Taxonomic Notes

The supra-generic classification applied here is adapted from Riedel (1967a,b) and Petrushevskaya (1971a,b) and is preferred to more recent alternatives (e.g. De Wever et al., 2001; Suzuki and Aita, 2011) because it is more practical when endeavouring to assign specimens of variable preservation to counting group categories for statistical analysis. In addition to the taxa listed below, the counting group categories include undifferentiated families and the following selected genera: *Ceratocyrtis*, *Cycladophora*, *Larcopyle*, *Lithomelissa*, *Lophocyrtis and Pseudodictyophimus*. These genus-level categories are used for specimens that cannot be confidently ascribed to one of the species listed below due to poor or incomplete preservation. As all the species ascribed to these genera have high-latitude affinities, the genus-level counts are included in the percentage of high-latitude taxa individuals present in each sample.

Subclass RADIOLARIA

Order SPUMELLARIA

Family ACTINOMMIDAE Haeckel

Actinommidae n.sp. A sensu Hollis [Plate 1, fig. 1]
Actinommidae n.sp. A, Hollis et al. 1997, p. 45, pl. 1, fig. 18-19.

Medium-sized actinommid with slightly irregular spheroidal cortical shell. Pores numerous, closely spaced, circular in regular hexagonal frames. 8 evenly spaced, slender, bladed radial spines. 1-2 medullary shells.

Genus *AMPHISPHAERA* Haeckel, emend. Petrushevskaya 1975

The genus name is applied in the sense of Petrusheskaya (1975). See Hollis (1997) for further discussion.

***Amphisphaera coronata* group (Ehrenberg), New Group** [Plate 1, fig. 2]
Stylosphaera coronata Ehrenberg 1874, p. 258; 1876, pl. 25, fig. 4; Ogane et al. 2009, pl. 12, fig. 1a-d; Suzuki et al. 2009, p. 244, pl. 1, fig. 13a-b.
Stylosphaera radiosa Ehrenberg 1876, pl. 24, fig. 5.
Ellipsostylus anisoxyphos Clark and Campbell 1942, p. 32, pl. 5, fig. 7, 11.
Lithatractus hederae Clark and Campbell 1942, p. 33, pl. 5, fig. 3.
Lithatractus pterosphaerus Clark and Campbell 1942, p. 33, pl. 5, fig. 33.
Stylosphaera coronata coronata (Ehrenberg), Sanfilippo and Riedel 1973, p. 520, pl. 1, fig. 13-17, pl. 25, fig. 4; Nishimura 1992, p. 329, pl. 1, fig. 2, pl. 11, fig. 9; Sanfilippo and Blome 2001, p. 217.

Stylosphaera coronata laevis (Ehrenberg), Sanfilippo and Riedel 1973, p. 520, pl. 1, fig. 19, pl. 25, fig. 5-6.
Stylosphaera coronata sabaca (Ehrenberg), Sanfilippo and Riedel 1973, p. 521, pl. 1, fig. 18, pl. 25, fig. 57-8.
Amphisphaera spp. gr. D. Hollis 1991, p. 71, pl. 3, fig. 20; 1993, p. 319.
Amphisphaera coronata Ehrenberg s.l., Hollis et al. 1997, p. 42.
Stylosphaera gigantea (Haeckel), Suzuki et al. 2009, p. 244, pl. 1, fig. 9.
Stylosphaera ex. gr. radiosa Ehrenberg, Suzuki et al. 2009, p. 244, pl. 1, fig. 8.

This species group includes all members of the genus with a subspherical to ellipsoidal outer shell and opposing polar spines of unequal length. Sanfilippo and Riedel (1973) distinguished *A. coronata* s.s. by the shorter polar spine having an arrow-shaped termination. Reillustration of the type specimen (Ogane et al., 2009) indicates that the species may be even more narrowly defined: the shorter polar spine has distinct ridges and increases in width prior to the arrow-like termination. The morphotype Sanfilippo and Riedel (1973) consider typical *S. coronata* compares well with *Lithatractus hederae* Clark and Campbell. Many of the other bipolar spumellarians described by Clark and Campbell (1942) are included in *A. coronata* group here. However, these narrow definitions do not reflect how the name has been applied in the past (e.g. Nishimura 1992; Suzuki et al., 2009) and so we use a broad definition of the species group that accommodates a wide range of variation. *A. macrosphaera* is distinguished by a spherical outer shell and the shorter spine being no longer than the width of the outer shell. *A. goruna* is distinguished by having at least one additional spine outside the polar plane. We include Suzuki et al.'s (2009) *Stylosphaera gigantea* and *Stylosphaera* ex**.** gr. *radiosa* in our concept of *A. coronata* gr.
Cosmopolitan.

***Amphisphaera radiosa* (Ehrenberg)** [Plate 1, fig. 3]
Stylosphaera radiosa Ehrenberg, 1854a, p. 246; 1876, pl. 24, fig. 5; Ogane et al. 2009, pl. 12, fig. 3a-4e (*non* Abelmann 1990).
Ellipsoxiphus? sp., Hollis et al. 1997, pl. 1, fig. 3-4.

This distinctive species is characterised by a strongly ellipsoidal outline, thickened outer shell and two polar spines of unequal length, the lenght of the shorter spine being equivalent to the thickness of the outer shell.

***Amphisphaera* aff. *radiosa* (Ehrenberg)** [Plate 1, fig. 4a, b] **= *Stylosphaera radiosa sensu* Abelmann**
Amphisphaera radiosa (Ehrenberg), Petrushevskaya 1975, p. 570, pl. 2, fig. 18-20; Hollis et al., 1997, p. 43, pl. 1, fig. 5-6 (*non* Crouch and Hollis 1996, p. 26).
Stylosphaera radiosa Ehrenberg, Abelmann 1990, p. 692, pl. 2, fig. 4a, b, c, 7; (?) Caulet 1991, p. 539 (non Ehrenberg 1854).

The species ascribed to *S. radiosa* by Abelmann (1990) bears little resemblance to the type specimen reillustrated by Ogane et al. (2009). Abelmann (1990) suggests that *A. radiosa* has a more spherical shell than *A. coronata* but this is clearly not the case. *A. radiosa* s.s. has a more ellipsoidal shell than *A. coronata* and is further distinguished by a thicker outer shell and more smoothly tapering polar spines, the shorter one of which is no longer than the thickness of the

outer shell. The species referred to *A.* aff *radiosa* here has a relatively small but thickened outer shell, which is subspheroidal, and one very short polar spine. Additional short spines or thorns may be present. This species compares well with the species reported by Petrushevskaya (1975) but is only tentatively synomised with the species described by Abelmann (1990) in which the shorter spine varies in length. The Late Oligocene FAD of this species at ODP Sites 689 and 690 is used to define the base of Abelmann's (1990) *Stylophaera radiosa* zone. The wider utility of this zone is questionable as *A. radiosa* first appears in the late Eocene at DSDP Site 277.

***Amphisphaera spinulosa (Ehrenberg)* = *A. goruna* (Sanfilippo and Riedel)** [Plate 1, fig. 5]

Stylosphaera spinulosa Ehrenberg 1874, p. 259; 1876, pl. 25, fig. 8; Caulet 1991, p. 539; Ogane et al. 2009, pl. 12, 6a-f (erroneously recorded as *Stylosphaera liostylus*).

Druppatractus cf. *coronatus* (Squinabol), Dumitrica 1973, p. 787, pl. 6, fig. 4,6; pl. 12, fig. 11.

Stylosphaera goruna Sanfilippo and Riedel 1973, p. 521, pl. 1, fig. 20-22; pl. 25, fig. 9, 10 (? fig. 11); Nishimura 1987, p. 729, pl. 1, fig. 3; Nishimura 1992, p. 329, pl. 1, fig. 1; pl. 11, fig. 8; Sanfilippo and Blome 2001, p. 219.

Amphisphaera spinulosa (Ehrenberg), Petrushevskaya 1975, p. 570, pl. 15, fig. 8; Hollis 1991, p. 69, pl. 3, fig. 11-15; 1993, p. 318, pl. 1, fig. 5.

Amphisphaera goruna (Sanfilippo and Riedel). Strong et al. 1995, p. 208, fig. 8G, 9A; Hollis 1997, p. 34, pl. 2, fig. 10, 11; Hollis et al. 1997, p. 42.

With the reillustration of Ehrenberg's type specimen of this species (Ogane et al. 2009) there can be little doubt the *A. goruna* is a junior synonym of *A. spinulosa*. The discontinuous range observed at Mead Stream (Strong et al. 1995; Hollis 1997) and possibly other regions may be a response to climatic changes, with the species appearing to show a preference for the cooler conditions of the Paleocene and the late Middle Eocene to Oligocene. Cosmopolitan.

***Amphisphaera*? *megapora* (Ehrenberg)** [Plate 1, fig. 6]

Cenosphaera megapora Ehrenberg 1874, p. 218, 1876, pl. 3, fig. 1; Ogane et al. 2009, pl. 3, fig. 1a-c.

Amphisphaera aff. *spinulosa* (Ehrenberg), Crouch and Hollis 1996, p. 26; Hollis et al. 1997, p. 43, pl. 1, fig. 1,2.

? *Amphisphaera spinulosa* (Ehrenberg) group. Petrushevskaya 1975 (in part), p. 570.

Distinguished from *A. spinulosa* by a spherical cortical shell and the absence of distinct polar spines. All radial spines are of similar length. As *A. spinulosa* was not encountered in Site 281 material (Crouch and Hollis 1996) it seems likely that the form recorded from the Eocene of DSDP Site 280 by Petrushevskaya (1975) is *A. megapora*.

Genus *ANOMALACANTHA* Loeblich & Tappan 1961

***Anomalocantha dentata* (Mast)**

Heteracantha dentata Mast 1910 p. 159, pl. 37, fig. 47,

Anomalocantha dentata (Mast), Benson 1966, p. 170, pl. 5, fig. 10-11.

Anomalocantha dentata (Mast), Petrushevskaya and Kozlova 1979, fig. 219, 427.

Cladococcus eocenica (Petrushevskaya and Kozlova 1979), Suzuki et al. 2009, p. 244, pl. 2, fig. 9.

Genus *STYLOSPHAERA* Ehrenberg, emend. Petrushevskaya 1975

***Stylosphaera minor* Clark and Campbell group** [Plate 1, fig. 7]

Stylosphaera minor Clark and Campbell 1942, p. 27, pl. 5, fig. 1, 2, 2a, 12; Petrushevskaya 1975, p. 569; Caulet 1986, p. 853; 1991, p. 539; Strong *et al.* 1995, p. 209; Shilov 1995, p. 124, pl. 3, fig. 2.

Amphisphaera minor (Clark and Campbell), Sanfilippo and Riedel 1973, p. 486, pl. 1, fig. 1-5; pl. 22, fig. 4; Chen 1975, p. 452, pl. 3, fig. 1; Westberg-Smith and Riedel 1984, p. 486.

Axoprunum minor (Clark and Cambell), Suzuki et al. 2009, p. 241, pl. 4, fig. 5a-6c.

Included in this complex are forms with a moderately large spherical, outer shell with numerous small circular pores, slender conical (rarely bladed) polar spines. Suzuki et al. (2009) observe the presence of equatorial beams and on this basis transfer the species to *Axoprunum*. These structures are not evident in the specimens we refer to *S. minor* here. Similar specimens that have equatorial beams characteristic of *Axoprunum* are placed in *A. pierinae* gr. here. Cosmopolitan.

Genus *ZEALITHAPIUM* O'Connor 1999a

***Zealithapium mitra* (Ehrenberg)** [Plate 1, fig. 8]

Cornutella mitra Ehrenberg, 1874, p. 221; 1876, pl. 2, fig. 8.

Lithapium mitra (Ehrenberg). Riedel and Sanfilippo 1970, p. 520, pl. 4, fig. 6, 7; Sanfilippo and Riedel 1973, p. 516; Palmer 1987, p. 356; Takemura 1992 (cf.), p. 742, pl. 7, fig. 2.; Hollis et al. 1997, p. 45, pl. 1, fig. 20.

Zealithapium mitra (Ehrenberg), O'Connor 1999a, p. 5-6, pl. 9, fig. 47; Moore and Kamikuri 2012, p. 13, pl. 10, fig. 5.

non *Zealithapium mitra* (Ehrenberg), Funakawa et al. 2006, p. 44, pl. 17, fig. 5.

Distinguished by its single cortical shell in the shape of an inflated cone, narrowing slightly at the open end. Meshwork is coarse with thorns arising from junctions of pore frames. We include only specimens with a simple horn. Funakawa's specimen looks like *Aspis sp. A*, with the characteristic 'cockscomb-like' apical spine, so we don't include it here. As Funakawa's specimen is very abundant at ODP Leg 199, it is likely that some the counted specimen might be *Z. mitra*, however the pictured specimen is not. Cosmopolitan.

Subfamily SATURNALINAE Deflandre

Genus *AXOPRUNUM* Haeckel

***Axoprunum bispiculum* (Popofsky)** [Plate 1, fig. 9]

Stylocontarium bispiculum Popofsky 1912, p. 91, pl. 2, fig. 2; Chen 1975, p. 454, pl. 21, fig. 1-2.

Axoprunum bispiculum (Popofsky), Takemura 1992, p. 741, pl. 1, fig. 1-2; Hollis et al. 1997, p. 43. pl. 1, fig. 14; Takemura and Ling 1997, p. 111; Kamikuri et al. 2006, p. 7; (*non* Suzuki et al. 2009).

Distinguished from *A. pierinae* by a larger, almost spherical cortical shell and shorter polar spines, which often diverge slightly from main axis. Intermediate forms occur in the early Oligocene. High-latitude.

***Axoprunum pierinae* (Clark and Campbell) group, New Group** [Plate 1, fig. 10, 11]
Lithatractus pierinae Clark and Campbell 1942, p. 34, pl. 5, fig. 25.
Sylatractus pictus Mamedov 1969, p. 99, pl. 2, fig. 4-4a.
Axoprunum pierinae (Clark and Campbell), Sanfilippo and Riedel 1973, p. 488, pl. 1, fig. 6-12, pl. 23, fig. 3; Petrushevskaya 1975, p. 571; Caulet 1991, p. 537; Takemura. 1992, p. 742, pl. 6, fig. 3-6; Nishimura 1992, p. 329; Strong *et al.* 1995, p. 208, fig. 10c; Crouch and Hollis 1996, p. 26; Hollis et al. 1997, p. 44, pl. 1, fig. 7-13; Takemura and Ling, 1997, pl. 1, fig. 1.
Axoprunum liostylum (Ehrenberg). Petrushevskaya and Kozlova 1972, p. 521, pl. 10, fig. 3; Petrushevskaya 1975, p. 571, pl. 2, fig. 22; Crouch and Hollis 1996, p. 26.
Axoprunum bispiculum (Popofsky), Suzuki et al. 2009, p. 241, pl. 1, fig. 3a-b.
Axoprunum venustum (Borisenko), Suzuki et al. 2009, p. 241, pl. 1, fig. 1, 2.
? *Axoprunum euterpe* (Haeckel), Caulet 1986, p. 852.
non *Stylosphaera liostylus* Ehrenberg 1875, pl. 25, fig. 2; Ogane et al. 2009, pl. 12, fig. 6a-f.

Ellipsoidal cortical shell with 2 conical polar spines, usually of unequal length; typically slender but may be thickened throughout or medially. 1-2 medullary shells supported by 2 strong polar beams and 4 evenly spaced equatorial beams. It is uncertain if this species group comprises a single polymorphic species or several distinct species. Variations in cortical shell thickness and size, polar spine thickness and shape and shape of outer medullary shell may have some ecological significance. Morphotypes with thicker polar spines appear to be restricted to southern high latitude locations (e.g. Takemura 1992, pl. 6, fig. 3-4; Hollis et al., pl. 1, fig. 7; Takemura and Ling 1997, pl. 1, fig. 1; Suzuki et al., 2009, pl. 1, fig. 1), whereas morphotypes with medially inflated polar spines appear to have had a bipolar distribution (e.g. Mamedov 1969, pl. 2, fig. 4-4a; Kozlova 1999, pl. 33, fig. 10, pl. 38, fig. 2; Suzuki et al. 2009, p. 1, fig. 2). At Site 277, however, there appears to be a gradation between these specimens with thickened spines, specimens that conform with the type species and specimens with near-spherical cortical shells (Hollis et al. 1997, pl. 1, fig. 9). For this reason, we combine this range of morphotypes into a single species group here. This group accommodates the forms ascribed to *A. liostylum* by Petrushevskaya (1975) and probably several of the species ascribed to *Axoprunum* by Petrushevskaya and Kozlova (1972). Ehrenberg's species bears little resemblance to the genus and instead may well be a synonym for *Amphisphaera spinulosa*. No figure is available for *A. euterpe* but Haeckel's (1887, p. 135) description conforms with *A. pierinae*. We include *A. venustum* and *A.* aff. *venustum* of Suzuki et al. (2009) in our concept of *A. pierinae*. Cosmopolitan.

***Axoprunum*? *irregularis* Takemura** [Plate 1, fig. 12]
Actinomma medusa (Ehrenberg) gr., Petrushevskaya 1975 (in part), p. 568, pl. 2, fig. 6-8.
? *Amphisphaera* sp. Chen 1975, pl. 6, fig. 1.
Axoprunum? *irregularis* Takemura 1992, p. 742, pl. 3, fig. 8-11; Hollis et al. 1997, p. 44, pl. 1, fig. 15; Takemura and Ling, 1997, pl. 1, fig. 2.
Axoprunum irregularis Takemura, Apel et al. 2002, p. 17, pl. 1, fig. 15-16.

Irregular-shaped, almost polygonal cortical shell with two slender, conical polar spines, usually set askew to main axis. Two medullary shells are supported by more than 6 radial bars. Lacks diagnostic features of the genus (elliposidal cortical shell, 6 symmetrically disposed internal beams) but provisionally retained in *Axoprunum* because of a possible phylogenetic link with *A. bispiculum* (see Takemura 1992). High-latitude.

Genus *SATURNALIS* Haeckel 1881, emend. Nigrini 1967

***Saturnalis circularis* Haeckel**
Saturnalis circularis Haeckel 1887, p. 131; Nigrini 1967, p. 24, pl. 1, fig. 9; Chen 1975, p. 454, pl. 24, fig. 2.

