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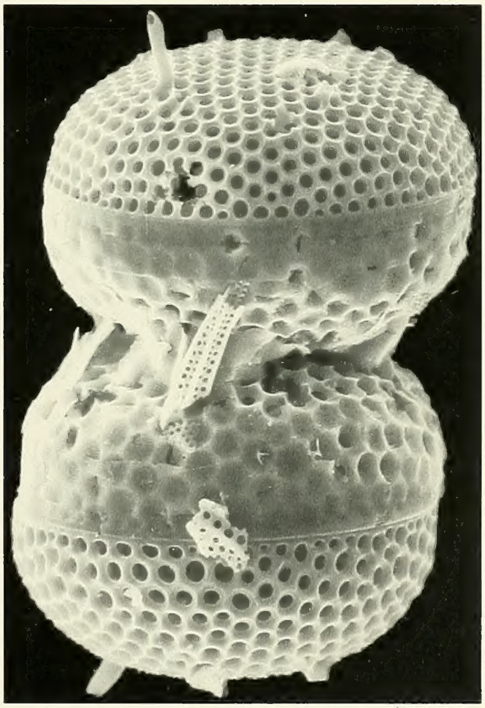


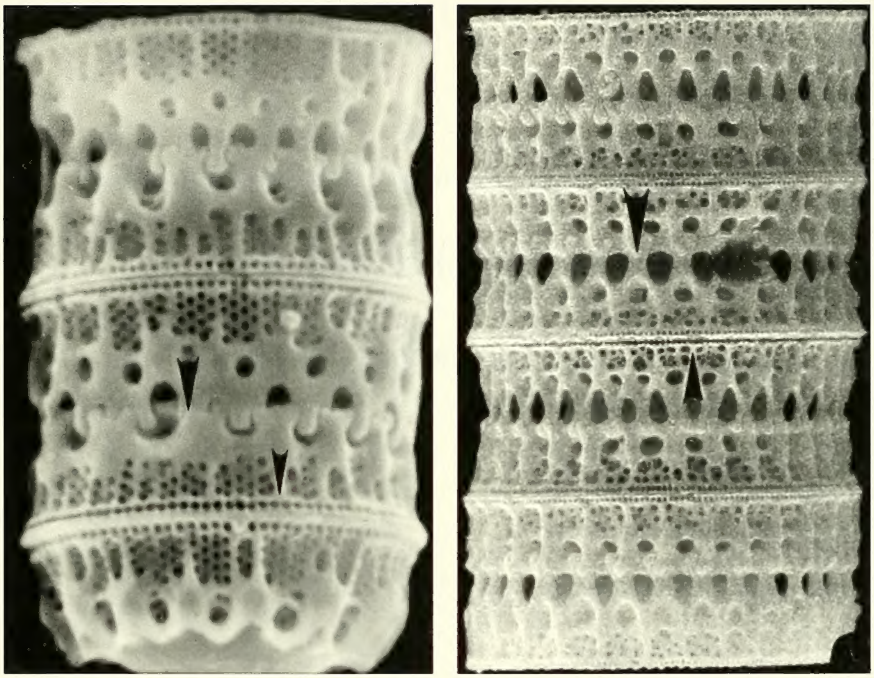
Stephanopyxis appendiculata Ehrenberg

California Academy of Sciences
San Francisco, California

Late Cretaceous Diatoms (Bacillariophyceae)

from the Marca Shale Member of the

Moreno Formation, California



Paralia crenulata (Grunow) Gleser
Late Cretaceous–Oligocene, marine

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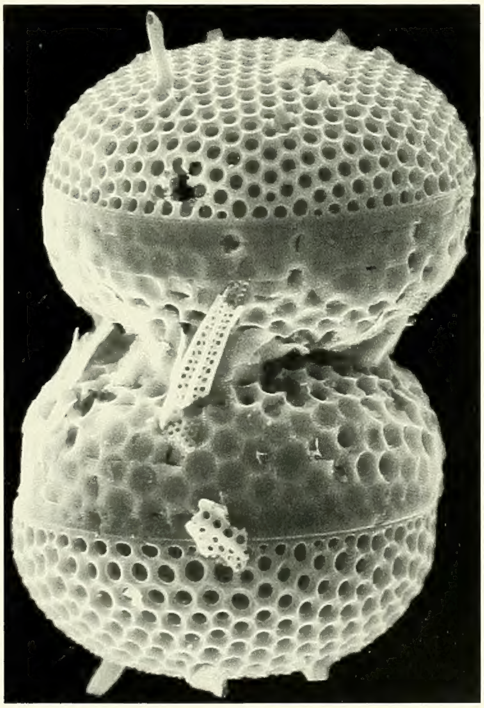

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LATE CRETACEOUS DIATOMS (BACILLARIOPHYCEAE) FROM THE MARCA SHALE MEMBER OF THE MORENO FORMATION, CALIFORNIA

By

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The morphology of 49 species of diatoms from the Upper Cretaceous Marca Shale Member of the Moreno Formation, California is documented by light and scanning electron microscopy. The arrangement of diatom taxa is in accordance with a recent classification of centric diatoms. Six new combinations are described herein, including: *Trigonium hertleinii* (Hanna) Nikolaev & Fourtanier comb. nov.; *Medlinia deciusii* (Hanna) Nikolaev & Kociolek comb. nov.; *Medlinia mucronata* (Schmidt) Nikolaev & Barron comb. nov.; *Sheshukovia excavata* (Heiberg) Nikolaev & Harwood comb. nov.; *Acanthodiscus paterus* (Long, Fuge & Smith) Nikolaev & Fourtanier comb. nov.; *Acanthodiscus immaculatus* (Hanna) Nikolaev & Barron comb. nov.

Keys words: Bacillariophyceae, marine fossil diatoms, Upper Cretaceous, Maastrichtian, morphology, taxonomy, Moreno Formation, Marca Shale Member.

Studies of Late Cretaceous diatoms have been largely superficial in nature, consisting mostly of biostratigraphic papers with little detailed treatment of diatom ultrastructure and classification. The relatively few scanning electron microscope (SEM) studies of Late Cretaceous diatoms that have been published treat only a fraction of the documented diatom flora.

The Marca Shale Member of the Moreno Formation of California is perhaps the most well known of Upper Cretaceous diatom deposits. This deposit offers a valuable record of a rich diatom assemblage that lived during the Late Cretaceous (Maastrichtian).

The history of taxonomic research on diatoms of the Marca Shale is modest. The first description of these fossils was produced by Hanna (1927) who presented a short follow-up report seven years later (Hanna 1934). In these two works, Hanna listed a total of 40 species, which included 7 new genera and 28 new species. Léfébure and Chenevière (1939) described the new species *Kittonia hannai* Léfébure & Chenevière based on materials collected by Hanna. Long, Fuge and Smith (1946) considered 116 taxa in their study of Cretaceous diatoms from the Marca Shale Member including three new genera, 67 new species and 11 new varieties. Analysis of the taxonomic composition of the fossil diatoms described by Long, Fuge and Smith (1946), guided by recent knowledge of Late Cretaceous diatoms, indicates that many species (more than 60%) are not from the Cretaceous Marca Shale Member, but are from deposits of a younger age, likely Eocene. This was confirmed during our studies of original materials from the collection of Long et al., received by the Diatom Collection at the Academy of Sciences of California from the estate of the late Victor Porguen.

In a series of short reports, Barker and Meakin (1944/1945, 1945, 1946, 1948, 1949) described two new genera, *Pomphodiscus* (*P. morenoensis* Barker & Meakin) and *Tortilaria* (*T. briggeri* Barker & Meakin) and 13 new species from the Marca Shale, including *Arachnoidiscus antiquus* Barker & Meakin, *A. interruptus* Barker & Meakin, *Eupodiscus vallatus* Barker & Meakin, *Kittonia pentagona* Meakin & Brigger and *Pyxilla capitata* Barker & Meakin.

Recent efforts to document the diatoms from the Marca Shale Member began with morphological studies of several species using scanning electron microscopy (SEM). Nikolaev (1983), and later Sims & Hasle (1987), investigated species of the genus *Stellarima*. The morphology of *Thalassiosiropsis wittiana* was studied by Hasle and Syvertsen (1985). Sims (1986, 1989, 1994) documented the morphology of *Sphynctolethus monstrosus, Coscinodiscus solidus, Benetorus fantasmus, Azpeiti-opsis morenoensis*, and species of the genus *Pomphodiscus*. *Pomphodiscus* is discussed by Sims & Ross (1988). Ross & Sims (1997) studied the morphology of *Trinacria fimbriata* Sims & Ross and *Actinodictyon uncum* (Long, Fuge & Smith) Ross & Sims. In a review of Cretaceous diatoms by Harwood & Nikolaev (1995), short remarks on the morphology of several diatom species from the Marca Shale Member were presented. Nikolaev and Harwood (2000a) addressed the taxonomic position of *Pomphodiscus*, described originally from the Marca Shale Member (Long et al. 1946). Sims (2000) studied some species from the genera *Triceratium, Lithodesmium* and *Eunotogramma*, based on Marca Shale Member material from the Long, Fuge and Smith collection. She established a new genus, *Euodiella*, with the generitype *E. bicornigera* (Hanna) Sims.

Appendix B contains the names of all taxa previously reported from Cretaceous sediments in California. In total, 56 genera and 174 species and varieties of diatoms have been reported. Two genera (*Aulacodiscus, Coscinodiscus*) each have 19 representatives, two others (*Triceratium, Biddulphia*) are represented by 12 taxa each, *Auliscus* has 11 representatives and *Actinoptychus* has 10 taxa. There are a total of 34 genera that are represented by a single taxon in this flora.

Based on our studies of the Marca Shale Member, more than 60% of the Latin names listed in Appendix B either belong to Eocene, not Cretaceous, assemblages or are synonymous with other names in the list. These are indicated as such in Appendix B. Thus, we conclude that the total number of Cretaceous diatoms in the Marca Shale Member includes not more than 63 species. It can be assumed that the diatoms described by Long, Fuge, and Smith (1946) included some from samples collected from the Eocene Kreyenhagen Formation, which is exposed a short distance to the east.

Knowledge of the taxonomic composition of this flora is important for paleoenvironmental reconstruction and biostratigraphic studies. Documentation of fossil diatoms from deposits like the Marca Shale Member will lead to the construction of a more natural system of classification that is based on a greater knowledge of the early evolutionary history of this important group of algae.

The object of the present report is to document and investigate the morphology of species from the Marca Shale Member of the Moreno Formation of California. We describe the morphology of the type specimens and estimate their taxonomic position in accordance with a recent system of classification of centric diatoms (Nikolaev & Harwood 2000b). We do not present the composition of diatoms in each sample, but anticipate that the current work will prompt a detailed biostratigraphic study of this deposit to mirror the recent descriptive sedimentology of the Moreno Formation by Fonseca-Rivera (1997).

MATERIALS AND METHODS

GEOLOGICAL SETTING

The Upper Cretaceous and lower Paleocene Moreno Formation is exposed along the western edge of the San Joaquin Valley in central California (Fig. 1). The formation is divided into four, lithologically distinct members, which include, from oldest to youngest, the Dosados, Terra Loma, Marca, and Dos Palos members. The Marca Shale Member includes laminated diatomaceous and phosphatic sediments that were deposited in a coastal upwelling environment on the slope and outer shelf during the latest Cretaceous. Since the 1920s, Late Cretaceous diatoms and silicoflagellates have been studied from three main sections of the Marca Shale Member: (1) Moreno Gulch (Hanna 1927); (2) Marca Canyon (Long et al. 1946); and (3) Dosados Canyon (Hanna 1928; 1934). Diatoms have not been re-

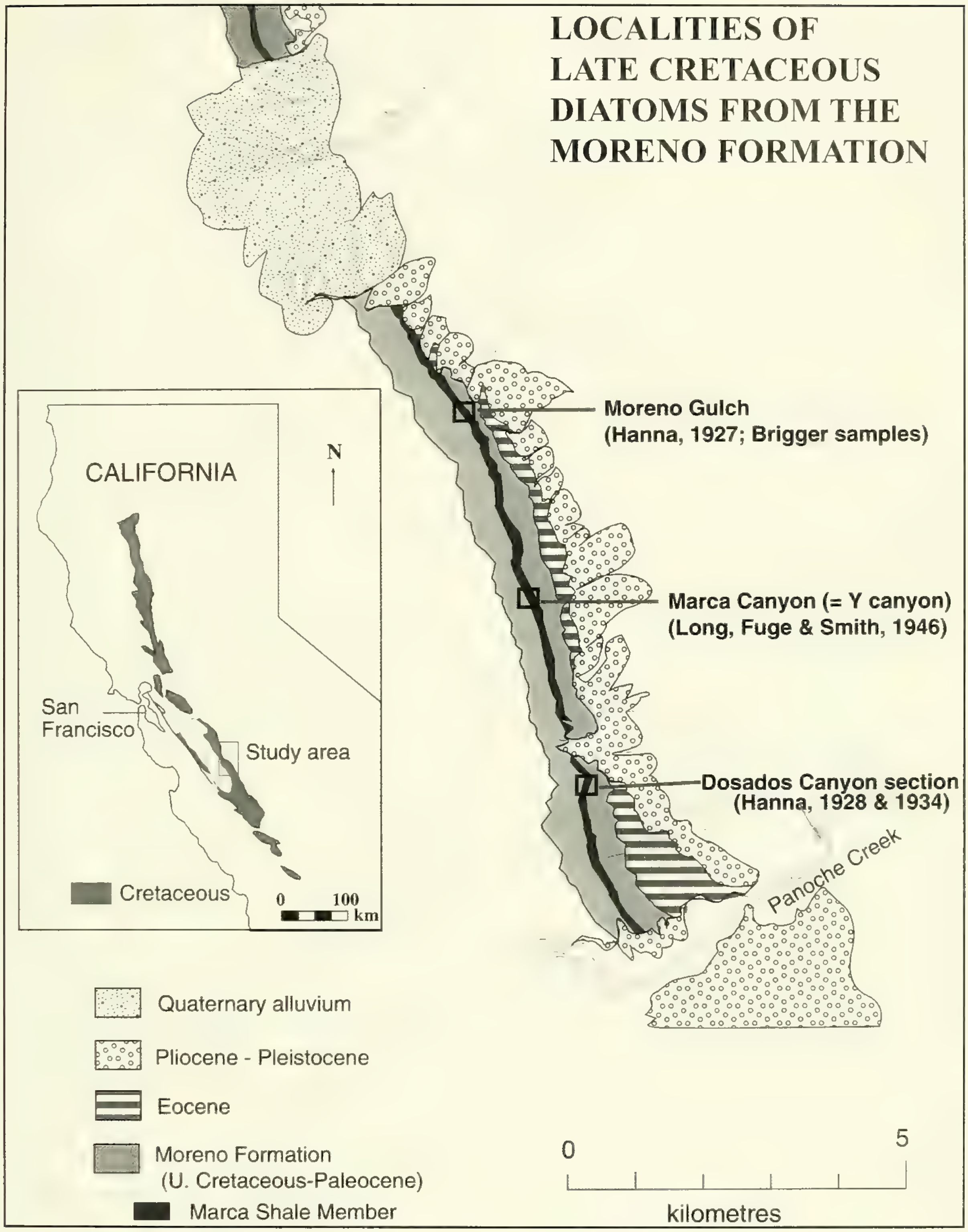

FIGURE 1. Localities of Late Cretaceous diatoms from the Marca Shale Member of the Moreno Formation, California.

ported from the other members of the Moreno Formation (Fonseca-Rivera, 1997; Barron, unpublished notes), which are more detrital in composition than the Marca Shale Member.

The Marca Shale Member crops out for about 15 km along the eastern flank of the Diablo Range in central California (Fig. 1). A stratigraphic thickness of 124 m has been measured in Dosados Canyon by Fonseca-Rivera (1997), who identified the Cretaceous-Tertiary boundary near the top of the Marca Shale Member, based on foraminiferal biostratigraphy. Unfortunately, diatom preservation is poor in the upper 10 m of the Marca Shale Member, and diatoms are not preserved across the Cretaceous-Tertiary boundary at this section.

Fonseca-Rivera (1997) observed distinct cyclical changes in coloration and cementation in the Marca Shale Member outcrops at Dosados Canyon. Buff and dark brown shale subunits alternate with one another, forming four distinct subunits that can be correlated for long distances along strike. The buff-colored shales are more diatom-rich, and display both massive and laminated texture, whereas the darker shales are more terrigenous-rich and contain fewer and more poorly-preserved diatom assemblages.

Planktonic and benthic foraminifers, dinoflagellates, and radiolarians place the Marca Shale Member in the uppermost Maastrichtian Stage, the terminal stage of the Cretaceous (Fonseca-Rivera, 1997). Based on identification of the Cretaceous-Tertiary boundary near the top of the Marca Shale Member and sedimentation rates that were estimated by 'varve' counting to range between about 45 and 75 cm/1000 yr., Fonseca-Rivera (1997) suggested that the Marca Shale Member represents about 1 million years of deposition, between ca. 66 and 65 Ma.

SELECTION OF SAMPLES FOR STUDY

Materials for this study came from the collections at the California Academy of Sciences. (Table 1). Material may be separated into two groups of samples. The first group includes samples from the collection reported by Hanna (1927) and by Brigger. The date of collection, location and age of the Hanna samples is known, they are from the Maastrichtian Moreno Formation. The samples from Brigger's collection are less well documented as the date and location of the samples and the stratigraphic position is unknown.

Other samples studied for this report (CAS 1144 and 610939) are from Moreno Gulch, northeast corner of Sec. 11, T.14S, R.11E or 36°44'N, 120°38'W. Samples from this locality were also studied by Hanna (1927)(Fig. 1).

