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Preliminary report on Pliocene radiolarians from the Nobori Formation, Tonohama Group, Shikoku, Southwest Japan.

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ABSTRACT

99 taxa of radiolarians were discriminated from the type section of the Nobori Formation, Tonohama Group, Shikoku, Southwest Japan. The preliminary investigation has revealed that the type locality of the formation, also that of planktonic foraminifera *Globorotalia tosaensis* whose first appearance defines the base of the zone N21, is correlative with both the *Sphaeropyle langii* zone (mid-latitude) and the *Spongaster pentas* zone (low-latitude) and that the age is middle to late Pliocene. The Nobori radiolarian fauna is considered to be a transitional type from typical low- to mid-latitude fauna, and is characterized by the predominant occurrence of pyloniaceans, on the other hand, the nassellarians are relatively rich in *Cycladophora pliocenica* representing one of cold water species. *Pseudodictyophimus hexaptesimus, Bathropyramis* (?) *pyrgina, Eucyrtidium lene* are newly described.

INTRODUCTION

Studies on the Pliocene radiolarians in Japan have been performed mainly in Northeast Japan where siliceous deposits ranging from the Upper Miocene to Pliocene are widely distributed. Radiolarian analyses on deep-sea sediments, such as the DSDP Leg 56 drilled near the Japan Trench (Sakai, 1980), have also contributed to accumulate the substantial knowledge. The results already made it possible to establish regional, mid-latitude radiolarian zonations (Sakai, 1984 ; Motoyama, 1992, etc.).

In contrast, the Pliocene sediments in Southwest Japan (the Kakegawa, Miyazaki and Shimajiri Groups, etc.) are in general very poor in siliceous microfossils. Unfortunately, even at the Sites 296 to 298A of the DSDP Leg 31, drilled in the Palau-Kyushu Ridge to the Nankai Trough area, Pliocene radiolarians could not be recovered (Ling, 1975). One can accordingly point out that lower mid-lattitude Pliocene radiolarians in the western Pacific region remain poorly undersood, much more detailed aspects of the faunal transition from low- to mid-latitude.

Against other Pliocene sediments in Southwest Japan, the Nobori Formation of the Tonohama Group, distributed in a small scale on the Pacific coast of Kochi Prefecture, Shikoku, has been known to yield abundant, both calcareous and siliceous microfossils, and many micropaleontologists studied foraminifers, calcareous nannoplanktons, and

diatoms from the formation (Takayanagi, 1953 ; Takayanagi and Saito, 1962 ; Uchio, 1967 ; Kurihara, 1968 ; Koizumi and Ujiie, 1976 ; Nishida, 1979 ; Takayama, 1980 ; etc.). However, there are no detailed studies dealing with radiolarians except the concise faunal description by Nakaseko and Sugano (1973). Although the stratigraphic interval of the formation is short, there is no need to stress that the detailed radiolarian analysis should be much valuable for our understanding of scarcely known lower mid-latitude Pliocene radiolarian fauna and also be one of clues to solve paleoenvironmental problems of this area.

The present paper thus represents the first comprehensive study of the radiolarian fauna from the Nobori Formation, and first of all aims at listing characteristic radiolarians from the type section after brief discussion of the faunal composition and age in the third chapter.

GEOLOGIC SETTING

The Tonohama Group, named by Katto et al. (1953), is sporadically distributed along the western coast of the Muroto Peninsula, Kochi Prefecture, and the Nobori Formation is the lowest of this group (the stratigraphic relationship of each formation of the Tonohama Group still remains uncertain, but the problem is not interesting of the present study). The studied samples were collected around the Locality A of Katto et al. (1953) (Fig. 1), which is famous for the type locality of the Nobori Formation as

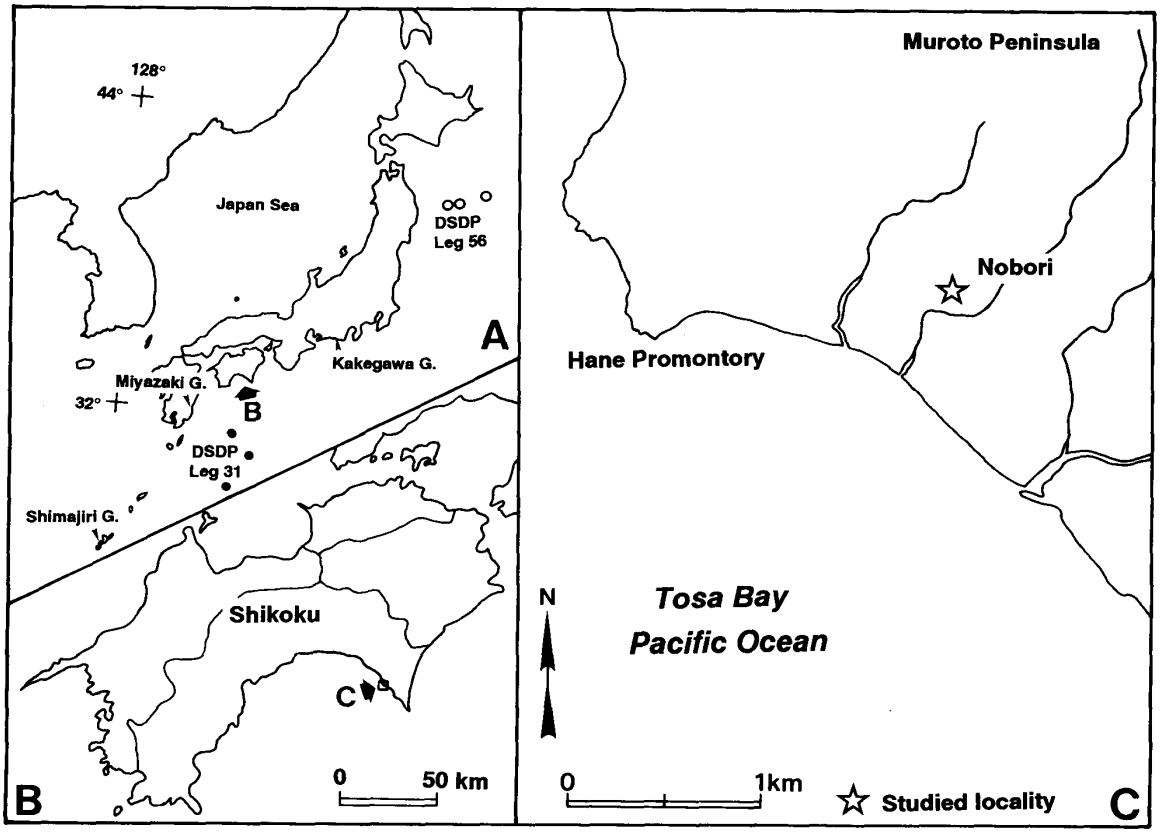

Figure 1 : Index map showing the locality of the studied section.

well as that of planktonic foraminifera *Globorotalia tosaensis* Takayanagi and Saito whose first appGearance defines the base of the zone N 21 (Blow, 1969). The lithology is represented by grayish massive siltstone which frequently yields fish-otoliths and both articulated and disarticulated shells of molluscan fossil "*Empleconia*" sp. Kurihara (1968) inferred that the siltostone was deposited on an upper part of the continental slope, based on the benthic foraminiferal fauna. In this study the samples were preliminarily collected at an interval of several meters from the siltstone. It is noteworthy that a particular horizon, approximately 20 cm in thickness, is considerably crowded with molluscan fossils supported by rather sandy matrix. The shell bed yeilds following taxa ; *Amussiopecten praesignis* (Yokoyama), "*Empleconia*" sp., *Fissidentalium yokoyamai* Makiyama, *Glycymeris* sp. cf. *G. rotunda* (Dunker), *Oblimopa japonica* (A. Adams), *Venericardia* sp. aff. *V. panda* (Yokoyama), fragments of oyster, many gastropods and so on. Judging from such a co-ocurrence and their mode of occurrence, it is assured that the bed includes some transported elements from the sublittoral zone. Therefore, we have to keep in mind that reworked microfossils may be common in the siltostone even if they do not show remarkable time gap and/or difference of depositional environments.

RADIOLARIAN FAUNAL REMARKS

Radiolarians are rather few in abundance as compared with other microfossils, and their preservation is generally moderate. Some specimens are partially dissoloved and others are sometimes replaced by pyrite. The specific composition and relative abundance of each species are considered to be equal through the examined samples, so that we do not subdivide the recovered radiolarian fauna into paticular assemblages in this time.

The Nobori radiolarian fauna is composed of more than 120 species including undescribed minor elements, of which 99 taxa (including indeterminable genera and species) are discriminated in this study. Judging from their state of preservation, it seems that some delicate forms were already dissolved completely. Therefore, one can estimate that the original components was 150 or more species at the lowest.

Of the spumellarian components, the most abundant and variable forms are pyloniaceans, represented by *Phorticium* spp., which are predominant even in the total fauna. Spongodiscids are the next abundant spumellarians. The remainders of spumellarians are relatively rare but collosphaerids, perhaps much susceptible to dissolution, may be more abundant originally. Entactinarians are common and constant in the composition through the samples. Nassellarians are dominated by theoperids and pterocorythids, and, in contrast, others commonly occupy a small portion of a nassellarian population. No specimens of cannobotryids were found in the samples. Species with relatively high abundance (abundant (**A**) (@ > 16%), common (**C**) (16 > @ > 4%), few (**F**) (4 > @ > 2%), and rare (**R**) (2 > @ > 1%)) are as follows ;

Actinomma sp. -**F** to **R**
Haeckeliella inconstans Dumitrica -**F**
Thecosphaera sp. A-**F** to **R**
Spongodiscus sp. -**F** to **R**

Phorticium spp. -**A** to **C**
Tetrapyle sp. -F to R
Larnacillidae (?) gen. et sp. indet. -**F** to **R**
Hexacontium spp. -**F** to **R**
Axoprunum bispiculum (Popofsky) -**F** to **R**
Cycladophora pliocenica Lombari and Lazarus -**C** to **F**
Eucyrtidium calvertense Martin group -**F** to **R**
Pterocanium charybdem (Müller) -**F** to **R**
Stichocorys peregrina (Riedel) -**F** to **R**
Lamprocyclas aegles (Ehrenberg) -**F** to **R**
Lamprocyrtis junonis (Haeckel) -**F** to **R**
Lithocircus spp. -**F** to **R**

Occurrences of other species are rare to very rare (@ <1%).

Most of the faunal components are either cosmopolitan or in common with low -latitude Pliocene fauna reported from the Pacific and Indian Oceans. It is, therefore, undoubted that the Nabori fauna has a certain affinity with contenporaneous low -latitude fauna. However, some cold water species, for example *Spongoplegma antarcticum* Haeckel, *Lamprotripus* (?) *mawsoni* (Riedel), *Pterocanium korotnevi* (Dogiel), *Cycladophora davisiana cornutoides* (Petrushevskaya) and *C. pliocenica* Lombari and Lazarus commonly occur in every sample studied. Moreover, it is notable that the last species is one of the most abundant nassellarians in the studied fauna.

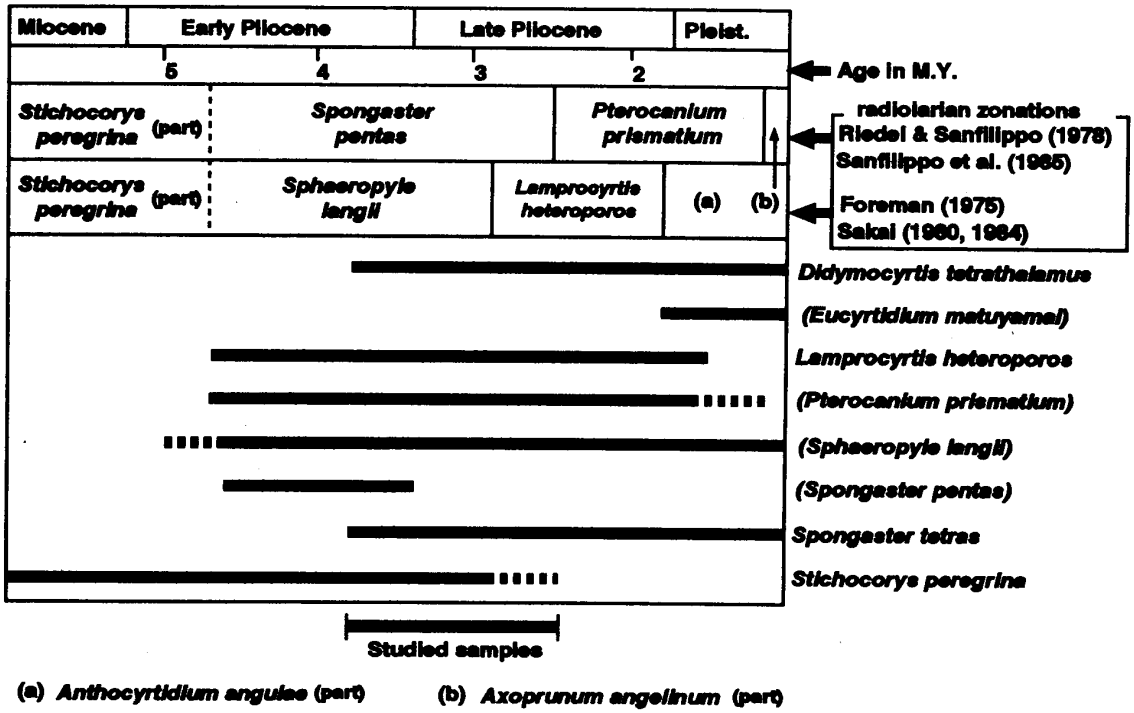

Figure 2 : Range chart of characteristic index species, also showing the age of the studied samples. Parenthesized species are absent in the Nobori fauna.

Co-existing of *Sticocorys pergiana* (Riedel), *Lamprocyrtis heteroporos* (Hays), *Didymocyrtis tetrathalamus* (Haeckel), *Spongaster tetras tetras* Ehrenberg in the fauna indicates that the samples are approximately correlative with the upper part of the *Sphaeropyle langii* zone (Foreman, 1975) of mid-latitude zonation as well as the upper part of the *Spongaster pentas* zone (Riedel and Sanfilippo, 1978) of low-latitude one. The studied samples are thus middle to late Pliocene in age, and the result well agrees with ones dated by other microfossils (Koizumi and Ujiie, 1976 ; Takayama, 1980 ; Tsuchi et al., 1989) (Fig. 2). However, one can notice that the fauna lacks diagnostic species of the mid-latitude fauna (i.e. *Spaeropyle langii* Dreyer) and some characteristic species of the low-latitude fauna (e.g. *Pterocanium prismatium* Riedel, *Theocorythium* spp., *Pterocorys* spp.).

It should be concluded, from what has been said above, that the Nobori fauna has a rather peculiar specific composition beside other contemporaneous radiolarian faunas. The composition seems to exhibit a transitional character from the typical low-to mid-latitude fauna, obviously reflecting the geographical situation of the

SYSTEMATIC PALEONTOLOGY

Characteristic radiolarians encountered during the study are systematically tabulated below. The families Excentrochonchidae, Hexalonchidae and Saturnalidae are tentatively assigned to the order Entactinaria proposed by Kozur and Mostler (1982), but the further investigations must be necessary. The generic taxonomy of acathodesmiids used in this study mainly follows that of the Petrushevskaya (1971b, 1981). Full descriptions or remarks are given for 35 taxa, including three new species, indicated by Gothic letters.

Order Spumellaria

Family Actinommidae Haeckel, 1862, emend. Riedel, 1967b

Genus *Acanthosphaera* Ehrenberg, 1858

***Acanthosphaera* sp. A**

Genus *Actinomma* Haeckel, 1862

***Actinomma* sp. A**

Genus *Anomalacantha* Loeblich and Tappan, 1961

***Anomalacantha* sp. A**

Genus *Cenosphaera* Ehrenberg, 1854a

***Cenosphaera* spp.**

Genus *Echinomma* Haeckel, 1881

***Echinomma* spp.**

Genus *Haeckeliella* Hollande and Enjumet, 1960

Haeckeliella inconstans Dumitrica, 1973

Genus *Spongoplegma* Haeckel, 1881

Spongoplegma antarcticum Haeckel, 1887

Genus *Stylatractus* Haeckel, 1887

Stylatractus neptunus Haeckel, 1887 group

Genus *Thecosphaera* Haeckel, 1887

***Thecosphaera* sp. A**

Actinommidae gen. et sp. indet.
Family Cocodiscidae Haeckel, 1862, emend. Sanfilippo and Riedel, 1980
Subfamily Artiscinae Haeckel, 1881, emend. Riedel, 1967b
Genus *Didymocyrtis* Haeckel, 1860a, emend. Sanfilippo and Riedel, 1980
Didymocyrtis tetrathalamus (Haeckel, 1887)
Subfamily Heliodiscinae Haeckel, 1881, emend. Dumitrica, 1984
Genus *Heliodiscus* Haeckel, 1862
Heliodiscus echiniscus Haeckel, 1887
Heliodiscus* sp. aff. *H. asteriscus Haeckel, 1887
Family Collosphaeridae Müller, 1858b
Genus *Acrosphaera* Haeckel, 1881
Acrosphaera inflata Haeckel, 1887
Acrosphaera spinosa (Haeckel, 1860)
Genus *Choenicosphaera* Haeckel, 1887
Choenicosphaera trepanata (Haeckel, 1887)
Genus *Otosphaera* Haeckel, 1887, emend. Nigrini, 1967
Otosphaera auriculata Haeckel, 1887
Family Orosphaeridae Haeckel, 1887
Orosphaeridae gen. et sp. indet.
Family Sphaerozoidae Müller, 1858b
Genus *Rhaphidozoum* Haeckel, 1862
Rhaphidozoum sp.
Family Spongodiscidae Haeckel, 1881, emend. Riedel, 1967b
Genus *Amphirhopalum* Haeckel, 1881, emend. Nigrini, 1967
Amphirhopalum ypsilon Haeckel, 1887
Genus *Euchitonia* Ehrenberg, 1860
Euchitonia furcata Ehrenberg, 1860 group
Genus *Hymeniastrum* Ehrenberg, 1847a
Hymeniastrum euclidis Haeckel, 1887 group
Genus *Ommatodiscus* Stöhr, 1880
Ommatodiscus fragilis Stöhr, 1880
Genus *Rhopalastrum* Ehrenberg, 1847a
Rhopalastrum profundum (Ehrenberg, 1860) group
***Rhopalastrum* sp.**
Genus *Spongaster* Ehrenberg, 1860
Spongaster tetras tetras Ehrenberg, 1860
Genus *Spongocore* Haeckel, 1887
Spongocore puella Haeckel, 1887
Genus *Spongodiscus* Ehrenberg, 1854a
Spongodiscus sp.
Genus *Spongopyle* Dreyer, 1889
Spongopyle osculosa Dreyer, 1889
Genus *Spongurus* Haeckel, 1860b
Spongurus* sp. aff. *S. pylomaticus Riedel, 1958
Family Porodiscidae Haeckel, 1887, emend. Kozlova in Petrushevskaya and

Kozlova, 1972
Genus *Flustrella* Ehrenberg, 1838
Flustrella sp.
Superfamily Pyloniacea Haeckel, 1881, emend. Dumitrica, 1989
Family Pyloniidae Haeckel, 1881, emend. Dumitrica, 1989
Subfamily Pyloniinae Haeckel, 1881, emend. Dumitrica, 1989
Genus *Larcospira* Haeckel, 1887
Larcospira quadrangula Haeckel, 1887 group
Genus *Phorticium* Haeckel, 1881
***Phorticium* spp.**
Genus *Tetrapyle* Müller, 1858a
Tetrapyle sp.
Family Larnacillidae Haeckel, 1887, emend. Dumitrica, 1989
Subfamily Tholoniinae Haeckel, 1887
Genus *Tholonium* Haeckel, 1887
Tholonium hexonium Haeckel, 1887
Larnacillidae (?) gen. et sp. indet.
Order Entactinaria
Family Excentroconchidae Hollande and Enjumet, 1960
Genus *Excentroconcha* Mast, 1910
Excentroconcha minor Mast, 1910
Family Hexalonchidae Haeckel, 1881, emend. Dumitrica, 1984
Genus *Hexacontium* Haeckel, 1881
***Hexacontium* spp.**
Family Saturnalidae Deflandre, 1953, emend. Dumitrica, 1985
Subfamily Axopruninae Dumitrica, 1985
Genus *Axoprunum* Haeckel, 1887
Axoprunum bispiculum (Popofsky, 1912)
Genus *Xiphosphaerantha* Haeckel, 1887
Xiphosphaerantha angelina (Campbell and Clark, 1944)
Order Nassellaria
Family Plagiacanthidae Hertwig, 1870, emend. Petrushevskaya, 1917a
Genus *Neosemantis* Popofsky, 1913
Neosemantis cladophora (Jørgensen, 1905)
Family Lophophaenidae Haeckel, 1881, emend. Petrushevskaya, 1917b
Genus *Arachnocorys* Haeckel, 1860b, emend. Petrushevskaya, 1971b
***Arachnocorys* sp. A**
Genus *Ceratocyrtis* Bütschli, 1882
***Ceratocyrtis* spp.**
Genus *Lampromitra* Haeckel, 1881
***Lampromitra* spp.**
Genus *Lamprotripus* Haeckel, 1881, emend. Petrushevskaya, 1971b
Lamprotripus* (?) *mawsoni (Riedel, 1958)
Genus *Lithomelissa* Ehrenberg, 1847b
Lithomelissa ultima Caulet, 1979

Genus *Lophophaena* Ehrenberg, 1847b
Lophophaena sp.
Genus *Pseudocubus* Haeckel, 1887
Pseudocubus warreni Goll, 1980
Genus *Pseudodictyophimus* Petrushevskaya, 1971b
Pseudodictyophimus gracilipes (Bailey, 1856)
Pseudodictyophimus hexaptesimus Sugiyama sp. nov.
Family Sethoperidae Haeckel, 1881, emend. Petrushevskaya, 1971a
Genus *Archipilium* Haeckel, 1881
Archipilium sp. A
Genus *Clathrolychnus* Haeckel, 1881
Clathrolychnus coarctatus (Ehrenberg, 1860)
Genus *Euscenium* Haeckel, 1887, emend. Petrushevskaya, 1981
***Euscenium* sp. A**
***Euscenium* sp. B**
Family Theoperidae Haeckel, 1881, emend. Riedel, 1967b
Genus *Bathropyramis* Haeckel, 1881, emend. Nishimura, 1990
Bathropyramis infundibulum (Haeckel, 1887)
Bathropyramis ramosa Haeckel, 1887
Bathropyramis* (?) *pyrgina Sugiyama sp. nov.
Genus *Bekomiforma* Sanfilippo and Riedel, 1974
Bekomiforma mynx Sanfilippo and Riedel, 1974
Genus *Calocycloma* Haeckel, 1887
Calocycloma* (?) *cassiopejae (Haeckel, 1887)
Genus *Cornutella* Ehrenberg, 1838
Cornutella profunda Ehrenberg, 1854b
Genus *Cycladophora* Ehrenberg, 1847a, emend. Lombari and Lazarus, 1988
Cycladophora davisiana cornutoides Petrushevskaya, 1967
Cycladophora pliocenica Lombari and Lazarus, 1988
Genus *Dictyophimus* Ehrenberg, 1947a, emend. Nigrini, 1967
Dictyophimus crisiae Ehrenberg, 1854b
Genus *Eucecryphalus* Haeckel, 1860, emend. Petrushevskaya, 1971b
Eucecryphalus elizabethae (Haeckel, 1887)
Genus *Eucyrtidium* Ehrenberg, 1847a, emend. Nigrini, 1967
Eucyrtidium calvertense Martin, 1904 group
Eucyrtidium lene Sugiyama sp. nov.
Eucyrtidium (?) *anomalum* (Haeckel, 1860b)
Genus *Gondwanaria* Petrushevskaya, 1975
Gondwanaria campanulaeformis (Campbell and Clark, 1944)
Genus *Lipmanella* Loeblich and Tappan, 1961
Lipmanella irregularis (Cleve, 1899)
Genus *Lithocampe* Ehrenberg, 1838
Lithocampe punctata Ehrenberg, 1844
***Lithocampe* sp. A**
Genus *Pterocanium* Ehrenberg, 1847a

Pterocanium charybdem (Müller, 1855)
Pterocanium korotnevi (Dogiel, 1952)
Pterocanium praetextum eucolpum Haeckel, 1887
Pterocanium diplotriaena (Dogiel, 1952)
Genus *Stichocorys* Haeckel, 1881
Stichocorys peregrina (Riedel, 1953)
Family Pterocorythidae Haeckel, 1881, emend. Riedel, 1967b
Genus *Anthocyrtidium* Haeckel, 1881
Anthocyrtidium nosicaae Caulet, 1979
Anthocyrtidium ophirense (Ehrenberg, 1872a)
Genus *Lamprocyclas* Haeckel, 1881, emend. Nigrini, 1967
Lamprocyclas aegles (Ehrenberg, 1854a)
Lamprocyclas margatensis (Campbell and Clark, 1944)
***Lamprocyclas* sp. A**
Genus *Lamprocyrtis* Kling, 1973
Lamprocyrtis heteroporos (Hays, 1965)
Lamprocyrtis junonis (Haeckel, 1887)
Family Carpocaniidae Haeckel, 1881, emend. Riedel, 1967b
Genus *Carpocanistrum* Haeckel, 1887
Carpocanistrum spp.
Family Artostrobiidae Riedel, 1967a, emend. Foreman, 1973
Genus *Botryostrobus* Haeckel, 1887, emend. Nigrini, 1977
Botryostrobus aquilonaris (Bailey, 1856)
Botryostrobus auritus (Ehrenberg, 1844)
Genus *Carpocanarium* Haeckel, 1887
Carpocanarium urna (Stöhr, 1880)
Genus *Phormostichoartus* Campbell, 1951, emend. Nigrini, 1977
Phormostichoartus sp. aff. *P. corbula* (Harting, 1863)
Genus *Spirocyrtis* Haeckel, 1881, emend. Nigrini, 1977
Spirocyrtis scalaris Haeckel, 1887
Family Acanthodesmiidae Haeckel, 1862, emend. Riedel, 1967b
Genus *Acanthodesmia* Müller, 1858b
Acanthodesmia vinculata (Müller, 1857)
Genus *Corythospyris* Haeckel, 1881
Corythospyris damaecornis (Haeckel, 1887)
Genus *Liriospyris* Haeckel, 1881
Liriospyris capoi (Goll, 1976)
Liriospyris scaphipes (Haeckel, 1887)
Liriospyris sp. aff. *L. capoi* (Goll, 1976)
Liriospyris sp. aff. *L. hyperborea* (Jørgensen, 1905)
Genus *Lithocircus* Muller, 1852, emend. Petrushevskaya, 1971b
Lithocircus sp. A
Lithocircus spp.
Genus *Lophospyris* Haeckel, 1881
Lophospyris muelleri (Stöhr, 1880)

Genus *Zygocircus* Bütschli, 1882
Zygocircus productus (Hertwig, 1879)

Most of descriptive terminology used in this study are traditional, and skeletal terms mainly follow those of Dumitrica (1985, 1989) and Sugiyama (1991, in press). However, some concerning entactinarian skeleton are redefined or changed herein although it is not substantial but only an expressive problem. The newly defined orientation is also applicable to some spmellarians. They are briefly explained in the following lines and schematically illustrated in Fig. 3.