Genus *SPONGATRACTUS* (Ehrenberg)

***Spongatractus pachystylus (*Ehrenberg)**
Spongosphaera pachystyla Ehrenberg, 1874, p. 256; 1876, pl. 26, fig.3.
Spongatractus pachystylus (Ehrenberg), Sanfilippo and Riedel, 1973, p. 519, pl. 2, figs.4-6; pl. 25, fig. 3, Kamikuri et al. 2012a, p. 4.

Thick-walled ellipsoidal shell covered with spongy meshwork, with two robust, bladed polar spines. Our single specimen was in a picked sample (DSDP 277-25, CC).

Family PHACODISCIDAE Haeckel

Genus *HELIODISCUS* Haeckel emend. O'Connor 1999b
= *Astrophacus* Haeckel (see O'Connor, 1999b)

***Heliodiscus inca* Clark and Campbell**
Heliodiscus inca Clark and Campbell 1942, p. 38, pl. 3, fig. 17; Hollis et al. 1997, p. 45, pl. 1, fig. 25, 26.
Heliodiscus hexasteriscus Clark and Campbell 1942 (in part), pl. 3, fig. 15.
Astrophacus inca (Clark and Campbell). Caulet 1986, p. 851; 1991, p. 537.

Lenticular cortical shell with 6-10 moderately long, bladed marginal spines. Surface of cortical shell roughened by raised sepaloid points or thorns at junctions between well-developed hexagonal pore frames. Distinguished from *H. linckiaformis* and *H. hexasteriscus s.s.* by much longer spines.

Genus *PERIPHAENA* Ehrenberg

***Periphaena decora* Ehrenberg**

Periphaena decora Ehrenberg, 1874, p. 246; 1876, pl. 28, fig. 6; Sanfilippo and Riedel 1973, p. 523, pl. 8, fig. 8-10; pl. 27, fig. 2-5; Caulet 1986, p. 853; Palmer 1987, p. 356; Caulet 1991, p. 538; Takemura 1992, p. 743, pl. 6, fig. 8; Strong et al. 1995, p. 209, fig. 10j; Crouch and Hollis 1996, p. 26; Hollis et al. 1997, p. 46, pl. 1, fig. 21-24; Scient.Party ODP 171B, 1998; Funakawa et al. 2006, p. 42, pl. 15, fig. 5-6; Kamikuri et al. 2012a, p. 4.
Heliodiscus pertsus Haeckel, Suzuki et al. 2009, p. 246, pl. 3, fig. 10.

Lenticular cortical shell with a marginal girdle of varying width, with or without marginal spines. Surface of cortical shell smooth, with numerous small pores. We include *Heliodiscus pertsus* of Suzuki et al. (2009) in our concept of *P. decora*. Cosmopolitan.

***Periphaena heliastericus* (Clark and Campbell)**
Heliodiscus heliastericus Clark and Campbell, p. 39, pl. 3, fig. 10, 11.
Periphaena heliasteriscus [sic] (Clark and Campbell), Sanfilippo and Riedel 1973, p. 523, pl. 9, fig. 1-6; pl. 27, fig. 8, 9; Caulet 1986, p. 853; 1991, p. 538; Caulet 1991, p. 538; Takemura 1992, p. 743, pl. 4, fig. 13; Strong *et al.* 1995, p. 209, fig. 10h; Crouch and Hollis 1996, p. 26.
Periphaena heliastericus (Clark and Campbell), Hollis et al. 1997, p. 46.
Heliodiscus perplexus Clark and Campbell, Suzuki et al. 2009, pl. 3, fig. 11.

Distinguished from *P. decora* by absence of marginal girdle. Usually has marginal spines. We include *Heliodiscus perplexus* of Suzuki et al. (2009) in our concept of *P. heliastericus*. Cosmopolitan.

Family SPONGODISCIDAE Haeckel

Genus *PLECTODISCUS* Kozlova

***Plectodiscus circularis* (Clark and Campbell)**
Porodiscus circularis Clark and Campbell 1945, p. 42, pl. 11, fig. 2, 6, 10.
Plectodiscus circularis (Clark and Campbell), Petrushevskaya and Kozlova 1972, p. 526, pl. 19, fig. 9-12; Hollis 2002, p. 288, pl. 2, fig. 20-22.
Xiphospira circularis (Clark and Campbell), Sanfilippo and Riedel 1973, p. 526, pl. 14, fig. 5-12; pl. 31, fig. 4-7; Nishimura 1992, p. 329, pl. 12, fig. 9.
Circodiscus circularis (Clark and Campbell), Suzuki et al. 2009, p. 254, pl. 16, fig. 12-13b.
Circodiscus sp. A and C, Suzuki et al. 2009, p. 254, pl. 17, fig. 1a-9.

Our broad definition of this species follows Sanfilippo and Riedel (1973). We include *Circodiscus* sp. A and C of Suzuki et al. in our concept of *P. circularis*. Cosmopolitan.

Genus *PERICHLAMYDIUM* Ehrenberg

***Perichlamydium limbatum* Ehrenberg**
Perichlamydium limbatum Ehrenberg 1847, p.43; 1854b, pl 22, fig 20; Haeckel, 1887, p. 514; Petrushevskaya, 1975, p. 575, pl. 6, fig. 11; pl. 39, figs. 1-4; Kruglikova 1977, pl 110, fig.

15.

Genus *SPONGODISCUS* Ehrenberg

***Spongodiscus craticulatus* (Stöhr)**
Spongodiscus craticulatus (Stöhr), Petrushevskaya 1975, pl. 5, fig. 9-10.

***Spongodiscus cruciferus* (Clark and Campbell)**
Spongasteriscus (Spongasteriscinus) cruciferus Clark and Campbell 1942, p. 50, pl. 1, fig. 1-6, 8, 10, 11, 16-18; Sanfilippo and Riedel 1973, p. 524, pl. 11, fig. 14-17; pl 28, fig. 10, 11; Riedel and Sanfilippo 1973, p. 740; Sanfilippo and Riedel 1974, p. 1024; Caulet 1991, p. 539; Crouch and Hollis 1996, p. 26; Hollis et al., 1997, O'Conner 1999a, p. 36, pl. 10, fig. 20; p. 50; Suzuki et al. 2009, p. 252, pl. 14, fig. 1a-5b.

Cosmopolitan.

***Spongodiscus festivus* (Clark and Campbell)**
Stylotrochus festivus Clark and Campbell 1942, p. 48, pl. 2, fig. 5-8; Suzuki et al. 2009, p. 251, pl. 13, fig. 4-7.
Stylotrochus nitidus Sanfilippo and Riedel 1973, p. 525, pl. 13, fig. 9-14, pl. 30, fig. 7-10; Caulet 1991, p. 539; Nishimura 1992, p. 329.

This species is distinguished by having numerous cylindrical spines radiating from the margin. We include forms with an internal meshwork that ranges from densely spongy (*S. festivus* s.s.) to being arranged in closely-spaced concentric rings (*S. nitidus* s.s). Cosmopolitan.

Genus *SPONGOPYLE Dreyer*

***Spongopyle osculosa* Dreyer** [Plate 1, fig. 13]
Spongopyle osculosa Dreyer, 1889, p. 42, pl. 6, fig. 99, 100; Riedel 1958, p. 226, pl. 1, fig. 12; Ling 1975, p. 725, pl. 4, fig. 6; Abelmann 1990, p. 693, pl. 3, fig. 11; Apel et al. 2002, p. 21; Expedition IODP 206, 2006.
Spongodiscus osculosus (Dreyer), Chen 1975, p. 455, pl. 24, fig. 4; Caulet 1991, p. 539; Hollis et al. 1997, p. 50; Suzuki et al. 2009, p. 251, pl. 12, fig. 12-14.
Spongodiscus resurgens Ehrenberg *osculosa* (Dreyer), Petrushevskaya 1975, p. 574, pl. 5, fig. 11; pl. 36, fig. 1-4.
Spongodiscus sp. D Suzuki et al. 2009, p. 252, pl. 12, fig. 10-11.
Spongodiscus osculosa (Dreyer), Suzuki et al. 2009, p. 251, pl. 12, fig. 12-14.

We include all forms with a circular to oval outline, covered with a spongy meshwork, no internal structure visible and a pylom or knotch on the rim. We include *Spongodiscus* sp. D of Suzuki et al. (2009) into our concept of *S. osculosa*. High-latitude.

Family SPONGURIDAE Haeckel, sensu Petrushevskaya, 1975

Genus *AMPHICRASPEDUM* Haeckel, sensu Sanfilippo and Riedel 1973

***Amphicraspedum murrayanum* Haeckel** [Plate 1, fig. 14]

Amphicraspedum murrayanum Haeckel 1887, p. 523, pl. 44, fig. 10; Sanfilippo and Riedel 1973, p. 524, pl. 10, fig. 3-6, pl. 28, fig. 1; Riedel and Sanfilippo 1973, p. 737; Sanfilippo and Riedel 1974, p. 1000; Nigrini 1974, p. 1065, pl. 3, fig. 2; Westberg-Smith & Riedel 1984, p. 488; Nishimura 1987, p. 719, pl. 1, fig. 14, 18; O'Connor 1999a, pl. 10, fig. 7; Sanfilippo and Nigrini 1998, pl.13.1, fig. 1; Nigrini and Sanfilippo 2000, pl. 3, fig. 11-13; Kamikuri et al. 2012a, p. 3.

Low-latitude.

***Amphicraspedum prolixum* Sanfilippo and Riedel group** [Plate 1, fig. 15-17]

Amphibrachium gracilis Lipman 1972, p. 55, pl. 9, fig. 11-13.

Amphicarydiscus gracilis (Lipman), Kozlova 1999 (in part), p. 98, pl. 15, fig. 5; (not pl. 20, fig. 3), pl. 22, fig. 15, pl. 42, fig. 1, 3.

Amphicraspedum prolixum Sanfilippo and Riedel gr. 1973, p. 524, pl. 11, fig. 1-5, 7-11, pl. 28, fig. 3-5; Nishimura 1987, p. 719; Westberg-Smith and Riedel 1984, p. 488; Strong *et al.* 1995, p. 208; Caulet 1991, p. 537; O'Connor 1999a, pl. 8, fig. 3.

Amphicraspedium? *prolixum* Sanfilippo and Riedel, Kozlova 1999, p. 100, pl. 20, fig. 5, 6, pl. 22, fig. 16, pl. 42, fig. 2 (also fig. 5), Apel et al. 2002, p. 16.

Spongurids with elongated cylindrical arms, thickened at the ends, and usually with longitudinally aligned meshwork; may or may not be inflated medially. This range in variation appears to conform to the description of *A. gracilis,* which may prove to be the senior synonym. Low-latitude.

Genus *AMPHYMENIUM* Haeckel

***Amphymenium splendiarmatum* Clark and Campbell** [Plate 1, fig. 18, 19]

Amphymenium splendiarmatum Clark and Campbell 1942, p. 46, pl. 1, fig. 12, 14; Sanfilippo and Riedel 1973, p. 524, pl. 11, fig. 6-8; pl. 28, fig. 6-8; Petrushevskaya 1975, p. 577, pl. 7, fig. 1; pl. 37, fig. 1-3; Caulet 1991, p. 537; O'Connor 1993, p. 40, pl. 2, fig. 16, 17; Scient. Party ODP171B; Apel et al. 2002, p. 16, pl. 4, fig. 8; Suzuki et al. 2009, p. 253, pl. 6, fig. 9-12; Kamikuri et al. 2012a, p. 3.

Amphymenium cf. *splendiarmatum* Clark and Campbell Hollis et al. 1997, p. 49, pl. 3, fig. 9.

? *Tessarastrum* sp. Caulet 1986, pl. 2, fig. 5.

Cosmopolitan.

Genus *SPONGURUS* Haeckel

***Spongurus bilobatus* Clark and Campbell**
Spongurus bilobatus Clark and Campbell 1942, p. 36, fig. 7-9. Blueford 1988, p. 252, pl. 6, fig. 9; pl. 7, fig. 1; Shilov 1995, p. 124; Hollis et al. 1997, p. 50, pl. 3, fig. 5-6.; Suzuki et al. (2009), p. 247, pl. 6, fig. 13-19.
Spongurus illepidus Krasheninnikov, Suzuki et al. 2009, p. 248, pl. 5, fig. 11-16.

We include *S. illpeidus* of Suzuki et al. (2009) in our concept of *S. bilobatus*. Cosmopolitan.

Family LITHELIIDAE Haeckel

We include in this family all spumellarians with spherical to ellipsoidal cortical shells, an inner shell structure of closely spaced spiral or concentric layers, and with or without a pylome.

Genus *LARCOPYLE* Dreyer, emend. Lazarus et al. 2005
Larcopyle Dreyer 1889 – preferred name for prune-shaped spumellarians ("prunoids")
Prunopyle Dreyer 1889 – type species is probably a stylosphaerin
Lithocarpium Stöhr, *sensu* Petrushevskaya 1975, p. 572. This is a nassellarian genus!

Spumellarians with an ellipsoidal or flattened ellipsoidal cortical shell (prune-shaped), usually bearing a pylome at one pole. A spongy, spiral, tightly concentric or pylonid inner shell structure is connected to the out shell either directly (last whorl in spiral) or by randomly distributed radial beams that may form radial spines.

***Larcopyle frakesi* (Chen)** [Plate 1, fig. 20]
Prunopyle frakesi Chen 1975, p. 454, pl. 10, fig. 1-3; Caulet 1991, p. 539; Takemura 1992, p. 742.
Lithocarpium monikae Petrushevskaya 1975, p. 572, pl. 4, fig. 6-10, pl. 30, fig. 1-7.

Cortical shell prune-shaped with small pylom, internal shell spongy. High-latitude.

***Larcopyle hayesi* (Chen)** [Plate 1, fig. 21]
Prunopyle hayesi Chen 1975, p. 454, pl. 9, fig. 3-5; Caulet 1986, p. 853; 1991, p. 539; Abelmann 1990, p. 693, pl. 3, fig. 14; Takemura 1992, p. 742, pl. 1, fig. 13, 14; Hollis et al. 1997, p. 48, pl. 2, fig. 12-14; Takemura and Ling, 1997, p. 114.
Ommatodiscus haeckeli Stöhr. Petrushevskaya 1975 (in part), p. 572, pl. 3, fig. 9, 12, 13; pl. 32, fig. 1-8.
Prunopyle cf. *decipiens* (Stöhr), Hollis et al. 1997, p. 47, pl. 2, fig. 18-24.
Larcopyle hayesi (Chen), Lazarus et al. 2005, p. 119, pl. 11, fig. 1-21.

Inflated ellipsoidal outer shell, with a densely spiral or concentric inner shell structure. Broad pylome is surrounded by short spines. We count all subspecies of *L. hayesi* to the high-latitude group (*Larcopyle hayesi irregularis* of Suzuki et al. (2009)).

***Larcopyle labyrinthusa* Lazarus** [Plate 1, fig. 22]
Larcopyle labyrinthusa Lazarus et al. 2005, p.111, pl.5, figs. 14-24.

Subspherical whorl-shaped shell, beams connecting the spirals, pylome present with rather long teeth. Described from middle Miocene of Weddell Sea (Lazarus et al., 2005). High-latitude.

***Larcopyle polyacantha* (Campbell and Clark) group** [Plate 1, fig. 23, 24]
Ommatodiscus fragilis Stöhr, 1880, p. 116, pl. 6, fig. 10.
Larnacantha polyacantha Campbell and Clark 1944 (in part), p. 30, pl. 5, fig. 4-6 (not fig. 7).
Prunopyle polyacantha (Campbell and Clark) Caulet 1991, p. 539; Crouch and Hollis 1996, p. 26; Hollis et al. 1997, p. 48, pl. 2, fig. 25-27 (also fig. 11).
Prunopyle titan Campbell and Clark 1944, p. 20, pl. 3, fig. 1-3; Hays 1965, p. 173, pl. 2, fig. 4; Caulet 1986, p. 853. Abelmann 1990, p. 693, pl. 3, fig. 16.
Lithocarpium polyacantha (Campbell and Clark). Petrushevskaya 1975, p. 572, pl. 3, fig. 6-8 (also fig. 9), pl 29, fig. 6; Abelmann 1990, p. 694, pl. 4, fig. 2; O'Connor 1993, p. 37, pl. 2, fig. 12, 13.
Lithocarpium fragilis (Stöhr). Petrushevskaya 1975, p. 572, pl. 4, fig. 2-4.
Prunopyle sp. B gr. Abelmann 1990, p. 693, pl. 4, fig. 3a, b.
Prunopyle fragilis (Stöhr). Crouch and Hollis 1996, p. 26; Hollis et al. 1997, p. 47, pl. 2, fig. 28-29.
Prunopyle cf. *titan* Campbell and Clark. Crouch and Hollis 1996, p. 26; Hollis et al. 1997, p. 49, pl. 2, fig. 31-32.
Larcopyle polyacantha (Campbell and Clark) group, Lazarus et al. 2005, p. 106, pl. 2, fig. 1-17; pl. 3, fig. 1; pl. 4, fig. 1-10.

Subcylindrical to ellipsoidal cortical shell, usually with clusters of spines at one or both poles. Inner shell structure composed of weakly increasing single or double spirals; spongy meshwork may obscure spiral structure. Caps may develop at poles. A pylome is usually present. We count all subspecies of *Larcopyle polyacantha* to *L. polyacantha* group (*L. polyacantha amplissa* of Suzuki et al. (2009)). High-latitude.

Larcopyle cf. pylomaticus (Riedel) [Plate 1, fig. 25a, b]
Larcopyle pylomaticus (Riedel), Lazarus et al. 2005, p.115, pl.9, fig.1-12.

The species differ from true *L. pylomaticus* by not having a double spiral with constantly spaced whorls. Our specimens have a thick shell with small pores, a diffuse, spongy inner structure with sometimes and a strong pylome with teeth. Our specimen differ from Lazarus et al. 2005, pl. 9, fig. 6, by having a more elliptical shape. High-latitude.

Genus *LITHELIUS* Haeckel

Lithelius* (?) *foremanae Sanfilippo and Riedel
Lithelius foremanae Sanfilippo and Riedel 1973, p. 522, pl. 7, fig. 1-6, pl. 26, fig. 4-5.
Lithelius (?) *foremanae* Sanfilippo and Riedel, Petrushevskaya 1975, p. 573, pl. 3, fig. 4
? *Lithelius* aff. *foremanae* Sanfilippo and Riedel, Hollis 1997, p. 44, pl. 5, fig. 7-9.

Our specimens are similar to Petrushevskaya's, with the inner whorl not clearly visible, what might be due to the orientation of the specimens as also mentioned by Sanfilippo and Riedel (1973). We therefore use Petrushevskaya's name. The cortical shell has irregular pores and a

surface with thorns and spines.