The second group of samples was selected from 28 diatom-rich samples of the Victor Porguen collection, and designated as coming from the collection of Long, Fuge & Smith. The date of collection, accuracy of location and stratigraphic position of these samples is not confidently known. We examined all 28 of the samples from this collection and selected 10 that, in our opinion, appear to be of Cretaceous age, as demonstrated by the assemblage composition and by comparison to other known Cretaceous diatom deposits. The age of the other 18 samples appears to be younger than Cretaceous and include taxa more typical of an Eocene diatom flora. Observations on the diatoms from those materials will be published later. The taxonomic composition of species in these new samples is almost the same as the first set of samples studied by Hanna (1927) from Moreno Gulch, which has further helped us to separate the questionable samples from the Porguen Collection.

Long et al. (1946) stated that the samples studied for their publication all came from "the fourth eastward-flowing gully shown of U.S. Geological Survey Topographic Map, Panoche Quadrangle, along the east flank of Panoche Hills, north of Panoche Creek, Sec. 24, T.14S, R.11E."

Based on this information and figure 1 of Long et al. (1946), this locality is in Marca Canyon ca. 36°42'N, 120°35'W (see Figure 1). This canyon is informally referred to as "Y" Canyon in the Long, Fuge & Smith samples from the V. Porguen collection. Samples from this locality, which were studied for this report, include CAS 615976, 615977, 615978, 615981, 615987, and 615990.

Certain samples from both the Brigger collection and from the Long, Fuge and Smith collec-

TABLE 1 Samples examined in this study.

CAS	*Collector, date*	*Location*	*Age*
1144	Hanna, 1927	Moreno Gulch	Cretaceous
610939	Brigger, unknown	Moreno Gulch	Cretaceous
610954	Brigger, unknown	Water Canyon (Dosados Canyon)	Cretaceous
610955	Brigger, unknown	Water Canyon (Dosados Canyon)	Cretaceous
615976	Smith, J., 1927?	Y Canyon (Marca Canyon)	Cretaceous
615977	Smith, J., 1927?	Y Canyon (Marca Canyon)	Cretaceous
615978	Smith, J., 1927?	Y Canyon (Marca Canyon)	Cretaceous
615980	Smith, J., 1927?	Water Canyon (Dosados Canyon)	Cretaceous
615981	Smith, J., 1927?	Y Canyon (Marca Canyon)	Cretaceous
615987	Smith, J., 1927?	Branch of Y Canyon (Marca Canyon)	Cretaceous
615988	Smith, J., 1927?	Water Canyon (Dosados Canyon)	Cretaceous
615990	Smith, J., 1927?	Y Canyon (top) (Marca Canyon)	Cretaceous
615995	Smith, J., 1927?	S.W. Second sample?	Cretaceous ?
615997	Smith, J., 1927?	Water Canyon (Dosados Canyon)	Cretaceous

tion from the V. Porguen collection are attributed to "Water Canyon" without further detail. These include CAS 610954 and 610955 from Brigger and 615980, 615988, and 615997 from Long et al. (1946).

"Water Canyon" is not a formal name on existing topographic maps of the area. Without further detail, it is highly likely that "Water Canyon" refers to Dosados Canyon. Long et al. (1946) show three known localities for Marca Shale Member diatoms on their figure 1: 1) Moreno Gulch; 2) the locality of their study, which is called "Y" Canyon by them but presently known as Marca Canyon; and 3) the locality of Hanna (1928, 1934) which is unnamed by them but equivalent to Dosados Canyon. Because Dosados Canyon contains seasonal water and because the locality was known to Long et al. (1946), it is reasoned that this locality was referred to by Long, Fuge, and Smith as "Water Canyon" in their collections. These samples then apparently come from Dosados Canyon, located in the central part of Sec. 6, T.15S, R12E at 36°39.5'N, 120°42.0'W (Fig. 1).

Another Cretaceous sample that was studied but presently does not have good locality information is CAS 615995, its locality is labelled as "S.W. second sample." This sample contains good Cretaceous diatoms (Gleser, pers. commun.) and undoubtedly comes from outcrops of the Marca Shale Member within the area of Figure 1.

METHODS

In order to accomplish the goals of this study, we used only fresh, clean and dry materials. The selection and orientation of individual specimens for SEM investigation from washed residues was performed with LOMO Model MM-1 and Narishige Model MN-15 micromanipulators following the techniques of Nikolaev (1982). Scanning electron microscope investigations of diatom micromorphology were conducted using a JOEL JSM–T330 SEM at the Department of Geosciences, University of Nebraska, a JSM–35 SEM at the Komarov Botanical Institute, and a Hitachi 520 SEM at the California Academy of Sciences. Light microscope examination and photomicrography were performed using a Leica DMRX microscope at the University of Nebraska.

TAXONOMIC LIST

Description of diatom taxa and their taxonomic position follows the system of classification of centric diatoms constructed by Nikolaev & Harwood (2000b), which is detailed further in Appendix A. The taxonomic list includes species where the Cretaceous age assignment is reliable, in that they were recovered from samples where the stratigraphic position was known. We identify taxa where age and stratigraphic position are uncertain. Diagnosis of each species was composed using the terminology recommended in Anonymous (1975). For each species, the age, location and sample identification number from the sample that was examined in SEM is given. To illustrate the morphological structure of the species we present LM photomicrographs of holotype and some paratype specimens from the collection of the California Academy of Sciences (CAS). Scanning electron microscope photomicrographs were selected to illustrate the specific morphological features that confirm the taxonomic assignment.

Class **Coscinodiscophyceae** Round & Crawford
Subclass **Archaegladiopsophycidae** Nikolaev & Harwood
Order **Archaegladiopsidales** Nikolaev & Harwood
Family **Thalassiosiropsidaceae** Nikolaev

Genus ***Thalassiosiropsis*** Hasle

Thalassiosiropsis wittiana (Pantocsek) Hasle in Hasle & Syvertsen 1985:89.

Plate 1, Figures 1–4

Coscinodiscus wittianus Pantocsek 1889:119.
Coscinodiscus lineatus Ehrenberg sensu Hanna 1932:180, pl. 8, figs. 1–3; Long, Fuge & Smith 1946:103, pl. 16, fig. 5.

Description: Frustule is discoid. Valves are circular, flat, 50–75 µm in diameter. Areolae are loculate with external foramen and an internal cribra arranged in straight tangential rows; 5–6 areolae and rows in 10 µm. Cribrum is interrupted; cribral pores, 4 in 1µm, are arranged in an indistinct radial pattern. Annular (multi-strutted) process is located in the center of the valve face and opens externally with a short conical tube and internally with a short tube that connects with the basal siliceous layer by narrow struts that alternate with small pores to form a ring around the conical tube. Valve mantle is low with smaller areolae, 10–12 in 10 µm, arranged in a ring.

Age: Fossil marine species. Late Cretaceous – Paleocene (Hasle & Syversen 1985)

Location: Marca Shale Member, Moreno Gulch, Marca Canyon, California, CAS 1144.

Genus ***Gladiopsis*** Gersonde & Harwood

Gladiopsis speciosa (Schulz) Gersonde & Harwood 1990:373.

Plate 2, Figures 1–7

Gladius speciosus Schulz 1935:391, pl. 1, fig. 6.
Tubularia pistillaris var. *grossepunctata* Long, Fuge & Smith 1946:116, pl. 18, fig. 12.
Pyxilla capitata Barker & Meakin 1948:234, pl. 28, fig. 4.

Description: Valves are cylindrical with high mantle, 10–14 µm in diameter; longer valves may reach up to 100 µm in height. Apex parallel or widening toward the apex. Areolae are loculate with external foramen and an internal continuous cribrum; 2.5 cribral pores in 10 µm. Areolae are arranged on the valve mantle and valve margin in longitudinal and diagonal rows, 5–6 areolae and rows in 10 µm. Valve face is flat or slightly convex, without areolae, but may possess porous canals. The annular (multi-strutted) process is located in the center of the valve face and opens externally with a short conical tube, and internally with a short tube that connects with the basal siliceous layer by narrow struts, which alternate with small pores to form a ring around the conical tube.

Age: Fossil marine species. Late Cretaceous.

Location: Marca Shale Member, Dosados Canyon, Marca Canyon, California, CAS 610954.

Remarks: The genus *Tubularia* Brun was created for the species *Tubularia pistillaris* (Brun 1894:88, plate VI, figs. 1, 2). Brun's species differs from our specimens by the arrangement of smaller pores on both sides of a pseudoraphe. This suggests *T. pistillaris* Brun belongs to the family Tabulariaceae and is not conspecific with specimens of *Gladiopsis speciosa*.

Order **Stephanopyxales** Nikolaev
Family **Stephanopyxaceae** Nikolaev ex Round & Crawford

Genus ***Stephanopyxis*** (Ehrenberg) Ehrenberg

Stephanopyxis appendiculata Ehrenberg 1854:pl. 18, fig. 4; Hanna 1927:32, pl. 4, fig. 9; Long, Fuge & Smith 1946:111.

Plate 3, Figures 1–6

Description: Cells are connected to form filamentous colonies. Frustule is spherical to short cylindrical, 8–50 μm long with diameter between 10–65 μm. Valves are circular or slightly ellipsoidal, convex with a ring of spines located near one-half radius of the valve face. Areolae are loculate with external foramina and an internal cribrum, arranged on the valve face and valve mantle in curved tangential rows, 3–5 areolae in 10 μm. Cribrum is interrupted, 3–5 cribral pores in 1 μm. Labiate processes are positioned to form apical and marginal rings; the apical ring is located at the boundary between the valve face and mantle. These open externally by a long tube and internally by a tubercle with a slit. Labiate processes, 3 in 10 μm, in the marginal ring are located on the cribrum of loculate areolae on the valve mantle. The processes include a small external opening and an internal small tubercle with an aperture.

Age: Marine species. Late Cretaceous–Recent (Gleser et al. 1988).

Location: Marca Shale Member, Dosados Canyon, Marca Canyon, California, CAS 1144, 610939, 610954.

Stephanopyxis barbadensis (Greville) Grunow 1884:p. 39; Long, Fuge & Smith 1946:111.

Plate 4, Figures 1–6

Cresswellia barbadensis Greville 1865:3, pl. 1, fig. 11.

Description: Valves are circular, convex, 45–120 μm in diameter. Areolae are loculate with external foramen and an internal cribrum arranged in tangential rows; 3 areolae in 10 μm at the center and 4 in 10 μm at the margin. Cribra, interrupted; cribral pores are in radial lines, 6–8 lines in 10 μm. Labiate processes form two rings. The first is located near the middle radius of the valve face, with 1–2 labiate processes in 10 μm. These labiate processes open externally as short conical tubes that form a ring of external spines, and open internally as tubercles with a slit. A second ring of labiate processes is located on the margin of the valve, positioned on the cribrum of marginal rows of areolae, 2 labiate processes in 10 μm. These open into the chamber of the areolae by a round aperture and open internally by a tubercle with a slit.

Age: Fossil marine species, Late Cretaceous – Oligocene (Gleser et al. 1988).

Location: Marca Shale Member, Moreno Gulch, Marca Canyon, California, CAS 610939.

Stephanopyxis discrepans Hanna 1927:33, pl. 4, figs. 10, 11.

Plate 5, Figures 1–6; Plate 6, Figures 1–6

Description: Cells form short colonies and different morphologies on "terminal" and "regular" valves. Frustule is short cylindrical. "Regular" valves (in the middle of the colonies) are circular, flat or slightly convex; 30–70 μm in diameter and 6–12 μm in height. Ring of spines with branching distal ends is located between the valve face and valve mantle; 3 spines in 10 μm. Areolae are loculate, 2–4 in 10 µm, irregularly arranged on the valve face and valve mantle, with external foramina of irregular shape and size and internal uninterrupted cribrum. Cribral pores, 30–35 in 10 mm, form radial rows and a quincunx pattern. Areolae on the valve face, immediately adjacent to the ring of spines, have larger foramina than other areolae. Labiate processes, 4 in 10 µm form a ring located between the valve face and the valve mantle. External openings of labiate processes are located on the ends of marginal spines. Internal openings are small and round.

The "terminal" cells of the colony have a circular valve, are slightly convex, and 15–35 µm in diameter. These cells possess a ring of spines with branching distal ends, 2–3 spines in 10 µm, located on the valve face near the middle radius of the valve face. Areolae are loculate, 6–9 in 10 µm, with an irregular arrangement on the valve face and mantle. External foramina are variable in shape and size and bear internal uninterrupted cribra. Small spines are present around the foramina; some are crossed by narrow bars. Cribral pores, 30–40 in 10 µm are arranged in quincunx pattern. Labiate processes, 3–4 in 10 µm, are arranged in a marginal ring. They open externally by a small aperture, and internally by a tubercle with radial orientated slit.

Age: Fossil marine species, Late Cretaceous

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 1144, 610954.

Remarks: Hanna (1927) noted two morphological forms of *Stephanopyxis discrepans*: one form possessing spines located on the boundary between the valve face and valve mantle (Hanna 1927, pl. 4, fig. 10, designated by Hanna as the holotype of the species), and the other form possessing spines located toward the center of the valve (Hanna 1927, pl. 4, fig. 11, designated by Hanna as paratype). Our studies show that 'regular' and 'terminal' cells in a colony have different structure and position of labiate processes, as reflected in the location of the ring of spines. The two forms illustrated by Hanna (1927) on pl. 4, figs. 10–11, correspond respectively to a regular cell and a terminal cell.

Stephanopyxis grunowii Grove & Sturt in Schmidt et al. 1888: pl. 130, figs. 1, 4; Hanna 1927:33, pl. 4, fig. 12; Long, Fuge & Smith 1946:111.

Plate 7, Figures 1–4

Description: Valves are circular, convex to hemispherical, 20–75 µm in diameter and 15–50 µm in height, with hyaline rim at the valve margin. Areolae are loculate with external foramen and an internal cribrum arranged as a full net with larger areolae (some are of irregular form) located in the center and at the edge of the valve. Areolae, 1 to 2 in 10 µm, are smaller near the middle radius of the valve face, 2–3 in 10 µm. Labiate processes form a ring near the boundary between the valve face and the valve mantle; they open externally as long conical tubes, and internally as small tubercles with round apertures.

Age: Fossil marine species. Late Cretaceous ? – early Oligocene (Gleser et al. 1988).

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, Marca Canyon, California, CAS 610954.

Stephanopyxis turris (Greville in Gregory) Ralfs in Pritchard 1861:826.

Plate 7, Figures 5–6

Creswellia turris Greville in Gregory 1857:64.

Description: Valves are semi-spherical to cylindrical, 15–25 µm in diameter and 15–35 µm in height. Areolae are loculate, 5–6 in 10 µm, with external foramen and an internal uninterrupted cribra, arranged in curved crossing rows on the valve face and mantle. Labiate processes form apical and marginal rings; apical ring, located near the boundary between the valve face and valve mantle, is identified externally by a ring of open short conical tubes, and internally by a ring of small tubercles with a slit. The marginal ring of labiate processes, located on the valve mantle, is identified externally by a series of round openings, and internally by small tubercles with a simple aperture.

Age: Marine species, Late Cretaceous – Recent (Gleser et al. 1988).

Location: Marca Shale Member, Dosados Canyon, California, CAS 610954.

Subclass **Paraliophycidae** Nikolaev & Harwood

Order **Paraliales** Crawford

Family **Paraliaceae** Crawford

Genus ***Paralia*** Heiberg

Paralia crenulata (Grunow) Gleser in Gleser et al. 1992:50; pl. 41, figs. 1–8.

Plate 8, Figures 1–8

Paralia sulcata var. *crenulata* Grunow 1884:44, tab. 5 (E), fig. 34.

Melosira fausta Schmidt sensu Hanna 1927:25, pl. 3, figs. 11–14.

Description: Frustules are cylindrical, connected in straight or slightly curved colonies. Valves are circular, 8–45 µm in diameter. The central part of the valve face is raised with radial ribs (12 in 10 µm) or flat with a marginal ring of openings (5 in 10 µm) and ring of small tubercles (7 in 10 µm). Valve mantle is perforated by porous canals, arranged in radial rows on the marginal part of valve face and valve mantle internally (30–35 rows in 10 µm), and arranged irregularly, or in vertical rows on the valve mantle, externally. A linking apparatus is formed by the marginal spines on each connected valve, and a ring of radial, teeth-like costae on the valve face that are slotted together in adjacent sibling valves. Labiate processes were not observed.

Age: Fossil marine species, Late Cretaceous – Oligocene (Gleser et al. 1992)

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, Marca Canyon, California, CAS 610954, 615990.

Remarks: Small specimens have more regular rows of porous canals on the valve mantle than large specimens.

Subclass **Heliopeltophycidea** Nikolaev & Harwood

Order **Heliopeltales** Nikolaev & Harwood

Family **Heliopeltaceae** H. L. Smith

Genus ***Actinoptychus*** Ehrenberg

Actinoptychus packii Hanna 1927:12, pl. 1, figs. 1–3.

Plate 9, Figures 1–4

Description: Valves are circular, 62– 85 µm in diameter, divided into six equal sectors with a hyaline field in center, and small hyaline fields located near margin of the valve face, on the corners and in the middle margin of the sectors. Porous canals, 17–20 in 10 µm are arranged in crossing rows (quincunx) on the valve face. Margin of valve face is narrow with radial rows of porous canals, nearly 30 in 10 µm. Valve margin is separated from the valve face by narrow hyaline ribs, which bear irregular small spines; 3–5 in 10 µm. Labiate processes are located near the margin of the valve face, on the convex sectors (view external). Labiate process open externally through a short tube that is located on marginal hyaline ribs; they open internally by radial curved slits. Narrow radial hyaline rays extend from the marginal labiate process toward the valve center. Valve mantle is narrow and hyaline.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 610955.