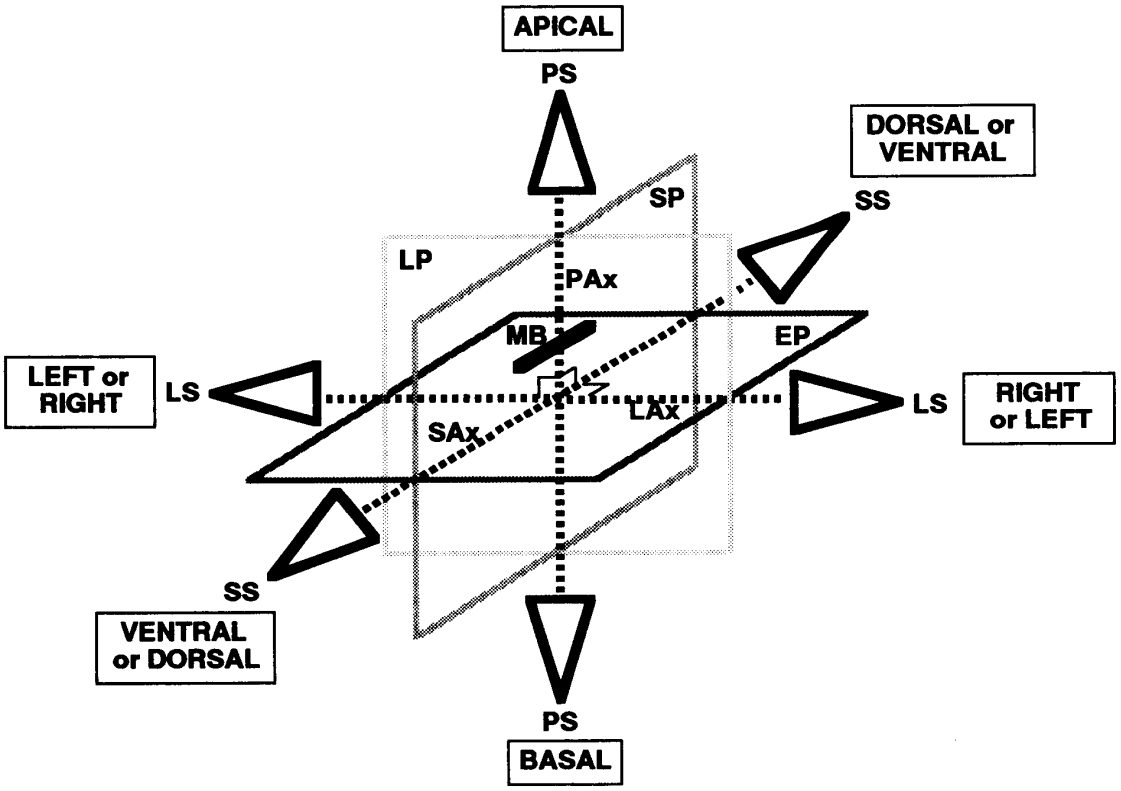

Figure 3 : Schematic illustration showing idealized skeletal orientation.

Polar axis (PAx) : A vertical axis perpendicular to the median bar (**MB**).
Sagittal axis (SAx) : A horizontal axis parallel to **MB**.
Lateral axis (LAx) : Another horizontal axis perpendicular to **MB**.
Equatorial plane (EP) : A horizontal plane parallel to **MB** and including **SAx**, **LAx** and equatorial spines (**ES**).
Sagittal plane (SP) : A meridional plane passing through **MB** and including **PAx** and **SAx**.
Lateral plane (LP) : Another meridional plane perpendicular to **MB** and including **PAx** and **LAx**.
Polar spines (PS) : Two spines oppositely directed and situated in **PAx**.
Sagittal spines (SS) : Two of **ES**, oppositely directed and situated in **SAx**.

Lateral spines (LS) : Two of **ES**, oppositely directed and situated in **LAx**.
Sagittal gates (SG) : One pair of gates aligned in the direction of **SAx**, and corresponding to **TG** of Dumitrica (1985).
Lateral gates (LG) : Another pair of gates aligned in the direction of **LAx**, and corresponding to **LG** (longitudinal gates) of Dumitrica (1985).

Defined in this way, one can immediately notice that two external spines of axoprunins are not "polar" but "lateral" ones, although they have conventionally been illustrated in vertical directions and named "polar" spines. This makes the external morphological differences from stylosphaerids much clear. Stylosphaerids commonly have a pyriform medullary shell and the two spines are aligned in the symmetrical axis (Nishimura, 1981 ; Dumitrica, 1985 ; Sugiyama, in press ; Sugiyama and Furutani, in press), which seems to correspond to **PAx** of axoprunins.

Acanthosphaera sp. A
Pl, 1, figs. 1, 2

Acanthosphaera sp. - Nishimura and Yamauchi, 1984, pl, 8, fig. 2.
Description: Shell latticed, single, pierced by circular to subcircular pores; lattice bars thick, ellipsoidal in cross section. Radial spines usually three-bladed, variable in length, arising from the junctions of the pore frames, without acute end.
Remarks : This species resembles *A. castanea* Haeckel, 1887, from which it is distinguished by its larger size of pores and much thicker spines.
Dimensions (in μm) : Based on 14 specimens. Diameter of shell ; 55-87. Length of spine ; up to 90.

Actinomma sp. A
Pl. 1, figs. 3a-8b ; Pl. 2, figs. 1, 2

Description : Test moderate in size, consisting of one cortical and two medullary shells which are all spherical. The inner medullary shell small, delicate, pierced by cirular pores as large as those of the cortical shell. Connecting bars between the inner and outer medullary shells are thin, usually rod-like, sometimes slightly bladed in the proximal and distal parts. The outer medullary shell is relatively thick, densely pierced by relatively small, circular to oval pores, and attached to the cortical shell through stout connecting bars which are independent of the preceding ones. They are usually threebladed, sometimes rod-like in the middle part, and rapidly increase the width at the most distal part by the furcation of three blades which are merged into the lattice bars of the cortical shell. The cortical shell thick, pierced by circular pores deeply set in markedly rugged frames (Pl. 1, fig. 3b). In some specimens short, three -bladed radial spines are present on the surface, but they are also independent of the connecting bars.
Remarks : This species resembles *A. okurai* Nakaseko and Nishimura, 1971, from which it differs in having a great number of pores on the cortical shell. Specimens without radial spines are similar to some species of *Thecosphaera* from which it is distinguished by having bladed connecting bars between the outer medullary and the

cortical shells.
Dimensions (im μm) : Based on 33 specimens. Diameter of inner medullary shell ; 10 -17. Diameter of outer medullary shell ; 30-45. Diameter of cortical shell ; 87-117. Length of spines ; up to 25.

Anomalacantha sp. A
Pl. 2, figs. 9, 10

Description : Shell single, spherical, pierced by circular pores hexagonally or pentagonally framed by thick, edged bars. Small, needle-like by-spines may be present on the junction of pore frames. Main spines about eight in number, three -bladed, tapered and slightly curved distally, having one verticil of two or three, inconspicuous apophyses.
Remarks : This species differs from *A. dentata* Mast, 1910, in having only a single verticil on each main spine.
Dimensions (in μm) : Based on 24.specimens. Diameter of shell ; 55-70. Length of main spine ; up to 140.

Cenosphaera spp.
Pl. 2, figs. 3, 6

Remarks : More than two species are included under the name.

Echinomma spp.
Pl. 2, figs. 4, 5, 7, 8

Remarks : Although the development of by-spines on the cortical shell is considerably variable, illustrated specimens under this name, possibly including *E. leptodermum* Jørgensen (1900, p, 57 ; 1905, p. 116, pl. 8, fig. 33), have common internal structure which is nearly same to *Actinomma* sp. A described above. However, *Echinomma* spp. have rather thick connecting bars between the outer medullary shell and the cortical shell.

Haeckeliella inconstans Dumitrica
Pl. 3, figs. 1-3

Heackeliella inconstans Dumitrica, 1973, p. 833, pl. 7, fig. 1, 2 ; pl. 18, figs. 7-22.
Remarks : A delicate internal sphere, one of the diagnostic features of the genus, cannot be observed in all specimens encountered.

Stylatractus neptunus Haeckel group
Pl. 3, figs. 7-10

Stylatractus neptunus Haeckel, 1887, p. 328, pl. 17, fig. 6.
Remarks : The test is composed usually of one cortical and two medullary shells. However, some specimens, possibly representing younger ontogenic stages, have only two shells corresponding to the inner and outer medullary ones (Pl. 3, fig 10). The polar spines originate from the outer medullary shell.

Thecosphaera sp. A

Pl. 4, figs. 1-4b

Description : Test consisting of a cortical and a double medullary shells. The Inner medullary shell very small, spherical to subspherical, delicate, with circular to subcircular pores, connected with the outer medullary shell by short, cylindrical bars. The outer medullary shell spherical, relatively thin, pierced by circular pores, attached through long, cylindrical, straight or slightly curved bars. The cortical shell spherical, pierced by circular pores which are as large as those on the outer medullary shell and 15 to 20 in number on the diameter. The pores set in hexagonal or pentagonal, thick frames having small nodes at their junctions. The frames are ridged, usually smooth but sometimes rugged like *Actinomma* sp. A described above.

Remarks : This species differs from *T. japonica* Nakaseko, 1971, one of the commonest species of the Japanese Neogene, in its large number of pores of smaller size. It rather resembles *T. miocenica* Nakaseko, 1971, or *T. dedoensis* Nakaseko, 1972, but the relationships remain uncertain.

Dimensions (in μm) : Based on 27 specimens. Diameter of inner medullary shell ; 15-20. Diameter of outer medullary shell ; 30-47. Diameter of cortical shell ; 90-125.

Heliodiscus sp. aff. *H. asteriscus* Haeckel

Pl. 5, figs. 6. 8b

aff. *Heliodiscus asteriscus* Haeckel, 1887, p. 445, pl. 33, fig. 8.

Remarks : This species differs from *H. asteriscus* in its much shorter radial spines. The other features are fairly identical to the latter species.

Rhopalastrum sp.

Pl. 8, fig. 8

Remarks : The three arms are bilaterally disposed like the genus *Euchitonia.*

Spongaster tetras tetras Ehrenberg

Pl. 7, figs. 3-5b ; Pl. 8, fig. 2

Spongaster tetras Ehrenberg, 1860, p. 833 ; 1872b, pl. 8 (3), fig. 8.

Spongaster tetras tetras Ehrenberg-Nigrini, 1967, p. 41, 6l. 5, figs. la, 1b.

Remarks : The internal structure was observed in some sectioned specimens (Pl. 7, figs. 5a, 5b). The investigation have proved that the center is a very small sphere surrounded by dense, numerous concentric layers.

Spongurus sp. aff. *S. pylomaticus* Riedel

Pl. 7, figs. 7-9

aff. *Spongurus pylomaticus* Riedel, 1958, p. 226, pl. 1. figs. 10, 11

Remarks : This species is somewhat similar to *S. pylomaticus* but differs from it in the shape of the test on which a pylome is absent. It resembles *Acanthosphaera elliptca* Ehrenberg (1872a, p. 301 ; 1872b, pl. 7, fig. 4) but the relationship is uncertain.

Larcospira quadrangula Haeckel group

Pl. 8, fig. 12 ; Pl. 9, figs. 1-5c

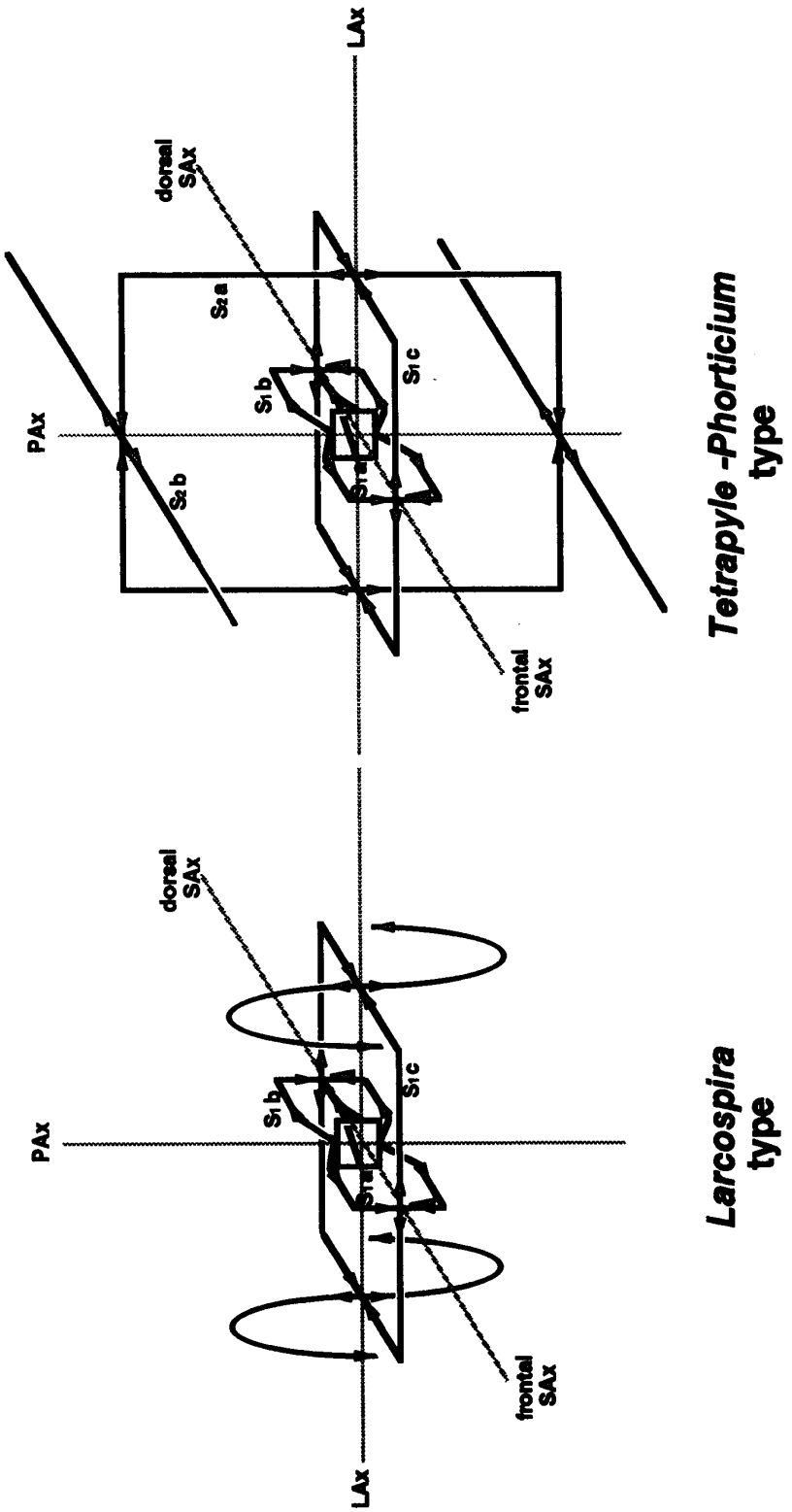

Figure 4 : Schematic illustration showing the modes of the shell growth of the genera *Larcospira, Tetrapyle* and *Phorticium.*

Larcospira quadorangula Haeckel, 1887, p. 696, pl. 49, fig. 3.

Description : Microsphere as with subfamily ; four frontal pores, two are equatorial and the other two are sagittal, are very small, one or two of which sometimes absent due to the fusion of microspheric bars (Pl. 9, fig. 4b). Mode of the shell growth is of the pyloniacean-type till the first system is built, and next it changes to double spiral mode. The spiral axis is either the same to or slightly oblique to **LAx**. Two spiral wings, one originates from the dorsal cap of S_1c and the other from the frontal cap of the same girdle, turn around **LAx** to the same direction with simultaneous increasing of the length to the direction of **LAx**, thus the crescent openings always face in opposite directions. The wings are attached to one another through numerous, cylindrical, thick bars ; surface more or less nodose ; pores irregular in size and arrangement.

Remarks : The mode of the shell growth is schematically illustrated in Fig. 4. There is no need to redescribe the external features in detail, thus the description forcuses only to the internal structure whose details have never been described or illustrated. The investigation has assuredly proved that the genus does not belong to the family Litheliidae, as indicated by Dumitrica (1989).

Dumitrica (1989) described the construction of the pyloniin microsphere in detail.

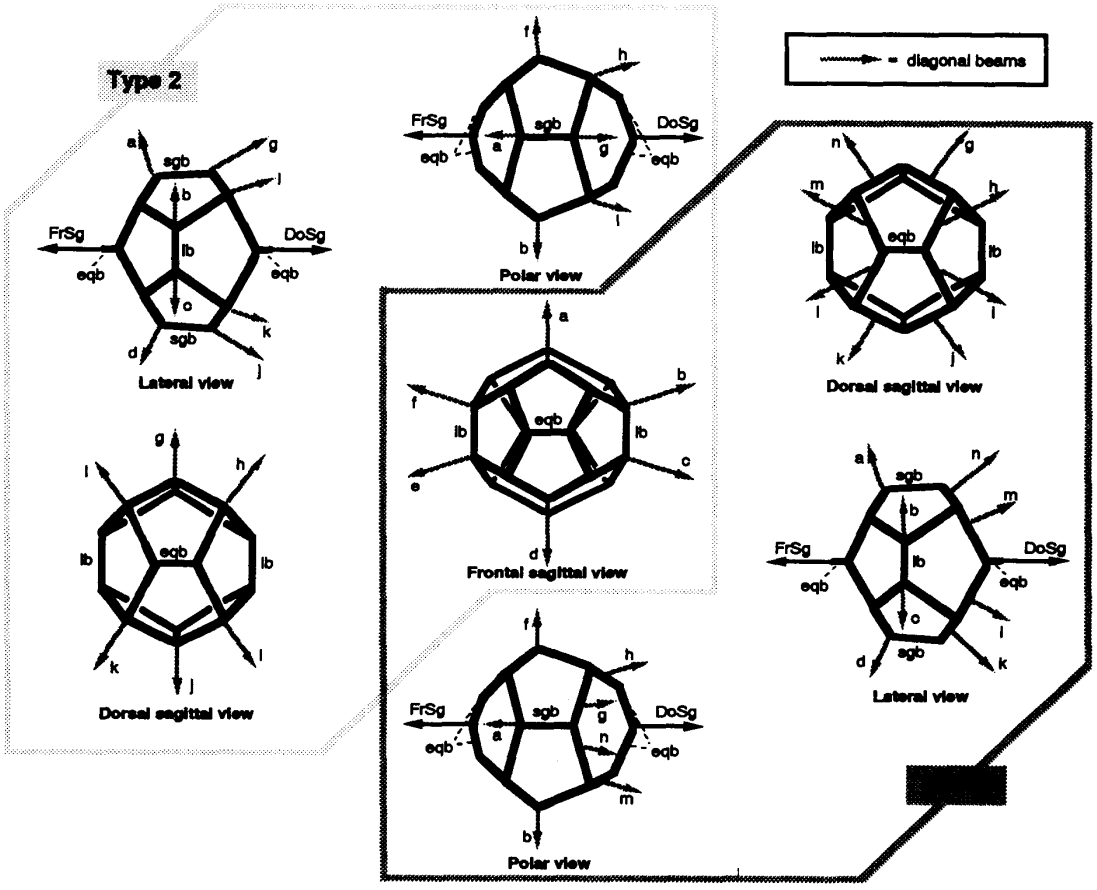

Figure 5 : Schematic illustration of two types of the microsphere of pyloniins.

The positions of the diagonal beams were, however, incorrectly understood although such a fact does not affect his classification at all. In our observation there are two types of the disposition (Fig. 5) ; one has 12 and the other has 14 diagonal beams and named type 1 and type 2, respectively. They have the same disposition in the frontal half, but the type 1 has only six diagonal beams on the dorsal half, whereas the type 2 possesses eight ones there. It results in that only two pores are visible on one pillar of **S_1b** in the type 1 from polar view whereas three pores are formed there in the type 2. We have not observed the type 2 on this species yet, but there are both the types 1 and 2 on the next genus *Phorticium*.

Dimensions (in μm) : Based on 45 specimens. Major diameter of test ; 50-125. Minor diameter of test ; 30-95. Diameter of S_1a (based on 14 sectioned specimens) ; 8-15.

Phorticium spp.

Pl. 10, figs. 1-9b ; pl. 11, figs. 2-4, 6a, 6b

Remarks : This group includes at least three species : The first is larger and has a relatively thick, subspherical outermost shell (Pl. 10, figs. 1-5b). The second is the most abundant species in the Nobori radiolarian fauna, and traditionally assignable to *P. pylonium* Haeckel or *P. clevei* (Jørgensen) (Pl. 10, figs. 6a-9a). The last is characterized by the presence of numerous radial skeletal elements extending to all directions, and possibly conspecific with *P. pylonium* Haeckel illustrated by Cleve (1889, pl. 3, fig. 2c).(Pl. 11, figs. 2-4, 6a, 6b). None of them are identified since the specific taxonomy is not sufficiently understood.

Hexacontium spp.

Pl. 13, figs. 5-7 ; Pl. 14, figs. 1-8b

Descriptive remarks : Except for some specific features, all the obtained specimens have a common shell construction composed of a cortical and a double medullary shells. The latter shell comprising a heteropolar microsphere whose structure perfectly agrees with that of *Pentactinosphaera* Nagata and Nishimura in Nakaseko et al. (1983), as mentioned by Dumitrica (1985) (the idealized skeletal structure is shown in Fig. 6). From the microsphere arise six, rod-like rays arranged in the three-dimensive axes of **PAx**, **SAx** and **LAx**. They change into four-bladed, stout bars beyond the medullary shell and penetrate the cortical shell as main spines. The outer medullary shell is delicate, thin, spherical to subspherical, pierced by circular pores, having needle-like by-spines like the genus *Axoprunum*. Judging from the externality of the cortical shell (the development of by-spines, the size of pores, etc.), it seems that more than four species are included under this name. However none were identified at the specific level because those external features are considerably variable and, moreover, many existing species belonging to the genera *Hexacontium* and *Hexalonche* may be artificial and synonymous.

Axoprunum bispiculum (Popofsky)

Pl. 12, figs. la-4d

Stylacontarium bispiculum Popofsky, 1912, p. 91, pl. 2, fig. 2.

Druppatractus aquilonius Hays, 1970, p. 214, pl. 1, figs. 4, 5.

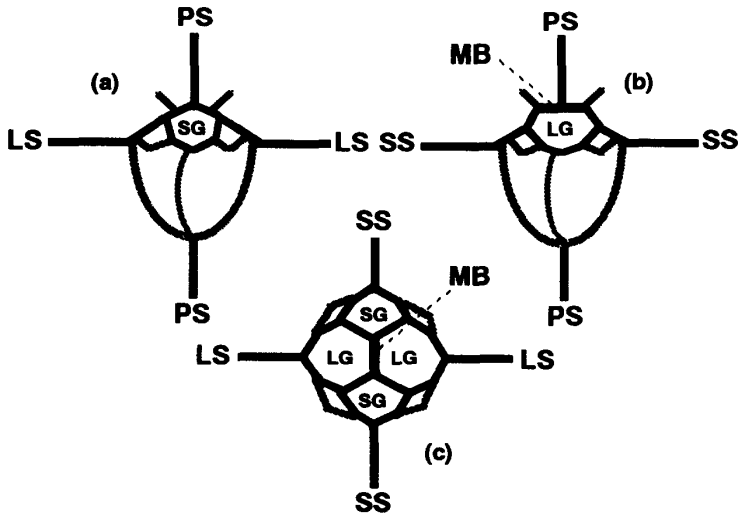

Figure 6 : Schematic illustration of hexalonchid microsphere.

Stylacontarium acquilonium (Hays)-Kling, 19737, p. 634, pl. 1, figs. 17, 20 ; pl. 14, figs. 1-4.

Description : Test composed of a cortical and a double medullary shells. The detailed features of the latter are the same to those of *Axoprunum stauraxonium* group figured by Dumitrica (1985, fig. 3a) except for the feature that some of bars connecting the medullary shell with the cortical shell are sometimes not in the sagittal plane. The medullary shell bears numerous, needle-like or forked by-spines on the surface. The cortical shell ellipsoidal, thick, pierced by circular pores deeply surrounded by hexagonal or pentagonal, ridged frames. Two **LS** extending from the microsphere, conical to rod-like, variable in length, sometimes unequal.

Remarks : The microsphere, which is the same to the next species, is schematically illustrated in Fig. 7. Both the genera *Axoprunum* and *Stylacontarium* have the same shell construction, which was already mentioned by Dumitrica (1985), and they are formally synonymized herein. Moreover, it is obvious that there are no significant morphologic differences for the specific distinction between this species and *D. aquilonius*, which has been referred to *Stylacontarium* by most investigators since Kling (1973). An unsolved problem is that the relationship between this species and *A. stauraxonium* Haeckel, 1887, the type species of the genus, is not well understood, because the original illustration of the latter species (Haeckel, 1887, pl. 48, fig. 4) is too poor.

Dimensions (in μm) : Based on 24 specimens. Major diameter of cortical shell ; 95-130. Minor diameter of cortical shell ; 85-110. Diameter of medullary shell (based on 11 sectioned specimens) ; 35-45. Length of **LS**; up to 95.

Xiphosphaerantha angelina (Campbell and Clark)

Pl. 13, figs. 1-3b

Stylosphaera angelina Campbell and Clark, 1944, p. 12, pl. 1, figs. 14-20.

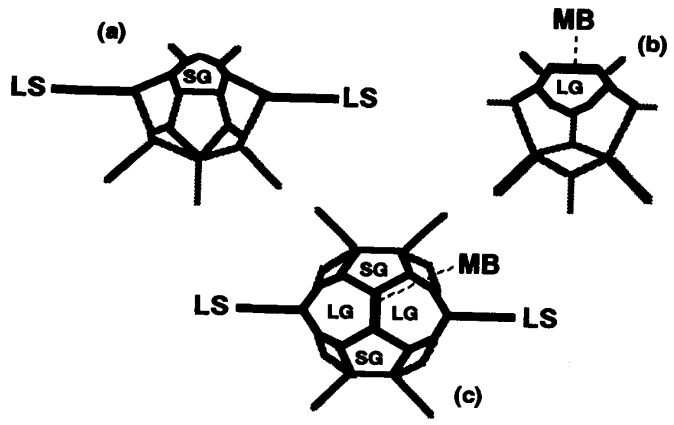

Figure 7 : Schematic illustration of axoprunin microsphere.

Axoprunum angelinum (Campbell and Clark)-Kling, 1973, p. 634, pl. 1, figs. 13-16 ; pl. 6, figs. 14-18.

