

Last Glacial to Holocene Polycystine radiolarians from the Japan Sea

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Abstract

Totally 157 species or species group of polycystine radiolarians including 54 supmellarians and 103 nassellarians were encountered in plankton samples and last glacial to Holocene sediments from the Japan Sea. Photomicrographs of all these taxa have been illustrated in 23 plates.

Key words: Polycystine, Radiolaria, Japan Sea, last Glacial, Holocene

Introduction

The Japan Sea is a semi-enclosed marginal sea of the Northwest Pacific Ocean surrounding by the Eurasian Continent, Japanese islands and Sakhalin Island (Fig. 1), and it holds a peculiar polycystine radiolarian (hereafter, radiolarian) assemblage due to a small exchange of seawater with adjacent oceans such as the North Pacific, East China Sea and Sea of Okhotsk (Itaki, 2003). The late Quaternary radiolarians in the Japan Sea have been well documented previously from aspects of paleoceanographic reconstruction or biotic response to the environmental changes (e.g. Sakai, 1984; Morley et al., 1986; Itaki, 2001, 2007; Itaki et al., 2004, 2007). Although most of these previous papers showed only results of statistical analysis or abundances of some selected species, it is still unknown that how diverse the whole radiolarian assemblage in the late Quaternary Japan Sea. Aim of this paper is to show photomicrographs of all radiolarian forms that author encountered previously through studies of plankton samples, surface sediments and sediment cores from the Japan Sea.

Materials and methods

Figure 1 and Table 1 show all sample locations, which author examined radiolarians. Because the wrong coordinates of plankton station GH99-N1 were described in Itaki (2003) and Itaki et al. (2004), here they are corrected as 43°46'N, 138°50'E. Detailed sample procedures have been shown in Itaki (2003) for plankton-net and surface sediment materials, and Itaki et al. (2004, 2007) and Itaki and Bjørklund (2007) for sediment cores.

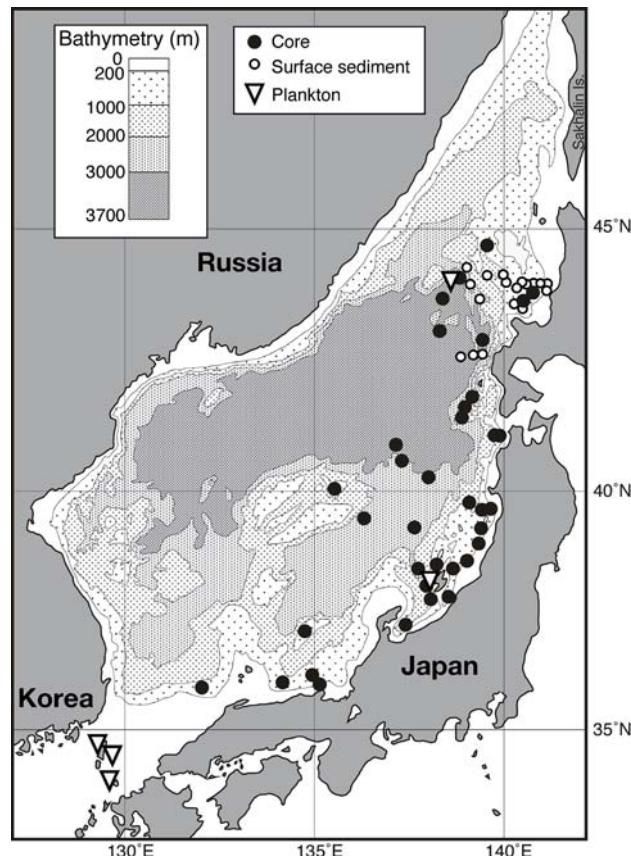


Fig. 1. Map showing sample locations.

Radiolarians were observed under an optical microscope at magnifications of 40 to 400X. Photomicrographs of radiolarians were taken using a digital camera system or a CCD camera system with video printer. A printed image from the CCD camera system was scanned to take it as a digital image. In order to observe a specimen from different directions, some tests were rotated in uncompleted Canada balsam on the slide.

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Taxonomic list

Totally 157 taxa of polycystine radiolarians (54 spumellarians and 103 nassellarians) were encountered in plankton samples and Holocene to last glacial sediments from the Japan Sea. Photomicrographs of all forms are shown in Plates 1 to 23. Same scale is used in all figures for recognizable size comparison of each specimen. All of these taxa and their synonym list are shown below. Synonym list for each species includes literatures, which (1) originally described, (2) gave a detailed description or emended its criteria, (3) changed its genus, and (4) showed substantial pictures or illustrations. Higher rank taxonomy was followed Riedel and Sanfilippo (1977).

Order POLYCYSTINA Ehrenberg

Suborder SPUMELLARIA Ehrenberg

Family ACTINOMMIDAE Haeckel

Acanthosphaera circopora Popofsky 1912

pl. 1, figs. 1-6

Acanthosphaera circopora n. sp. Popofsky, 1912, p. 97, text-fig. 9.

Actinomma boreale Cleve 1899

pl. 2, figs. 5, 6, 11

Actinomma boreale n. sp. Cleve, 1899, p. 26, pl. I, figs. 5c, 5d.

Actinomma boreale Cleve. Cortese and Bjørklund, 1998, p. 151-152, pl. 1, figs. 1-18, pl. 3, figs. 1-3 and 6.

Cromyechinus borealis (Cleve). Jørgensen, 1905, p. 117, pl. 8, figs. 35, 36, 37a-d; Hülsemann, 1963, p. 16, fig. 8; Bjørklund, 1974, p., 19, figs. 6A (right), 6C, 6G, 6J, 6K, p. 23, fig. 7A.

Actinomma leptodelmum leptodelmum (Jørgensen 1899)

pl. 2, figs. 1-4

Echinomma leptideruma n. sp. Jørgensen, 1899, p. 57-58.

Actinomma boreale n. sp. Cleve, 1899, pl. 1, figs. 5a, 5b [not holotype].

Echinomma leptoderum Jørgensen. Jørgensen, 1905, p. 116, pl. 8, fig. 33; Bjørklund, 1976b, pl. 1, figs. 13, 14, pl. 2, figs. 1-6.

Actinomma leptodermum (Jørgensen). Nigrini and Moore, 1979, S35-36, pl. 3, fig. 7.

Actinomma leptodelma leptodelma (Jørgensen). Cortese and Bjørklund, 1998, p. 153, pl. 2, figs 1-14, pl. 3, figs. 4-5, 9-10, 15-16 [type specimens or topotypes].

Actinomma medianum Nigrini 1967

pl. 3, figs. 4-5

Actinomma medianum Nigrini, 1967, p. 27-29, pl. 2, fig. 2a, 2b.

Actinomma sp. A

pl. 3, fig. 2

Actinomma sp. B

pl. 3, fig. 6

Cenosphaera reticulata (Haeckel 1860a)

pl. 4, figs. 1-5

Cyrtidosphaera reticulata n. sp. Haeckel, 1860a, p. 803

Cyrtidosphaera reticulata Haeckel. Haeckel, 1862, p. 349, pl. 11, fig. 2.

Cenosphaera (Cyrtidosphaera) reticulata (Haeckel). Haeckel, 1887, p. 66.

Cenosphaera reticulata Haeckel [sic]. Hollande and Enjumet, 1960, p. 87-88, pl. 32, fig. 1, pl. 33, figs. 1, 2.

Cladococcus bifurcus Haeckel 1860a

pl. 1, figs. 7-9

Cladococcus (Cladococcus) bifurcus n. sp. Haeckel, 1860, p. 801.

Cladococcus bifurcus Haeckel. Haeckel, 1862, p. 368-369, pl. 13, figs. 7, 8.

Cladococcus sp.

pl. 1, fig. 10

Cromyechinus antarctica (Dreyer 1889)

pl. 2, figs. 8, 10

Prunopyle antarctica n. sp. Dreyer, 1889, p. 100-101, fig. 75.

Prunopyle antarctica Dreyer. Riedel, 1958, p. 225, pl. 1, figs. 7, 8.

Cromyechinus antarctica (Dreyer). Petrushevskaya, 1968, p. 22-27, figs. 13 (I-VII), 14 (I-VII).

Heliosphaera radiata Popofsky 1912

pl. 1, figs. 11-12

Heliosphaera radiata n. sp. Popofsky, 1912, p. 98, text-fig. 10.

Hexactinium pachydermum Jørgensen 1899

pl. 3, fig. 8

Hexactinium pachydermum n. sp. Jørgensen, 1899, p. 53.

Hexactinium pachydermum Jørgensen. Jørgensen, 1905, p. 115-116, pl. 8, fig. 31; Bjørklund, 1976b, pl. 1, figs. 4-9 [type specimens or topotypes].

Hexactinium laevigatum Haeckel 1887

pl. 3, figs. 9-10

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Hexacontium (Hexacontanna) laevigatum n. sp. Haeckel, 1887, p. 193, pl. 24, fig. 6.

Hexacontium laevigatum Haeckel. Nigrini and Moore, 1979, S47-48, pl. 5, figs. 2a, 2b.

***Hexacontium sarmentum* Su 1982**

pl. 3, fig. 1

Hexacontium sarmentum n. sp. Su, 1982, p. 276-277, 282, pl. 1, figs. 5, 6.

Remarks: This species resembles *Actinomma haysi* Bjørklund (1976a), however differs from it by thinner cortical shell and longer radial spines.

***Hexacontium* sp.**

pl. 3, figs. 3, 7

Remarks: The present form is characterized by spherical cortical shell with many thin thorns. Three-bladed spines extend outward from the subspherical medullary shell.

***Rhizoplegma boreale* (Cleve 1899)**

pl. 4, figs. 7-8

Hexadoras borealis n. sp. Cleve, 1899, p. 30, pl. 2, figs. 4a-4c.

Rhizoplegma boreale (Cleve). Jørgensen, 1899, p. 61-62; Jørgensen, 1905, p. 118, pl. 9, fig. 38, pl. 10, figs. 38e, 38f; Bjørklund, 1976b, pl. 3, figs. 10-16, pl. 4, figs. 1-3.

***Sphaeropyle langii* Dreyer 1899**

pl. 2, figs. 7, 9

Sphaeropyle langii n. sp. Dreyer, 1889, p. 89, fig. 54.

***Spongosphaera streptacantha* Haeckel 1860b**

pl. 4, fig. 6

Spongosphaera streptacantha n. sp. Haeckel, 1860b, p. 840-841.

Spongosphaera streptacantha Haeckel. Haeckel, 1862, p. 455-456, pl. 26, figs. 1-3; Takahashi, 1991, p. 65, pl. 7, fig. 6.

***Stylosphaera melpomene* Haeckel 1887**

pl. 3, figs. 11-12

Stylosphaera (Stylosphaerella) melpomene n. sp. Haeckel, 1887, p. 135-136, pl. 16, fig. 1.

Stylosphaera melpomene Haeckel. Takahashi and Honjo, 1981, p. 147, pl. 2, fig. 14.

Family PHACODISCIDAE Haeckel

***Heliodiscus asteriscus* Haeckel 1887**

pl. 5, fig. 1

Heliodiscus (Heliodiscetta) asteriscus n. sp. Haeckel, 1887, p. 445, pl. 33, fig. 8.

Heliodiscus asteriscus Haeckel. Nigrini and Moore, 1979, S73-74, pl. 9, figs. 1, 2.

***Heliodiscus echiniscus* Haeckel 1887**

pl. 5, figs. 2-4

Heliodiscus (Heliodiscilla) echiniscus n. sp. Haeckel, 1887, p. 448, pl. 34, fig. 5.

Heliodiscus echiniscus Haeckel. Nigrini, 1967, p. 34-35, pl. 3, figs. 2a, 2b.

Family COCCODISCIDAE Haeckel

***Didymocystis tetrathalamus* (Haeckel 1887)**

pl. 5, figs. 5-8

Panartus (Panarella) tetrathalamus n. sp. Haeckel, 1887, p. 378, p. 40, fig. 3.

Ommatartus tetrathalamus (Haeckel). Riedel and Sanfilippo, 1971, p. 1588, pl. 1c, figs. 5-7.

Didymocystis tetrathalamus (Haeckel). Sanfilippo and Riedel, 1980, text-fig. 1g; Boltovskoy and Riedel, 1987, p. 98, pl. III, figs. 1, 1a.

***Spongoliva ellipsoides* Popofsky**

pl. 5, figs. 9-12

Spongoliva ellipsoides n. sp. Popofsky, 1912, p. 117, text-fig. 28.

Cyassis irregularis n. sp. Nigrini, 1968, p. 53, pl. 1, figs. 2a-2c.

Spongoliva cf. ellipsoides Popofsky. Takahashi and Honjo, 1981, p. 148, pl. 1, fig. 17.

Family PORODISCIDAE Haeckel

***Amphirhopalum ypsilon* Haeckel 1887**

pl. 7, fig. 9

Amphirhopalum (Amphirhopoma) ypsilon n. sp. Haeckel, 1887, p. 522.

Amphicraspedum (Amphicraspedina) wyvilleanum n. sp. Haeckel, 1887, p. 523, pl. 45, fig. 12.

Amphirhopalum ypsilon Haeckel [sic]. Nigrini and Moore, 1979, S75-77, pl. 10, figs. 1a, 1b, 1c, 1d, 1e.

***Circodiscus microporus* (Stöhr 1880)**

pl. 7, fig. 8

Trematodiscus microporus n. sp. Stöhr, 1880, p. 108, pl. 4, fig. 17.

Porodiscus (Trematodiscus) microporus (Stöhr). Haeckel, 1887, p. 493.

Circodiscus microporus (Stöhr). Petrushevskaya and Kozlova, 1972, p. 526, pl. 19, figs. 1-7.

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Porodiscus microporous (Stöhr). Renz, 1974, p. 794, pl. 15, fig. 16.

Triastrum aurivillii n. sp. Cleve, 1901, p. 53, pl. 7, figs. 16, 17.

***Euchitonita furcata* Ehrenberg 1872a**

pl. 6, figs. 1-8

Euchitonita furcata n. sp. Ehrenberg 1872a, p. 308.

Euchitonita furcata Ehrenberg. Ehrenberg, 1872b, p. 288-289, pl. 6, fig. III-6; Nigrini and Moore, 1979, S85-86, pl. 11, figs. 2a, 2b.

***Flustrella* sp.**

pl. 7, fig. 4

***Stylochlamydium venustum* (Bailey 1856)**

pl. 7, figs. 1-3

Perichlamidium venustum n. sp. Bailey, 1856, p. 5, pl. 1, figs. 16, 17.

Perichlamidium venustum Bailey. Itaki and Bjørklund 2006, p. 458, pl. 4, figs. 1-4, 7, pl. 5., fig. 1 [lectotype and paralectotypes by reexamination of the type specimens].

Stylochlamydium (Stylochlamys) venustum (Bailey). Haeckel, 1887, p. 515.

Stylochlamydium venustum (Bailey). Ling et al., 1971, p. 711-712, pl. 1, figs. 7, 8.

Spongotorchus (?) *venustum* (Bailey). Nigrini and Moore, 1979, S119-120, pl. 15, figs. 3a, 3b.

Remarks: The present species resembles *Perichlamydium praetextum* (Ehrenberg), which was shown its figure in Ehrenberg (1854, pl. 22, fig. 20). Futher taxonomic study may be required.

***Styłodictya stellata* Bailey 1856 group**

pl. 7, figs. 5-7

Styłodictya stellata n. sp. Bailey, 1856, p. 5-6, pl. 1, fig. 20.

Styłodictya stellata Bailey. Kruglikova, 1969, pl. 4, figs. 9, 10; Itaki and Bjørklund 2006, p. 458, pl. 5, figs. 3-7 [lectotype and paralectotypes by reexamination of the type specimens]; Itaki et al., 2008, pl. 2, figs. 10-11.

Styłodictya validispina n. sp. Jørgensen, 1905, p. 119, pl. 10, fig. 40.

Styłodictya validispina Jørgensen. Bjørklund, 1976b, pl. 4, fig. 4 [type specimen or topotype].

Styłodictya stellata Bailey group. Petrushevskaya, 1975, p. 576, pl. 6, fig. 9.

***Triastrum aurivillii* Cleve 1901**

pl. 7, fig. 10

Family SPONGODISCIDAE Haeckel

***Dictyocoryne profunda* Ehrenberg 1872a**

pl. 7, fig. 15

Dictyocoryne profunda n. sp. Ehrenberg, 1872a, p. 307.

Dictyocoryne profunda Ehrenberg. Ehrenberg, 1872b, p. 288-289, pl. 6, fig. 23; Boltovskoy and Riedel, 1980, p. 115-116, pl. 3, fig. 10.

Hymeniastrum euclidis Haeckel. Nigrini and Moore, 1979, S91-92, pl. 12, fig. 3.

***Dictyocoryne truncatum* (Ehrenberg 1861)**

pl. 7, figs. 11-14

Rhopalodictyum truncatum n. sp. Ehrenberg, 1861, p. 301.

Dictyocoryne truncatum (Ehrenberg). Nigrini and Moore, 1979, S89-90, pl. 12, figs. 2a, 2b.

***Spongaster tetras* tetras Ehrenberg 1861**

pl. 8, fig. 1

Spongaster tetras n. sp. Ehrenberg, 1861, p. 301.

Spongaster tetras Ehrenberg. Ehrenberg, 1872b, p. 298-299, pl. 6, fig. III-8.

Spongaster tetras *tetras* Ehrenberg. Nigrini, 1967, p. 41-43, pl. 5, figs. 1a, 1b.

***Spongaster tetras* Ehrenberg *irregularis* Nigrini 1967**

pl. 8, fig. 2

Spongaster tetras Ehrenberg *irregularis* n. subsp. Nigrini, 1967, p. 43-44, pl. 5, fig. 2.

***Spongaster* sp.**

pl. 8, figs. 3-5

***Spongodiscus resurgens* Ehrenberg 1854**

pl. 8, figs. 8-9

Spongodiscus resurgens n. sp. Ehrenberg, 1854, pl. 35B-B.IV, fig. 16.

Spongodiscus resurgens Ehrenberg. Takahashi, 1991, p. 84, pl., 19, fig. 1.

***Spongodiscus biconcavus* Haeckel 1887**

pl. 8, figs. 11-12

Spongodiscus (*Spongodisculus*) *biconcavus* n. sp. Haeckel 1887, p. 577.

Spongodiscus biconcavus Haeckel. Popofsky, 1912, p. 143-144, pl. 6, fig. 2; Takahashi, 1991, p. 84, pl., 19, fig. 10.

- Spongotrochus glacialis* Popofsky 1908, group**
pl. 8, figs. 10, pl. 9, figs. 1-5
- Spongotrochus glacialis* n. sp. Popofsky, 1908, p. 228-229, pl. 26, fig. 8, pl. 27, fig. 1, pl. 28, fig. 2.
- Spongotrochus glacialis* Popofsky. Petrushevskaya 1968, p. 40-50, figs. 21 (I-VII), 22 (I-VII), 26 (II).
- Schizodiscus stylotrochoides* Dogiel n. sp. Dogiel and Reshetnyak, 1952, p. 11, fig. 5.
- Schizodiscus stylotrochoides* Dogiel. Petrushevskaya 1968, figs. 23 (I-III).
- “*Spongotrochus beringianus* Dogiel”. Petrushevskaya, 1968, figs. 24 (I-III), 25 (I-V).
- Spongotrochus glacialis* Popofsky group. Petrushevskaya 1975, p. 575, pl. 5, fig. 8, pl. 34, fig. 6, pl. 35, figs. 1-6.
- Remarks:** Two forms of plate 9, figures 4 and 5 might be the same as “*Spongotrochus beringianus* Dogiel”, which Petrushevskaya (1968) regarded as a new species of Dogiel in her literature. A specimen of plate 8, figure 10 resembles *Spongotrochus brevispinus* Haeckel (1860b; figures in 1862, pl. 27, figs. 4-5).
- Spongocore cylindrica* (Haeckel 1860b)**
pl. 8, fig. 6
- Spongurus cylindricus* n. sp. Haeckel, 1860b, p. 844-845.
- Spongurus cylindricus* Haeckel. Haeckel, 1862, p. 465-466, pl. 27, fig. 1.
- Spongocore cylindrica* (Haeckel). Boltovskoy and Riedel, 1980, p. 116, pl. 3, fig. 12.
- Spongurus* cf. *elliptica* (Ehrenberg)**
pl. 11, fig. 10
- Acanthosphaera elliptica* n. sp. Ehrenberg, 1872a, p. 301.
- Acanthosphaera elliptica* Ehrenberg, Ehrenberg, 1872b, p. 284-285, pl. 7, fig. 4.
- Spongurus* cf. *elliptica* (Ehrenberg). Nigrini and Moore, 1979, S63-64, pl. 8, fig. 2.
- Spongurus pylomaticus* Riedel 1858**
pl. 8, fig. 7
- Spongurus pylomaticus* n. sp. Riedel, 1958, p. 226, pl. 1, figs. 10, 11.
- Spongurus pylomaticus* Riedel. Nigrini and Moore, 1979, S65-66, pl. 8, figs. 3a, 3b.
- Family PYLONIIDAE Haeckel**
***Octopyle stenozona* Haeckel 1887**
pl. 10, figs. 11-13
- Octopyle (Octopylura) stenozona* n. sp. Haeckel, 1887, p. 652,

pl. 9, fig. 11.
Octopyle stenozona Haeckel. Nigrini and Moore, 1979, S123-124, pl. 16, figs. 2a, 2b.

Remarks: The present species is similar to the *Tetrapyle octacantha* Müller group, but different from the latter by narrow second transverse and lateral girdles, a pair of the heavy cyrindrical beams arising from the inner shell and its generally quadrangular outline.

***Phorticium polycladum* Tan and Tchang 1976**

pl. 11, fig. 4
Phorticium polycladum n. sp. Tan and Tchang, 1976, p. 267, text-figs. 39a, 39b.

***Phorticium pylonium* Haeckel 1887**

pl. 11, figs. 1-2
Phorticium (Phortopyle) pylonium n. sp. Haeckel, 1887, p. 709, pl. 49, fig. 10.

***Streblacantha circumtexta* (Jørgensen 1899)**

pl. 11, fig. 3
Sorolarcus circumtextus n. sp. Jørgensen, 1899, p. 65.
Streblacantha circumtexta (Jørgensen). Jørgensen, 1905, p. 121-122, pl. 11, fig. 46, pl. 12, fig. 46; Bjørklund, 1976b, pl. 5, figs. 9-12 [type specimens or topotypes].

***Tetrapyle octacantha* Müller 1858, group**

pl. 10, figs. 1-10
Tetrapyle octacantha n. sp. Müller, 1858, p. 33-35, pl. 2, figs. 11, 12, pl. 3, figs. 1-6.
Tetrapyle octacantha Müller. Nigrini and Moore, 1979, S125-126, pl. 16, figs. 3a, 3b.
Tetrapyle (Tetrapylissa) circularis n. sp. Haeckel, 1887, p. 645, pl. 9, fig. 8.
Tetrapyle circularis Haeckel. Tan and Tchang, 1976, p. 259-260, text-fig. 28.
Schizomma quadrilobum n. sp. Ehrenberg, 1861, p. 301.
Schizomma quadrilobum Ehrenberg. Ehrenberg, 1872b, p. 149, 159, 298-299, pl. 10, figs. 12-14.
Tetrapyle quadriloba (Ehrenberg). Haeckel, 1862, p. 436; Stöhr, 1880, p. 89, pl. 1, fig. 15; Popofsky, 1912, p. 150-151, text-figs. 70-72.
Tetrapyle octacantha Müller group, Itaki et al., 2007, p. 117, 122, pl. 1, figs. 6-12.
Octopyle octospinosa n. sp. Tan and Tchang, 1976, p. 262, 307-306, figs. 32a-e.