Remarks: Narrow hyaline rays were not observed in the SEM, in either internal or external views. The rays may be structures within the basal siliceous layer.

Actinoptychus taffii Hanna 1927:13, pl. 1, fig. 4.

Plate 10, Figures 1–4

Description: Frustule is discoidal. Valves are circular, 55–70 µm in diameter, divided into six equal sectors with a hexagonal hyaline field located in the center of the valve face. Small hyaline fields are also located on the edge of each corner of the sectors. Porous canals are arranged in crossing rows (quincunx), 15–18 rows in 10 µm, and covered externally by a system of anastomosing ribs that form a net-like structure with 7–8 pits or depressions in 10 µm. The valve margin is narrow, with radial rows of porous canals, 20–25 in 10 µm. Labiate processes are located centrally along the margin of the convex (view external) sectors. The labiate processes open externally through small tubercles with a round opening, and open internally through a straight radial slit, surrounded by a hyaline field. Valve mantle is narrow.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 610954.

Remarks: Narrow hyaline rays that divide the convex sector near the valve margin, visible in LM, were not observed in the SEM.

Genus ***Centroporus*** Pantocsek

Centroporus californicus Long, Fuge & Smith 1946:102, pl. 16, fig. 8.

Plate 11, Figures 1–5

Description: Valves are circular, 60–70 µm in diameter, with a convex center of the valve face and a concave ring near the middle radius of the valve. A convex zone near one-sixth radius of valve is replaced toward the margin by an undulating zone at the valve edge. Porous canals, 35–40 in 10 µm, are arranged in irregular rows on the valve face, and in radial rows near the valve margin. On the top of the marginal undulations, a wide slit from a narrow hyaline field extends toward the center of the valve face.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Marca Canyon, Dosados Canyon, California, CAS 615988.

Remarks: A very rare species. Only one specimen was examined in the SEM, and only an external view. Information about the internal structure of the marginal perforation is lacking, but this structure may be a labiate process. Radial ribs and hyaline fields are visible in the LM (plate 11, figs. 1, 2), but were not observed on the external valve face in the SEM. Undulations of the valve face and location of labiate processes are very similar to those in *Lepidodiscus elegans* Witt.

Genus ***Debya*** Pantocsek

Debya californica Long, Fuge & Smith 1946:106, pl. 16, fig. 15.

Plate 12, Figures 1–6

Description: Valves are circular, 50–133 µm in diameter, with a small central elevation, three radial narrow ridges, and a marginal concentrical ridge on the border between valve face and mantle. Porous canals, 20–30 in 10 µm, are arranged in irregular rows on the valve face and valve mantle. Anastomosing ribs form an external net with 8–10 pits in 10 µm. Labiate processes, located on the end of radial ridges, open externally through small tubercles with a round aperture in the center, and open internally through a long wave–shaped slit.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Marca Canyon, California, CAS 610939.

Genus ***Glorioptychus*** Hanna

Glorioptychus callidus Hanna 1927:20, pl. 2, figs. 7–8.

Plate 13, Figures 1–7

Description: Valves are circular, rarely subquadrate; 30–95 µm in diameter, with a central hexagonal hyaline field that divides the valve into six alternately depressed and elevated sectors that occupy about two-thirds the length of the valve radius. The marginal part of valve face is divided into 18 alternately depressed and elevated zones. Porous canals are arranged in crossing rows (quincunx), 25–30 porous canals in 10 µm. Anastomosing ribs form an external net of 4–5 pits in 10 µm. Labiate processes are located in the center of the marginal elevation (view external) that is located marginally from the larger sub-central elevations. Labiate processes open externally through a small tubercle with a round aperture, and open internally through a long wave-shaped curving slit, or through a lightly curved slit. Valve mantle is narrow with short radial ribs; 5–6 in 10 µm.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 610954, 610955.

Remarks: The small specimens differ from large ones by the rectangular form of the valve, more small porous canals and the internal structure of the labiate processes (Plate 13, Figs. 6, 7).

Genus ***Haynaldia*** Pantocsek

Haynaldia strigillata (Witt in A. Schmidt et al.) Hanna 1934:353, pl. 48, figs. 1–2.

Plate 14, Figures 1–5

Coscinodiscus strigillatus Witt in A. Schmidt et al. 1889: pl. 138, fig. 20.

Description: Valves are circular, 75–110 µm in diameter, with a slightly convex central and marginal parts of valve face. Porous canals, 5–7 in 10 µm, are arranged irregularly on the internal valve face only, and occur in vertical rows on the valve mantle, 13–15 rows in 10 µm. Anastomosing ribs form an irregular network on the external valve face; near the valve margin the anastomosing ribs are orientated radially. Small spines are located on the external valve face. Labiate processes form a marginal ring at the border between the valve face and mantle. Labiate processes open externally by small round apertures and internally by two horseshoe-shaped slits.

Age: Fossil marine species, Late Cretaceous – Paleocene.

Location: Marca Shale Member, Dosados Canyon, California, CAS 610954, CAS 615990.

Remarks: The strong siliceous, external wall of *H. strigillata* with a system of anastomosing ribs and spines are characters that suggest this taxon is a resting spore. The interior structure of the labiate process is very similar to that of *Aulacodiscus erectus* Long, Fuge & Smith, but A. erectus bears loculate areolae with external cribrum. The taxonomic position of *H. strigillata* within the family Heliopeltaceae is problematic, based on the shape of the labiate processes.

Order **Auliscales** Gleser
Family **Auliscaceae** Hendey

Genus ***Hendeya*** Long, Fuge & Smith

Hendeya dehiscens Long, Fuge & Smith 1946: 107, pl. 18, fig. 16.

Plate 15, Figures 1–5

Description: Valves are elliptical, slightly convex, 45–58 µm in length and 30–45 µm in width. Porous canals, 40–45 in 10 µm, are arranged in curved irregular rows on the valve face, becoming more regular near the margin. Labiate processes (usually two) and two ocelli are located near the margin and are arranged symmetrically across the transapical axis. Labiate processes open externally as round apertures and internally as small tubercles, each with a slit. Ocelli located on the apex of a small elevation, bordered by a narrow hyaline rib.

Age: Fossil marine species; Late Cretaceous.

Location: Marca Shale Member, Marca Canyon, California, CAS 615990.

Subclass **Coscinodiscophycidae** Round & Crawford
Order **Coscinodiscales** Round & Crawford
Family **Coscinodiscaceae** Kützing

Genus ***Coscinodiscus*** Ehrenberg

Coscinodiscus marginatus Ehrenberg 1843:412, Long, Fuge & Smith 1946:104, pl. 16, fig. 13.

Plate 16, Figures 1–6

Description: Valves are circular, almost flat with a short vertical mantle; diameter 90–120 µm. Areolae are loculate with external uninterrupted cribra and internal foramina; 2–3 areolae in 10 µm near the center of valve face, and 3–4 areolae in 10 µm near the valve margin. The edge of the valve mantle bears one row of elongated areolae; 3 areolae in 10 µm. Areolae are arranged in irregular radial and secondary curved rows. Labiate processes, 3 in 10 µm, form a marginal ring on the valve mantle. Labiate processes open externally through small apertures and internally through short tubes, each with an elliptical aperture. Two macro-labiate processes are located within the ring of labiate processes, replacing the position of a labiate process. They open externally as elliptical apertures located in small depressions, and internally as tubes with wide ends and curved slits.

Age: Marine species, Eocene – Recent (Sancetta 1987).

Location: Marca Shale Member, Marca Canyon, Dosados Canyon, California, CAS 610954.

Remarks: The specimens of *C. marginatus* illustrated with SEM by Wornardt (1971) from the Monterey Formation, California (Upper Miocene) and by Sancetta (1987) from North Pacific sediments (Upper Pliocene-Recent) have a valve mantle with a ring depression that forms the ring-shaped collar. A similar depression and ring-shaped collar are visible on the original illustrations of Ehrenberg (1843, 1854) from Richmond, Virginia (Lower Miocene?). Specimens noted here from the Moreno Formation do not possess the depression and ring–shaped collar that are close to *C. radiatus* Ehrenberg. The latter species, however, does bear a marginal ring of labiate processes as well as rare labiate processes that are located on the valve face (Sancetta 1987).

The Cretaceous age of *C. marginatus* is doubtful. We found only one specimen in sample 610954 together with Cretaceous species. This taxon is common in the Miocene diatomite floras of California (Hanna 1932, Barron 1975), leading us to suspect that is a contaminant that was added to the sample accidentally. This and other samples rarely included recent, freshwater diatoms.

Order **Aulacodiscales** Nikolaev & Harwood
Family **Aulacodiscaceae** (Schütt) Lemmermann

Genus ***Aulacodiscus*** Ehrenberg

Aulacodiscus archangelskianus Witt 1886:154, pl. 6, figs. 11–12; Long, Fuge & Smith 1946: 96, pl. 14, fig. 13; Hanna 1934:353, pl. 48, fig. 7.

Plate 17, Figures 1–6

A. pugnalus Hanna 1927:14, pl. 1, Figs. 6–7.
A. archangelskianus var. *pugnalus* (Hanna) Long, Fuge & Smith 1946:97.

Description: Valves are circular, 90–160 µm in diameter, bearing a central hyaline field and four to five (rarely six) radial elevations with a narrow radial hyaline ray at the top of each of elevation. Areolae are loculate with external cribra, 7–9 in 10 µm, arranged irregularly around the central hyaline field and becoming more regularly arranged in radial rows towards the margin. Radial rows of smaller locular areolae are present on the mantle; 16–20 rows in 10 µm. Labiate processes are located on the top of the radial elevations near the valve margin, opening externally as conical tubes and internally as horseshoe-shaped slits.

Age: Fossil marine species, Late Cretaceous – early Eocene (Strelnikova 1974).

Location: Marca Shale Member. Moreno Gulch, Marca Canyon, Dosados Canyon, California, CAS 610954.

Remarks: This taxon exhibits high variability in arrangement of areolae and in height of the radial elevations.

Order **Eupodiscales** Nikolaev & Harwood
Family **Eupodiscaceae** Kützing

Genus ***Rattrayella*** De Toni

Rattrayella churchii Hanna 1934:355, pl. 48, figs. 3–5.

Plate 18, Figures 1–6

Description: Valves are circular, 55–80 µm in diameter, with undulating valve surface. Central area is slightly convex, marginal area is more convex, and the middle area is slightly depressed. Areolae are loculate with external cribra, arranged in radial rows; 20–22 rows in 10 µm. Small tubercles, 8–10 in 10 µm, are located on the exterior of the valve face. Labiate processes, 3–5, located on the border between the valve face and mantle, open externally as short conical tubes and open internally as small tubercles with radially oriented slits. A marginal ring of thick spines is present along the margin. They are slender at the base and broader at the ends. Three or four marginal ocelli are located at the top of the small elevations within the marginal ring of spines. Porelli of the ocellus are arranged in crossing rows and are surrounded by a hyaline costa.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Dosados Canyon, California, CAS 610954.

Order **Stellarimales** Nikolaev & Harwood
Family **Stellarimaceae** Nikolaev ex Hasle & Sims

Genus ***Stellarima*** Hasle

Stellarima distincta (Long, Fuge & Smith) Sims 1987:234, figs. 19, 26, 32–33.

Plate 19, Figures 1–5

Coscinodiscus distinctus Long, Fuge & Smith 1946:103, pl. 15, fig. 15.

Description: Valves are circular and weakly convex, 40–170 µm in diameter. Areolae are loculate with external cribra; 9–11 areolae in 10 µm, arranged in radial and curved tangential rows; areolae are smaller near the margin, 13–15 in 10 µm. A single labiate process is located near the center of the valve; opening externally and internally by a slit. Valve mantle is straight with vertical rows of small areolae; 30–35 rows in 10 µm.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Dosados Canyon, California, CAS 610954.

Stellarima steinyi (Hanna) Sims 1987:230, figs. 1–7, 27–28.

Plate 20, Figures 1–6

Coscinodiscus steinyi Hanna 1927:19, pl. 2, figs. 5–6.

Description: Valves, 60–340 µm in diameter, circular, convex with a small central depressed hyaline field. Areolae are loculate with external cribra, 11–13 in 10 µm, arranged in radial rows organized into fascicles. Rows of areolae within each fascicle are parallel to the central and longest row. Valve mantle is narrow and hyaline. One labiate process, rarely several, located near the valve center, opens externally as a slit and internally as a tubercle with a lateral slit.

Age: Fossil marine species, Late Cretaceous – Paleocene.

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 610954.

Genus ***Azpeitiopsis*** Sims

Azpeitiopsis morenoensis (Hanna) Sims 1994: 171, figs. 21–28, 53.

Plate 21, Figures 1–6

Coscinodiscus morenoensis Hanna 1927:18, pl. 2, figs. 3–4.

Description: Valves are circular, 55–200 µm in diameter, weakly convex with a deep small central depression. Areolae are loculate without a velum, 2–5 in 10 µm, arranged in radial rows and organized into fascicles. Rows of areolae in each fascicle are parallel to the central and longest row. Areolae are smaller near the valve margin, 6–7 in 10 µm. One labiate process is located on the side of the central depression, opening externally as a short tube and internally as a long slit. Mantle is narrow with one to two rows of small areolae; 11–13 in 10 µm.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 610954.

Genus ***Pomphodiscus*** Barker & Meakin

Pomphodiscus craspedodiscoides (Sims) Nikolaev & Harwood 2000a:170.

Plate 22, Figure 6

Benetorus craspedodiscoides Sims 1994:169, figs. 13–20, 52.

Coscinodiscus morenoensis sensu Long, Fuge & Smith 1946:104, pl. 17, fig. 3.

Description: Valves are circular, weakly convex with concave ring around the central dome; 65–85 µm in diameter. Areolae are loculate with large external openings and small internal apertures, 3–6 in 10 µm, arranged in radial rows. The central part of the valve face, from 1/3 to 2/3 diameter of the valve, is covered on the outside by a circular, domed, siliceous hyaline layer, with a large teardrop-shaped opening near the edge of the dome. The internal siliceous layer of the central chamber is convex toward the inside of the valve and bears radial rows of pores, 6–7 in 10 µm, that continue as apertures of the valve face. A single labiate process is located in the center of the dome.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Dosados Canyon, Marca Canyon, California, CAS Holotype 3397.

Remarks: This species is very rare in the Moreno Gulch deposit and was not noted in studied samples. The species is common in the Late Cretaceous deposit from the Kerguelen Plateau (Southern Ocean), where it was studied in detail (Nikolaev & Harwood 2000a).

Pomphodiscus morenoensis (Long, Fuge & Smith) Barker & Meakin 1946:144, pl. 22, figs. 5–6.

Plate 22, Figures 1–5

Craspedodiscus morenoensis Long, Fuge & Smith 1946:105, pl. 17, fig. 1.

Benetorus morenoensis (Long, Fuge & Smith) Sims 1994:167, figs. 7–12, 51, 56–57.

Description: Valves are circular, 54–70 µm in diameter, weakly convex with a narrow concave region surrounding a sub-central ovoid dome. Areolae are loculate with large external openings and small internal apertures, 6–7 in 10 µm, arranged in radial rows and forming weak fascicles. Vela were not observed. Mantle bears two rows of poroid areolae, 13–16 in 10 µm. Valve mantle is separated from the valve face by a narrow ridge. A single labiate process is located near the valve center, opening externally and internally by a slit. The central part of the valve exterior is covered by an ovoid, sub-central, siliceous blister-like layer with gentle relief, and a large subcircular opening at the edge of the dome. The internal siliceous layer of this chamber is broadly convex to the inside of the valve, but has a minor central concavity with radial rows of pores, 11–16 in 10 µm, that continue as apertures across the valve face.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Dosados Canyon, California, CAS 610955.

Family **Trigoniumiaceae** Gleser

Genus ***Trigonium*** Cleve

Trigonium hertleinii (Hanna) Nikolaev & Fourtanier comb. nov.

Plate 23, Figures 1–6

Basionym: *Triceratium hertleinii* Hanna 1927: Occas. Papers Cal. Acad. Sciences, 12:35, pl. 4, fig. 15.

Description: Valves are triangular with rounded sides and rounded corners; 35–65 µm in length. Valve face possesses a round central depression, and convex marginal area. Areolae are loculate with external cribra arranged in irregular rows in the central depression, 2–3 areolae in 10 µm, and arranged in radial rows on the marginal area of the valve face, 3–4 areolae in 10 µm. Labiate processes were not found. Pseudocelli are variable in size and located on each of the rounded corners of the valve face. A small elongate tubercle is present laterally from the pseudocellus. Valve mantle is vertical and hyaline.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Marca Canyon, Dosados Canyon, California, CAS 610954.

Remarks: The species bears loculate areolae with external cribra and pseudoocelli, both of which are features of the genus *Trigonium*. *Trigonium hertleinii* differs from the generitype *T. arcticum* Cleve by the presence of the central depression and the absence of labiate processes.

Subclass **Biddulphiophycidae** Round & Crawford

Order **Hemiaulales** Round & Crawford

Family **Hemiaulaceae** Heiberg

Genus ***Hemiaulus*** Ehrenberg

Hemiaulus polymorphus Grunow 1884:14; Hanna 1927:20, pl. 2, figs. 9–10.

Plate 24, Figure 6; Plate 25, Figures 1–3

Description: Valves are narrow lanceolate; 15–45 µm in length and 9–15 µm in width; with pseudosepta that separate the valve in three or more chambers, and two polar elevations with ocelli and a lateral linking spine. Areolae are poroid with external cribra and internal foramina arranged in irregular radial rows on the valve face and the valve mantle. Valve mantle is separated from the valve face by a narrow siliceous ridge. A single labiate process is located near the center of the valve face with an external conical tube and an internal small tubercle with a slit.

Remarks: Valve size and number of pseudosepta is highly variable in this species.