***Lithelius minor* Jörgensen group** [Plate 1, fig. 26-28]
Litheliid gen. gr. A. Petrushevskaya and Kozlova 1972, p. 529, pl. 5, fig. 14, 15.
Lithelius minor Jörgensen. Nigrini and Moore 1979, p. S135, pl. 17, fig. 3, 4a, b. O'Connor 1993, p. 37, pl. 10, fig. 3, 4; Westberg-Smith et al. 1986, p. 772.
Lithelius minor Jörgensen gr. Hollis, 1997, p. 45. pl. 6, fig. 6-16; Hollis et al., 1997, p. 47.
Ommatodiscus aff. *haeckeli* Stöhr, Hollis et al. 1997, p. 47, pl. 2, fig. 16, 17.
Larcopyle compositus (Mamedov), Suzuki et al. 2009, p. 250, pl. 5, fig. 17, pl. 10, fig. 1-7.
Larcopyle hayesi hayesi (Chen), Suzuki et al. 2009, p. 250, pl. 10, fig. 8-18.

In this group we include spumellarians with spirally-concentric structures of varying width and size and no pylome. We include *Larcopyle compositus* and *Larcopyle hayesi hayesi* of Suzuki et al. (2009), which don't have the characteristic pylome of the genus *Larcopyle*.
Cosmopolitan.

Genus *SPHAEROPYLE* Dreyer, 1888

Spheroidal test with concentric inner shells and distinct pylome.

Sphaeropyle tetrapila* (Hays) = *Larcopyle tetrapila / Prunopyle tetrapila [Plate 1, fig. 29]

Prunopyle tetrapila Hays 1965, p. 172, pl. 2, fig. 5; Chen 1975, p. 454, pl. 23, fig. 3-4; Abelmann 1990, p. 693, pl. 3, fig. 16; Caulet 1991, p. 539; Takemura 1992, p. 742, pl. 2, fig. 1-2; Hollis et al. 1997, p. 48, pl. 2, fig. 30; Takemura and Ling 1997, p. 114.

Transferred to *Sphaeropyle* based on spherical outline of test. High-latitude.

Order NASSELLARIA

Family TRISSOCYCLIDAE Haeckel

Members of this family have not been differentiated, except the taxon below.

Genus *ZYGOCIRCUS* Bütschli

***Zygocircus bütschli* Haeckel**
Zygocircus bütschli Haeckel, Petrushevskaya and Kozlova 1972, p. 534, pl. 41, fig. 8-11; Takemura 1992, p. 743, pl. 5, fig. 4; Hollis et al., 1997, pl. 3, fig. 11; Takemura and Ling, 1997, pl. 1, fig. 4.

Family PLAGIACANTHIDAE Haeckel, emend. Petrushevskaya, 1971a

Genus *AMPHICENTRIA* Ehrenberg 1861

***Amphicentrica sp. 1* sensu Suzuki** [Plate 2, fig. 1]
Amphicentria sp. 1, Suzuki et al. 2009, p. 257, pl. 22, fig. 4.

This species is characterized by a large cephalis with a large open area on its top.
High-latitude.

Genus ANTARCTISSA Petrushevskaya 1967

***Antarctissa cylindrica* Petrushevskaya**
Antarctissa cylindrica Petrushevskaya 1975, p. 591. pl. 11, fig. 19-20; Caulet 1991, p. 537; Lazarus 1992, p. 797; Takemura 1992, p. 739.

High-latitude.

***Antarctissa robusta* Petrushevskaya**
Antarctissa robusta Petrushevskaya 1975, p. 591. pl. 11, fig. 21-22; Abelmann 1990, p. 694; Caulet 1991, p. 537; Lazarus 1992, p. 797; Apel et al. 2002, p. 16, pl. 5, fig. 8.

High-latitude.

Genus *ARCHIPILIUM* Haeckel 1881

***Archipilium macropus* (Haeckel)**
Sethopilium macropus Haeckel 1887 p.1203; pl.97, fig.9.
Archipilium spp. aff. *A. macropus* (Haeckel), Petrushevskaya and Kozlova 1972, pl. 29, fig. 14.
Archipilium macropus (Haeckel), Petrushevskaya 1981, p. 249

Genus *CALLIMITRA* Haeckel, emend. Goll 1979

***Callimitra* aff. *atavia* Goll** [Plate 2, fig. 2]
? *Callimitra atavia* Goll 1979, p. 338, pl. 5, fig. 1, 5-9, 11. O'Connor 1993, p. 60, pl. 5, fig. 26, 27; Hollis et al. 1997, pl. 3, fig. 30.

Differs from *C. atavia* by having a latticed cephalic structure connecting four branched spines,

rather than a solid peforate cephalis.

Genus *CERATOCYRTIS* Bütschli, sensu Petrushevskaya 1971b

Ceratocyrtis spp. [Plate 2, fig. 3-5]
We include all Ceratocyrtids, a small spherical cephalis, sometimes with short spines, a robust shell often spinose in the upper part, irregular pores. All ceratocyrtids have a high-latitude affinity (*Ceratocyrtis rhabdophora* of Suzuki et al. (2009) included).

Genus CLADOSCENIUM

***Cladoscenium ancoratum* Haeckel**
Cladoscenium ancoratum Haeckel 1887, pl. 53, fig.13.
Cladoscenium ancoratum Haeckel, Abelmann 1992, pl.4, fig. 9.

Genus *CORYTHOMELISSA* Campbell

***Corythomelissa adunca* (Sanfilippo and Riedel)**
Spongomelissa adunca Sanfilippo and Riedel 1973, pl. 34, fig. 1.
Corythomelissa horrida Petrushevskaya. Takemura 1992, p. 744, pl. 3, fig. 14. Takemura and Ling 1997, p. 111.
Corythomelissa adunca (Sanfilippo and Riedel), Strong *et al.* 1995, p. 208, fig. 9b; Hollis et al., 1997, p. 51.

This species is distinguished from *C. cucumella* Sanfilippo and Riedel and *C. horrida* Petrushevskaya by the thorax being open at the base, although it may terminate in a thckened peristiome with an interned rim. In these other two species, the thorax contracts distally and terminates in a constricted peristome, which may be closed with a latticed plate. In the specimen illustrated by Takemura (1992), the thorax is not constructed distally, terminating with a ragged margin. We assume the same species was also recorded by Takemura and Ling (1997). *C. adunca* bears some resemblance to *Pseudictyophimus gracilipes* but is distinguished by its large hemispherical cephalis, comprising 2-3 lobes, and the absence of a well-developed vertical spine, extending outside the cephalis. If a vertical spine does protrude from the cephalis in *C. adunca*, it is surrounded by a short latticed tube.

Genus *LITHOMELISSA* Ehrenberg
All Lithomelissa spp. we identified at sites 277, 280, 281 and 283 cannot be confidently ascribed to one of the species listed below (*L. ehrenbergi, L. sphaerocephalis, L. tricornis, L. gelasinus, L. robusta, L. sakai*) due to poor or incomplete preservation. As all of these species have a high-latitude affinity, we count *Lithomelissa* spp to the high-latitude group. However, we don't count the specimens named as Lithomelissa sp. 4, 5, F, G, H, I from Site 1172, due to insufficient illustration and as we don't consider these to be one of the specimens listed above.

***Lithomelissa challengerae* Chen** [Plate 2, fig. 6-8]
Lithomelissa challengerae Chen 1975, p. 457, pl. 8, fig. 3; Caulet 1991, p. 521,523; Takemura 1992, p. 744, pl. 4, fig. 11-12; Takemura and Ling 1997, p. 113.

High-latitude.

***Lithomelissa* cf. *challengerae* Chen** [Plate 2, fig. 9]
Lithomelissa challengerae Chen, Hollis et al. 1997, p. 51, pl. 3, fig. 21
? *Lithomelissa challengerae* Chen 1975, p. 457, pl. 8, fig. 3; Takemura 1992, p. 744, pl. 4, fig. 11, 12; Takemura and Ling 1997, p. 113.

This species was poorly illustrated by Chen (1975) but, assuming the same species was illustrated by Takemura (1992), the species encountered at DSDP Site 277 differs in having perforated lateral and dorsal wings and a broadly bladed apical horn (cf. *Lithomelissa spongiosa* Butschli 1882, p. 33, fig. 25).

***Lithomelissa ehrenbergi* Bütschli** [Plate 2, fig. 10, 11]
Lithomelissa macroptera Ehrenberg 1876 (in part), pl. 3, fig. 8 (not fig. 9-10).
Lithomelissa ehrenbergi Bütschli 1882, p. 519, pl. 33, fig. 21; Haeckel 1887, p. 1204; Caulet 1991, p. 538, pl. 2, fig. 3; Crouch and Hollis 1996, p. 26; Hollis et al. 1997, p. 51, pl. 3, fig. 17-20; Suzuki et al., 2009, p. 256, pl. 20, fig. 1a-b.
Lithomelissa sp. B aff. *L. mitra* Butschli, Chen 1975, p. 458, pl. 8, fig. 4-5.
Lithomelissa haeckeli Bütschli, Suzuki et al. 2009, p. 256, pl. 20, fig. 2.

Characterised by a bulbous, perforate cephalis with well-devleoped apical, dorsal and lateral spines (see comments in Caulet 1991, p. 533, and figure in Ehrenberg 1875, pl. 3, fig. 8). Distinguished from *L. haeckeli* by having straight or slightly curved dorsal and lateral spines; spines in *L. haeckeli* are strongly convex. We include *L. haeckeli* of Suzuki et al. (2009) in our concept of *L. ehrenbergi*. High-latitude.

***Lithomelissa gelasinus* O'Connor** [Plate 2, fig. 12, 13]
Lithomelissa gelasinus O'Connor, 1997, pl. 2, fig. 3-6, pl. 6, fig. 6-9; Hollis et al. 1997, p. 52, pl. 3. fig. 15-16; Kamikuri et al. 2006, p. 8.

Poreless, but dimpled cephalis, irregular pore size on abdomen. Very similar to *L. sphaerocephalis* from which it is distinguished by a thorax which is cylindrical rather than conical and of about as wide as the cephalis. High-latitude.

***Lithomelissa* cf. *haeckeli* Bütschli** [Plate 2, fig. 14]
Lithomelissa cf. *haeckeli* Bütschli, Hollis et al. 1997, p. 52, pl. 3, fig. 22.
cf. *Lithomelissa haeckeli* Bütschli, 1882, p. 519, pl. 33, fig. 23.

Uncertainly ascribed to *L. haeckeli* based on the strongly curved lateral spines.

***Lithomelissa macroptera* Ehrenberg** [Plate 2, fig. 15a, b]
Lithomelissa macroptera Ehrenberg 1874, p. 241; 1876, pl. 3, fig. 9-10 (not fig. 8).
non *Dictyophimus macropterus* (Ehrenberg), Takahashi p.116; pl.39, fig.8-11.

Haeckel 1887 does not illustrate this species and modern specimens (e.g. Takahashi) do not appear to be in the concept of Ehrenberg's illustration.

***Lithomelissa robusta* Chen** [Plate 2, fig. 16]
Lithomelissa robusta Chen 1975, p. 457, pl. 9, fig. 1, 2; Caulet 1991, p. 538; Funakawa and Nishi 2005, p. 233.
non *Lithomelissa robusta* Chen 1975, Hollis et al. 1997, p. 52, pl. 3, fig. 23; Abelmann 1990, p. 695, pl. 5, fig. 2.

Cephalis is markedly smaller than thorax. The specimen of Hollis et al. 1997 is *Lithomelissa ehrenbergi*. As pointed out by Funakawa and Nishi (2005), Abelmann's specimen differ from the original described specimen by lacking three thoracic wings. High-latitude.

***Lithomelissa sphaerocephalis* Chen** [Plate 2, fig. 17]
Lithomelissa sphaerocephalis Chen 1975, p. 457, pl. 8, fig. 1, 2; Caulet 1991, p. 538; Takemura 1992, p. 744, pl. 4, fig. 8, 9; Crouch and Hollis 1996, p. 26; Hollis et al. 1997, p. 52, pl. 3. Fig. 12-13; Takemura and Ling 1997, p. 113.

Spheroidal cephalis, dimpled, poreless, bears a short apical spine. Short downward directed dorsal and lateral spines. Thorax conical, with subcircular to irregular pores, often covered with spongy meshwork. High-latitude.

***Lithomelissa tricornis* Chen** [Plate 2, fig. 18]
Lithomelissa tricornis Chen 1975, p. 458, pl. 8, fig. 6-7; Abelmann 1990, p. 695, pl. 5, fig. 3; Takemura 1992, p. 744, pl. 2, fig. 11-12; Hollis et al. 1997, p. 53; Takemura and Ling, 1997, p. 113.

Distinguished from other Lithomelissa spp. by possessing three apical spines. High-latitude.

***Lithomelissa? sakaii* O'Connor** [Plate 2, fig. 19]
Lithomelissa sakaii O'Connor 2000, p. 200, pl.2, fig. 9-15.

Robust shell, latticed feet and apical horn, irregular pore size. High-latitude.

Genus *LOPHOPHAENA* Ehrenberg, emend. Petrushevskaya 1971b

***Lophophaena capito* Ehrenberg**
Lophophaena capito Ehrenberg 1874, p. 242; 1876, pl. 8, fig. 6; Petrushevskaya and Kozlova 1972, p. 535, pl. 33, fig. 20-23; Petrushevskaya 1975, pl. 9, fig. 21 (not from Leg 29); Crouch and Hollis 1996, p. 26; Apel et al. 2002, p. 18, pl. 6, fig. 6; Funakawa et al. 2006, p. 20, pl. 3, fig. 3-4.

Cosmopolitan.

***Lophophaena simplex* Funakawa**

Lophophaena simplex Funakawa 1994, p.465-466, pl.8, fig.1a-2c

Genus *PSEUDODICTYOPHIMUS* Petrushevskaya

All specimens assigned to the genus Pseudodictyophimus are considered to be high-latitude. [Plate 2, fig. 24-27]

***Pseudodictyophimus galeatus* Caulet** [Plate 2, fig. 20]
Pseudodictyophimus galeatus Caulet 1991, p. 534, pl. 2, fig. 9-10.

This species differs from *Pseudodictyophimus gracilipes* gr. by having a thick-walled, spongy shell. High-latitude.

***Pseudodictyophimus gracilipes* (Bailey) group, New group** [Plate 2, fig. 21-23]
Dictyophimus gracilipes Bailey, 1856, p. 4, pl. 1, fig. 8; Abelmann 1990, p. 696, pl. 7, fig. 10.
Pseudodictyophimus gracilipes (Bailey). Petrushevskaya 1971b, p. 93, fig. 47-49; 1975, p. 592, pl. 11, fig. 17; Caulet 1986, p. 853; Apel et al. 2002, p. 20, pl. 7, fig. 12.
Lithomelissa dupliphysa Caulet, Crouch and Hollis 1996, p. 26.

Petrushevskaya (1971b) described two subspecies of *P. gracilipes*: *P. gracilipes gracilipes* and *P. gracilipes tetracanthus*. The latter is said to be confined to the tropics whereas the former is restricted to high latitudes (bipolar). However, the type specimen appears to bear closest resemblance to *P. g. tetracantha* despite being described from the boreal Kamchatka Sea (Bailey 1856). Nevertheless, the specimens encountered in our study are consistent with Petrushevskaya's inference as they most closely resemble the high latitude morphotype: *P. g. gracilipes*. This subspecies is distinguised by a lobate outline, a cephalis that is subcircular in outline, and large irregularly distibruted pores. *P. g. tetracantha* is distinguished by a subtriangular outline, thin tapering feet, and smaller regularly distributed pores. High-latitude.

Genus *TRIPODISCINUS* Haeckel, *sensu* Petrushevskaya and Kozlova 1979

***Tripodiscinus clavipes* (Clark and Campbell)**
Tripilidium clavipes Clark and Campbell 1942, p. 64, pl. 9, fig. 29; Abelmann 1990, p. 695, pl. 5, fig. 1; Caulet 1991, p. 539.
Tripodiscinus clavipes (Campbell). Petrushevskaya and Kozlova 1979, p. 115, fig. 302; Caulet 1986, p. 854; Apel et al. 2002, p. 21, pl. 6, fig. 9.
? *Clathrocanium* sp. O'Connor 1993, p. 60, pl. 10, fig. 16.

Cosmopolitan.

Family CANNOBOTRYIDAE Haeckel

Genus *ARTOBOTRYS* Petrushevskaya

Placed in the Cannobotryidae by Petrushevskaya (1971).

***Artobotrys auriculaleporis* (Clark and Campbell)**
Lophophaena auriculaleporis Clark and Campbell 1942, p. 76, pl. 8, fig. 20, 27-29; Blueford 1988, p. 246, pl. 3, fig. 1-3.
Lophocyrtis biaurita (Ehrenberg), Foreman 1973 (in part), p. 442, pl. 8, fig. 23.
Artobotrys auriculaleporis (Clark and Campbell), Caulet 1991, p. 537; Shilov 1995, p. 127, pl. 4, fig. 4.
Lophocyrtis? *auriculaleporis* (Clark and Campbell), Strong *et al.* 1995, p. 208, fig. 10s, t.
Cycladophora auriculaleporis (Clark and Campbell), Hollis et al., 1997, p. 59 pl. 3, fig. 31.
Artobotrys norvegiensis (Bjørklund and Kellogg), Suzuki et al. 2009, p. 258, pl. 21, fig. 3.

Distinguished from *Artobotrys biaurita* by a stout thorax with regularly arranged pores, at least in the central area, and a short peristome that is not flared. Suzuki et al. (2009) specimen of *A. norvegiensis* are included here.
Cosmopolitan.

***Artobotrys titanothericeraos* (Clark and Campbell)**
Lophoconus titanothericeraos Clark and Campbell 1942, p. 89, pl. 8, fig. 24-26, 28, 30-37.
Artobotrys titanothericeraos (Clark and Campbell), Suzuki et al. (2009), p. 259, pl. 21, fig. 4a-5b.
Artobotrys kryschotofovichi (Lipman 1953), Suzuki et al. 2009, p. 259, pl. 21, fig. 6.

Distinguished from *Artobotrys auriculaleporis* by having three segments and a well-defined lumbar stricture. Possibly restricted to cool-water mid-latitude afinities, as so far only known from California and New Zealand. We include *A. kryschotofovichi* of Suzuki in our concept of *A. titanothericeraos*.