Description : Test composed of a cortical shell and a double medullary one. The detailed features of the latter shell are the same to that of *Xiphosphaerantha venus* group figured by Dumitrica (1985, fig. 3B). By-spines absent on the medullary shell. Connecting bars between the outer medullary and cortical shells extending all direction, some of which directly arise from the microsphere and the rests project from the surface of the outer medullary shell. The cortical shell ellipsoidal to spherical, sometimes having bristle or spongy mantle on the surface ; the pores circular, small, surrounded by rugged frame (Pl. 13, fig. 2b). Two **LS** prolonged from the microsphere, conical to rod-like, variable in length.

Remarks : In contrast with the precedent species, this species has been assigned to the genus *Axoprunum* by most workers. However, the internal structure is quite different from the type species of *Axoprunum* since the connecting bars between the medullary and cortical shells radiate to all directions, which was already stressed by Nishimura (1982). This species differs from *Stylatractus universus* Hays, 1970, in having simply tapered **LS**.

Dimensions (in μm) : Based on 24 specimens. Major diameter of cortical shell ; 120 -147. Minor diameter of cortical shell ; 105-137. Diameter of medullary shell (based on six sectioned specimens) ; 37-50. Length of **LS** ; up to 87.

Lamprotripus (?) *mawsoni* (Riedel)

Pl. 16, figs. 4-5a

Dictyophimus mawsoni Riedel, 1958, p. 234, pl. 3, figs. 6, 7.

Lamprotripus mawsoni (Riedel)-Petrushevskaya and Kozlova, 1972, p. 534.

Description : Test large, massive, externally composed of two segment with a indistinct collar stricture. Cephalis formed of a well-developed eucephalic lobe and a very small antecephalic one ; cephalic wall pierced by small, circular pores, with a stout, rod -like apical spine and many, conical by-spines. Internal spicule composed of **MB**, **A**, **D**, two **L**. **V** and **Ax** absent. **A** extending into a stout apical spine beyond the junction

of two arches **AL** ; **D** and two **L** prolonged into three thick feet. Arch **LL** indistinct from the base. **L-R** distinct. **L'** may or may not be developed. Thorax large, widest at the middle, more or less tapering distally ; pores large subangular ; lattice bars thick, bearing small, conical by-spines. The feet proximally hemming the thorax, detached from it beyond the middle, and distally tapered to form acute tips.

Remarks : Only specimens without **V** were examined. It is obvious from the above description that this species does not belong to the genus *Lamprotripus* Haeckel, 1881, emend. Petrushevskaya, 1971b. Thus this species may belong to a new genus.

Dimensions (in μm) : Based on 11 specimens. Length of apical spine ; up to 50. Length of feet ; up to 150. Height of cephals plus thorax ; 78-100. Maximum width of thorax ; 87-97.

Arachnocorys sp. A

Pl. 18, figs. 4a, 4b

Description : The first segment subspherical, consisting of very small ante- and large eucephalic lobes, pierced by circular to oval pores, ornamented by some needle-like by -spines of various length. Internal spicule missing **V**. **A** extending into a stout spine beyond **DR**. **PR** distinct. **D**, two **L**, two **l'** and **V'** distally become thick and curved downward to connect eucephalis and thorax. Collar region with large six gates. The second segment frustum in shape, thinly latticed, with oval to irregularly shaped pores.

Remarks : Only three specimens were obtained. This species differs from other species of the genus in having thick by-spines on the cephalis.

Dimensions (in μm) : Based on three specimens. Height of test except by-spines ; 55 -62. Maximum width of the second segment; 55-60. Length of by-spines; up to 45.

Ceratocyrtis spp.

Pl. 15, figs. 2-3b, 5

Remarks : *C. galea* (Cleve) (1898, p. 33, pl. 4, fig. 3) and *C. historicosa* (Jørgensen) (1905, p. 137, pl. 16, figs. 86-88) are possibly included under the name. Their skeletal structures are the same to *Ceratocyrtis* sp. aff. *C. histricosa* described by Sugiyama (in press).

Lampromitra spp.

Pl. 16, figs. 1-3

Remarks : This group probably includes *L. erosa* Cleve (1900, p. 10, pl. 4, figs. 2, 3) and *L. petrushevskayae* Dumitrica (1973, p. 837, pl. 23, figs. 6, 7).

Lithomelissa ultima Caulet

Pl. 17, figs. 1a, 1b

Lithomelissa ultima Caulet, 1979, p. 129, pl. 1, figs. 2, 3.

Remarks : The internal spicule is composed of **MB**, **A**, **D**, two **L** and short **Ax** ; **A** is free in cephalic cavity, extending into the apical spine ; **D** and two **L** extend into three, long, three-bladed feet ; **D** may have minor branches. The arch structure is complex ; two arches **AL** are completely free in the cephalis.

Pseudocubus warreni Goll

Pl. 18, figs. 1a-3c

(?) *Pseudocubus octostylus* Haeckel-Petrushevskaya, 1971b, p. 150, pl. 71, fig. 14 ; pl. 75, fig. 7.

Pseudocubus cf. *vema* (Hays)-Dumitrica, 1973, p. 836, pl. 12, figs. 1-6 ; pl. 22, figs. 6, 7.

Pseudocubus vema (Hays)-Sanfilippo and Riedel, 1975, p. 67, pl. 1, figs. 8-11. -Sanfilippo, 1988, p. 176, pl. 1, figs. 16-18.

Pseudocubus warreni Goll, 1980, p. 437, pl. 3, figs. 5, 6.

Helotholus vema Hays-Lazarus, 1990, p. 717, pl. 7, figs. 1-5.

Description : Fundamental skeletal construction as with *P. obeliscus* Haeckel, 1887, the type species of the genus (see Sugiyama, in press), but irregularly variable ; **D** very short, extending nearly downward ; **A'**, two **l'** two **L** and **V'** extending slightly downward from the horizontal ; **V** always absent ; **Ax** wart-like ; **L-R** indistinct ; **DR** often ambiguous or possibly missing. Except the neighborhood of **MB** and some minor elements, all skeleton is three-bladed. Each distal part of **A'** two **l'**, two **L** and **V'** generally has a verticil of three or four apophyses or arches ; one is directed downward, generally short, two are directed laterally and the remainder directed upward, curved, irregularly branched distally, commonly fused with other branches to form a framework of large, dome-shaped cephalic wall. Delicate lamellar may be developed between the frames as cephalic wall.

Remarks : Although most recent workers have identified this species as *Helothothus vema* Hays, typical specimens of *H. vema* have **V**, very long **Ax** and six longitudinal scaffolds, and lack bladed skeleton, as noted by Sugiyama (in press). *P. warreni* is, therefore, easily distinguished from it by lacking such features. Although they were not common in the studied materials, specimens with well-developed cephalic wall resemble the species of the genus *Steganocubus* Sugiyama (in press). However, the genus *Steganocubus* completely lack bladed scaffolding and generally have long **D**, and appear to be another offshoot from *P. obeliscus* taking account of the stratigraphic distribution.

Dimensions (in μm) : Based on 14 specimens. Total height of test ; 50-85. Total width of test ; 85-150.

Pseudodictyophimus hexaptesimus Sugiyama sp. nov.

Pl. 17, figs. 4a-5b

Description : Internal skeleton as with *P. gracilipes* ; **A** extending into a short, three-bladed spine ; **D** and two **L** prolonged into three-bladed feet ; **V** penetrating cephalic wall to form a short cone outside. There are other three feet extending to more closer to vertical direction than the preceding three ones ; one of them is situated just on or near the ventral side of the test and always free from the skeleton ; the other two are disposed between **D** and **Ll** and between **D** and **Lr**, respectively, and prolonged from two **L'**. Cephalis clearly lobate ; eucephalis hemispherical, externally prominent, with small nodes on the lattice bars ; antecephalis low ; postcephalis indistinct externally. Thorax flattened conical and short. All pores circular to subangular.

Remarks : This species is distinguished from *P. gracilipes*, by having six feet. It resembles *Lamprotripus quinqueradiatus* Dogiel in Petrushevskaya (1971b) and *L.* sp.

illustrated by Petrushevskaya (1971b, pl. 50, figs, 6, 7) in general shape, from which it is distinguished by its more inflated thorax and stout, three-bladed feet.
Dimension (in μm) : Based on 13 specimens. Height of test except feet ; 38-65. Total width of test ; 80-150. Length of apical spine ; up to 20. Length of feet ; up to 95.
Holotype : ESN 146734 (Pl. 17, figs. 4a-4c).
Etymology : From the Greek *hex*, six, and *ptesimos*, winged.

Euscenarium sp. A
Pl. 15, figs. 7a, 7b

Description : Cephalis small, with circular to oval pores of various size. Internal spicule composed of **MB**, **A**, **D**, two **L**, **V** and short **Ax** ; **A**, **D** and two **L** distally become three-bladed ; **A** free in the cephalis, extending into a stout, three-bladed apical spine as long as the cephalis ; **D** and two **L** extending into thick, three-bladed feet shorter than the apical spine ; lateral blades of **D** and two **L** branching off from the middle and connected with the collar ; **V** extending 45 upward from the horizontal, prolonged into a short, three-bladed spine ; arches **AD** and two **AL** clearly visible from the basal side. Some lattice bars of the cephalis extend downward to form short, imcomplete thorax.
Remarks : This species somewhat resembles *E. joergenseni* Dumitrica, 1978, from which it is distinguished by its much thicker apical spine and feet.
Dimensions (in μm) : Based on two specimens. Length of apical spine ; 35-40. Length of feet ; up to 30. Height of cephalis ; 30-33. Width of cephalis ; 40-43.

Euscenarium sp. B
Pl. 15, figs. 6a, 6b

Description : Cephalis small, hemispherical, pierced by circular to oval pores, with distinct arch structure on the wall and collar ; internal spicule composed of **MB**, **A**, **D**, two **L**, **V** and indistinct **Ax** ; **MB** short ; **A** free in the cephalic cavity, extending into an apical spine which is short and three-bladed ; **D** and two **L** extending into three, long feet which are also three-bladed. The lateral blades on the feet are jagged by many verticils of small branches, from which poorly developed, distally imperfect thorax is formed.
Remarks : This species differs from *E.* sp. A in its thinner, jagged apical spine and feet.
Dimensions (in μm) : Based on three specimens. Length of apical spine ; up to 35. Length of feet ; up to 95. Height of cephalis ; 38-43. Width of cephalis ; 55-65.

Bathropyramis (?) *pyrgina* Sugiyama sp. nov.
Pl. 19, figs. 7a-11

Plectopyramis spp. (*partim*)-Nakaseko and Nishimura, 1982, p. 102, pl. 45, figs. 3, 5.
(?) *Bathropyramis* sp. -Nishimura, 1990, p. 154, figs. 32-1a, 1b, 5a-5c.
Description : Cephalis very small, imperforate, with scattered microgranular, having one or two, conical to rod-like spines. The spines may be very long, as long as or longer than thorax, but the preservation is not good in the available materials. In the cephalic cavity **MB**, two **L**, **V** and **Ax** are visible from the base. **A**, **D** and possibly two **l** may be embeded within the cephalic wall. Thorax very long, pyramidal, distally flared, consisting of ten or more longitudinal bars which extend downward from the

cephalis and regularly intersected by transverse rings ; pores plugged in the proximal part and square to roundish square in the distal part. A few or several longitudinal bars may be rather thicker than others. Secondary longitudinal bars present or absent in the distal part of the thorax.

Remarks : The generic assignment is tentative. This species somewhat resembles *Plectopyramis polypleura* Haeckel illustrated by Petrushevskaya (1971b) from which it differs in its less number of longitudinal bars. When thicker longitudinal bars are present on the test, they do not always correspond to the prolongations of the skeletal elements.

Dimensions (in μm) : Based on 11 specimens. Height of test except apical spines ; 140 -250. Maximum width of thorax ; 130-220. Length of spines ; up to 60.

Holotype : ESN 146742 (Pl. 19, figs. 7a, 7b).1

Etymology : From the Greek *pyrginos*, tower-like.

Calocycloma (?) *cassiopejae* (Haeckel)

Pl. 20, figs. 3-6b

Clathrocyclas cassiopejae Haeckel, 1887, p. 1390, pl. 59, fig. 5.

Calocyclas menumentum Haeckel-Renz, 1974, p. 789, pl. 16, fig. 25 ; 1976, p. 128, pl. 5, fig. 1.-Riedel and Sanfilippo, 1977, pl. 23, fig. 2.

Clathrocyclas monumentum (Haeckel)-Nishimura and Yamauchi, 1984, p. 49, pl. 35, fig. 13.

Clathrocyclas sp. aff. *C. cassiopejae* Haeckel-Nishimura and Yamauchi, 1984, p. 49, pl. 41, figs. 11, 12.

Description : Cephalis small, hemispherical, with a stout, conical apical spine and numerous, small by-spine; pores small, circular to oval. Internal spicule composed of **MB**, **A**, **D**, two **L**, two **l**, **V** and wart-like **Ax** ; **A** extending into the apical spine ; **D** and two **L** extend downward and may penetrate the shell outside (Pl. 20, fig. 6b) ; **V** marged into the cephalic wall. Collar stricture marked by a change of pore size. Thorax truncated conical, with or without by-spines ; pores much larger than those of the cephalis, irregularly arranged, circular to oval, framed by thick, usually ridged bars. Lumbar stricture externally marked by a change in contour, internally rimmed by a thick ring. Abdomen short, considerably variable in shape from inverted frustum to nearly cylindrical, with or without by-spines on the surface, with a wide oppening on the bottom ; pores larger than thoracic ones, circular to oval, irregularly arranged, framed by thick bars which are circular in cross section ; abdominal margin variable in outline, commonly thick rimmed and zigzaged. Marginal feet variable in number and length, extending downward from the vertexes of the abdominal margin. Secondary, loose lattice work may be developed between the feet and abdomen.

Remarks : Except the widely opened abdomen, the general features of this species are fairly comparable with *Calocycloma casta* Haeckel, 1887, the type species of the genus. One can also refer this species to the genus *Calocyclura* Haeckel, 1887 (= *Calompterium* Clark and Campbell, 1945), whose type species is *C. monumentum* Haeckel, 1887. However, the cephalic features of *C. monumentum*, including its apical spine and collar stricture, are rather different from this species. This species is also similar to the early Oligocene species *Lophocyrtis (Sciadiopeplus) oberhaensliae* Sanfilippo, 1990.

In the present state of knowledge the precise generic assignment is thus difficult to determine.

Dimensions (in μm) : Based on 21 specimens. Length of apical spine ; up to 60. Height of test except apical spine ; 160-270. Maximum width of abdomen. 160-190.

Eucyrtidium lene Sugiyama sp. nov.

Pl. 23, figs. 6a-9

Description : Test moderate in size, smooth, formed of six or seven, possibly more segments. Cephalis small, spherical, with a short apical spine, partly sunk into thorax. From the basal view four collar pores are visible. **A** is free inside the cephalis, and connects with the apical spine. Thorax and abdomen short, truncated conical, rapidly increasing the width. Pores of these three segments small, circular, irregulary scattered. Collar and lumbar strictures slightly marked externally. Fourth and the subsequent segments are nearly cylindrical except the last one. They are gradually tapered beyond the middle of the test, and connected with one another without pronounced strictures. Pores of those segments are small, circular, generally aligned in many longitudinal rows and disposed quincuncially. The number and continuity of the rows are, however, more or less variable among the specimens encountered. Some rows distally disappear or unite with neighbor ones. Pores of the last segment, which is thinly walled and has a strongly constricted mouth surrounded by a differentiated peristome, has irregularly arranged pores.

Remarks : This species resembles *Lithocampe punctata* Ehrenberg, 1844, from which it is distinguished by its short thorax and pore arrangement. Although both the species have strongly constricted mouth on the base, the feature seems not to suitable for the generic classification. This species also differs from *E. calvertense* Martin, 1904, in its shape of the first three segment and also having a strongly constricted mouth on the base.

Dimensions (in μm) : Based on 24 specimens. Total length ;133-170. Maximum width of test ; 89-97. Diameter of mouth ; 12-30.

Holotype : ESN 146775 (Pl. 23, figs. 6a, 6b).

Etymology : From the Latin *lenis*, smooth.

Gondwanaria campanulaeformis (Campbell and Clark)

Pl. 21, figs. 8-9b

Lithomelissa campanulaeformis Campbell and Clark, 1944, p. 41, pl. 6, fig. 1.

Sethoconus (?) *dogieli* Petrushevskaya, 1967, p. 95, pl. 53, figs. 1, 2.

Gondwanaria dogieli (Petrushevskaya) group-Petrushevskaya, 1975, p. 585.

Remarks : The skeletal structure is marked by free, two arches **AL** (Pl. 21, fig. 9b).

Lithocampe sp. A

Pl. 22, figs. 4a-6

Description : Test spindle-shaped, generally composed of five to eight segments. Cephalis as with genus, with or without a short apical spine. Vertical spine distinct in the skeleton. Thorax frustum in shape, commonly the longest segment, with small, circular pores arranged irregularly or transverse rows. Abdomen and the subsequent

segments except the last one gradually increasing the width ; pores usually similar to those of thorax, sometimes becoming irregular in the shape and arrangement in distal segments. The last segment more or less tapering ; pores similar to those of the preceding segment.

Remarks : This species somewhat resembles *Eucyrtidium acuminatum* (Ehrenberg, 1844) from which it is distinguished by having much longer thorax and lacking longitudinal arrangement of pores on the segments. These features are fairly in common with *L. punctata*from which it differs in its spindle-shaped test.

Dimensions (in μm) : Based on 14 specimens. Total height ; 140-230. Maximum width of test ; 78-105. Length of apical spine ; up to 12.

Anthocyrtidium nosicaae Caulet

Pl. 25, figs. 5, 6

Anthocyrtidium nosicaae Caulet, 1979, p. 132, pl. 2, fig. 6.

Remarks : Some specimens completely lack marginal teeth (Pl. 25, fig. 5).

Lamprocyclas sp. A

Pl. 27, figs. 1a, 1b

Remarks : This species is first of all characterized by its flared apical spine. Moreover, it have a small cone extending from **V**. Except them other features are similar to *L. margatensis* (Campbell and Clark) (1944, p. 47, pl. 6, figs. 17, 18). Their real relationship is, however, at the present time not well understood, and it possibly represents only a variational form of *L. margatensis*

Lamprocyrtis junonis (Haeckel)

Pl. 27, figs. 2-4c

Theoconus junonis Haeckel, 1887, p. 1401, pl. 69, fig. 7.

Lamprocyclas junonis (Haeckel)-Petrushevskaya and Kozlova, 1972, p. 545, pl. 36, fig. 8.

Lamprocyrtis hannai (Campbell and Clark)-Foreman, 1975, p. 620, pl 9, figs. 17-19.

Lamprocyrtis neoheteroporos Kling-Nishimura and Yamauchi, 1984, p . 51, pl. 36, figs. 7 (?), 11, 13.

Description : Internal spicule as with family. Cephalis spherical to ovate-cylindrical, rugged, with samll, circular pores, bearing a short, three-bladed apical spine. Collar stricture shallow, marked by a gentle flexure. Thorax frustum, longer than cephalis, having a crest-like bump on the dorsal side in most specimens ; pores larger than those of the cephalis, closely spaced, commonly aligned in longitudinal rows, framed by ridged bars. Lumbar stricture indistinct externally, rimmed by a ring internally. Abdomen long, generally barrel-shaped, and may terminate at a narrow, poreless peristome which commonly bears very short, thorn-like terminal teeth ; abdominal pores circular to oval, much larger than those of the thorax, clearly aligned in longitudinal rows and quincuncially arranged ; lattice bars rather thick, circular in cross section.

Remarks : Although they are not formally synonymized herein, many specimens identified as *L. hannai* (Campbell and Clark) (1944, p. 48, pl. 6, figs. 21, 22) by previous

investigators apparently belong to this species. This species is characterized by its regular pore arrangement and having a bump on the dorsal side of the thorax.
Dimensions (in μm) : Based on 17 specimens. Total height ;155-193. Maximum width of abdomen ; 89-97. Length of apical spine ; up to 30.

Carpocanarium urna (Stöhr)
Pl. 28, figs. 6.

Cryptocalpis urna Stöhr, 1880, p. 06, pl. 3, fig. 6.
Carpocanium calycothes Stöhr, 1880, p. 96, pl. 3, fig. 7.
Carpocanarium spp. (*partim*)-Riedel and Sanfilippo, 1971, p. 1599, pl.1I, figs. 20, 23-25 ; pl. 2J, figs. 8, 9.
Description : Internal spicule as with genus. Cephalis small, hemispherical, rugged, having a vertical pore, with or without a short apical spine ; pores very small, scatterd, usually plugged. Collar stricture marked externally by a gentle change in contour. Three thin bars, prolonged from **D** and two **L**, may arise obliquely downward from the collar stricture. The bars are often fused with thoracic wall, and look like thin ribs. Thorax barrel-shaped to campanulate ; wall thick, rugged ; pores circular to subcircular, separated, longitudinally aligned and quincuncially arrnaged. Peristome strongly developed, cylindrical, smooth, and distally becoming thin.
Remarks : This species is distinguished from other species of the genus by its small, regularly aligned and arranged pores.
Dimensions (in μm) : Based on nine specimens. Total height ; 78-125. Maximum width of thorax ; 50-70.

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Plate 1

Figs. 1, 2 : *Acanthosphaera* sp. A.
Fig. 1 : ESN 146601.
Fig. 2 : ESN 146602.
Figs. 3a-8b : *Actinomma* sp. A.
Fig. 3a : ESN 146603. Fig. 3b : Enlargement of the shell surface.
Fig. 4a : Sectioned specimen, ESN 146604. Fig. 4b : Enlargement of the double medullary shell.
Fig. 5 : Transmitted lihgt micrograph, ESN 146605.
Fig. 6 : Transmitted light micrograph, ESN 146606.
Fig. 7 : Sectioned specimen, ESN 146607.
Fig. 8a : Sectioned specimen, ESN 146608. Fig. 8b : Enlargement of the double medullary shell.
Scale bars : 3b, 4b, 8b=20μm ; others=50μm.

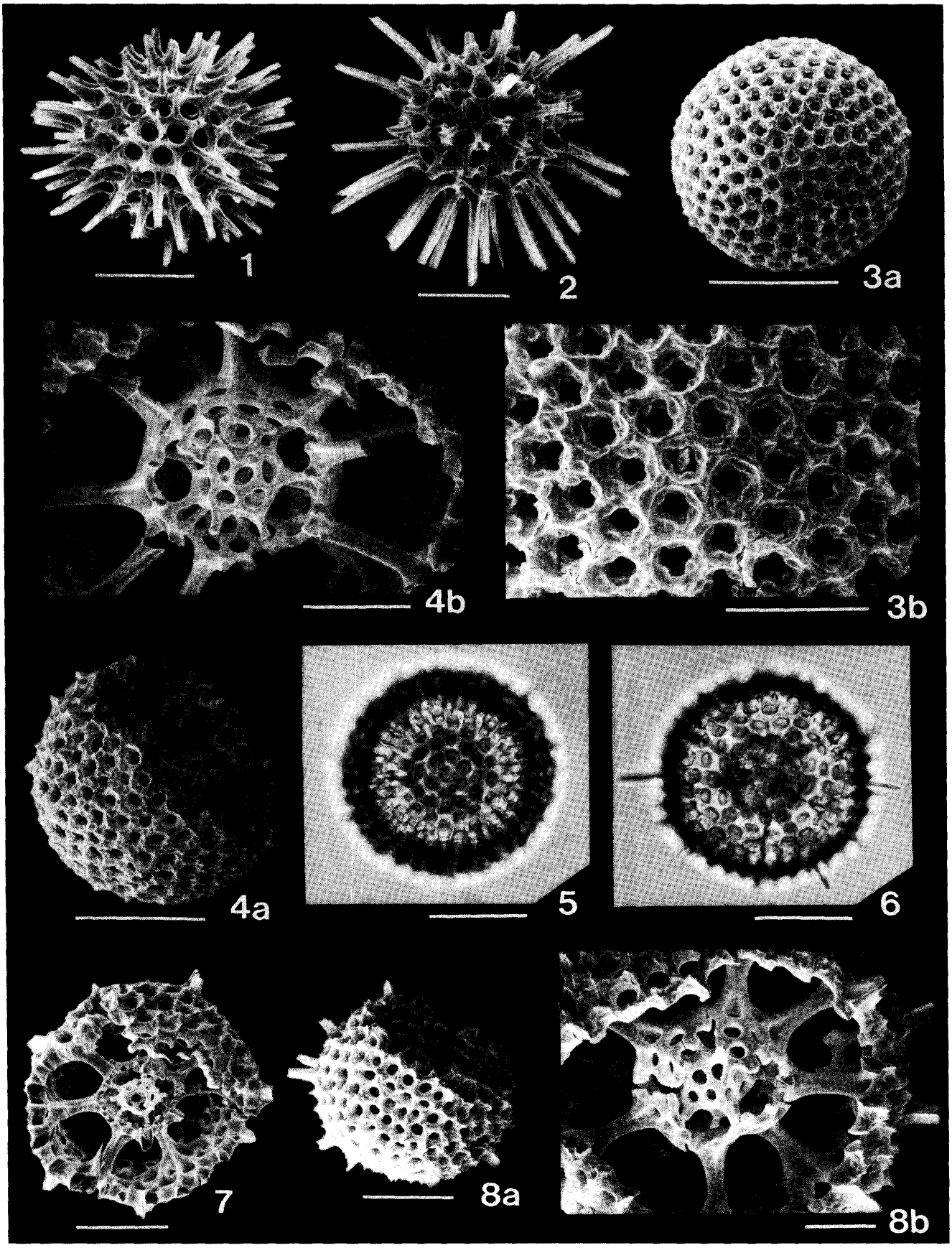
1
2
3a
4b
3b
4a
5
6
7
8a
8b

Plate 2

Figs. 1, 2 : *Actinomma* sp. A.
Fig. 1 : Sectioned specimen, transmitted light micrograph, ESN 146609.
Fig. 2 : Sectioned specimen, transmitted light micrograph, ESN 146610.
Figs. 3, 6 : *Cenosphaera* spp.
Fig. 3 : ESN 146611.
Fig. 6 : ESN 146612.
Figs. 4, 5, 7, 8 : *Echinomma* spp.
Fig. 4 : ESN 146613.
Fig. 5 : ESN 146614.
Fig. 7 : ESN 146615.
Fig. 8 : ESN 146616.
Figs. 9, 10 : *Anomalacantha* sp. A
Fig. 9 : ESN 146617.
Fig. 10 : ESN 146617.
Scale bars are 50 μm.