Age: Fossil marine species, Late Cretaceous – Miocene (Strelnikova 1974).

Location: Marca Shale Member, Dosados Canyon, Marca Canyon, California, CAS 610954, 615990, 615578.

Genus ***Sphynctolethus*** Hanna

Sphynctolethus monstrosus Hanna 1927:32, pl. 4, figs. 7–8. Sims 1986:243; figs. 1–7, 61.

Plate 24, Figures 1–5

Description: Valves are broadly lanceolate; 45–70 µm in length and 15–25 µm in width, with a domed center and two polar elevations with a "costate" ocellus and lateral linking spine. Areolae are poroid with external velum, 13–15 in 10 µm, arranged in radial rows on the valve face and in vertical rows on the valve mantle. Numerous isolated porous canals are located between the poroid areolae, and numerous tubular spines are located on the external surface of the valve face. The valve mantle is separated from the valve face by a narrow marginal ridge, 3–5 µm in height. A single labiate process is located at the center of the valve, at the middle of a small hyaline field; it opens internally through a small tubercle with a slit and externally through a "fluted" tube.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Marca Canyon, Dosados Canyon, California, CAS 610954, 615990.

Genus ***Trinacria*** Heiberg

Trinacria aries Schmidt et al. 1886: pl. 96, figs. 14–17; Hanna 1927:36, pl. 5, figs. 1–2.

Plate 25, Figures 4–6

Description: Valves are triangular with a slightly convex valve face and nearly vertical valve mantle with sides 25–40 µm in height. Three polar elevations with pseudocelli are surrounded by short linking spines. Polar elevations are separated from the valve face by a short pseudoseptum. Poroid areolae, 5 in 10 µm, with external vela, are arranged in irregular rows on the valve face and mantle. Isolated porous canals are smaller than the poroid areolae and located between them. The valve face is separated from the valve mantle by a marginal ridge. A single labiate process is located near the center of the valve and opens externally through a short tube and internally through a tubercle with a slit.

Age: Fossil marine species, Late Cretaceous – Paleocene (Proschkina-Lavrenko 1949).

Location: Marca Shale Member, Moreno Gulch, Marca Canyon, Dosados Canyon, California, CAS 610955.

Trinacria insipiens Witt 1885:172, pl. 10, fig. 1; pl. 11, fig. 5, 7, 11; pl. 12, fig. 2; Hanna 1927:37, pl. 5, figs. 7–9.

Plate 26, Figures 1–4

Description: Valves are triangular and slightly convex with straight or slightly concave sides, height of sides 45–75 µm. Three polar elevations bear a pseudoocellus and small connecting spines. Areolae are poroid with external vela, 5–7 in 10 µm, and are arranged in irregular rows on the valve face. One row of areolae comprises the valve mantle, which is separated from the valve face by a marginal ridge. A labiate process, sometimes several, is located on the valve face midway between the valve center and the margin, opening externally as a short conical tube and internally as a tubercle with a slit.

Age: Fossil marine species, Late Cretaceous – Eocene.

Location: Marca Shale Member, Moreno Gulch, Marca Canyon, California, CAS 610939, 615978.

Family **Sheshukoviaceae** Gleser

Genus ***Sheshukovia*** Gleser

Sheshukovia excavata (Heiberg) Nikolaev & Harwood comb. nov

Plate 29, Figures 1–5

Basionym: *Trinacria excavata* Heiberg 1863: Conspectus Criticus Diatomacearum Danicarum: p. 51, pl. 4, fig. 9. Hanna 1927:37, pl. 5, fig. 6.

Description: Valves are triangular with a nearly flat valve face and straight or concave sides, 40–95 µm in length. Three polar elevations each bear a pseudoocellus and small spines. Poroid areolae with external vela, 5–7 in 10 µm, are arranged in irregular radial rows on the valve face. One row of areolae on the valve mantle. Rare isolated pores are located between the poroid areolae The valve face is separated from the valve mantle by a low marginal ridge. Labiate process es are scattered irregularly on the valve face, opening externally as small tubes and internally as small tubercles, each with a slit.

Age: Marine fossil species, Late Cretaceous – Eocene (Strelnikova 1974).

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 610954.

Remarks: Position of ocelli on the polar elevations and absence of linking spines suggests transfer of this species from the genus *Trinacria* to *Sheshukovia*.

Genus ***Medlinia*** Sims

Medlinia deciusii (Hanna) Nikolaev & Kociolek comb. nov.

Plate 27, Figures 4–6

Basionym: *Trinacria deciusii* Hanna 1927: Occas. Papers Cal. Acad. Sciences, 12:36, pl. 5, figs. 3–5.

Description: Valves are triangular with a flat valve face and concave or straight sides 20–35 µm in length, and three polar elevations with flat hyaline plate. The valve face is separated from the polar elevation by a pseudoseptum. Poroid areolae with external vela, 3–4 in 10 µm, arranged in irregular rows on the valve face and valve mantle. A single labiate process is located near one side of the valve and opens externally through a short tube and internally through a tubercle with a slit.

Age: Marine fossil species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 610955.

Remarks: The polar elevations do not possess pseudocelli, a feature which suggests placement in the genus *Medlinia* (Sims 1998).

Medlinia mucronata (Schmidt) Nikolaev & Barron comb. nov.

Plate 26, Figures 5–6

Basionym: *Triceratium mucronatum* Schmidt et al., 1886: Atlas der DiatomaceenKunde, pl. 111, figs. 1–2.
Synonym: *Trinacria mucronata* (Schmidt) Hanna 1927:38, pl. 5, fig. 10.

Description: Valves are triangular and slightly convex with slightly concave sides, 65–80 µm in length, and bearing slightly raised polar elevations covered with small areolae. Poroid areolae with external cribra, 5–7 in 10 µm, arranged in irregular rows on the valve face and forming one row on the valve mantle, which is separated from the valve face by a hyaline marginal ridge. A single labiate process, rarely multiple, is located near one side of the valve, and opens externally through a short tube and internally through a tubercle with a slit.

Age: Marine fossil species, Late Cretaceous – Eocene (A. Schmidt 1886 in Schmidt 1874–1959).

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 610955.

Remarks: Absence of linking spines and pseudocelli justifies the transfer of this species to genus *Medlinia* (Sims 1998).

Genus ***Euodiella*** Sims

Euodiella bicornigera (Hanna) Sims 2000:385, Figs. 1–6, 50–51.

Plate 28, Figures 1–5

Triceratium bicornigerum Hanna 1927:34, pl. 4, figs. 13–14.

Description: Frustule is prismatic. Valves are semi-elliptical to sub-triangular with one straight side, 60–80 µm in length, that opposes a curved side with a rounded end. The valve face is almost flat, with two polar elevations that bear a pseudoocellus at the end of each straight side. Areolae are poroid with external vela, 6–8 areolae in 10 µm, arranged in radial rows that originate from a 'center' located eccentrically closer to the the rounded end. The valve face is separated from the valve mantle by a hyaline marginal ridge. A single labiate process is located toward the rounded end, near the focal center of the radial rows of areolae and on the edge of a hyaline field. The labiate process opens externally through a curved slit with raised lips and internally through a tubercle with a slit. Two pseudocelli are located on ventral mantle and top of elevation.

Age. Fossil marine species – Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California. CAS 610954.

Euodiella tristictia (Hanna) Sims 2000:393; figs 25–30, 59, 61.

Plate 27, Figures 1–3

Trinacria tristictia Hanna 1927:38, pl. 5, figs. 11–12.

Description: Valves are triangular with a slightly convex valve face and straight sides, 45–65 µm in length, and vertical mantle. Three polar elevations bear small areolae and are separated from the valve face by a deep depression. Poroid areolae with external vela, 6–7 in 10 µm, arranged in radial rows on the valve face and in irregular rows on the valve mantle. Isolated porous canals are located between the rows of poroid areolae. The valve mantle and valve face are separated by a ridge, which is the same height as the elevations; height of ridges decrease and disappear towards the polar elevations. A single labiate process located near the center of the valve opens externally through a slit with raised lips and internally through a tubercle with a slit. Two elongate pseudocelli are located on the boss edge on one side of the vertical mantle.

Age: Marine fossil species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 610955.

Order **Stictodiscales** Round & Crawford
Family **Stictodiscaceae** (Schütt) Simonsen

Genus ***Pseudostictodiscus*** Grunow

Pseudostictodiscus picus Hanna 1927:28, pl. 3, figs. 1–4.

Plate 30, Figures 1–5

Description: Valves are circular, 25–30 µm in diameter with central hyaline field. The central part of the valve face is concave and the marginal part is convex; these regions are separated by a narrow circular hyaline ridge. Two small lateral elevations are located on the valve mantle. Poroid areolae have external vela and are arranged in radial rows; individual areolae are elongated in a radial orientation. Internal foramina are arranged in irregular rows (externally) on the margin of the central depression, 6–10 areolae in 10 µm; on the marginal part of the valve face they are arranged in radial rows that are separated by small radial ribs, 10 rows in 10 µm. A single, narrow labiate process opens externally by a radial slit and internally through a wider slit located at the edge of the central hyaline field.

Age: Marine fossil species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, California, CAS 610939.

Genus ***Arachnoidiscus*** Ehrenberg

Arachnoidiscus ehrenbergii Bailey ex Ehrenberg 1849:64; Long, Fuge & Smith 1946:95, pl. 13, fig. 6.

Plate 31, Figures 1–5

Description: Valves are circular, 80–190 µm in diameter. Valve face is flat or slightly convex with a central hyaline field. Poroid areolae with vola, 3–6 in 10 µm, arranged in radial and concentric rows. Areolae are separated by an internal system of radial ribs. Secondary concentric ribs are infrequent. A central ring of labiate processes, each open externally by a radial slit and internally by a slit with raised lips.

Age: Marine species, Late Cretaceous – Recent (Strelnikova, 1974).

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, Marca Canyon, California, CAS 610939, 610954.

Remarks: The structure of the internal system of ribs is highly variable in this species.

Genus ***Benetorus*** Hanna

Benetorus fantasmus Hanna 1927:16, pl. 1, figs. 9–10; Sims 1994:66, figs. 1–6, 49–50, 54–55; Nikolaev & Harwood 2000a:174, pl. 3 fig. 20, pl. 4 figs. 21–28.

Plate 32, Figures 1–7

Description: Valves are circular, 50–60 µm in diameter, with a ring-shaped chamber located at the middle radius. Poroid areolae with small vola, and are arranged in radial rows on the marginal part of the valve face, 10–12 rows in 10 µm. Radial rows of foramina continue on the internal layer of the ring-shaped chamber as radial rows of pores, 14–15 rows in 10 µm and are arranged irregularly on the central part of valve interior/exterior where they cross a hyaline line. A narrow ring-shaped hyaline zone is located between the radial rows of pores on the inner layer of the chamber and the rows of foramina toward the margin. The external layer of the chamber is hyaline. The ring-shaped chamber is separated by an isthmus. A single labiate process is located on the side of the chamber and turned towards the center of the valve face. This process opens externally as a short tube and opens internally as a small elongated tubercle with a slit and two elongate apertures in the basal siliceous layer. The valve face is separated from the valve mantle by a low and narrow ridge. Small porous canals, 23–25 in 10 µm, are arranged in one row on the valve mantle.

Age: Marine fossil species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, Marca Canyon, California, CAS 610955, 615990.

Remarks: Sims (1994) united *Benetorus fantasmus* with poroid areolae and ring-shaped chamber with *B. morenoensis*, which has loculate areolae and a central chamber. Hanna (1927) believed *B. fantasmus* was near to the genus *Stictodiscus*, a position confirmed by the presence of poroid areolae in these taxa (Nikolaev & Harwood 2000a).

TAXA OF UNCERTAIN SYSTEMATIC POSITION

Acanthodiscus paterus (Long, Fuge & Smith) Nikolaev & Fourtanier comb. nov.

Plate 33, Figures 1–5

Basionym: *Melosira patera* Long, Fuge & Smith 1946: Journal of Paleontology, 20(2):109, pl. 17, fig. 18.

Description: Valves are circular and almost flat, 75–95 µm in diameter. The valve face and valve mantle are hyaline, without perforations. The marginal portion of the valve face, 4–7 µm wide, is ornamented with irregular curved ridges, 3–5 in 10 µm. Processes are absent.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 610939, 610954.

Remarks: *Acanthodiscus convexus* Hajós & Stradner (1975) has a convex valve face and marginal system of ridges. Our specimen differs from this species by the flat valve face and less elevated marginal ridges. This taxon is removed from genus *Melosira* C.A. Agardh (generitype *M. nummuloides* Agardh), based on the absence of areolae and labiate processes, and transferred to genus *Acanthodiscus* Pantocsek (generitype *A. rugosus* Pantocsek).

Acanthodiscus immaculatus (Hanna) Nikolaev & Barron comb. nov.

Plate 34, Figures 1–4

Basionym: *Coscinodiscus immaculatus* Hanna 1927, Occas. Papers Cal. Acad. Sciences, 12:17, pl. 2, fig. 2.

Description: Valves are circular, 80–90 µm in diameter, with a flat hyaline valve face, and a short hyaline mantle. No perforations, processes or distinctive ornamentation were observed.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 610955.

Remarks: This species is removed from the genus *Coscinodiscus* (generitype *C. argus* Ehrenberg) based on the absence of areolae and labiate processes. We include it in the genus *Acanthodiscus* tentatively because our specimens do not have a marginal ring of ridges.

Pseudopyxilla russica (Pantocsek) Forti 1909:28, pl. 1, fig. 13; Hanna 1927:27, pl. 4, fig. 4.

Plate 35, Figures 1–2

Pyxilla russica Pantocsek 1892: pl. 19, fig. 277.
Pyxilla rossica Pantocsek, 1905:91.

Description: Frustule is cylindrical. Valves are circular and hyaline, 15–30 µm in diameter, with a semi-spherical valve face and a long valve mantle. No perforations or processes were observed.

Age: Fossil marine species, Late Cretaceous – Neogene (Strelnikova 1974).

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 610954.

Pseudopyxilla sp.

Plate 35, Figure 3

Description: Valves are circular, 22 µm in diameter, with semi-spherical valve face and long hyaline valve mantle. Porous canals, 40–45 in 10 µm perforate irregularly the valve face. Processes are unknown.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 610955.

Remarks. This specimen differs from other members of the genus *Pseudopyxilla* by the presence of perforations on the valve face.

Odontotropis galeonis Hanna 1927:26, pl. 4, figs. 1–3.

Plate 35, Figures 4, 6

Description: Frustule is asymmetrical and heterovalvar. Valves are lanceolate or elliptical, 60–90 μm long and 20–35 μm wide. The epivalve bears a narrow and high trapezium-shaped costa along the longitudinal axis that terminates in two long spines. The hypovalve bears two polar elevations and longitudinal costa with two curved spines near the end of the valve. No perforations or processes were observed.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 610939, 610954.

Kentrodiscus aculeatus Hanna 1927:22, pl. 3, fig. 6.

Plate 37, Figures 1–5

Description: Frustule is a short cylinder, heterovalvar, 35–45 μm in diameter and 50–70 μm in height. Epitheca is circular and convex with a long, nearly-straight hyaline central horn. Hypotheca is convex without a horn. Spines cover the valve face of both valves. Valve mantle is vertical. No perforations or processes were observed.

Age: Fossil marine species, Late Cretaceous.

Location: Marcà Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 610939, 610954, 610955.

Kentrodiscus andersonii Hanna 1927:23, pl. 3, figs. 7–8.

Plate 36, Figures 6–7

Description: Frustule is a short cylinder, 23–30 μm in diameter and 30 –35 μm in length, heterovalvar. Epitheca is convex with a long curved horn; spines are arranged irregularly on the valve face. Hypotheca is slightly convex with small irregular spines. Valve mantle is vertical. No perforations or processes were observed.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, D6sad6s Cany6n, California, CAS 610954.

Remarks: SEM observations show that *K. aculeatus* and *K. andersonii* are very similar morphologically and differ only by the curvature of the horn. We believe that they could be conspecific.

Kentrodiscus blandus Long, Fuge & Smith 1946:107, pl. 19, figs. 3–5.

Plate 36, Figures 1–5

Description: Frustule is a short cylinder, 42–55 μm in diameter and 60–75 μm in length, heterovalvar. Epitheca is conical and hyaline, bearing a long horn with curved radial costa. Hypotheca is hyaline and slightly convex, bearing short irregular spines. A wide slit is located at the top of the horn. Valve mantle is vertical.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Dosados Canyon, Marca Canyon, California, CAS 610955.

Remarks: The slit on the top of the horn may be the external part of a labiate process.

Liradiscus ovalis Greville 1865:5, pl. 1, figs. 15–16; Hanna 1927:23, pl. 3, fig. 5.

Plate 38, Figures 1–7

Description: Valve is elliptical and rarely almost circular, convex, 35–45 μm long and 30–35 μm wide, bearing a system of external anastomosing ribs and/or short spines which form 2 to 5 cells in 10 μm. Valve margin is narrow and hyaline. Perforations and processes are absent.

Age: Fossil marine species, Late Cretaceous –Miocene (Hanna 1932).

Location: Marca Shale Member, Moreno Gulch, California, CAS 1144.

Xanthiopyxis grantii Hanna 1927:39, pl. 5, figs. 13–14.

Plate 39, Figures 1–5

Description: Frustule is heterovalvar. Valve is linear-elliptical, 48–65 µm long and 10–15 µm wide, slightly convex on the long axis. Porous canals, 35–40 in 10 µm are arranged in irregular rows on the valve face of one valve, which also bears small spines and a system of anastomosing ribs, 6–10 cells in 10 µm. The other valve is hyaline, without perforations, but bearing flattened spines scattered across the valve face. Processes are absent.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, Marca Canyon, California, CAS 610954, 615990.

