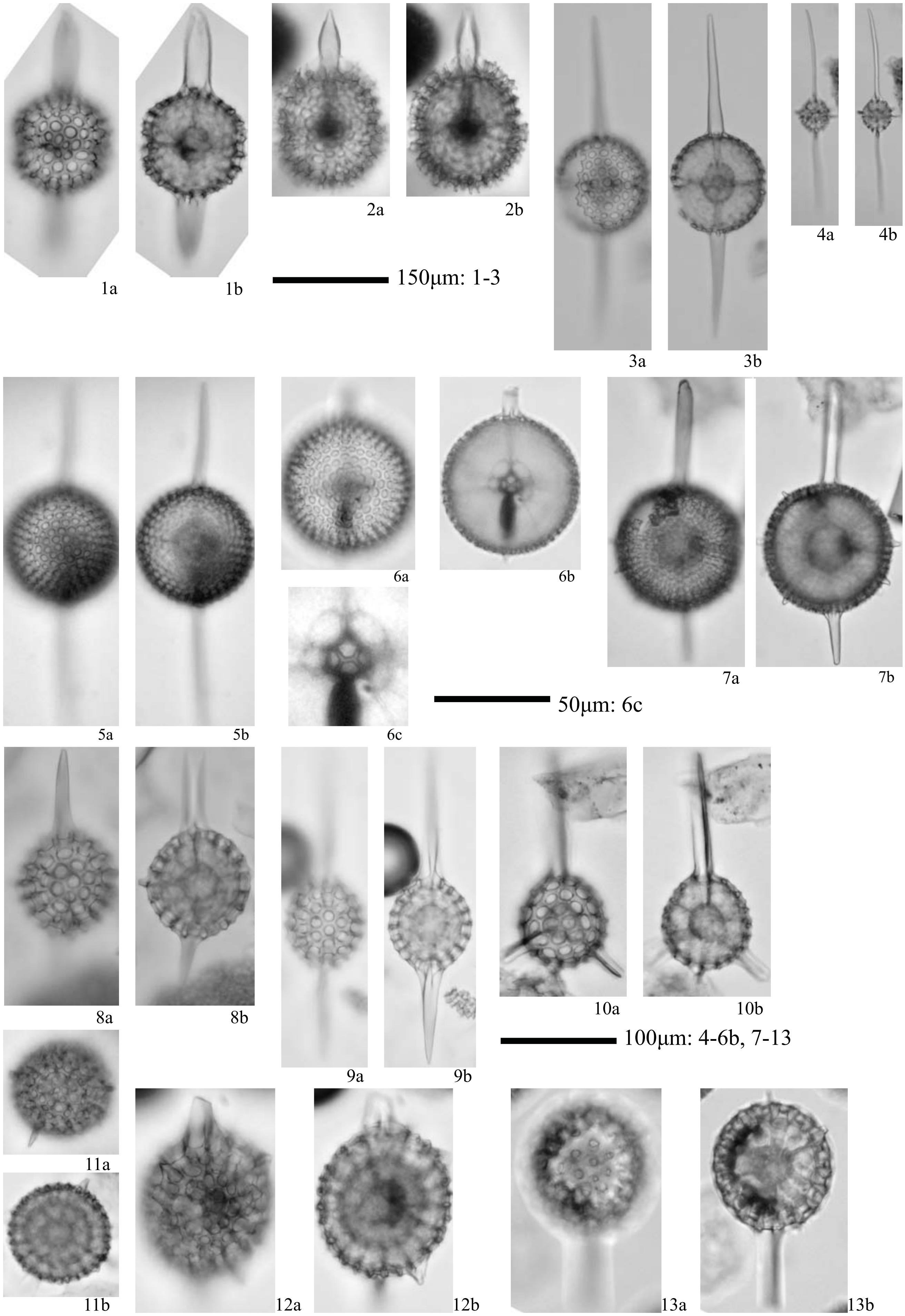
16. *Polypleuris fenestrata* (Haeckel)
(1172A-40X-CC)

17. *Arachnocalpis* (?) sp. 1
(1172A-45X-CC)

18. *Lipmanium* (?) sp. A
(1172A-40X-CC)

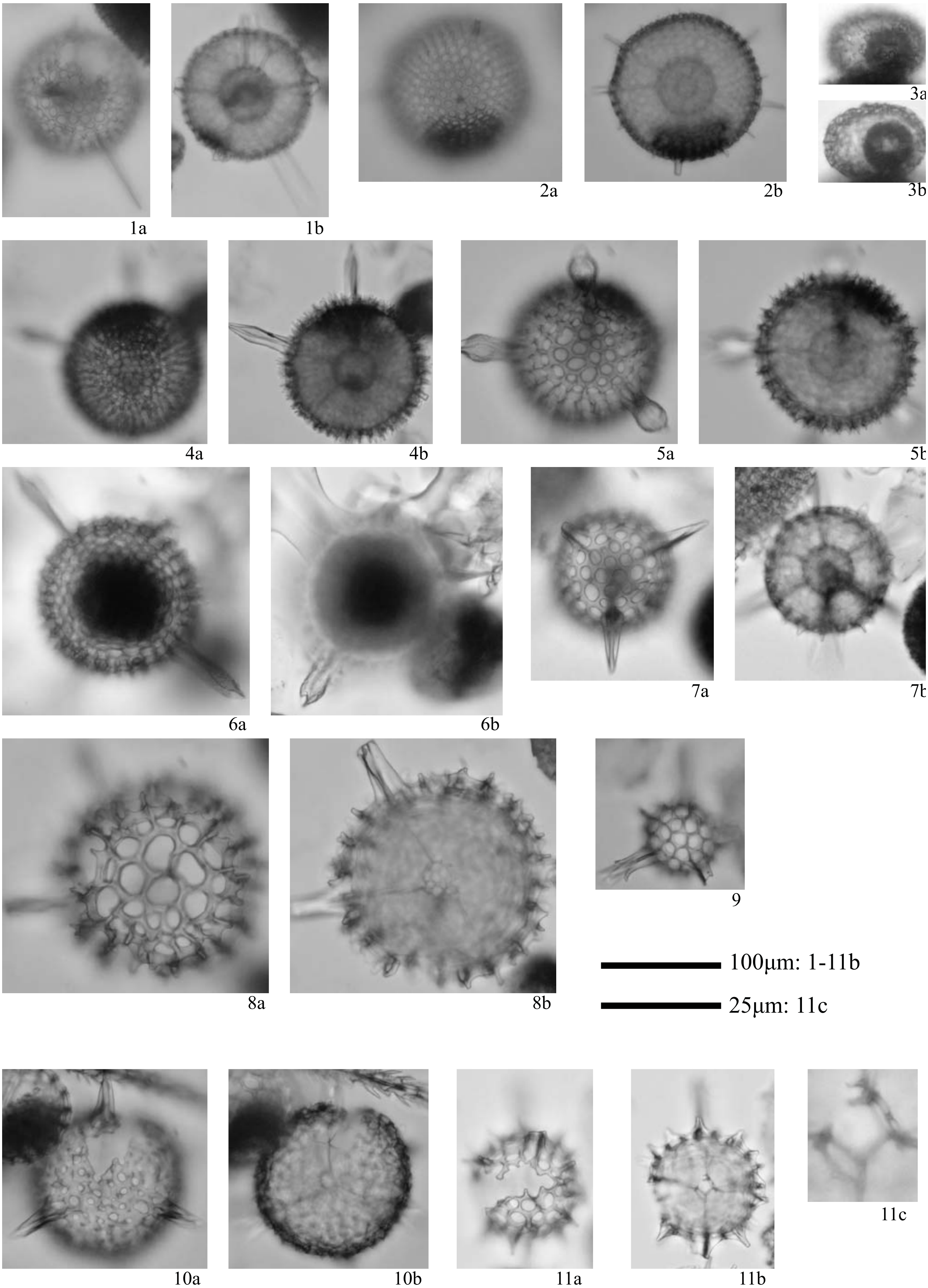
19. *Liriospyris* sp. B
(1172A-43X-CC).

Plate 1



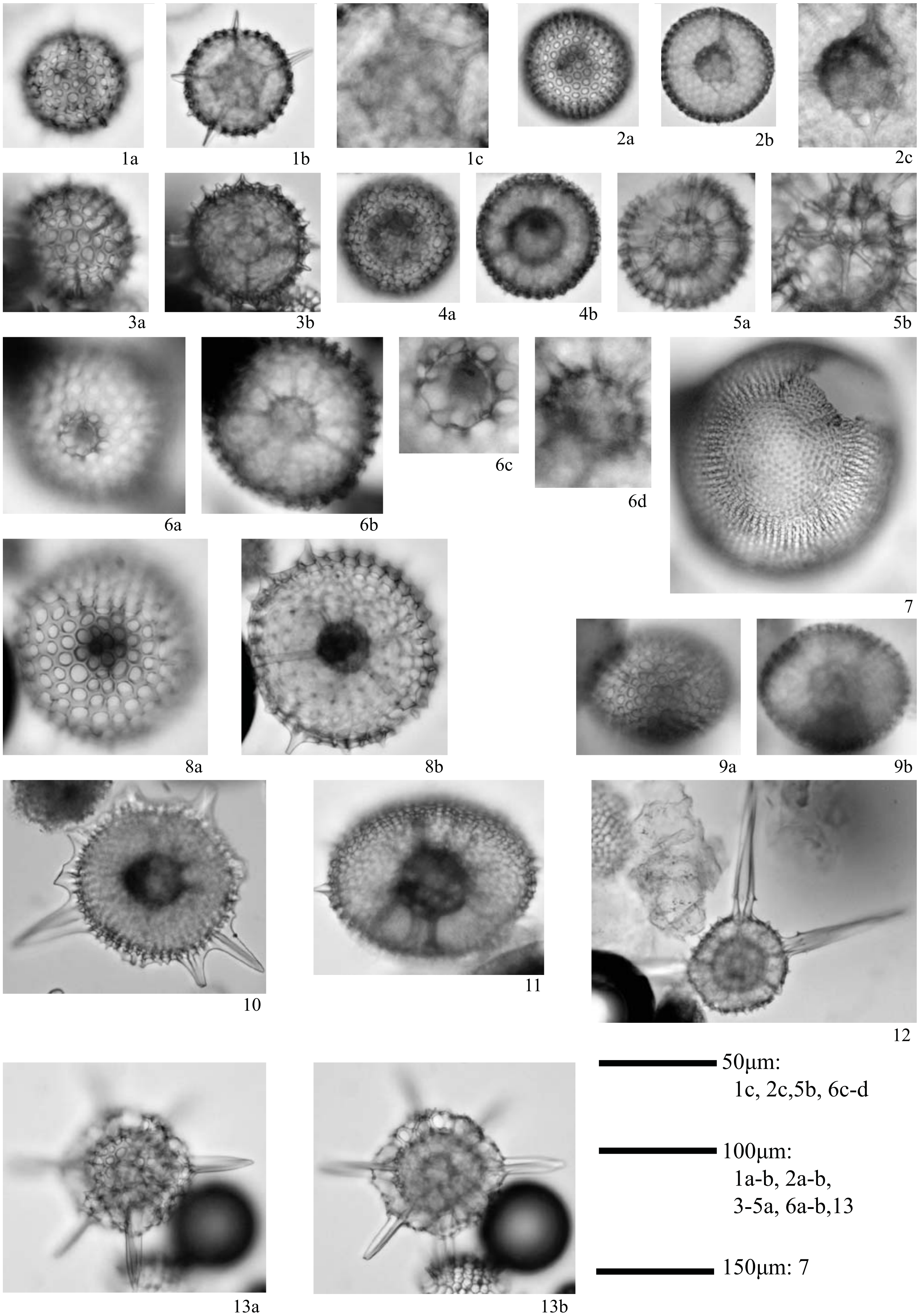
1a
1b
2a
2b
150µm: 1-3
3a
3b
4a
4b
5a
5b
6a
6b
6c
50µm: 6c
7a
7b
8a
8b
9a
9b
10a
10b
100µm: 4-6b, 7-13
11a
11b
12a
12b
13a
13b