Genus *BOTRYOCELLA* Haeckel 1881

***Botryocella*? sp. A, sensu Apel 2002** [Plate 3, fig. 1-4]
Botryocella? sp. A, Apel, p. 44, pl. 6, fig. 12.

Genus *GLYCOBOTRYS* Campbell

This genus includes many species that have previously been placed in *Botryocella*. Campbell (1951) notes that the type species of the latter genus has a closed thorax and lacks cephalic tubes. Campbell described *Glycobotrys* as having cephalic tubules and a fenestrated (open) thorax. We apply the name to all cannobotryiids with simple tubes extending from the antecephalic or postcephalic lobe, with or without a closed thorax. This definition encompasses the range of variation exhibited by the type species, *Lithobotrys geminata* Ehrenberg (1876, pl. 3, fig. 19) and related species, *Lithobotrys nasuta* Ehrenberg (1876, pl. 3, fig. 21).

***Glycobotrys nasuta* (Ehrenberg) group, New Group** [Plate 3, fig. 5-7]

Lithobotrys nasuta Ehrenberg, 1874, p. 237; 1876, pl. 3, fig. 21.
Botryopyle dictyocephalus (Haeckel) gr. Riedel and Sanfilippo 1971 (in part), p. 1602, pl. 2J, fig. 18; pl. 3F, fig. 12. Takemura 1992, p. 743, pl. 3, fig. 7. O'Connor 1993, p. 56, pl. 10, fig. 15. Takemura and Ling, 1997, p. 111.
Botryocella aff. *cribrosa* (Ehrenberg) gr. Petrushevskaya and Kozlova 1972, p. 554, pl. 39, fig. 4-6.
Botryocella? *appenninica* Vinassa de Regny gr. Petrushevskaya 1975, p. 589, pl. 13, fig. 16.
Botryocella cribrosa (Ehrenberg) gr. Caulet 1986, p. 852.
Botryopyle sp. Crouch and Hollis 1996, p. 26.
Botryocella pauciperforata O'Connor 1999a, p. 10, pl. 1, fig. 21a-24; pl. 5, fig. 20a-24.
Glycobotrys geminata (Ehrenberg), Suzuki et al. 2009, p. 258, pl. 18, fig. 1a-b.
non *Lithobotrys cribrosa* Ehrenberg 1874, p. 237; 1876, pl. 3, fig. 20 (no cephalic tubes).

We include in this group all morphotypes with a large antecephalic lobe and a postcephalic tube. Thorax may be open or closed. Distinguished from *Botryopyle dictyocephalus* by a postcephalic tube at base of cephalis. Cosmopolitan.

Family ARTOSTROBIIDAE Riedel

Genus *BURYELLA* Foreman

***Buryella granulata* (Petrushevskaya)**
Lithocampe sp. A, Dumitrica 1973, p. 789, pl. 10, fig. 3; pl. 11, fig. 3.
Lithocampe? *granulata* Petrushevskaya 1977, p. 18, pl. 3, fig. a, b, v.
Stichomitra granulata (Petrushevskaya). Hollis 1991, p. 134, pl. 20, fig. 7-12; 1993, p. 321, pl. 1, fig. 10, 11. Strong et al. 1995, p. 209, fig. 8j.
Buryella granulata (Petrushevskaya), Hollis 1997, p. 80, pl. 21, fig. 1-5; Hollis et al. 1997, p. 57, pl. 5, fig. 6.
Dictyoprora sp. A, Suzuki et al. 2009, p. 263, pl. 18, fig. 4.

Genus *SIPHOCAMPE* Haeckel, emend. Nigrini 1977
= *Lithomitra* Bütschli, 1882; *Lithomitrella* Haeckel, 1887.

***Siphocampe lineata* (Ehrenberg)**
Lithocampe lineata Ehrenberg, 1838, p. 130 (in part); 1854b, pl. 22, fig. 26 (not pl. 36, fig. 16).
Lithomitra lineata (Ehrenberg), Haeckel 1887, p. 1484 (in part); Riedel and Sanfillippo 1971 (in part), p. 1600, pl. 1l, fig. 2, 8, 11 (not fig. 1, 3-7, 9-10); pl. 2l, fig. 15 (not fig. 14, 16).
Siphocampe lineata (Ehrenberg), Nigrini 1977, pl. 3, fig. 9-10.

Distinguished by its slender abdomen, which has a smooth outline and pores arranged in widely spaced transverse rows.

***Siphocampe nodosaria* (Haeckel)**
Lithomitra nodosaria Haeckel 1887, p. 1484, pl. 79. fig. 1; Petrushevskaya1967, pl. 83, figs. 8-9; Kruglikova 1969, pl. 4, fig. 3; Petrushevskaya and Kozlova 1972, pl. 24, figs. 29-30.

? *Lithomitra embrionalis* Vinassa de Regny 1900, pl. 3, fig. 21.
Lithomitra eruca Haeckel. 1887, p. 1485. pl. 79, fig. 3; Petrushevskaya 1971b, pl. 122, fig. 6; Petrushevskaya and Kozlova 1972, p. 539, pl. 24,figs. 32. 33.
? *Siphocampe annulosa* Haeckel. 1887, p. 1500, pl. 79. fig. 10; cf. Nakaseko, 1963, p. 195, pl. 4, fig. 8.
Lithomitra lineata (Ehrenberg), Riedel and Sanfillippo 1971 (in part), p. 1600, pl. 1l, fig. 1, 3-7, 9-10 (not 2, 8, 11); pl. 2l, fig. 14, 16 (not fig. 15); Foreman 1973, p. 431, pl. 8, fig. 18-19.
Siphocampe nodosaria (Haeckel), Nigrini 1977, p. 256, pl. 3, fig. 11; Takemura 1992, p. 743, pl. 3, fig. 15; O'Connor 1993, p. 52, pl. 4, fig. 23-24; Takemura and Ling, 1997, p. 114; Apel et al. 2002, p. 21, pl. 9, fig. 11.
Siphocampe arachnea (Ehrenberg), Abelmann 1990, p. 698, pl. 8, fig. 4a, b. Strong *et al.* 1995, p. 209.
Siphocampe imbricata (Ehrenberg), Caulet 1991, p. 539, pl. 3, fig. 13; Suzuki et al. 2009, p. 264, pl. 18, fig. 12a-b.
Siphocampe elegans (Ehrenberg), Suzuki et al. 2009, p. 263, pl. 18, fig. 10.

Distinguished by abdominal indentations and longitudinal ridges between pores. Cosmopolitan.

***Siphocampe quadrata* (Petrushevskaya and Kozlova)**
Lithamphora sacculifera quadrata Petrushevskaya and Kozlova 1972, p. 539, pl. 30, fig. 4-6 (also fig. 1, 2 and Pl. 24, fig. 7).
Lithomitra docilis Foreman 1973, p. 431, pl. 8, fig. 20-22; pl. 9, fig. 3-5; Johnson 1974, p. 552, pl. 3, fig. 16; Johnson 1978, p. 781; Nishimura 1992, p. 329.
Siphocampe? *quadrata* (Petrushevskaya and Kozlova), Nigrini 1977, p. 257, pl. 3, fig. 12; Caulet 1991, p. 539; Takemura 1992, p. 743, pl. 7, fig. 7; Takemura and Ling, 1997, p. 114; Funakawa et al. 2006, p. 19, pl. 2, fig. 14-15; Suzuki et al., 2009, p. 264, pl. 18, fig. 9.
Siphocampe? sp. Caulet 1986, pl. 2, fig. 11.
Siphocampe sacculifera (Clark and Campbell), Suzuki et al., 2009, p. 264, pl. 18, fig. 11a-b.

Distinguished by smooth outline and abdominal pores arranges in closely spaced transverse row, with no longitudinal ridges. Abdomen is widest medially. Cosmopolitan.

***Siphocampe (?) acephala* (Ehrenberg) group** [Plate 3, fig. 8-10]
? *Eucyrtidium elegans* Ehrenberg, 1854b, pl. 36, fig. 17; 1876, pl. 11, fig. 12.
? *Eucyrtidium acephalum* Ehrenberg, 1876, p. 70, pl. 11, fig. 5.
Lithomitra laevigata Principi 1909, p. 17, pl. 1, fig. 55.
Lithomitra urnula Clark and Campbell 1942, p. 91, pl. 9. fig. 19.
Lithomitra elizabethae Clark and Campbell 1942, p. 92, pl. 9, fig. 18.
Lithocampe minuta Clark and Campbell 1942, p. 93, pl. 9, fig. 17.
Theocampe spp. Johnson 1974, pl. 3, fig. 13-15 (also fig. 11).
Theocampe amphora Haeckel. Chen 1975 (in part), p. 456, pl. 2, fig. 2.
Theocampe minuta (Clark and Campbell), Petrushevskaya 1975, p. 578, pl. 26, figs. 5, 6.
Siphocampe acephala (Ehrenberg). Nigrini 1977, p. 254, pl. 3, fig. 5. Takemura 1992, p. 743, pl. 6, fig. 9. Takemura and Ling, p. 114.
Lithomitrella minuta (Clark and Campbell) Petrushevskaya and Kozlova 1979, p. 154, fig. 412, 413, 478; Shilov 1995, p. 127, pl. 2, fig. 5; Caulet 1986, p. 853.
Lithomitrella elizabethae (Clark and Campbell), Petrushevskaya and Kozlova 1979, p. 153, fig.

418, 419, 483-486, 540-544; Shilov 1995, p. 127.
Artostrobus elegans (Ehrenberg). Caulet 1986, p. 851.
Lithomitrella acephala (Ehrenberg). Caulet 1986, p. 853.
Siphocampe pachyderma (Ehrenberg). Caulet 1991, p. 539, pl. 3, fig. 12.
Siphocampe missilis O'Connor 1994, p. 340, pl. 1, fig. 7, 9-12. pl. 3, fig. 8-12.
Siphocampe acephala (Ehrenberg) group, Hollis et al. 1997, p. 54, pl. 4, fig. 8-20.
Siphocampe minuta (Clark and Campbell), Suzuki et al. 2009, p. 264, pl. 18, fig. 5a-6b.
non *Siphocampe elizabethae* (Clark and Campbell), Nigrini 1977, p. 256, pl. 3, fig. 6 (= S.? amygdala).

Bullet-shaped test of 3 segments. Cephalis partially submerged in thorax, becoming more prominent in later part of range, lacks vertical tube, rarely bears a small apical horn. Thorax hemispherical, with 3-5 rows of circular pores. Lumbar stricture absent to distinct. Abdomen cylindrical, may narrow distally, with 4-8 rows of small subcircular pores, becoming large and subquadrangular in later part of range.

Specimens referred to this species by Nigrini (1977) and subsequent workers appear closer to Principi's species than *E. acephalum s.s.* Under Nigrini's usage the species ranges from Early to Late Eocene (*Phormocyrtis striata striata* to *Theocyrtis bromia* Zones). Takemura reported the species in the Middle Eocene, with an isolated occurrence in Early Oligocene. For practical considerations co-occurring variants have not been differentiated, i.e. *S. elegans* (Ehrenberg), which has a well-developed apical horn, *S. missilis* O'Connor, which has a perforate, centred, rather than asymmetrically-placed, cephalis and a longer abdomen with 8-17 rows of pores.

This species group is tentatively placed in *Siphocampe* because its artostrobiid cephalic structure has not been confirmed. It appears to be closely related to the multisegmented *S.*? *amygdala*.

***Siphocampe*? *amygdala* (Shilov)** [Plate 3, fig. 11, 12]
Theoperid gen. et sp. indet. Johnson, 1974, pl. 3, fig. 12.
Siphocampe elizabethae (Clark and Campbell). Nigrini 1977, p. 256, pl. 3, fig. 6.
Lithomitrella elizabethae (Clark and Campbell). Caulet 1986, p. 853.
Archaeodictyomitra? sp. Takemura 1992, p. 744, pl. 3, fig. 1-2.
Mita sp. Strong *et al.* 1995, p. 209, fig. 10x.
Dictyomitra amygdala Shilov 1995, p. 126, pl. 1, fig. 4-6b.
Siphocampe? "*elizabethae*" sensu Nigrini, Hollis et al. 1997, p. 55, pl. 4, fig. 21-26.
Dictyoprora? *amygdala* (Shilov), Suzuki 2009, p. 263, pl. 18, fig. 3.
non Lithomitra elizabethae Clark and Campbell 1942, p. 92, pl. 9, fig. 18.

Fusiform test of 5-6 segments with indistinct strictures. Thorax hemi-spherical with pores evenly distributed and smaller than in subsequent segments. Pores of post-thoracic segments longitudinally aligned and arranged in 3 rows on each segment. Outline smooth to slightly lobate, narrows distally, basal margin ragged. Differs from *S. acephala* gr. in that the post-thoracic part is not a single abdomen but 2-5 segments, each having 2-3 rows of subcircular pores. Cosmopolitan.

Genus *SPIROCYRTIS* Haeckel, emend. Nigrini

Spirocyrtis greeni O'Connor
Spirocyrtis greeni O'Connor 1999a, p. 8, pl. 1, fig. 15-20b, pl. 5, fig. 16a-19.

***Spirocyrtis joides* (Petrushevskaya)**
Botryostrobus sp. P, Petrushevskaya and Kozlova 1972, p. 539, pl. 24, fig. 8-11.
Botryostrobus joides Petrushevskaya 1975, p. 585, pl. 10, fig. 37; Hull 1996, p. 137, pl. 4, fig. 5, 6, 20; Sanfilippo and Fourtanier 2003, p. 11, pl. P1, fig. 3, 12.
Spirocyrtis sp. A. Hollis et al. 1997, p. 56, pl. 4, fig. 33-35.

Narrowly conical test of 6-10 segments. Thorax truncate-conical with 3 rows of pores. Cephalis hemispherical, internal features obscured by a "cockscomb" of webbed spines linking apical horn and vertical tube. Post-thoracic segments are rounded with 4 rows of closely-spaced subcircular pores. Final segment narrows, may terminate with a narrow peristome. Cosmopolitan.

Genus *THEOCAMPE* Haeckel (= *DICTYOPRORA* Haeckel)

***Theocampe amphora* (Haeckel)**
Dictyocephalus amphora Haeckel 1887, p. 1305, pl. 62, fig. 4.
Theocampe amphora (Haeckel), Foreman 1973, p. 431, pl. 8, fig. 7, 9-13; pl. 9, fig. 8, 9; Chen 1975 (in part), p. 456, pl. 2, fig. 2; Johnson 1978, p. 782; Hollis et al. 1997, p. 56, pl. 4, fig. 38-39.
Dictyoprora amphora (Haeckel), Nigrini 1977, p. 250, pl. 4, fig. 1, 2; Palmer 1987, p. 355; Caulet 1991, p. 538; O'Connor 1993, p. 48, pl. 4, fig. 14, pl. 10, fig. 10; Shilov 1995, p. 126, pl. 2, fig. 7-8; Funakawa et al. 2006, p. 16, pl. 2, fig. 1-2.
non ?*Dictyoprora amphora* (Haeckel), Lazarus & Pallant 1989, p. 363, pl. 6, fig. 8, 9.

Cosmopolitan.

***Theocampe urceolus* (Haeckel)**
Dictyocephalus urceolus Haeckel, 1887, p. 1305.
Theocampe urceolus (Haeckel), Foreman 1973, p. 432, pl. 8, fig. 14-17; pl. 9, fig. 6, 7; Chen 1975, p. 456, pl. 3, fig. 7; Hollis et al. 1997, p. 56, pl. 4, fig. 36-37.
Dictyoprora urceolus (Haeckel), Nigrini 1977, p. 251, pl. 4, fig. 9, 10; Palmer 1978, p. 356; O'Connor 1993, p. 50, pl. 10, fig. 11.
? *Dictyoprora physothorax* Caulet 1991, p. 535, pl. 3, fig. 11.
Dictyoprora pirum (Ehrenberg), Takemura 1992, p. 743, pl. 5, fig. 11; Takemura and Ling, 1997, p. 111.

Specimens with a thorax as wide as the abdomen (= *T. physothorax*) are included in *T. urceolus* here. Takemura's figured specimen lacks the flattened abdomen characteristic of *T. pirum*. Cosmopolitan.

Family ACROPYRAMIDIDAE Haeckel

Genus *ARTOSTROBUS* Haeckel

***Artostrobus annulatus* (Bailey)**
Cornutella annulatus Bailey 1856, p. 3, fig. 5.
Artostrobus annulatus (Bailey), Ling 1973, p. 781, pl. 2, fig. 14; Petrushevskaya 1975, p. 579, pl. 10, fig. 4, 5; Hollis et al. 1997, p. 57, pl. 5, fig. 1-2; Reynolds 1980; Abelmann 1990, p. 683/685/687.

High-latitude.

***Artostrobus* cf. *pretabulatus* Petrushevskaya** [Plate 3, fig. 13]
cf. *Artostrobus*? *pretabulatus* Petrushevskaya 1975, p. 580, pl. 10, fig. 2-3.
Artostrobus cf. *pretabulatus* Petrushevskaya, Takemura 1992, p. 745, pl. 5, fig. 12. Crouch and Hollis 1996, p. 26; Hollis et al., 1997, p. 57, pl. 5, fig. 3; Takemura and Ling, 1997, p. 111.

Distinguished from *A. pretabulatus* by a broader more conical thorax. High-latitude.

Genus *CINCLOPYRAMIS* Haeckel
Cinclopyramis Haeckel 1879; *Bathropyramis* Haeckel 1882; *Peripyramis* Haeckel 1882; *Sethopyramis* Haeckel 1882; *Enneapleuris* Haeckel 1887

As noted by Suzuki et al. (2009), the synonymised generic names have been applied inconsistently in the past and serve only to confuse species level discrimination within what is here considered to be a single long-ranging genus. *Cinclopyramis* is the senior synonym.

***Cinclopyramis circumtexta* (Haeckel)**
Peripyramis circumtexta Haeckel 1887. p. 1162, pl. 54, fig. 5; Riedel 1958, p. 231, pl. 2, fig. 8-9; Kling 1973, p. 637, pl. 2, fig. 15-19, pl. 9, fig. 1-3; Chen 1975, p. 462; Petrushevskaya 1975, pl. 13, fig. 29, pl. 44, fig. 5-6; Weaver 1983, p. 678; Abelmann 1990, p. 683; Expedition 306 Scientists 2006.
Sethopyramis magnifica Clark and Campbell 1942, p. 72, pl. 8, fig. 1, 5, 9.
Bathropyramis magnifica (Clark and Campbell), Hollis et al. 1997, p. 57, pl. 6, fig. 22.
Cinclopyramis quadrata (Haeckel), Suzuki et al., 2009, p. 262, pl. 22, fig. 13.
non *Bathropyramis quadrata* Haeckel 1887, p. 1159, pl. 54, fig. 1.