Pterotheca evermannii Hanna 1927:31, pl. 4, fig. 6.

Plate 39, Figures 6–7

Description: Valve is cylindrical, 10–15 µm in diameter with a central horn with several vertical costae on the horn, which extend perpendicularly outward near the apex of the horn. Perforations and processes are absent.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 610955.

Pterotheca crucifera Hanna 1927:30, pl. 4, fig. 5.

Plate 39, Figures 8–9

Description: Valve is circular, 20–38 µm in diameter with a convex center and bearing curved radial ribs; 4–8 ribs in 10 µm, and a long curved central horn, with rare spines extending perpendicularly from near the apex of the horn. Valve mantle is vertical and hyaline. Perforations and processes are absent.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, California, CAS 610955.

Micrampulla parvula Hanna 1927:26, pl. 3, fig. 15.

Plate 39, Figures 10–11

Description: Body is spherical, 15– 20 µm in diameter, bearing a cylindrical flaring extension, long or short. A system of anastomosing ribs is present on the spherical part of the body, forming 10–12 pits in 10 µm. Pits are perforated by rare pores. Cylindrical, flaring extension is hyaline, with low longitudinal curved costa.

Age: Fossil marine species, Late Cretaceous.

Location: Marca Shale Member, Moreno Gulch, Dosados Canyon, Marca Canyon, California, CAS 610939, 615990.

Remarks: This specimen is a fragment of an unknown diatom or belongs to another group of unknown organisms.

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Appendix A

The system of classification used in this report, based on
Nikolaev & Harwood (2000b), with changes and additions.

Class Coscinodiscophyceae Round & Crawford

Subclass Archaegladiopsophycidae Nikolaev & Harwood

Order Archaegladiopsidales Nikolaev & Harwood
- **Family Archaegladiopsidaceae** Nikolaev & Harwood
  - **Genus:** ***Archaegladiopsis*** Nikolaev & Harwood
- **Family Praethalassiosiropsidaceae** Nikolaev & Harwood
  - **Genus:** ***Praethalassiosiropsis*** Gersonde & Harwood
- **Family Thalassiosiropsidaceae** Nikolaev
  - **Genera:** ***Thalassiosiropsis*** Hasle in Hasle & Syvertsen, ***Gladiopsis*** Gersonde & Harwood
- **Family Rhynchopyxidaceae** Nikolaev & Harwood
  - **Genus:** ***Rhynchopyxis*** Gersonde & Harwood

Order Gladiales Nikolaev & Harwood
- **Family Gladiaceae** Nikolaev & Harwood
  - **Genera:** ***Gladius*** Forti & Schulz, ***Amblypyrgus*** Gersonde & Harwood, ***Ancylopyrgus*** Gersonde & Harwood, ***Basilicostephanus*** Gersonde & Harwood
- **Family Kerkiaceae** Nikolaev & Harwood
  - **Genus:** ***Kerkis*** Gersonde & Harwood

Order Stephanopyxales Nikolaev
- **Family Stephanopyxidaceae** Nikolaev ex Round & Crawford
  - **Genera:** ***Stephanopyxis*** (Ehrenberg) Ehrenberg, ***Costopyxis*** Gleser, ***Creswellia*** Arnott ex Greville in Gregory, ***Endictya*** Ehrenberg, ***Systephania*** Ehrenberg
- **Family Eustephaniaceae** Komura
  - **Genera:** ***Eustephanias*** Komura, ***Biturricula*** Komura, ***Dactylacanthis*** Komura, ***Stephanonycites*** Komura
- **Family Triceratiaceae** (Schütt) Lemmermann
  - **Genera** ***Triceratium*** Ehrenberg, ***Porguenia*** Sullivan
- **Family Hydroseraceae** Nikolaev & Harwood
  - **Genus** ***Hydrosera*** Wallich

Order Thalassiosirales Gleser & Makarova
- **Family Thalassiosiraceae** Lebour
  - **Genera:** ***Thalassiosira*** Cleve, ***Bacterosira*** Gran. ***Cymatotheca*** Hendey, ***Detonula*** Schütt ex De Toni, ***Lomonycus*** Komura, ***Minidiscus*** Hasle, ***Nephrodiscus*** Komura , ***Planktoniella*** Schütt, ***Porosira*** Jorgensen
- **Family Lauderiaceae** (Schütt) Lemmermann, emend. Round & Crawford
  - **Genus:** ***Lauderia*** Cleve
- **Family Skeletonemataceae** Lebour, emend. Round
  - **Genus:** ***Skeletonema*** Greville

Order Stephanodiscales Nikolaev & Harwood

Family Stephanodiscaceae Gleser & Makarova

Genera: ***Stephanodiscus*** Ehrenberg, ***Concentrodiscus*** Khursevich, Moisseeva & Sukhova, ***Crateriportula*** Flower & Håkansson, ***Cyclostephanopsis*** Loginova, ***Cyclostephanos*** Round in Round in Theriot et al., ***Cyclotella*** (Kützing) de Brébisson, ***Cyclotubicoalitus*** Stoermer, Kociolek & Cody, ***Mesodictyon*** Theriot & Bradbury, ***Pliocaenicus*** Round & Håkansson, ***Pleurocyclus*** Casper & Scheffler, ***Stephanocostis*** Genkal & Kuzmina, ***Tertiarius*** Håkansson & Khursevich

Family Ectodictyonaceae Khursevich

Genus: ***Ectodyction*** Khursevich & Tcherniaeva

Subclass Paraliophycidae Nikolaev & Harwood

Order Paraliales Crawford

Family Paraliaceae Crawford

Genus: ***Paralia*** Heiberg

Family Praeparaliaceae Nikolaev & Harwood

Genus: ***Praeparalia*** Nikolaev & Harwood

Family Radialiplicataceae Gleser & Moisseeva

Genera: ***Radialiplicata*** (Gleser) Gleser, ***Bipalla*** Gleser, ***Ellerbeckia*** Crawford

Family Pseudopodosiraceae (Sheshukova) Gleser

Genera: ***Pseudopodosira*** Jousé in Proschina-Lavrenko emend. Vekschina, ***Anuloplicata*** (Gleser) Gleser

Order Archepyrgales Nikolaev & Harwood

Family Archepyrgaceae Nikolaev & Harwood

Genus: ***Archepyrgus*** Gersonde & Harwood

Order Aulacoseirales Nikolaev ex Moisseeva & Makarova

Family Aulacoseiraceae Moisseeva

Genera: ***Aulacoseira*** Thwaites, ***Alveolophora*** Moisseeva & Nevretdinova, ***Pseudoaulacosira*** Lupikina & Khursevich

Family Orthoseiraceae Crawford

Genus: ***Orthoseira*** Thwaites

Subclass Heliopeltophycidae Nikolaev & Harwood

Order Heliopeltales Nikolaev & Harwood

Family Heliopeltaceae Smith

Genera: ***Actinoptychus*** Ehrenberg, ***Actinodictyon*** Pantocsek, ***Centroporus*** Pantocsek, ***Debya*** Pantocsek, ***Glorioptychus*** Hanna, ***Haynaldia*** Pantocsek, ***Horodiscus*** Hanna, ***Lepidodiscus*** Witt, ***Thumia*** Cleve ex Taylor, ***Truania*** Pantocsek, ***Tschestnovia*** Pantocsek, ***Upothema*** Long Fuge & Smith

Order Auliscales Gleser

Family Auliscaceae Hendey

Genera: ***Auliscus*** Ehrenberg, ***Actinodiscus*** Greville, ***Australodiscus*** Porguen & Sullivan, ***Corona*** Greville, ***Craspedoporus*** Greville, ***Glyphodiscus*** Greville, ***Grovea*** Schmidt ex Van

Heurck, ***Hendeya*** Long, Fuge & Smith, ***Isodiscus*** Rattray, ***Meretrosulus*** Hanna, ***Monopsia*** Grove & Sturt, ***Noszkya*** Lefébure & Chenevière, ***Sextiputeus*** Ross & Sims

Order Microorbiales Nikolaev & Harwood
Family Microorbiaceae Nikolaev & Harwood
Genus ***Microorbis*** Gersonde & Harwood
Family Duniacea Nikolaev & Harwood
Genus ***Dunia*** Nikolaev & Harwood
Family Archaelepidodiscaceae Nikolaev & Harwood
Genera: ***Archaelepidodiscus*** Nikolaev & Harwood, ***Praehorodiscus*** Nikolaev & Harwood
Family Trochuaceae Nikolaev & Harwood
Genus ***Trochus*** Gersonde & Harwood

Subclass Coscinodiscophycidae Round & Crawford

Order Coscinodiscales Round & Crawford
Family Coscinodiscaceae Kützing, emend. Round & Crawford
Genera: ***Coscinodiscus*** Ehrenberg, ***Craspedodiscus*** Ehrenberg, ***Cristodiscus*** Gleser & Olshtinskaya, ***Kozloviella*** Jousé, ***Palmeria*** Greville, ***Porodiscus*** Greville, ***Pseudotriceratium*** Grunow, ***Stoschia*** Janisch ex Grunow in Van Heurck
Family Hemidiscaceae Hendey emend. Simonsen
Genera: ***Hemidiscus*** Wallich, ***Actinocyclus*** Ehrenberg, ***Araniscus*** Komura, ***Cestodiscus*** Greville, ***Cosmiodiscus*** Greville, ***Lobodiscus*** Lupikina & Khursevich, ***Mammidion*** Long, Fuge & Smith, ***Pontodiscus*** Temniskova-Topalova in Temniskova-Topalova et al., ***Roperia*** Grunow ex Pelletan, ***Spumorbis*** Komura, ***Undatodiscus*** Lupikina
Family Azpeitiaceae Gleser & Makarova
Genus: ***Azpeitia*** Peragallo in Tempère & Peragallo
Family **Ethmodiscaceae** Round
Genera: ***Ethmodiscus*** Castracane

Order Melosirales Gleser
Family Melosiraceae Kützing, emend, Round & Crawford
Genus: ***Melosira*** Agardh, ***Druridgia*** Donkin
Family Trochosiraceae Gleser
Genera: ***Trochosira*** Kitton, ***Distephanosira*** Gleser, ***Skeletonemopsis*** Sims, ***Stranguloneme*** Greville, ***Trochosirella*** Komura, ***Trochosiropsis*** Gleser
Family Hyalodiscaceae Gleser
Genera: ***Hyalodiscus*** Ehrenberg, ***Podosira*** Ehrenberg

Order Aulacodiscales Nikolaev & Harwood
Family Aulacodiscaceae (Schütt) Lemmermann
Genera: ***Aulacodiscus*** Ehrenberg, ***Pyrgodiscus*** Kitton ex Cleve, ***Schuettia*** De Toni

Order Asterolamprales Round & Crawford
Family Asterolampraceae Smith emend Gombos
Genera: ***Asterolampra*** Ehrenberg, ***Asteromphalus*** Ehrenberg, ***Rylandsia*** Greville & Ralfs in Greville, ***Siphonodiscus*** Komura
Family Brightwelliaceae Nikolaev & Harwood

Genera: ***Brightwellia*** Ralfs in Pritchard, ***Bergonia*** Tempère in Brun et al., ***Discodiscus*** Gombos, ***Hyperion*** Gombos

Family Neobruniaceae Hendey

Genus: ***Neobrunia*** Kuntze

Family Thaumatonemataceae Nikolaev & Harwood

Genus: ***Thaumatonema*** Greville

Order Eupodiscales Nikolaev & Harwood

Family Eupodiscaceae Kützing

Genera: ***Eupodiscus*** Bailey, ***Cerataulus*** Ehrenberg, ***Pleurosira*** (Meneghini) Trevisan di San Leon, ***Rattrayella*** De Toni, ***Zygoceros*** Ehrenberg

Family Parodontellaceae Komura

Genera: ***Parodontella*** Komura, ***Acigonium*** Komura, ***Stylorium*** Komura, ***Thammodiscus*** Komura

Order Stellarimales Nikolaev & Harwood

Family Stellarimaceae Nikolaev ex Hasle & Sims

Genera: ***Stellarima*** Hasle & Sims, ***Azpeitiopsis*** Sims, ***Fenestrella*** Greville, ***Pomphodiscus*** Barker & Meakin

Family Trigoniaceae Gleser

Genus: ***Trigonium*** Cleve

Family Gossleriellaceae Round

Genus: ***Gossleriella*** Schmidt

Subclass Biddulphiophycidae Round & Crawford

Order Biddulphiales Krieger

Family Biddulphiaceae Kützing

Genera: ***Biddulphia*** Gray, ***Alveoflexus*** Hendey & Sims, ***Amphitetras*** Ehrenberg, ***Ancoropsis*** Hendey & Sims, ***Biddulphiopsis*** Von Stosh & Simonsen, ***Cortinocornus*** Gleser, ***Eucampia*** Ehrenberg, ***Huttonia*** Grove & Sturt, ***Lampriscus*** Schmidt in Schmidt, ***Lisitzinia*** Jousé, ***Odontella*** Agardh, ***Peponia*** Greville, ***Pseudoauliscus*** Schmidt

Family Bellerochaeceae Crawford

Genera: ***Bellerochea*** Van Heurck

Family Gyrocylindraceae Strelnikova & Nikolaev

Genus: ***Gyrocylindrus*** Strelnikova & Nikolaev

Family Kittoniaceae Gleser

Genus: ***Kittonia*** Grove & Sturt

Order Bilinguales Nikolaev & Harwood

Family Bilinguaceae Nikolaev & Harwood

Genus ***Bilingua*** Gersonde & Harwood

Order Briggerales Nikolaev & Harwood

Family Briggeraceae Nikolaev & Harwood

Genera: ***Briggera*** Ross & Sims, ***Dicladiopsis*** De Toni, ***Maluina*** Ross & Sims, ***Pseudoaulacodiscus*** Vekshina

Family Streptothecaceae Crawford

Genera: ***Streptotheca*** von Stosch, ***Neostreptotheca*** von Stosch

Order Hemiaulales Round & Crawford

Family Hemiaulaceae Heiberg

Genera: ***Hemiaulus*** Ehrenberg, ***Abas*** Ross & Sims, ***Ailuretta*** Sims, ***Arcus*** Olshtynskaja, ***Baxteriopsis*** Karsten in Engler & Prantl, ***Bonea*** Ross & Sims, ***Cerataulina*** Peragallo ex Schütt in Engler & Prantl, ***Climacodium*** Grunow, ***Dextradonator*** Ross & Sims, ***Fontigonium*** Sims & Hendey, ***Keratophora*** Pantocsek, Monile Ross & Sims, ***Monobranchia*** Schrader in Schrader & Fenner, ***Pseudorutilaria*** (Grove & Sturt ex DeToni & Levi) Grove & Sturt ex DeToni, ***Solium*** Heiberg, ***Sphynctolethus*** Hanna, ***Strelnikovia*** Ross & Sims, ***Trinacria*** Heiberg

Family Sheshukoviaceae Gleser

Genera: ***Sheshukovia*** Gleser, ***Entogonia*** Greville, ***Euodiella*** Sims, ***Eurossia*** Sims in Mahood et al., ***Medlinia*** Sims

Family Isthmiaceae Schütt

Genus: ***Isthmia*** Agardh

Order Lithodesmiales Round & Crawford

Family Lithodesmiaceae Round

Genera: ***Lithodesmium*** Ehrenberg, ***Ditylum*** Bailey ex L.W. Bailey, ***Lithodesmioides*** von Stosch.

Order Stictodiscales Round & Crawford

Family Stictodiscaceae (Schütt) Simonsen

Genera: ***Stictodiscus*** Greville, ***Arachnoidiscus*** Deane ex Shaldbolt, ***Pseudostictodiscus*** Grunow ex Schmidt, ***Rhaphidophora*** Long, Fuge & Smith, ***Rocella*** Hanna, ***Stictocyclus*** Mann, ***Stictolecanon*** Komura

Family Benetoraceae Sims

Genus: ***Benetorus*** Hanna

Family Chrysanthemodiscaceae Round

Genus: ***Chrysanthemodiscus*** Mann

Family Plurifenestraceae Komura

Genera: ***Plurifenestra*** Komura, ***Unguella*** Komura

Order Anaulales Round & Crawford

Family Anaulaceae (Schütt) Lemmerman

Genera: ***Anaulus*** Ehrenberg, ***Eunotogramma*** Weisse, ***Porpeia*** Bailey, ***Terpsinoë*** Ehrenberg

Order Chaetocerotales Round & Crawford

Family Chaetocerotaceae Ralfs

Genera: ***Chaetoceros*** Ehrenberg, ***Acanthoceros*** Honigmann, ***Attheya*** West, ***Bacteriastrum*** Shadbolt, ***Chasea*** Hanna, ***Gonioceros*** Peragallo in Peragallo & Peragallo

Family Leptocylindraceae Lebour

Genus: ***Leptocylindrus*** Cleve in Petersen

Order Cymatosirales Round & Crawford

Family Cymatosiraceae Hasle, Von Stosch & Syvertsen

Genera: ***Cymatosira*** Grunow, ***Arcocellulus*** Hasle, von Stosch & Syvertsen, ***Bogorovia*** Jousé,

Brockmanniella Hasle, von Stosch & Syvertsen, ***Campylosira*** Grunow ex Van Heurck, ***Extubocellulus*** Hasle, Von Stosch & Syvertsen, ***Leyanella*** Hasle, von Stosch & Syversen, ***Minutocellus*** Hasle, von Stosch & Syvertsen, ***Papiliocellulus*** Hasle, von Stosch & Syvertsen, ***Plagiogrammopsis*** Hasle, von Stosch & Syvertsen, ***Rossiella*** Desikachary & Maheshwari

Family Rutilariaceae De Toni

Genera: ***Rutilaria*** Greville, ***Kisseleviella*** Sheshukova-Poretzkaya, ***Spinivinculum*** Ross & Sims, ***Syndetocystis*** Ralfs ex Greville

Subclass Rhizosoleniophycidae Round & Crawford

Order Rhizosoleniales Silva, emend. Round & Crawford

Family Rhizosoleniaceae De Toni

Genera: ***Rhizosolenia*** Brightwell, ***Calyptrella*** Hernández-Becerril & Meave del Castillo, ***Dactyliosolen*** Castracane, ***Guinardia*** H. Peragallo, ***Pseudosolenia*** Sundström, ***Urosolenia*** Round & Crawford in Round et al.