Remarks: This species group has included many similar forms previously described. Two forms of plate 10, figures

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8 and 10 have a pair of cylindrical beams arising from both polar axis of the inner shell and joining with the second lateral girdle. This character is similar to genus *Octopyle*, however it seems to be unstable structure as shown in plate 10, figures 4 and 9. Therefore, such form (i.g. *Octopyle octospinosa* Tan and Tchang) is regarded as the *T. octacantha* group in this paper.

Family LITHELIIDAE Haeckel

Litheliidae gen. et sp. indet. C

pl. 11, fig. 13

Larcopyle buetschlii Dreyer 1889

Plate 11, Figure 11; Plate 12, Figures 1-21

Larcopyle buetschlii n. sp. Dreyer, 1889, p. 124-125, fig. 70.

Larcopyle buetschlii Dreyer. Takahashi and Honjo, 1981, p. 150, pl. 5, fig. 15.

Larcopyle buetschlii Dreyer [sic]. Nigrini and Moore, 1979, S131-132, pl. 17, figs. 1a, 1b.

Remarks: Well-developed forms of the present species found in the Japan Sea have somewhat thicker cortical shell than that of original figure by Dreyer (1889), and are rather similar to *Larcopyle polyacantha polyacantha* (Campbell and Clark) of Lazarus et al. (2005). Further taxonomic study may be required.

Larcopyle weddellium Lazarus, Faust and Popova-Goll

2005

pl. 11, fig. 5

Larcopyle weddellium n. sp. Lazarus, Faust and Popova, 2005, p. 117-119, pl. 10, figs. 1-14.

Larcopyle nebulum Lazarus, Faust and Popova-Goll

2005

pl. 11, fig. 9

Larcopyle nebulum n. sp. Lazarus, Faust and Popova, 2005, p. 111, pl. 5, figs. 1-13.

Larcospira minor (Jørgensen 1899)

pl. 11, figs. 6-8

Lithelius minor n. sp. Jørgensen, 1899, p. 65-66, pl. 5, fig. 24.

Lithelius minor Jørgensen. Nigrini and Moore, 1979, S135-136, pl. 17, figs. 3, 4a, 4b.

Larcospira minor (Jørgensen). Jørgensen, 1905, p. 121; Bjørklund, 1976b, pl. 5, figs. 2-8 [type specimens or topotypes].

Larcospira quadrangula Haeckel 1887

pl. 10, figs. 14-15

Larcospira (Larcospirema) quadrangula n. sp. Haeckel, 1887, p. 696, pl. 49, fig. 3.

Larcospira quadrangula Haeckel. Nigrini and Moore, 1979, S133-134, pl. 17, fig. 2.

Tholospira cervicornis Haeckel 1887

pl. 11, figs. 14-17

Tholospira (Tholospiromium) cervicornis n. sp. Haeckel, 1887, p. 700, pl. 49, fig. 5.

Tholospira cervicornis Haeckel. Popofsky, 1912, p. 152, text-fig. 73; Takahashi and Honjo, 1981, p. 150, pl. 5, figs. 16-18.

Tholospira sp.

pl. 11, fig. 12

Order NASSELLARIA Ehrenberg

Family ACANTHODESMIIDAE Haeckel

Acanthodesmia vinculata Müller 1857

pl. 13, figs. 1-3

Lithocircus vinculatus n. sp. Müller, 1857, p. 484.

Acanthodesmia vinculata Müller, 1858, p. 30, pl. 1, figs. 4-6 (non fig. 7).

Eucoronis (Acrocoronis) angulata n. sp. Haeckel, 1887, p. 978, pl. 82, fig. 3.

Acanthodesmia viniculata (Müller) [sic]. Petrushevskaya, 1971, p. 278-279, fig. 143 (I-VII), figs. 144 (I-VI).

Giraffospyris angulata (Haeckel). Goll, 1972a, p. 965, pl. 63, figs. 1-4; Nigrini and Moore, 1979, N11-12, pl. 19, figs. 2a-2d, 3a, 3b.

Eucoronis (Lithocoronis) challengerii n. sp. Haeckel, 1887, p. 978, pl. 82, fig. 4.

Eucoronis challengerii Haeckel. Tan and Tchang, 1976, p. 272, text-fig. 44.

Acanthodesmia micropora (Popofsky 1908)

pl. 13, figs. 4-5

Semantis micropora n. sp. Popofsky, 1908, p. 268, pl. 30, fig. 4.

Acanthodesmia micropora (Popofsky). Petrushevskaya, 1971, p. 279, fig. 16 (VI), figs. 135 (I-IX).

Ceratospyris borealis Bailey 1856

pl. 13, figs. 6, 10, 11

Ceratospyris borealis n. sp. Bailey, 1856, p. 3, pl. 1, fig. 3.

Ceratospyris borealis Bailey. Nigrini and Moore, 1979, N9-10, pl. 19, figs. 1a-1d; Itaki and Bjørklund, 2006, p. 450, pl. 1, figs. 3-8 [lectotype and paralectotypes by examination

of the type specimens].

Tristylospyris sp. Nigrini, 1970, p. 170, pl. 3, figs. 3-6.

Triceraspyris (?) sp. Ling et al., 1971, p. 713-714, pl. 2, figs. 1-3.

Tholospyris borealis (Bailey). Kruglikova, 1974, p. 192-193, pl. 2, fig. 9.

***Ceratospyris* cf. *borealis* Bailey 1856**

pl. 13, fig. 9

***Ceratospyris* sp.**

pl. 13, fig. 19

***Clathrocircus stapedius* Haeckel 1887**

Pl. 13, figs. 13-14

Clathrocircus stapedius n. sp. Haeckel, 1887, p. 962, pl. 92, fig. 8.

Clathrocircus stapedius Haeckel. Goll, 1972a, p. 963, pl. 51, fig. 3.

***Clathrocircus* sp.**

pl. 13, fig. 12

***Eucoronis* sp.**

pl. 13, fig. 7

***Tholospyris rhombus* (Haeckel 1887)**

pl. 13, fig. 8

Archicircus rhombus n. sp. Haeckel, 1887, p. 942, pl. 81, fig. 7.

Tholospyris rhombus (Haeckel). Goll, 1972b, p. 455, pl. 16, figs. 1-11.

***Lophospyris pentagona* (Ehrenberg 1872a)**

pl. 13, fig. 20

Ceratospyris pentagona n. sp. Ehrenberg, 1872a, p. 303.

Ceratospyris pentagona Ehrenberg. Ehrenberg, 1872b, p. 286-287, pl. 10, fig. 15.

Lophospyris pentagona Ehrenberg. Petrushevskaya, 1971, p. 254, figs. 132 (I-IX).

***Phormospyris stabilis* (Goll) *scaphipes* (Haeckel 1887)**

pl. 13, figs. 15-16

Tristylospyris (*Tristylospyrula*) *scaphipes* n. sp. Haeckel, 1887, p. 1033, pl. 84, fig. 13.

Tholospyris scaphipes (Haeckel). Goll, 1969, p. 328-329, pl. 58, figs. 1-8, 13, 14, text-fig. 1; Goll, 1972a, p. 969, pl. 82, figs. 1-4, pl. 83, fig. 1.

Phormospyris stabilis scaphipes (Haeckel). Goll, 1976, p. 394, 396, pl. 8, figs. 1-15, pl. 9, figs. 1-5; Nigrini and Moore, 1979, N19-20, pl. 20, figs. 2a-2d.

***Phormospyris stabilis* Goll *capoi* Goll 1976**

pl. 13, figs. 17-18

Phormospyris stabilis capoi n. sp. Goll, 1976, p. 392, 394, pl. 5, figs. 1, 2, pl. 6, figs. 1-8, 13, pl. 7, figs. 1-3, 5-8.

***Zygocircus productus* (Hertwig 1879) group**

pl. 14, figs. 1-15

Lithocircus productus n. sp. Hertwig, 1879, p. 69, pl. 7, fig. 4.

Zygocircus productus (Hertwig). Petrushevskaya, 1969, p. 644, pl. 3, fig. 3, pl. 6, fig. 11; Petrushevskaya, 1971, p. 281, fig. 16 (II), figs. 145 (X, XI).

Zygocircus productus productus (Hertwig). Goll, 1979, p. 382, pl. 2, fig. 3.

Zygocircus productus (Hertwig) group. Takahashi, 1991, p. 101, pl. 27, figs. 13, 14.

Family PLAGIACANTHIDAE Hertwig

***Acanthocorys castanoides* Tan and Tchang 1976**

pl. 14, figs. 16-24

Acanthocorys castanoides n. sp. Tan and Tchang, 1976, p. 281, 309-310, figs. 57a-57c.

Remarks: This species is similar to *Antarctissa* (?) sp. 1 and *Antarctissa* (?) sp. 2 of Nimmergut (2002), however it is distinguished from them by slightly campanulate thorax.

***Acanthocorys* cf. *castanoides* Tan and Tchang 1976**

Plate 14, Figure 25

***Antarctissa* (?) sp. 2 of Nimmergut (2002)**

pl. 14, fig. 26, pl. 16, fig. 3

Antarctissa (?) sp. 2. Nimmergut 2002, p. 132, pl. 1, fig. 4, pl. 6, figs. 1, 2.

***Arachnocorallium calvata* (Haeckel 1887)**

pl. 16, figs. 16-17

Psilomelissa calvata n. sp. Haeckel, 1887, p. 1209, pl. 56, fig. 3.

Arachnocorallium calvata (Haeckel). Petrushevskaya, 1971, p. 136-137, fig. 57 (VI), figs. 70 (I-VIII).

***Arachnocorallium* aff. *calvata* (Haeckel 1887)**

pl. 16, fig. 23

***Arachnocorallium circumtexta* Haeckel 1860b**

pl. 14, fig. 35

Arachnocorallium circumtexta n. sp. Haeckel, 1860b p. 837-838.

Arachnocorallium circumtexta Haeckel. Haeckel, 1862, p. 304-305, pl. 6, figs. 9-11; Petrushevskaya, 1971, p. 125, 128, fig.

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65 (III-V), figs. 67 (I-II).

***Arachnocorys dubius* Dogiel in Dogiel and Reshetnyak (1952)**
pl. 14, figs. 27-34

Arachnocorys dubius Dogiel n. sp. Dogiel and Reshetnyak, 1952, p. 19-20, fig. 12.

Plectacantha (=*Arachnocorys*) *dubius* Dogiel. Petrushevskaya, 1971, figs. 71 (III-V).

***Arachnocorys pentacantha* Popofsky 1913**
pl. 14, figs. 36-38

Arachnocorys pentacantha n. sp. Popofsky, 1913, p. 366-368, pl. 32, figs. 5, 6, text-figs. 84-86.

Arachnocorys pentacantha Popofsky. Petrushevskaya, 1971, p. 128-129, figs. 65 (VIII-IX), figs. 66 (V-VI).

***Arachnocorys umbellifera* Haeckel 1860b**
pl. 14, fig. 39

Arachnocorys umbellifera n. sp. Haeckel, 1860b, p. 837-838.

Arachnocorys umbellifera Haeckel, 1862, p. 305-306, pl. 6, fig. 12; Petrushevskaya, 1971, p. 125, figs. 65 (VI-VII), figs. 66 (I-IV).

***Archipera triclavigera* Tan and Tchang 1976**
pl. 16, figs. 14, 21, 22, 29

Archipera triclavigera n. sp. Tan and Tchang, 1976, p. 273-274, 308-309, figs. 47a-47c.

***Archiscenium tricolpium* (Haeckel 1887)**
pl. 18, figs. 1-2

Euscenium (*Euscenarium*) *tricolpium* n. sp. Haeckel, 1887, p. 1147, pl. 53, fig. 12.

Archiscenium tricolpium (Haeckel). Petrushevskaya, 1971, p. 75-76, pl. 36, fig. 2.

***Dimelissa thoracites* (Haeckel 1860b)**
pl. 15, figs. 1-8

Lithomelissa thoracites n. sp. Haeckel, 1860b, p. 836-837.

Lithomelissa thoracites Haeckel. Haeckel, 1862, p. 301-302, pl. 6, figs. 2-8.

Dimelissa thoracites (Haeckel). Petrushevskaya, 1971, p. 134, pl. 69, figs. 7, 8.

***Dimelissa aff. thoracites* (Haeckel 1860b)**
pl. 15, figs. 14-16

***Lithomelissa setosa* Jørgensen 1905**

pl. 15, figs. 38-45

Lithomelissa setosa (Cleve). Jørgensen 1899, p. 81-82, pl. 4, fig. 21.

Lithomelissa setosa n. sp. Jørgensen, 1905, p. 135-136, pl. 16, figs. 81-83, pl. 18, fig. 108.

Lithomelissa setosa Jørgensen. Bjørklund 1974, p. 24-26, figs. 8A-H; Bjørklund 1976b, pl. 8, figs. 1-13 [type specimens or topotypes], pl. 11, figs. 19-23; Itaki et al., in press, pl. 1, figs. 7-11.

***Lithomelissa laticeps* Jørgensen 1905**

pl. 15, figs. 31-32

Lithomelissa laticeps n. sp. Jørgensen, 1905, p. 136, pl. 16, fig. 84.

***Lithomelissa* sp. A**
pl. 16, figs. 4-5

***Lithomelissa* sp. B**
pl. 16, fig. 1

***Lithomelissa* sp. C**
pl. 16, fig. 2

***Lithomelissa* sp. D of Itaki et al. (2008)**

pl. 17, figs. 15-23

Lithomelissa sp. D. Itaki et al., 2008, pl. 1, fig. 6.

Lithomelissa setosa Jørgensen. Takahashi, 1987, p. 230, fig. 5e.

***Lophophphaena hispida* (Ehrenberg 1861)**
pl. 15, figs. 34-37

Dictyocephalus hispidus n. sp. Ehrenberg, 1861, p. 298.

Dictyocephalus hispidus Ehrenberg. Ehrenberg, 1872b, p. 288-289, pl. 5, fig. 18.

Lophophphaena hispida (Ehrenberg). Petrushevskaya, 1971, p. 115, 117, fig. 57 (IV), figs. 61 (I-III).

***Lophophphaena cf. hispida* (Ehrenberg 1861)**
pl. 15, figs. 27, 29, 30

***Lophophphaena variabilis* (Popofsky 1913)**
pl. 15, figs. 21-23

Acanthocorys variabilis n. sp. Popofsky, 1913, p. 360-364, text-figs. 71-81.

Lophophphaena variabilis (Popofsky). Petrushevskaya, 1971, p. 111, figs. 57 (II-III), figs. 59 (III-VI).

***Lophophphaena buetschlii* (Haeckel 1887)**
pl. 15, figs. 20, 24-26

Lithomelissa (*Micromelissa*) *buetschlii* n. sp. Haeckel, 1887, p. 1207, pl. 56, fig. 1.

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Lophophphaena buetschlii (Haeckel). Petrushevskaya, 1971, p. 109-111, figs. 58 (I-X).

Lophophphaena cylindrica (Cleve 1900)

pl. 15, figs. 28

*Dictyocephalus cylindricus*n. sp. Cleve, 1900, p. 7, pl. 4, fig. 10.

Lophophphaena cylindrica (Cleve). Petrushevskaya, 1971, p. 117, fig. 57 (V), figs. 61 (IV-VI).

Lophophhaenoma witjazii Petrushevskaya 1971

pl. 15, fig. 33

Lophophhaenoma witjazii n. sp. Petrushevskaya, 1971, p. 118, figs. 62 (III-VII).

Lophophphaena sp. A

pl. 16, figs. 6-10

Lophophphaena sp. B

pl. 16, figs. 11-13, 15, 18

Lophophphaena sp. C

pl. 16, figs. 20, 25

Lophophphaena sp. D

pl. 16, fig. 19

Lophophphaena sp. F

pl. 15, figs. 9, 10, 19

Lophophphaena spp.

pl. 15, figs. 11-13, 17-18

Neosemantis distephanus (Haeckel 1887)

Plate 16, Figures 31-33

Semantis distephanus n. sp. Haeckel, 1887, p. 957, pl. 83, fig. 3.

Neosemantis distephanus (Haeckel). Popofsky, 1913, p. 299, pl. 29, fig. 2.

Neosemantis distephanus (Haeckel) – Petrushevskaya, 1971, p. 152, 154, figs. 77 (I-III).

Neosemantis bjoerkundi Goll *bjoerkundi* Goll 1979

pl. 16, fig. 30

Neosemantis bjoerkundi n. sp. Goll *bjoerkundi* n. subsp. Goll, 1979, p. 384, pl. 2, figs. 10-16.

Peridium spinipes Haeckel 1887

pl. 16, figs. 26-28

Peridium (Archiperidium) spinipes n. sp. Haeckel, 1887, p. 1154, pl. 53, fig. 9.

Peridium spinipes Haeckel. Popofsky, 1913, p. 327-329, text-figs. 31, 32 (not 33, 34).

Phormacantha hystrix (Jørgensen 1899)

pl. 16, figs. 34-37

Peridium hystrix n. sp. Jørgensen, 1899, p. 76-77.

Phormacantha hystrix (Jørgensen). Jørgensen 1905, p. 132, pl. 14, figs. 59-63; Petrushevskaya, 1971, p. 129, fig. 68 (I-V); Bjørklund, 1976b, p. 1138, pl. 6, figs. 12-18 [type specimens or topotypes].

Plectacantha cremastoplegma Nigrini 1968

pl. 17, figs. 1-4

Plectacantha cremastoplegma n. sp. Nigrini, 1968, p. 55, pl. 1, fig. 3a, 3b, 3c, text-fig. 2.

Plectacantha oikiskos Jørgensen 1905

pl. 16, figs. 41-45

Plectacantha oikiskos n. sp. Jørgensen, 1905, p. 131-132, pl. 13, figs. 50-57.

Plectacantha oikiskos Jørgensen. Bjørklund, 1976b, pl. 6, figs. 8-10 [type specimens or topotypes].

Plectacantha trichoides Jørgensen 1905

pl. 16, figs. 38-40

Plectacantha trichoides n. sp. Jørgensen, 1905, p. 132, pl. 13, fig. 58.

Plectacantha trichoides Jørgensen. Petrushevskaya, 1971, p. 140, figs. 68 (VI-IX); Bjørklund, 1976, pl. 6, fig. 11 [type specimen or topotype].

Plectacantha sp. A

pl. 16, fig. 24

Plectacantha sp. B

pl. 17, figs. 5-6

Pseudocubus obeliscus Haeckel 1887

pl. 17, figs. 7-10

Pseudocubus obeliscus n. sp. Haeckel, 1887, p. 1010, pl. 94, fig. 11.

Pseudocubus obeliscus Haeckel. Petrushevskaya, 1971, p. 150, figs. 76 (I-VI).

Pseudocubus octostylus Haeckel 1887

pl. 17, figs. 11-12

Pseudocubus octostylus n. sp. Haeckel, 1887, p. 1010.

Pseudocubus octostylus Haeckel. Petrushevskaya, 1971, p. 150, fig. 71 (XIV), fig. 75 (VII).

Pseudocubus sp.
pl. 17, figs. 13-14

Ceratocyrtis sp. B
pl. 19, figs. 11-20

Pseudodictyophimus gracilipes (Bailey 1856)
pl. 17, figs. 24-28

Dictyophimus gracilipes n. sp. Bailey, 1856, p. 4, pl. 1, fig. 8.
Dictyophimus gracilipes Bailey. Itaki and Bjørklund, 2006, p. 452, pl. 1, figs. 18, 19 [lectotype and paralectotype].
Pseudodictyophimus gracilipes (Bailey). Petrushevskaya, 1971, p. 93, 95, fig. 35 (VII), figs. 47 (I-VIII), figs. 48 (I-VI), figs. 49 (I-VII).

Pseudodictyophimus sp.
pl. 18, fig. 3

Pteroscenium pinnatum Haeckel 1887
pl. 18, figs. 4-5

Pteroscenium pinnatum n. sp. Haeckel, 1887, p. 1152, pl. 53, figs. 14-16.

Tetraplecta pinigera Haeckel 1887
pl. 18, figs. 6-7

Tetraplecta pinigera n. sp. Haeckel, 1887, p. 924, pl. 91, fig. 8.
Tetraplecta pinigera Haeckel. Takahashi, 1991, p. 93, pl. 24, figs. 1-5.

Trisulcus sp.
pl. 15, fig. 46

Family SETHOPHORMIDIDAE Haeckel
Ceratocyrtis galeus (Cleve 1899)
pl. 19, figs. 3-10

Sethoconus galea n. sp. Cleve, 1899, p. 33, pl. 4, fig. 3.
Sethoconus (?) *galea* Cleve. Petrushevskaya, 1968, p. 90-92, fig. 52(II).

Ceratocyrtis galeus (Cleve). Bjørklund, 1976b, pl. 11, figs. 1-3.

Ceratocyrtis historicosa (Jørgensen 1905)
pl. 20, figs. 1-3, 7-8

Helotholus histrionica n. sp. Jørgensen, 1905, p. 137, pl. 16, figs. 86-88.

Ceratocyrtis histrionica (Jørgensen). Petrushevskaya, 1971, p. 98, 101, figs. 52 (II-IV).

Ceratocyrtis histrionica (Jørgensen). Bjørklund, 1976b, pl. 8, figs. 19-24 [type specimens or topotypes].

Ceratocyrtis sp. A
pl. 20, figs. 4-6

Ceratocyrtis spp. (young form)
pl. 19, figs. 1-2

Corocalyptra kruegeri Popofsky 1908
pl. 21, figs. 24-26

Corocalyptra kruegeri n. sp. Popofsky, 1908, p. 289, pl. 35, fig. 8.
Coracalyptra kruegeri Popofsky [sic]. Popofsky, 1913, p. 381-383, text-figs. 96-98; Renz, 1976, p. 119, pl. 4, fig. 6.

Eucecrysphalus cervus (Ehrenberg 1872a)
pl. 20, figs. 9-17

Eucyrtidium cervus n. sp. Ehrenberg, 1872a, p. 308.
Eucyrtidium cervus Ehrenberg. Ehrenberg, 1872b, p. 290-291, pl. 9, fig. 21.
Eucecrysphalus cervus (Ehrenberg). Petrushevskaya, 1971, p. 223-224, figs. 104 (I-VII).

Eucecrysphalus elisabethae (Haeckel 1887)
pl. 20, fig. 19

Corocalyptra elisabethae n. sp. Haeckel, 1887, p. 1323, pl. 59, fig. 10.
Eucecrysphalus elisabethae (Haeckel). Petrushevskaya, 1971, p. 224, figs. 105 (I-V).

Eucecrysphalus sp.
pl. 20, fig. 18

Lampromitra erosa Cleve 1900
pl. 18, figs. 8-9

Lampromitra erosa n. sp. Cleve, 1900, p. 10, pl. 4, figs. 2, 3.
Lampromitra erosa Cleve. Riedel et al., 1974, p. 710, pl. 59, fig. 13, pl. 62, fig. 7.
Lampromitra sinuosa n. sp. Popofsky, 1913, p. 347-348, pl. 31, figs. 1, 2.
Ceratocyrtis sinuosa (Popofsky). Petrushevskaya, 1971, p. 101, fig. 29 (V), figs. 53 (II-VI).

Tetraphormis callipilum Haeckel 1887
pl. 18, fig. 10

Theophormis callipilum n. sp. Haeckel, 1887, p. 1387, pl. 70, figs. 1-3.

Family THEOPERIDAE Haeckel***Cycladophora cornuta* (Bailey 1856)****pl. 21, fig. 14***Halicalyptera*(?) *cornuta* n. sp. Bailey, 1856, p. 5, pl. 1, figs. 13, 14.*Halicalyptera*(?) *cornuta* Bailey. Itaki and Bjørklund, 2006, p. 456, pl. 3, figs. 5-10 [lectotype and paralectotypes].*Cycladophora davisianna* (Ehrenberg) var. *cornutoides* n. var.

Petrushevskaya, 1968, p. 124, figs. 70 (I-III).