Plate 2



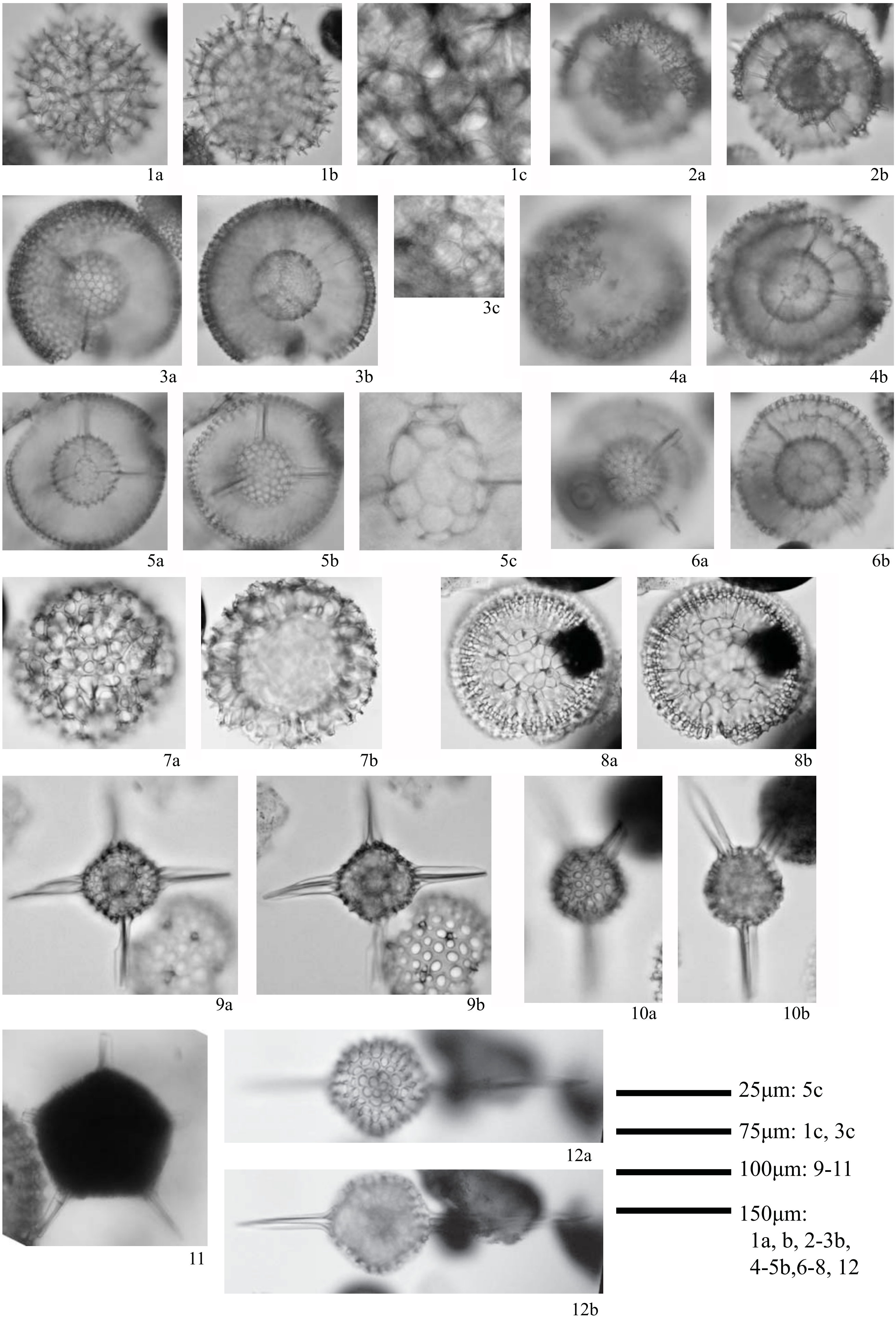
1a
1b
2a
2b
3a
3b
4a
4b
5a
5b
6a
6b
7a
7b
8a
8b
9
100µm: 1-11b
25µm: 11c
10a
10b
11a
11b
11c

Plate 3



1a
1b
1c
2a
2b
2c
3a
3b
4a
4b
5a
5b
6a
6b
6c
6d
7
8a
8b
9a
9b
10
11
12
13a
13b
50µm:
1c, 2c,5b, 6c-d
100µm:
1a-b, 2a-b,
3-5a, 6a-b,13
150µm: 7

Plate 4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1b
1c
2a
2b
3a
3b
3c
4a
4b
5a
5b
5c
6a
6b
7a
7b
8a
8b
9a
9b
10a
10b
11
12a
12b
25μm: 5c
75μm: 1c, 3c
100μm: 9-11
150μm:
1a, b, 2-3b,
4-5b,6-8, 12

Plate 5

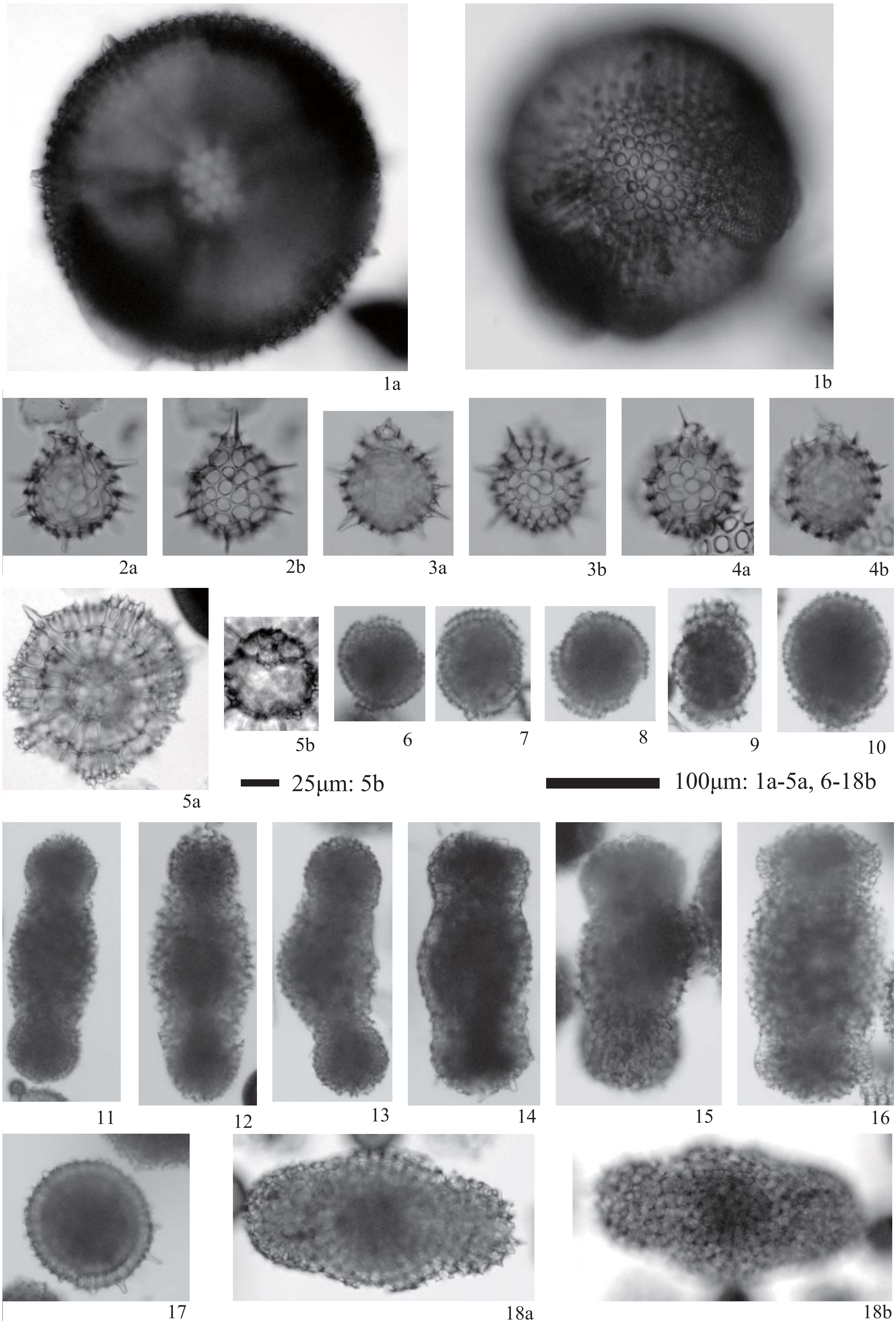

1a
1b
2a
2b
3a
3b
4a
4b
5a
5b
6
7
8
9
10
25µm: 5b
100µm: 1a-5a, 6-18b
11
12
13
14
15
16
17
18a
18b