Family Probosciaceae Nikolaev & Harwood

Genus: ***Proboscia*** Sundström

Family Pyxillaceae (Schütt) Simonsen

Genus: ***Pyxilla*** Greville

Order Corethrales Round & Crawford

Family Corethraceae Lebour

Genus: ***Corethron*** Castracane

Genera of Unknown Taxonomic Position

Dasyangea Harwood & Gersonde, ***Gyrodiscus*** Witt, ***Mastogonia*** Ehrenberg, ***Pyrgupyxis*** Hendey, ***Pseudopyxilla*** Forti, ***Pterotheca*** Grunow ex Forti, ***Kentrodiscus*** Pantocsek, ***Kreagra*** Gersonde & Harwood, ***Calyptosporium*** Harwood & Gersonde, ***Odontotropis*** Grunow, ***Meristosolen*** Harwood & Gersonde, ***Liradiscus*** Greville, ***Xanthiopyxis*** (Ehrenberg) Ehrenberg, ***Micrampulla*** Hanna, ***Poretzskia*** Jousé, ***Cladogramma*** Ehrenberg

Appendix B

Diatoms reported from the Moreno Formation, California

Legend: **Bold case** – Currently accepted name of confirmed Cretaceous taxa
(Normal case) – Synonyms of confirmed Cretaceous taxa
Normal case – Taxa of uncertain age
* – taxa treated in this work
[Cr.] – Confirmed Cretaceous age
[Cr. Syn.] = Synonym of confirmed Cretaceous taxa
[age ?] – Cretaceous age, not confirmed

* ***Acanthodiscus immaculatus*** (Hanna) Nikolaev & Barron; Hanna 1927 [Cr]
* ***Acanthodiscus paterus*** (Long et al.) Nikolaev & Barron; Hanna 1927 [Cr.]
Actinodictyon uncum (Long et al.) Ross & Sims; Ross & Sims 1997 [Cr.]
Actinodictyon weissflogii var. *unca* Long et al.; Long et al. 1946 [Cr.]
Actinoptychus chenevierei Long et al.; Long et al. 1946 [age ?]
Actinoptychus glabratus var. *incisus* Grunow; Long et al. 1946 [age ?]
Actinoptychus indeterminatus Long et al.; Long et al. 1946 [age ?]
* ***Actinoptychus packii*** Hanna; Hanna 1927 [Cr.]
Actinoptychus packii* var. *immaculatus Long et al.; Long et al. 1946 [Cr.]
Actinoptychus rotula Long et al.; Long et al. 1946 [age ?]
Actinoptychus signatus Long et al.; Long et al. 1946 [age ?]
Actinoptychus summissus Schmidt; Long et al. 1946 [age ?]
* ***Actinoptychus taffii*** Hanna; Hanna 1927
Actinoptychus undulatus Ehrenberg var.; Long et al. 1946 [age ?]
Anaulus californicus Long et al.; Long et al. 1946 [age ?]
Anaulus undulatus Long et al.; Long et al. 1946 [age ?]
Arachnoidiscus antiquus Barker & Meakin; Barker & Meakin 1944 [age ?]
* ***Arachnoidiscus ehrenbergii*** Bailey; Long et al. 1946 [Cr.]
Arachnoidiscus indicus Ehrenberg; Long et al. 1946 [Cr.]
Arachnoidiscus interruptus Barker & Meakin; Barker & Meakin 1945 [age ?]
Aulacodiscus allorgei Chenevière; Long et al. 1946 [age ?]
Aulacodiscus alternans Long et al.; Long et al. 1946 [age ?]
Aulacodiscus americanus Long et al.; Long et al. 1946 [age ?]
* ***Aulacodiscus archangelskianus*** Witt; Hanna 1934; Long et al. 1946 [Cr.]
(*Aulacodiscus archangelskianus* var. *pugnalus*) (Hanna) Long et al.; Long et al. 1946 [Cr.]
Aulacodiscus brownei Norman; Long et al. 1946 [age ?]
Aulacodiscus cellulosus var. *inflatus* Long et al.; Long et al. 1946 [age ?]
Aulacodiscus cretaceous Hanna; Hanna 1927 [Cr.]
Aulacodiscus erectus Long et al.; Long et al. 1946 [age ?]
Aulacodiscus fugei Barker & Meakin; Barker & Meakin 1946 [age ?]
Aulacodiscus lahusenii var. *marginalis* Witt; Long et al. 1946 [age ?]
Aulacodiscus morenoensis Long et al.; Long et al. 1946 [age ?]
(*Aulacodiscus pugnalus*) Hanna; Hanna 1927 [Syn. Cr.]
Aulacodiscus rellae Hanna & Grant; Long et al. 1946 [age ?]
Aulacodiscus sagittarius Long et al.; Long et al. 1946 [age ?]
Aulacodiscus sagittarius var. *distentus* Long et al.; Long et al. 1946 [age ?]
Aulacodiscus stelliformis Barker & Meakin; Barker & Meakin 1946 [age ?]

Aulacodiscus striatus Long et al. Long et al. 1946 [Cr.]
Aulacodiscus validus Barker & Meakin; Barker & Meakin 1946 [age ?]
Auliscus aenigmus Hanna; Hanna 1927 [Cr.]
Auliscus bubo Long et al.; Long et al. 1946 [age ?]
Auliscus dilectus Long et al.; Long et al. 1946 [age ?]
Auliscus hardmanianus var. *maculosus* Long et al.; Long et al. 1946 [age ?]
Auliscus hendeyi Long et al.; Long et al. 1946 [age ?]
Auliscus paleaceus Long et al.; Long et al. 1946 [age ?]
Auliscus priscus Long et al.; Long et al. 1946 [age ?]
Auliscus scutulum Long et al.; Long et al. 1946 [age ?]
Auliscus spissus Long et al.; Long et al. 1946 [age ?]
Auliscus trioculatus Long et al. Long et al. 1946 [age ?]
Auliscus whartonii Long et al.; Long et al. 1946 [age ?]
* ***Azpeitiopsis morenoensis*** (Hanna) Sims; Sims 1994 [Cr.]
(*Benetorus craspedodiscoides*) Sims; Sims 1994 [Syn. Cr.]
* ***Benetorus fantasmus*** Hanna; Hanna 1927, 1934; Sims 1994 [Cr.]
(*Benetorus morenoensis*) (Long et al.) Sims; Sims 1994 [Syn. Cr.]
Biddulphia apiculata Long et al.; Long et al. 1946 [age ?]
Biddulphia gurowii Pantocsek; Long et al. 1946 [age ?]
Biddulphia impressa Long et al.; Long et al. 1946 [age ?]
Biddulphia lacunosa Long et al.; Long et al. 1946 [age ?]
Biddulphia longaeva Long et al.; Long et al. 1946 [age ?]
Biddulphia patens Barker & Meakin; Barker & Meakin 1949 [age ?]
Biddulphia perplexa Long et al.; Long et al. 1946 [age ?]
Biddulphia primordinalis Long et al.; Long et al. 1946 [age ?]
Biddulphia suborbiculata Long et al.; Long et al. 1946 [age ?]
Biddulphia tuomeyii Bailey; Long et al. 1946 [Cr.]
Biddulphia undulata Long et al.; Long et al. 1946 [age ?]
Biddulphia vennulosa Barker & Meakin; Barker & Meakin 1949 [age ?]
Briggera morenoensis Ross & Sims; Ross & Sims 1985 [Cr.]
* ***Centroporus californicus*** Long et al.; Long et al. 1946 [Cr.]
Chasea bicornis Hanna; Hanna 1934 [Cr.]
Cladogramma jordanii Hanna; Hanna 1927 [Cr.]
Cladogramma morenoensis Long et al.; Long et al. 1946 [age ?]
Coscinodiscus circumspectus Long et al.; Long et al. 1946 [age ?]
Coscinodiscus clarescens Long et al.; Long et al. 1946 [age ?]
Coscinodiscus convexus Schmidt; Long et al. 1946 [age ?]
Coscinodiscus definitus Long et al.; Long et al. 1946 [age ?]
Coscinodiscus denarius Schmidt; Long et al. 1946 [age ?]
(*Coscinodiscus distinctus*) Long et al.; Long et al. 1946 [Syn. Cr.]
Coscinodiscus duplex Long et al.; Long et al. 1946 [age ?]
(*Coscinodiscus immaculatus*) Hanna; Hanna 1927 [Syn. Cr.]
Coscinodiscus inordinatus Long et al.; Long et al. 1946 [age ?]
(*Coscinodiscus lineatus*) Ehrenberg; Hanna 1934; Long et al. 1946 [Syn. Cr.]
Coscinodiscus maculosus Long et al.; Long et al. 1946 [age ?]
* *Coscinodiscus marginatus* Ehrenberg; Long et al. 1946 [age ?]
(*Coscinodiscus morenoensis*) Hanna; Hanna 1927; Long et al. 1946 [Syn. Cr.]

Coscinodiscus nitidulus Grunow; Long et al. 1946 [age ?]
Coscinodiscus obscurus Schmidt; Long et al. 1946 [age ?]
Coscinodiscus solidus Strelnikova; Sims 1989 [Cr.]
(*Coscinodiscus steinyi*) Hanna; Hanna 1927; Long et al. 1946 [Syn. Cr.]
Coscinodiscus subtilis Ehrenberg var.; Long et al. 1946
Coscinodiscus superbus var. *californicus* Long et al.; Long et al. 1946
(*Craspedodiscus morenoensis*) Long et al.; Long et al. 1946 [Syn. Cr.]
* ***Debya californica*** Long et al.; Long et al. 1946 [Cr.]
Endyctia oceanica Ehrenberg; Long et al. 1946 [age ?]
Eunotogramma marginopunctatum Long et al.; Long et al. 1946 [age ?]
Eunotogramma productum var. *rectum* Long et al.; Long et al. 1946 [age ?]
Eunotogramma sp.; Long et al. 1946 [age ?]
Eupodiscus lineatus Barker & Meakin; Barker & Meakin 1946 [age ?]
Eupodiscus radiatus Bailey; Long et al. 1946 [age ?]
Eupodiscus vallatus Barker & Meakin; Barker & Meakin 1945 [age ?]
* ***Euodiella bicornigera*** (Hanna) Sims [Cr.]
* ***Euodiella tristictia*** (Hanna) Sims [Cr.]
* ***Gladiopsis speciosa*** (Schulz) Gersonde & Harwood [Cr.]
* ***Glorioptychus callidus*** Hanna; Hanna 1927; Long et al. 1946 [Cr.]
* ***Haynaldia strigillata*** Witt in Schmidt et al.; Hanna 1934 [Cr.]
* ***Hemiaulus polymorphus*** Grunow; Hanna 1927 [Cr.]
* ***Hendeya dehiscens*** Long et al.; Long et al. 1946 [Cr.]
Horodiscus macroscriptus Hanna; Hanna 1927 [Cr.]
Huttonia cretacea Long et al.; Long et al. 1946 [age ?]
* ***Kentrodiscus aculeatus*** Hanna; Hanna 1927 [Cr.]
* ***Kentrodiscus andersonii*** Hanna; Hanna 1927 [Cr.]
* ***Kentrodiscus blandus*** Long et al.; Long et al. 1946 [Cr.]
Kittonia hannai Lefébure & Chenevière; Lefébure & Chenevière 1939; Long et al. 1946 [Cr.]
Kittonia pentagona Meakin & Brigger 1949 [age ?]
Lepidodiscus sp.; Long et al. 1946 [age ?]
* ***Liradiscus ovalis*** Greville; Hanna 1927 [Cr.]
Lithodesmium californicum Grunow; Long et al. 1946 [age ?]
Lithodesmium margaritaceum; Long et al. 1946 [age ?]
Mammidion elegans Long et al.; Long et al. 1946 [age ?]
* ***Medlina deciusii*** (Hanna) Nikolaev & Kociolek [Cr.]
* ***Medlinia mucronata*** (Schmidt) Nikolaev & Barron [Cr.]
Melosira dens-serrae Long et al.; Long et al. 1946 [age ?]
(*Melosira fausta*) Schmidt; Hanna 1927 [Syn. Cr.]
Melosira patera Long et al.; Long et al. 1946 [Syn. Cr.]
Meretrosulus gracilis Hanna; Hanna 1927; Long et al. 1946 [Cr.]
Monopsia mammosa Grove & Sturt; Long et al. 1946 [age ?]
* ***Micrampulla parvula*** Hanna; Hanna 1927, 1934 [Cr.]
* ***Paralia crenulata*** (Grunow) Gleser [Cr.]
* ***Odontotropis galeonis*** Hanna; Hanna 1927 [Cr.]
Planktoniella californica Long et al.; Long et al. 1946 [age ?]
Podosira mirabilis Long et al.; Long et al. 1946 [age ?]
Podosira superba Long et al.; Long et al. 1946 [age ?]

Podosira superba var. *reticulata* Long et al.; Long et al. 1946 [age ?]
* ***Pomphodiscus craspedodiscoides*** (Sims) Nikolaev & Harwood [Cr.]
* ***Pomphodiscus morenoensis*** (Long et al.) Barker & Meakin; Barker & Meakin 1946 [Cr.]
Porpeia sp.; Long et al. 1946 [age ?]
* ***Pseudopyxilla russica*** (Pantocsek) Forti; Hanna 1927 [Cr.]
* ***Pseudostictodiscus picus*** Hanna 1927; Hanna 1927 [Cr.]
* ***Pterotheca crucifera*** Hanna; Hanna 1927 [Cr.]
* ***Pterotheca evermannii*** Hanna; Hanna 1927 [Cr.]
(*Pyxilla capitata*) Barker & Meakin; Barker & Meakin 1948 [Syn. Cr.]
* ***Rattrayella churchii*** Hanna; Hanna 1934 [Cr.]
Rhaphidophora elegans Long et al.; Long et al. 1946 [age ?]
* ***Sheshukovia excavata*** (Heiberg) Nikolaev & Harwood [Cr.]
* ***Sphynctolethus monstrosus*** Hanna; Hanna 1927; Sims 1986 [Cr.]
* ***Stellarima distincta*** (Long et al.) Sims; Sims 1987 [Cr.]
* ***Stellarima steinyi*** (Hanna) Sims; Sims 1987 [Cr.]
* ***Stephanopyxis appendiculata*** (Ehrenberg) Schmidt; Hanna 1927; Long et al. 1946 [Cr.]
* ***Stephanopyxis barbadensis*** Greville; Long et al. 1946 [Cr.]
* ***Stephanopyxis discrepans*** Hanna; Hanna 1927 [Cr.]
* ***Stephanopyxis grunowii*** Grove & Sturt; Hanna 1927; Long et al. 1946 [Cr.]
Stephanopyxis reticulata Long et al.; Long et al. 1946 [Cr.]
Stephanopyxis rudis Greville; Long et al. 1946 [age ?]
* ***Stephanopyxis turris*** (Greville in Gregory) Ralfs in Pritchard [Cr.]
Stictodiscus concinnus Long et al.; Long et al. 1946 [age ?]
Stictodiscus grossepunctatus Long et al.; Long et al. 1946 [age ?]
Terpsinoë anguinea Long et al.; Long et al. 1946 [age ?]
* ***Thalassiosiropsis wittiana*** (Pantocsek) Hasle in Hasle & Syvertsen; Sims 1994 [Cr.]
Tortilaria briggeri Barker & Meakin; Barker & Meakin 1948 [age ?]
Triceratium album Long et al.; Long et al. 1946 [age ?]
Triceratium bellum Long et al.; Long et al. 1946 [age ?]
(*Triceratium bicornigerum*) Hanna; Hanna 1927; Long et al. 1946 [Syn. Cr.]
Triceratium cellulosum var. *californicum* Long et al.; Long et al. 1946 [age ?]
Triceratium dignum Long et al.; Long et al. 1946 [age ?]
(*Triceratium hertleinii*) Hanna; Hanna 1927; Long et al. 1946 [Syn. Cr.]
Triceratium lunatum Long et al.; Long et al. 1946 [age ?]
Triceratium lustratum Long et al.; Long et al. 1946 [age ?]
Triceratium morenoense Barker & Meakin; Barker & Meakin 1949 [age ?]
Triceratium perplexum Long et al.; Long et al. 1946 [age ?]
Triceratium pruninosum Long et al.; Long et al. 1946 [age ?]
(*Triceratium swastika*) Long et al.; Long et al. 1946 [age ?]
* ***Trigonium hertleinii*** (Hanna) Nikolaev & Fourtanier [Cr.]
* ***Trinacria aries*** Schmidt et al.; Hanna 1927; Long et al. 1946 [Cr.]
(*Trinacria deciusii*) Hanna; Hanna 1927 [Syn. Cr.]
Trinacria deciusii var. *summaria* Long et al.; Long et al. 1946 [age ?]
(*Trinacria excavata*) Heiberg; Hanna 1927 [Syn. Cr.]
Trinacria fimbriata Sims & Ross 1988 [Cr.]
* ***Trinacria insipiens*** Witt; Hanna 1927; Long et al. 1946 [Cr.]
Trinacria interlineata Long et al.; Long et al. 1946 [age ?]