Cycladophora cornuta (Bailey). Kruglikova, 1975, fig. 3.5.***Cycladophora davisianna* Ehrenberg 1861****pl. 21, figs. 1-13***Cycladophora* (?) *davisianna* n. sp. Ehrenberg, 1861, p. 297.*Pterocodon davisiannus* n. sp. Ehrenberg, 1872b, p. 298-299, pl. 2, fig. 10.*Cycladophora davisianna* Ehrenberg. Ehrenberg, 1872b, p. 288-289, pl. 2, fig. 11; Petrushevskaya, 1968, p. 120-122, figs. 69 (I-VII); Motoyama, 1997, p. 50, pl. 1, figs. 4-10.*Theocalyptra davisianna* (Ehrenberg). Riedel, 1958, p. 239, pl. 4, figs. 2, 3, text-fig. 10.*Cycladophora davisianna davisianna* Ehrenberg. Bjørklund and Ciesielski, 1994, p. 74; pl. 1, figs. 1-15.***Dictyophimus* sp.****pl. 22, fig. 1*****Eucyrtidium acuminatum* (Ehrenberg 1844)****pl. 22, figs. 8-16***Lithocampe acuminata* n. sp. Ehrenberg, 1844, p. 84.*Eucyrtidium acuminatum* (Ehrenberg). Ehrenberg, 1847, p. 43; Ehrenberg, 1854, pl. 22, fig. 27; Petrushevskaya, 1971, p. 217-218, figs. 94 (I-VIII), figs. 95 (I-III); Nigrini and Moore, 1979, N61-62, pl. 24, figs. 3a, 3b.**Remarks:** The present form occurred in the Japan Sea is somewhat different its morphology (especially pore size) from the original figure by Ehrenberg (1854), however it is tentatively regarded as the present species in this paper.***Eucyrtidium anomalum* (Haeckel 1860b)****pl. 22, fig. 20***Lithocampe anomala* n. sp. Haeckel, 1860b, p. 839.*Eucyrtidium anomalum* (Haeckel). Haeckel, 1862, p. 323-324, pl. VII, figs. 11-13; Petrushevskaya, 1971, p. 219-220, figs. 98 (I-IV).***Eucyrtidium hexastichum* (Haeckel 1887)****pl. 22, figs. 18-19***Lithostrobus (Conostrobus) hexastichus* n. sp. Haeckel, 1887, p. 1470, pl. 80, fig. 15.*Eucyrtidium hexastichum* (Haeckel). Petrushevskaya, 1971, p. 220-221, figs. 99 (III-X).***Eucyrtidium* sp.****pl. 22, fig. 17*****Gondwanaria dogielii* (Petrushevskaya 1968)****pl. 21, fig. 15***Sethoconus* (?) *dogielii* n. sp. Petrushevskaya, 1968, p. 94, figs. 53 (I-II).*Gondwanaria dogielii* (Petrushevskaya) group. Petrushevskaya, 1975, p. 585.***Lithopera bacca* Ehrenberg 1872a****pl. 21, fig. 23***Lithopera bacca* n. sp. Ehrenberg, 1872a, p. 314-315.*Lithopera bacca* Ehrenberg. Ehrenberg, 1872b, p. 296-297, pl. 8, fig. 1; Sakai, 1980, p. 710, pl. 8, fig. 9.***Litharachnium tentrium* Haeckel 1860b****pl. 22, figs. 28-29***Litharachnium tentorium* n. sp. Haeckel, 1860b, p. 836.*Litharachnium tentorium* Haeckel. Haeckel, 1862, p. 281-282, pl. 4, figs. 7-10; Petrushevskaya, 1971, p. 227, figs. 108 (I-III), figs. 109 (I-IV).***Lipmanella dictyoceras* (Haeckel 1860b)****pl. 21, figs. 20-22***Lithornithium dictyoceras* n. sp. Haeckel, 1860b, p. 840.*Dictyoceras virchowii* Haeckel, 1862, p. 333-334, pl. 8, figs. 1-5 [unavailable name].*Dictyoceras virchowii* (Haeckel). Haeckel, 1887, p. 1325-1326; Takahashi and Honjo, 1981, p. 153, pl. 9, figs. 7, 8.*Lipmanella virchowii* (Haeckel). Petrushevskaya, 1971, figs. 100 (I-VIII).*Lipmanella dictyoceras* (Haeckel). Kling, 1973, p. 636, pl. 4, figs. 24-26; Kling, 1979, p. 309, pl. 2, fig. 8; Boltovskoy and Riedel, 1980, p. 125, pl. 5, fig. 12.***Lipmanella pyramidale* (Popofsky 1913)****pl. 21, figs. 16-17***Theopelium pyramidale* n. sp. Popofsky, 1913, p. 376, pl. 37, fig. 1.*Lipmanella pyramidale* (Popofsky). Takahashi, 1991, p. 121, pl. 40, fig. 18.***Lipmanella* sp.****pl. 21, fig. 18**

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***Lophocorys polyacantha* Popofsky 1913**

pl. 21, fig. 19

Lophocorys polyacantha n. sp. Popofsky, 1913, p. 400-401, text-fig. 122.

Lophocorys polyacantha Popofsky. Kling, 1979, p. 309, pl. 1, fig. 27.

***Pterocanium praetextum* (Ehrenberg 1872a)**

pl. 22, figs. 2-3

Lychnocanium praetextum n. sp. Ehrenberg, 1872a, p. 316.

Lychnocanium praetextum Ehrenberg. Ehrenberg, 1872b, p. 296-297, pl. 10, fig. 2.

Pterocanium (Pterocanarium) praetextum (Ehrenberg). Haeckel, 1887, p. 1330-1331.

Pterocanium praetextum (Ehrenberg). Petrushevskaya, 1971, p. 230, figs. 114 (I-III).

Pterocanium praetextum praetextum (Ehrenberg). Nigrini, 1967, p. 68-70, pl. 7, fig. 1; Nigrini and Moore, 1979, N41-42, pl. 23, fig. 2.

***Pterocanium* sp.**

pl. 22, figs. 4-5

***Stichocorys seriata* Jørgensen 1905**

pl. 22, figs. 21-27

Stichocorys seriata n. sp. Jørgensen, 1905, p. 140, pl. 18, figs. 102-104.

Stichocorys seriata Jørgensen. Itaki et al., 2008, pl. 1, figs. 24-25.

Stichocorys seriata (Jørgensen). Bjørklund, 1976b, pl. 10, figs. 7-12 [type specimens or topotypes].

Spirocyrtis aff. *S. scalaris* Haeckel. Kling, 1973, p. 639, pl. 5, figs. 24-26.

Spirocyrtis subscalaris Nigrini. Itaki, 2003, pl. 1, figs. 16-18; Itaki and Ikebara, 2003, figs. 4 (e-f).

Theoperidae gen. et sp. indet.

pl. 22, fig. 7

Family CARPOCANIIDAE Haeckel

***Carpocanistrum acephalum* Haeckel 1887**

pl. 23, figs. 1-2

Carpocanistrum acephalum n. sp. Haeckel, 1887, p. 1171, pl. 52, fig. 10.

***Carpocanistrum* sp.**

pl. 23, figs. 3-4

Remarks: The present form is characterized by small ovate thorax with a small downward spine (dorsal spine?), longer abdomen with small rounded pores on the wall and teeth around the mouth. This resembles Carpoaniidae gen. sp. of Petrushevskaya (1971, figs. 85-VII) or *Eucyrtidium cryptopora* Ehrenberg (1860, p. 769; 1872, pl. 7, fig. 14).

Family PTEROCORYTHIDAE Haeckel

***Pterocorys macroceras* (Popofsky 1913)**

pl. 23, figs. 5-9

Lithopilum macroceras n. sp. Popofsky, 1913, p. 377-379, text-figs. 91-95, pl. 38, fig. 2.

Pterocorys macroceras (Popofsky). Petrushevskaya, 1971, p. 234, figs. 120 (I-VIII).

***Theocorys veneris* Haeckel 1887**

pl. 22, fig. 6

Theocorys (Theocoronium) veneris n. sp. Haeckel, 1887, p. 1415, pl. 69, fig. 5.

Theocorys veneris Haeckel. Renz, 1976, p. 137-138, pl. 5, fig. 11.

Family ARTOSTROBIIDAE Riedel

***Lithamphora furcaspiculata* Popofsky 1908**

pl. 23, figs. 10-12

Lithamphora furcaspiculata n. sp. Popofsky, 1908, p. 295-296, pl. 36, figs. 6-8.

Lithamphora cf. *furcaspiculata* Popofsky. Petrushevskaya, 1971, figs. 125 (IV-VI).

Lithamphora furcaspiculata Popofsky. Petrushevskaya, 1971, figs. 125 (VII-IX).

***Siphocampe lineata* (Ehrenberg 1839) group**

pl. 23, fig. 13

Lithocampe lineata Ehrenberg, 1839, p. 130.

Lithocampe lineata Ehrenberg. Ehrenberg, 1854, pl. 22, fig. 26 (only) [lectotype designated by Riedel, 1958].

Siphocampe lineata (Ehrenberg) group – Nigrini, 1977, p. 256, pl. 3, figs. 9, 10.

***Spirocyrtis scalaris* Haeckel 1887**

pl. 23, fig. 14

Spirocyrtis (Spirocyrtidium) scalaris n. sp. Haeckel, 1887, p. 1509, pl. 76, fig. 14.

Spirocyrtis scalaris Haeckel. Petrushevskaya, 1971, p. 237, figs. 126 (I-IV).

Family CANOBOTRIDHIDAE Haeckel

Acrobotrys teralans Renz 1967

pl. 23, figs. 32-37

Acrobotrys teralans n. sp. Renz, 1976, p. 152-153, pl. 7, fig. 8.*Amphimelissa setosa* (Cleve 1899)

pl. 23, figs. 40-41

Botryopyle setosa n. sp. Cleve, 1899, p. 27, pl. 1, figs. 10a, 10b.*Amphimelissa setosa* (Cleve). Jørgensen, 1905, p. 137, pl. 18, fig. 109.*Botryopyle cribosa* (Popofsky 1913) group

pl. 23, figs. 15-27

Acrobotrissa cribosa n. sp. Popofsky, 1913, p. 322, text-fig. 29.*Botryopyle cribosa* (Popofsky). Petrushevskaya, 1971, p. 163, 165, figs. 84 (I-III).*Botryopyle dictyocephalus* Haeckel 1887 group

pl. 23, figs. 38-39

Botryopyle dictyocephalus n. sp. Haeckel, 1887, p. 1113, pl. 96, fig. 6.*Botryopyle dictyocephalus* Haeckel. Petrushevskaya, 1971, figs. 83 (I-V).*Botryopyle dictyocephalus* Haeckel group. Riedel and Sanfilippo, 1971, p. 1602, pl. 2j, fig. 18, pl. 3f, fig. 12.*Botryocyrtis scutum* (Harting 1863)

pl. 23, figs. 42-43

Haliomma scutum n. sp. Harting, 1863, p. 11, pl. 1, fig. 18.*Botryocyrtis scutum* (Harting). Nigrini, 1967, p. 52-54, pl. 6, figs. 1a-1c.*Botryocyrtis scutum* (Harting). Nigrini and Moore, 1979, N105-106, pl. 28, figs. 1a, 1b.*Botryocampe inflata* (Bailey 1856)

pl. 23, figs. 28-31

Lithobotrys inflatum n. sp. Bailey, 1856, p. 5, pl. 1, fig. 15.*Lithobotrys inflatum* Bailey. Itaki and Bjørklund, 2006, p. 458, pl. 3, figs. 11-18 [lectotype and paralectotypes].*Botryocampe inflata* (Bailey). Haeckel, 1862, p. 345; Kruglikova, 1974, p. 195, pl. 2, figs. 20-22; Itaki et al., in press, pl. 1, figs. 29-30.

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Explanation of plates

Plate 1

ACTINOMMIDAE:

1–6. *Acanthosphaera circopora* Popofsky

(1: core D-GC6, 3-4 (7.4-9.0 cm), 2: core D-GC6, 4-11 (71.7-74.2 cm), 3: core GH93-820, 288 cm, 4: core D-GC6, 4-7 (61.9-64.3 cm), 5: core D-GC6, 3-7 (14.9-17.4 cm), 6: core D-GC6, 4-7 (61.9-64.3 cm))

7–9. *Cladococcus bifurcus* Haeckel

(7: core D-GC6, 3-6 (12.4-14.9 cm), 8: core D-GC6, 4-11 (71.7-74.2 cm), 9: core D-GC6, 4-15 (81.6-84.0 cm))

10. *Cladococcus* sp.

(core D-GC6, 4-11 (71.7-74.2 cm))

11–12. *Heliosphaera radiata* Popofsky

(11: core GH93-820, 124 cm, 12: core D-GC6, 3-12 (27.3-29.7 cm))

(core GH93-820, 288 cm)

3, 7. *Hexacontium* sp.

(3: core GH95-1202, 6_64-66 (9-11 cm), 7: core D-GC6, 3-6 (12.4-14.9 cm))

4–5. *Actinomma medianum* Nigrini

(4: core KT94-14- PC9, 2-6 (14.1-16.5 cm), 5: core D-GC6, 3-19 (44.6-47.1 cm))

6. *Actinomma* sp. B

(core GH93-820, 288 cm)

8. *Hexacontium pachydermum* Jørgensen

(core D-GC6, 3-12 (27.3-29.7 cm))

9–10. *Hexacontium laevigatum* Haeckel

(9 and 10: core D-GC6, 3-12 (27.3-29.7 cm))

11–12. *Stylosphaera melpomene* Haeckel

(11 and 12: core GH93-820, 140 cm)

Plate 2

ACTINOMMIDAE:

1–4. *Actinomma leptodelmum leptodelmum* (Jørgensen)

(1: core GH93-820, 0 cm, 2: core GH93-820, 5 cm, 3: core GH93-820, 0 cm, 4: core GH93-820, 93 cm)

5–6, 11. *Actinomma boreale* Cleve

(5: core GH93-820, 65 cm, 6 and 11: core GH93-820, 38 cm)

7, 9. *Sphaeropyle langii* Dreyer

(7: core GH93-820, 0 cm, 9: core GH93-820, 297 cm)

8, 10. *Cromyechinus antarctica* (Dreyer)

(8 and 10: core GH93-820, 0 cm)

Plate 4

ACTINOMMIDAE:

1–5. *Cenosphaera reticulata* (Haeckel)

(1. core GH872-308, 1/3_0-2 (0-2 cm), 2 and 3. core D-GC6, 3-18 (42.1-44.6 cm), 4. core D-GC6, 3-20 (47 cm), 5. core D-GC6, 3-14 (32.2-34.7 cm)),

6. *Spongosphaera streptacantha* Haeckel

(core KT94-14- PC9, 2-6 (14.1-16.5 cm))

7–8. *Rhizoplegma boreale* (Cleve)

(7. core KT94-14- PC9, 3-37 (181.5-183.9 cm), 8. core KR02-06-7GC5, 4-17 (268.9-271.4 cm))

Plate 3

ACTINOMMIDAE:

1. *Hexacontium sarmentum* Su

(core D-GC6, 3-3 (5.0-7.4 cm))

2. *Actinomma* sp. A

PHACODISCIDAE:

1. *Heliodiscus asteriscus* Haeckel

(core D-GC6, 3-8 (17.4-19.8 cm))

2–4. *Heliodiscus echiniscus* Haeckel

(2 and 4. core D-GC6, 3-19 (44.6-47.1 cm), 3. core D-GC6, 4-29 (116.0-118.5 cm))

COCCODICIDAE:

5–8. *Didymocystis tetrathalamus* (Haeckel)

(5. core D-GC6, 3-7 (14.9-17.4 cm), 6. core D-GC6, 3-4 (7.4- 9.9 cm), 7. core D-GC6, 3-2 (2.5-5.0 cm), 8. core KT94-14- PC9, 2-17 (40.0-42.2 cm))

9–12. *Spongoliva ellipsoïdes* Popofsky

(9. core D-GC6, 3-15 (34.7-37.2 cm), 10. core D-GC6, 3-7 (14.9-17.4 cm), 11. core D-GC6, 3-18 (42.1-44.6 cm), 12. core D-GC6, 3-15 (34.7-37.2 cm)).

SPONGODISCIDAE:

11–14. *Dictyocoryne truncatum* (Ehrenberg)

(11 and 12. core D-GC6, 3-12 (27.3-29.7 cm), 13. core D-GC6, 3-6 (12.4-14.9 cm), 14. core D-GC6, 3-12 (27.3-29.7 cm))

15. *Dictyocoryne profunda* Ehrenberg

(core GH93-820, 109 cm)

Plate 8**Plate 6**

PORODISCIDAE:

1–8. *Euchitonita furcata* Ehrenberg

(1. grab GH96-327, surface sediment, 2. core D-GC6, 3-7 (14.9-17.4 cm), 3. core D-GC6, 3-8 (17.4-19.8 cm), 4. core D-GC6, 3-14 (32.2-34.7 cm), 5. core KT94-14- PC9, 2-6 (14.1-16.5 cm), 6. core D-GC6, 4-19 (91.4-93.9 cm), 7. core D-GC6, 4-11 (71.7-74.2 cm), 8. core D-GC6, 3-14 (32.2-34.7 cm))

Plate 7

PORODISCIDAE:

1–3. *Stylochlamydium venustum* (Bailey)

(1. core GH872-308, cc_10-12 (291-293 cm), 2. core GH872-308, cc_bottom (300 cm), 3. core KT94-14- PC9, 3-32 (169.3-171.7 cm))

4. *Flustrella* sp.

(core GH93-820, 109 cm)

5–7. *Stylobdictya stellata* Bailey group

(5. core GH93-820, 354 cm, 6. grab GH96-286, surface sediment, 7. core GH93-820, 288 cm)

8. *Circodiscus microporus* (Stöhr)

(core KT94-14- PC9, 2-1 (0-2.4 cm))

9. *Amphirrhopalum ypsilon* Haeckel

(core D-GC6, 3-20 (47 cm))

10. *Triastrum aurivillii* Cleve

(core D-GC6, 3-16 (37.2-39.7 cm))

SPONGODISCIDAE:

1. *Spongaster tetras tetras* Ehrenberg

(core D-GC6, 3-20 (47 cm))

2. *Spongaster tetras* Ehrenberg *irregularis* Nigrini

(core D-GC6, 3-15 (34.7-37.2 cm))

3–5. *Spongaster* sp.

(3: core D-GC6, 3-7 (14.9-17.4 cm), 4: core D-GC6, 3-15 (34.7-37.2 cm), 5: core D-GC6, 4-19 (91.4-93.9 cm))

6. *Spongocore cylindrica* (Haeckel)

(grab GH96-270, surface sediment)

7. *Spongurus pylomaticus* Riedel

(core KT94-14- PC9, 2-1 (0-2.4 cm))

8–9. *Spongodiscus resurgens* Ehrenberg

(8: core GH95-1202, 6_56-58 (1-3 cm), 9: core D-GC6, 3-12 (27.3-29.7 cm))

10. *Spongotrochus glacialis* Popofsky group

(grab GH96-335, surface sediment)

11–12. *Spongodiscus biconcavus* Haeckel

(11: core KT94-14- PC5, 1-1 (0-2.4 cm), 12: core D-GC6, 4-27 (111.1-113.6 cm))

Plate 9

SPONGODISCIDAE:

1–5. *Spongotrochus glacialis* Popofsky group

(1 and 5: grab GH96-270, surface sediment, 2: core GH93-820, 124 cm, 3: core GH98-1232, #1181 (0-2.4 cm), 4: grab GH96-260, surface sediment)

Plate 10

PYLONIIDAE:

1–10. *Tetrapyle octacantha* Müller group

(1: core GH872-308, 1/3_0-2 (0-2 cm), 2 and 3: core D-GC6, 3-6 (12.4-14.9 cm), 4: core D-GC6, 3-3 (5.0-7.4 cm), 5: core D-GC6, 3-2 (2.5-5.0 cm), 6: core KT94-14-PC5, 1-1 (0-2.4 cm), 7: core KT94-14- PC9, 2-1 (0-2.4 cm), 8: grab GH96-335, surface sediment, 9: core GH95-1202, 6_56-58 (1-3 cm), 10: core D-GC6, 3-4 (7.4- 9.9 cm))

11. *Octopyle stenozona* Haeckel

(11: core GH95-1202, 6_56-58 (1-3 cm), 12: core D-GC6, 3-12 (27.3-29.7 cm), 13: core D-GC6, 3-19 (44.6-47.1 cm))

14–15. *Larcospira quadrangula* Haeckel

(14: core GH95-1202, 6_64-44 (9-11 cm), 15: core D-GC6, 3-20 (47 cm))

Plate 11

PYLONIIDAE:

1–2. *Phorticum pylonium* Haeckel

(1: core D-GC6, 3-14 (32.2-34.7 cm), 2: core GH93-820, 235 cm)

3. *Streblacantha circumtexta* (Jørgensen)

(core D-GC6, 3-18 (42.1-44.6 cm))

4. *Phorticum polycladum* Tan and Tchang

(core D-GC6, 4-19 (91.4-93.9 cm))

LITHELIIDAE:

5. *Larcopyle weddellium* Lazarus, Faust and Popova-Goll

(core KT94-14- PC9, 3-27 (157.2-159.6 cm))

6–8. *Larcospira minor* (Jørgensen)

(6: core GH93-820, 215 cm, 7: core KT94-14- PC9, 2-17 (40.0-42.2 cm), 8: core GH93-820, 246 cm)

9. *Larcopyle nebulum* Lazarus, Faust and Popova-Goll

(core GH93-820, 5 cm)

11. *Larcopyle buetschlii* Dreyer

(core D-GC6, 3-16 (37.2-39.7 cm))

12. *Tholospira* sp.

(core GH872-308, 1/3_0-2 (0-2 cm))

13. Litheliidae gen. et sp. indet. C

(core BO92-10- HJ-1, 186 cm)

14–18. *Tholospira cervicornis* Haeckel

(14 and 15: core D-GC6, 4-11 (71.7-74.2 cm), 16: core D-GC6, 3-20 (47 cm), 17: core D-GC6, 3-19 (44.6-47.1 cm), 18: D-GC6, 3-20 (47 cm))

SPONGODISCIDAE:

10. *Spongurus* cf. *elliptica* (Ehrenberg)

(core GH93-820, 109 cm)

Plate 12

LITHELIIDAE:

1–21. *Larcopyle buetschlii* Dreyer

(1, 2, 16 and 19: core GH93-820, 288 cm, 3: core GH98-1232, #1181 (0-2.4 cm), 4, 5 and 14: plankton net GH99-N1, 200-300 m, 5 and 6: plankton net GH99-N1, 160-200 m, 7, 10 and 12: plankton net GH99-N1, 0-160 m, 8: core GH95-1202, 6_56-58 (1-3 cm), 9: core GH95-1202, 6_64-66 (9-11 cm), 13: core D-GC6, 3-2 (2.5-5.0 cm), 15 and 18: plankton net GH99-N1, 300-500 m, 17: core D-GC6, 3-4 (7.4- 9.9 cm), 20: core GH93-820, 272 cm, 21: core GH93-820, 107 cm)

Plate 13

ACANTHODESMIIDAE:

1–3. *Acanthodesmia vinculata* Müller

(1 and 2: core D-GC6, 3-18 (42.1-44.6 cm), 3: core D-GC6, 3-16 (37.2-39.7 cm))

4–5. *Acanthodesmia micropora* (Popofsky)

(4: core GH93-820, 204 cm, 5: core GH93-820, 235 cm)

6, 10–11. *Ceratospyris borealis* Bailey

(6: core GH93-820, 65 cm, 10: core GH93-820, 93 cm, 11: core GH93-820, 109 cm)

7. *Eucoronis* sp.