The specimens of *C. circumtexta* illustrated by Riedel (1958) indicate that the species is the senior synonym for *S. magnifica* Clark and Campbell. Both species are distinguished from *C. quadrata* by having a small subcircular cephalis with a distinct collar stricture, transverse pore frames being slightly offset between longitudinal beams, and a change in contour in the proximal thorax where pores change from being circular to rectangular. In *C. quadrata*, transverse beams are closely aligned along the length of the shell. According to Petrushevskaya, the distinctive outer layer of coarsely spongy meshwork is only seen from the middle Miocene onwards. However, Clark and Campbell (1942) mention this secondary mesh also occurring in some Eocene specimens. Cosmopolitan.

Genus *CORNUTELLA* Ehrenberg

***Cornutella profunda* Ehrenberg 1854**
Cornutella clathrata profunda Ehrenberg 1854a, p. 241; Ehrenberg 1854b, pl. 35B, fig. 21
Cornutella profunda Ehrenberg, Riedel 1958, p. 232, pl. 3, figs. 1-2; Kling 1973, p. 635, pl. 3, fig. 1-4, pl. 9, fig. 8-17; Chen 1975, p. 459; Petrushevskaya 1975, p. 587, pl. 13, fig. 29, pl. 44, fig. 5-6; Pisias & Moore 1978, p. 847, pl. 1, fig. 5; Kamikuri et al. 2006, p. 7; Suzuki et al. 2009, p. 263, pl. 22, fig. 12a-b.

Cosmopolitan.

Family AMPHIPYNDACIDAE Riedel

We included in this family multisegmented nassellarians with the cephalis devided into two superposed chambers by a transverse internal ledge.

Family EUCYRTIDIIDAE Ehrenberg

Genus *ASPIS* Nishimura 1992

***Aspis sp. A*, sensu Hollis 2002** [Plate 3, fig. 14-16]
Ceratocyrtis sp., Dumitrica 1973, p. 788, pl. 3, fig. 2-4.
Aspis sp. A, Hollis 2002, p. 303, pl. 6, fig. 1-2.

High-latitude. So far only encountered in the SW Pacific of the Paleocene, and of the Eocene and early Oligocene of Leg 29 (this study).

Genus *CALOCYCLOMA* Haeckel

***Calocycloma ampulla* (Ehrenberg)**
Calocycloma ampulla (Ehrenberg), Foreman 1973, p. 434, pl. 1, fig. 1-5; pl. 9, fig. 20; Strong *et al.* 1995, p. 208, fig. 9v-x; Hollis et al. 1997, p. 58.

***Clathrocyclas universa* Clark and Campbell**
Clathrocyclas universa Clark and Campbell 1942, p. 86, pl. 7, fig. 8-12, 14-21, 25; Chen 1975, p. 459, pl. 1, fig. 2, 3; Petrushevskaya 1975, pl. 15, fig. 15-16; Blueford 1988, p. 244, pl. 2, fig. 1-3; Takemura 1992, p. 745, pl. 7, fig. 8; Strong *et al.* 1995 (in part), p. 208; Shilov 1995, p. 125; Hollis et al. 1997, p. 59, pl. 5, fig. 17-20; Takemura and Ling 1997, p. 111; Kamikuri et al. 2012a, p. 3.
Clathrocyclas ex. gr. *extensa* Clark and Campbell, Suzuki et al. 2009, p. 265, pl. 21, fig. 8-9.

We included *Clathrocyclas* ex. gr. aff *extensa* and C. ex. gr. *extensa* from Suzuki et al. (2009).
Cosmopolitan.

Genus *CYCLADOPHORA* Ehrenberg, emend. Lombari and Lazarus 1988

Distinguished from *Clathrocyclas* by a smaller, subspherical, cephalis with pores smaller and/or less numerous than those of the thorax, and flared thorax divided into upper and lower parts.

***Cycladophora cosma cosma* Lombari and Lazarus** [Plate 3, fig. 17]
Cycladophora cosma cosma Lombari and Lazarus 1988, p.104, pl. 1, figs. 1-6; Scient.Party ODP177, 1999.

High-latitude. Lombardi and Lazarus (1988) consider this specie as high-latitude, as it was found in Miocene sediments of high-latitude sites.

***Cycladophora humerus* (Petrushevskaya)** [Plate 3, fig. 18]
Clathrocyclas humerus Petrushevskaya 1975, p. 586, pl. 15, fig. 17, 12, 22, 23; pl. 43, fig. 1- 2.
Cycladophora humerus (Petrushevskaya), Lombari and Lazarus 1988, p. 123, pl. 9, fig. 1-6; Abelmann 1990, p. 698, pl. 8, fig. 3, Caulet 1991, p. 538.
Cycladophora cf. *humerus* (Petrushevskaya), Hollis et al. 1997, p. 59, pl. 5, fig. 21.

The form recorded by Hollis et al. (1997) is distinguished from *C. humerus* s.s. by a higher thorax with a subcylindrical lower part. In this respect this species is similar to the Paleocene species illustrated by Petrushevskaya (1975, pl. 15, fig. 18-20) but the latter has fewer pores (6-7 in a transverse row).
High-latitude.

Genus *CYMAETRON* Caulet 1991

***Cymaetron sinolampas* Caulet**
Cymaetron sinolampas Caulet 1991, p. 536, pl. 4, fig. 10-12.

Genus *CYRTOLAGENA* Haeckel 1887

***Cyrtolagena laguncula* Haeckel**
Cyrtolagena laguncula Haeckel 1879
Cyrtopera laguncula Haeckel 1887, p. 1451; pl. 75, fig. 10.
Cyrtopera laguncula Haeckel 1887, Abelmann 1990, p. 696; Lazarus and Pallant 1989, p. 361, pl. 4, fig. 9-10; Caulet 1991, p. 538; Takahashi 1991, p. 119, pl. 73, fig. 15; Benson 1966, p. 510-513, pl. 35, fig. 3-4; Chen 1975, p. 460, pl. 18, fig. 9.

Cosmopolitan.

Genus *EUCYRTIDIUM* Ehrenberg

***Eucyrtidium antiquum* Caulet** [Plate 3, fig. 19]
Eucyrtidium sp., Chen 1975, p. 461, pl. 7, fig. 6-8; O'Connor 1993 (in part), p. 73, pl. 8, fig. 6, 7.

Eucyrtidium antiquum Caulet 1991, pl. 4, fig. 1, 2 (also fig. 5); Hollis et al. 1997, p. 60, pl. 5, fig. 30-31; Takemura and Ling 1997, p. 113, pl. 1, fig. 9.; Suzuki et al. (2009), p.259, pl. 21, fig. 14; Scient.Party ODP 177, 1999.
Eucyrtidium cheni Takemura 1992, p. 746, pl. 4, fig. 1-4.

E. cheni was synonymised with *E. antiquum* by Takemura and Ling (1997).

High-latitude.

***Eucyrtidium mariae* Caulet**
Eucyrtidium mariae Caulet 1991, p. 536, pl. 4, fig. 3, 4. Crouch and Hollis 1996, p. 26; Hollis et al. 1997, p. 61 (as *E.*? *mariae*).

Distinguished from *E. spinosum* by a more slender and thin-walled test, with small circular pores lacking well-developed frames. Internal segmentation of post-thoracic chambers frequently asymmetric. High-latitude.

***Eucyrtidium microporum* Ehrenberg**
Eucyrtidium microporum Ehrenberg, 1874, p. 230; 1876, pl. 11, fig. 20.
Stichopodium? *microporum* Ehrenberg, Funakawa et al., 2006, pl. 13, fig. 3-4.

***Eucyrtidium montiparum* Ehrenberg** [Plate 3, fig. 22]
Eucyrtidium montiparum Ehrenberg, Hollis et al. 1997, p. 61, pl. 5, fig. 25-27, Nishimura 1992, p. 329.
Eucyrtidium cf. *cheni* Takemura, Strong *et al.* 1995, p. 208, fig. 11x, y.
? *Eucyrtidium* aff. *montiparum* Ehrenberg, Petrushevskaya and Kozlova 1972, p. 548, pl. 26, fig. 2-4.
Eucyrtidium ventriosum O'Connor 1999a, p. 21, pl. 3, fig. 17-21b, pl. 6, fig. 28a-31.
non *Eucyrtidium montiparum* Ehrenberg, Funakawa et al. 2006, p. 23, pl. 5, fig. 10.
Eucyrtidium sp. F Funakawa et al. 2006, pl. 6, fig. 1-3.

Differs from *E. nishimurae* by lacking an elongate, subcylindrical, spongy fourth segment. Cosmopolitan.

***Eucyrtidium nishimurae* Takemura and Ling** [Plate 3, fig. 20a, b]
Eucyrtidium nishimurae Takemura and Ling 1997, p. 113, pl. 2, fig. 1-6; Suzuki et al. (2009), p. 259, pl. 21, fig. 15.

Spongy fourth segment. High-latitude.

***Eucyrtidium spinosum* Takemura** [Plate 3, fig. 21]
Eucyrtidium sp. A, Petrushevskaya 1975, p. 581, pl. 14, fig. 21-22.
Eucyrtidium? aff. *montiparum* Ehrenberg, Caulet 1991, p. 538, pl. 4, fig. 5- 7.
Eucyrtidium spinosum Takemura 1992, p. 746, pl. 5, fig. 5-8; Crouch and Hollis 1996, p. 26; Hollis et al. 1997, p. 61, pl. 5, fig. 38-31; Takemura and Ling 1997, p. 113, pl. 1, fig. 10, Scient.Party ODP 177, 1999.

High-latitude.

Genus *EURYSTOMOSKEVOS* Caulet

***Eurystomoskevos cauleti* O'Connor** [Plate 3, fig. 23a, b]
Eurystomoskevos "*cauleti*" O'Connor, Hollis et al. 1997, p. 61, pl. 5, fig. 4-5 (nom. Nud.).
Eurystomoskevos cauleti O'Connor 1999a, pl. 3, fig. 22-26; pl. 7, fig. 1a-3.

Distinguished from *E. petrushevskaae* by a smaller apical horn, a more distinct cephalis and a thorax that usually is not flared. High-latitude.

***Eurystomoskevos petrushevskaae* Caulet** [Plate 3, fig. 24]
Diplocyclas sp. A Petrushevskaya and Kozlova 1972, p. 541, pl. 33, fig. 14-16; Petrushevskaya 1975, p. 587, pl. 24, fig. 4; Chen 1975, p. 460, pl. 7, fig. 4, 5; Takemura 1992, p. 746, pl. 3, fig. 16.
Eurystomoskevos petrushevskaae Caulet 1991, p. 536, pl. 3, fig. 14, 15; O'Connor 1993, p. 74, pl. 8, fig. 12-14; Crouch and Hollis 1996, p. 26; Hollis et al.1997, p. 62, pl. 5, fig. 22-23; Scient.Party ODP 177, 1999; Suzuki et al. 2009, p. 265, pl. 22, fig. 5a-6, Funakawa et al. 2006, p. 38, pl. 13, fig. 9; Kamikuri et al. 2012a.

High-latitude.

Genus *EUSYRINGIUM* Haeckel

***Eusyringium fistuligerum* (Ehrenberg)** [Plate 3, fig. 25]
Eucyrtidium fistuligerum Ehrenberg 1874, p. 229; 1876, pl. 9, fig. 3
Eusyringium fistuligerum (Ehrenberg), Foreman 1973, p. 435, pl. 11, fig. 6; Chen 1975, p. 461, pl. 3, fig. 3; Johnson 1978, p. 781; Sanfilippo et al. 1985, p. 672, fig. 17.2a-c; Strong et al. 1995, p. 208, fig. 11C; Sanfilippo and Blome 2001, p. 212; Funakawa et al. 2006, p. 35, pl. 12, fig. 1-3; Suzuki et al. (2009), pl. 22, fig. 14; Kamikuri et al. 2012a, p. 3, pl. 1, fig. 4.

Cosmopolitan.

***Eusyringium lagena* (Ehrenberg)**
Eusyringium lagena (Ehrenberg), Foreman 1973, p. 435, pl. 11, fig. 4-5; Chen 1975, p. 461; Johnson 1978, p. 781; Sanfilippo et al. 1985, p. 672, fig. 17.2a-c; Palmer 1987, p. 356; Strong *et al.* 1995, p. 208, fig. 11c; Hollis et al. 1997, p. 62, pl. 5, fig. 15-16; Sanfilippo and Blome 2001, p. 212; Kamikuri et al. 2012a, p. 3, pl. 1, fig. 5.

Cosmopolitan.

Genus *PHORMOCYRTIS* Haeckel 1887

***Phormocyrtis striata striata* Brandt**
Phormocyrtis striata striata Brandt, Foreman 1973, p. 438, pl. 7, fig. 5, 6, 9; Chen 1975, p. 456, pl. 3, fig. 8; Sanfilippo et al. 1985, p. 679, fig. 20.1a, b; Johnson 1990, p. 407; O'Connor 1993, p. 78, pl. 9, fig. 8; Strong et al. 1995, p. 209, fig. 9o, p; Hollis et al. 1997, p. 65.

Genus *SETHOCYRTIS* Haeckel

***Sethocyrtis chrysallis* Sanfilippo and Blome** [Plate 3, fig. 26a, b]
Sethocyrtis sp. Chen 1975, p. 459, pl. 1, fig. 4, 5; Takemura 1992, p. 747, pl. 7, fig. 14, 15; Strong et al. 1995 (in part), p. 209, fig. 11w; Takemura and Ling 1997, p. 114, pl. 1, fig. 11.
Sethocyrtis sp. A Hollis et al. 1997, p. 65, pl. 6, fig. 7.
Sethocyrtis chrysallis Sanfilippo and Blome 2001, p. 206, fig. 6j-n.

Cosmopolitan.

Genus *THYRSOCYRTIS* Ehrenberg

***Thyrsocyrtis pinguisicoides* O'Connor** [Plate 3, fig. 27]
Thyrsocyrtis sp. Dinkelman 1973, p. 788, pl. 3, fig. 7, 8.
Theocotyle "pinguisicoides" O'Connor, Hollis et al. 1997, p. 65, pl. 6, fig. 10-12 (*nom. nud.*).
Thyrsocyrtis pinguisicoides O'Connor 1999a, p. 29, pl. 4, fig. 28-32; pl. 7, fig. 28a-31; Kamikuri et al. 2012b, p. 104; Funakawa et al. 2006, p. 34, pl. 4, fig. 7-12; Moore and Kamikuri 2012, p. 12, pl. 9, fig. 13-16.

Distinguished from other members of the genus by the absence of terminal feet. Low-latitude.

Family LYCHNOCANIIDAE Haeckel

Genus *DICTYOPHIMUS* Ehrenberg, emend. Nigrini 1967

Three-segmented, with 3 thoracic ribs that form divergent feet. Distinguished from *Pterocyrtidum* by indistinct separation between thorax and abdomen, triangular outline and large pores. Pterocyrtidium has a bullet-shaped outline. *Rhopalocanium* is similar to *Pterocyrtidium* but the feet extend from the abdomen and are often connected to it by transverse bars.

***Dictyophimus pocillum* Ehrenberg**
Dictyophimus pocillum Ehrenberg 1874, p. 223; 1876, pl. 5, fig. 6. Petrushevskaya and Kozlova 1972, p. 553, pl. 29, fig. 5; Caulet 1991, p. 538; O'Connor 1999b, p. 500, pl. 4, fig. Q, R.

Cosmopolitan.

***Dictyophimus*? *archipilium* Petrushevskaya** [Plate 4, fig. 1a, b, 2]
Dictyophimus? *archipilium* Petrushevskaya 1975, p. 583, pl. 25, fig. 1, 2; Caulet 1991, p. 538.

Dictyophimus cf. *archipilium* Petrushevskaya, Crouch and Hollis 1996, p. 26 (in part); Hollis et al. 1997, p. 60 (in part).
Dictyophimus archipilium Petrushevskaya, Apel et al. 2002, p. 18, pl. 7, fig. 10.

This species is distinguished by its small size, weak apical horn and terminal feet that extend out from the lower thorax, and typically are short protuberences. Hollis et al (1997) failed to identify the distinguishing features of this species and erroneously included some specimens in which the feet were attached to the abdomen. Such specimens are referred to *D.*? aff. *archipilium* here (sensu Hollis 1997). This species may be better referred to *Pterocyrtidium*. High-latitude.

***Dictyophimus*? aff. *archipilium* Petrushevskaya** [Plate 4, fig. 3a,b-8]
Dictyophimus? spp. Dumitrica 1973, p. 788, pl. 7, fig. 3-9; pl. 8, fig. 4; pl. 9, fig. 8; pl. 12, fig. 6, 7; pl 13, fig. 14. Hollis 1993, p. 322.
Dictyophimus sp. A, Strong et al. 1995, p. 208, fig. 8o; Hollis et al. 1997, p. 60.
Dictyophimus cf. *archipilium* Petrushevskaya, Crouch and Hollis 1996, p. 26 (in part); Hollis et al. 1997, p. 60 (in part), pl. 5, fig. 38-19.
Dictyophimus aff. *archipilium* Petrushevskaya, Hollis 1997, p. 82, pl. 22, fig. 5-7.

This Paleocene-Eocene species is distinguished from *D.*? *archipilium* by its distinctive feet, which extend from the base of the thorax and are connected to the abdomen by transverse bars. These bars are evident in the specimens referred to *D.* cf. *archipilium* by Hollis et al. (1997), indicating that the species persists into the Early Oligocene. This species may be better referred to *Rhopalocanium*. High-latitude.

***Dictyophimus*? aff. *constrictus* Nishimura** [Plate 4, fig. 9, 10]
aff. *Dictyophimus*? *constrictus* Nishimura 1992, O'Connor 1999a, pl. 9, fig. 13.