Plate 6

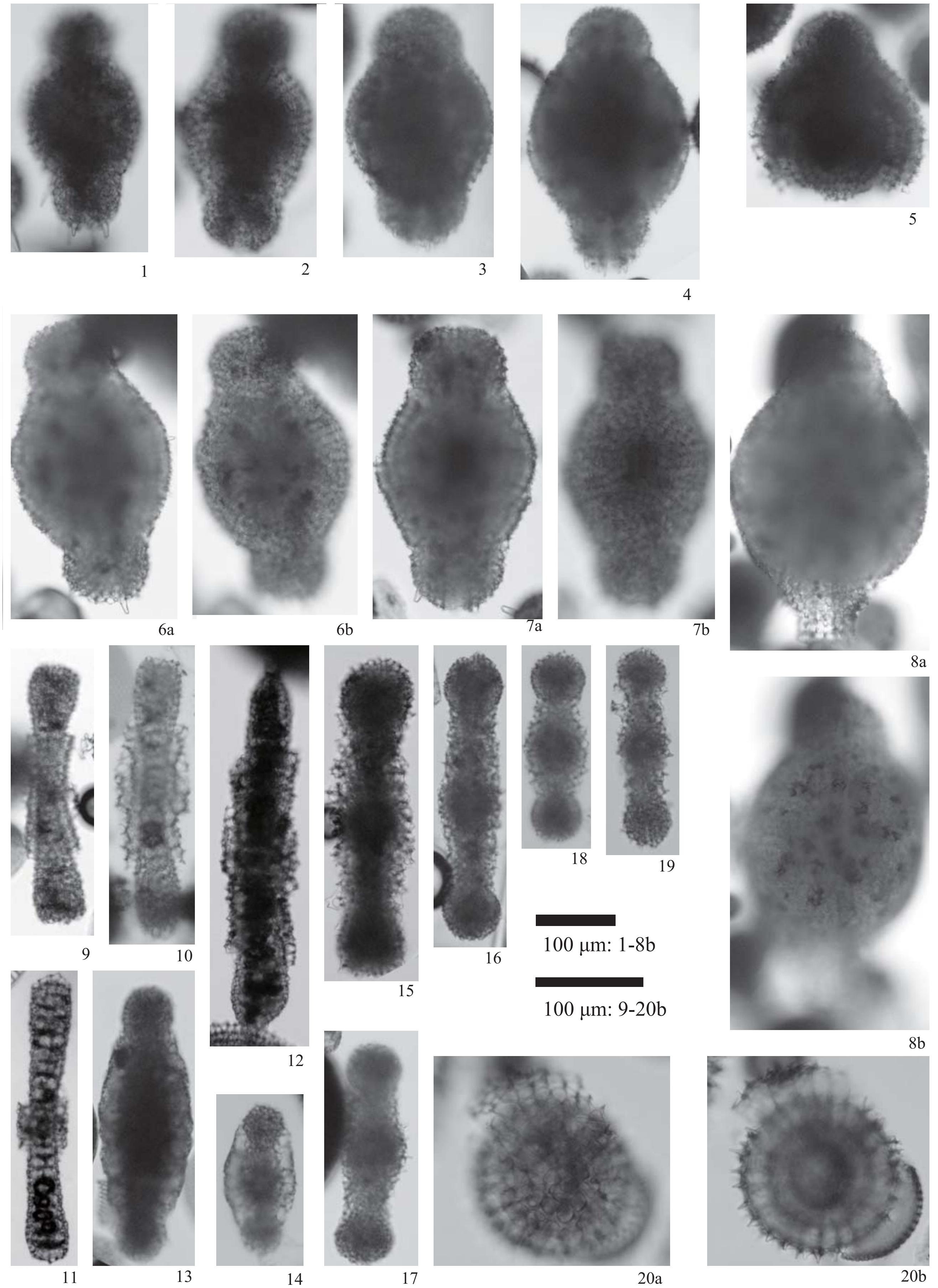

1
2
3
4
5
6a
6b
7a
7b
8a
8b
9
10
11
12
13
14
15
16
17
18
19
20a
20b
100 μm: 1-8b
100 μm: 9-20b

Plate 7

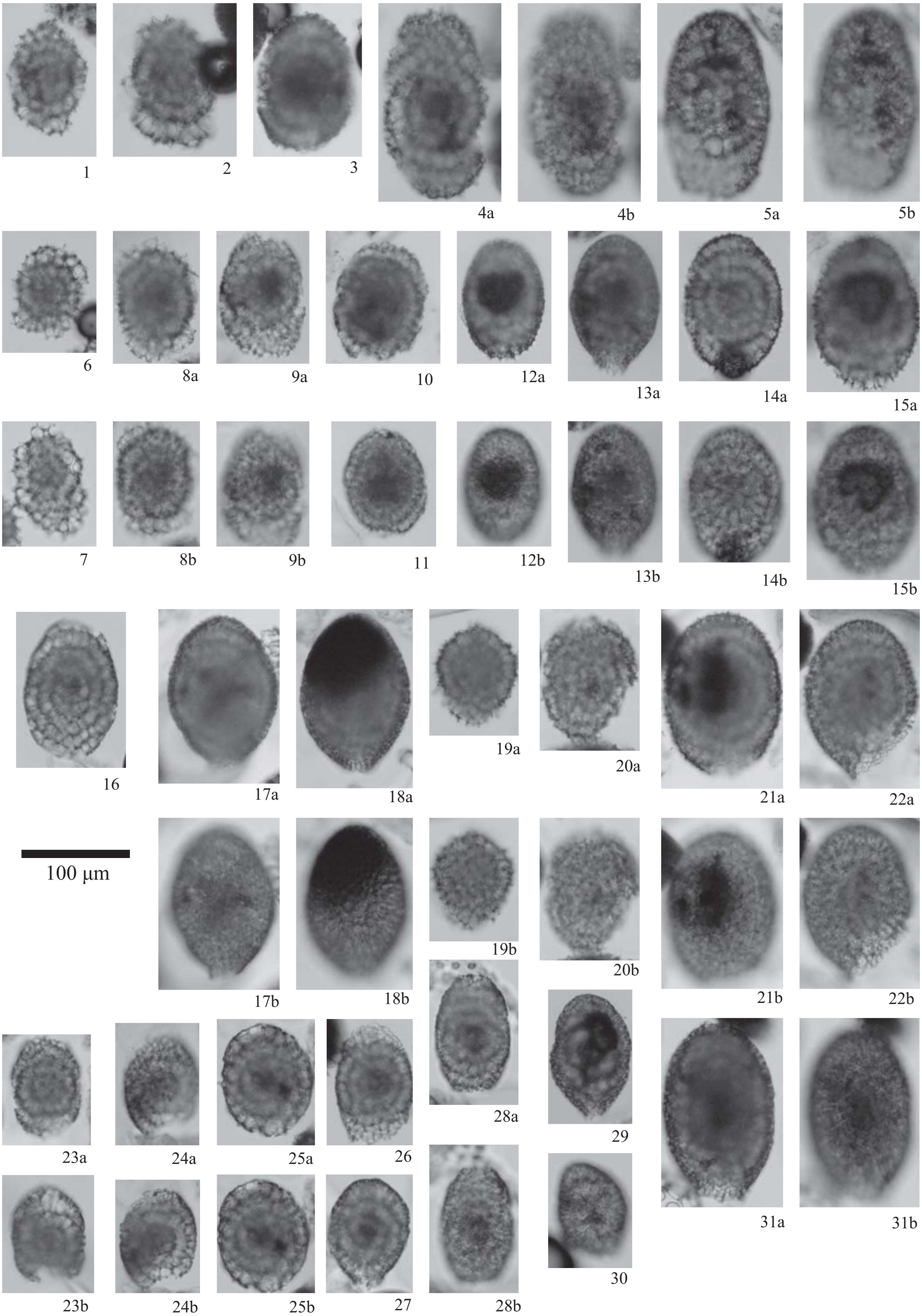
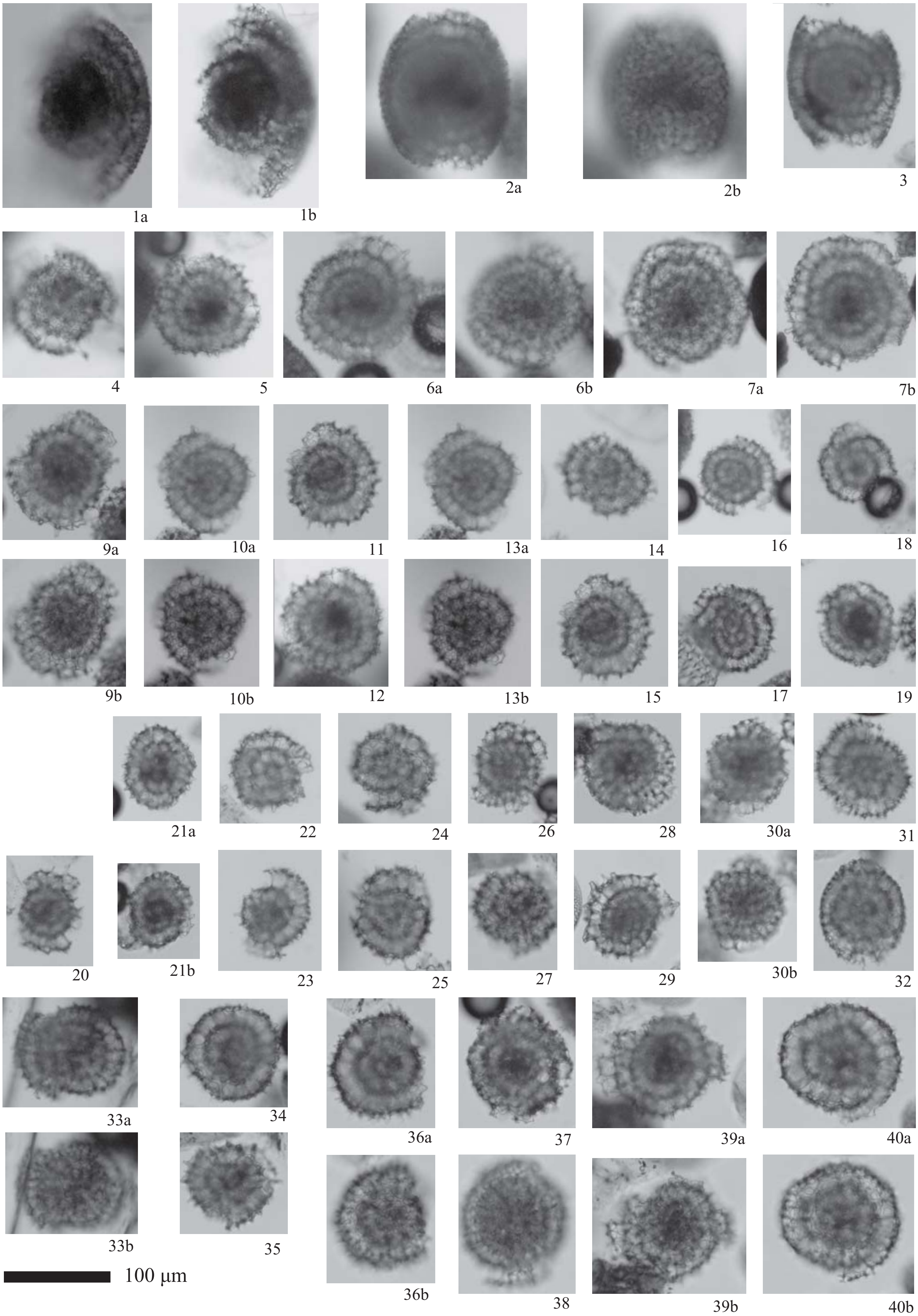
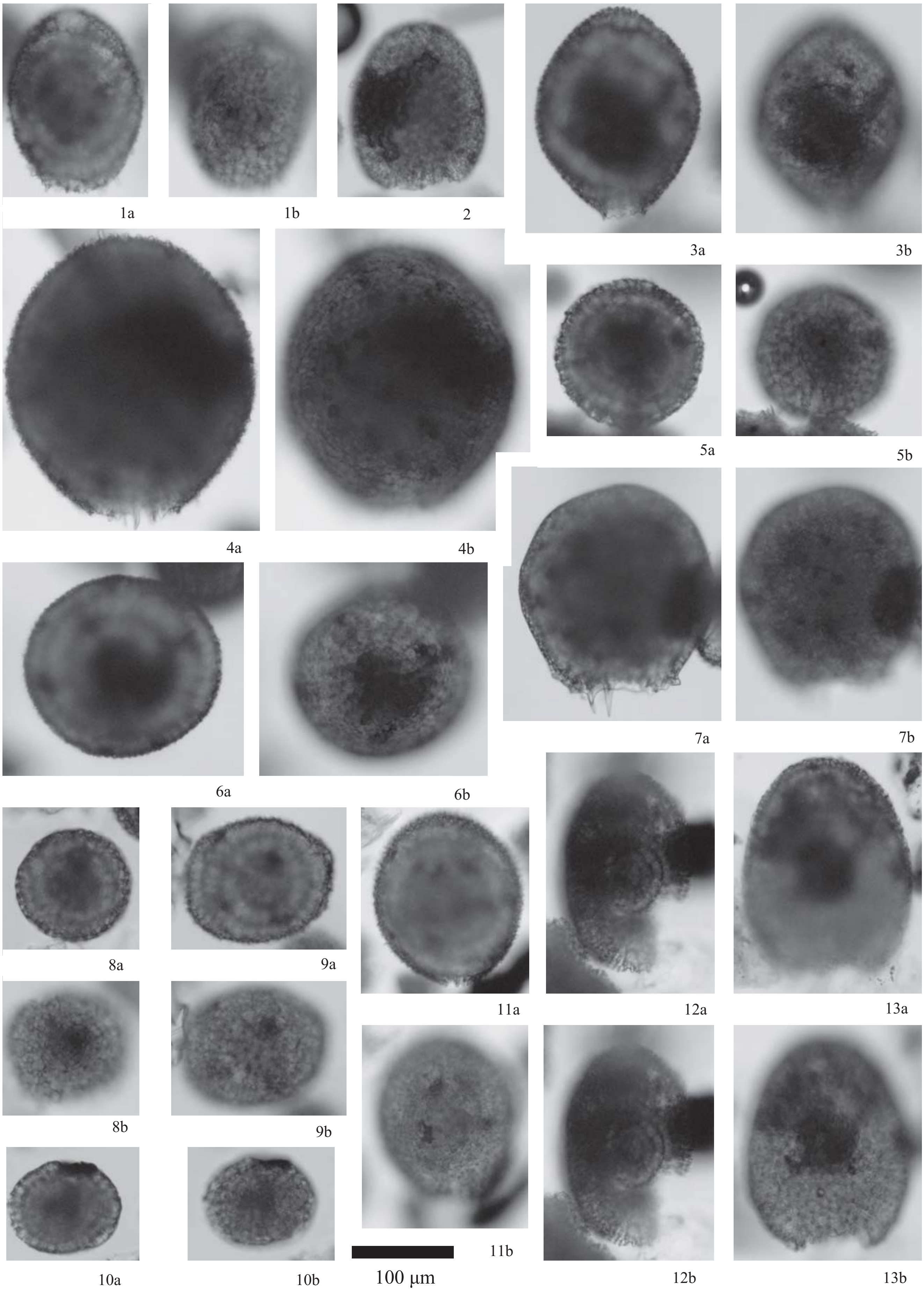