(*Trinacria mucronata*) (Schmidt) Hanna; Hanna 1927; Long et al. 1946 [Syn. Cr.]
Trinacria nitescens Long et al.; Long et al. 1946 [age ?]
(*Trinacria tristictia*) Hanna; Hanna 1927 [Syn. Cr.]
(*Tubularia pistillaris* var. *grossepunctata*) Long et al.; Long et al. 1946 [Syn. Cr.]
Upothema californica Long et al.; Long et al. 1946 [age ?]
****Xanthiopyxis grantii*** Hanna; Hanna 1927, 1934 [Cr.]

PLATES
1–39

Plate 1

Figs. 1–4 – ***Thalassiosiropsis wittiana***: Fig. 1 – Hypotype, CAS 3394 (Coll. Long, Fuge & Smith 1946); general view. Fig. 2 – External view of the valve face, showing tangential crossing rows of the foramina of loculate areolae, and the tube of the annular process (arrow). Fig. 3 – Internal view of the valve face showing the annular process (arrow), tangential arrangement of loculate areolae and cribral pores arranged in an indistinct radial pattern. Fig. 4 – Detail of Fig. 3, central part of the valve face showing cribral pores of the interrupted cribrum, chambers of loculate areolae, and the central annular process (arrow).

Fig. 1 – Light micrograph (LM); Figs. 2–4 – Scanning electron micrograph (SEM). Scale bars: Figs. 1–3 = 10 μm; Fig. 4 = 1 μm. Figs. 2–4 – CAS 1144.

PLATE 1

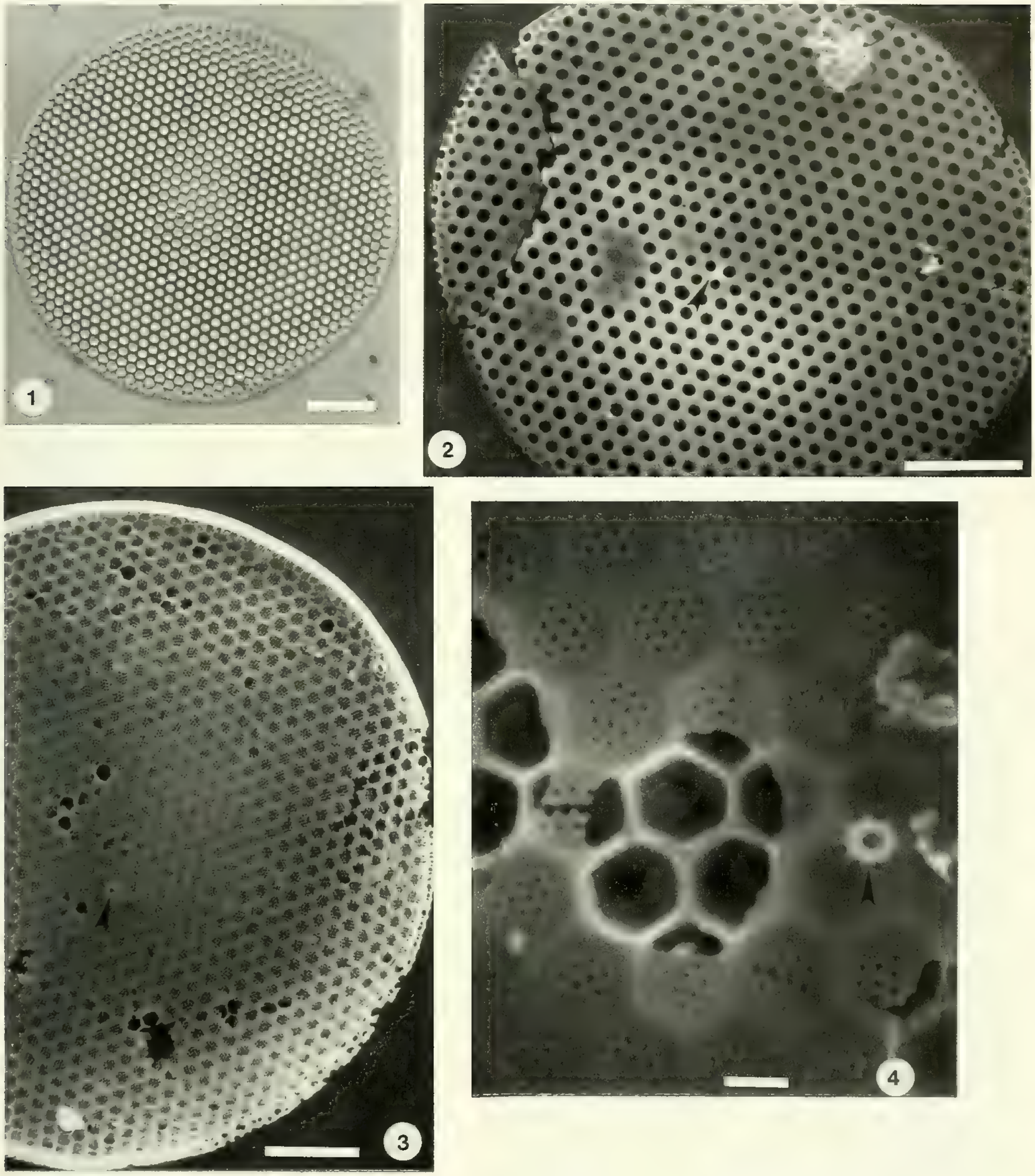

Plate 2

Figs. 1–7 – ***Gladiopsis speciosa***: Figs. 1–2 – Holotype CAS 3441 (*Tubularia pistillaris* var. *grossipunctata* in the collection of Long, Fuge & Smith 1946); general view. Figs. 3–4 – External part of the valve mantle showing the longitudinal and diagonal crossing rows of loculate areolae, and the central (terminal) position of the annular process on the valve face (arrows). Fig. 5 – External view of the valve apex showing the longitudinal and diagonal crossing rows of areolae on the valve mantle, and the hyaline valve face with the central opening of the annular process (arrow). Fig. 6 – Fragment of the broken valve mantle showing the external foramen and internal cribrum of the loculate areolae. Fig. 7 – Detail of Fig. 6 showing cribral pores of the cribrum and a cross-section of the chambers of the loculate areolae.

Figs. 1–2 – LM; Figs. 3–7 – SEM. Scale bars: Figs. 1–3, 5–6 = 10 µm; Figs. 4, 7 = 1 µm. Figs. 3–7 – CAS 610954.

PLATE 2

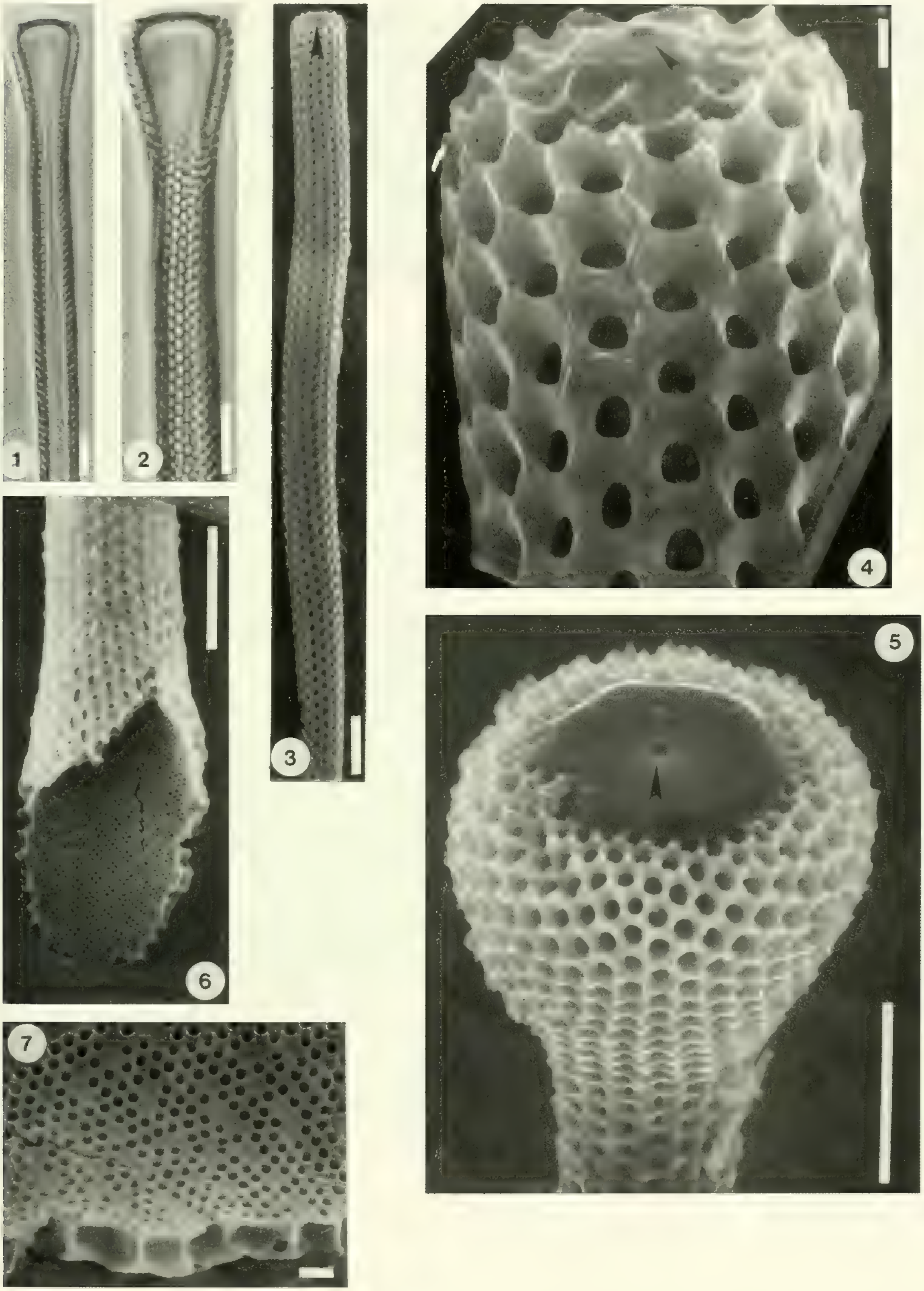

Plate 3

Figs. 1–6 – ***Stephanopyxis appendiculata***: Fig. 1 – Two frustules connected in a short colony. Fig. 2 – Valve view. Fig. 3 – Two spherical frustules connected by spines (external tubes of labiate processes) and part of the girdle wall of former mother cell (central part of colony). Fig. 4 – External girdle view of a frustule and a valve showing the linking spine attachment and packing arrangement of the foramen of the loculate areolae. Fig. 5 – Valve interiors showing the interrupted cribrum of the loculate areolae and the apical ring of labiate processes (arrows). Fig. 6 – Detail of Fig. 5 showing the marginal ring of tuberculate labiate processes with a slit, located on the cribrum of loculate areolae (arrows).

Figs. 1–2 – LM; Figs. 3–6 – SEM. Scale bars: Figs. 1–5 = 10 µm; Fig. 6 = 1 µm. Figs. 1–2, 5–6 – CAS 1144; Fig. 3 – CAS 610954; Fig. 4 – CAS 610939.

PLATE 3

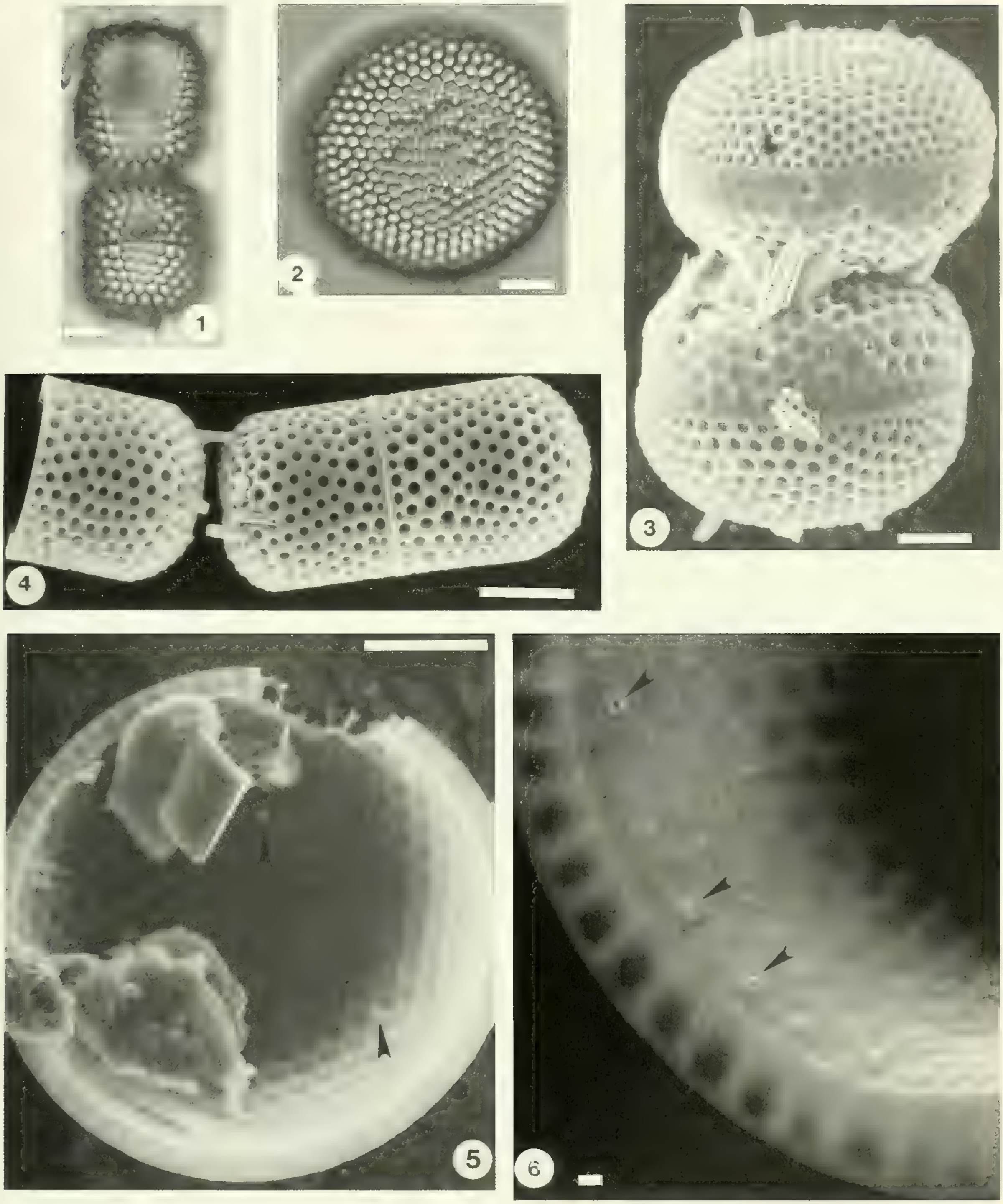

Plate 4

Figs. 1–6 – ***Stephanopyxis barbadensis***: Fig. 1 – Valve face showing the arrangement of loculate areolae and location of the external tubes of labiate processes (arrows). Fig. 2 – Valve mantle showing convexity of the valve face and arrangement of the areolae. Fig. 3 – External view of the valve face showing the arrangement of the loculate areolae and the ring of external tubes of the labiate process (arrows). Fig. 4 – Internal view of the valve showing the interrupted cribrum of loculate areolae with the first ring of tubercle labiate processes (large arrow), and the second ring of labiate processes that are located on the cribrum of areolae (small arrow). Fig. 5 – Detail of Fig. 4 showing the radial orientation of the rows of cribral pores and the tuberculate labiate processes with a slit (arrows). Fig. 6 – Broken wall of the valve near the margin showing features of the second ring of labiate processes, such as the location of the external tube of the labiate process on the cribrum of loculate areolae (arrow).

Figs. 1–2 – LM; Figs. 3–6 – SEM. Scale bars: Figs. 1–4 = 10 µm; Figs. 5–6 = 1 µm. Figs. 1–6 – CAS 610939.