Genus *LYCHNOCANIUM* Ehrenberg, sensu O'Connor 1999

***Lychnocanium amphitrite* (Foreman)** [Plate 4, fig. 11a, b, c, 12]
Lychnocanoma amphitrite Foreman 1973, p. 437, pl. 11, fig. 10; Chen 1975, p. 462, pl. 2. fig. 7; Caulet 1986, p. 853; Palmer 1987, p. 356; Takemura 1992, p. 747, pl. 7, fig. 9-10; O'Connor 1993, p. 76, pl. 8, fig. 29; Strong *et al.* 1995, p. 208, fig. 11k-l; Takemura and Ling 1997, p. 114, pl. 1, fig. 21; Funakawa et al. 2006, p. 35, pl. 12, fig. 8; Suzuki et al. 2009, p. 261, pl. 19, fig. 5a-6b; Moore and Kamikuri 2012, p. 9, pl. 7, fig. 1-2; Kamikuri et al. 2012b, p. 102.
Lychnocanoma bellum (Clark and Campbell), Foreman 1973 (in part), pl. 1, fig. 17.
Lychnocanium amphitrite (Foreman), Hollis et al. 1997, p. 63, pl. 6, fig. 1-4.

Specimens with any vestige of a third segment, such as that figured by Foreman (1973, pl. 1, fig. 17), are here included in *L. amphitrite*. Cosmopolitan.

***Lychnocanium babylonis* (Clark and Campbell)** [Plate 4, fig. 13a, b, 14]
Dictyophimus babylonis Clark and Campbell 1942, p. 67, pl. 9, fig. 32, 36.
Lychnocanoma babylonis (Clark and Campbell), Foreman 1973, p. 437, pl. 2, fig. 1; Chen 1975, p. 462, pl. 2. fig. 8; Caulet 1986, p. 853; Strong et al. 1995, p. 208, fig. 11a, b; Funakawa et al. 2006, p. 35, pl. 13, fig. 1; Kamikuri et al. 2012a, p. 4; Kamikuri et al. 2012b, p. 102.

Lychnocanoma cf. *babylonis* Clark and Campbell, Takemura 1992, p. 747, pl. 7, fig. 13; Takemura and Ling, 1997, p. 114.
Sethochytris babylonis (Clark and Campbell), Hollis et al., 1997, p. 65, pl. 5, fig. 32; Hollis, 2002; Johnson 1990, p. 407.

Cephalis may be partially encased in thoracic wall. Distinguished from *Lychnocanium auxillum* and *Rhopalocanium ornatum* by the absence of an abdomen. Cosmopolitan.

***Lychnocanium bellum* Clark and Campbell** [Plate 4, fig. 15, 16]
Lychnocanium bellum Clark and Campbell 1942, p. 72, pl. 9, fig. 35, 39; Hollis et al. 1997, p. 63, pl. 6, fig. 5-6.
Lychnocanoma bellum (Clark and Campbell); Foreman 1973 (in part), p. 437, pl. 11, fig. 9; Johnson 1978, 481; Caulet 1986, p. 853; Johnson 1990, p. 407; Caulet 1991, p. 538; Strong et al. 1995, p. 208, fig. 11i, j; Sanfilippi and Blome 2001, p. 214; Suzuki et al. 2009, p. 261, pl. 19, fig. 1a-b.

Cosmopolitan.

***Lychnocanium* aff. *carinatum* Ehrenberg** [Plate 4, fig. 17]
? *Lychnocanium carinatum* Ehrenberg 1876, p. 78, pl. 8, fig. 5; Haeckel 1887,p. 1226.
Theopodium sp. aff. *Lychnocanium carinatum* Ehrenberg, Nishimura, 1992, p. 7, fig. 11.

This Paleocene species was ascribed to *Theopodium* by Nishimura (1992) because it consists of three segments and has three solid feet. As the third segment is not fully developed and it other respects this species closely resembles *L. auxilla*, we transfer the species to *Lychnocanium*. This species is distinguished from *L. sphinx* by the presence of a third segment. It is distinguished from *L. auxilla* by having longitudinal costae on the thorax. It is distinguished from both species by having feet that curve inwards.

***Lychnocanium conicum* Clark and Campbell**
Lychnocanium conicum Clark and Campbell 1942, p. 71, pl. 9, fig. 38.
Lychnocanoma? *conica* (Clark and Campbell), Suzuki et al. 2009, p. 261, pl. 19, fig. 1a-b.
non Lychnocanoma conica (Clark and Campbell). Abelmann 1990, p. 697, pl. 6, fig. 8; pl. 7, fig. 1a, b; Takemura 1992, p. 747, pl. 2, fig. 13-14; Takemura and Ling 1997, p. 114, pl. 1, fig. 20.

L. conicum s.s. differs from the morphotypes ascribed to the species by Abelmann (1990) and subsequent researchers, by having a pear-shaped thorax with and small aperture. It differs from *L. babylonis* by having a more inflated thorax and more slender feet.

Lychnocanium continuum Ehrenberg
Lychnocanium continuum Ehrenberg, 1874, p. 243; 1876, pl. 7, fig. 11; Funakawa et al. (2006), pl. 12, fig. 7.

***Lychnocanium tetrapodium* Ehrenberg** [Plate 4, fig. 18a, b]
Lychnocanium tetrapodium Ehrenberg 1874, p. 244; Ogane et al. 2009, pl. 7, fig. 9.
? Lychnocanoma tetrapodium (Ehrenberg), Kamikuri et al. 2012b, p. 103, pl. 2, fig. 9, 10.

Distinguished by having four feet. Kamikuri et al.'s specimen has only three feet.

***Lychnocanium waiareka* O'Connor**
Lychnocanium waiareka O'Connor 1999a, p. 25, pl. 4, fig. 6-11, pl. 7, fig. 12a-15.
Lychnocanium tripodium Ehrenberg, Hollis et al. 1997, p. 64, pl. 5, fig. 34-37.
? *Lychnocanium hamosum* Ehrenberg 1876, pl. 7, fig. 9; Ogane et al. 2009, pl. 7, fig. 8a-b.
? *Lychnocanium tripodium* Ehrenberg 1876, pl. 7, fig. 2.
? *Lychnocanium neptunei* O'Connor 1997, pl. 3, fig. 7-10, pl. 9, fig. 7-12.

This species is distinguished by a campanulate thorax, which is almost as wide as it is long, and terminal feet that are only slightly flared. A delicate abdomen is preserved on well-preserved specimens. In less well-preserved specimens, all that remains of the abdomen are short thorns on the inner sides of the feet (e.g. Hollis et al. 1997, pl. 5, fig. 35-37). Such forms closely resemble *L. hamosum* Ehrenberg. We provisionally include specimens with smooth feet (e.g. Hollis et al. 1997, pl. 5, fig. 34), which may be *L. tripodium* Ehrenberg or *L. neptunei* O'Connor.

Genus *PTEROCODON* Ehrenberg 1847

***Pterocodon apis* Ehrenberg** [Plate 4, fig. 19, 20a, b]
Pterocodon apis Ehrenberg 1874, p. 255, Ehrenberg 1876, pl. 19, fig. 3; Ogane et al. 2009, pl. 5, fig. 8a-d.
? *Pteropilium* sp. B, O'Connor 1999b, p. 507, pl. 6, fig. C.

Three segmented, strong apical horn, two lateral wings from thorax, described from Barbados, Tertiary deposits. O'Conner's species is similar, but seems to have fewer pores on thorax and abdomen. Our specimens have larger, hexagonal pores on the abdomen and smaller, rounded pores on the thorax.

Genus *PTEROPILIUM* Haeckel 1882

The genus *Pteropilium* differs from the closely allied *Dictyoceras* in the development of three free, vertical, latticed cephalic wings, expanded between the apical horn of the cephalis and the three wings of the torax; they may be direct prolongations of the latter. *Pteropilium* may have evolved from *Callimitra* or *Clathrocorys* by development of an abdomen.

***Pteropilium* aff. *contiguum* (Ehrenberg)** [Plate 4, fig. 21]
Pteropilium aff. *Pterocanium contiguum* Caulet 1991, p. 539, pl. 2, fig. 11..
aff. *Pterocanium contiguum* Ehrenberg 1874, p. 255, 1876, pl. 17, fig. 7.

Family LOPHOCYRTIIDAE sensu Sanfilippo and Caulet

Genus *APHETOCYRTIS* Sanfilippo and Caulet

The genus comprises the lineage: *Aphetocyrtis gnomabax – A. rossi – A. catalexis*. All three species have a porous subspherical cephalis with a small apical horn; a hemispherical to campanulate (bell-shaped) thorax with a rough thorny surface; and a subcylindrical to inverted truncate conical abdomen that may be closed and lacks a peristome or terminal feet.

Sanfilippo and Caulet (1998) differentiate species in this genus by skeletal features within the cephalis that are difficult to apply consistently to variably preserved material and to published illustrations. We focus on more general features of species that facilitate discrimination in our census studies.

This genus appears to arise in low latitudes in the Middle Eocene (*A. gnomabax*) and migrate to high latitudes in the late Middle to Late Eocene, with *A. rossi* (Late Eocene – Late Oligocene) largely and *A. catalexis* (Late Oligocene – Miocene) completely restricted to high latitudes.

***Aphetocyrtis bianulus* (O'Connor)** [Plate 5, fig. 1]

Theocorys bianulus O'Connor 1997, p. 84, pl. 4, fig. 1-4; pl. 10, fig. 1-4; pl. 11, fig. 5; Sanfilippo and Fourtanier 2003, p. 12, pl. P1, fig. 8, 9, 13; Funakawa et al. 2006, p. 24, pl. 6, fig. 7.

Aphetocyrtis bianulus (O'Connor), Suzuki et al. 2009, pl. 18, fig. 16a-b.

Closely resembles *A. rossi*, differing by having two distinctive bulges in the abdomen. High-latitude.

***Aphetocyrtis gnomabax* Sanfilippo and Caulet** [Plate 5, fig. 2-7]

Calocyclas semipolita Clark and Campbell, Caulet 1991, p. 537, pl. 4, fig. 9.

Aphetocyrtis gnomabax Sanfilippo and Caulet 1998, p. 16, pl. 2, fig. 6, 7, 10, 11, 14-17; pl. 7, fig. 10-13.

? *Cyrtocapsella* aff. *japonica* (Nakaseko), Takemura 1992, p. 746, pl. 1, fig.11-12.

non *Calocyclas semipolita* Clark and Campbell, Strong et al. 1995, p. p. 208, fig. 10V [*L. semipolita*?].

non *Calocyclas* cf. *semipolita* Clark and Campbell, Abelmann 1990, p. 697, pl. 7, fig. 4 [*A. catalexis*].

Thorax is bell-shaped to narrowly hemispherical. Pores of thorax and abdomen are of similar size. Abdomen is subcyclindrical to inverted conical with a ragged basal margin. High-latitude.

***Aphetocyrtis rossi* Sanfilippo and Caulet** [Plate 5, fig. 8-11]

Calocyclas semipolita? Clark and Campbell, Chen 1975, p. 459, pl. 6, fig. 3-6.

Calocyclas asperum (Ehrenberg), Caulet 1992, p. 537, pl. 4, fig. 8, fig. 4, no. 4 (not no. 3)

Calocyclas cf. *semipolita* Clark and Campbell, Takemura 1992, p. 745, pl. 4, fig. 5-6; Takemura and Ling 1997, p. 111, pl. 1, fig. 16.

Calocyclas semipolita Clark and Campbell group, Crouch and Hollis 1996, p. 26; Hollis et al. 1997, p. 58, pl. 5, fig. 11-12.

Cyrtocapsella robusta Abelmann, Hollis et al., 1997, p. 60, pl. 5, fig. 13-14.

Amphetocyrtis rossi Sanfilippo and Caulet 1998, p. 18, pl. 2, fig. 8-9, 12-13; pl. 7, fig. 1-9.

Aphetocyrtis cf. rossi Sanfilippo and Caulet, Suzuki et al. (2009), p. 260, pl. 18, fig. 17.

Hemispherical thorax. Subcylindrical abdomen with pores slightly larger than on thorax, narrows distally, may be closed with a lattice plate. Distinguished from *A. gnomabax* and *C. robusta* by its

hemispherical thorax. Distinguished from *Lophocyrtis (Apoplanius) aspera* by thorax and abdomen being of similar thickness. The two morphotypes illustrated by Hollis et al. (1997) appear to represent end-member variation within the species from slender forms with the cephalis free of the thoracic wall and a long cylindrical abdomen, open distally ("*C. semipolita*"), to more squat forms with the cephalis partly enclosed in the thoracic wall and a short abdomen, which is closed or has a basal lattice plate ("*C. robusta*"). High-latitude.

Genus *CLINORHABDUS* Sanfilippo and Caulet

Comprises the lineage *Clinorhabdus anantomus -- C. ocymora -- C. robusta -- C. longithorax*. Distinguished from other lophocyrtids by a short apical horn (when present), a bell-shaped or truncate conical thorax, and an abdomen that is subcylindrical and commonly closed. This genus is endemic to the Anatrctic and ranges from the Middle Eocene to the Early Miocene.

***Clinorhabdus anantomus* Sanfilippo and Caulet** [Plate 5, fig. 12, 13]
Clinorhabdus anantomus Sanfilippo and Caulet 1998, p. 20, pl. 1, fig. 14-25; pl. 8, fig. 1a-b, 3a-b.

Apical spine, vertical spine and apophyses from mitral arches protrude from cephalis as, respectively, a moderately robust apical horn, a short spines and several short thorns. Thorax has a distinct neck and primary dorsal and lateral spines may protrude as short spines. Abdomen thin-walled with a ragged distal margin. High-latitude.

***Clinorhabdus robusta* (Abelmann) emend. Sanfilippo and Caulet**
Cyrtocapsella robusta Abelmann 1990, p. 696, pl. 5, fig. 10, 11; Caulet 1991, p. 538, fig. 4; Takemura 1992, p. 746, pl. 1, fig. 5, 6; Takemura and Ling, 1996, p. 111, pl. 1, fig. 18
Clinorhabdus robusta (Abelmann), Sanfilippo and Caulet 1998, p. 22, pl. 1, fig. 7-10; pl. 8, fig. 9-14.
Not *Cyrtocapsella robusta* Abelmann, Hollis et al. 1997, p. 60, pl. 5, fig. 13-14 [= A rossi]

Abdomen is subcyclindrical or inverted truncate conical and usually closed. Pores of the abdomen only slightly larger than those of thorax. High-latitude.

Genus *LOPHOCYRTIS* Haeckel 1887 sensu Sanfilippo 1990

The genus includes *Lophocyrtis jacchia* and all of its descendants. Most species have three segments, pores of thorax quincuncially arranged; many have an apical horn, three feet and a closed abdomen.

Subgenus *APOPLANIUS* Sanfilippo and Caulet

The subgenus comprises the lineage *L. (A.) klydus -- L. (A.) keraspera -- L. (A.) aspera -- L. (A.) nomas*. The transition from *L. (A.) klydus* to *L. (A.) aspera* includes a shorteningand reduction in number of spines protruding from the cephalis; an expansion of the proximal thorax with overall shape changing from narrowly campanulate to hemispherical, and reduction in the abdomen, in

length, width and test thickness.
The first three members of the lineage span the early Eocene to Oligocene in low latitudes and co-occur in the middle to late Eocene in high latitudes.

Lophocyrtis (Apoplanius) aspera **(Ehrenberg), emend. Sanfilippo and Caulet** [Plate 5, fig. 14a, b-16]
Eucyrtidium asperum Ehrenberg 1874, p. 226; 1876, pl. 8, fig. 15.
Calocyclas asperum (Ehrenberg), Petrushevskaya and Kozlova 1972, p. 548, pl. 28, fig. 16-18; Strong et al. 1995, p. 208, fig. 9E, Crouch and Hollis 1996, p. 26.
Theocyrtis diabloensis (Clark and Campbell), Chen 1975, p. 459, pl. 5, figs. 4-6 (not fig. 7).
Calocyclas sp. B, Takemura 1992, p. 745, pl. 5, fig. 13; Takemura and Ling 1997, fig. 11, pl. 1, fig. 15; Hollis et al. 1997, p. 58, pl. 5, fig. 7-10.
Lophocyrtis (Apoplanius) aspera (Ehrenberg), Sanfilippo and Caulet 1998, p. 14, pl. 3A, fig. 5-10, pl. 3B, fig. 1, 2, 5-9, pl. 6, fig. 6-8. C; O'Connor 1999a, p. 32, pl. 9, fig. 5; Funakawa et al. 2006, p. 25, pl. 7, fig. 5-7 (not 4=L. keraspera).

Subsphaerical thorax. Antarctic forms have a thicker walled abdomen than tropical forms, however the abdomen is often incomplete. Short apical horn. High-latitude.

Lophocyrtis (Apoplanius) keraspera **Sanfilippo and Caulet** [Plate 5, fig. 17-19]
Lophocyrtis (Apoplanius) keraspera Sanfilippo and Caulet 1998, p. 14, pl. 3a, fig. 13-15, pl. 3b, fig. 12-14, pl. 6, fig. 9-12.

This species is distinguished by a strong apical horn, short vertical horn, hemispherical thorax with short spines projecting from lower part in some specimens, and subcylindrical to truncate conical abdomen. Abdomen is thin-walled and often incomplete. High-latitude.

Subgenus *LOPHOCYRTIS* Haeckel emend. Sanfilippo and Caulet 1998

Species have three segments. Subspherical cephalis is perforate cephalis and bears a well-developed apical horn, which may bear thorns distally. Inflated hemispherical thorax has a rough, sometimes thorny surface. Subcylindrical to inverted truncate conical abdomen has a proximal row of larger pores, no distinct peristome. Some species have three terminal or subterminal feet. Primarily a tropical subgenus with incursions in high latitudes in the Middle Eocene.

Lophocyrtis (Lophocyrtis) jacchia hapsis **Sanfilippo and Caulet** [Plate 5, fig. 20-22]
Calocyclas sp. C, Takemura 1992, p. 745, pl. 7, figs. 3-4.
Lophocyrtis jacchia (Ehrenberg), Chen 1975, p. 461, pl. 3, fig. 5, 6.
Lophocyrtis (Lophocyrtis) jacchia hapsis Sanfilippo and Caulet, 1998, p. 10, pl. 5, fig 6, 7a-b, 9.
Lophocyrtis haywardi O'Connor 1999a, pl. 3, fig. 27-31.

High-latitude variety of *L. jacchia jacchia*.

Subgenus *PARALAMPTERIUM* Sanfilippo

***Lophocyrtis (Paralampterium) dumitricai* Sanfilippo**
Lophocyrtis (Paralampterium) dumitricai Sanfilippo 1990, p. 308, pl. 3, fig. 7-13; O'Connor 1993, p. 74, pl. 8, fig. 18 19; Strong *et al.* 1995, p. 208, fig. 11n; Crouch and Hollis 1996, p. 26; Hollis et al. 1997, p. 62, pl. 6, fig. 19; Suzuki et al. 2009, p. 260, pl. 19, fig. 8a-b.