1
2
3
4a
4b
5a
5b
6
8a
9a
10
12a
13a
14a
15a
7
8b
9b
11
12b
13b
14b
15b
16
17a
18a
19a
20a
21a
22a
100 µm
17b
18b
19b
20b
21b
22b
28a
29
23a
24a
25a
26
31a
31b
30
23b
24b
25b
27
28b

Plate 8



1a
1b
2a
2b
3
4
5
6a
6b
7a
7b
9a
10a
11
13a
14
16
18
9b
10b
12
13b
15
17
19
21a
22
24
26
28
30a
31
20
21b
23
25
27
29
30b
32
33a
34
36a
37
39a
40a
33b
35
36b
38
39b
40b
100 μm

Plate 9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2
3a
3b
4a
4b
5a
5b
6a
6b
7a
7b
8a
9a
11a
12a
13a
8b
9b
10a
10b
100 µm
11b
12b
13b

Plate 10

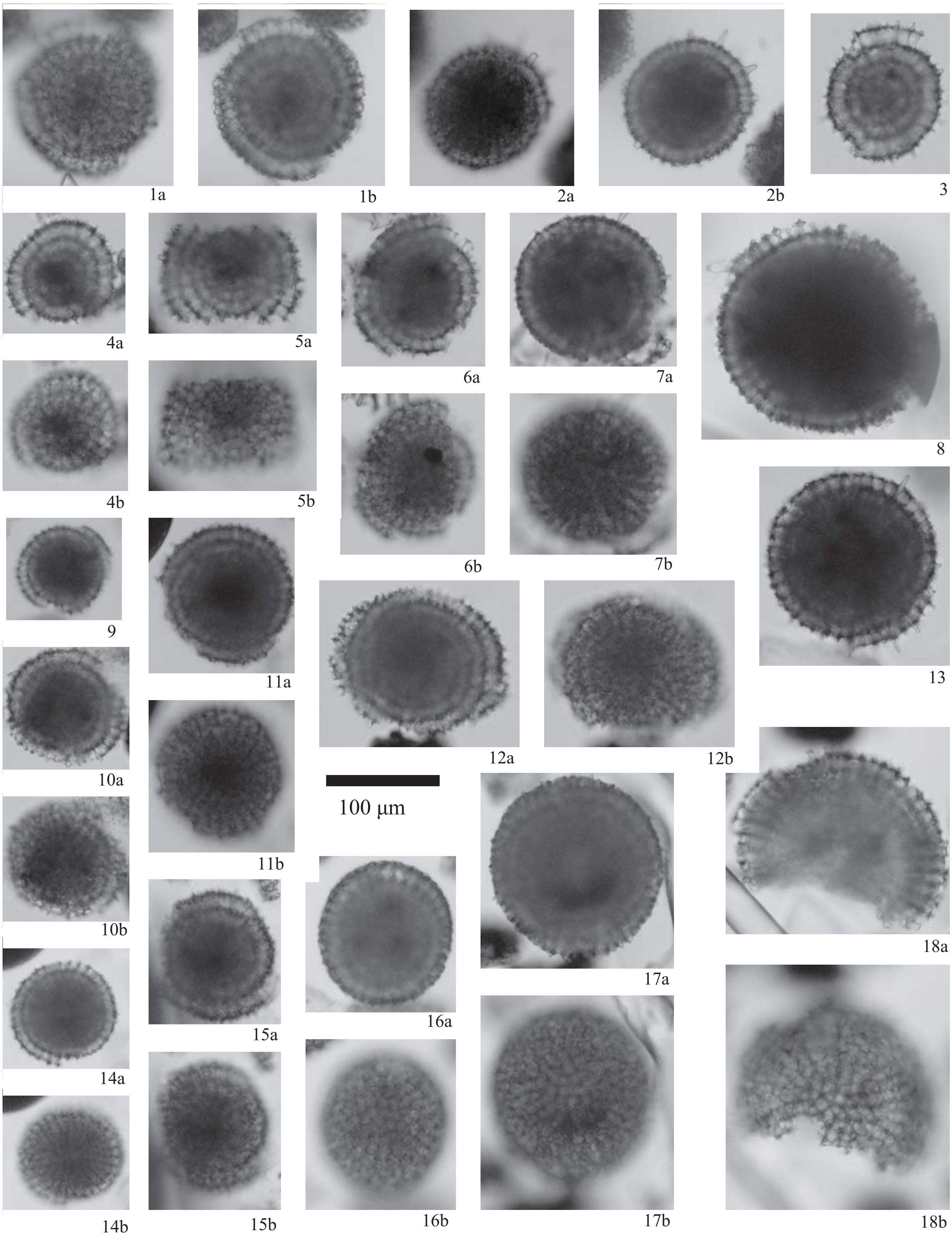
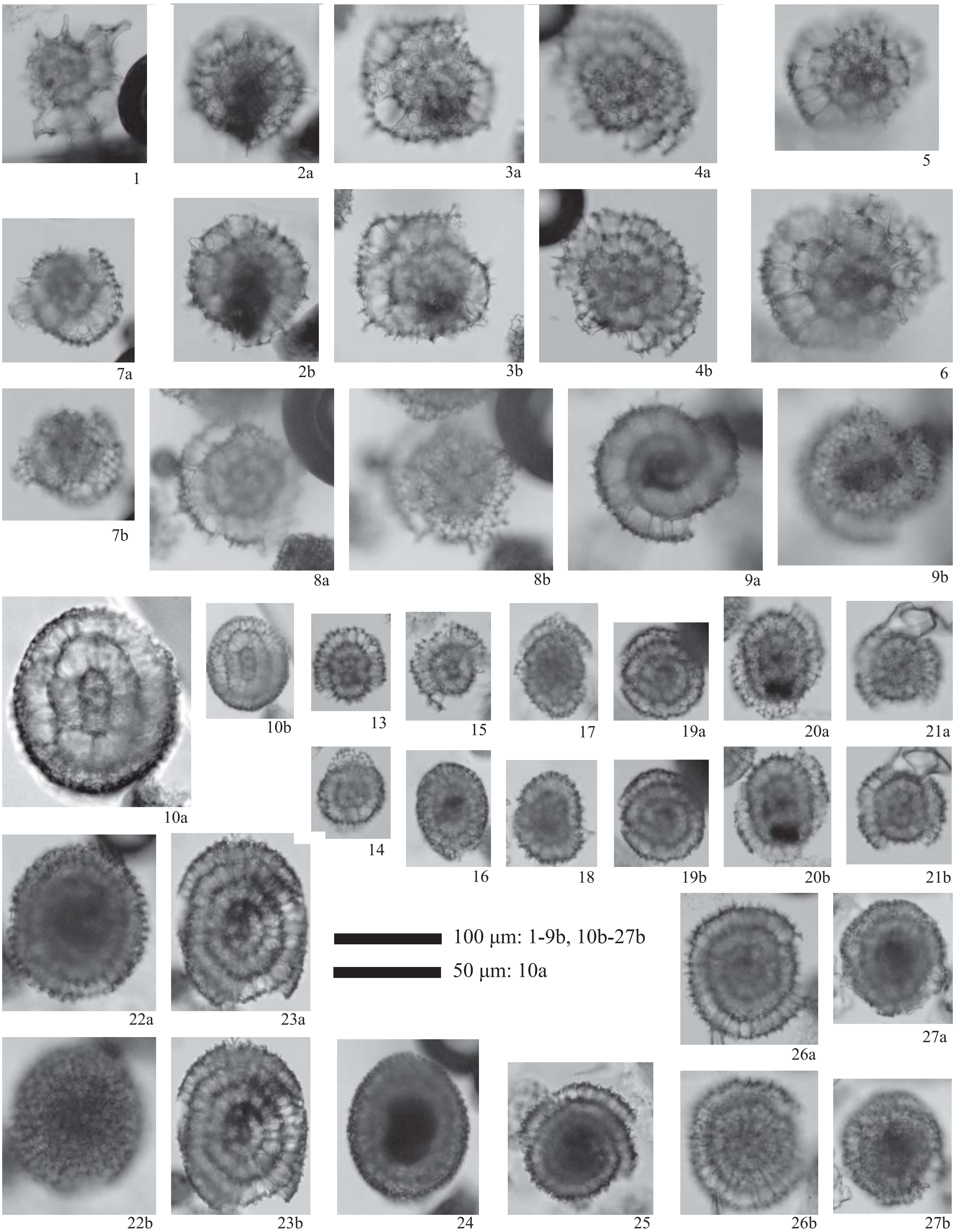