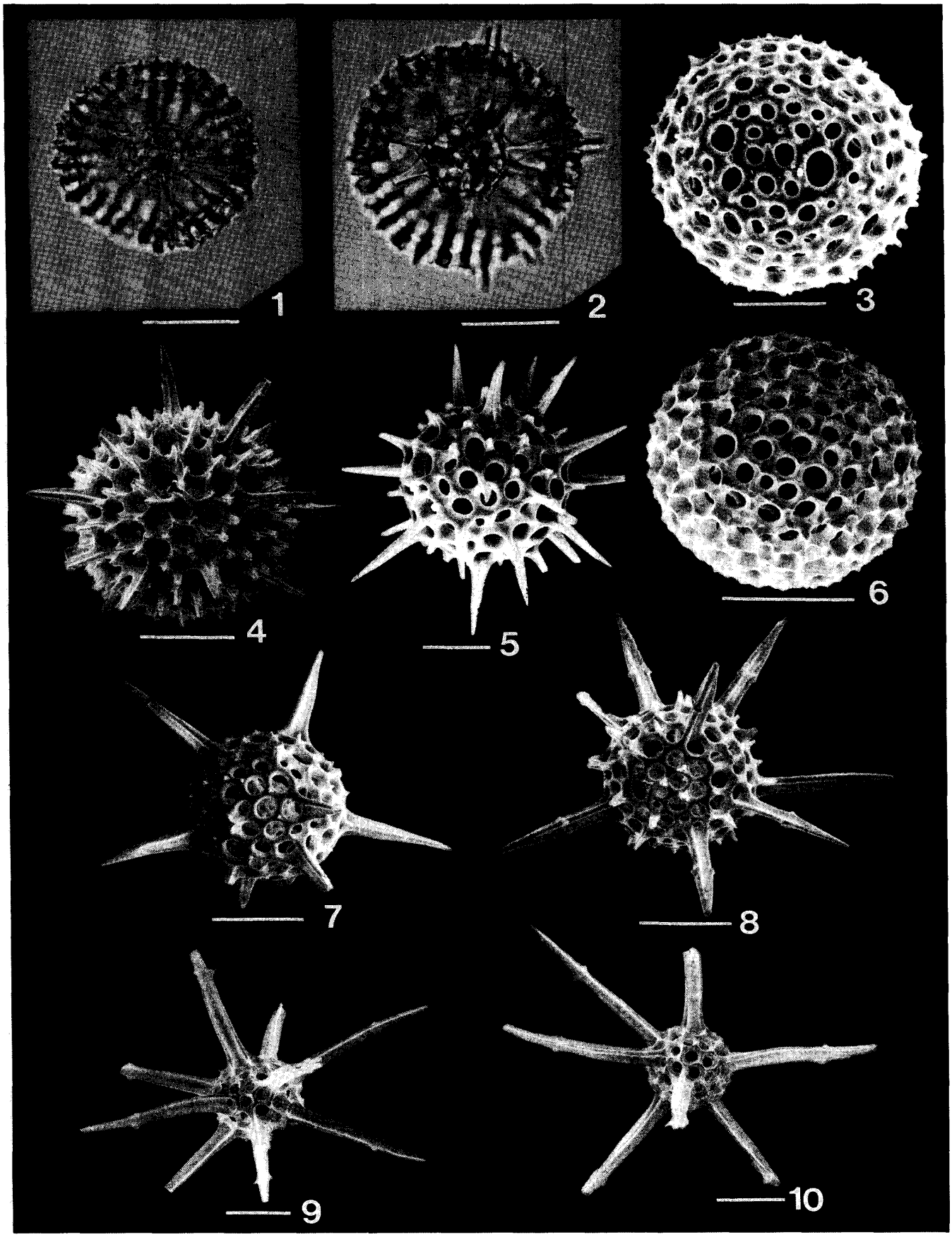
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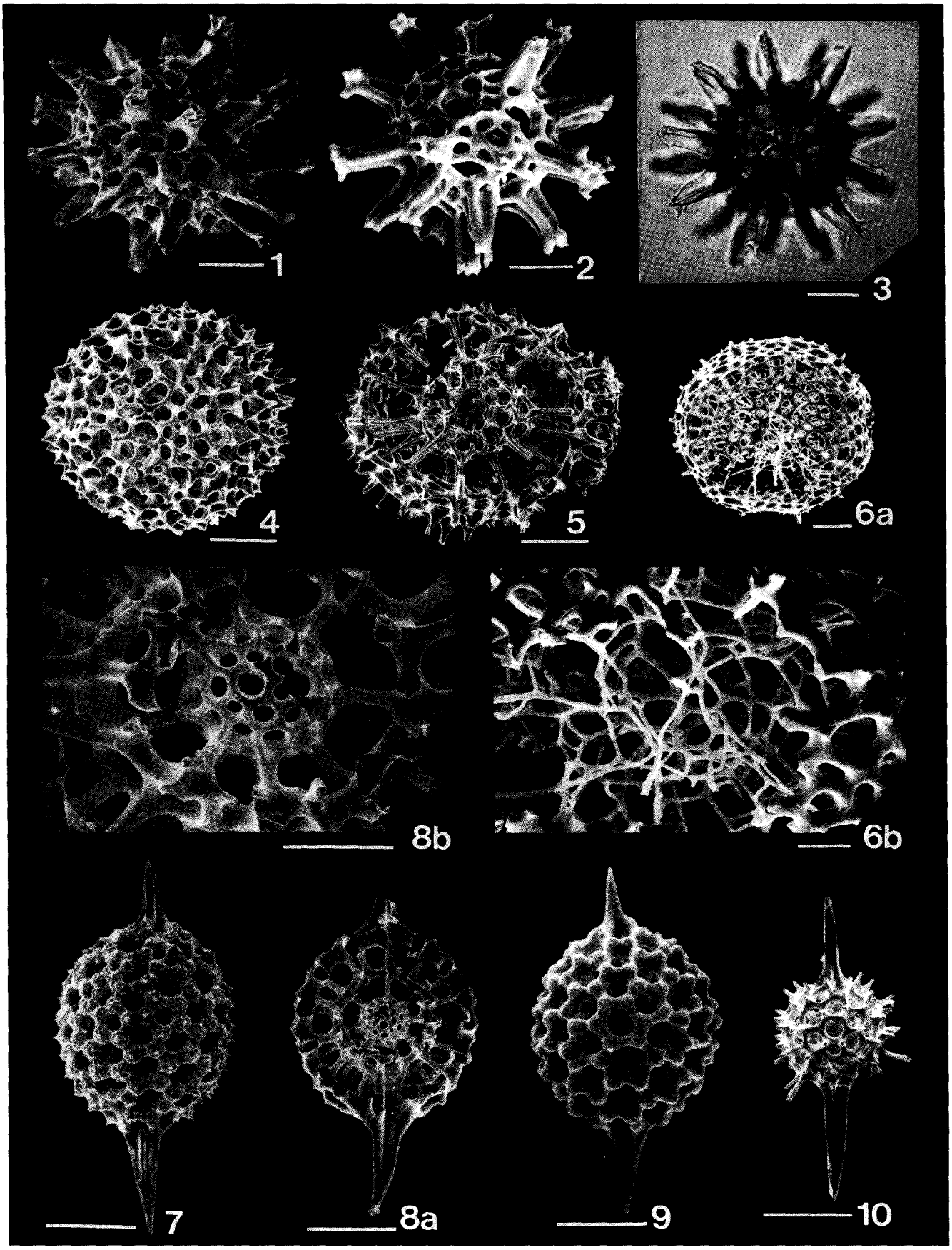
Plate 3

Figs. 1-3 : *Haeckeliella inconstans* Dumitrica.
Fig. 1 : ESN 146619.
Fig. 2 : ESN 146620.
Fig. 3 : Transmitted light micrograph, ESN 146621.
Figs. 4-6b : *Spongoplegma antarcticum* Haeckel.
Fig. 4 : ESN 146622.
Fig. 5 : ESN 146623.
Fig. 6a : ESN 146624. Fig. 6b : Enlargement of the internal structre.
Figs. 7-10 : *Stylatractus neptunus* Haeckel group.
Fig. 7 : A gerontic form (?), ESN 146625.
Fig. 8a : ESN 146626. Fig. 8b : Enlargement of the inner medullary shell.
Fig. 9 : The commonest form, ESN 146627.
Fig. 10 : An immature form having two shells, ESN 146628.
Scale bars: 6b, 8b=20μm ; others=50μm.


1
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3
4
5
6a
8b
6b
7
8a
9
10

Plate 4

Figs. 1-4b : *Thecosphaera* sp. A.
Fig. 1 : Broken specimen, ESN 146629.
Fig. 2 : Transmitted light micrograph, ESN 146630.
Fig. 3 : Sectioned specimen, transmitted light micrograph, ESN 146631.
Fig. 4a : Broken specimen, ESN 146632. Fig. 4b : Enlargement of the double medullary shell.
Fig. 5 : Detached radial spine of Spumellaria gen. et sp. indet., ESN 146633.
Figs. 6a, 6b : Actinomiidae gen. et sp. indet.
Fig. 6a : 146634. Fig. 6b : Enlargement of the shell surface.
Figs. 7a-8 : *Didymocyrtis tetrathalamus* (Haeckel).
Fig. 7a : Sectioned specimen, ESN 146635. Fig. 7b : Enlargement of the internal structure.
Fig. 8 : ESN 146636.
Scale bars : 4b, 6b, 7b=20μm ; others=50μm.

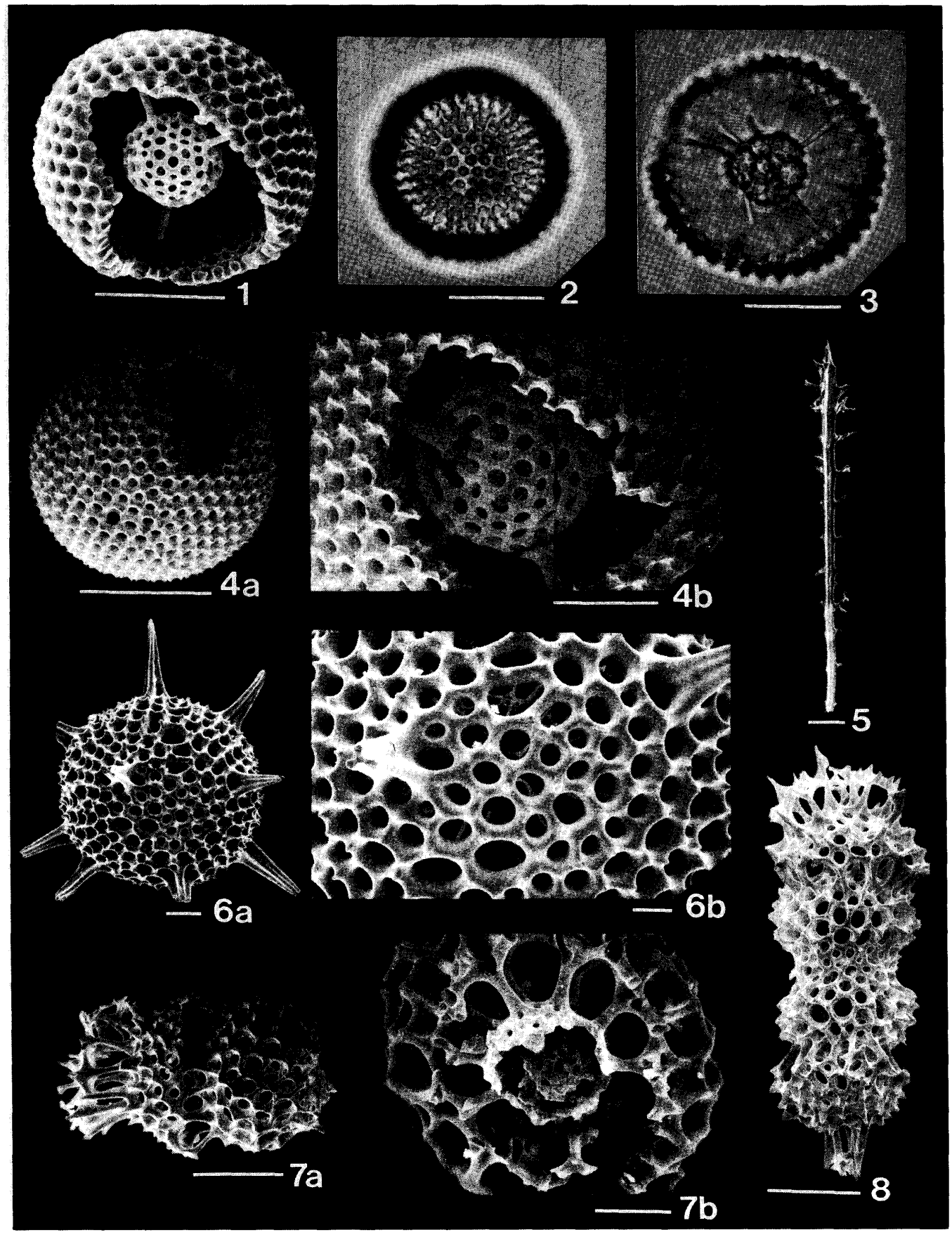

1
2
3
4a
4b
5
6a
6b
7a
7b
8

Plate 5

Figs. 1-5b : *Heliodiscus echiniscus* Haeckel.
Fig. 1 : ESN 146637, completely discoidal form.
Fig. 2 : ESN 146638, slightly distorted form.
Fig. 3 : ESN 146639, box-like form.
Fig. 4a : ESN 146640, asymmetrical box-like form. Fig. 4b : Enlargement of the double medullary shell.
Fig. 5a : ESN 146641, discoidal form, equatorial view. Fig. 5b : Enlargement of the double medullary shell.
Figs. 6-8b : *Heliodiscus* sp. aff. *H. asteriscus* Haeckel.
Fig. 6 : ESN 146642.
Fig. 7 : ESN 146643.
Fig. 8a : ESN 146644. Fig. 8b : Enlargement of the double medullary shell.
Scale bars : 4b, 5b, 8b=20μm ; other=50μ

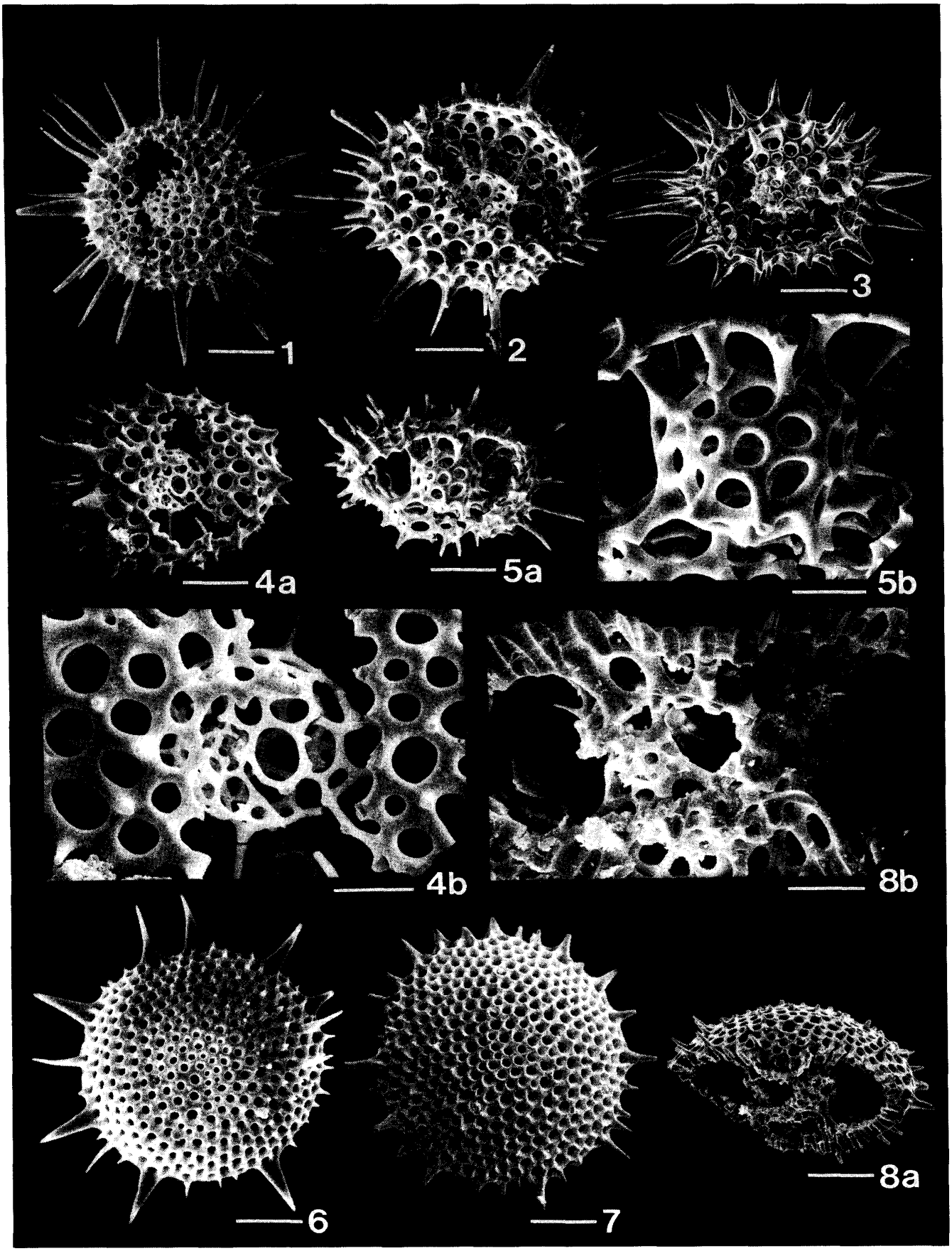
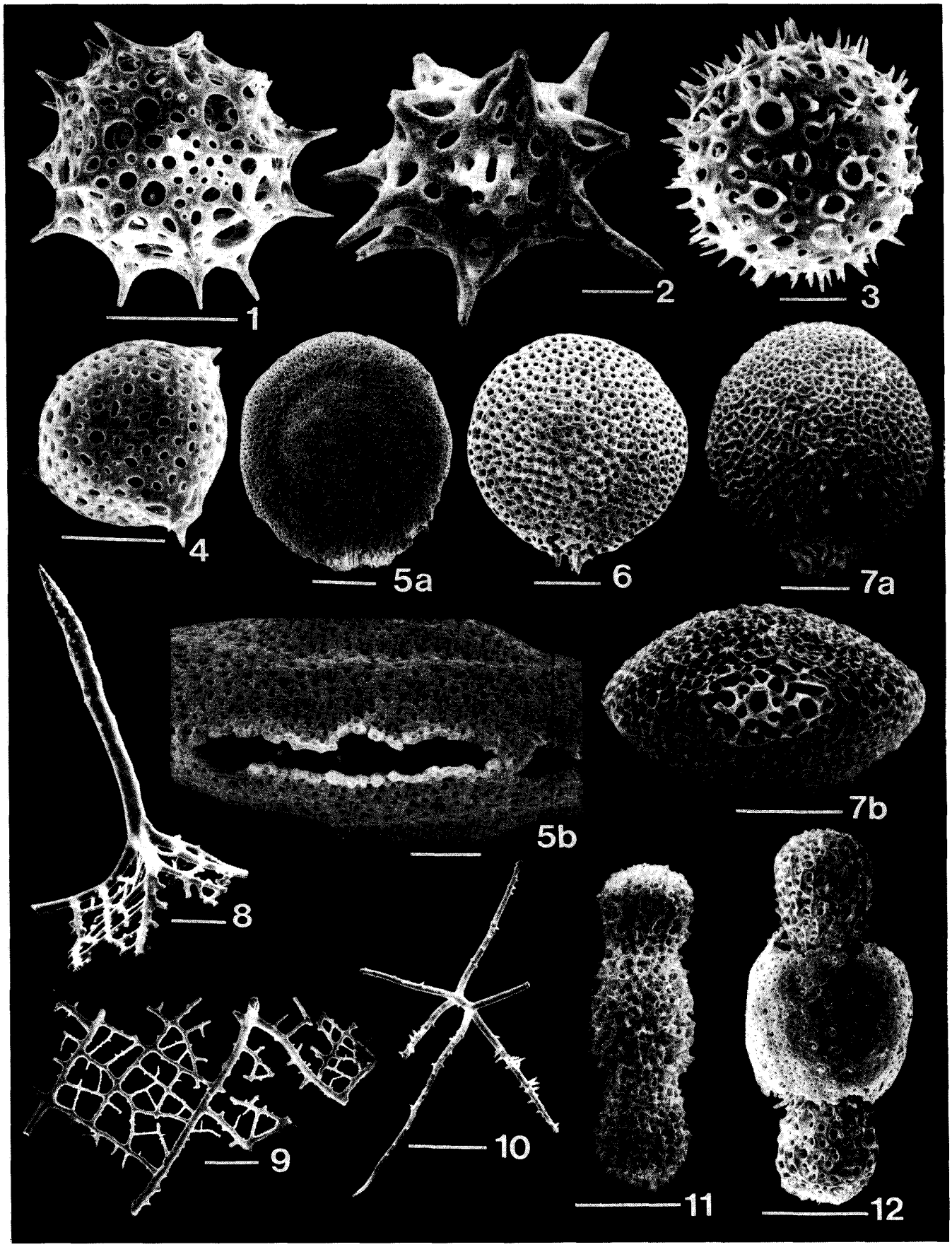

1
2
3
4a
5a
5b
4b
8b
6
7
8a

Plate 6

Fig. 1 : *Acrosphaera spinosa* (Haeckel), ESN 146645.
Fig. 2 : *Acrosphaera inflata* Haeckel, ESN 146646.
Fig. 3 : *Choenicosphaera trepanata* (Haeckel), ESN 146647.
Fig. 4 : *Otosphaera auriculata* Haeckel, ESN 146648.
Figs. 5a, 5b : *Ommatodiscus fragilis* Stöhr
Fig. 5a : ESN 146649. Fig. 5b. Basal view showing the details of the aperture.
Figs. 6-7b : *Spongopyle osculosa* Dreyer.
Fig. 6 : ESN 146650.
Fig. 7a : ESN 146651. Fig. 7b : Basal view showing the detrails of the aperture.
Figs. 8, 9. Orosphaeridae gen. et sp. indet.
Fig. 8 : ESN 146652.
Fig. 9 : ESN 146653.
Fig. 10 : *Rhaphidozoum* sp., ESN 146654.
Figs. 11, 12 : *Spongocore puella* Haeckel.
Fig. 11, ESN 146655.
Fig. 12, ESN 146656.
Scale bars : 8, 9, 10=10μm ; 2, 5b=20μm ; others=50μm


1
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3
4
5a
6
7a
5b
7b
8
9
10
11
12

Plate 7

Figs. 1-2b : *Excentroconcha minor* Mast.
Fig. 1 : ESN 146657.
Fig. 2a : ESN 146658. Fig. 2b : Enlargement of the pointed portion in 2a.
Figs. 3-5b : *Spongaster tetras tetras* Ehrenberg.
Fig. 3 : ESN 146659.
Fig. 4 : Odd specimen, ESN 146660.
Fig. 5a : Sectioned specimen, ESN 146661. Fig. 5b : Enlargement of the center.
Fig. 6 : *Amphirhopalum ypsilon* Haeckel, ESN 146662.
Figs. 7-9 : *Spongurus* sp. aff. *S. pylomaticus* Riedel.
Fig. 7 : Sectioned specimen, ESN 146663.
Fig. 8 : Immature form (?), ESN 146664.
Fig. 9 : Mature form, ESN 146665.
Scale bars : 1, 2b, 5b=20μm ; others=50μm.