(core D-GC6, 3-16 (37.2-39.7 cm))

8. *Tholospiry rhombus* (Haeckel)

(core D-GC6, 4-11 (71.7-74.2 cm))

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- 9. *Ceratospyris cf. borealis* Bailey**
 (core GH93-820, 288 cm)
- 12. *Clathrocircus* sp.**
 (core D-GC6, 3-6 (12.4-14.9 cm))
- 13–14. *Clathrocircus stapedius* Haeckel**
 (13: core D-GC6, 3-6 (12.4-14.9 cm), 14: core D-GC6, 3-16 (37.2-39.7 cm))
- 15–16. *Phormospyris stabilis* (Goll) *scaphipes* (Haeckel)**
 (15: core D-GC6, 3-14 (32.2-34.7 cm), 16: core D-GC6, 3-14 (34.7-37.2 cm))
- 17–18. *Phormospyris stabilis capoi* Goll**
 (17: core D-GC6, 3-12 (27.3-29.7 cm), 18: core D-GC6, 3-8 (17.4-19.8 cm))
- 19. *Ceratospyris* sp.**
 (core D-GC6, 4-15 (81.6-84.0 cm))
- 20. *Lophospyris pentagona* (Ehrenberg)**
 (core D-GC6, 4-31 (121.0-123.4 cm))
- 26. *Antarctissa* (?) sp. 2 of Nimmergut (2002)**
 (core GH98-1232, #1181 (0-2.4 cm))
- 27–34. *Arachnocorys dubius* Dogiel**
 (27: grab GH96-270, surface sediment, 28: grab GH96-286, surface sediment, 29: core GH95-1202, 6_64-66 (9-11 cm), 30: core GH95-1202, 6_64-66 (9-11 cm), 31-34: core D-GC6, 3-18 (42.1-44.6 cm))
- 35. *Arachnocorys circumtexta* Haeckel**
 (core D-GC6, 3-18 (42.1-44.6 cm))
- 36–38. *Arachnocorys pentacantha* Popofsky**
 (36: core GH95-1202, 7_4-6 (49-51 cm), 37: core D-GC6, 3-18 (42.1-44.6 cm), 38: core D-GC6, 3-14 (32.2-34.7 cm))
- 39. *Arachnocorys umbelifera* Haeckel**
 (core GH95-1202, 7_4-6 (49-51 cm))

Plate 15

PLAGIACANTHIDAE:

- 1–8. *Dimelissa thoracites* (Haeckel)**
 (1: grab GH96-327, surface sediment, 2: core D-GC6, 3-12 (27.3-29.7 cm), 3, 5 and 7: core D-GC6, 3-15 (34.7-37.2 cm), 4: core D-GC6, 3-2 (2.5-5.0 cm), 6: core D-GC6, 3-3 (5.0-7.4 cm), 8: core GH93-820, 294 cm)
- 9, 10, 19. *Lophophphaena* sp. F**
 (9 and 19: core GH98-1232, #1181 (0-2.4 cm), 10: core D-GC6, 4-19 (91.4-93.9 cm))
- 11. *Lophophphaena* spp.**
 (11: core GH98-1232, #1181 (0-2.4 cm), 12: grab GH96-335, surface sediment, 13: core GH93-820, 403 cm)
- 14–16. *Dimelissa* aff. *thoracites* (Haeckel)**
 (14: core D-GC6, 3-6 (12.4-14.9 cm), 15: core D-GC6, 3-15 (34.7-37.2 cm), 16: core D-GC6, 3-4 (7.4-9.0 cm))
- 17–18. *Lophophphaena* spp.**
 (17 and 18: grab GH96-286, surface sediment)
- 20, 24–26. *Lophophphaena buetschlii* (Haeckel)**
 (20: core D-GC6, 3-7 (14.9-17.4 cm), 24: core D-GC6, 3-4 (7.4-9.0 cm), 25: core D-GC6, 3-2 (2.5-5.0 cm), 26: core D-GC6, 3-6 (12.4-14.9 cm))
- 21–23. *Lophophphaena variabilis* (Popofsky)**
 (21: core D-GC6, 3-16 (37.2-39.7 cm), 22: core D-GC6,

Plate 14

ACANTHODESMIIDAE:

- 1–15. *Zygomiscus productus* (Hertwig) group**
 (1: core KT94-14- PC9, 2-17 (40.0-42.2 cm), 2, 4 and 8: core D-GC6, 3-14 (32.2-34.7 cm), 3: core GH93-820, 50 cm, 5: core GH93-820, 50 cm, 6: core GH93-820, 246 cm, 7: core GH93-820, 0 cm, 9: core GH93-820, 215 cm, 10: core D-GC6, 4-23 (101.3-103.7 cm), 11: core GH93-820, 160 cm, 12: core D-GC6, 3-18 (42.1-44.6 cm), 13: core GH93-820, 310 cm, 14: core D-GC6, 3-15 (34.7-37.2 cm), 15: core GH93-820, 109 cm)
- PLAGIACANTHIDAE:**
- 16–24. *Acanthocorys castanoides* Tan and Tchang**
 (16 and 22: core D-GC6, 4-11 (71.7-74.2 cm), 17, 18 and 21: core D-GC6, 3-4 (7.4-9.0 cm), 19: core D-GC6, 3-7 (14.9-17.4 cm), 20: core D-GC6, 3-2 (2.5-5.0 cm), 23: core KT94-14- PC9, 2-17 (40.0-42.2 cm), 24: grab GH96-335, surface sediment)
- 25. *Acanthocorys* cf. *castanoides* Tan and Tchang**
 (grab GH96-270, surface sediment)

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- 3-6 (12.4-14.9 cm), 23: core D-GC6, 3-12 (27.3-29.7 cm))
- 27, 29, 30. *Lophophphaena* cf. *hispida* (Ehrenberg)**
 (27: core D-GC6, 3-14 (32.2-34.7 cm), 29: core D-GC6, 3-15 (34.7-37.2 cm), 30: core D-GC6, 4-19 (91.4-93.9 cm))
- 28. *Lophophphaena cylindrica* (Cleve)**
 (core D-GC6, 3-20 (47 cm))
- 31, 32. *Lithomelissa laticeps* Jørgensen**
 (31: core D-GC6, 3-3 (5.0-7.4 cm), 32: core KT94-14-PC9, 2-6 (14.1-16.5 cm))
- 33. *Lophophenoma witjazii* Petrushevskaya**
 (core D-GC6, 4-7 (61.9-64.3 cm))
- 34-37. *Lophophphaena hispida* (Ehrenberg)**
 (34: core D-GC6, 3-3 (5.0-7.4 cm), 35 and 37: core D-GC6, 3-4 (7.4-9.0 cm), 36: core D-GC6, 3-7 (14.9-17.4 cm))
- 38-45. *Lithomelissa setosa* Jørgensen**
 (38, 42 and 44: core D-GC6, 3-3 (5.0-7.4 cm), 39: core D-GC6, 3-6 (12.4-14.9 cm), 40: core D-GC6, 3-14 (32.2-34.7 cm), 41: core GH93-820, 204 cm, 43: core D-GC6, 3-18 (42.1-44.6 cm), 45: core D-GC6, 3-15 (34.7-37.2 cm))
- 46. *Trisulcus* sp.**
 (core GH93-820, 50 cm)

Plate 16

PLAGIACANTHIDAE:

- 1. *Lithomelissa* sp. B**
 (core D-GC6, 4-19 (91.4-93.9 cm))
- 2. *Lithomelissa* sp. C**
 (core GH93-820, 235 cm)
- 3. *Antarctissa* (?) sp. 2 of Nimmergut (2002)**
 (core D-GC6, 4-23 (101.3-103.7 cm))
- 4-5. *Lithomelissa* sp. A**
 (4 and 5: core GH93-820, 288 cm)

6-10. *Lophophphaena* sp. A

(6 and 8: core GH93-820, 403 cm, 7: core GH93-820, 294 cm, 9: core GH93-820, 272 cm, 10: core GH93-820, 235 cm)

11-13, 15, 18. *Lophophphaena* sp. B

(11: core D-GC6, 4-19 (91.4-93.9 cm), 12: core D-GC6, 3-20 (47 cm), 13: core D-GC6, 3-14 (32.2-34.7 cm), 15 and 18: core GH93-820, 310 cm)

- 14, 21, 22, 29. *Archipera triclavigera* Tan and Tchang**
 (14: core D-GC6, 3-7 (14.9-17.4 cm), 21: core D-GC6, 3-3 (5.0-7.4 cm), 22: core GH98-1232, #1181 (0-2.4 cm), 29: core D-GC6, 3-19 (44.6-47.1 cm))
- 16-17. *Arachnocalloium calvata* (Haeckel)**
 (16: core D-GC6, 3-14 (32.2-34.7 cm), 17: core GH93-820, 93 cm)
- 19. *Lophophphaena* sp. D**
 (core GH93-820, 246 cm)
- 20, 25. *Lophophphaena* sp. C**
 (20: core GH93-820, 346 cm, 25: core GH93-820, 246 cm)
- 23. *Arachnocalloium* aff. *calvata* (Haeckel)**
 (core D-GC6, 3-12 (27.3-29.7 cm))
- 24. *Plectacantha* sp. A**
 (core D-GC6, 4-23 (101.3-103.7 cm))
- 26-28. *Peridium spinipes* Haeckel**
 (26 and 27: core D-GC6, 3-4 (7.4-9.0 cm), 28: core D-GC6, 3-2 (2.5-5.0 cm))
- 30. *Neosemantis bjoerkundi bjoerkundi* Goll**
 (core GH93-820, 235 cm)
- 31-33. *Neosemantis distephanus* (Haeckel)**
 (31: core D-GC6, 4-7 (61.9-64.3 cm), 32: core D-GC6, 3-14 (32.2-34.7 cm), 33: core KT94-14- PC9, 2-17 (40.0-42.2 cm))
- 34-37. *Phormacantha hystrix* (Jørgensen)**
 (34, 36 and 37: grab GH96-327, surface sediment, 35: core D-GC6, 3-16 (37.2-39.7 cm))
- 38-40. *Plectacantha trichoides* Jørgensen**
 (38: core GH93-820, 65 cm, 39: core GH872-308, 1/3_0-2 (0-2 cm), 40: core D-GC6, 3-16 (37.2-39.7 cm))
- 41-45. *Plectacantha oikiskos* Jørgensen**
 (41: core D-GC6, 3-20 (47 cm), 42-44: core GH98-1232, #1181 (0-2.4 cm), 45: core D-GC6, 3-4 (7.4-9.0 cm))

Plate 17

PLAGIACANTHIDAE:

- 1-4. *Plectacantha cremastoplegma* Nigrini**
 (1: core GH98-1232, #1181 (0-2.4 cm), 2: core GH95-1202, 7_4-6 (49-51 cm), 3: core KT94-14- PC9, 3-32 (169.3-171.7 cm), 4: core D-GC6, 3-20 (47 cm))

5, 6. *Plectacantha* sp. B

(5: core D-GC6, 3-14 (32.2-34.7 cm), 6: core KT94-14- PC9, 2-6 (14.1-16.5 cm))

7–10. *Pseudocubus obeliscus* Haeckel

(7: core D-GC6, 3-4 (7.4-9.0 cm), 8: core KT94-14- PC9, 2-17 (40.0-42.2 cm), 9: core KT94-14- PC9, 2-1 (0-2.4 cm), 10: core D-GC6, 3-18 (42.1-44.6 cm))

11–12. *Pseudocubus octostylus* Haeckel

(11: core D-GC6, 3-19 (44.6-47.1 cm), 12: core KT94-14- PC9, 2-6 (14.1-16.5 cm))

13–14. *Pseudocubus* sp.

(13: core D-GC6, 4-4 (54.5-56.9 cm), 14: core D-GC6, 3-3 (5.0-7.4 cm))

15–23. *Lithomelissa* sp. D of Itaki et al. (in press)

(15: core GH93-820, 403 cm, 16: core GH93-820, 397 cm, 17: core GH93-820, 255 cm, 18: core GH93-820, 140 cm, 19: core D-GC6, 3-18 (42.1-44.6 cm), 20: core GH93-820, 334 cm, 21: core D-GC6, 3-18 (42.1-44.6 cm), 22: core GH93-820, 38 cm, 23: core GH93-820, 297 cm))

24–28. *Pseudodictyophimus gracilipes* (Bailey)

(24 and 27: core D-GC6, 3-15 (34.7-37.2 cm), 25: core D-GC6, 3-16 (37.2-39.7 cm), 26: core GH93-820, 334 cm, 28: core D-GC6, 3-12 (27.3-29.7 cm))

Plate 18**PLAGIACANTHIDAE:****1–2. *Archiscenium tricolpium* (Haeckel)**

(1: core D-GC6, 3-8 (17.4-19.8 cm), 2: core D-GC6, 3-16 (37.2-39.7 cm))

3. *Pseudodictyophimus* sp.

(core D-GC6, 3-12 (27.3-29.7 cm))

4–5. *Pteroscenium pinnatum* Haeckel

(4: core KT94-14- PC9, 2-6 (14.1-16.5 cm), 5: core D-GC6, 3-15 (34.7-37.2 cm))

6–7. *Tetraplecta pinigera* Haeckel

(6: core KT94-14- PC9, 2-17 (40.0-42.2 cm), 7: core D-GC6, 3-20 (47 cm))

SETHOPHORMIDIDAE:**8–9. *Lampronmitra erosa* Cleve**

(8: core D-GC6, 3-16 (37.2-39.7 cm), 9: core D-GC6, 3-7 (14.9-17.4 cm))

10. *Tetraphormis callipilium* Haeckel

(core D-GC6, 3-19 (44.6-47.1 cm))

Plate 19**SETHOPHORMIDIDAE:****1–2. *Ceratocyrtis* spp. (young form)**

(1: core KT94-14- PC9, 2-6 (14.1-16.5 cm), 2: grab GH96-286, surface sediment)

3–10. *Ceratocyrtis galeus* (Cleve)

(3: core GH95-1202, 6_56-58 (1-3 cm), 4: grab GH96-270, surface sediment, 5: core GH93-820, 0 cm, 6 and 9: core GH93-820, 5 cm, 7: core GH93-820, 160 cm, 8: core GH93-820, 140 cm, 10: core GH93-820, 93 cm)

11–20. *Ceratocyrtis* sp. B

(11: core GH93-820, 354 cm, 12 and 17: core GH95-1202, 7_4-6 (49-51 cm), 13: core D-GC6, 3-2 (2.5-5.0 cm), 14: core GH93-820, 109 cm, 15 and 19: core D-GC6, 3-6 (12.4-14.9 cm), 16: core D-GC6, 3-20 (47 cm), 18: grab GH96-270, surface sediment, 20: core D-GC6, 3-7 (14.9-17.4 cm))

Plate 20**SETHOPHORMIDIDAE:****1–3, 7–8. *Ceratocyrtis historicosa* (Jørgensen)**

(1: grab GH96-270, surface sediment, 2: core GH95-1202, 6_56-58 (1-3 cm), 3: grab GH96-335, surface sediment, 7: core KT94-14- PC9, 2-6 (14.1-16.5 cm), 8: core D-GC6, 3-16 (37.2-39.7 cm))

4–6. *Ceratocyrtis* sp. A

(4 and 5: core GH872-308, 1/3_0-2 (0-2 cm), 6: core D-GC6, 3-4 (7.4-9.0 cm))

9–17. *Eucecrysphalus cervus* (Ehrenberg)

(9: core D-GC6, 3-14 (32.2-34.7 cm), 10 and 11: core D-GC6, 3-12 (27.3-29.7 cm), 12: core KT94-14- PC9, 2-6

Last Glacial to Holocene Polycystine from Japan Sea

(14.1-16.5 cm), 13: core D-GC6, 3-19 (44.6-47.1 cm), 14:
core GH95-1202, 7_4-6 (49-51 cm), 15: core D-GC6, 4-7
(61.9-64.3 cm), 16 and 17: core D-GC6, 3-2 (2.5-5.0 cm))

Plate 22

ARTOSTROBIIDAE:

18. *Eucecyphalus* sp.

(core GH95-1202, 6_64-66 (9-11 cm))

19. *Eucecyphalus elisabethae* (Haeckel)

(core D-GC6, 3-18 (42.1-44.6 cm))

6. *Theocorys veneris* Haeckel

(core D-GC6, 3-4 (7.4-9.0 cm))

THEOPERIDAE:

Plate 21

THEOPERIDAE:

1–13. *Cycladophora davisianna* Ehrenberg

(1: grab GH96-270, surface sediment, 2: core GH93-820, 272 cm, 3: core GH93-820, 73 cm, 4 and 6: core GH93-820, 0 cm, 5 and 7: core D-GC6, 3-3 (5.0-7.4 cm), 8: core GH93-820, 38 cm, 9: core GH93-820, 98 cm, 10: core GH93-820, 5 cm, 11: core GH93-820, 310 cm, 12: core GH93-820, 294 cm, 13: core GH93-820, 403 cm)

14. *Cycladophora cornuta* (Bailey)

(core GH93-820, 5 cm)

15. *Gondwanaria dogieli* (Petrushevskaya)

(core KT94-14- PC9, 2-6 (14.1-16.5 cm))

16–17. *Lipmanella pyramidale* (Popofsky)

(16: core D-GC6, 3-19 (44.6-47.1 cm), 17: grab GH96-270, surface sediment)

18. *Lipmanella* sp.

(core GH95-1202, 7_4-6 (49-51 cm))

19. *Lophocorys polyacantha* Popofsky

(core D-GC6, 3-8 (17.4-19.8 cm))

20–22. *Lipmanella dictyoceras* (Haeckel)

(20 and 22: core GH98-1232, #1181 (0-2.4 cm), 21: core GH93-820, 346 cm)

23. *Lithopera bacca* Ehrenberg

(core GH872-308, 1/3_0-2 (0-2 cm))

24–26. *Corocalyptra kruegeri* Popofsky

(24: core D-GC6, 4-23 (101.3-103.7 cm), 25: core D-GC6, 3-19 (44.6-47.1 cm), 26: core D-GC6, 3-15 (34.7-37.2 cm))

1. *Dictyophimus* sp.

(core GH93-820, 246 cm)

2–3. *Pterocanium praetextum* (Ehrenberg)

(2: core D-GC6, 3-6 (12.4-14.9 cm), 3: core D-GC6, 3-16 (37.2-39.7 cm))

4–5. *Pterocanium* sp.

(4: grab GH96-270, surface sediment, 5: core GH93-820, 288 cm)

7. *Theoperidae gen. et sp. indet.*

(core D-GC6, 4-27 (111.1-113.6 cm))

8–16. *Eucyrtidium acuminatum* (Ehrenberg)

(8: core GH93-820, 65 cm, 9 and 14: core D-GC6, 3-14 (32.2-34.7 cm), 10, 11 and 16: core D-GC6, 3-18 (42.1-44.6 cm), 12: core GH872-308, 1/3_0-2 (0-2 cm), 13: core D-GC6, 4-7 (61.9-64.3 cm), 15: core D-GC6, 3-12 (27.3-29.7 cm))

17. *Eucyrtidium* sp.

(core D-GC6, 4-19 (91.4-93.9 cm))

18–19. *Eucyrtidium hexastichum* (Haeckel)

(18: core KT94-14- PC9, 2-6 (14.1-16.5 cm), 19: core D-GC6, 3-14 (32.2-34.7 cm))

20. *Eucyrtidium anomalum* (Haeckel)

(core D-GC6, 4-15 (81.6-84.0 cm))

21–27. *Stichocorys seriata* Jørgensen

(21: grab GH96-335, surface sediment, 22: D-GC6, 3-2 (2.5-5.0 cm), 23: core D-GC6, 3-3 (5.0-7.4 cm), 24: core GH95-1202, 7_4-6 (49-51 cm), 25: core D-GC6, 4-19 (91.4-93.9 cm), 26: core D-GC6, 3-15 (34.7-37.2 cm), 27: core D-GC6, 3-12 (27.3-29.7 cm))

28–29. *Litharachium tentrium* Haeckel

(28: grab GH96-335, surface sediment, 29: core D-GC6, 4-11 (71.7-74.2 cm))

Plate 23**CANOBOTRIDHIDAE:****15–27. *Botryopyle cribosa* (Popofsky) group**

(15: core GH93-820, 334 cm, 16: core D-GC6, 3-7 (14.9-17.4 cm), 17: core D-GC6, 4-23 (101.3-103.7 cm), 18-20: core GH93-820, 294 cm, 21: core GH93-820, 109 cm, 22: core GH93-820, 215 cm, 23: core D-GC6, 3-16 (37.2-39.7 cm), 24: core GH98-1232, #1181 (0-2.4 cm), 25: core GH93-820, 235 cm, 26: core D-GC6, 3-12 (27.3-29.7 cm), 27: core GH93-820, 38 cm)

28–31. *Botryocampe inflata* (Bailey)

(28: core GH93-820, 0 cm, 29: core GH93-820, 65 cm, 30: core GH93-820, 38 cm, 31: core GH93-820, 294 cm)

32–37. *Acrobotrys teralans* Renz

(32 and 33: core D-GC6, 3-7 (14.9-17.4 cm), 34: core D-GC6, 3-15 (34.7-37.2 cm), 35: core D-GC6, 4-23 (101.3-103.7 cm), 36: core D-GC6, 3-16 (37.2-39.7 cm), 37: core D-GC6, 3-8 (17.4-19.8 cm))

38–39. *Botryopyle dictyocephalus* Haeckel group

(38: core D-GC6, 3-18 (42.1-44.6 cm), 39: core D-GC6, 3-15 (34.7-37.2 cm))

40–41. *Amphimelissa setosa* (Cleve)

(40: core GH93-820, 246 cm, 41: core GH93-820, 288 cm)

42–43. *Botryocyrtis scutum* (Harting)

(42: core D-GC6, 3-6 (12.4-14.9 cm), 43: core D-GC6, 3-15 (34.7-37.2 cm))

CARPOCANIIDAE:**1–2. *Carpocanistrum acephalum* Haeckel**

(1: core D-GC6, 3-18 (42.1-44.6 cm), 2: core D-GC6, 3-14 (32.2-34.7 cm))

3–4. *Carpocanistrum* sp.

(3: core D-GC6, 4-23 (101.3-103.7 cm), 4: core D-GC6, 4-11 (71.7-74.2 cm))

PTEROCORYTHIDAE:**5–9. *Pterocorys macroceras* (Popofsky)**

(5: core KT94-14- PC9, 2-6 (14.1-16.5 cm), 6: core D-GC6, 3-15 (34.7-37.2 cm), 7: core D-GC6, 3-4 (7.4-9.0 cm), 8: core D-GC6, 3-12 (27.3-29.7 cm), 9: core GH93-820, 288 cm)

ARTOSTROBIIDAE:**10–12. *Lithamphora furcaspiculata* Popofsky**

(10: core GH93-820, 403 cm, 11: core GH93-820, 354 cm, 12: core GH93-820, 397 cm)

13. *Siphocampe lineata* (Ehrenberg) group

(core GH93-820, 160 cm)

14. *Spirocyrtis scalaris* Haeckel

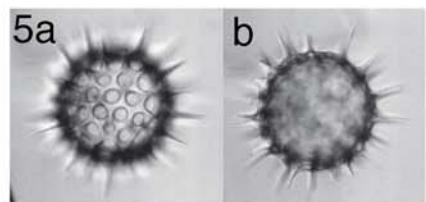
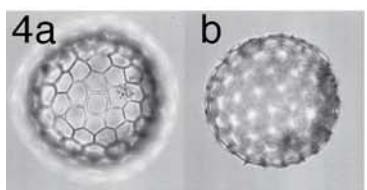
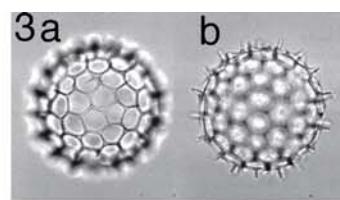
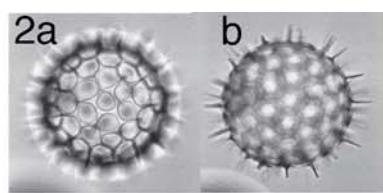
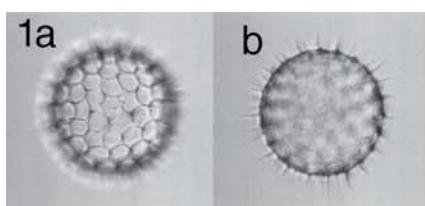
(core D-GC6, 4-19 (91.4-93.9 cm))

Last Glacial to Holocene Polycystine from Japan Sea

Table 1. List of examined sample location, used sampler, mesh size of sieve and publication.