1a
1b
2a
2b
3
4a
5a
6a
7a
8
4b
5b
6b
7b
9
11a
13
10a
12a
12b
100 µm
10b
11b
18a
17a
16a
15a
14a
14b
15b
16b
17b
18b

Plate 11


1
2a
3a
4a
5
7a
2b
3b
4b
6
7b
8a
8b
9a
9b
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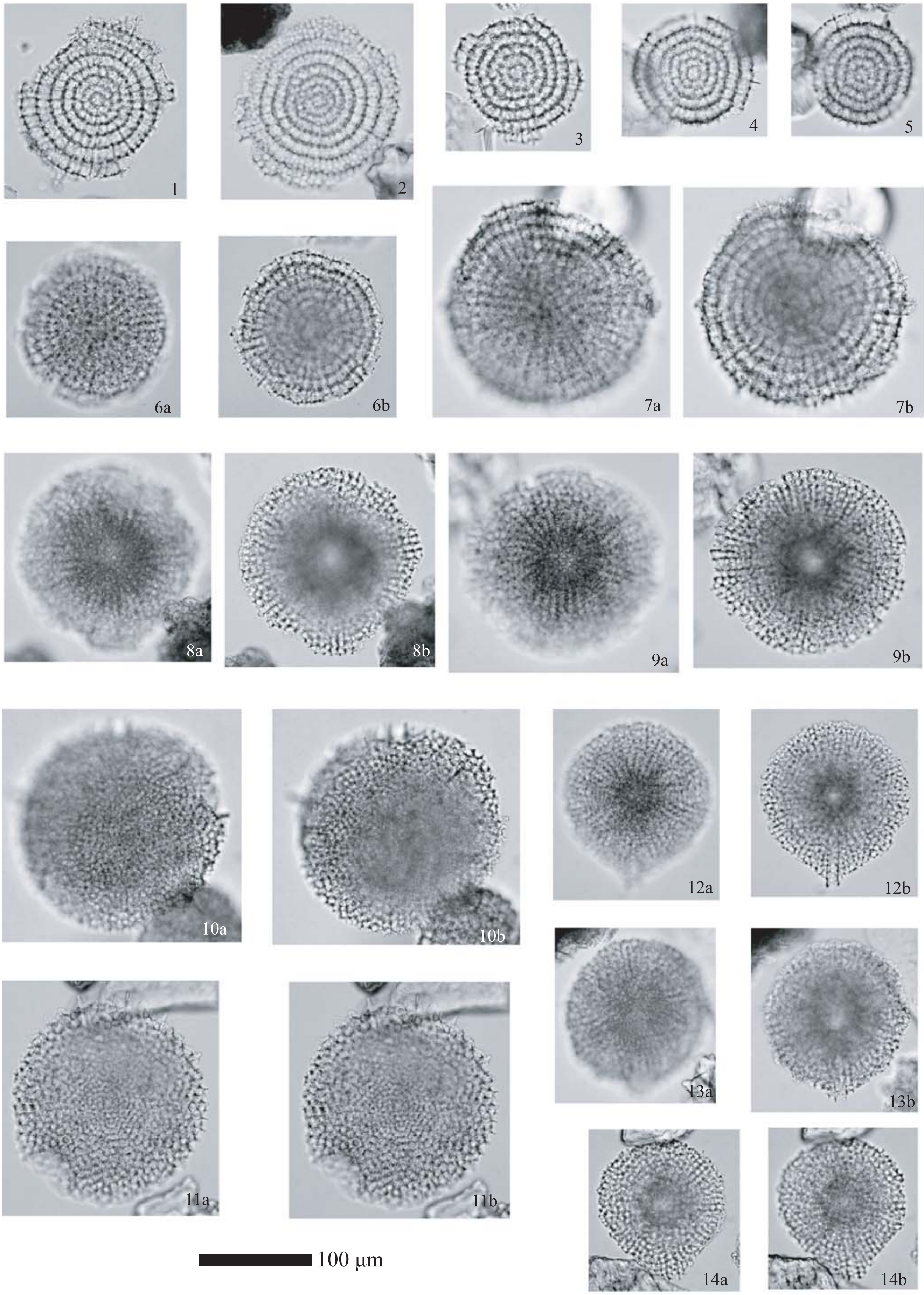
13
15
17
19a
20a
21a
10a
14
16
18
19b
20b
21b
22a
23a
100 µm: 1-9b, 10b-27b
50 µm: 10a
26a
27a
22b
23b
24
25
26b
27b

Plate 12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6a
6b
7a
7b
8a
8b
9a
9b
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10b
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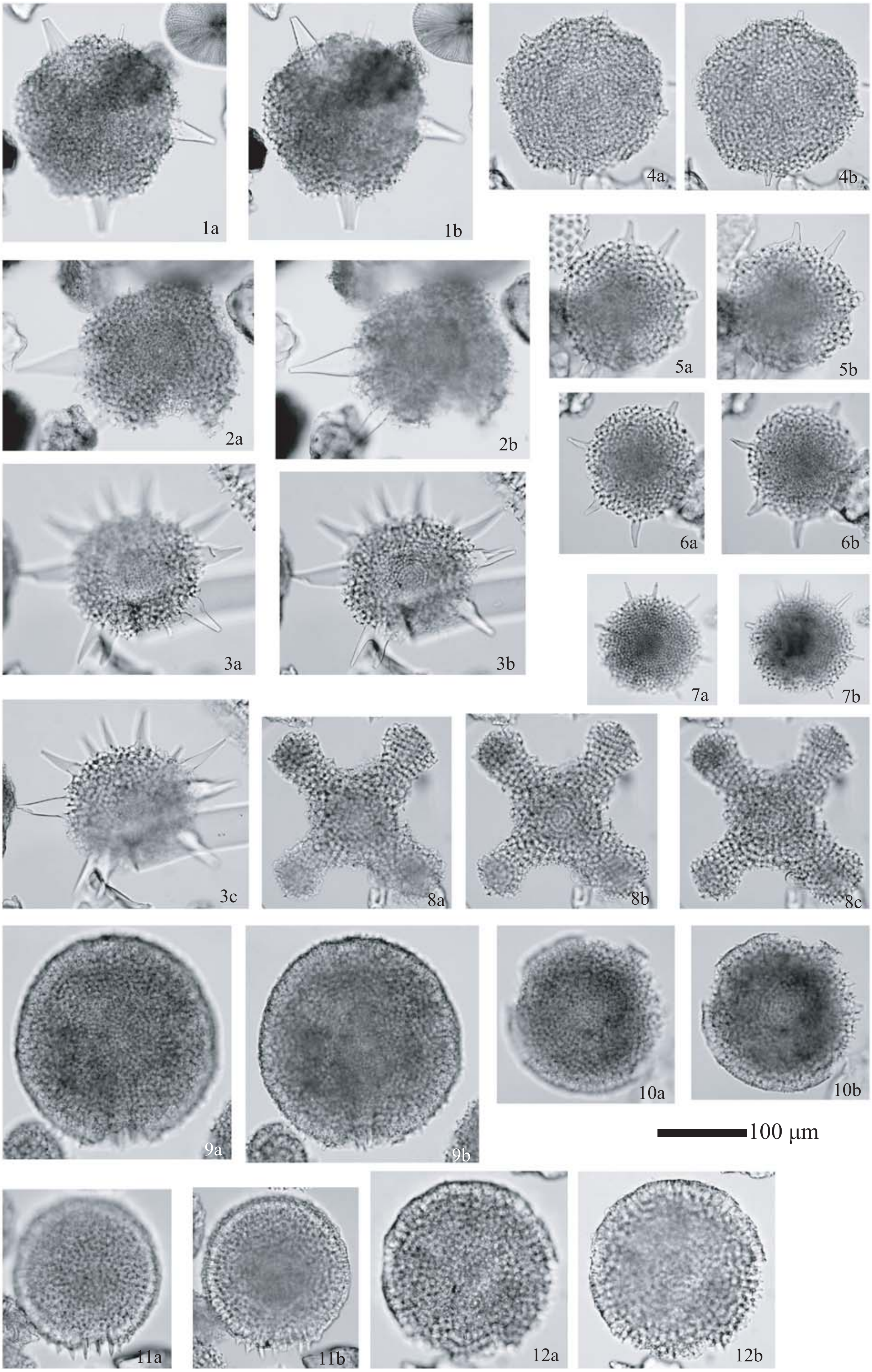
12b
13a
13b
11a
11b
14a
14b
100 µm

Plate 13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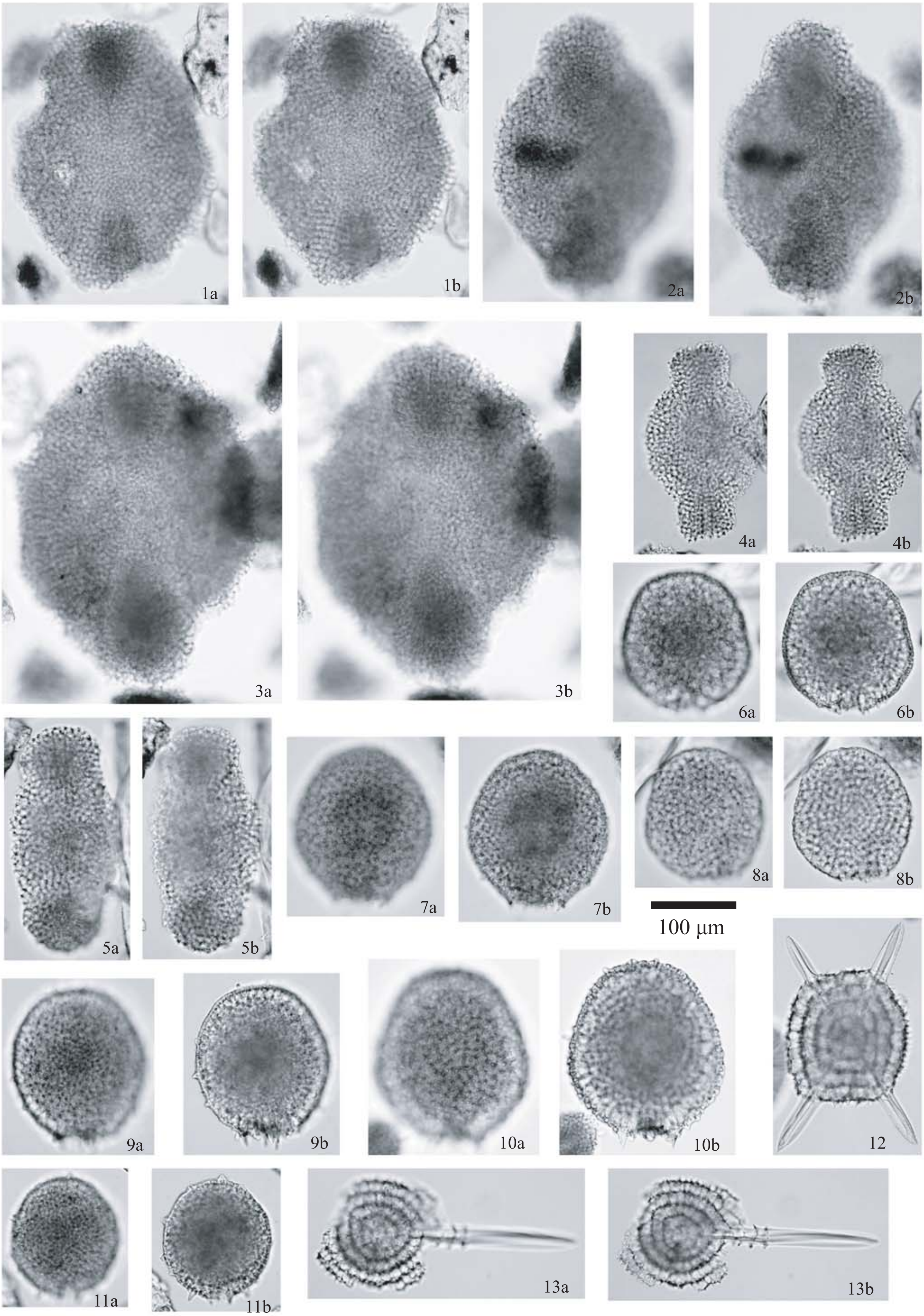
1b
4a
4b
5a
5b
2a
2b
6a
6b
3a
3b
7a
7b
3c
8a
8b
8c
9a
9b
10a
10b
100 µm
11a
11b
12a
12b