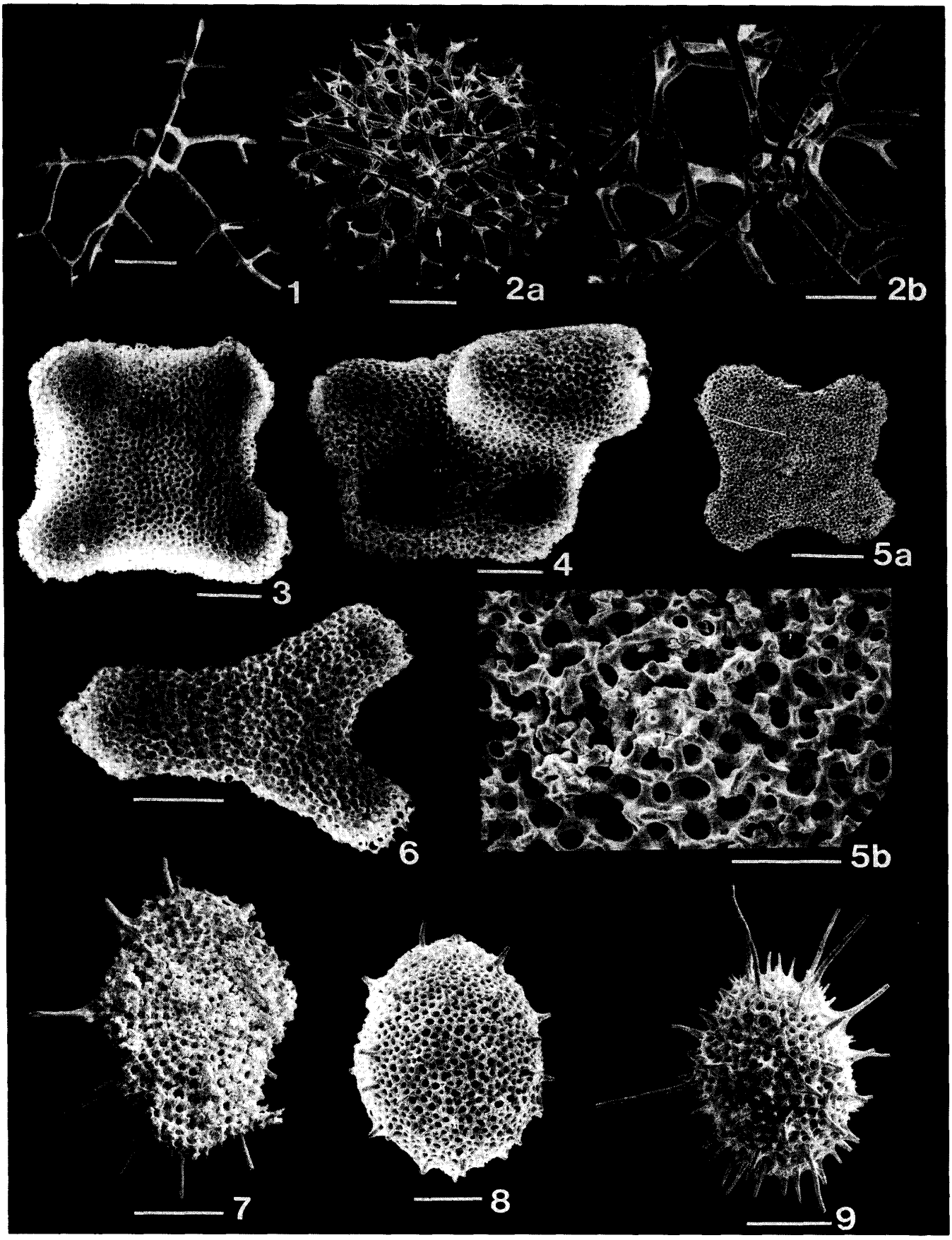
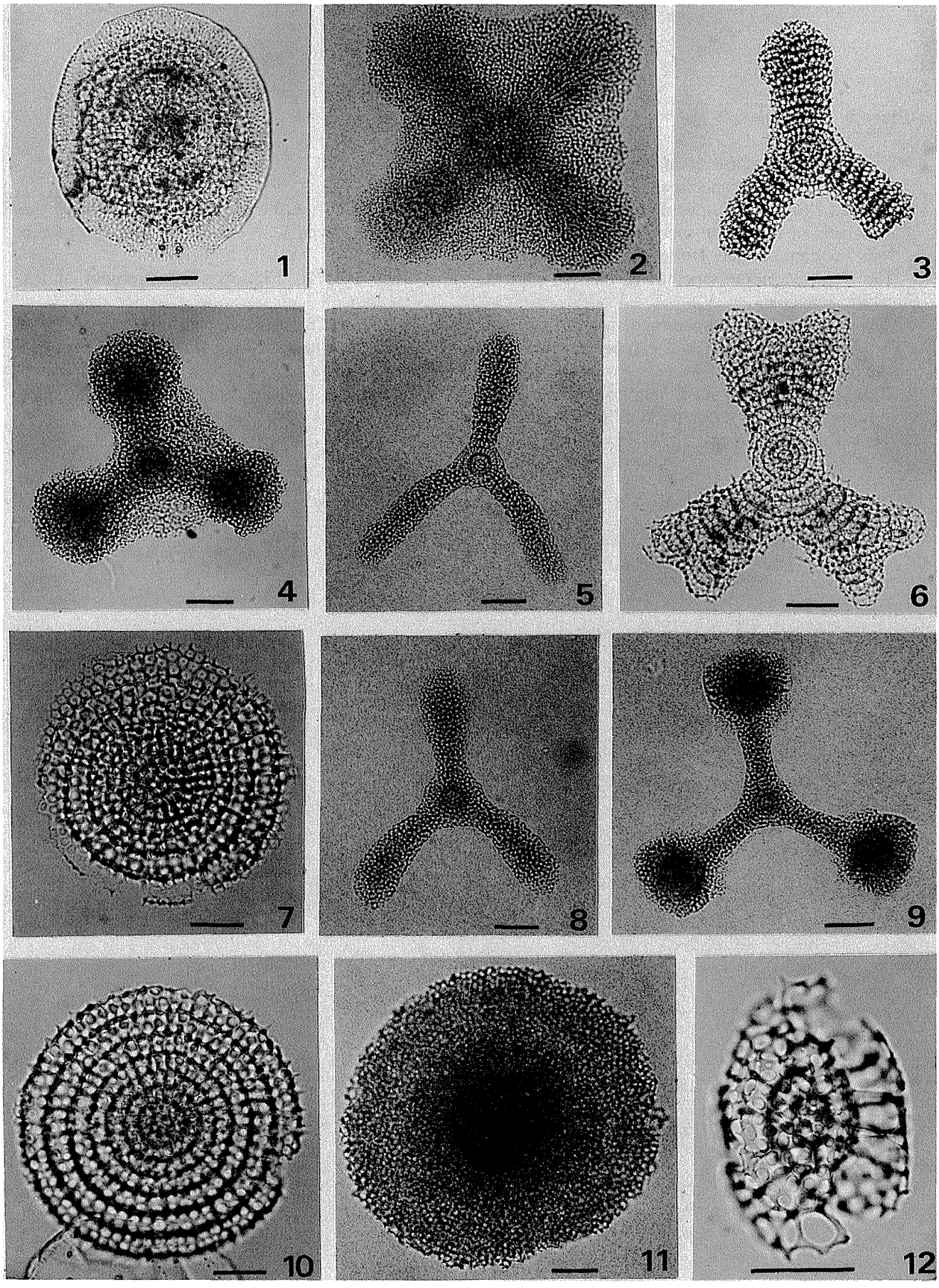

1
2a
2b
3
4
5a
5b
6
7
8
9

Plate 8

All figures are transmitted light micrographs.
Fig. 1 : *Ommatodiscus fragilis* Stöhr, ESN 14666.
Fig. 2 : *Spongaster tetras tetras* Ehrenberg, ESN 14667.
Figs. 3, 6 : *Amphirhopalum ypsilon* Haeckel, ESN 146668.
Fig. 4 : *Hymeniastrum euclidis* Haeckel group, ESN 146669.
Fig. 5 : *Euchitonia furcata* Ehrenberg group, ESN 146670.
Figs. 7, 10 : *Flustrella* sp.
Fig. 7 : ESN 146671.
Fig. 10 : ESN 146672.
Fig. 8 : *Rhopalastrum* sp., ESN 146843.
Fig. 9 : *Rhopalastrum profundum* (Ehrenberg) group, ESN 146844.
Fig. 11 : *Spongodiscus* sp, ESN 146673.
Fig. 12 : *Larcospira quadrangula* Haeckel, ESN 146674.
Scale bars are 20μm.


1
2
3
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5
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11
12

Plate 9

Figs. 1-5c : *Larcospira quadrangula* Haeckel group.

Fig. 1 : Complete specimen, ESN 146675.

Fig. 2a : Sectioned specimen, polar view, ESN 146676. Fig. 2b : Enlargement of 2a showing the details of up to the second system. The microsphere is the type 1. Note that a half cap of **S_1b** is broken, so that **DoSg** is clearly visible.

Fig. 3a : Sectioned specimen, frontal sagittal view, ESN 146677. Fig. 3b : Enlargement of the microsphere.

Fig. 4a : Sectioned specimen, frontal sagittal view, ESN 146678. Fig. 4b : Enlargement of the microsphere which is the type 1. Note that one frontal pore (sagittal pore) is absent. Fig. 4c : Polar view of 4b.

Fig. 5a : Sectioned specimen, dorsal sagittal view, ESN 146679. Fig. 5b : Enlargement of 5a. The microsphere is the type 1. Fig. 5c : Lateral view of 5b.

Scale bars : 3b=10μm ; 1, 2a, 3a=50μm ; others=20μm.

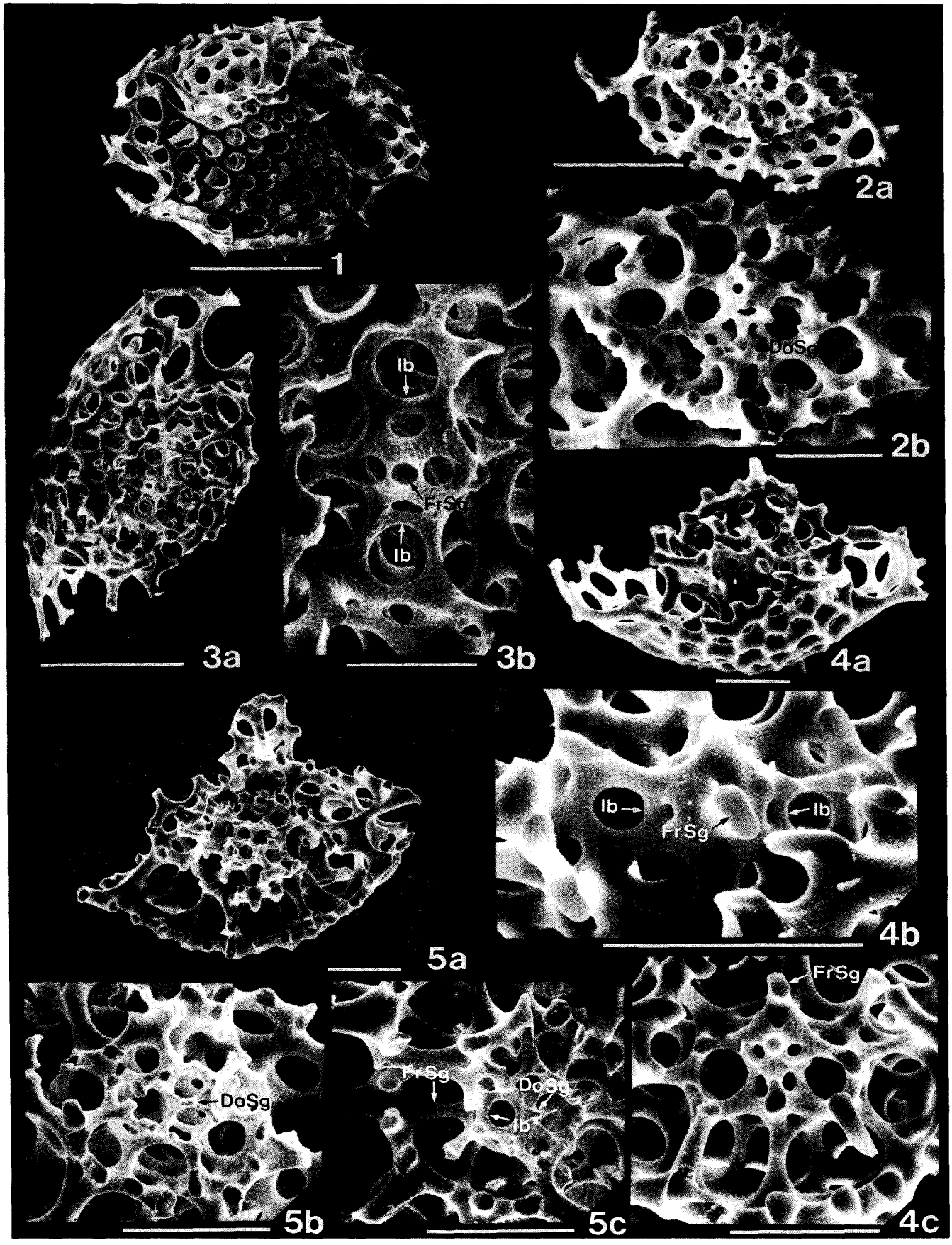
1
2a
2b
DoSg
3a
3b
Ib
FrSg
Ib
4a
4b
Ib
FrSg
Ib
5a
5b
DoSg
5c
FrSg
DoSg
Ib
4c
FrSg

Plate 10

Figs. 1-9b : *Phorticium* spp.

Fig. 1 : ESN 146680.

Fig. 2 : ESN 146681.

Fig. 3 : ESN 146682.

Fig. 4 : ESN 146683.

Fig. 5a : Sectioned specimen, lateral view, ESN 146684. Fig.5b : Enlargement of up to the second system.

Fig. 6a : Sectioned specimen, polar view, ESN 146685. Fig. 6b : Enlargement of the first system. The microsphere is the type 2.

Fig. 7 : ESN 146686.

Fig. 8 : ESN 146687.

Fig. 9a : Sectioned specimen, oblique polar view, ESN 146688. Fig. 9b : Frontal sagittal view of the first system.

Scale bars : 5b, 6b, 9b=20μm ; others=50μm.

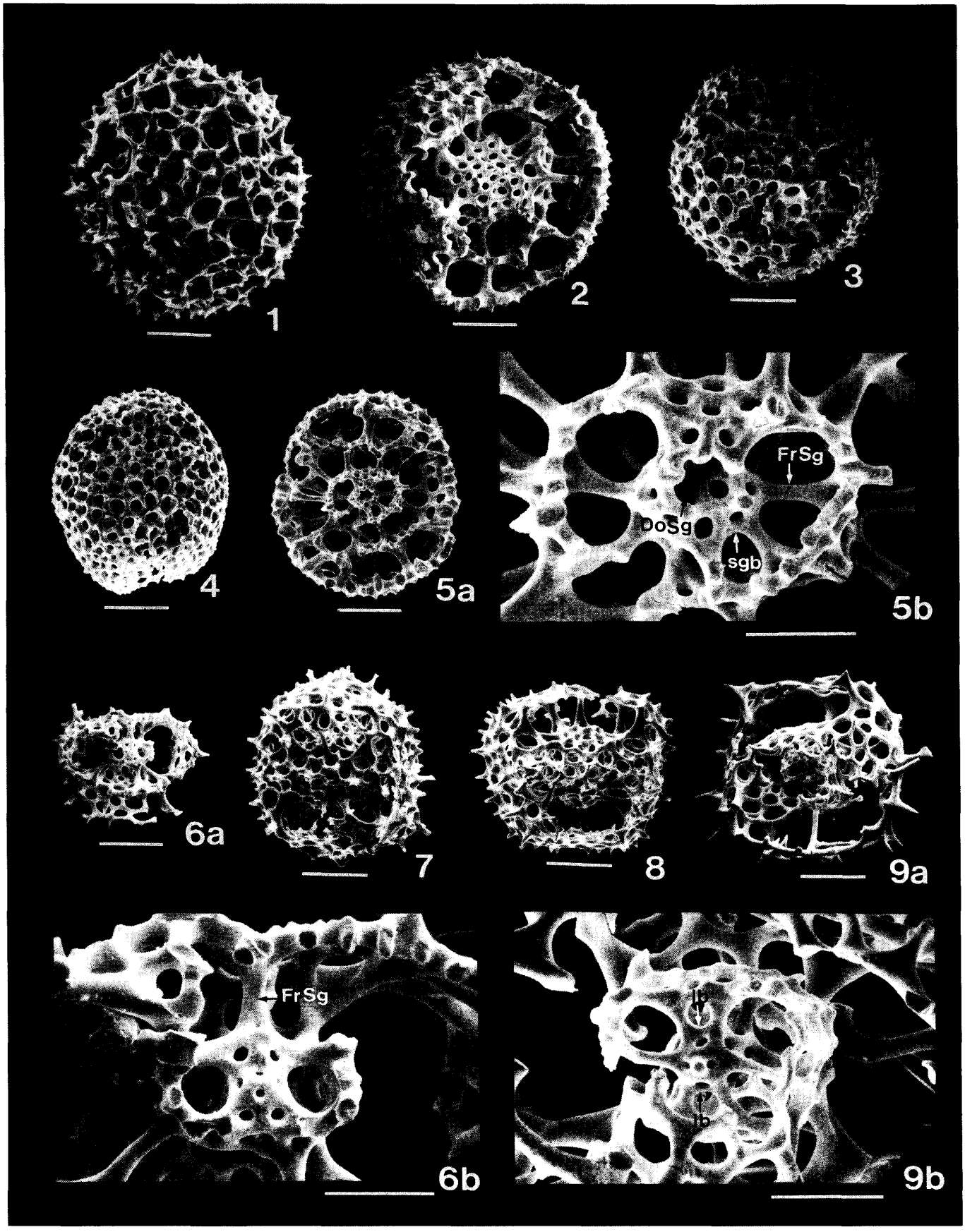
1
2
3
4
5a
FrSg
PoSg
sgb
5b
6a
7
8
9a
FrSg
6b
Ib
Ib
9b

Plate 11

Fig. 1 : *Tetrapyle* sp., ESN 1466689.
Figs. 2-4, 6a, 6b : *Phorticium* spp.
Fig. 2 :ESN 146690.
Fig. 3a : Sectioned specimen, oblique lateral view, ESN 146691. Fig. 3b : Lateral view of the microsphere which is the type 1.
Fig. 4 : Transmitted light micrograph, ESN 146692.
Fig. 6a : Sectioned specimen, frontal sagittal view, ESN 146693. Fig. 6b : Enlargement of the microsphere.
Figs. 5, 7, 8 : Larnacillidae (?) gen. et sp. indet. A.
Fig. 5 : ESN 146694.
Fig. 7 : ESN 146695.
Fig. 8 : ESN 146696.
Fig. 9 : *Tholonium hexonium* Haeckel, transmitted light micrograph, ESN 146697.
Scale bars : 3b, 62=20μm ; others=50μm..

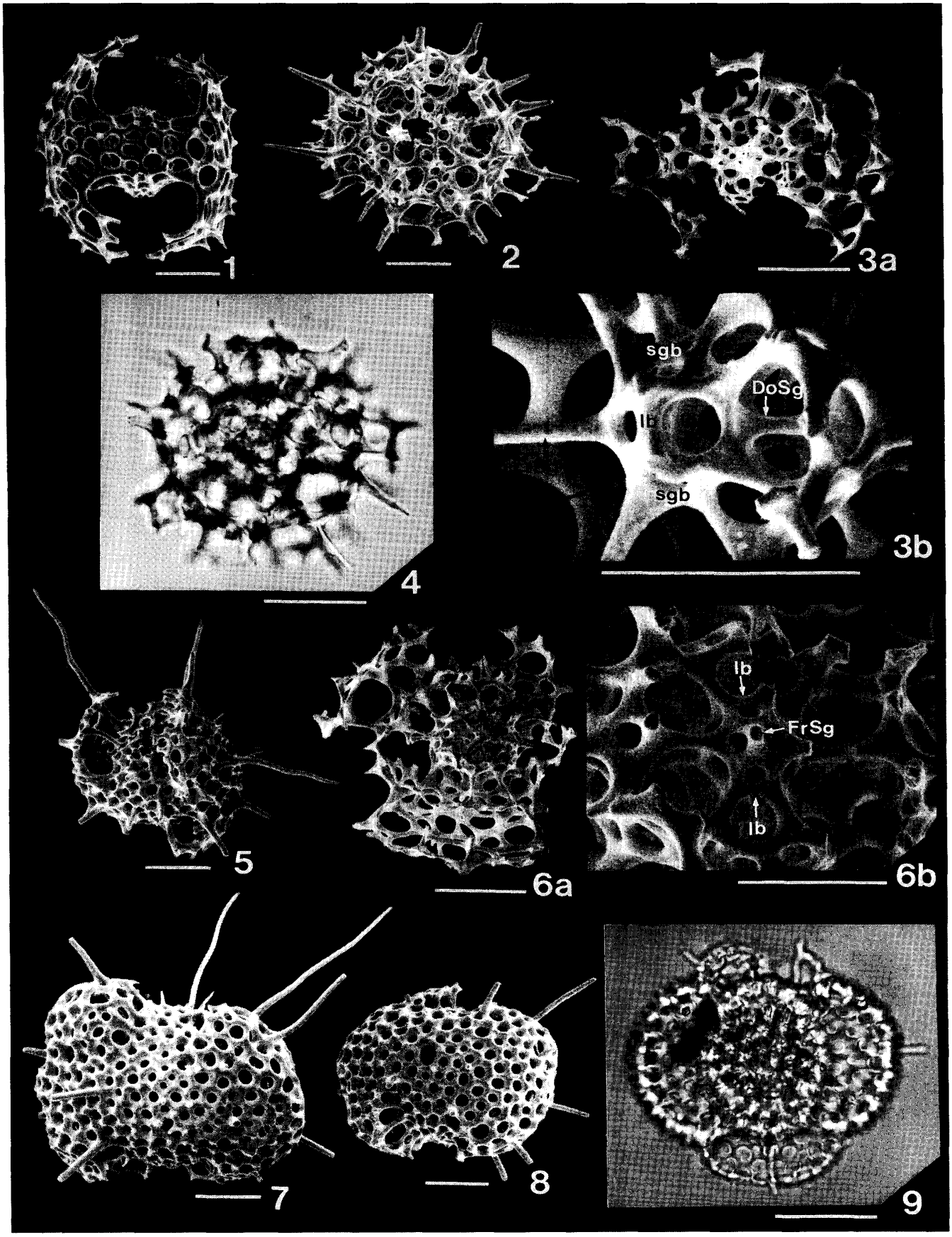
1
2
3a
sgb
DoSg
lb
sgb
3b
4
5
6a
lb
FrSg
lb
6b
7
8
9

Plate 12

Figs. 1a-4a : *Axoprunum bispiculum* (Popofsky).

Fig. 1a : ESN 146698. Fig. 1b. Enlargement of 1a showing the details of the cortical shell and bifurcated by-spines on the medullary shell.

Fig. 2 : ESN 146699.

Fig. 3 : ESN 146700.

Fig. 4a : Sectioned specimen, ESN 146701. Fig. 4b : Apical view of the microsphere. Fig. 4c : Oblique sagittal view of 4b. Fig. 4d : Just sagittal view of 4b.

Scale bars : 1a, 2, 3, 4a=50μm ; others=20μm.

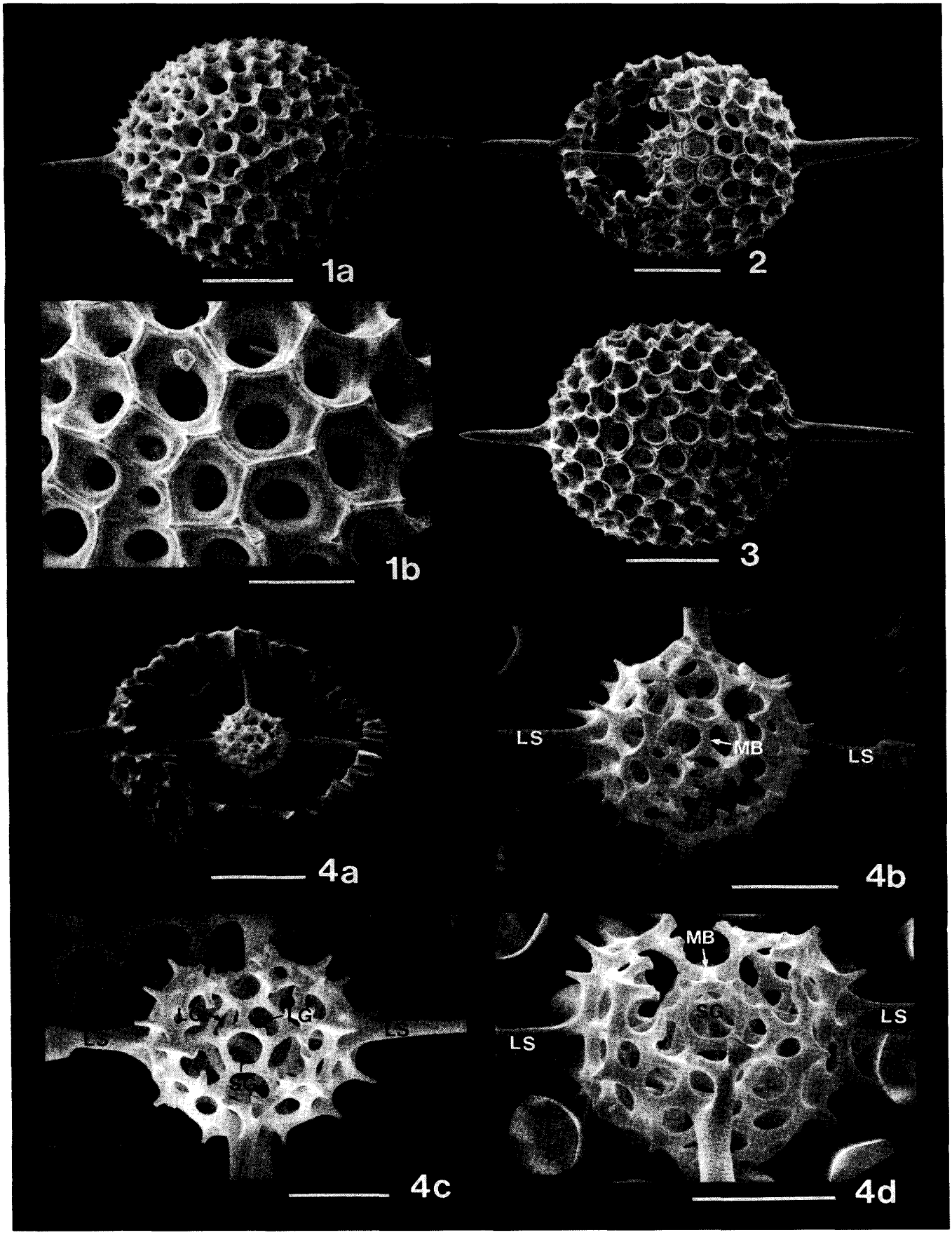
1a
2
1b
3
4a
LS
MB
LS
4b
LG
LG
LS
LS
SG
4c
MB
SG
LS
LS
4d

Plate 13

Figs. 1-3b : *Xiphosphaerantha angelina* (Campbell and Clark).
Fig. 1 : ESN 146702.
Fig. 2a : ESN 146703. Fig. 2b : Enlargement of 2a showing the details of the cortical shell.
Fig. 3a : Sectioned specimen, oblique apical view, ESN 146704. Fig. 3b : Enlargement of 3a, just apical view.
Figs. 4-7 : *Hexacontium* spp.
Fig. 4 : ESN 146705. Longer spines correspond to **LS.**
Fig. 5 : ESN 146706.
Fig. 6 : ESN 146707.
Fig. 7 : ESN 146708.
Scale bars: 2b, 3b=20μm ; others=50μm.

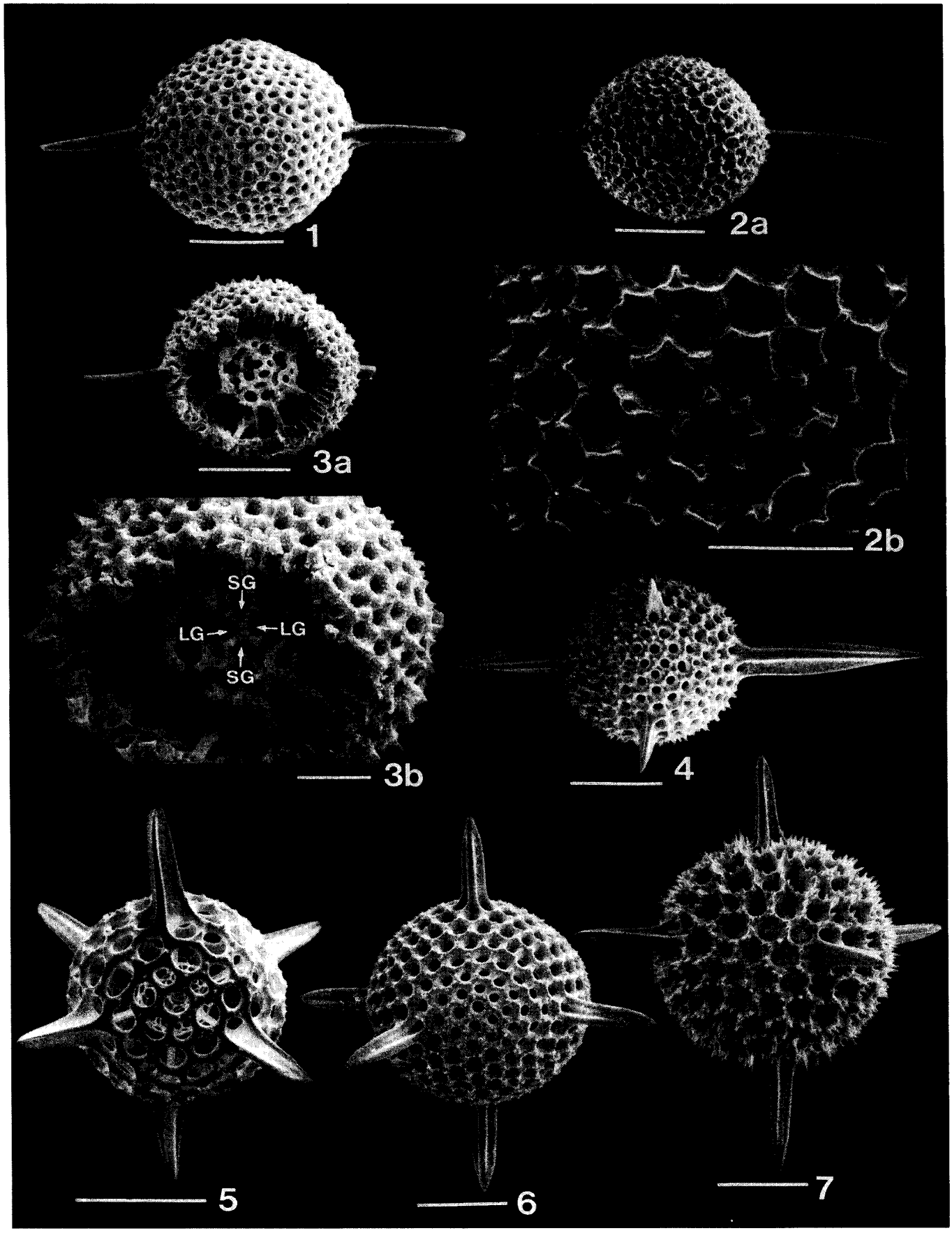
1
2a
3a
2b
SG
LG
LG
SG
3b
4
5
6
7

Plate 14

Figs. 1-8b : *Hexacontium* spp.
Fig. 1 : ESN 146709.
Fig. 2 : ESN 146710.
Fig. 3 : ESN 146711.
Fig. 4 : ESN 146712.
Fig. 5 : ESN 146713.
Fig. 6a : Immature specimen (?) lacking the cortical shell, ESN 146714. Fig. 6b : Enlargement of 6a showing the microsphere, oblique view.
Fig. 7 : ESN 146715.
Fig. 8a : Sectioned specimen, ESN 146716. Fig. 8b : Enlargement of 8a showing the microsphere, just lateral view.
Scale bars : 6b, 8b=20μm ; others=50μ.