Cruise or Field work	Local no. or Station	Latitude	Longitude	Water depth (m)	Sampler	Meshe size used in procedure (μm)	Publications
BO89-08	TB-4	44°04'N	139°00'E	3,500	Piston corer	45	Ikehara et al. (2004)
BO94-10	HJ-1	43°02'N	138°28'E	3,613	Piston corer	63	Itaki et al. (2004), Itaki & Ikehara (2003)
GH872	308	35°58'N	134°26'E	316	Gravity corer	45	in preparation
	K-A	35°55'N	135°10'E	232	Gravity corer	45	in preparation
	K-B	36°05'N	135°00'E	283	Gravity corer	63	Itaki, 2007
GH882	316	37°08'N	137°27'E	1,022	Gravity corer	45	in preparation
GH892	1	37°34'N	138°07'E	1,114	Gravity corer	45	in preparation
	2	37°42'N	138°30'E	522	Gravity corer	45	in preparation
	3	38°17'N	138°40'E	669	Gravity corer	45	in preparation
	4	38°32'N	138°51'E	759	Gravity corer	45	in preparation
	27	39°05'N	137°30'E	2,237	Gravity corer	45	Nakajima & Itaki (2007)
GH90	505	37°47'N	137°59'E	1,685	Gravity corer	45	in preparation
	508	38°17'N	137°55'E	1,828	Gravity corer	45	Nakajima & Itaki (2007)
	513	38°27'N	138°21'E	643	Gravity corer	45	in preparation
	520	38°39'N	138°48'E	789	Gravity corer	45	in preparation
GH92	703	39°30'N	136°30'E	2,638	Gravity corer	63	Itaki (2003)
GH93	820	41°13'N	136°37'E	3,339	Gravity corer	45	Itaki & Björklund (2007)
	826	41°29'N	136°36'E	3,425	Gravity corer	45	Nakajima & Itaki (2007)
GH93	YO-1	38°51'N	139°15'E	626	Gravity corer	45	in preparation
	YO-2	39°13'N	139°21'E	849	Gravity corer	45	Katayama & Itaki (2007)
GH95	184	43°00'N	139°35'E	3,325	Gravity corer	45	in preparation
	260	43°44'N	140°30'E	802	Gravity corer	45	in preparation
	1202	41°22'N	138°55'E	1,384	Gravity corer	63	Itaki et al. (2004)
	1203	41°50'N	139°10'E	2,250	Gravity corer	63	Itaki et al. (2004)
	1208	43°46'N	138°50'E	3,435	Gravity corer	63	Itaki et al. (2004), Itaki & Björklund (2007)
GH96	143	42°36'N	138°55'E	3,653	Grab sampler	63	Itaki (2003)
	145	42°36'N	139°15'E	2,625	Grab sampler	63	Itaki (2003)
	153	42°40'N	139°30'E	2,994	Grab sampler	63	Itaki (2003)
	255	43°44'N	139°40'E	2,282	Grab sampler	63	Itaki (2003)
	260	43°44'N	140°30'E	802	Grab sampler	63	Itaki (2003)
	261	43°48'N	139°35'E	1,760	Grab sampler	63	Itaki (2003)
	270	43°52'N	139°51'E	1,091	Grab sampler	63	Itaki (2003)
	276	43°56'N	139°45'E	1,264	Grab sampler	63	Itaki (2003)
	279	43°56'N	140°15'E	683	Grab sampler	63	Itaki (2003)
	286	44°00'N	140°10'E	781	Grab sampler	63	Itaki (2003)
	327	43°52'N	140°40'E	672	Grab sampler	63	Itaki (2003)
	329	43°52'N	141°00'E	360	Gravity corer	45	in preparation
	334	43°60'N	140°55'E	460	Grab sampler	63	Itaki (2003)
	335	43°56'N	141°05'E	337	Grab sampler	63	Itaki (2003)
	336	43°60'N	141°15'E	165	Grab sampler	63	Itaki (2003)
	1162	43°28'N	140°45'E	509	Grab sampler	63	Itaki (2003)
	1183	43°48'N	141°20'E	60	Grab sampler	63	Itaki (2003)
	1188	43°56'N	141°10'E	260	Grab sampler	63	Itaki (2003)
	1189	43°56'N	141°20'E	93	Grab sampler	63	Itaki (2003)
GH96	1217	41°42'N	139°05'E	1,785	Gravity corer	63	Itaki et al. (2004)
GH98	1232	44°48'N	139°42'E	838	Gravity corer	45, 63	Itaki & Ikehara (2003)
GH99	1256	40°54'N	139°52'E	823	Gravity corer	63	in preparation
	1262	39°29'N	139°30'E	569	Gravity corer	63	Katayama & Itaki (2007)
	N1	43°46'N	138°50'E	3,430	Plankton net (0-2,000m)	63	Itaki (2003)
KR02-06	7GC8	36°13'N	131°42'E	1,650	Gravity corer	45	in preparation
	DGC6	37°04'N	134°42E	946	Gravity corer	45	Itaki et al. (2007)
KT94-15	PC3	40°00'N	135°36'E	983	Piston corer	63	Itaki (2003)
	PC-5	40°01'N	138°12'E	2,885	Piston corer	63	Itaki et al. (2004)
	PC-9	39°34'N	139°24'E	807	Piston corer	63	Itaki (2001), Itaki & Ikehara (2003), Itaki et al. (2004)
	MC8	39°51'N	139°11'E	1,473	Multiple corer	63	Itaki (2003)
KT95-14	JSP1	41°04'N	139°58'E	502	Piston corer	63	Itaki (2003)
MD01	2407	37°04'N	134°42'E	932	Piston corer	45	Itaki et al. (2007), Itaki (2007)
	2408	39°34'N	139°24'E	806	Piston corer	45	Itaki et al. (2007)
Sado Island in 2002	off Tassha	ca. 6 km west of off Tassha	—	—	Plankton net (0-10m)	45	Itaki et al. (2003)
Tsushima & Iki islands in 2006	1	33°56'N	129°43'E	92	Plankton net (0-80m)	63	in preparation
	S-12	34°27'N	129°27'E	76	Plankton net (0-76m)	63	in preparation
	I-11	34°33'N	129°16'E	148	Plankton net (0-140m)	63	in preparation

Plate 1



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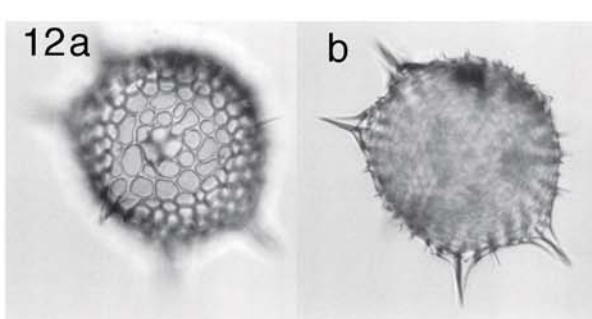
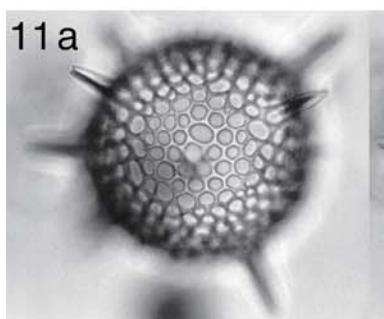
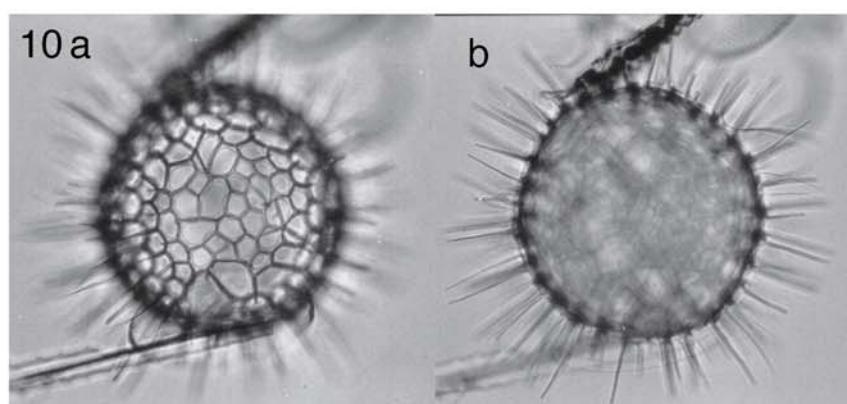
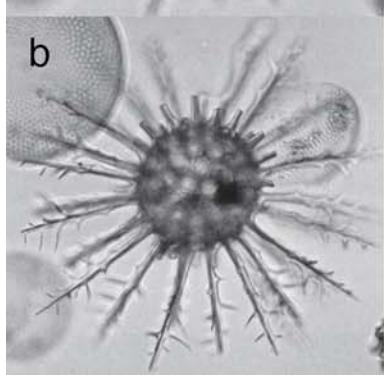
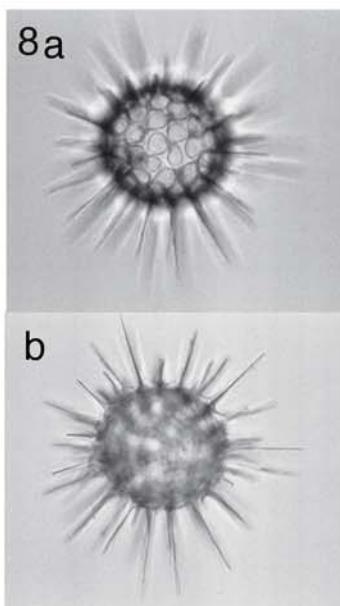
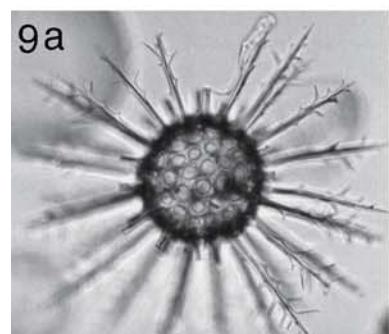
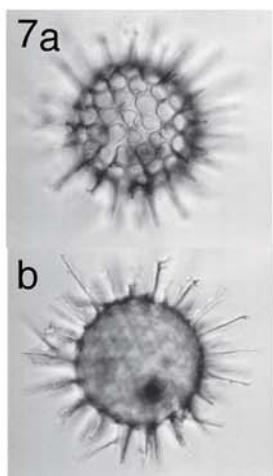
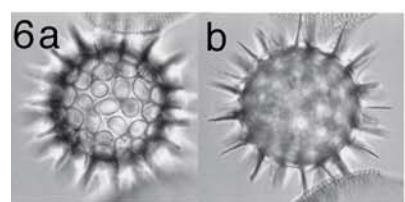


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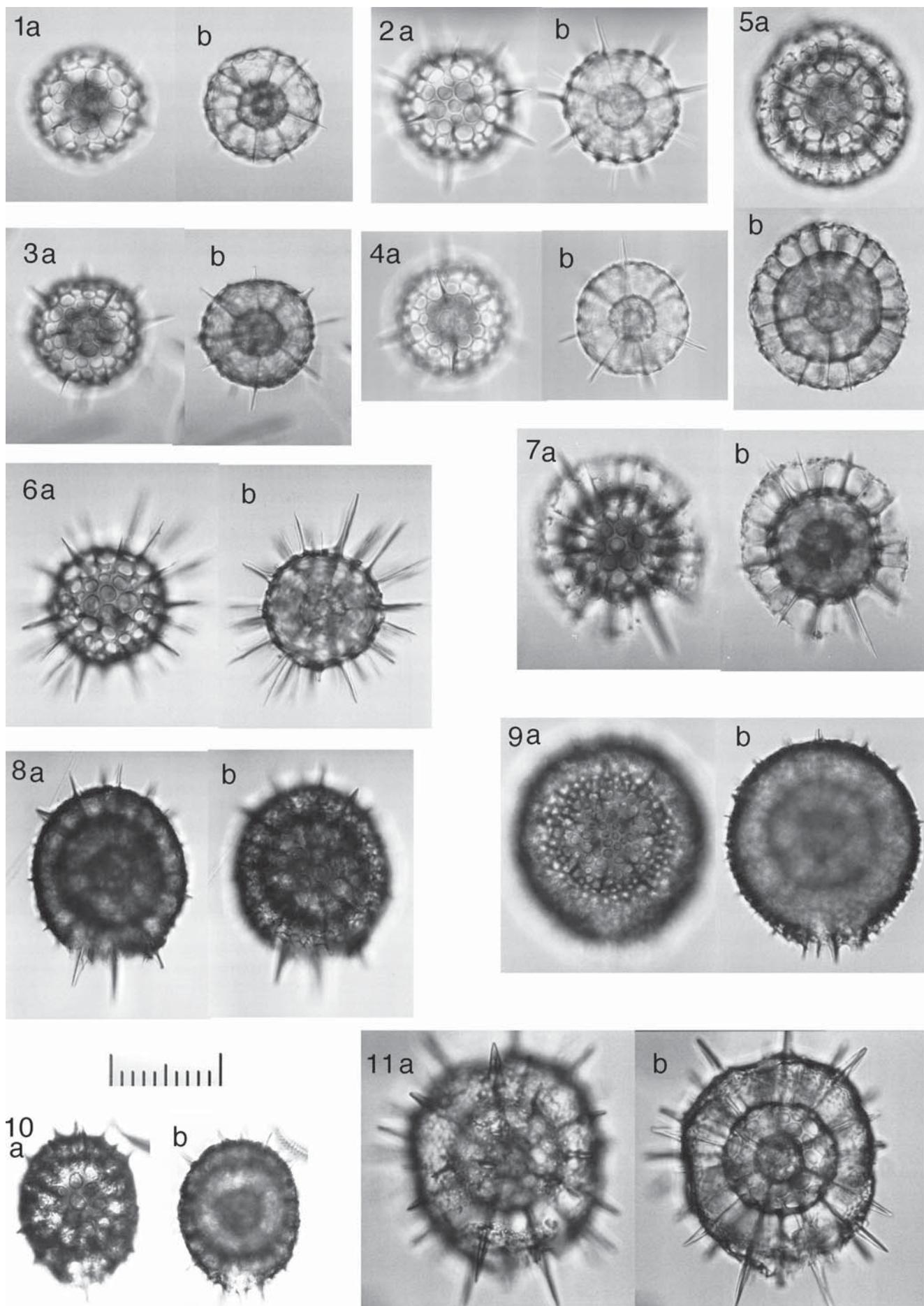


Plate 3

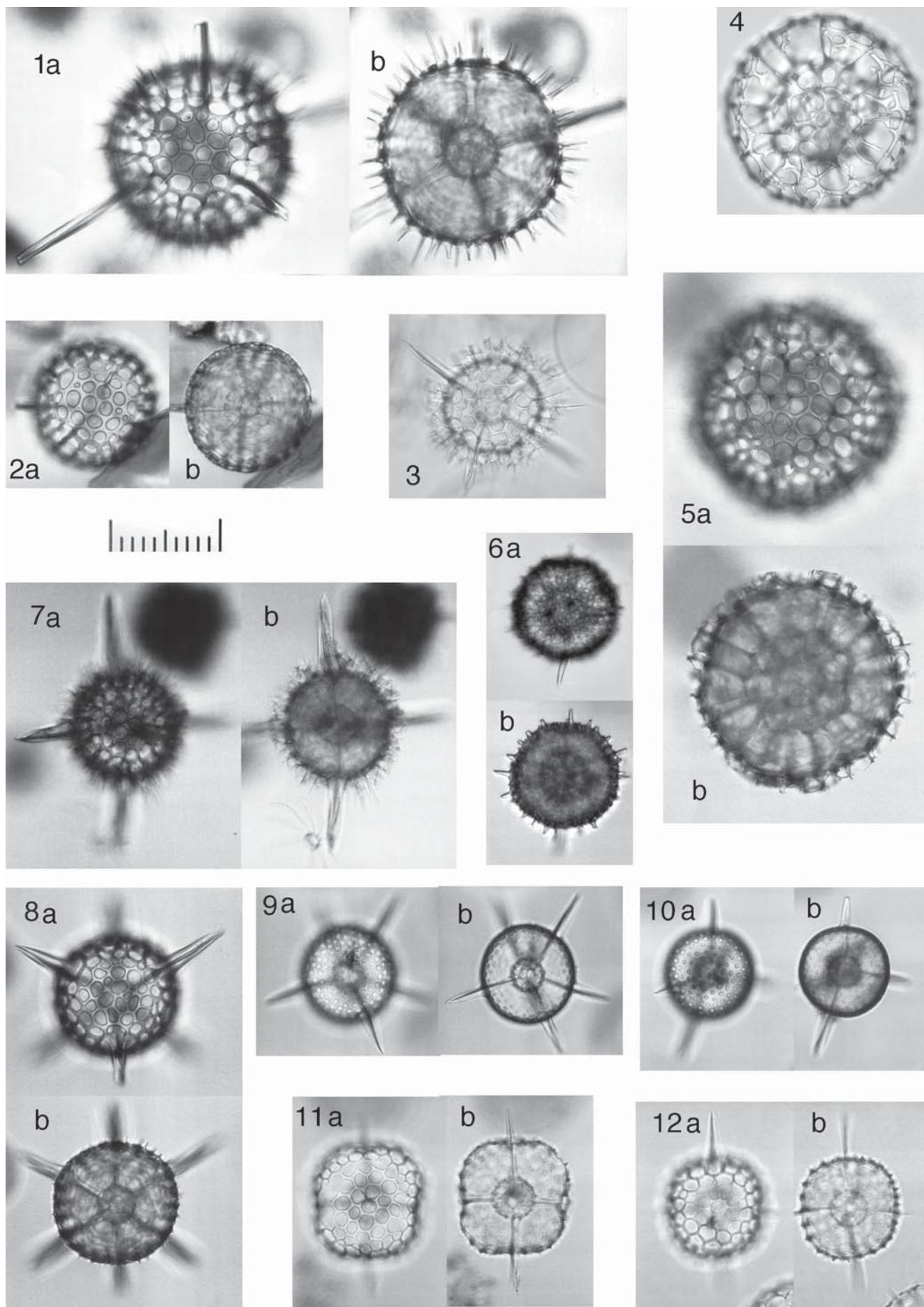
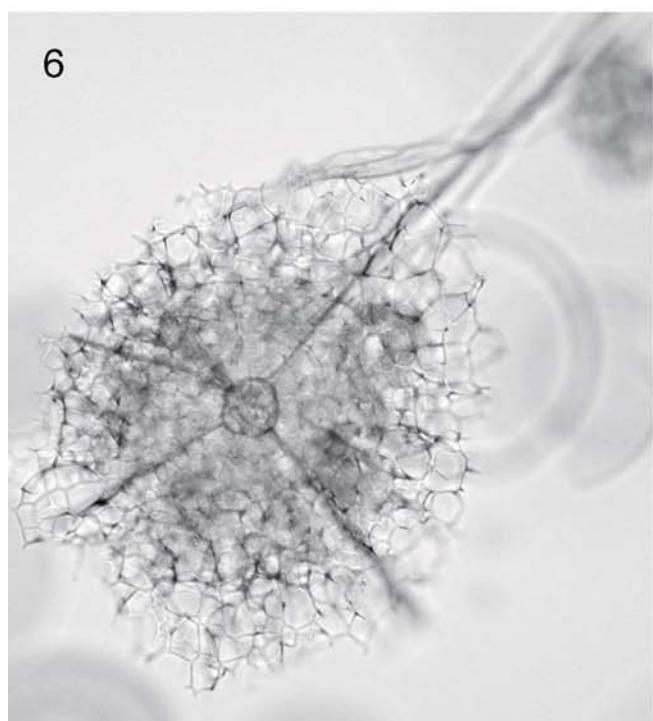
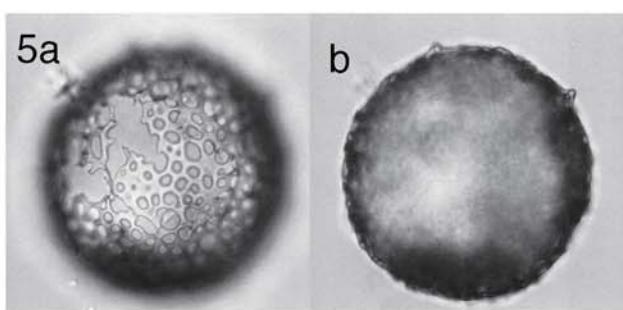
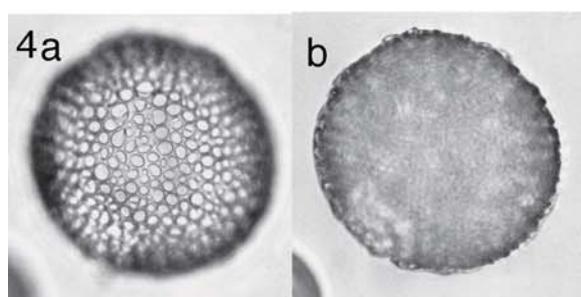
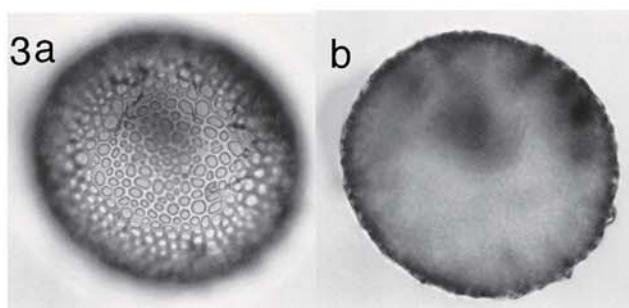
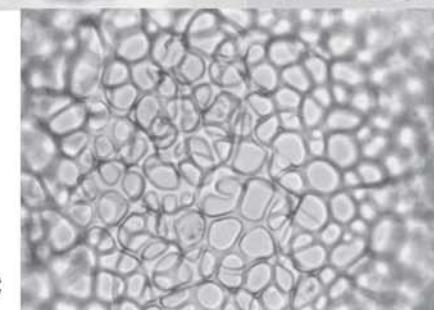
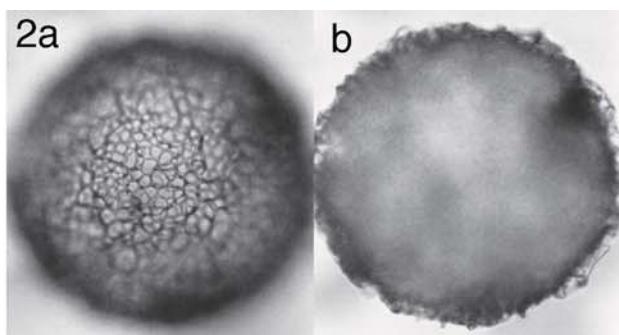
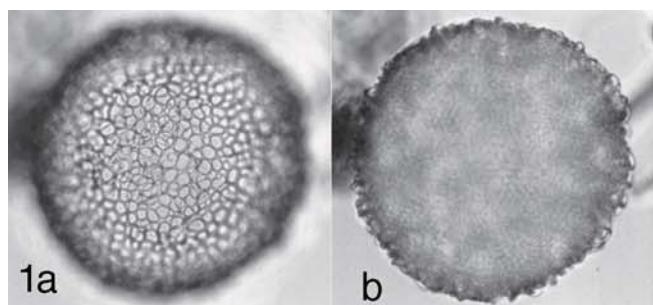