Plate 14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1b
2a
2b
3a
3b
4a
4b
6a
6b
5a
5b
7a
7b
8a
8b
100 µm
9a
9b
10a
10b
12
11a
11b
13a
13b

Plate 15

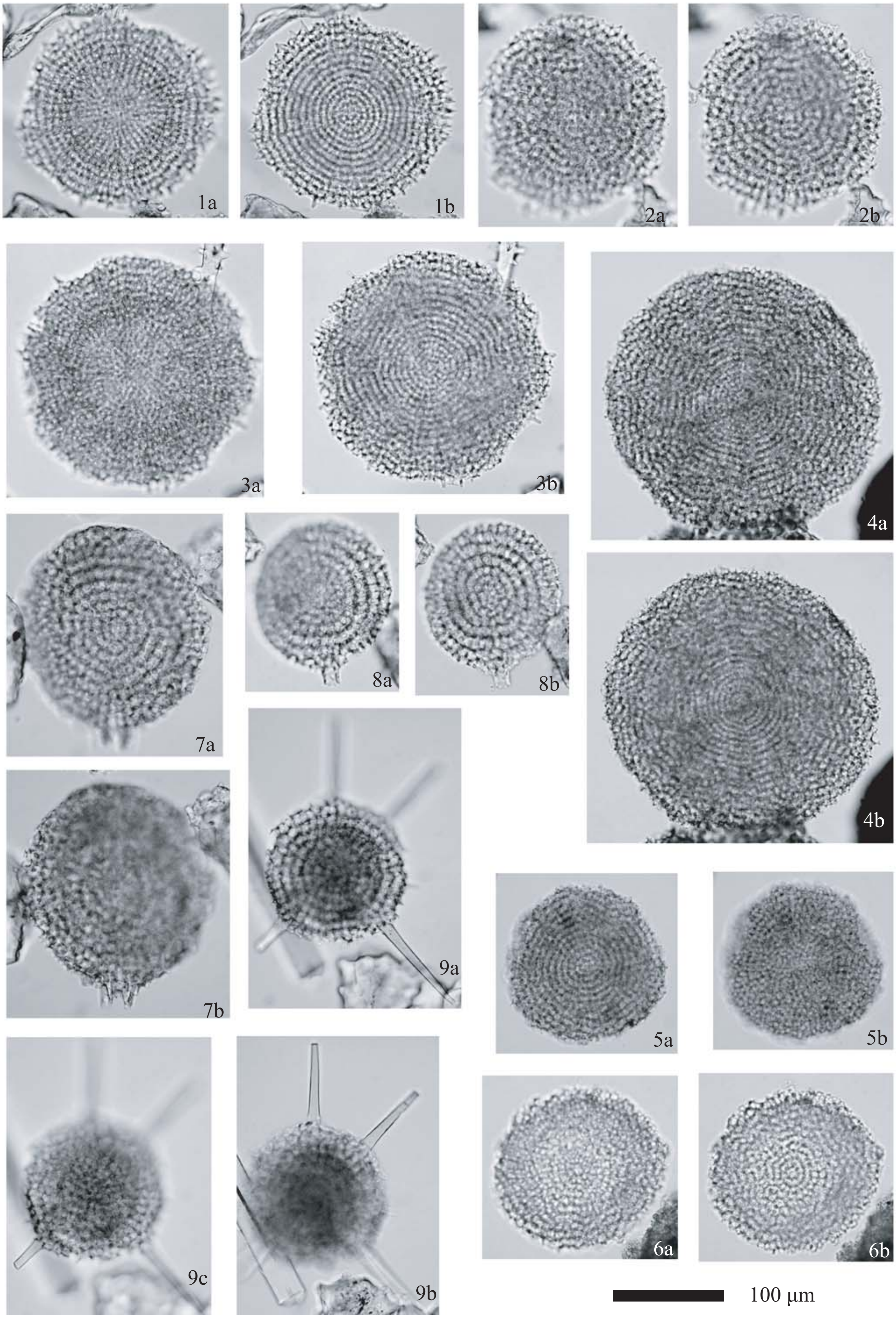


Plate 16

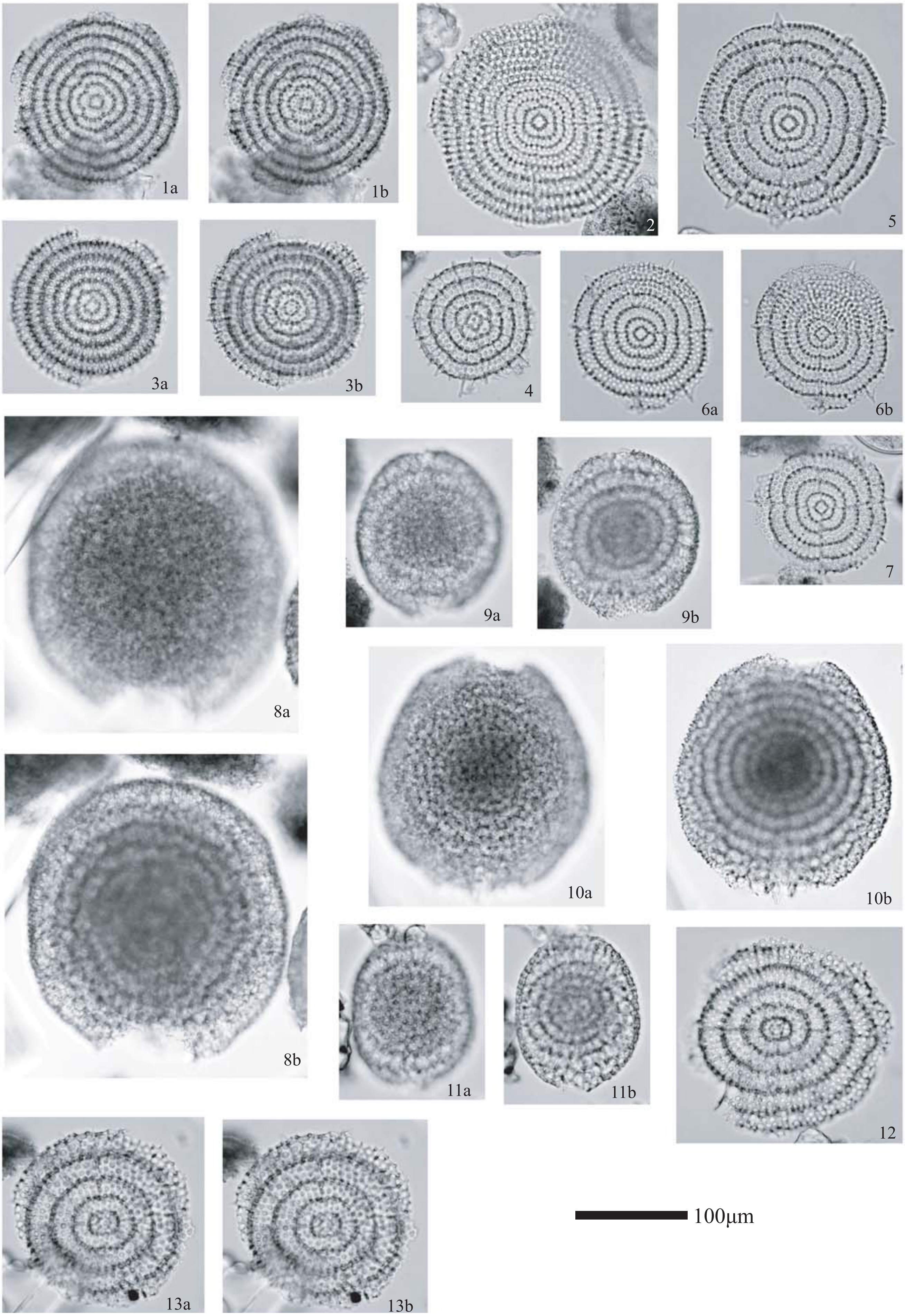


Plate 17

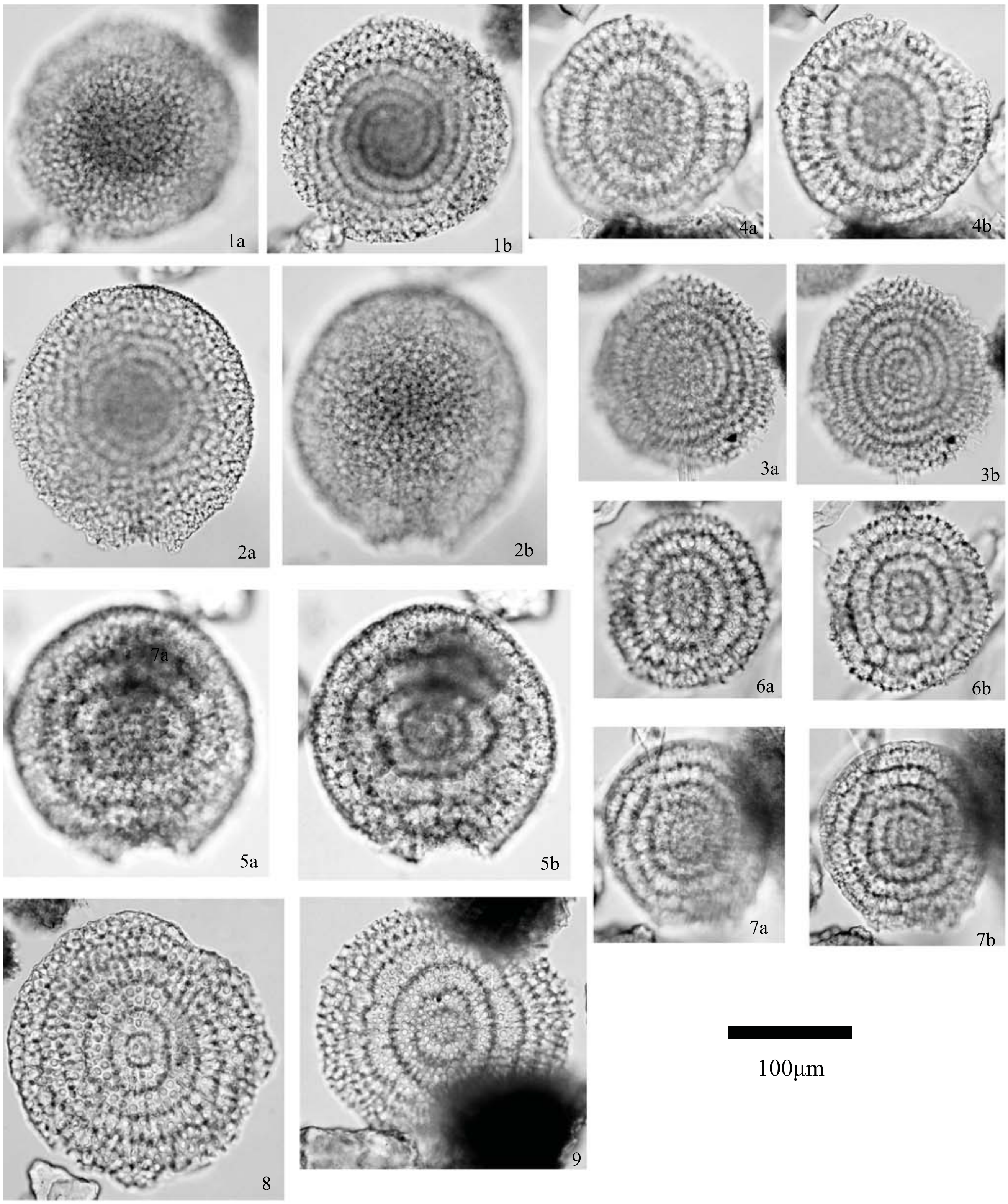
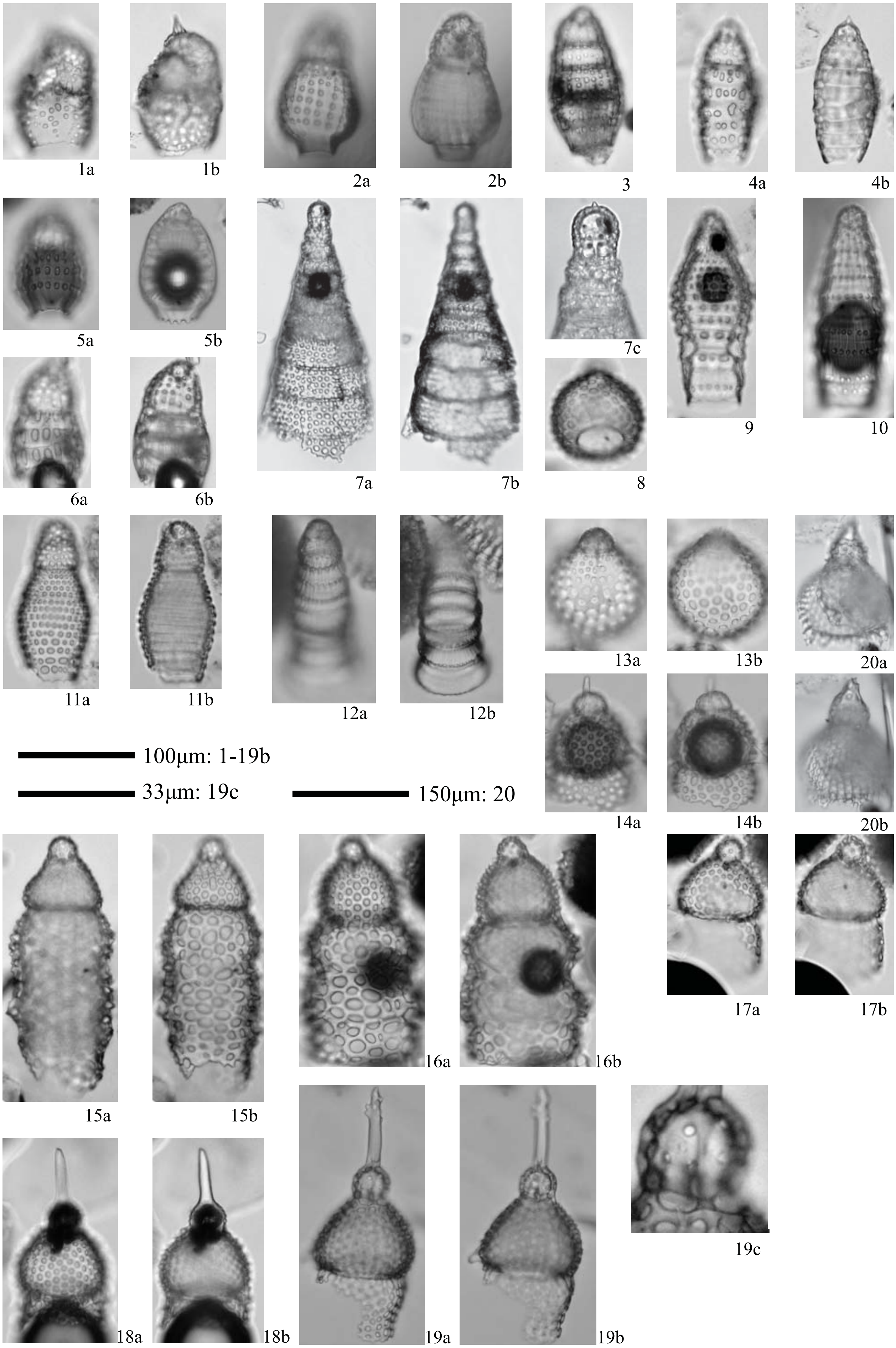