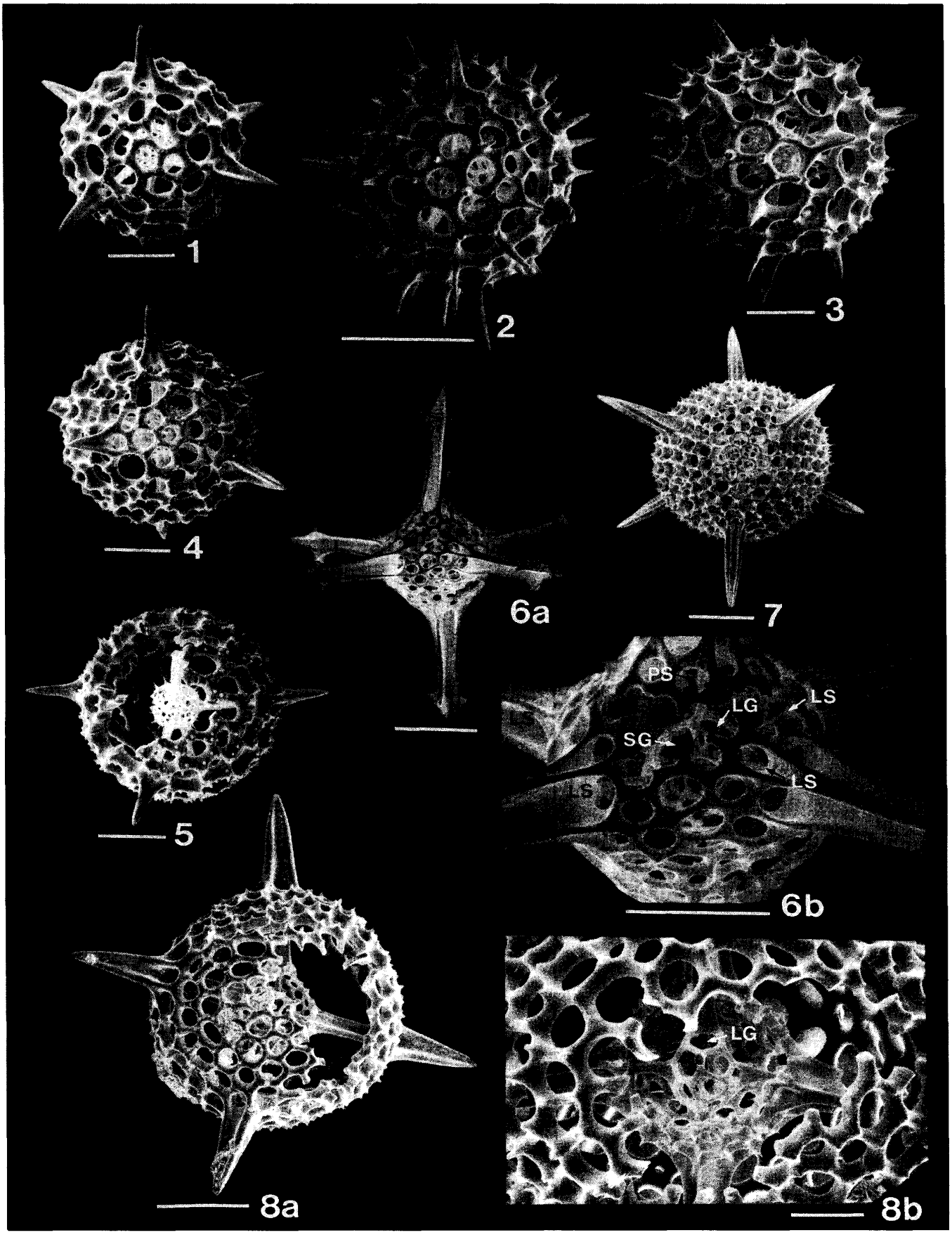
1
2
3
4
6a
7
5
PS
LG
LS
SG
LS
LS
6b
LG
8a
8b

Plate 15

Fig. 1 : *Archipilium* sp. A, ESN 146718.
Figs. 2-3b, 5 : *Ceratocyrtis* spp.
Fig. 2 : Left lateral view, ESN 146719.
Fig. 3a : Right lateral view, ESN 146720. Fig. 3b : Basal view of 3a. Proximal part of **D** is broken off. Arrows point to **L'**
Fig. 5 : Right lateral view, ESN 146721.
Figs. 4a, 4b : *Clathrolychnus coarctatus* (Ehrenberg).
Fig. 4a : Oblique left lateral view, ESN 146722. Fig. 4b : Basal view of 4a.
Figs. 6a, 6b : *Eucenarium* sp. B.
Fig. 6a : Oblique ventral view, ESN 146723. Fig. 6b : Basal view of 6a.
Figs. 7a, 7b : *Eucenarium* sp. A.
Fig. 7a : Oblique right lateral view, ESN 146724. Fig. 7b : Basal view of 7a. **V** is broken off.
Scale bars : 3a, 3b, 4b, 7a, 7b=20μm ; others=50μm.

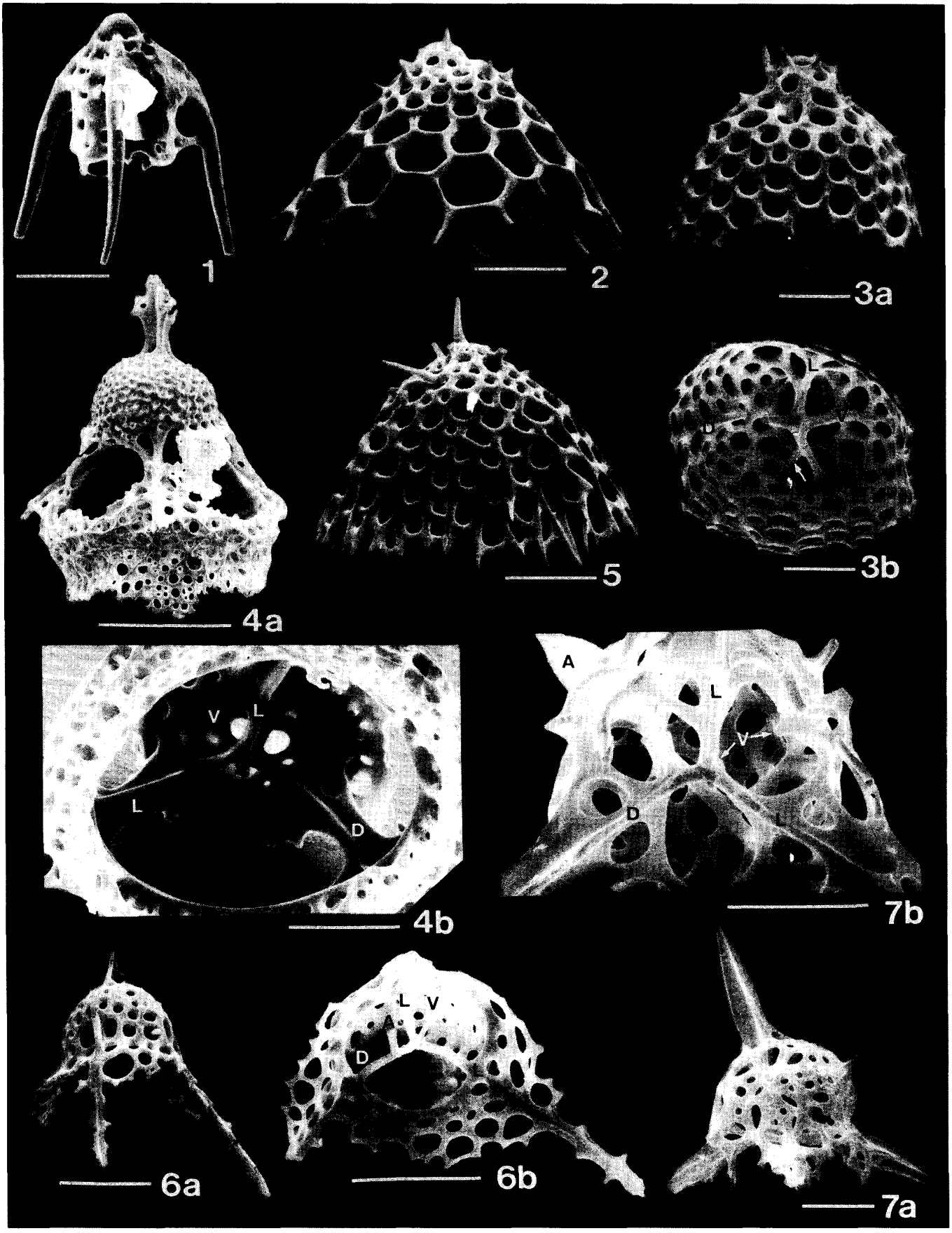
1
2
3a
3b
4a
4b
5
6a
6b
7a
7b
A
L
V
D

Plate 16

Figs. 1-3 : *Lampromitra* spp.
Fig. 1 : Oblique dorsal view, ESN 146725.
Fig. 2a : Right lateral view, ESN 146726. Fig. 2b : Basal view of 2a. **V** is broken off.
Fig. 3 : Oblique ventral view, ESN 146727.
Figs. 4-5b : *Lamprotripus* (?) *mawsoni* (Riedel).
Fig. 4 : Left lateral view, ESN 146728.
Fig. 5a : Left lateral view, ESN 146729. Fig. 5b : Basal view of 5a.
Figs. 6-7b : *Lophophaena* sp.
Fig. 6 : Oblique dorsal view, ESN 146730.
Fig. 7a : Oblique dorsal view, ESN 146731. Fig. 7b : Basal view of 7a.
Scale bars : 2a, 5b, 7b=20μm ; others=50μm.

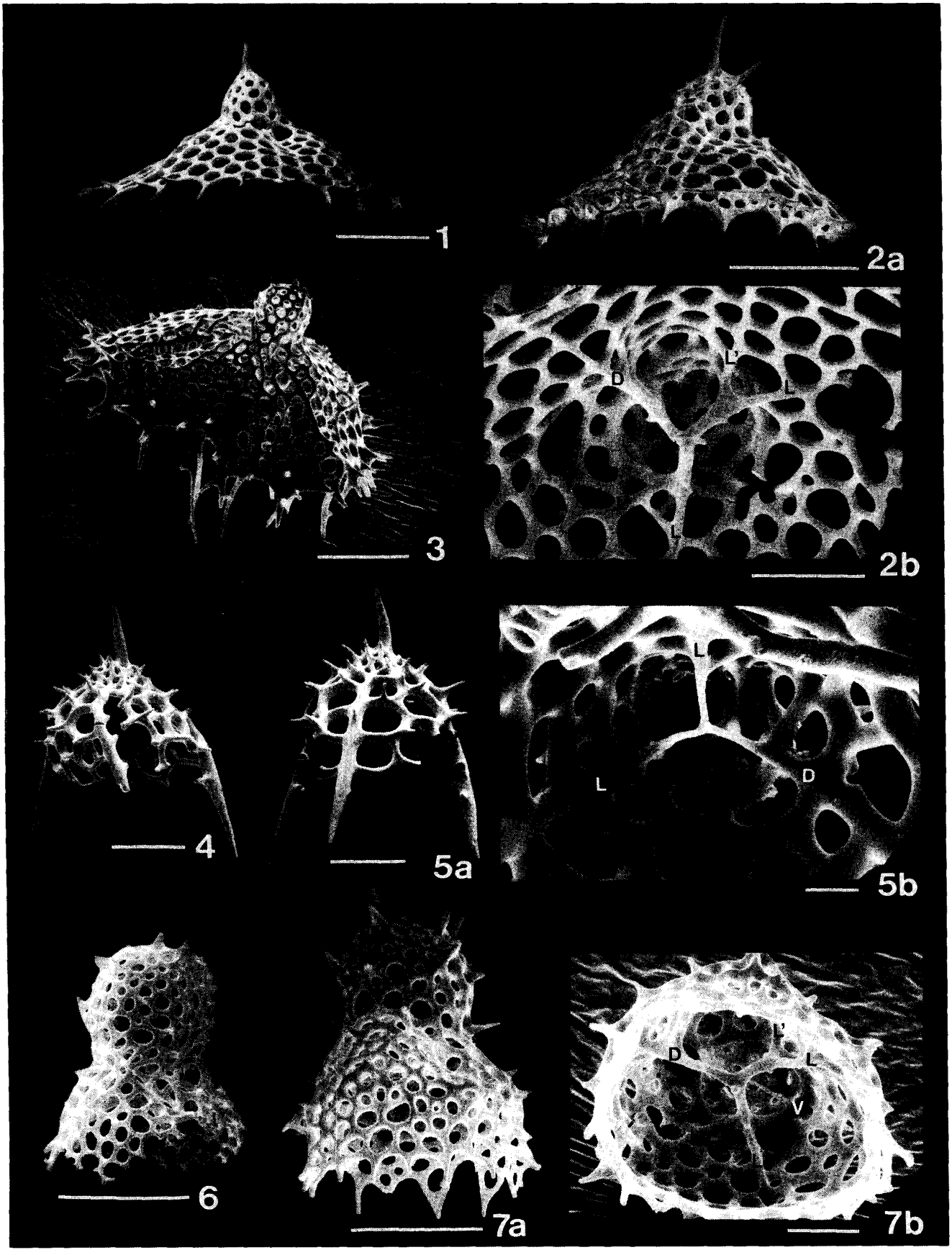
1
2a
3
D
L'
L
L
2b
4
5a
L
L
D
5b
6
7a
L'
D
L
V
7b

Plate 17

Figs. 1a, 1b : *Lithomelissa ultima* Caulet.
Fig. 1a : Dorsal view, ESN 146732. Fig. 1b : Basal view of 1a.Arrows point to the arch **AL.**
Figs. 2-3b : *Pseudodictyophimus gracilipes* (Bailey).
Fig. 2 : Left lateral view, ESN 146733.
Fig. 3a : Right lateral view, ESN 146734. Fig. 3b : Basal view of 3a. Arrows point to **D'**.
Figs. 4a-5b : *Pseudodictyophimus hexaptesimus* Sugiyama sp. nov.
Fig. 4a : Holotype, oblique dorsal view, ESN 146734. Fig. 4b : Basal view of 4a. **V** is broken off.
Fig. 4c : Enlargement of 4b. Arrows point to **D'**.
Fig. 5a : Paratype, oblique right lateral view, ESN 146735. Fig. 5b : Basal view of 5a.
Scale bars : 1b, 3b, 4a-4c=20μm, others=50μm.

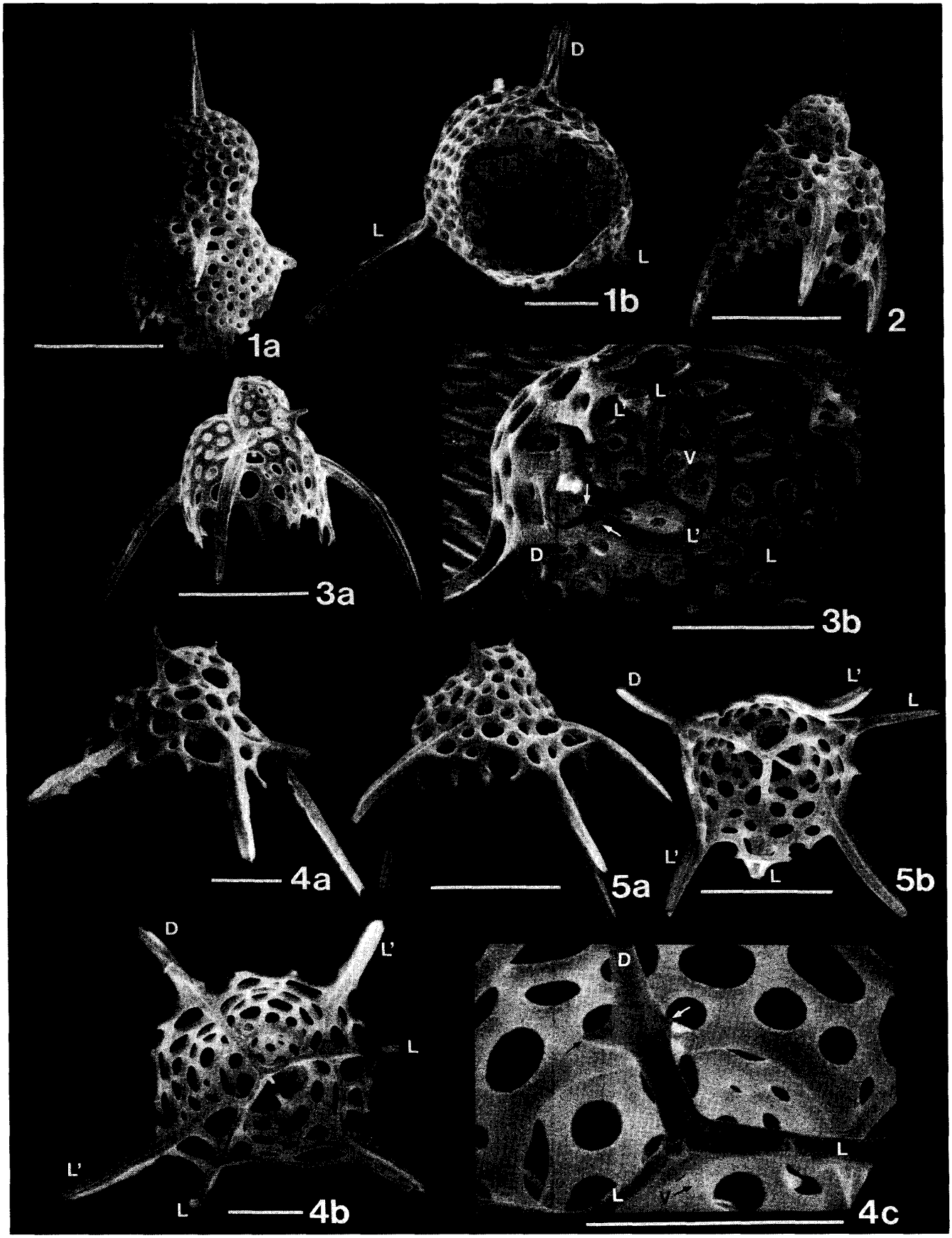
D
L
L
1b
1a
2
L
L'
V
L'
D
L
3b
3a
D
L'
L
L'
L
5b
4a
5a
D
L'
L
L'
4b
D
L
L
4c

Plate 18

Figs. 1a-3c : *Pseudocubus warreni* Goll.

Fig.1a : Dorsal view, immature specimen (?), ESN 146839. Fig. 1b : Basal view of 1a.

Fig. 2a : Right lateral view, ESN 146840. Fig. 2b : Oblique basal view of 2a. Fig. 2c : Enlargement of 2b.

Fig. 3a : Left lateral view, ESN 146841. Fig. 3b : Oblique lateral view of 3a. Fig. 3c : Basal view of 3a.

Figs. 4a, 4b : *Arachnocorys* sp. A.

Fig. 4a :: Oblique ventral view, ESN 146842. Fig. 4b : Basal view of 4a.

Scale bars : 1a, 1b=50μm ; others=20μm.

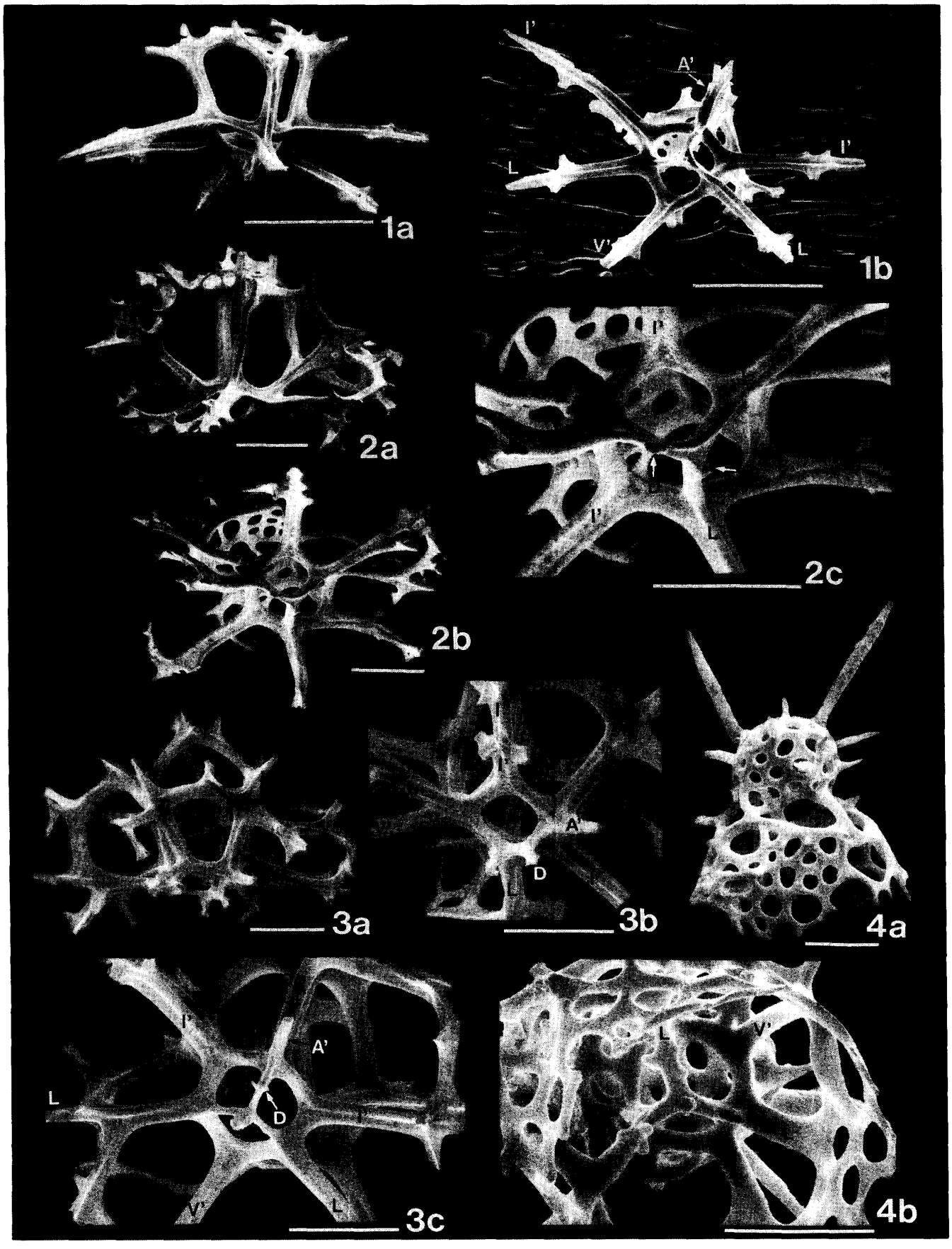
1a
1b
2a
2b
2c
3a
3b
3c
4a
4b
A'
D
L
V'

Plate 19

Figs. 1–2b : *Bathropyramis infundibulum* (Haeckel).
Fig. 1 : ESN 146736.
Fig. 2a : ESN 146737. Fig. 2b : Basal view of 2a.
Figs. 3, 4 : *Bathropyramis ramosa* Haeckel.
Fig. 3 : ESN 146738.
Fig. 4 : ESN 146737.
Figs. 5, 6 : *Cornutella profunda* Ehrenberg.
Fig. 5 : ESN 146740.
Fig. 6 : ESN 146741.
Figs. 7a–11 : *Bathropyramis* (?) *pyrgina* Sugiyama sp. nov.
Fig. 7a, Holotype, ESN 146742. Fig. 7b : Basal view of 7a.
Fig. 8 : Paratype, ESN 146743.
Fig. 9 : Paratype, ESN 146744.
Fig. 10 : Paratype, ESN 146745.
Fig. 11 : Paratype, ESN 146746.
Scale bars : 2b, 7b=20μm ; others=50μm.