Plate 4



1mm



Plate 5

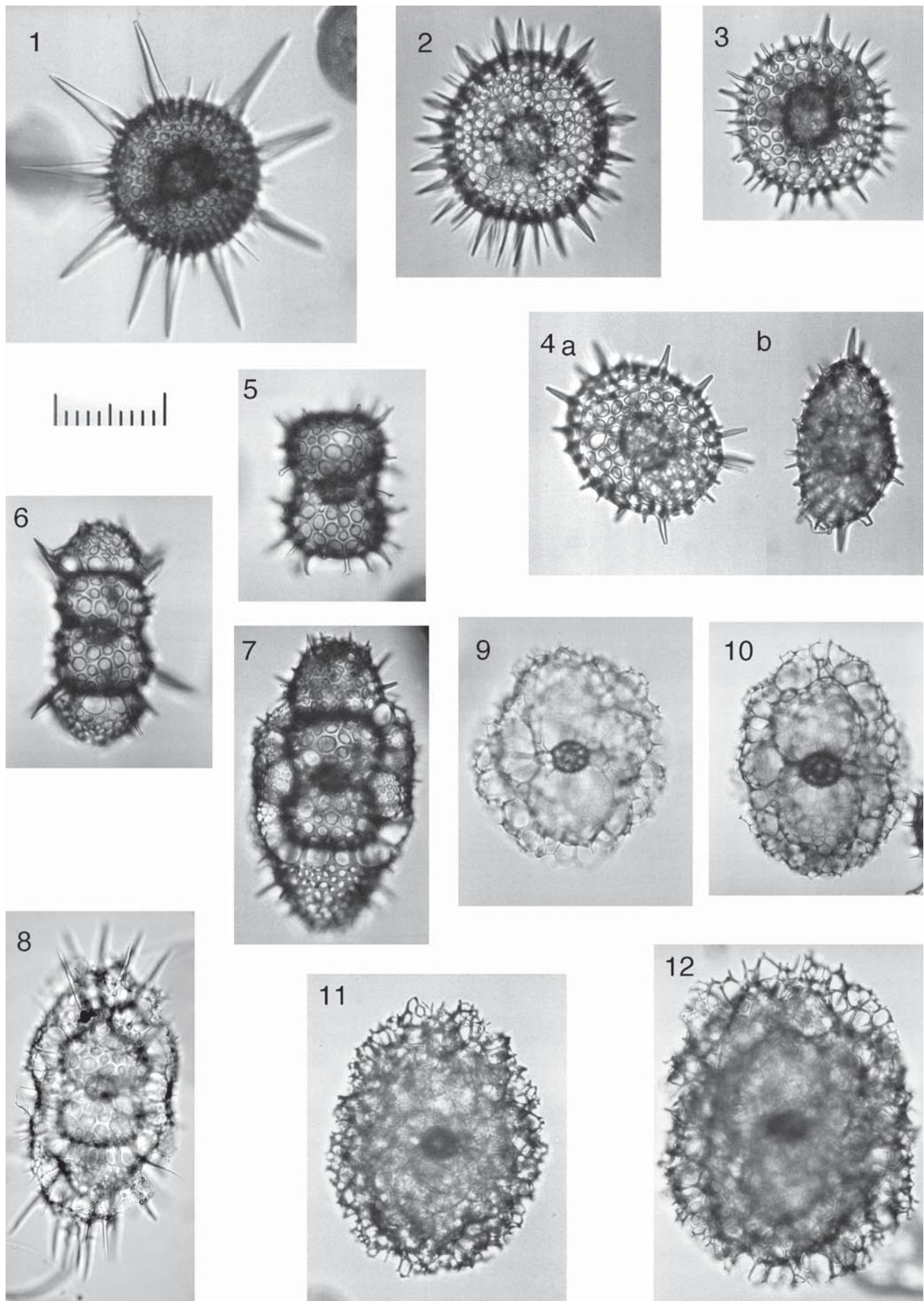
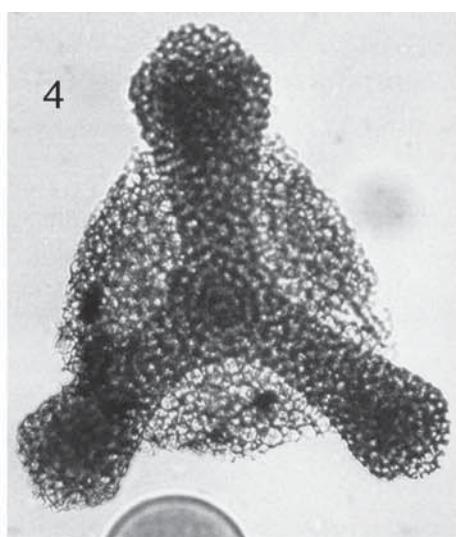
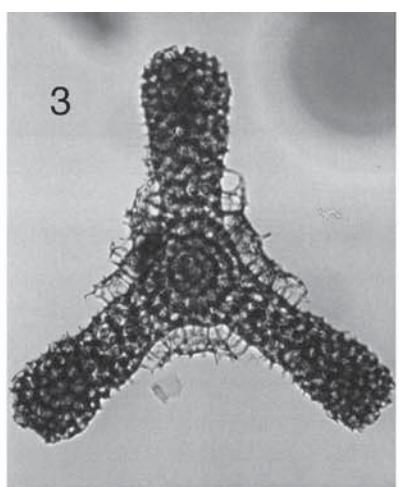
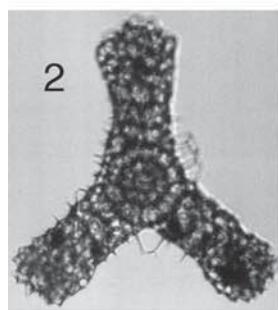
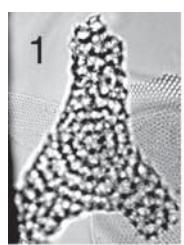
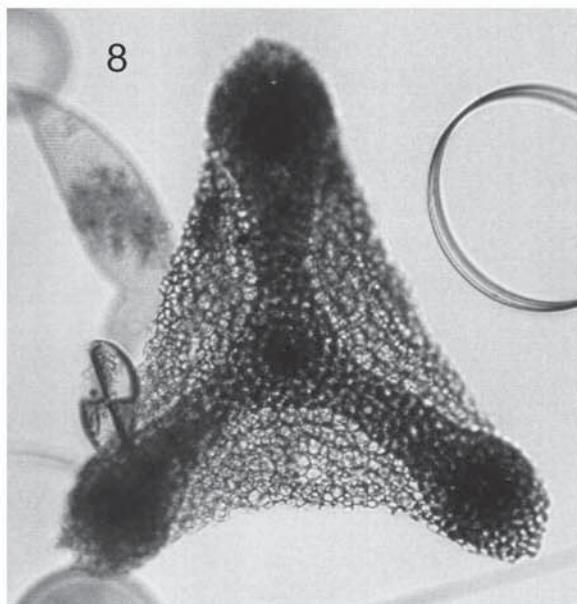
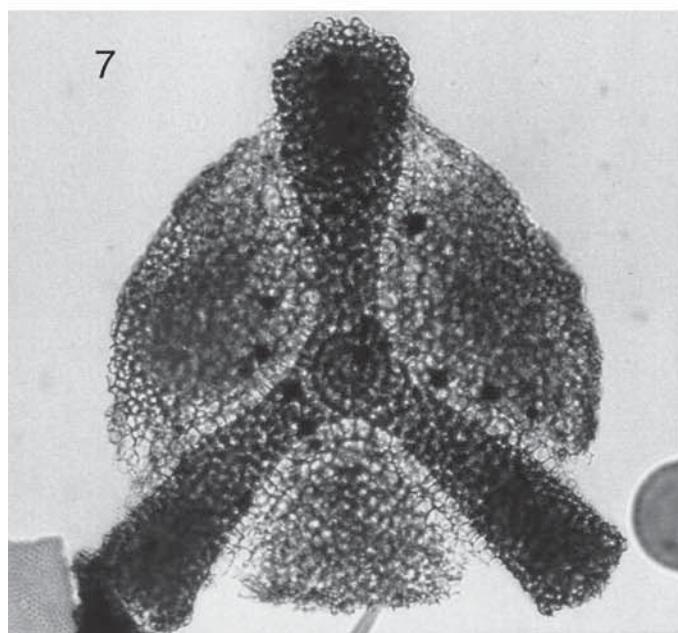
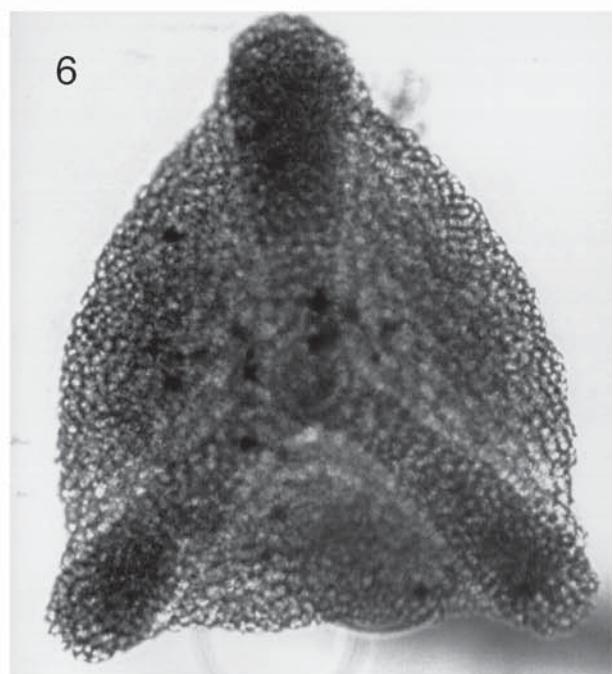
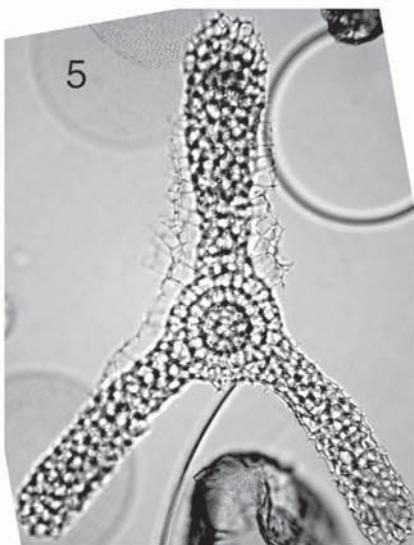


Plate 6



1μm



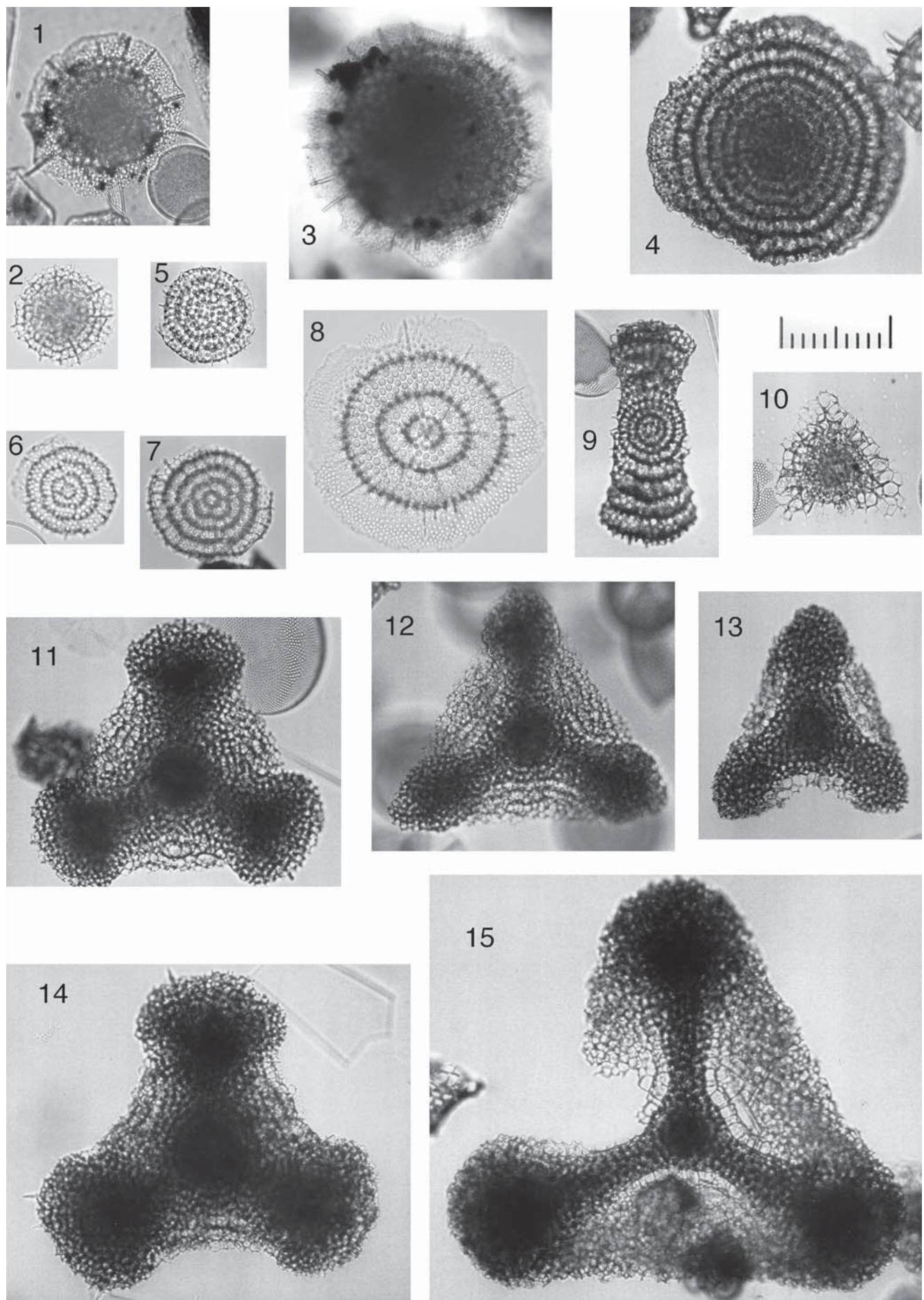
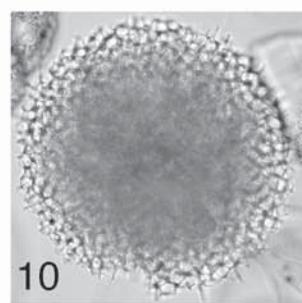
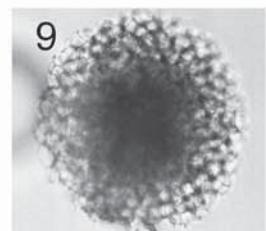
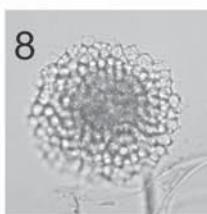
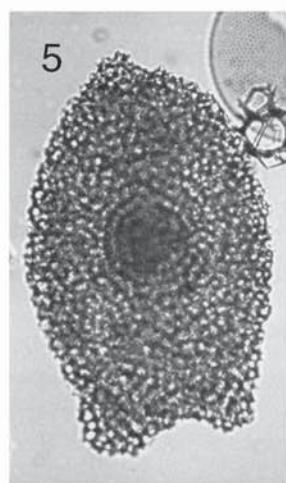
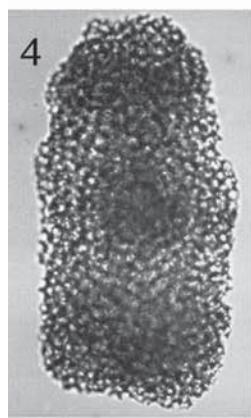
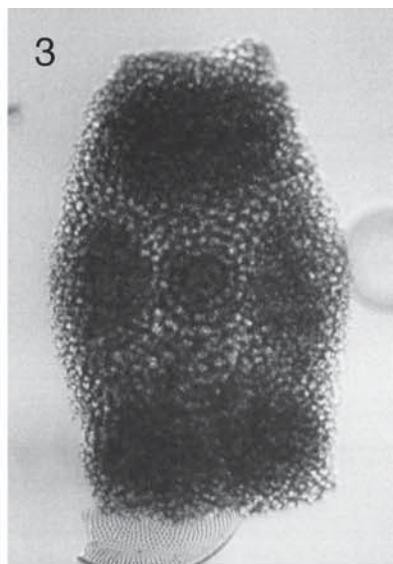
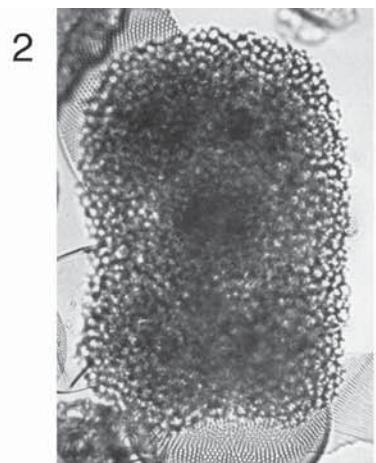
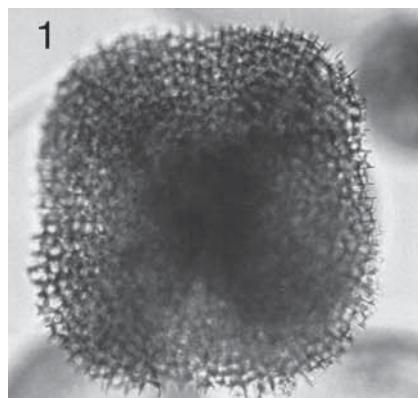
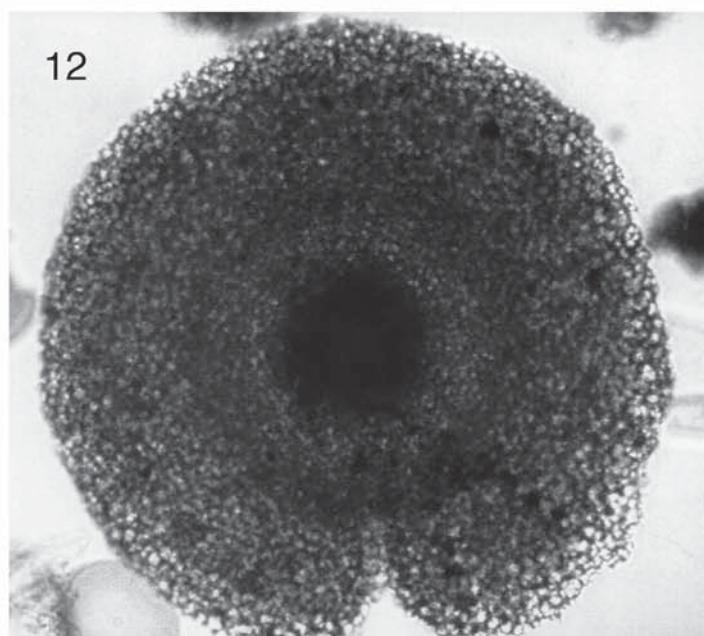
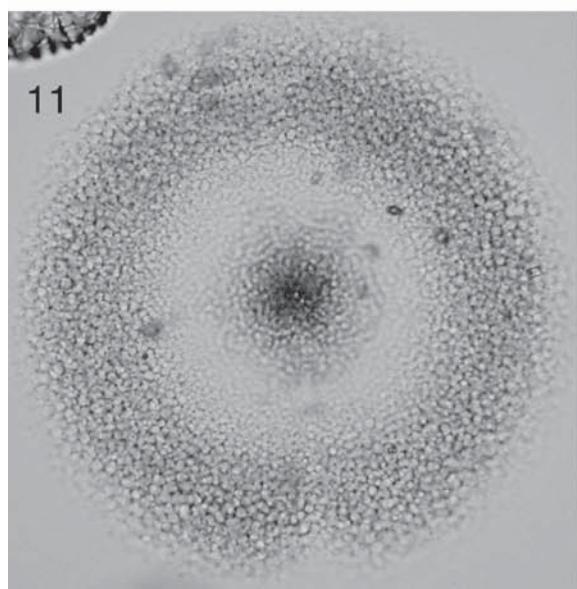
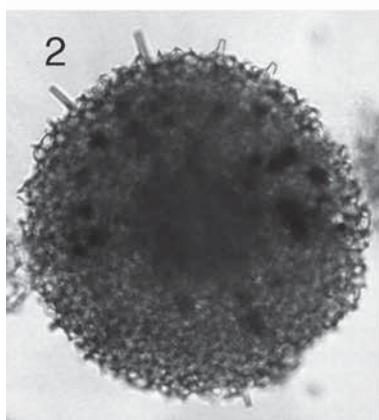
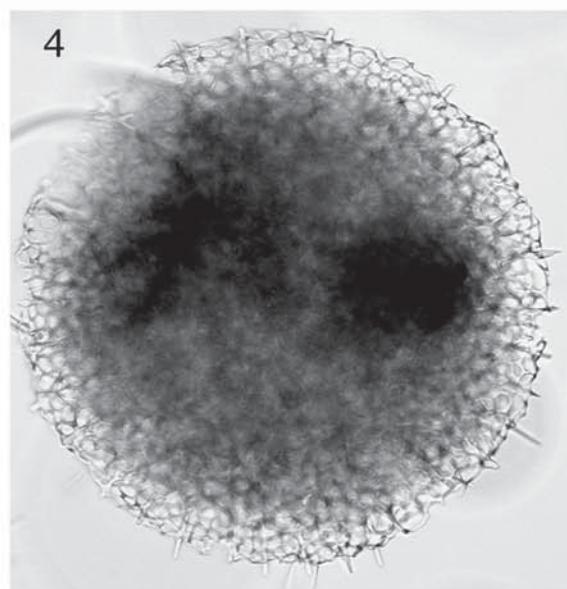
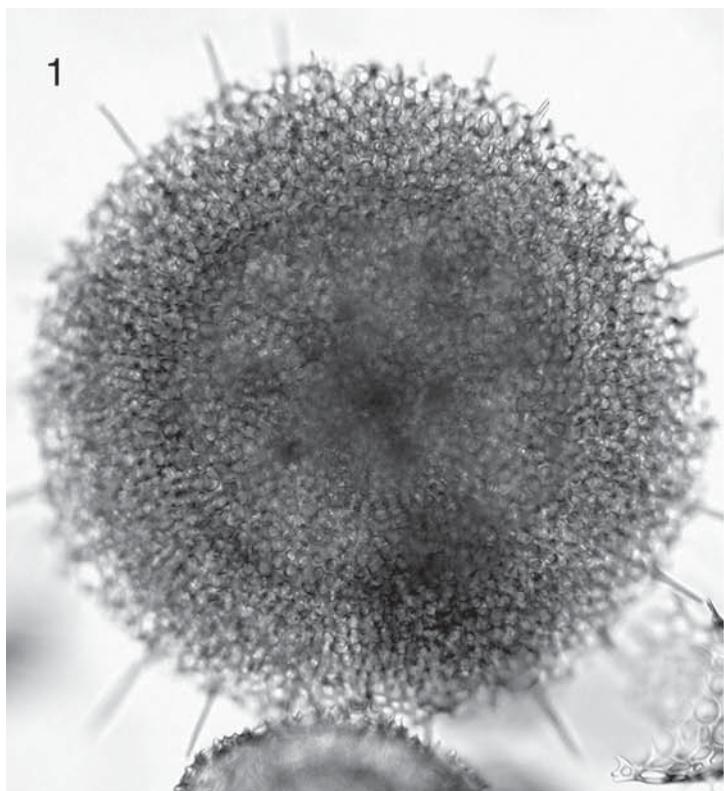