Plate 18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2a
2b
3
4a
4b
5a
5b
6a
6b
7a
7b
7c
8
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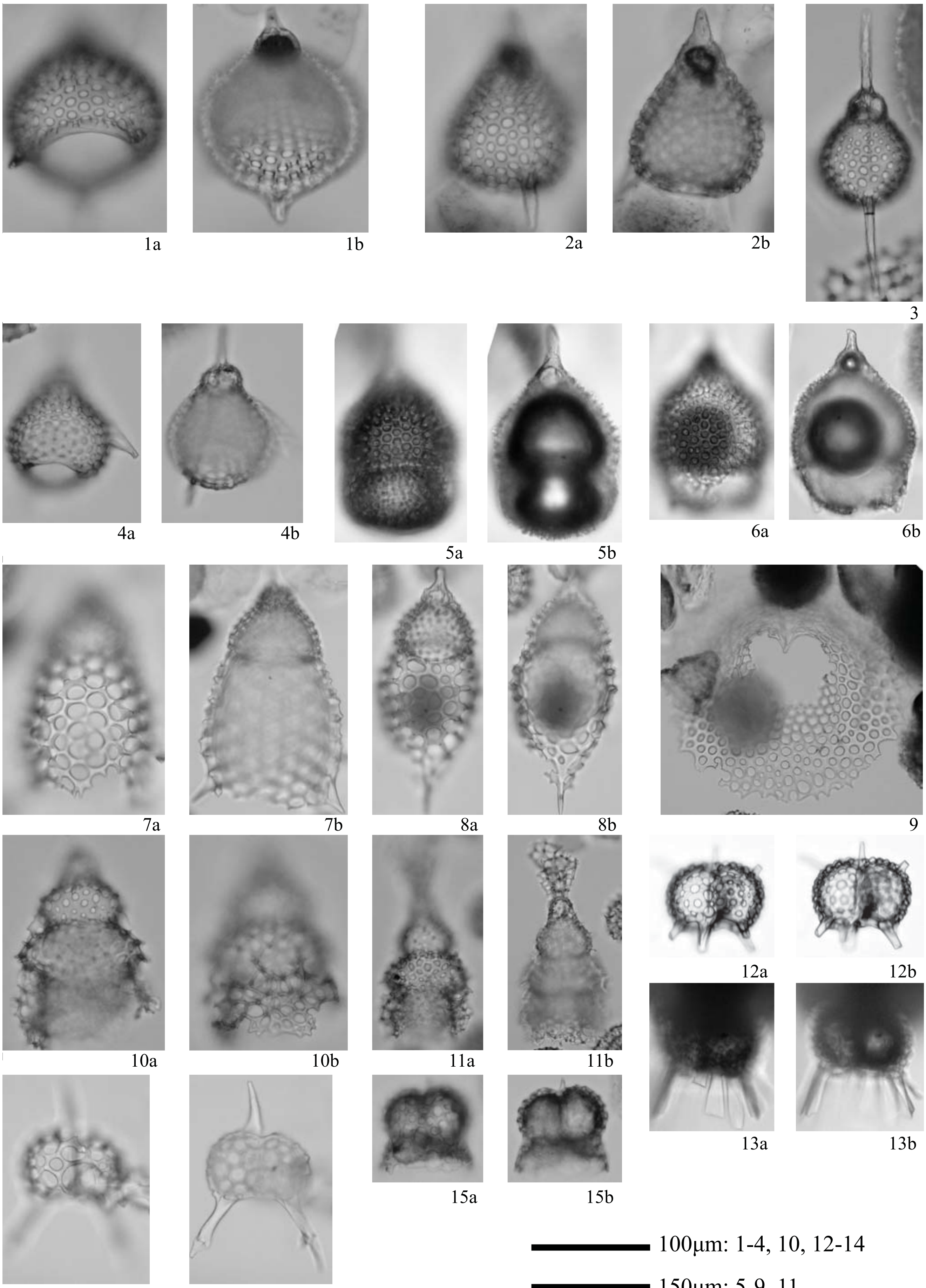
11a
11b
12a
12b
13a
13b
20a
14a
14b
20b
100µm: 1-19b
33µm: 19c
150µm: 20
15a
15b
16a
16b
17a
17b
18a
18b
19a
19b
19c