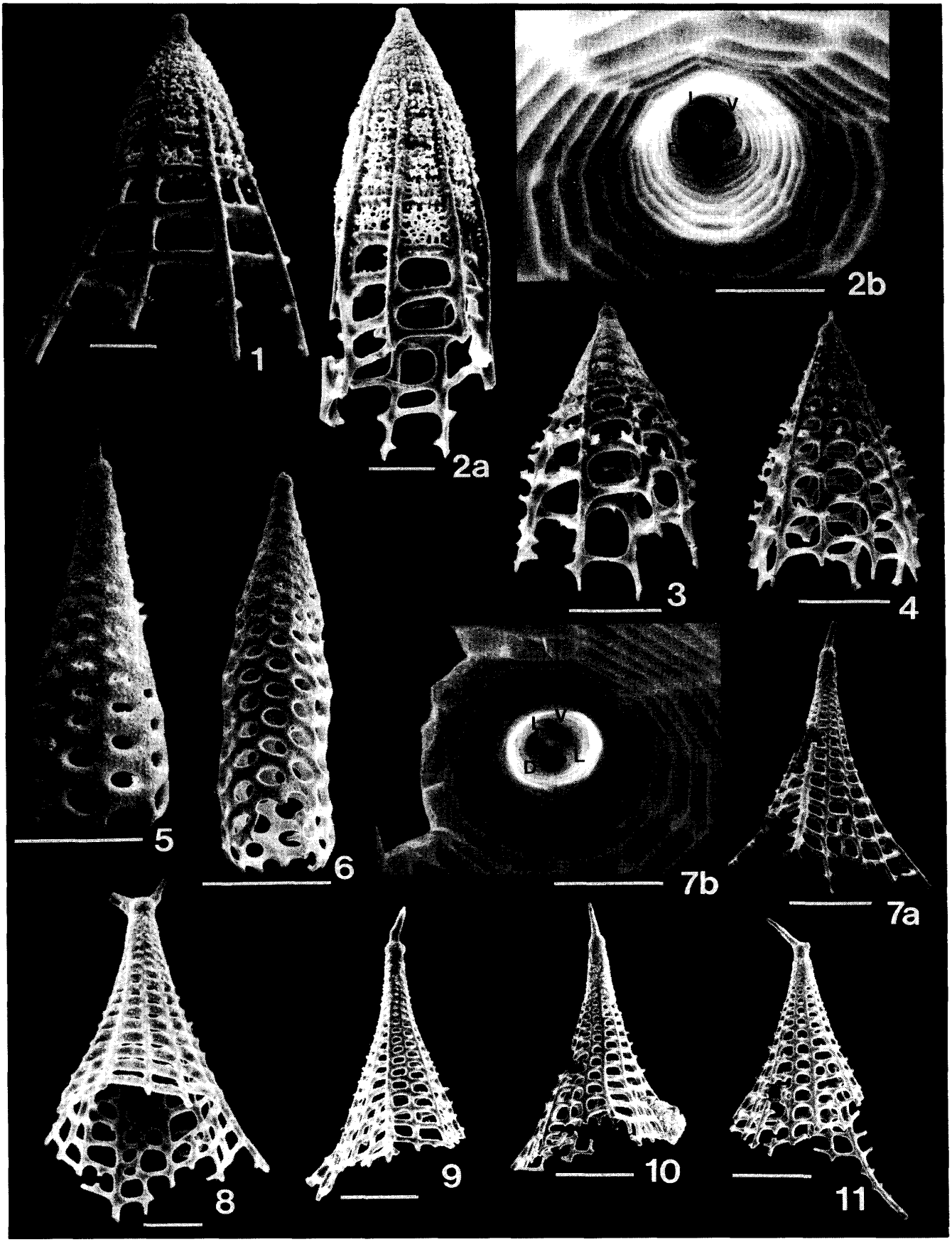
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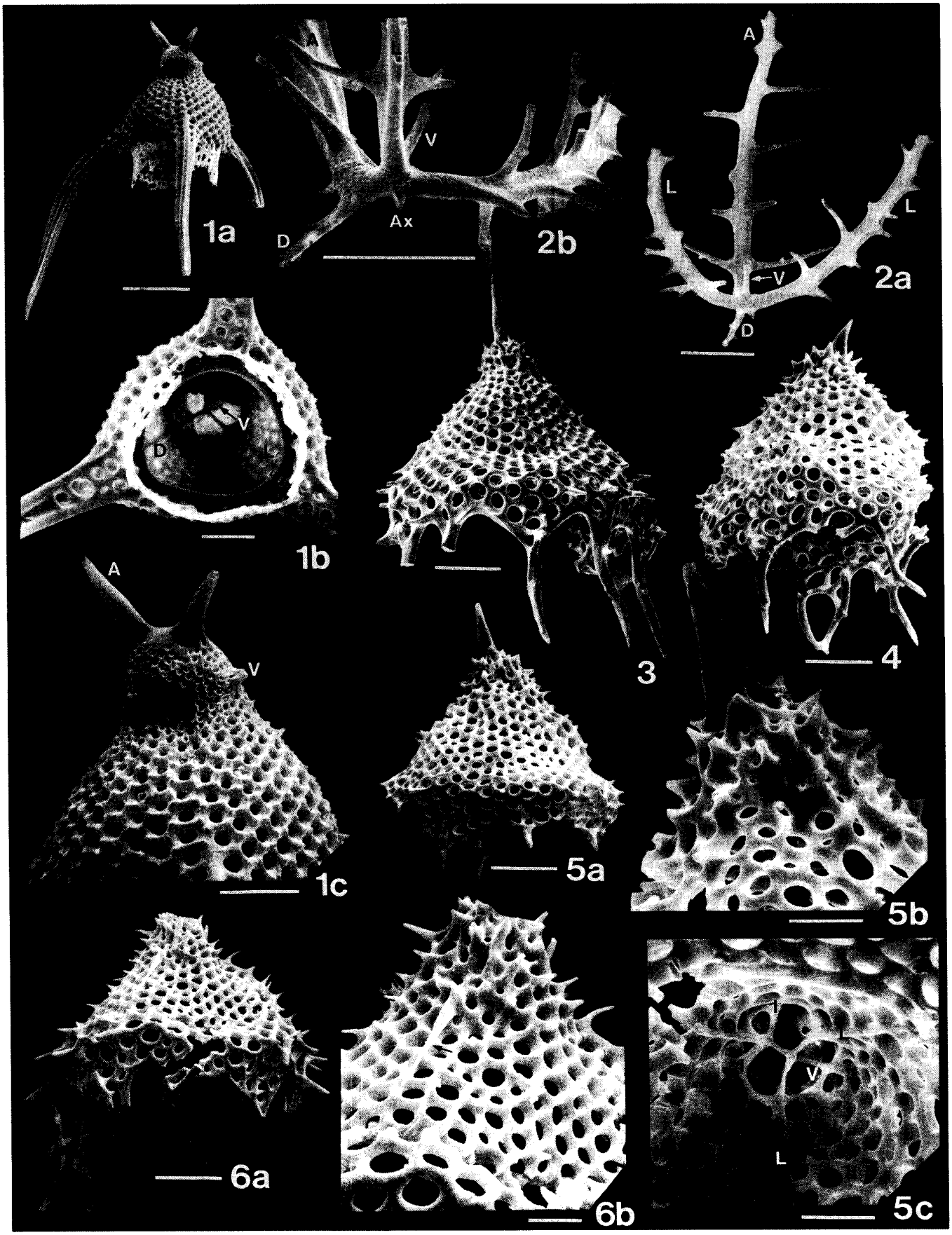
Plate 20

Figs. 1a-1c : *Bekomiforma mynx* Sanfilippo and Riedel.
Fig. 1a : Right lateral view, ESN 146747. Fig. 1b : Basal view of 1a. Fig. 1c : Enlargement of 1a showing the details of the cephalis.
Figs. 2a, 2b : *Neosemantis cladophora* (Jørgensen).
Fig. 2a : Ventral view, ESN 146748. Fig. 2b : Enlargement of 2a, oblique right lateral view.
Figs. 3-6b : *Calocycloma* (?) *cassiopejae* (Haeckel).
Fig. 3 : Oblique dorsal view, ESN 146749.
Fig. 4 : Left latera view, ESN 146750.
Fig. 5a : Right lateral view, ESN 146751. Fig. 5b : Enlargement of the cephalis. Fig. 5c : Basal view showing the internal skeleton.
Fig. 6a : Oblique dorsal view, ESN 146752. The apical spine is broken off. Fig. 6b : Enlargement of 6a. Arrow points to the prolongation of **D.**
Scale bars : 1b, 1c, 2a, 2b, 5b, 5c, 6b=20μm ; others=50μm.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6a
6b
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5c

Plate 21

Figs. 1-3b : *Cycladophora pliocenica* Lombari and Lazarus.
Fig. 1 : Left lateral view, ESN 146753.
Fig. 2 : Left lateral view, ESN 146754.
Fig. 3a : Left lateral view, ESN 146755. Fig. 3b : Basal view showing the internal skeleton.
Figs. 4, 5 : *Cycladophora davisiana cornutoides* Petrushevskaya.
Fig. 4 : Right lateral view, ESN 146756. **A** is broken off.
Fig. 5 : Left lateral view, ESN 146757. **A** and **V** are broken off.
Figs. 6-7b : *Eucecryphalus elizabethae* (Haeckel).
Fig. 6 : Right lateral view, ESN 146758.
Fig. 7a : Left lateral view, ESN 146759. Fig. 7b : Basal view showing the internal skeleton.
Figs. 8-9b : *Gondowanaria campanulaeformis* (Campbell and Clark).
Fig. 8 : Left lateral view, ESN 146760.
Fig.9a : Left lateral view, ESN 146761. Fig. 9b : Basal view showing the internal skeleton. Arrows point to the arches **AL.**
Scale bars : 3b, 7b, 9b=20μm ; others=50μm.

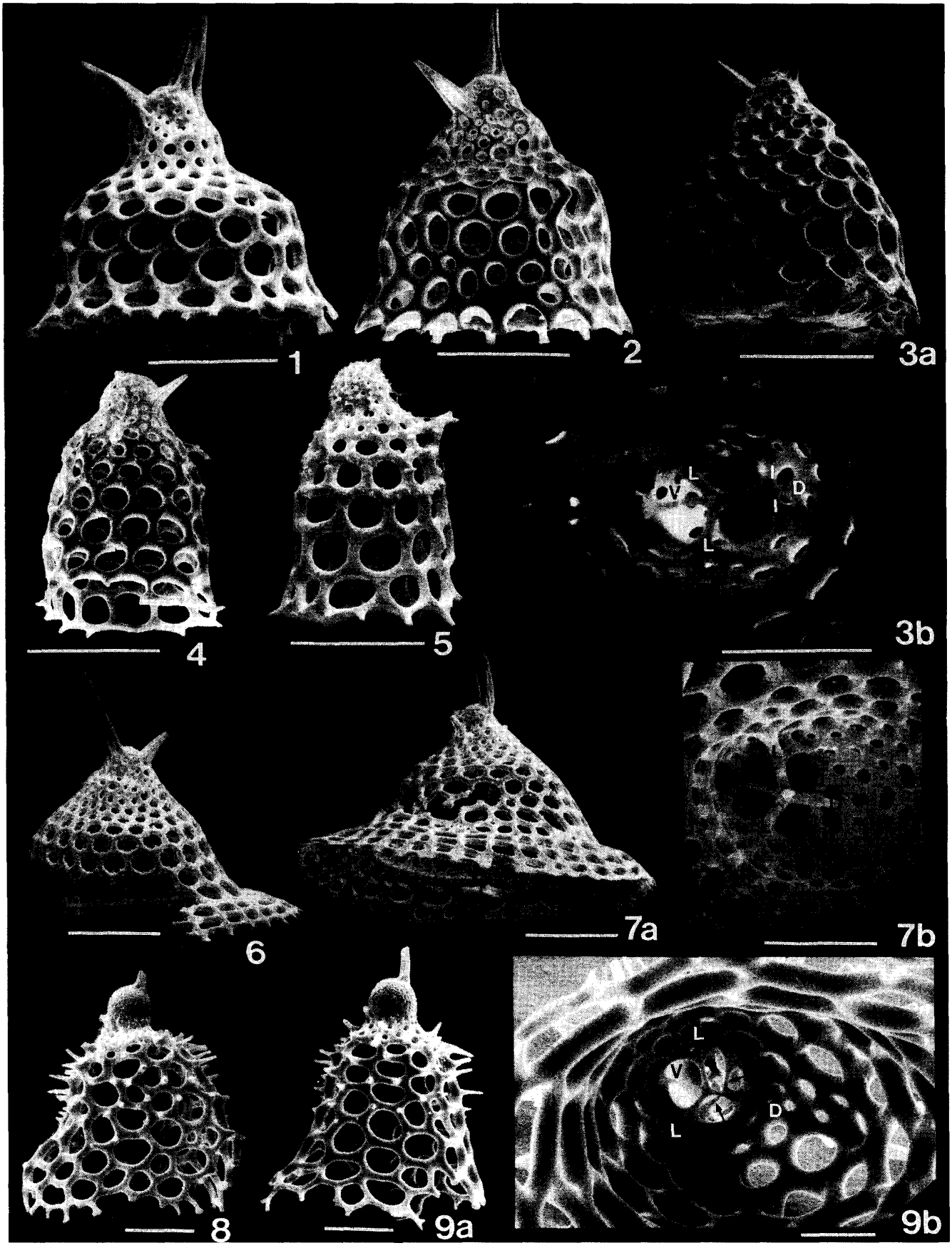
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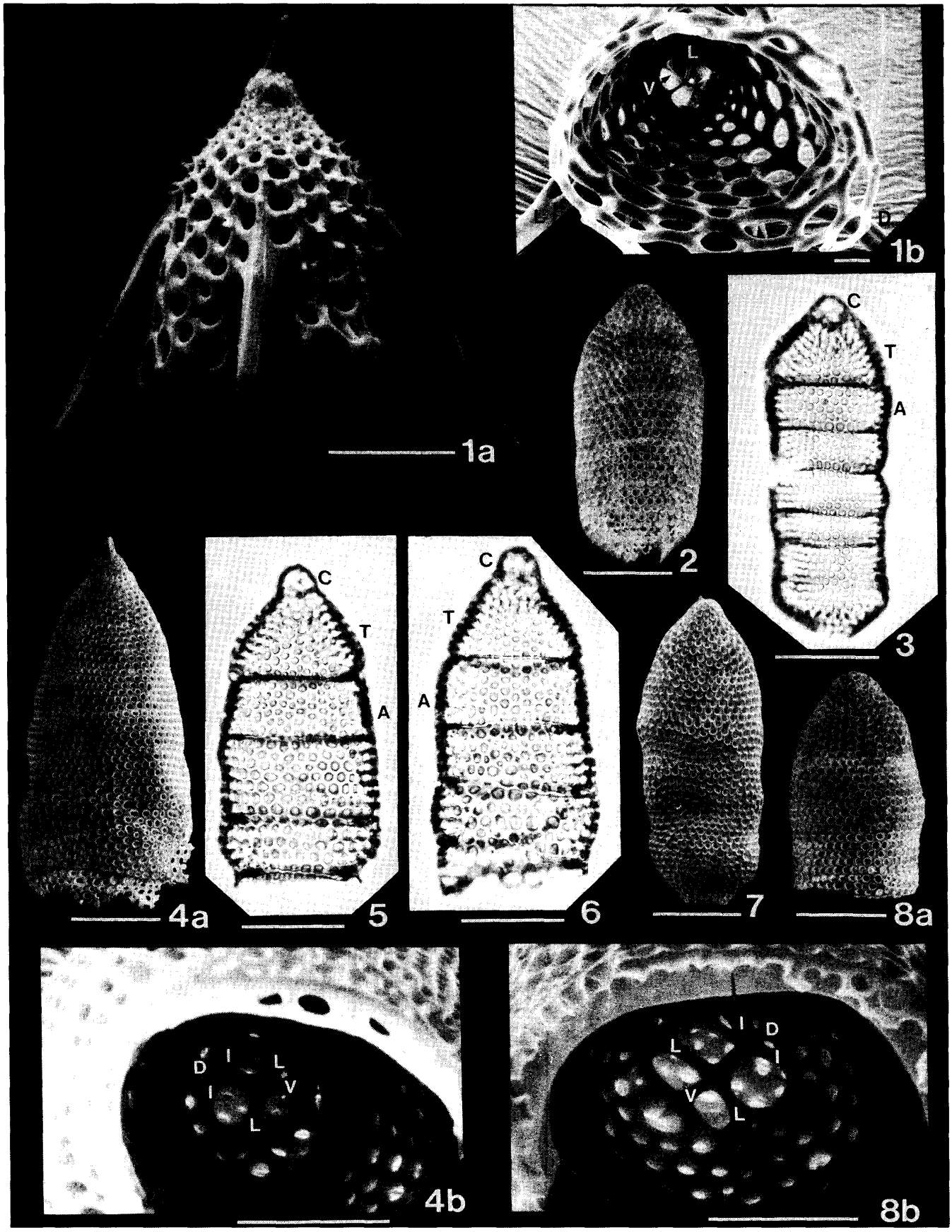
Plate 22

Figs. 1a, 1b : *Dictyophimus crisiae* Ehrenberg.
Fig. 1a : Oblique left lateral view, ESN 146762. Fig. 1b : Basal view of 1a.
Figs. 2v 3, 7-8b : *Lithocampe punctata* Ehrenberg.
Fig. 2 : ESN 146763.
Fig. 3 : Transmitted light micrograph, ESN 146764. C=cephalis, T=Thorax, A=Abdomen. The abbreviations are also applicable to Pl. 22, figs. 5, 6 and Pl. 23, figs. 4, 6a.
Fig. 7 : ESN 146765.
Fig. 8a : ESN 146766. The lower part of the test is broken off. Fig. 8b : Basal view of 7a.
Figs. 4a-6 : *Lithocampe* sp. A
Fig. 4a : ESN 146767. Fig. 4b : Basal view of 4a.
Fig. 5 : Transmitted light micrograph, ESN 146768.
Fig. 6 : Transmitted light micrograph, ESN 146769.
Scale bars : 1b, 4b, 7b=20μm ; others=50μm.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8a
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I
L
V
I
L
4b
I
D
L
I
V
L
8b

Plate 23

Figs. 1-5 : *Eucyrtidium calvertense* Martin group.
Fig. 1 : ESN 146770.
Fig. 4 : ESN 146771.
Fig. 3a : ESN 146772. Fig. 3b : Basal view showing the internal skeleton.
Fig. 4 : ESN 146773.
Fig. 5 : ESN 146774.
Figs. 6a-9 : *Eucyrtidium lene* Sugiyama sp. nov.
Fig. 6a : Holotype, transmitted light micrograph, focus on the cephalis. ESN 146775. Fig. 6b : Focus on the shell surface.
Fig. 7a : Paratype, ESN 146776. Fig. 7b : Basal view of 7a showing the aperture.
Fig. 8 : Paratype, ESN 146777.
Fig. 9 : Paratype, ESN 146778.
Scale bars : 3b, 7b=20μm ; others=50μm.

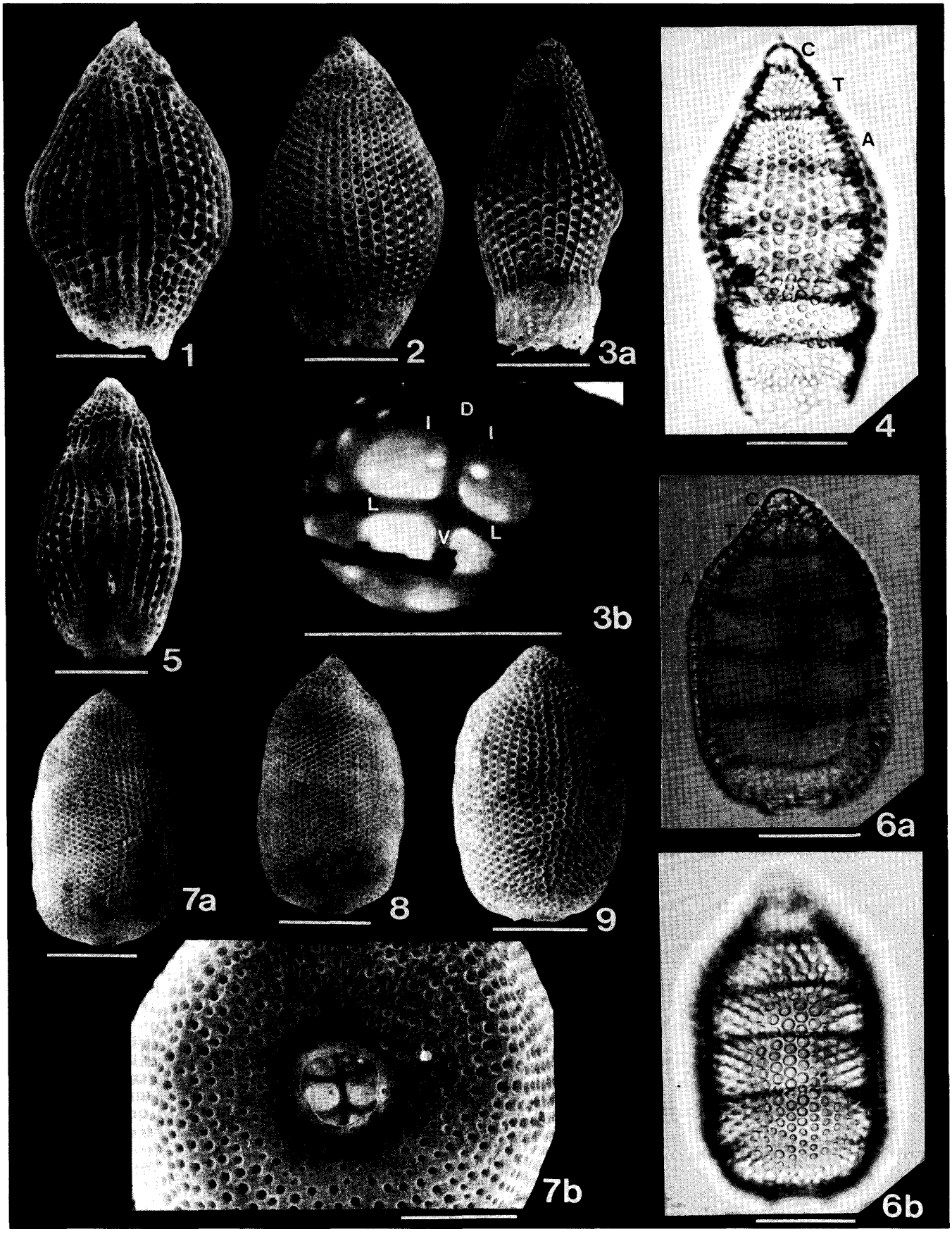
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Plate 24

Fig. 1 : *Lipmanella irregularis* (Cleve), right lateral view, ESN 146779. **A** is broken off.
Figs. 2a, 2b : *Eucyrtidium* (?) *anomalum* (Haeckel).
Fig. 2a : Right lateral view, ESN 146780. Fig. 2b : Enlargement of the cephalis.
Figs. 3, 4 : *Stichocorys peregrina* (Riedel).
Fig. 3 : Oblique ventral view, ESN 146781.
Fig. 4 : Left lateral view, ESN 146782.
Figs. 5a-6 : *Pterocanium korotnevi* (Dogiel).
Fig. 5a : Oblique ventral view, ESN 146783. Fig. 5b : Basal view showing the internal skeleton.
Fig. 6 : Dorsal view, ESN 146784.
Figs. 7-8b : *Pterocanium charybdeum* (Müller).
Fig. 7 : Dorsal view, ESN 146785.
Fig. 8a : Left lateral view, ESN 146786. Fig. 8b : Basal view showing the internal skeleton.
Scale bars : 2b, 5b, 8b=20μm ; others=50μm.

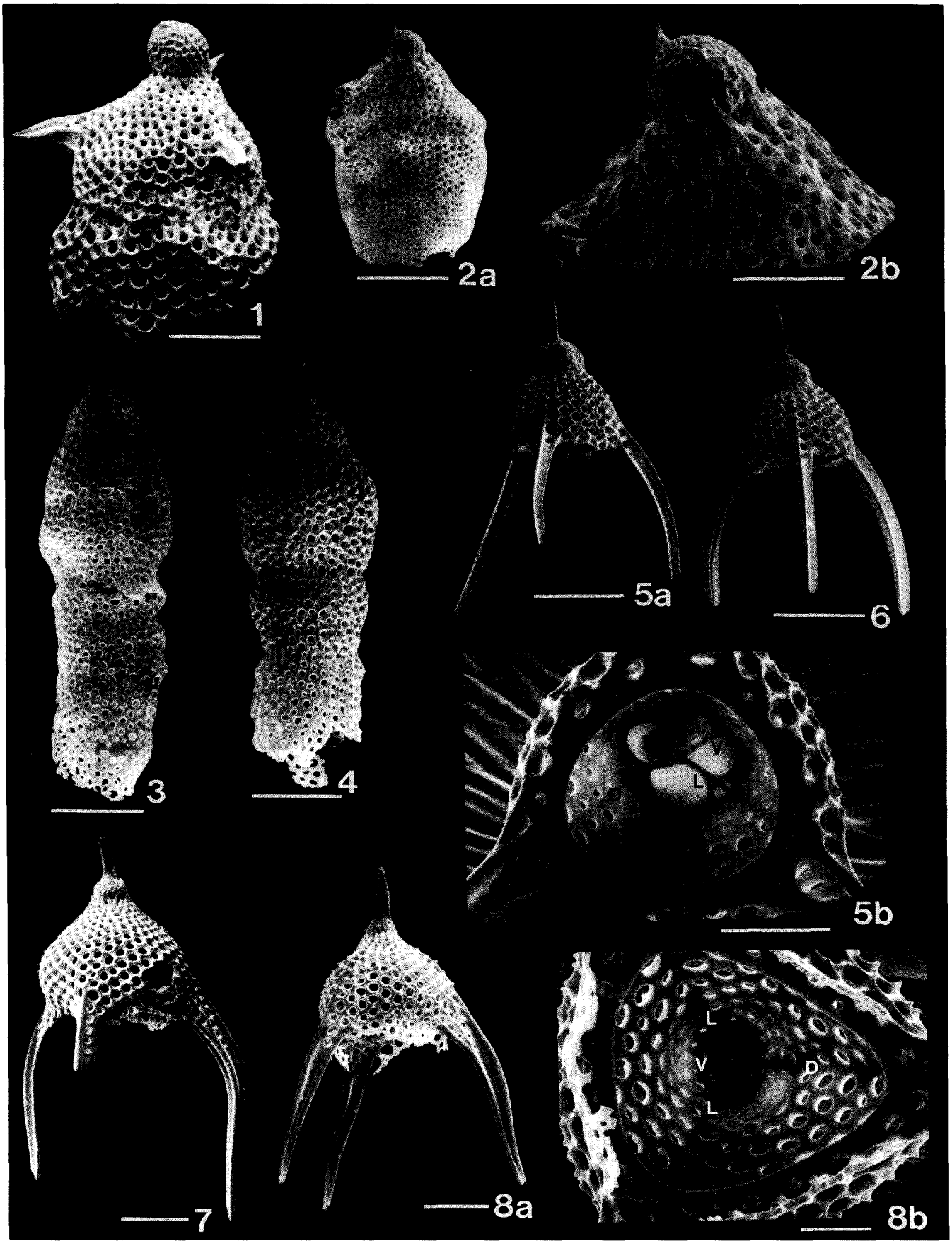
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Plate 25

Figs. 1a-2 : *Pterocanium praetextum eucolpum* Haeckel.
Fig. 1a : Left lateral view, ESN 146787. Fig. 1b : Enlargement of the cephalis. Fig. 1c : Basal view of 1a showing the internal skeleton.
Fig. 2 : Left lateral view, ESN 146788.
Figs. 3a-4c : *Pterocanium diplotriaena* (Dogiel).
Fig. 3a : Right lateral view, ESN 146789. Fig. 3b : Enlargement of the cephalis. Fig. 3c : Basal view showing the internal skeleton.
Fig. 4a : Right lateral view, ESN 146790. Fig. 4b : Enlargement of the cephalis. Fig. 4c : Basal view showing the internal skeleton.
Figs. 5v 6 : *Anthocyrtidium nosicaae* Caulet.
Fig. 5 : Left lateral view, ESN 146791.
Fig. 6 : Right lateral view, ESN 146792.
Scale bars : 1b, 1c, 3b, 3c, 4b, 4c=20μm ; others=50μm.