Sanfilippo (1990) found mid- to high-latitude occurrences in late early Eocene to early Oligocene sediments. Cosmopolitan.

***Lophocyrtis (Paralampterium) longiventer* (Chen)** [Plate 5, fig. 23, 24]
Cyclampterium? *longiventer* Chen 1975, p. 459, pl. 10, fig. 7; Palmer 1987, p. 355.
Lophocyrtis (Paralampterium) longiventer (Chen), Sanfilippo 1990, p. 309, pl. 3, fig. 1-5; Strong et al. 1995, p. 208, fig. 11m; Crouch and Hollis 1996, p. 26; Hollis et al 1997, p. 63, pl. 6, fig. 13-17; Takemura and Ling, 1997, pl. 1, fig. 12 (and fig. 13); Suzuki et al. 2009, p. 260, pl. 19, fig. 7a-b.
Cyclampterium milowi Riedel and Sanfilippo, Takemura 1992, p. 745, pl. 5, fig. 1-3.

High-latitude.

Family PTEROCORYTHIDAE Haeckel, emend. Moore 1972

Genus *CRYPTOCARPIUM* Sanfilippo and Riedel

***Cryptocarpium bussonii* (Carnevale) group, New Group** [Plate 5, fig. 25a, b, 26a, b]
Sethocorys bussonii Carnevale 1908, p. 31, pl. 4, fig. 17.
Sethocorys cristata Carnevale 1908, p. 31, pl. 4, fig. 18, 19.
Dictyocephalus bergontianus Carnevale 1908, p. 32, pl. 4, fig. 20.
Dictyocephalus crassus Carnevale 1908, p. 32, pl. 4, fig. 21.
Carpocanistrum spp. Riedel and Sanfilippo 1971 (in part), p. 1596, pl. 3D, fig. 4, 8, 9; Abelmann 1990, p. 695, pl. 5, fig. 13; Takemura 1992, p. 744, pl. 3, fig. 5, 6; O'Connor 1993 (in part), p. 57, pl. 5, fig. 14; Crouch and Hollis 1996, p. 26; Hollis et al., 1997, p. 66, pl. 6, fig. 26-27; Takemura and Ling 1997, p. 111.
Tricolocapsa bergontiana (Carnevale). Caulet 1986, p. 854.

Subconical to ovate test of 2 segments. Cephalis weakly lobed, ovate, imperforate, no apical spine. Thorax egg-shaped to subconical, basal aperture surrounded by a thick peristome. Thoracic pores quincuncially arranged in hexagonal frames. Cosmopolitan.

***Cryptocarpium ornatum* (Ehrenberg)**
Cryptoprora ornata Ehrenberg, Sanfilippo et al. 1985, p. 693, fig. 27.2a, b.
Phormocyrtis proxima (?) Clark and Campbell, Chen 1975, p. 456, pl. 2, fig. 6.
Cryptocarpium ornatum (Ehrenberg), Hollis et al., 1997, p. 66, pl. 6, fig. 23-25; Kamikuri et al. 2012a, p. 3; Funakawa et al. 2006, p. 28, pl. 9, fig. 6-8.

Cosmopolitan.

Genus *LAMPROCYCLAS* Haeckel

***Lamprocyclas particollis* O'Connor** [Plate 5, fig. 27]
Lamprocyclas "*particollis*" O'Connor, Hollis et al. 1997, p. 66, pl. 7, fig. 1-7 (*nom. nud*.).
Lamprocyclas particollis O'Connor, 1999a, pl. 3, fig. 5-11; pl. 6, fig. 19a-23.

Distinguished from *L. matakohe* by pores of the thorax and abdomen being of equivalent size, and a weakly differentiated peristome; from *Calocycletta parva* Moore (1972) by an elongate, rather than ovate, cephalis with a eucephalic lobe that extends into a markedly bladed apical horn; from *Anthocyrtidium odontatum* O'Connor (1994, p. 342, pl. 2, fig. 5-8; pl. 4, fig. 1-5) by a distinct lumbar stricture and a thorax which tends to be campanulate rather than hemispherical. High-latitude.

Genus *STICHOPILIUM Haeckel*

***Stichopilium cf. bicorne (*Haeckel)** [Plate 5, fig. 28a, b-29a, b]
Stichopilium bicorne Haeckel 1887, p. 1437, pl. 77, fig. 9; Takahashi, 1981, p. 254, pl. 39, figs. 13-19.
Stichopilium bicorne? Lazarus 1992, pl. 9, fig. 9-10, 12-17.

Unlike to the original description, the species encountered in this study consist of a thorax and abdomen that are fairly narrow and short. Our species are similar to Lazarus' species.

Genus *THEOCYRTIS* Haeckel

***Theocyrtis tuberosa* Riedel** [Plate 5, fig. 30]
Theocyrtis tuberosa Riedel, 1959, p.298, pl.2, figs.10-11; Johnson 1978, p. 782; Sanfilippo et al. 1985 (in part), p. 701, fig. 32.1a-b; Nigrini 1985, p. 523; Palmer 1987, p. 357; Johnson 1990, p. 407; Takemura 1992, p. 744, pl. 6, fig. 1, 2; O'Connor 1993 (in part), p. 70, pl. 7, fig. 22; Aitchison and Flood 1995, p. 573; Takemura and Ling 1997, p. 114; Funakawa et al. 2006, p. 30;
Theocyrtis aff. *tuberosa* Riedel, Strong *et al.* 1995, p. 209, fig. 10y; Hollis et al. 1997, p. 67.

The early form of *T. tuberosa* described by Strong et al. (1995) has well-developed plicae but lacks tubercles on the thorax. Low-latitude.

Family SETHOPHORMIDIDAE

All taxa assigned to this family are having a wide conical to flat dicyrtid shape with a large cephalis, which is not always preserved.

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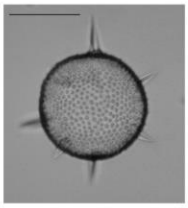
Plate 1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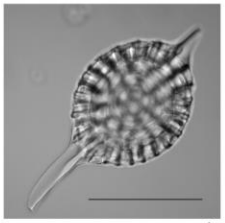
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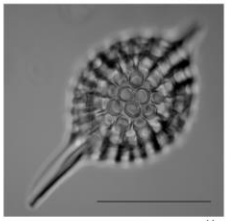
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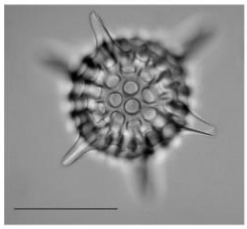
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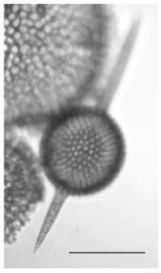
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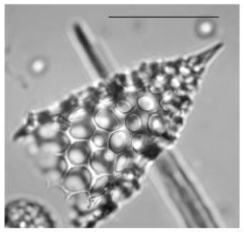
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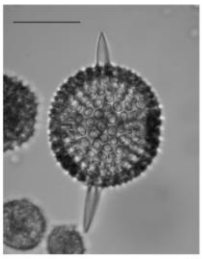
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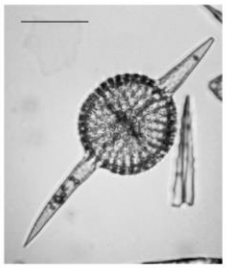
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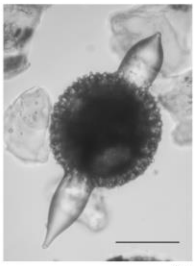
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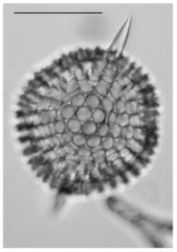
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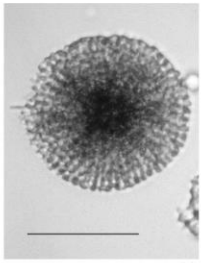
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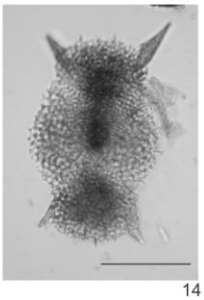
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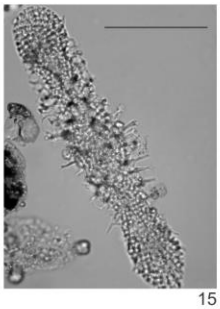
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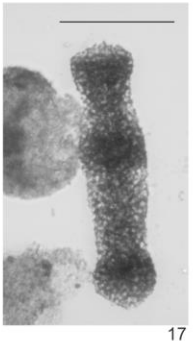
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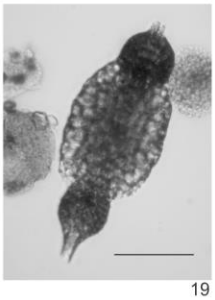
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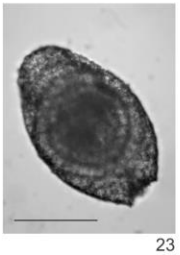
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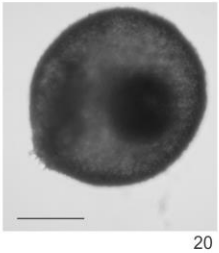
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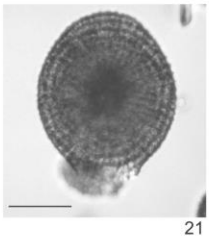
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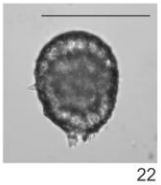
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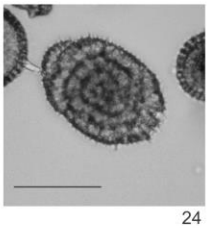
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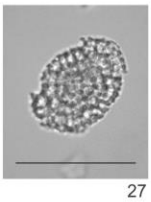
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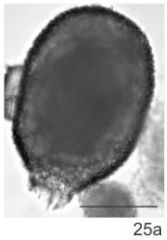
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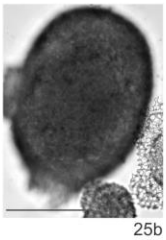
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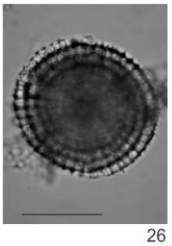
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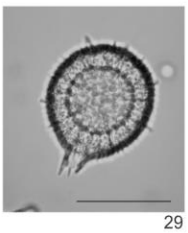
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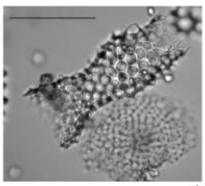
Plate 1. Scale bars equal 100µm. Images of selected radiolarian species:

1) Actinommidae n.sp. A sensu Hollis (DSDP 277, 23-1, 33cm, slide A), **2) *Amphisphaera coronata* gr.** (DSDP277, 25-1, 60cm, slide A), **3) *Amphisphaera radiosa*** (DSDP277, 24-2, 20cm, slide B), **4a,b) *Amphisphaera* aff. *radiosa*** (DSDP277, 17-3, 33cm), **5) *Amphisphaera spinulosa*** (DSDP283, 8-2, 25cm, slide A), **6) *Amphisphaera? megapora*** (DSDP277, 25-1, 60cm, slide C), **7) *Stylosphaera minor*** (DSDP277, 32-3, 100cm), **8) *Zealithapium mitra*** *(*DSDP277, 23-1, 33cm, slide B), **9) *Axoprunum bispiculum*** (DSDP 277, 17-3, 33cm), **10, 11) *Axoprunum pierinei* gr.** (10: DSDP277, 25-1, 60cm, slide A; 11: DSDP281, 14-1, 100cm, slide A), **12) *Axoprunum? irregularis*** (DSDP277, 15-3, 100cm), **13) *Spongopyle osculosa*** (DSDP277, 24-2, 20cm, slide B), **14) *Amphicraspedum murrayanum*** (DSDP277, 32-3, 100cm), **15-17) *Amphicraspedum prolixum* gr.** (15: DSDP277, 22-1, 82cm, slide A; 16: DSDP280A, 6-2, 60cm, slide A; 17: DSDP277, 33-2, 100cm), **18, 19) *Amphymenium splendiarmatum*** (DSDP277, 32-3, 100cm), **20) *Larcopyle frakesi*** (DSDP280A, 5-1, 104cm, slide C), **21) *Larcopyle hayesi*** (DSDP277, 24-2, 20cm, slide B), **22) *Larcopyle labyrinthusa*** (DSDP280A, 5-1, 104cm, slide C), **23, 24) *Larcopyle polyacantha* gr.** (23: DSDP280A, 5-1, 104cm, slide C; 24: DSDP277, 24-2, 20cm, slide B), **25a,b) *Larcopyle* cf. *pylomaticus*** (DSDP280A, 5-1, 104cm, slide C), **26-28) *Lithelius minor* gr.** (26: DSDP277, 32-3, 100cm; 27-28: DSDP277, 24-2, 20cm, slide B), **29) *Sphaeropyle tetrapila*** (DSDP277, 18-3, 20cm).

Plate 2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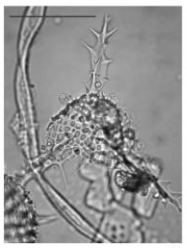
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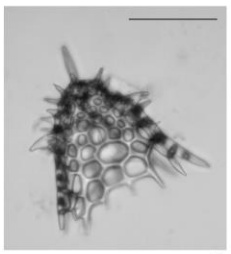
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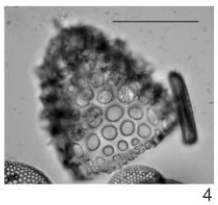
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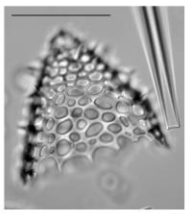
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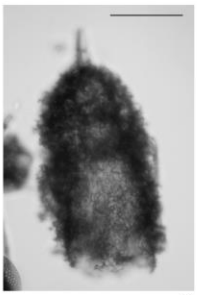
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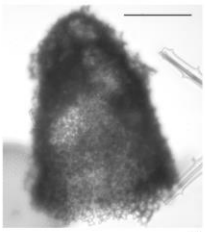
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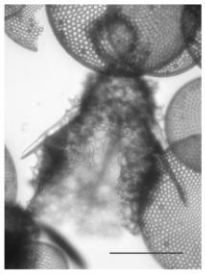
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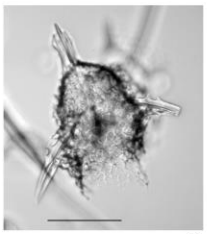
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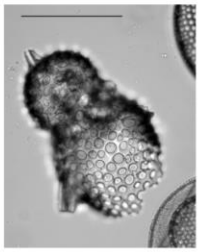
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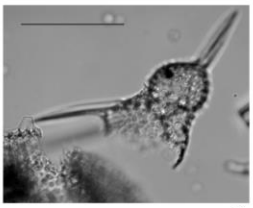
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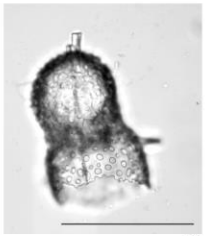
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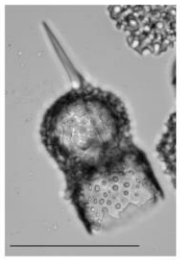
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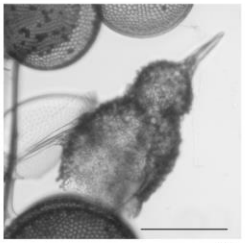
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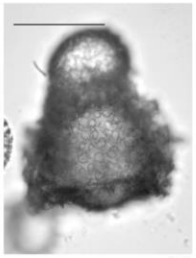
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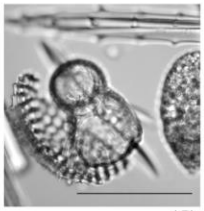
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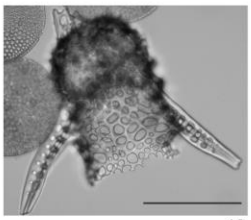
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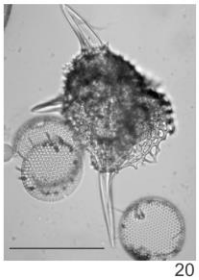
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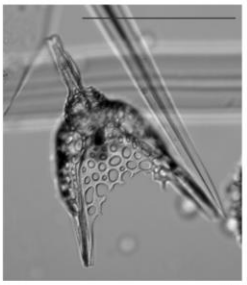
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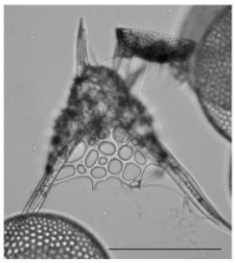
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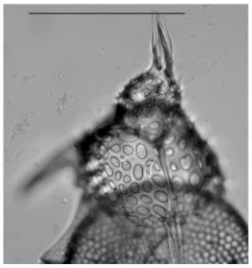
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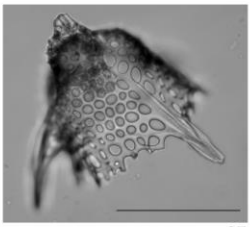
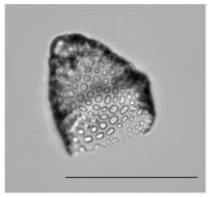

27

Plate 2. Scale bars equal 100µm. Images of selected radiolarian species:

1) ***Amphicentria*** **sp. 1** sensu Suzuki (DSDP277, 22-1, 82cm, slide B), **2)** ***Callimitra*** **aff.** ***atavia*** (DSDP277, 22-1, 82cm), **3-5)** ***Ceratocyrtis*** **spp.** (3-4: DSDP280A, 5-1, 104cm, slide C, B; 5: DSDP283, 7-1, 20cm, slide A), **6-8)** ***Lithomelissa challengerae*** (DSDP280A, 6-2, 60cm, slide A), **9)** ***Lithomelissa*** **cf.** ***challengerae*** (DSDP277, 23-1, 33cm, slide B), **10-11)** ***Lithomelissa ehrenbergi*** (10: DSDP280A, 5-1, 104cm, slide B; 11: DSDP283, 6-2, 40cm, slide A), **12, 13)** ***Lithomelissa gelasinus*** (DSDP280A, 5-1, 104cm, slide A), **14)** ***Lithomelissa*** **cf.** ***haeckeli*** (DSDP277, 22-1, 82cm, slide B), **15a,b)** ***Lithomelissa macroptera*** (DSDP283, 5-2, 25cm, slide A), **16)** ***Lithomelissa robusta*** (DSDP280A, 7-1, 90cm, slide A), **17)** ***Lithomelissa sphaerocephalis*** (DSDP280A, 7-3, 40cm, slide A), **18)** ***Lithomelissa tricornis*** (DSDP280A, 7-1, 90cm, slide A), **19)** ***Lithomelissa? sakaii*** (DSDP280A, 5-1, 104cm, slide B), **20)** ***Pseudodictyophimus galeatus*** (DSDP280A, 7-3, 40cm, slide A), **21-23)** ***Pseudodictyophimus gracilipes*** **gr.** (21-22: DSDP280A, 7-1, 90cm, slide A; 23: DSDP283, 5-2, 25cm, slide B), **24-27)** ***Pseudodictyophimus*** **spp.** (24: DSDP280A, 7-3, 40cm, slide A; 25-26: DSDP280A, 7-1, 90cm, slide A; 27: DSDP280A, 5-1, 104, slide A).