Plate 19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1b
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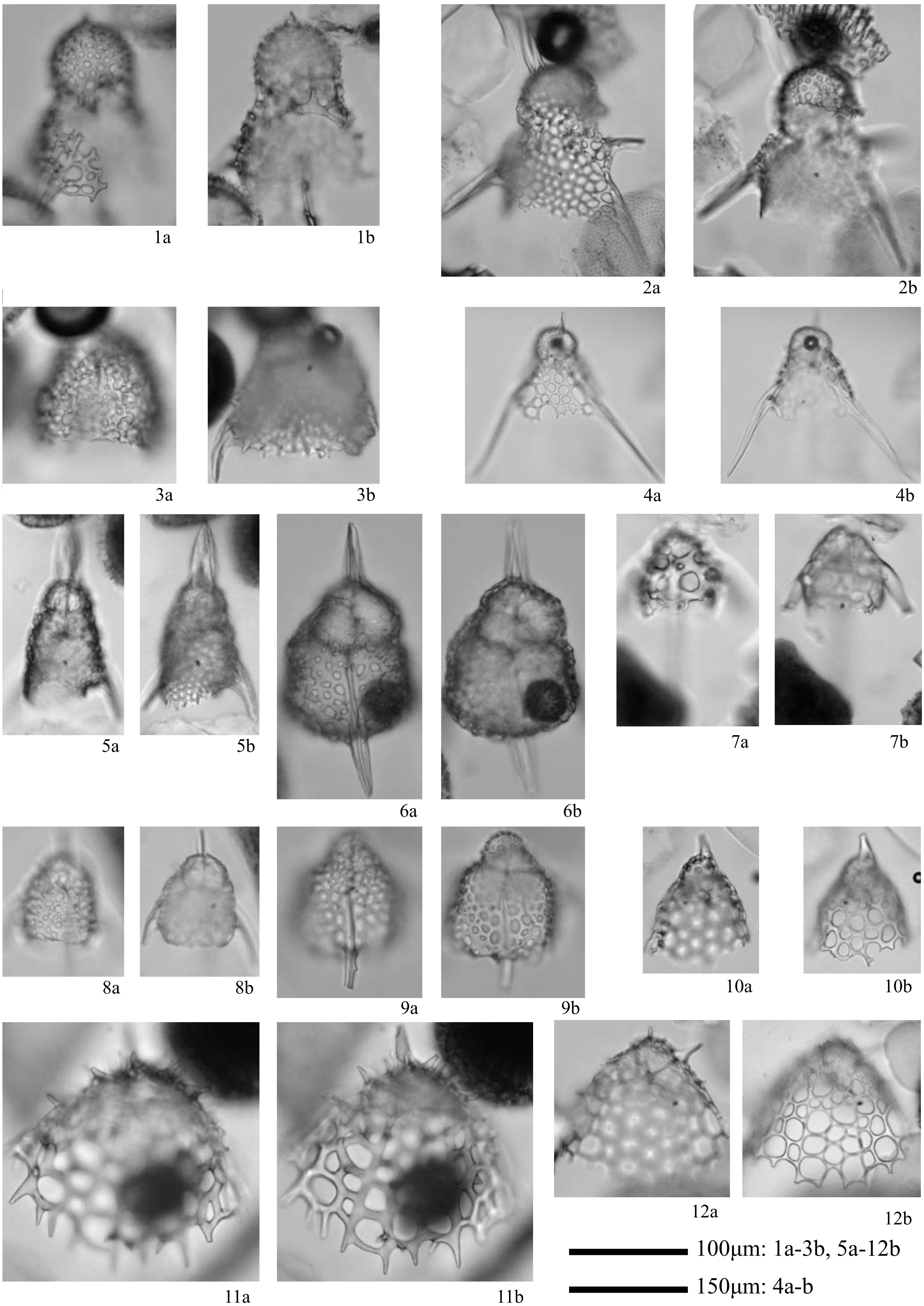
4a
4b
5a
5b
6a
6b
7a
7b
8a
8b
9
10a
10b
11a
11b
12a
12b
13a
13b
14a
14b
15a
15b
100µm: 1-4, 10, 12-14
150µm: 5-9, 11

Plate 20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1b
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2b
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3b
4a
4b
5a
5b
6a
6b
7a
7b
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8b
9a
9b
10a
10b
11a
11b
12a
12b
100μm: 1a-3b, 5a-12b
150μm: 4a-b

Plate 21

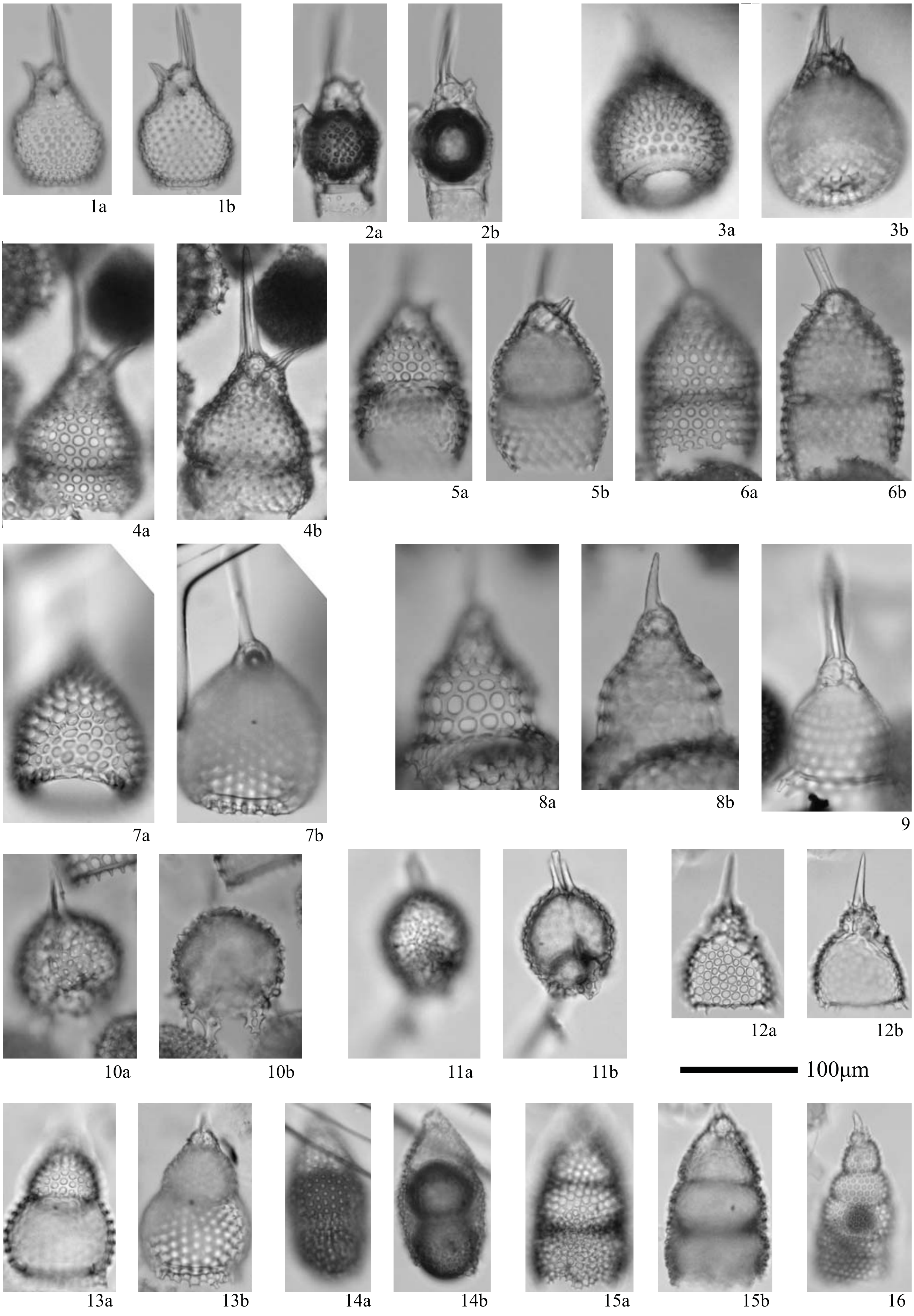
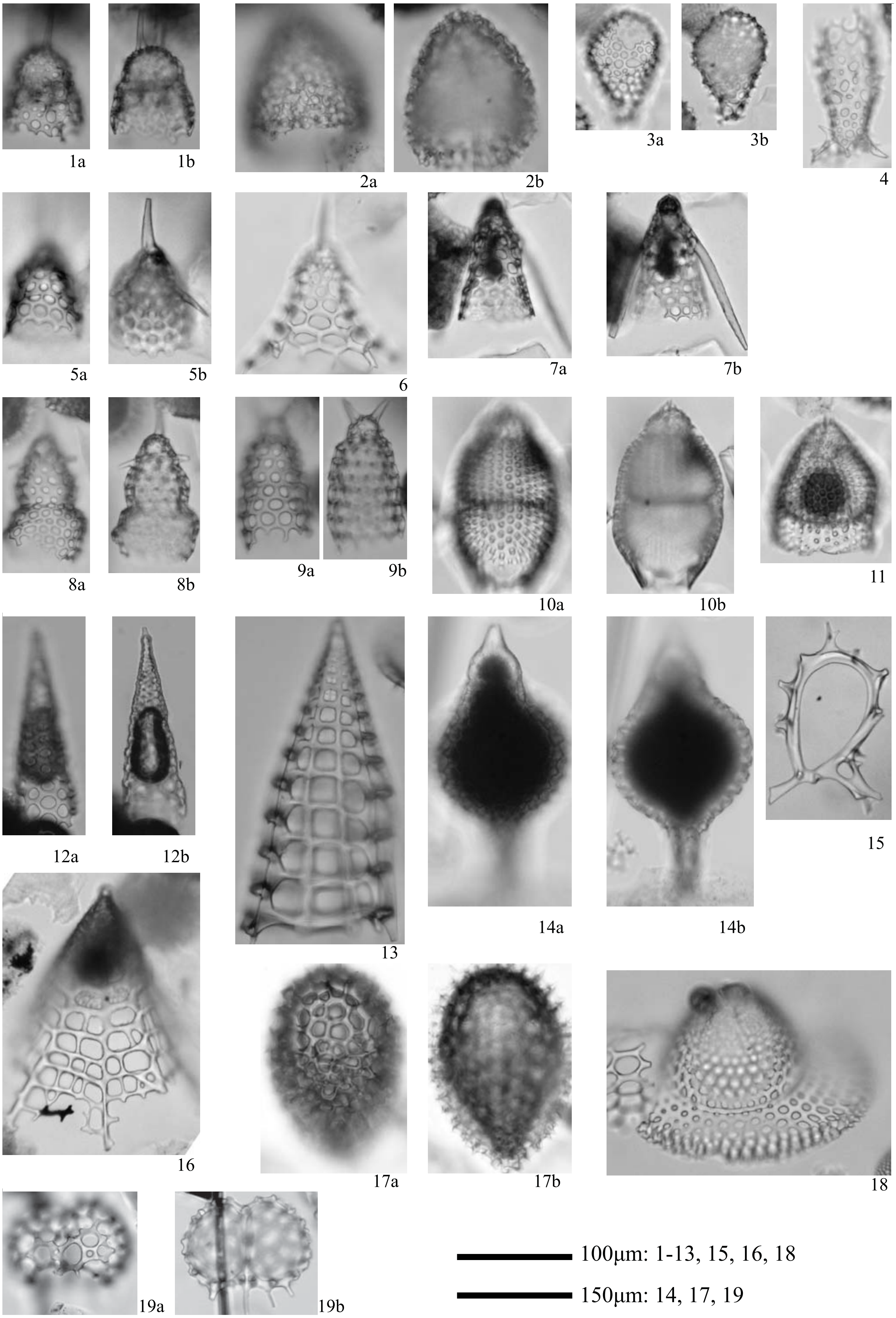

1a
1b
2a
2b
3a
3b
4a
4b
5a
5b
6a
6b
7a
7b
8a
8b
9
10a
10b
11a
11b
12a
12b
100μm
13a
13b
14a
14b
15a
15b
16

Plate 22



100µm: 1-13, 15, 16, 18

150µm: 14, 17, 19