Plate 8



lumlnul





lumlnml

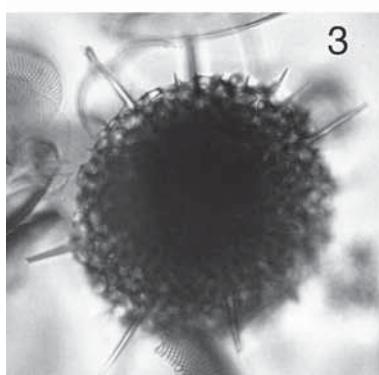
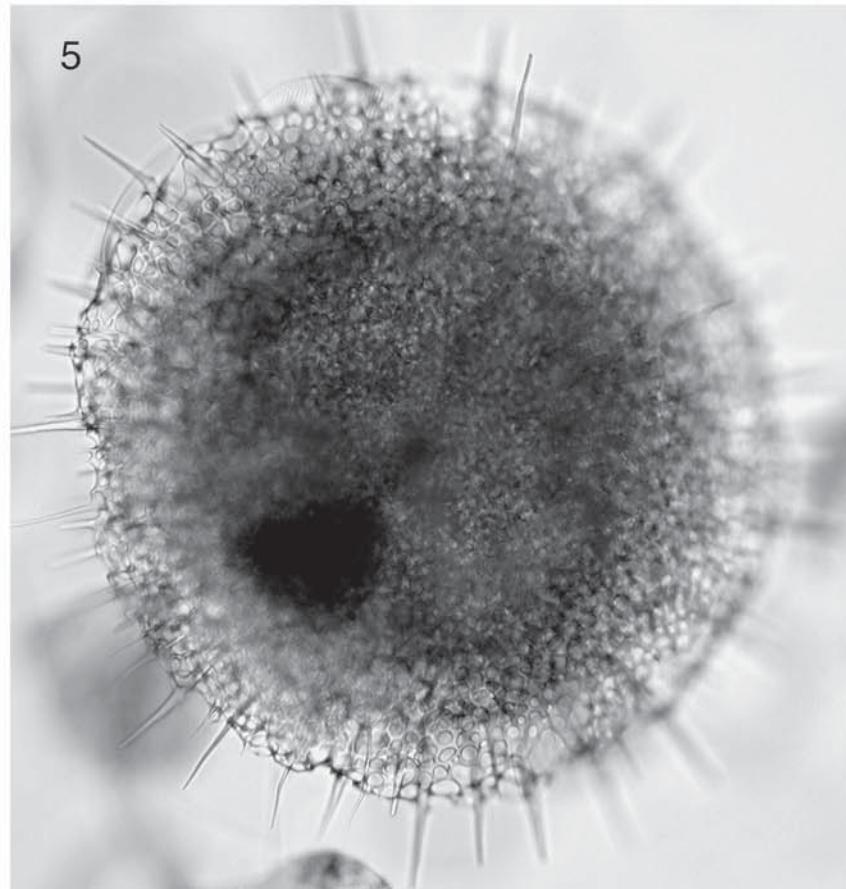


Plate 10

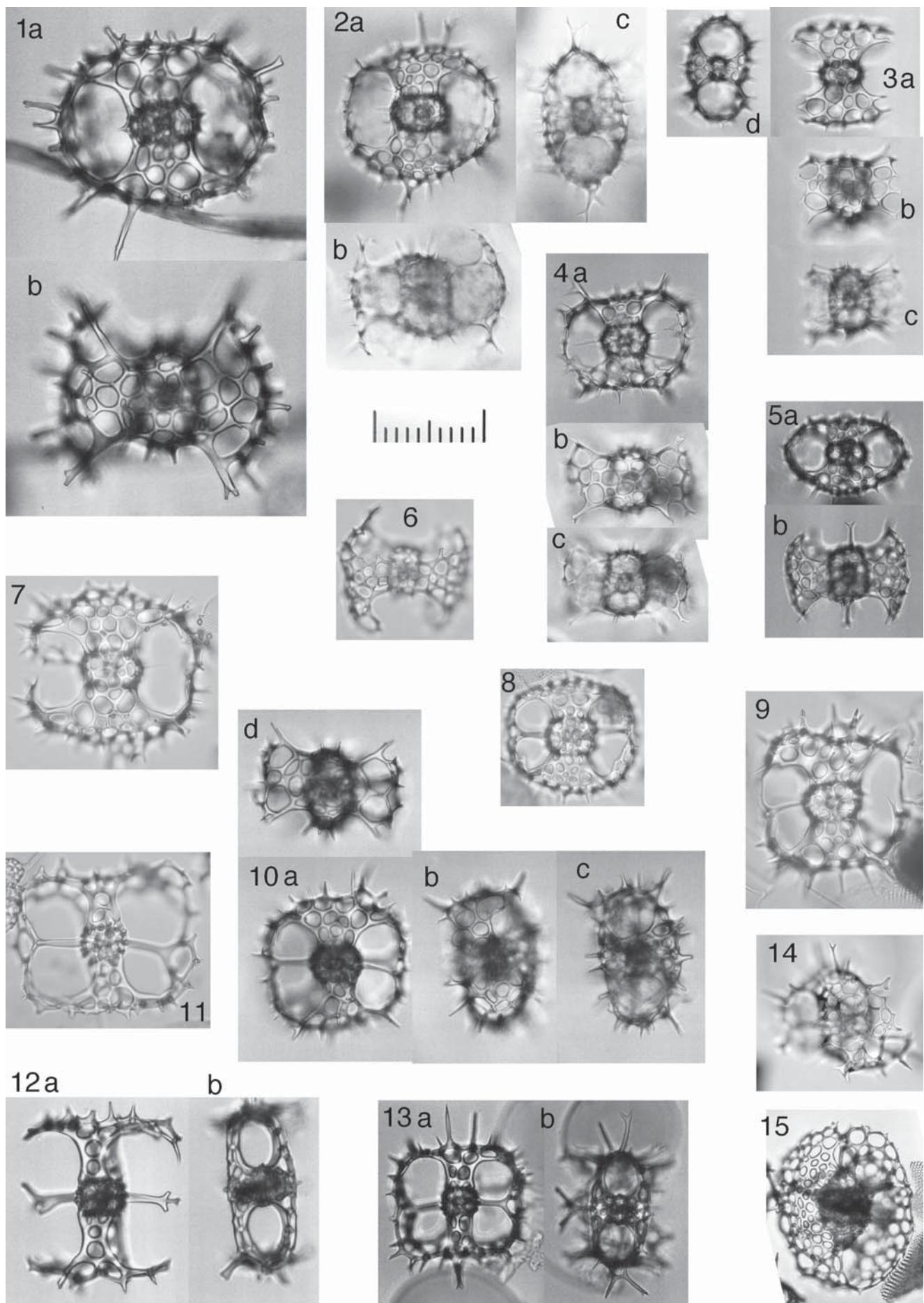


Plate 11

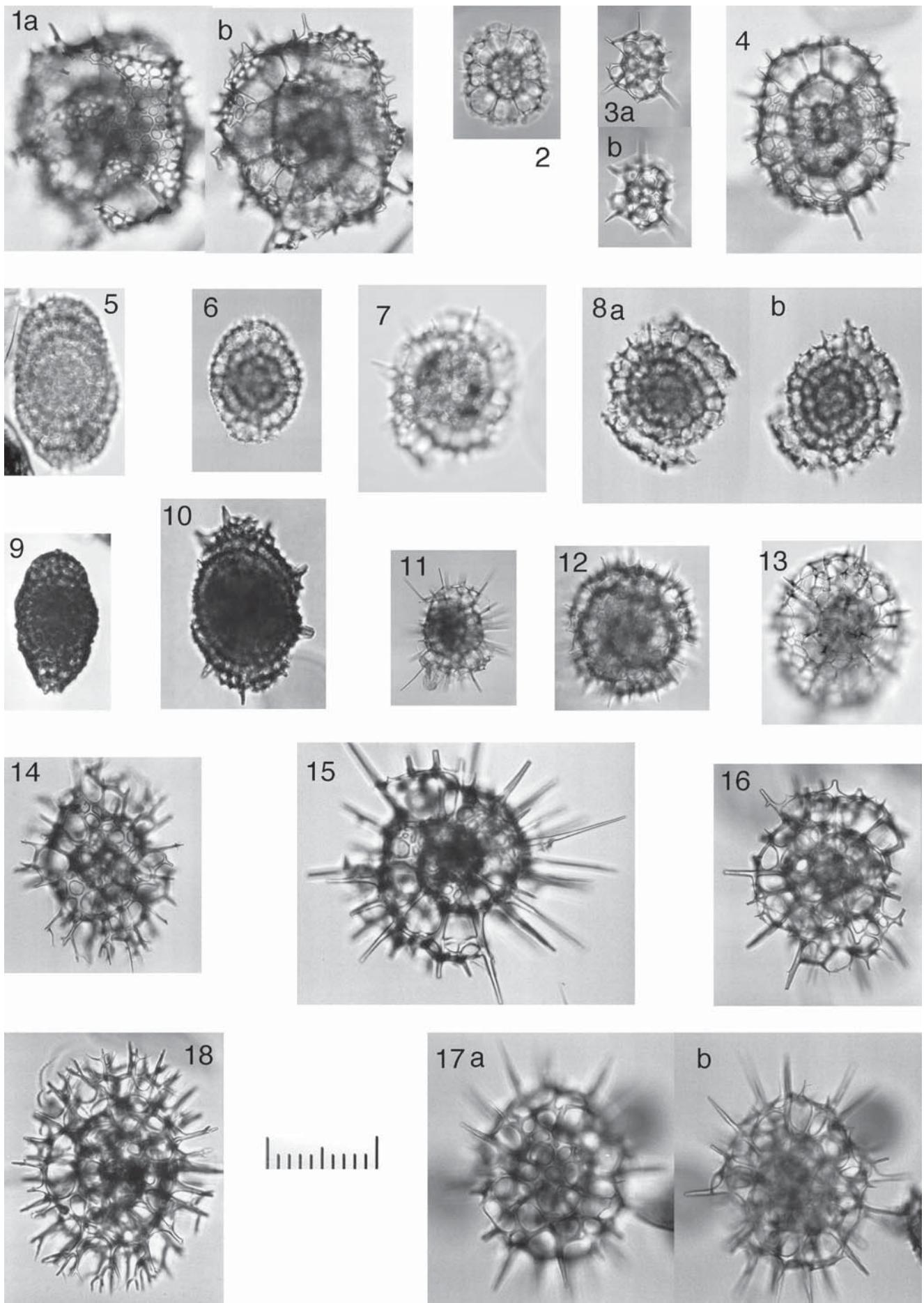
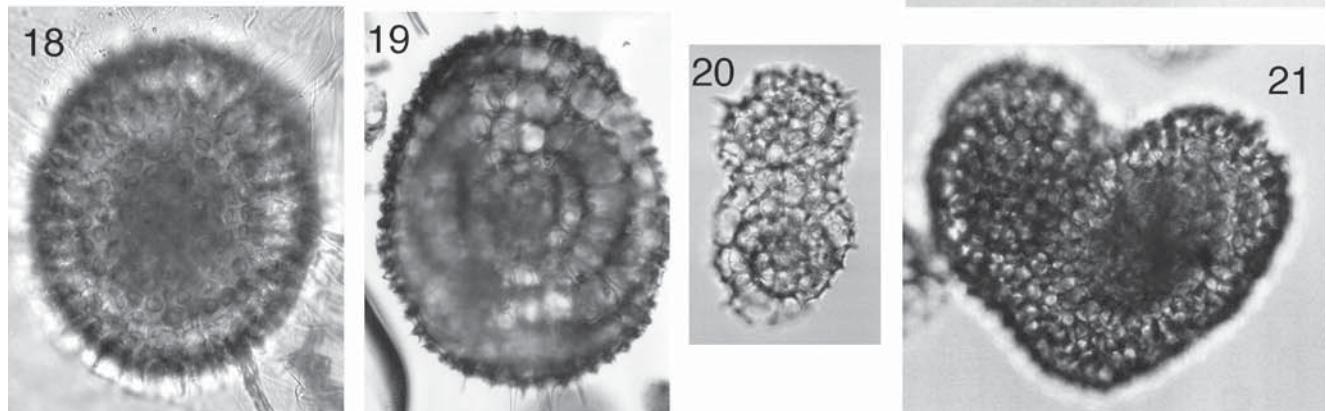
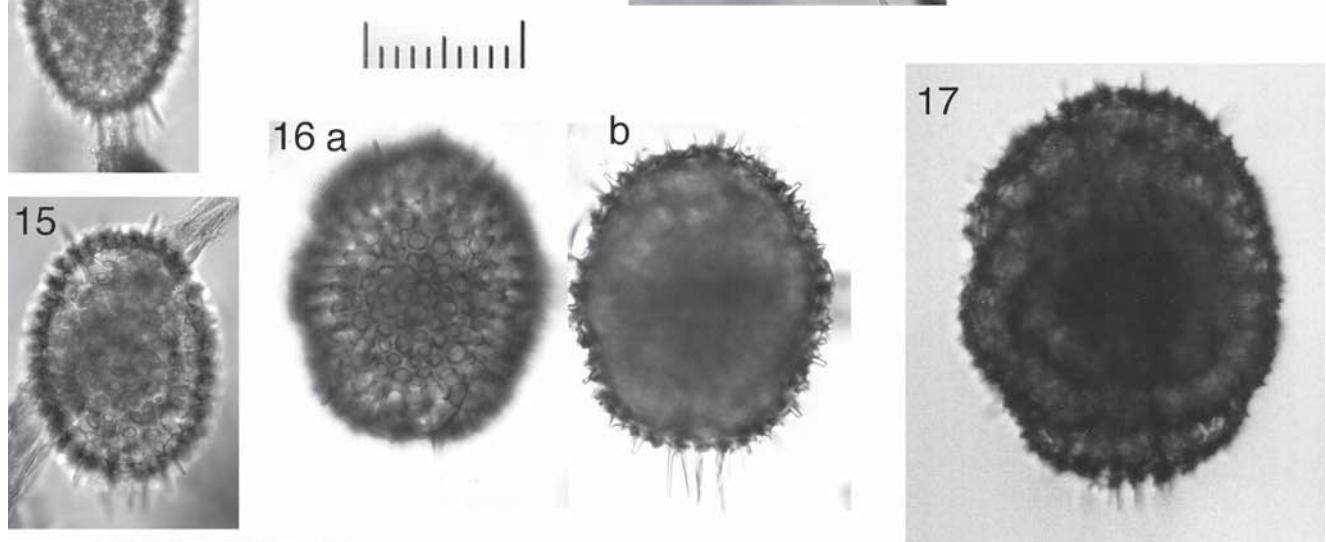
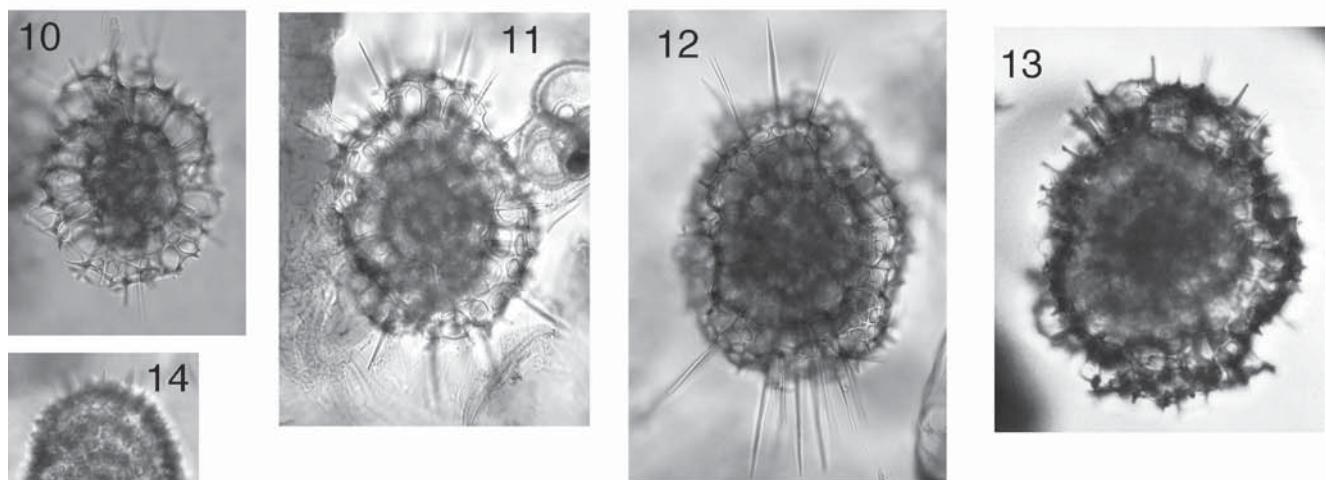
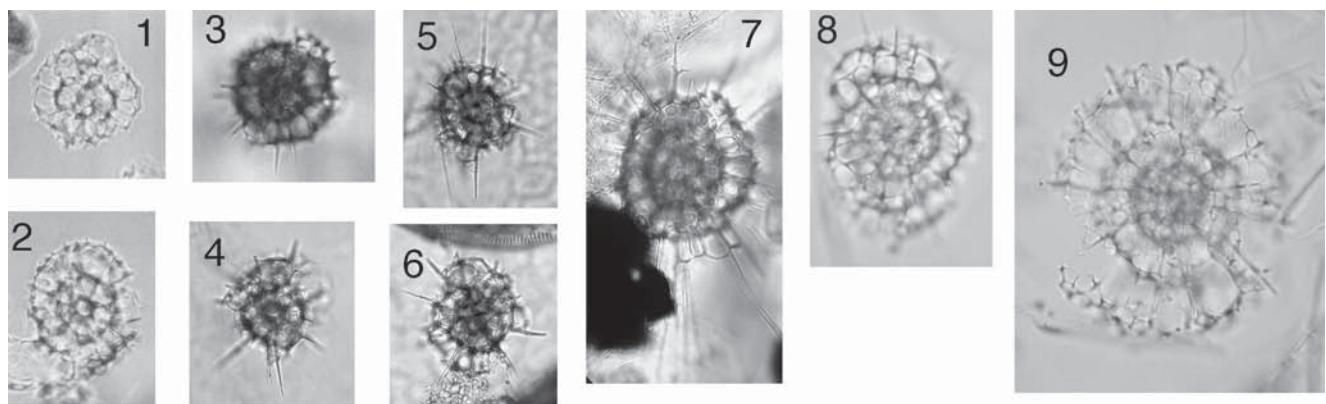