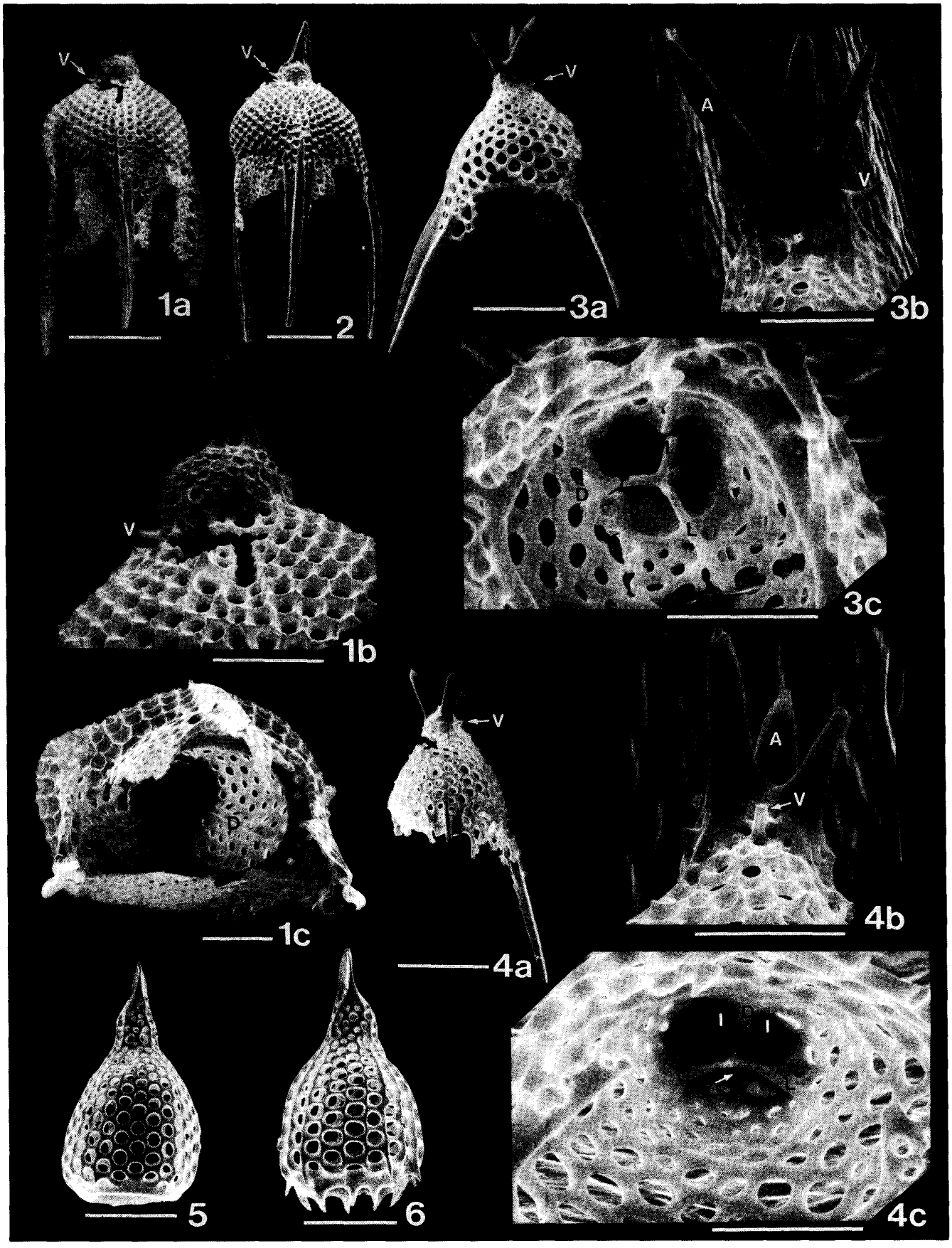
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Plate 26

Figs. 1-2b : *Anthocyrtidium ophirense* (Ehrenberg).
Fig. 1 : Right lateral view, ESN 146793.
Fig. 2a : Left lateral view, ESN 146794. Fig. 2b : Basal view showing the internal skeleton. Arrows point to the arches **AL.**
Figs. 3-5b : *Lamprocyclas aegles* (Ehrenberg).
Fig. 3 : Oblique ventral view, ESN 146795.
Fig. 4 : Right lateral view, ESN 146796.
Fig. 5a : Left lateral view, ESN 146797. Fig. 5b : Basal view showing the internal skeleton. Arrow points to the arch **AL.**
Figs. 6a-8 : *Lamprocyclas margatensis* (Campbell and Clark).
Fig. 6a : Left lateral view, ESN 146798. Fig. 6b : Enlargement of 6a showing the details of the cephalis and upper half of the thorax. Fig. 6c : Basal view showing the internal skeleton.
Fig. 7 : Right lateral view, untypical form with a distinct lumbar stricture, ESN 146799.
Fig. 8 : Left lateral view, ESN 146866.
Scale bars 2b, 5b, 6b, 6c=20μm ; others=50μm.

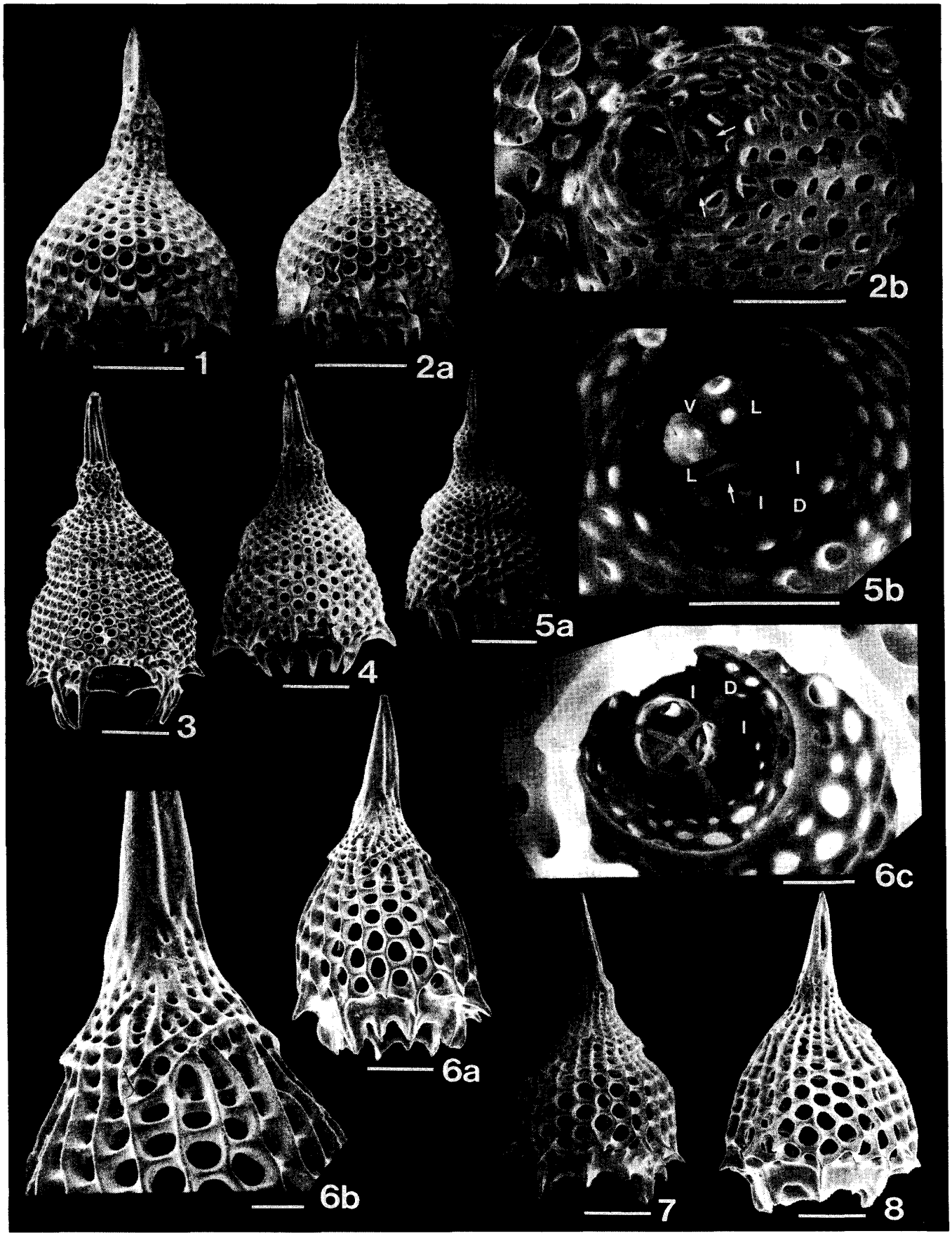
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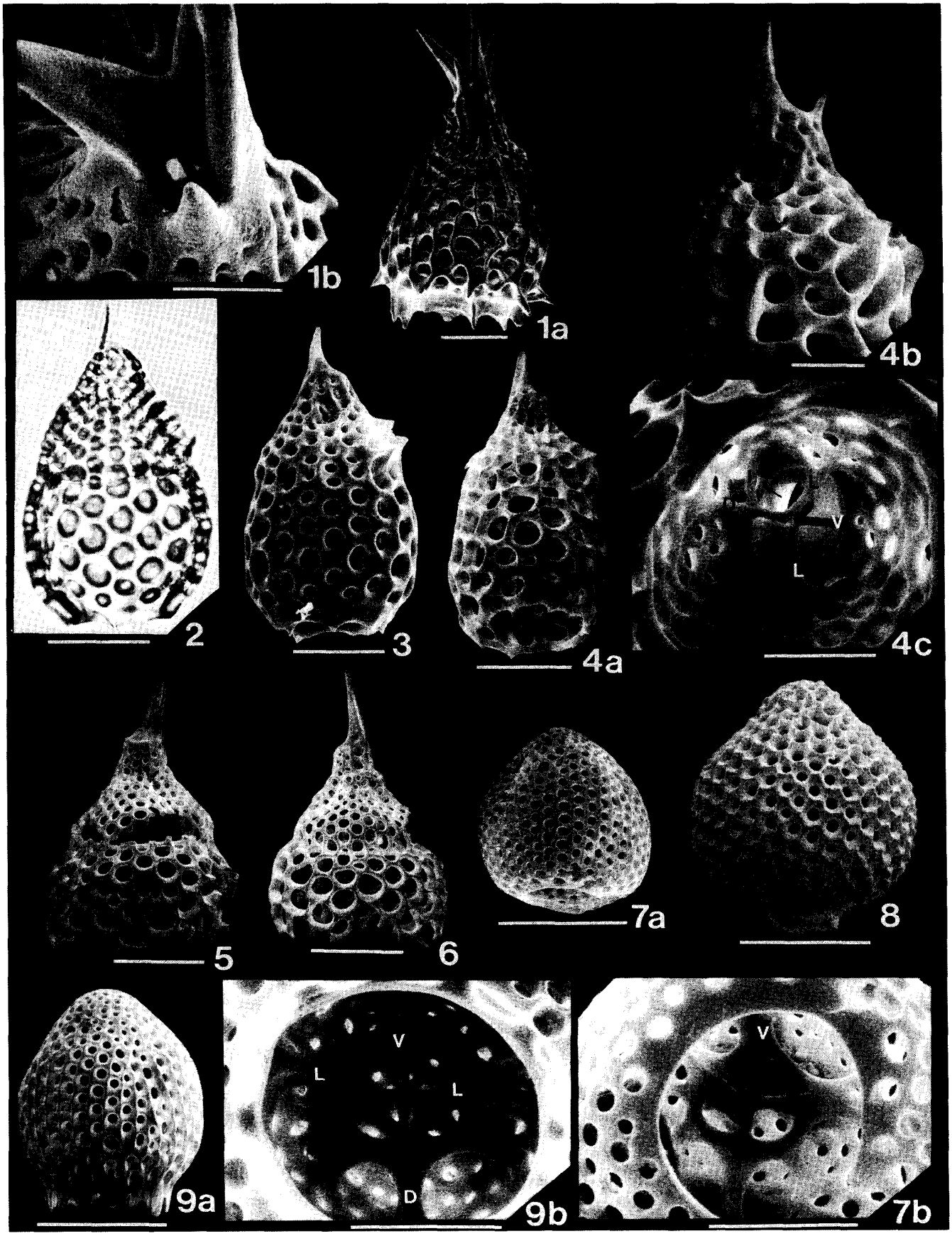
Plate 27

Fig. 1a, 1b : *Lamprocyclas* sp. A.
Fig. 1a : Left lateral view, ESN 146801. Fig. fb : Apical view of the flared apical spine.
Figs. 2-4c : *Lamprocyrtis junonis* (Haeckel).
Fig. 2 : Right lateral view transmitted light micrograph, ESN 146802.
Fig. 3 : Right lateral view, ESN 146803.
Fig. 4a : Right lateral view, ESN 146804. Fig. 4b : Enlargement of 4a showing the details of the cephalis and upper half of the thorax. Fig. 4c : Basal view showing the internal skeleton. Arrows point to the arches **AL**.
Figs. 5, 6 : *Lamprocyrtis heteroporos* (Hays).
Fig. 5 : Left lateral view, ESN 146805.
Fig. 6 : left lateral view, ESN 146806.
Figs. 7a-9b : *Carpocanistrum* spp.
Fig. 7a : Ventral view, ESN 146807. Fig. 7b : Basal view showing the internal skeleton.
Fig. 8 : Ventral view, ESN 146808.
Fig. 9a : Ventral view, ESN 146809. Fig. 9b : Basal view showing the internal skeleton.
Scale bars : 1b, 4b, 4c, 7b, 9b=20μm ; others=50μm.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7b

Plate 28

Fig. 1a-2b : *Botryostrobus auritus* (Ehrenberg).
Fig. 1a : Left lateral view, ESN 146810. Fig. 1b : Enlargement of the cephalis showing the vertical pore, ventral view.
Fig. 2a : Right lateral view, ESN 146811. Fig. 2b : Basal view showing the internal skeleton.
Figs. 3a, 3b : *Botryostrobus aquilonaris* (Bailey).
Fig. 3a : Left lateral view, ESN 146812. Fig. 3b. Basal view showing the internal skeleton.
Fig. 4 : *Phormostichoartus* sp. aff. *P. corbula* (Harting), left lateral view, ESN 146813.
Fig. 5 : *Spirocyrtis scalaris* Haeckel, right lateral view, ESN 146814.
Figs. 6, 7 : *Carpocanarium urna* (Stöhr).
Fig. 6 : Right lateral view, ESN 146815.
Fig. 7 : Oblique dorsal view, ESN 146816.
Figs. 8a, 8b : *Acanthodesmia vinculata* (Müller).
Fig. 8a : Ventral view, ESN 146817. Fig. 8b : Basal view of 8a.
Scale bars : 1b, 2b, 3b, 8b=20μm ; others=50μm.

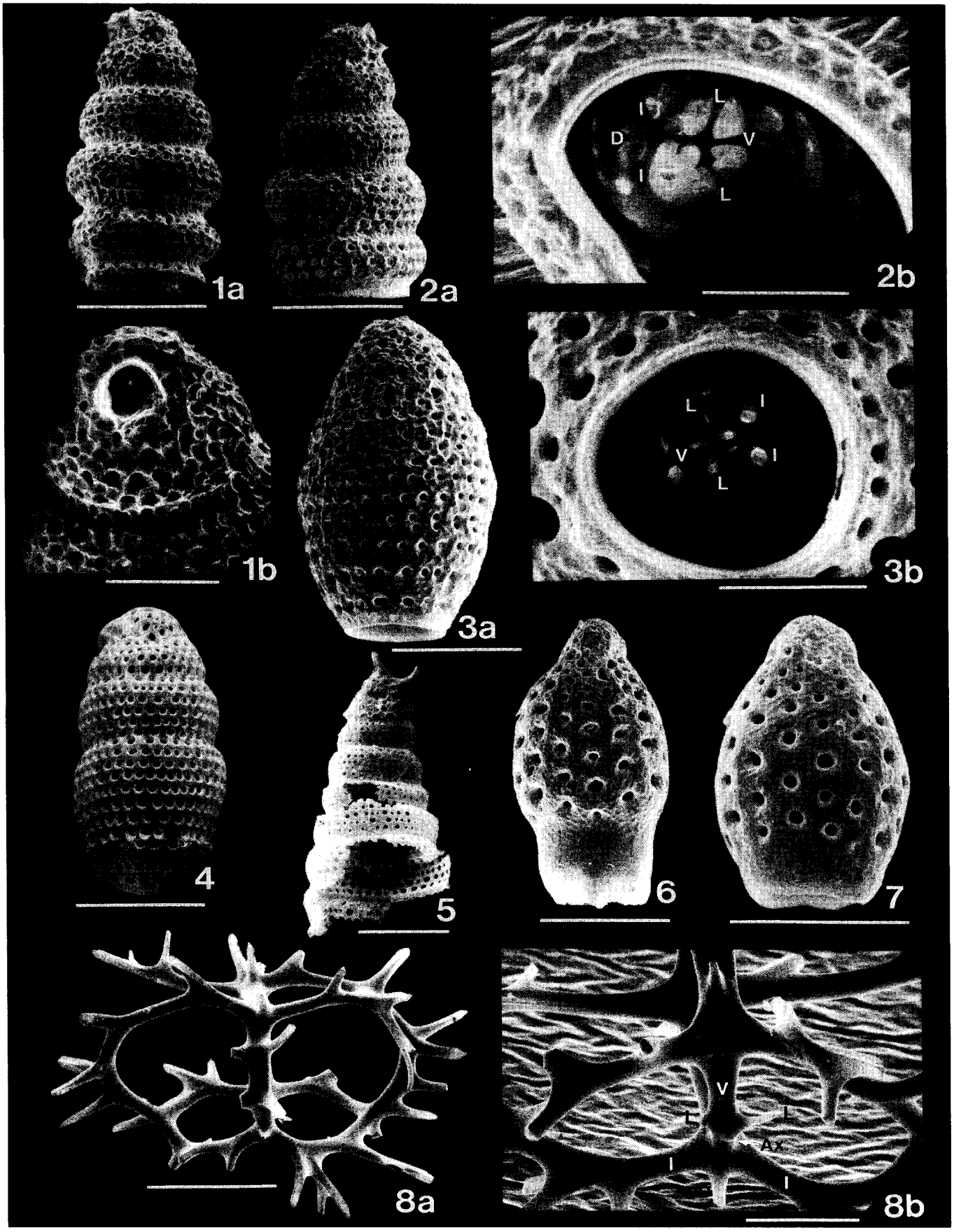
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Plate 29

Figs. 1a, 1b : *Corythospyris damaecornis* (Haeckel).
Fig. 1a : Ventral view, ESN 146818. Fig. 1b : Oblique basal view of 1a.
Fig. 2 : *Liriospyris* sp. aff. *L. hyperborea* (Jørgensen), ventral view, ESN 146819.
Fig. 3, 6 : *Liriospyris scaphipes* (Haeckel).
Fig. 3 : Dorsal view, ESN 146820.
Fig. 6 : Ventral view, ESN 146821.
Fig. 4 : *Liriospyris capoi* (Goll), ventral view, ESN 146822.
Fig. 5 : *Liriospyris* sp. aff. *L. capoi* (Goll), dorsal view, ESN 146823.
Figs. 7, 8 : *Lophospyris muelleri* (Stöhr).
Fig. 8 : Ventral view, ESN 146824.
Fig. 8 : Oblique ventral view, broken specimen, ESN 146825.
Figs. 9-10b : *Zygocircus productus* (Hertwig).
Fig. 9 : Right lateral view, ESN 146826.
Fig. 10a : Left lateral view, ESN 146827. Fig. 10b : Enlargement of 10a.
Scale bars are 20μm.

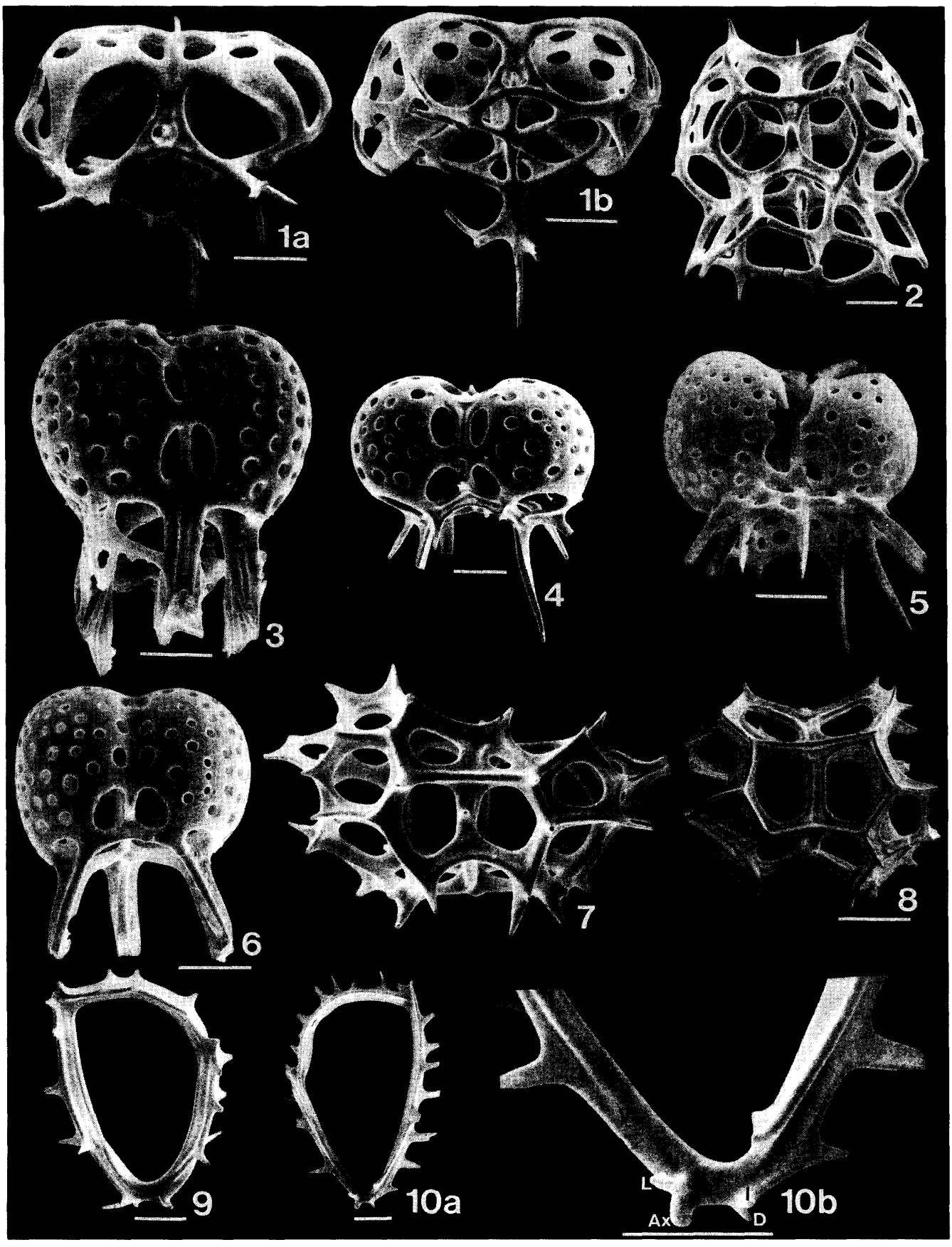
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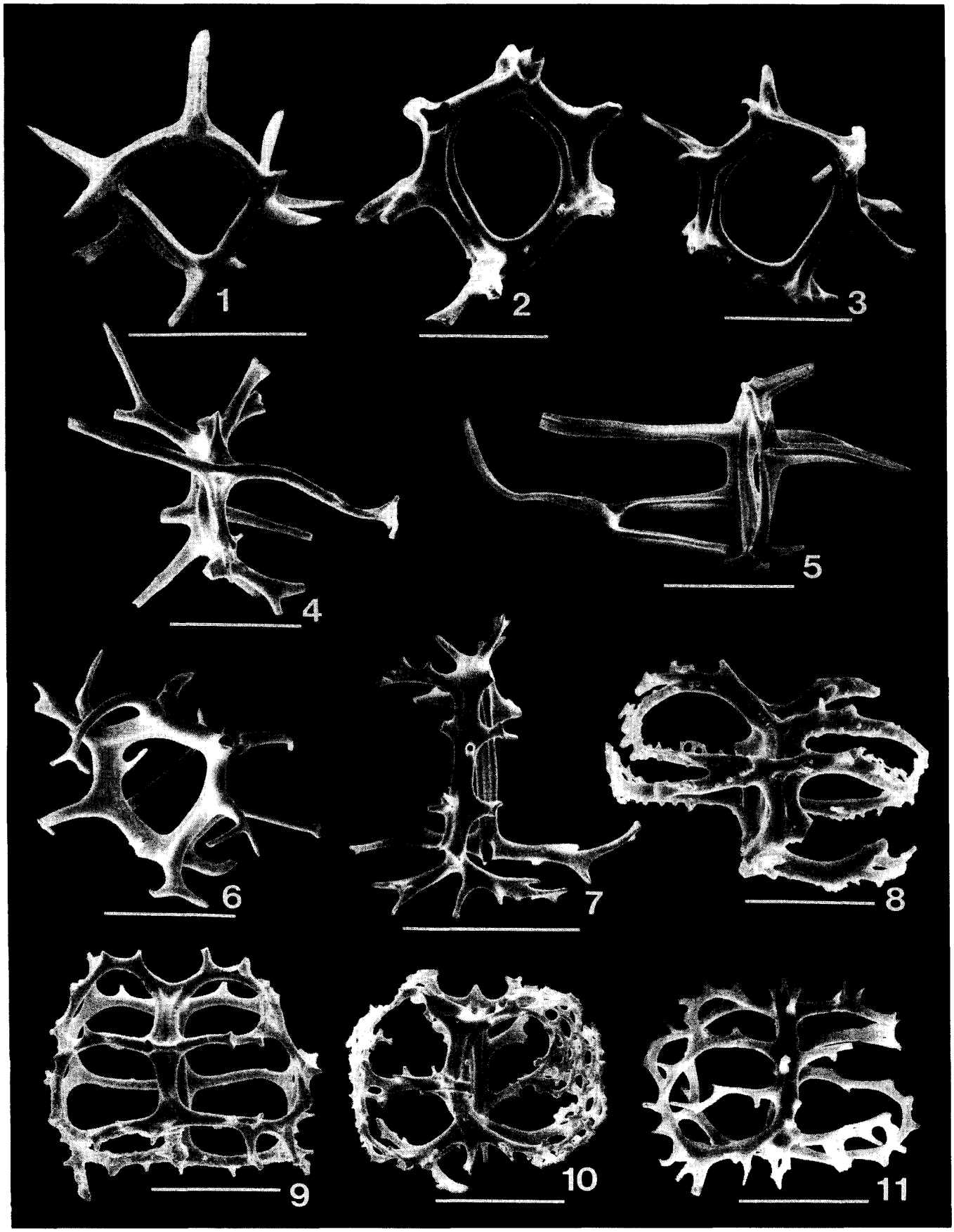
Plate 30

Fig. 1 : *Lithocircus* sp. A, right lateral view, ESN 146828.
Figs. 2-11 : *Lithocircus* spp, ESN 146829-38.
Figs. 1, 2, 3, 6 are lateral view, whereas others are sagittal view.
Scale bars are 50μm.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