Plate 3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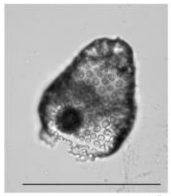
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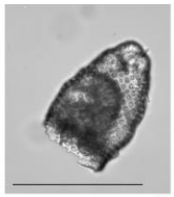
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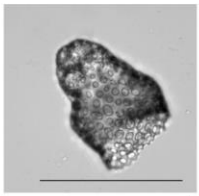
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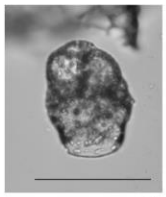
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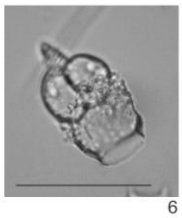
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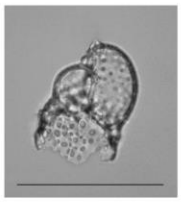
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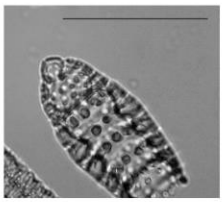
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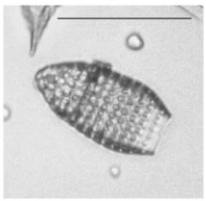
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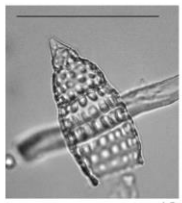
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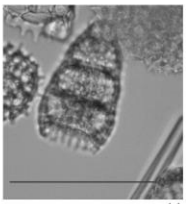
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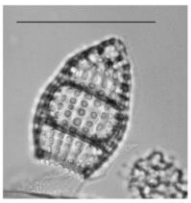
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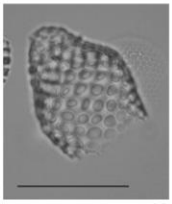
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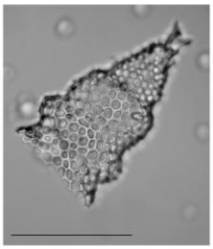
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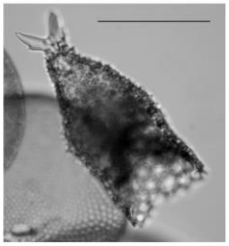
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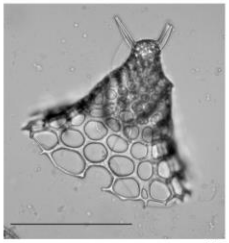
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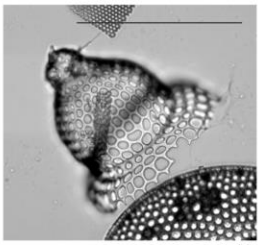
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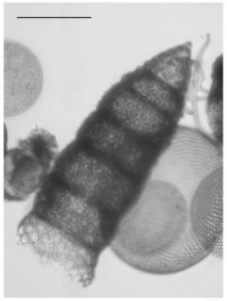
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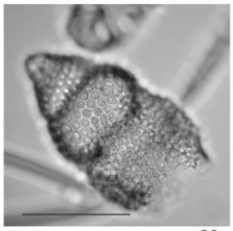
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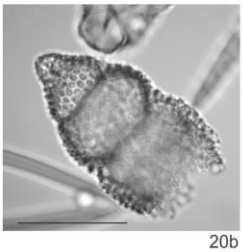
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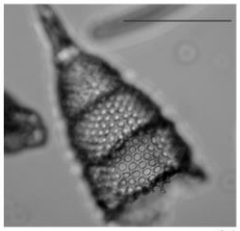
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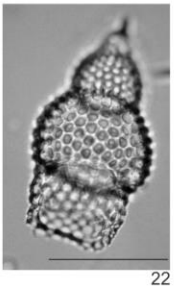
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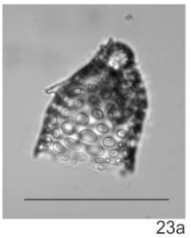
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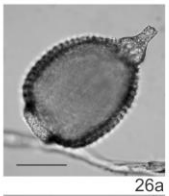
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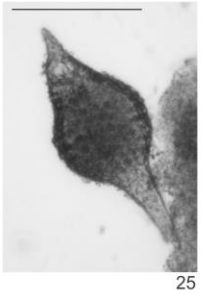
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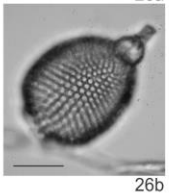
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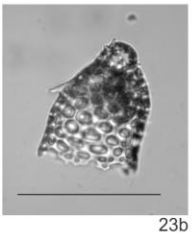
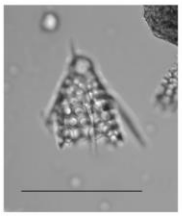

23b

Plate 3. Scale bars equal 100µm. Images of selected radiolarian species:

1-4) *Botryocella* sp. A sensu Apel (DSDP280A, 5-1, 104cm, slide A), **5-7) *Glycobotrys nasuta* gr.** (5: DSDP280A, 5-1, 104cm, slide A; 6: DSDP277, 25-1, 60cm, slide A; 7: DSDP277, 24-2, 20cm, slide A), **8-10) *Siphocampe* (?) *acephala* gr.** (DSDP277, 25-1, 60cm, slide A), **11, 12) *Siphocampe? amygdala*** (11: DSDP277, 24-2, 20cm, slide B; 12: DSDP277, 23-1, 33cm, slide A), **13) *Artostrobus* cf. *pretabulus*** (DSDP277, 23-1, 33cm, slide A), **14-16) *Aspis* sp. A** (14: DSDP 277, 22-1, 82; 15: DSDP 283, 7-5, 94cm, slide A; 16: DSDP 280A, 6-2, 60cm, slide A), **17) *Cycladophora cosma cosma*** (DSDP280A, 7-3, 40cm, slide A), **18) *Cycladophora humerus*** (DSDP280A, 5-1, 104cm, slide A), **19) *Eucyrtidium antiquum*** (DSDP280A, 7-1, 90cm, slide A), **20a,b) *Eucyrtidium nishimurae*** (DSDP283, 8-2, 25cm, slide A), **21) *Eucyrtidium spinosum*** (DSDP283, 7-5, 94cm, slide A), **22) *Eucyrtidium montiparum*** (DSDP277, 23-1, 33cm, slide A), **23a,b) *Eurystomoskevos cauleti*** (DSDP280A, 7-3, 40cm, slide A), **24) *Eurystomoskevos petrushevskaae*** (DSDP277, 23-1, 33cm, slide A), **25) *Eusyringium fistuligerum*** (DSDP277, 33-2, 20cm, slide A), **26a,b**) ***Sethocyrtis chrysallis*** (DSDP277, 32-3. 100cm), **27) *Thyrsocyrtis pinguisicoides*** (DSDP277, 23-1, 33cm, slide A).

Plate 4


1a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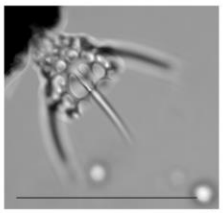
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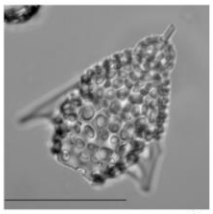
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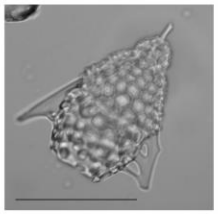
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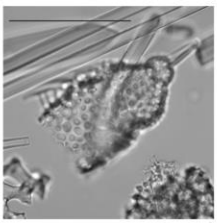
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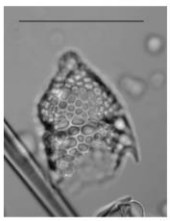
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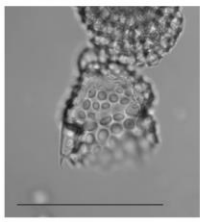
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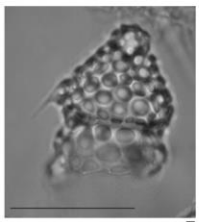
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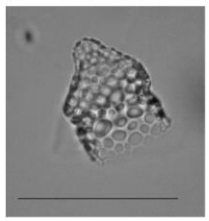
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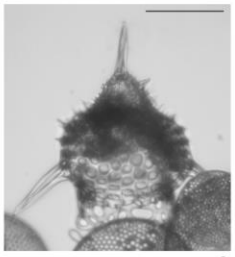
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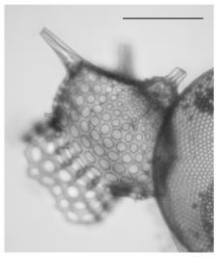
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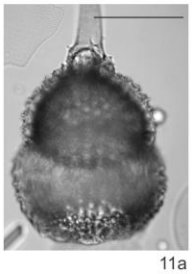
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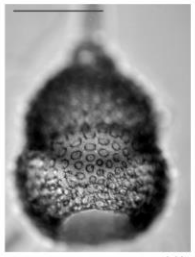
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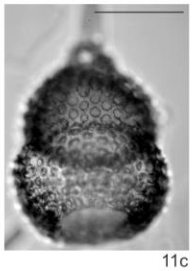
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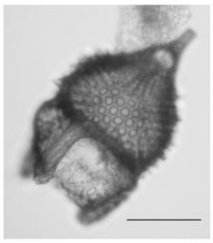
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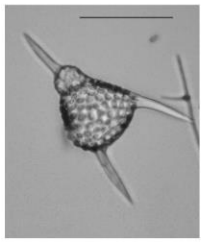
13a


13b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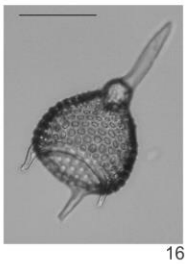
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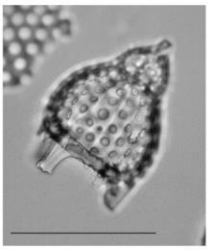
17


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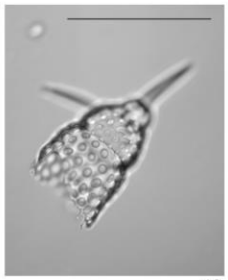
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20a


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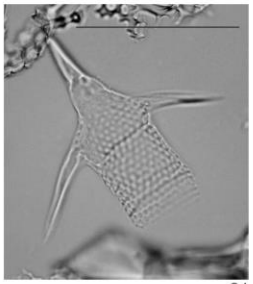
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Plate 4. Scale bars equal 100µm. Images of selected radiolarian species:

1a,b, 2) ***Dictyophimus*****? *archipilium*** (DSDP283, 7-1, 20cm, slide A), **3a,b-8)** ***Dictyophimus*****? aff *archipilium*** (3: DSDP277, 17-3, 33cm; 4-6: DSDP283, 8-1, 40cm, slide B; 7-8: DSDP277, 23-1, 22cm, slide A), **9, 10)** ***Dictyophimus*** **aff.** ***constrictus*** (9: DSDP280A, 9-1, 90cm, slide A, 10: DSDP280A, 6-2, 60cm), **11a-c, 12)** ***Lychnocanium amphitrite*** (11: DSDP283, 5-2, 25cm, slide B; 12: DSDP277, 33-2, 20cm slide A), **13a,b, 14)** ***Lychnocanium babylonis*** (13: DSDP283, 8-2, 25cm, slide A; 14: DSDP277, 23-1, 33cm, slide A), **15, 16)** ***Lychnocanium bellum*** (DSDP277, 25-1, 60cm, slide A), **17)** ***Lychnocanium*** **aff.** ***carinatum*** (DSDP277, 26-1, 60cm, slide A), **18a,b)** ***Lychnocanium tetrapodium*** (DSDP277, 23-1, 33cm, slide A), **19, 20a,b)** ***Pterocodon apis*** (19: DSDP283, 7-1, 20cm, slide B; 20: DSDP283, 6-2, 40cm, slide A), **21)** ***Pteropilium*** **aff.** ***contiguum*** (DSDP277, 23-1, 33cm, slide A).

Plate 5

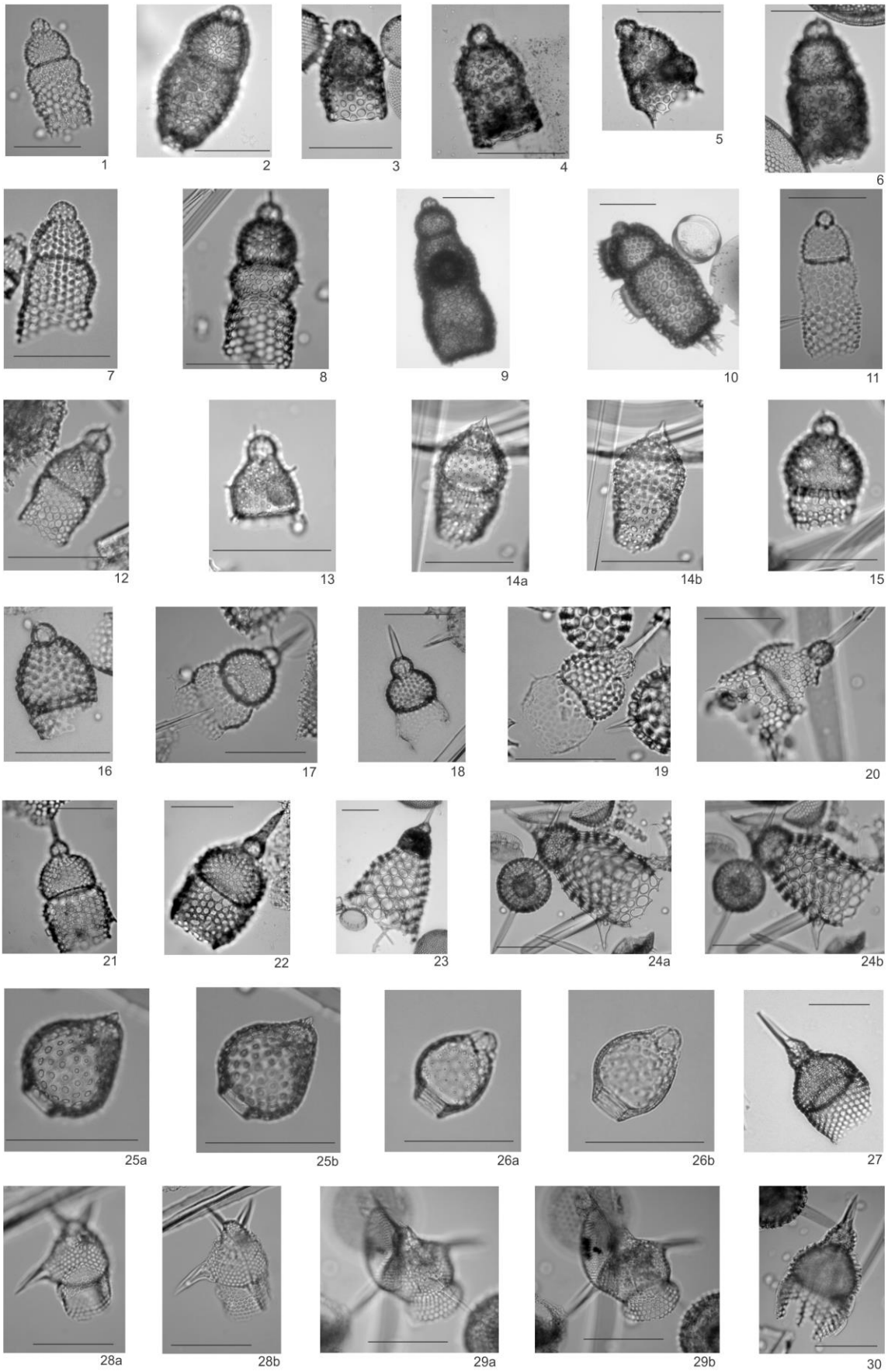
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Plate 5. Scale bars equal 100µm. Images of selected radiolarian species:

1) ***Aphetocyrtis bianulus*** (DSDP277, 22-1, 82cm, slide A), **2-7)** ***Aphetocyrtis gnomabax*** (2: DSDP280A, 6-2, 60cm, slide A; 3-6: DSDP280A, 5-1, 104cm, slide A; 7: DSDP277, 24-2, 20cm, slide A), **8-11)** ***Aphetocyrtis rossi*** (8: DSDP283, 6-2, 40cm, slide A; 9: DSDP280A, 5-1, 104cm, slide A; 10: DSDP280A, 7-1, 90cm, slide A; 11: DSDP277, 23-1, 33cm, slide A), **12, 13)** ***Clinorhabdus anantomus*** (DSDP283, 7-1, 20cm, slide A), **14a,b-16)** ***Lophocyrtis aspera*** (14-15: DSDP283, 7-1, 20cm, slide A; 16: DSDP277, 24-2, 20cm, slide A), **17-19)** ***Lophocyrtis keraspera*** (DSDP277, 23-1, 33cm, slide A), **20-22)** ***Lophocyrtis jacchia hapsis*** (20: DSDP283, 8-1, 40cm, slide A; 21-22: DSDP277, 32-3, 100cm), **23, 24)** ***Lophocyrtis longiventer*** (23: DSDP280A, 5-1, 104cm, slide A; 24: DSDP283, 5-2, 25cm, slide B), **25a,b, 26a,b)** ***Cryocarpium bussonii*** **gr.** (DSDP277, 18-3, 20cm), **27)** ***Lamprocyclas particollis*** (DSDP277, 25-1, 60cm, slide A), **28a,b, 29a,b)** ***Stichopilium*** **cf.** ***bicorne*** (28: DSDP283, 7-1, 20cm, slide A; 29: DSDP283, 6-2, 40cm, slide A), **30)** ***Theocyrtis tuberosa*** (DSDP283, 5-2, 25cm, slide B).