Plate 12



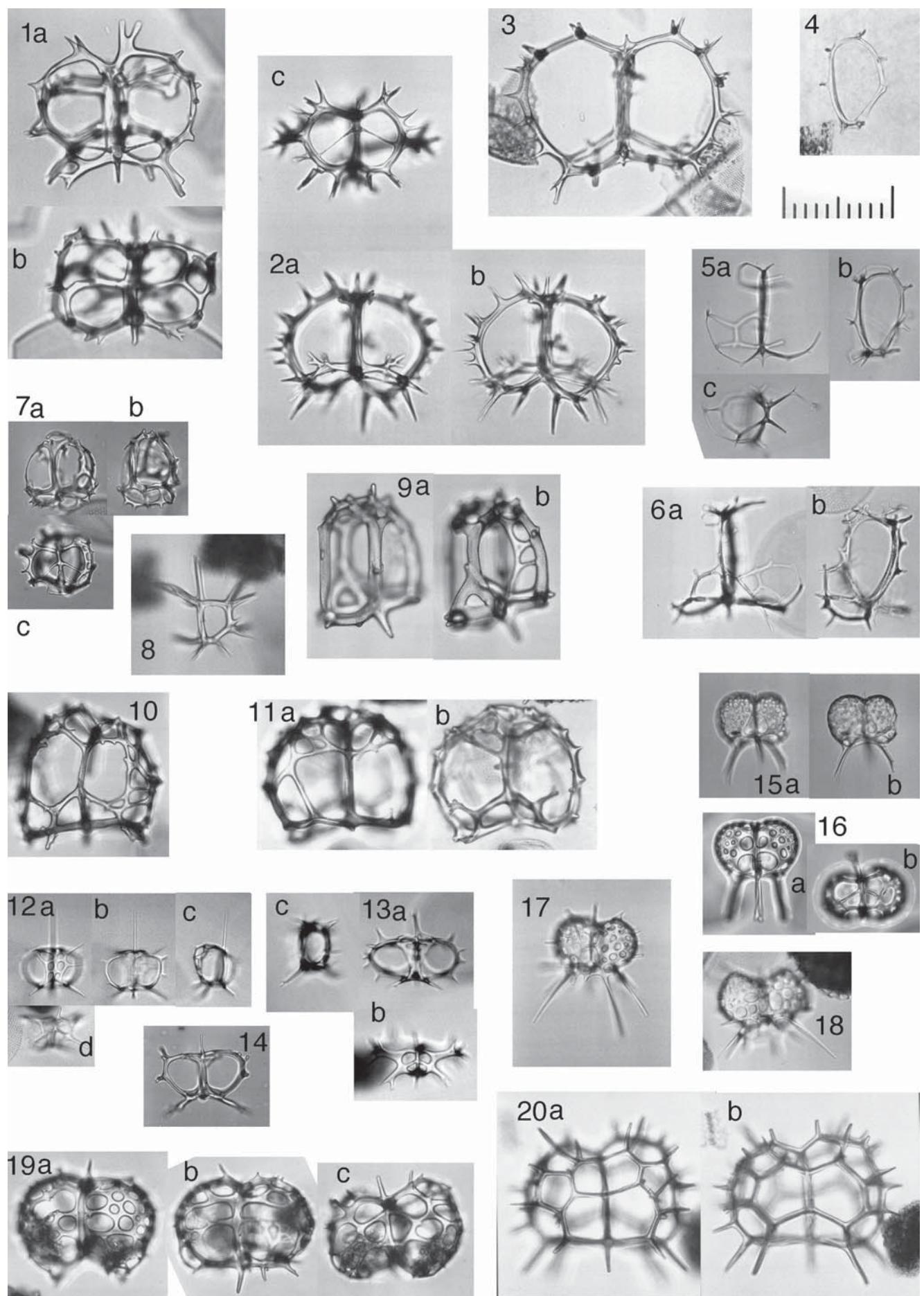


Plate 14

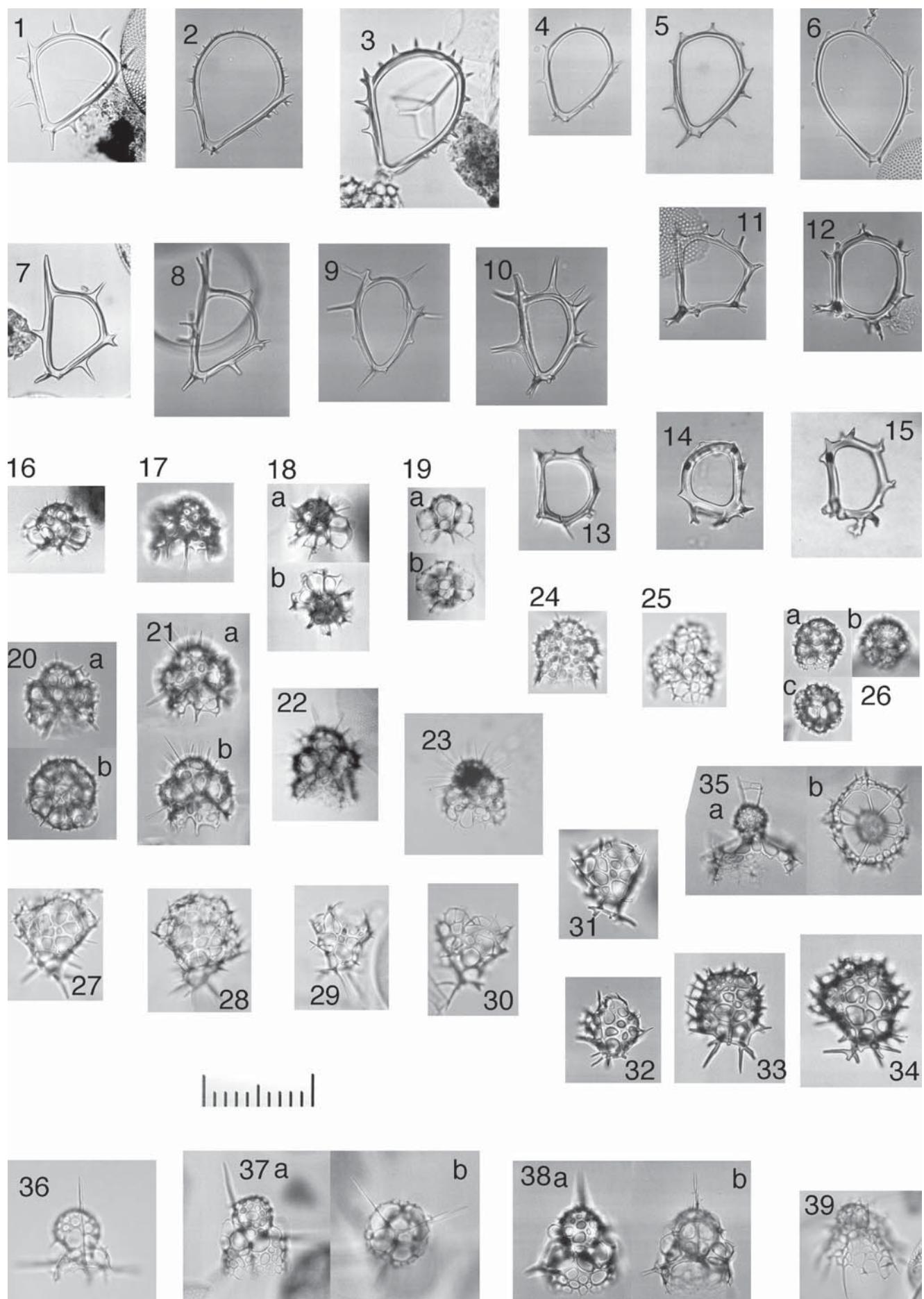


Plate 15

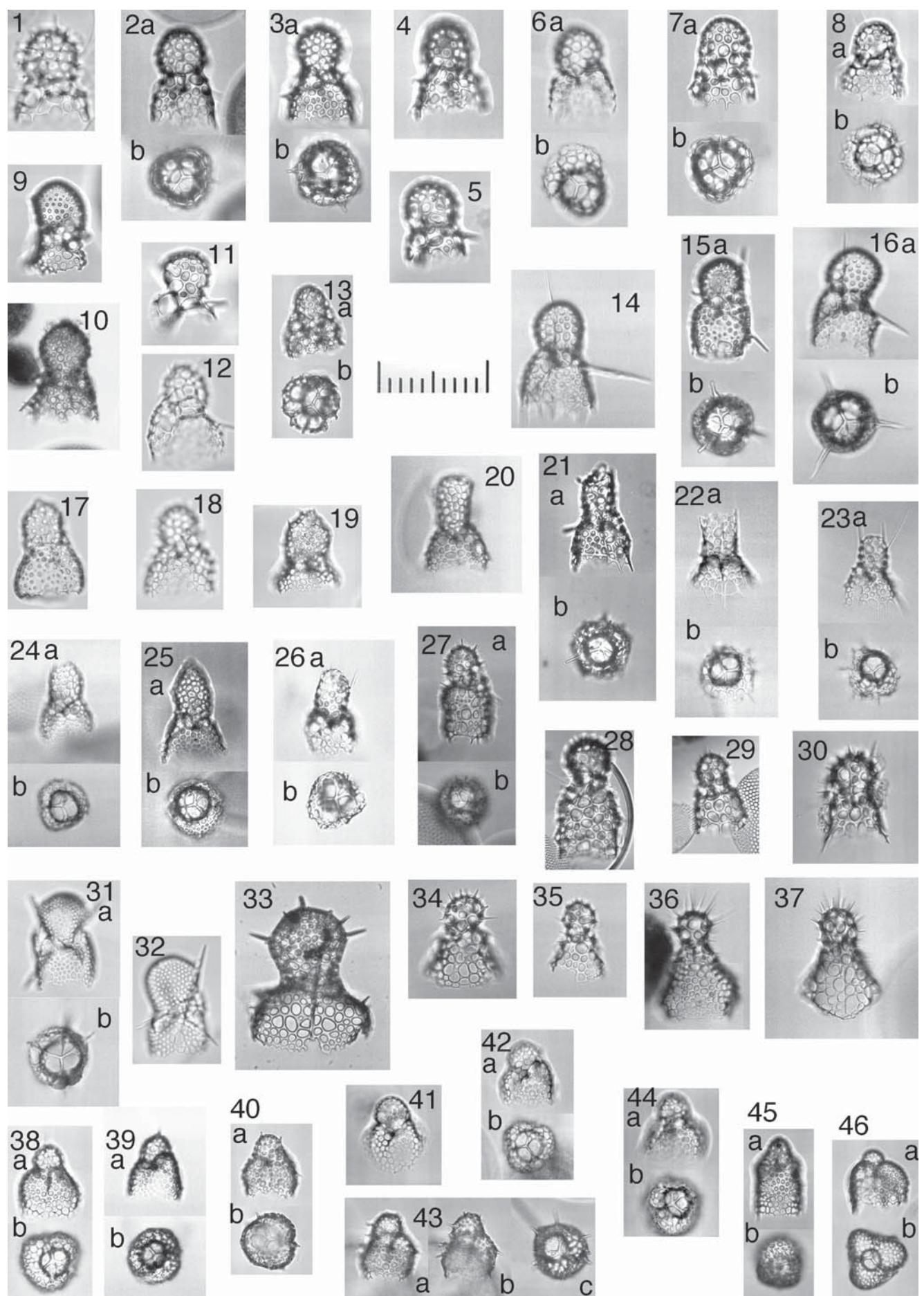
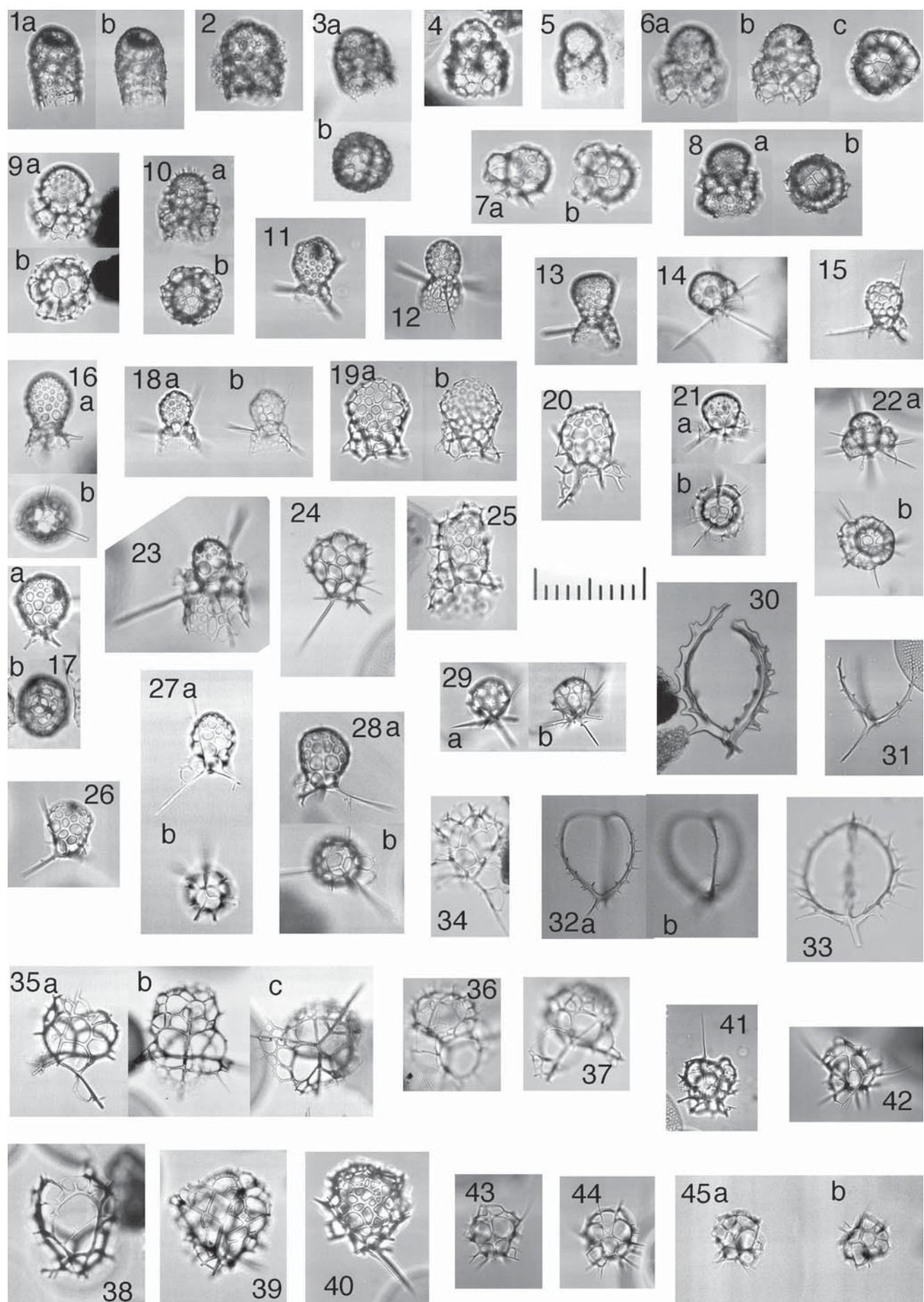
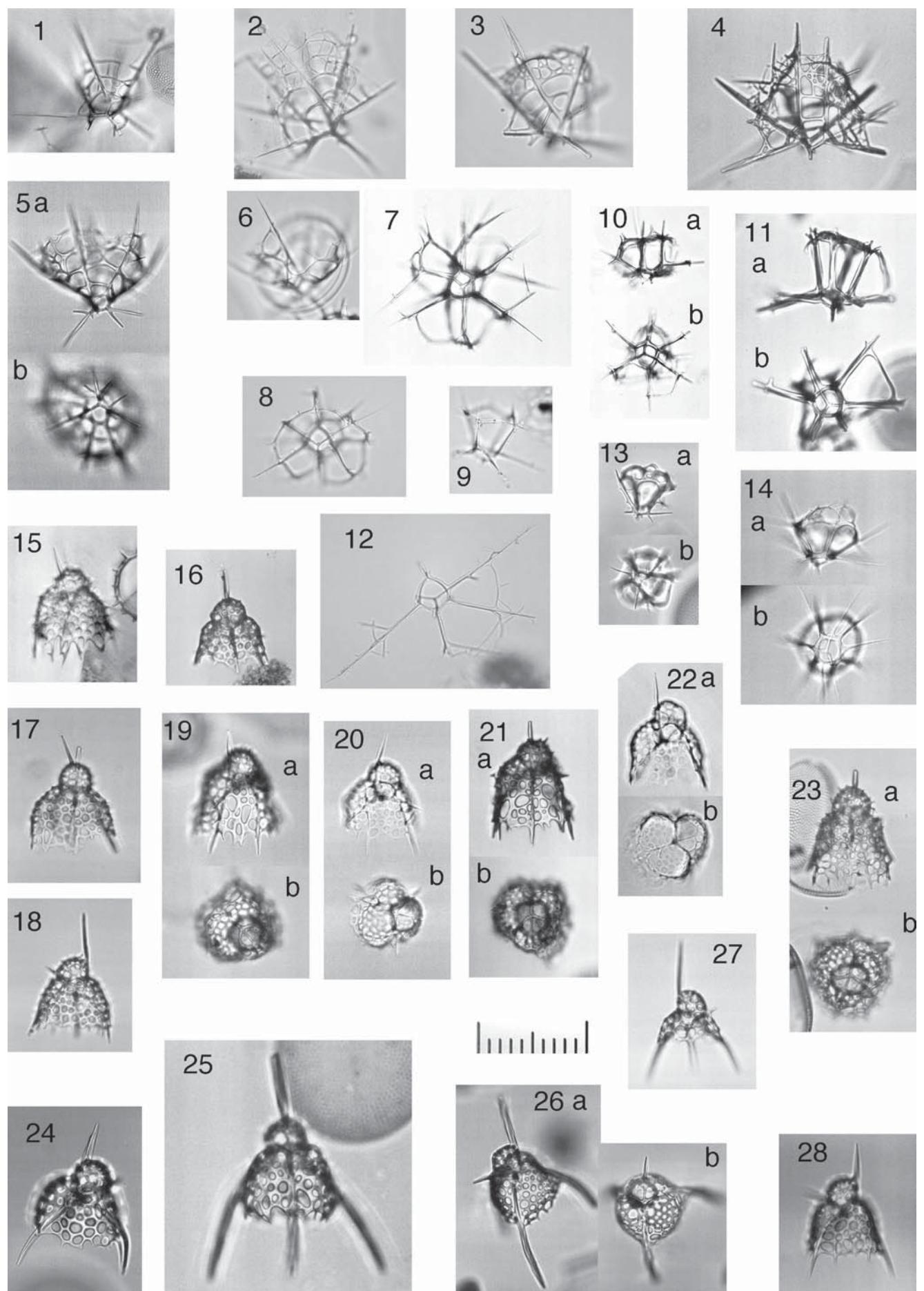
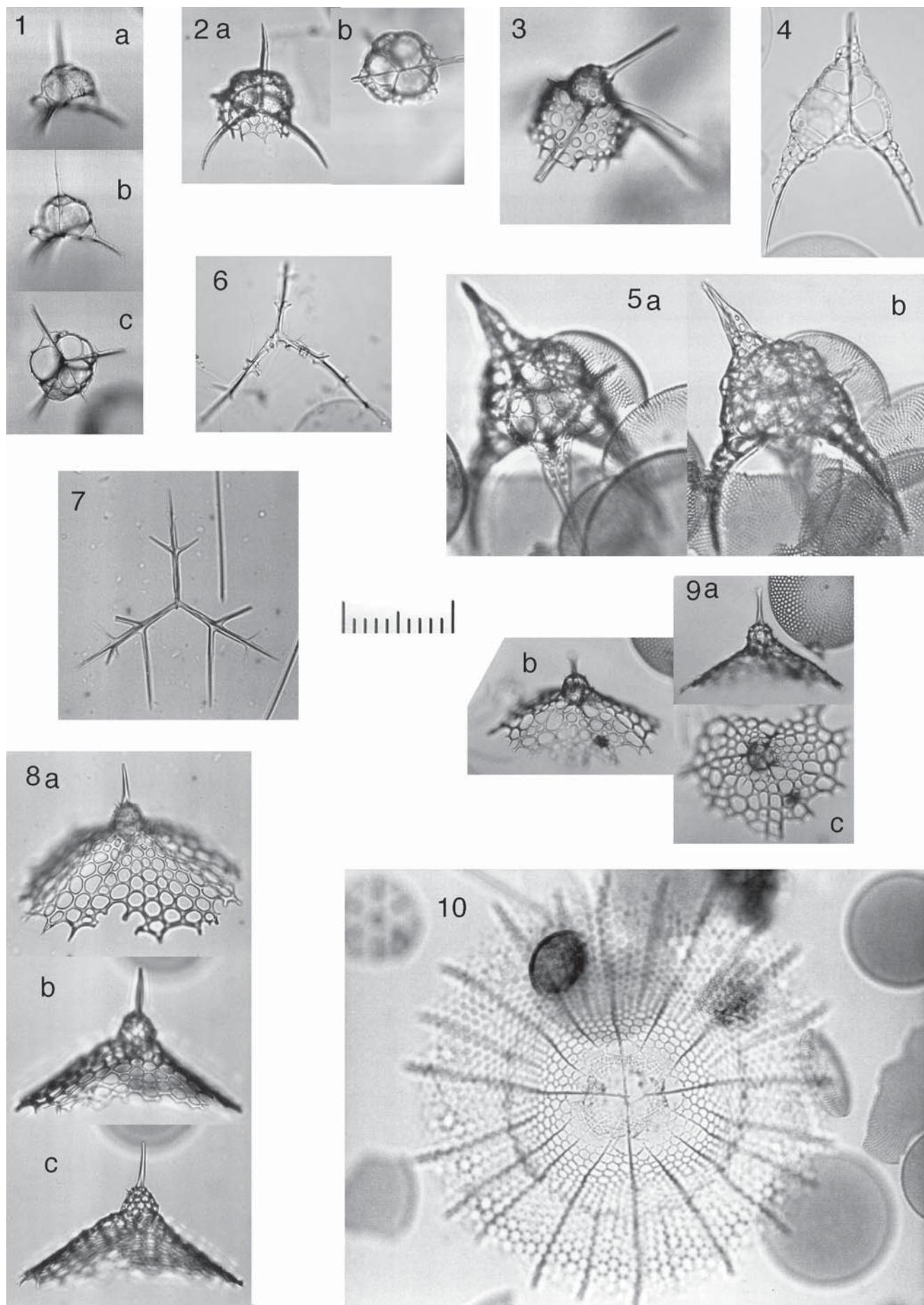


Plate 16







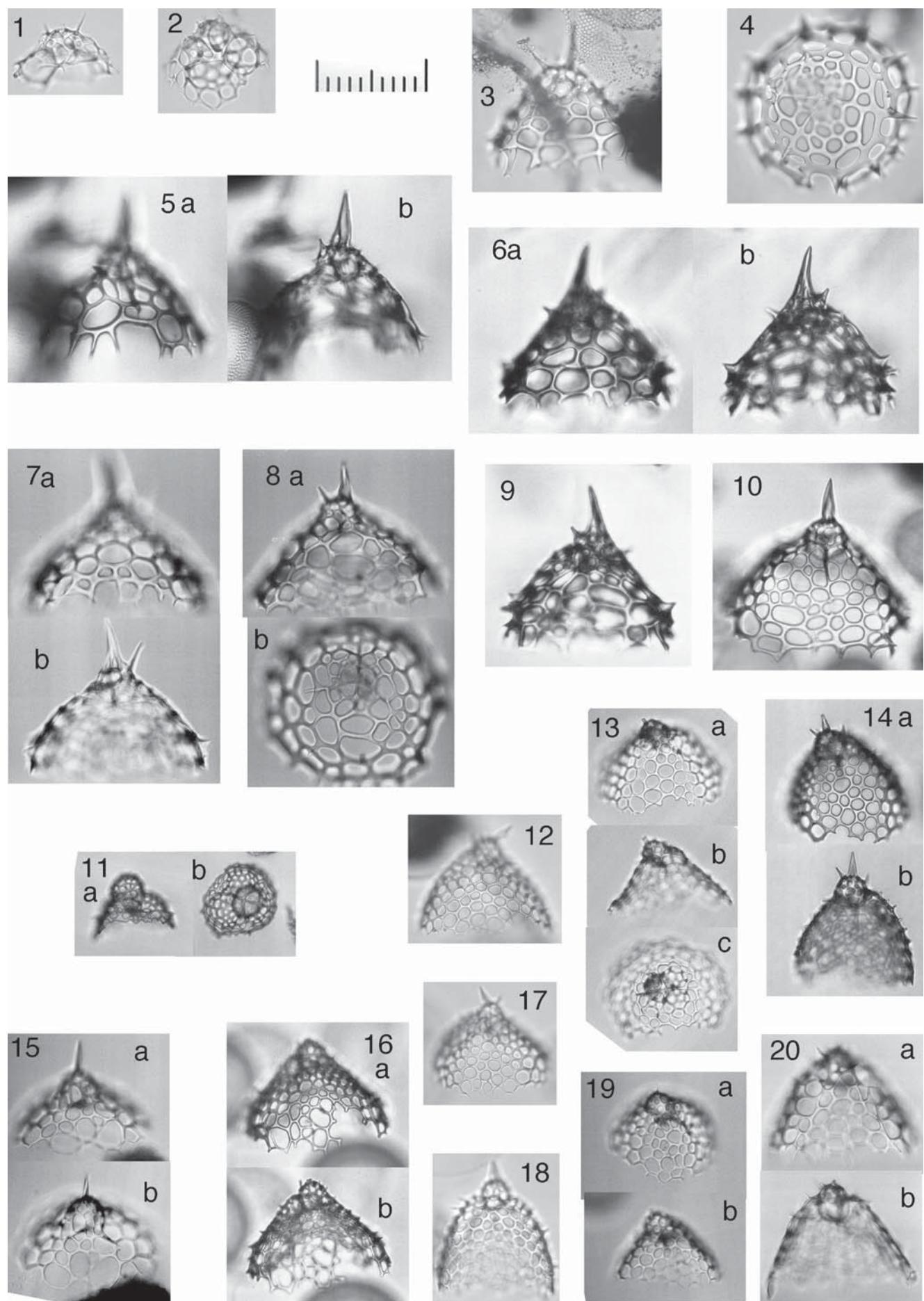


Plate 20

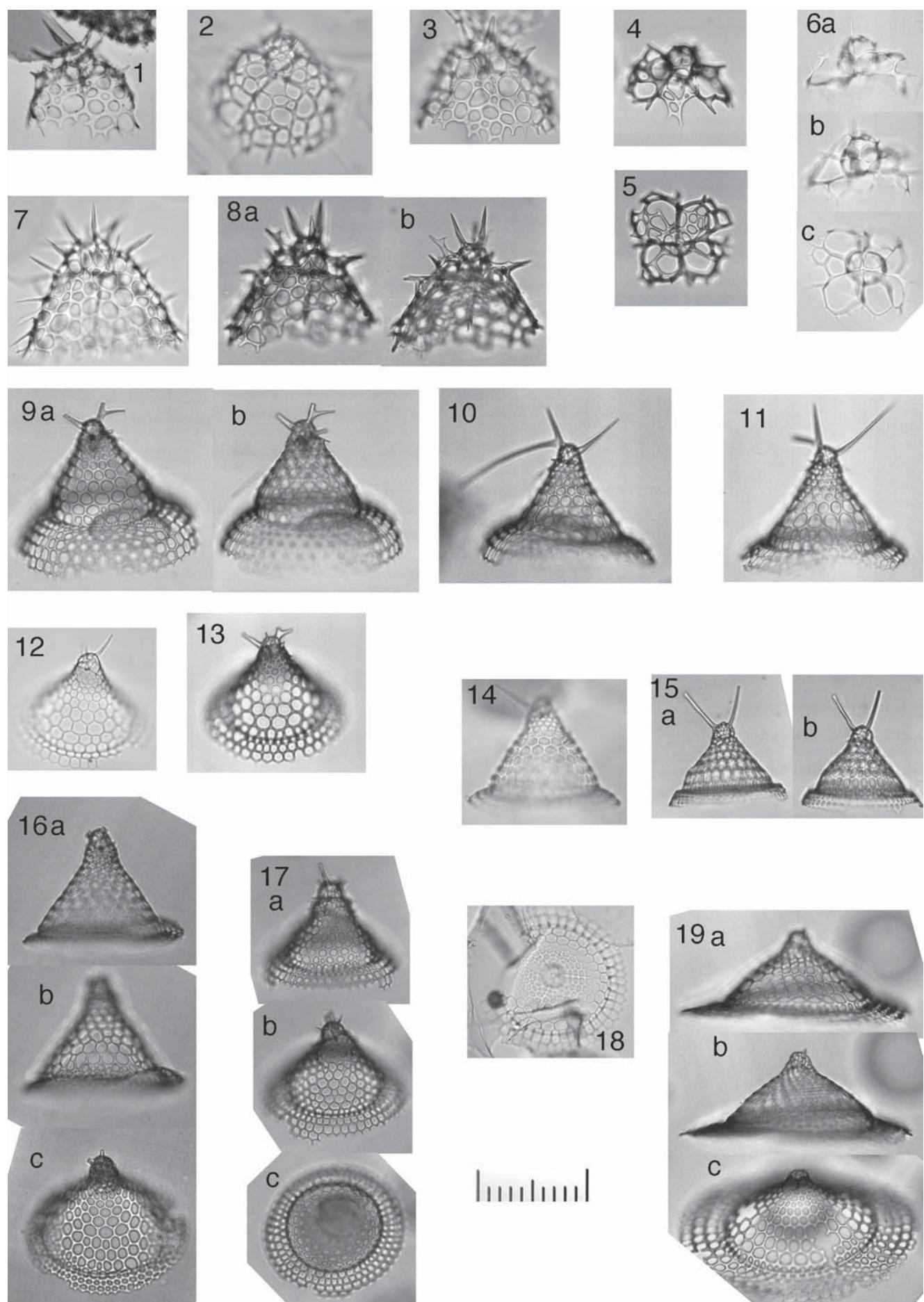


Plate 21