PLATE 4

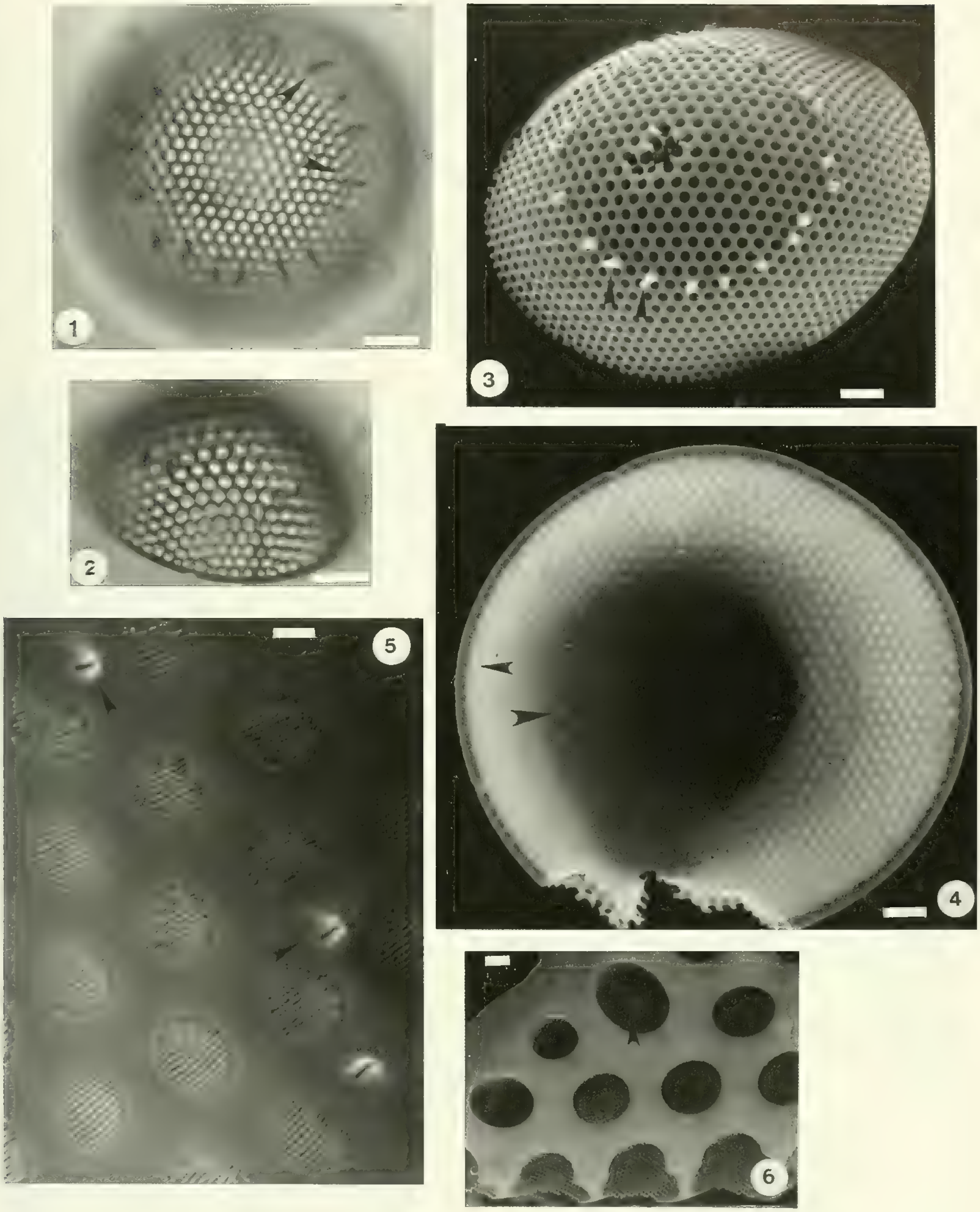

Plate 5

Figs. 1–6 – ***Stephanopyxis discrepans***: Fig. 1 – Holotype CAS 2036; valve of a "regular" cell from the central part of a colony. Figs. 2–3 – External views of a valve. Fig. 2 – Valve face and part of the valve mantle showing the arrangement of areolae and the form of marginal spines (external tube of the labiate processes). Fig. 3 – Detail of Fig. 2, showing the irregular size of areolae and a portion of the marginal ring of spines with small openings (arrows) that are the external tubes of the marginal ring of labiate processes. Fig. 4 – Internal view of the valve face and valve mantle showing the uninterrupted cribrum of the loculate areolae and the location of the labiate processes (arrows). Fig. 5 – Broken wall of the valve mantle showing the external arrangement of the loculate areolae and spines, the internal pattern of the uninterrupted cribrum, and the location of labiate processes (arrow). Fig. 6 – External view of the valve mantle showing the arrangement of areolae and the location of the ring of marginal spines.

Figs. 1 – LM; Figs. 2–6 – SEM. Scale bars: Figs. 1–2, 4–6 = 10 µm; Fig. 3 = 1 µm. Figs. 2–5 – CAS 610954; Fig. 6 – CAS 1144.

PLATE 5

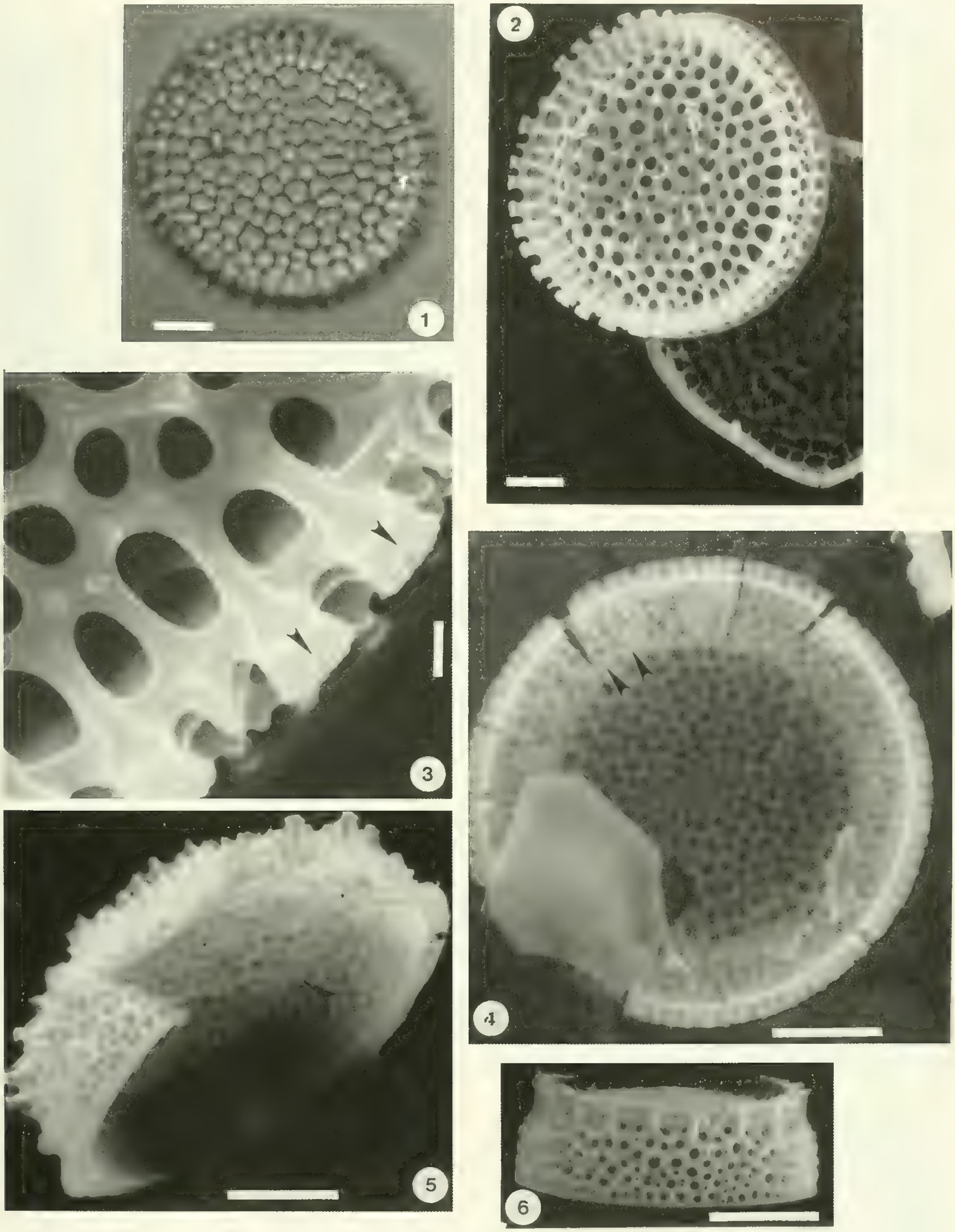

Plate 6

Figs. 1–6 – ***Stephanopyxis discrepans***: Fig. 1 – Paratype CAS 2037; valve of a "terminal" cell. Fig. 2 – External view of the valve face and valve mantle showing the irregular size and form of the foramen of loculate areolae and the ring of spines. Fig. 3 – Broken valve face revealing the cross-sectional form of the external foramina (top) and internal cribrum (base) of the loculate areolae. Fig. 4 – Oblique view of a valve showing the internal and external features of the valve mantle, including uninterrupted cribrum, rings of labiate processes (arrows), and the form and distribution of the external branching spines. Figs. 5–6 – Internal valve view showing the uninterrupted cribrum of loculate areolae and the ring of labiate processes (arrows). Fig. 6 – Detail of Fig. 5 showing the quincunx pattern of the cribral pores of the cribrum and the tuberculate form of the labiate processes (arrows).

Figs. 1 – LM; Figs. 2–6 – SEM. Scale bars: Figs. 1–2, 4–5 = 10 μm; Figs. 3, 6 = 1 μm. Figs. 2–3, 5–6 – CAS 610954; Fig. 6 – CAS 1144.

PLATE 6

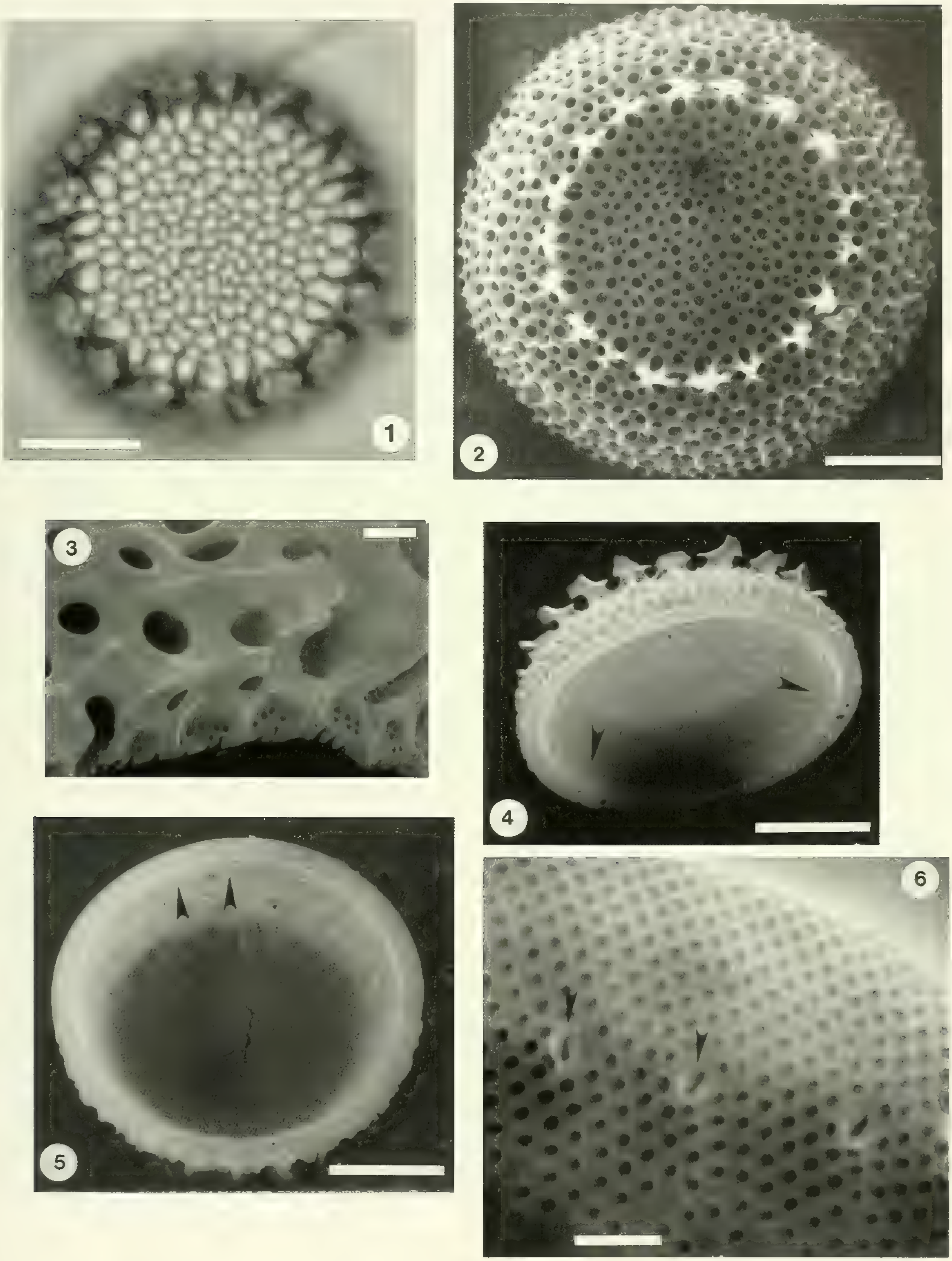

Plate 7

Figs. 1–4 – ***Stephanopyxis grunowii***: Fig. 1 – Valve. Fig. 2 (left) – External view of the valve face and mantle showing the irregular form of the external foramen and the ring of labiate processes marked by the external tubes (arrows). Fig. 2 (right) – Internal view of the valve showing broken cribrum and location of labiate processes (arrows). Fig. 3 – External view of the valve face with foramen of irregular form and tubes of labiate processes (arrows). Fig. 4 – Interior part of the valve margin (lower left) showing the broken cribrum of loculate areolae and the tubercle with a round aperture of the labiate processes (arrows). Figs. 5 – 6 – ***Stephanopyxis turris***: Fig. 5 – External and internal view of the valve mantle showing rows of foramen of the loculate areolae, external tubes of the apical labiate processes (large arrow) at the edge of the valve face, and the internal view of the marginal ring of labiate processes on the valve mantle (small arrows). Fig. 6 – Internal view of the valve with a broken wall showing the broken cribrum, the marginal ring of labiate processes with round apertures (small arrows), and the internal form of an apical labiate process with a slit (large arrow).

Fig. 1 – LM; Figs. 2–6 – SEM. Scale bars: Figs. 1–3, 5 = 10 µm; Figs. 4, 6 = 1 µm. Figs. 1–6 – CAS 610954.

PLATE 7

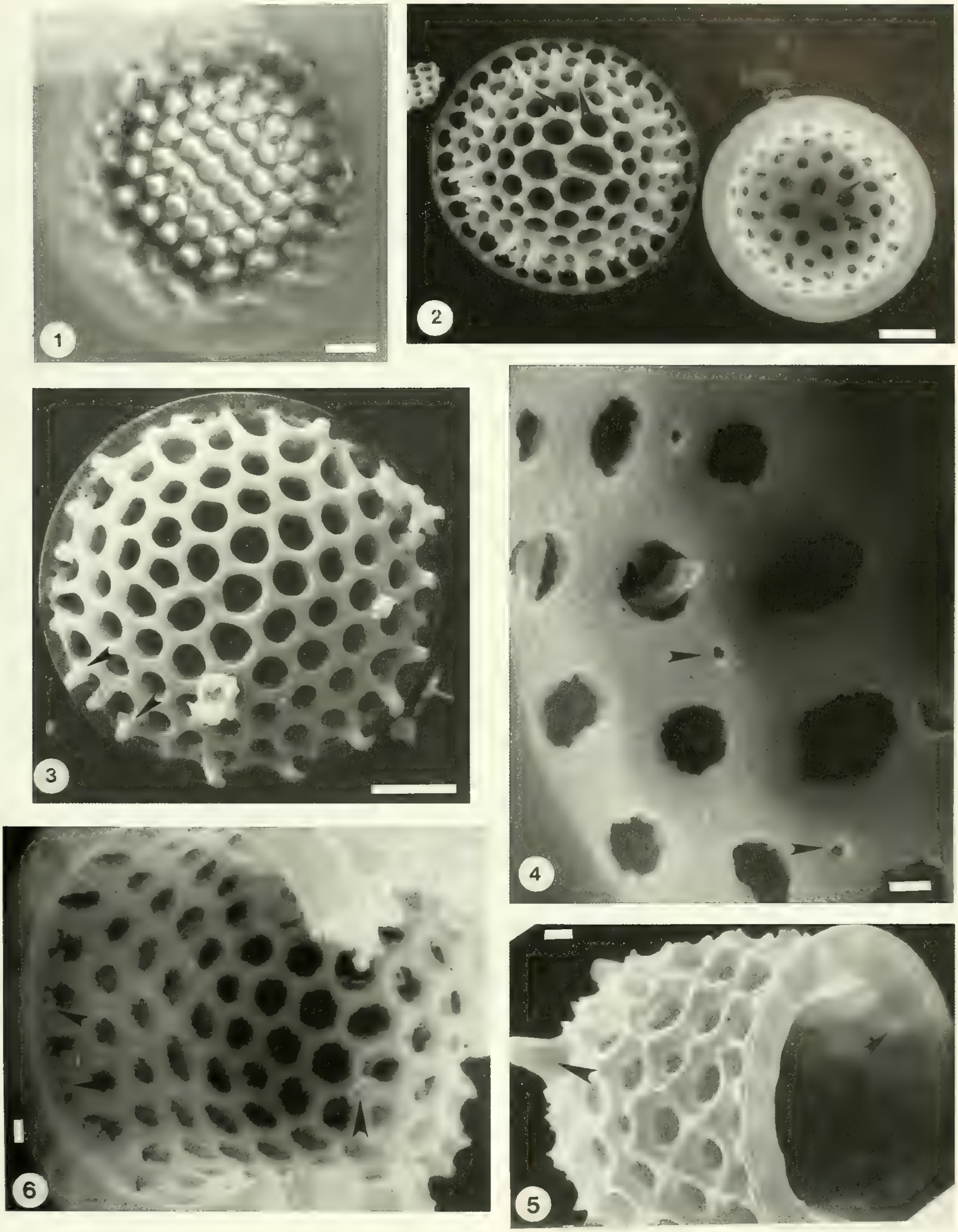

Plate 8

Figs. 1–8 – ***Paralia crenulata***: Fig. 1 – Girdle view of a colony comprising 3 frustules and one valve. Fig. 2 – Valve face. Figs. 3, 7 – External views of a colony of three central frustules and two valves at each end; connection of the epitheca and hypotheca is indicated by the small arrow, and the connection of frustules is indicated by the large arrow. Fig. 4 – External view of a colony showing the raised central connecting ribs on the valve face and the structure of the valve margin and valve mantle; marginal linking spines are broken. Fig. 5 – External view of the valve face showing marginal rings of pores with large and small openings (arrows). Fig. 6 – Internal view of the valve face and valve mantle showing the radial and quincunx rows of porous canals on the valve mantle and the hyaline valve face. Fig. 7 – Girdle view of a colony; connection of the epitheca and hypotheca is indicated by the small arrow, and the connection of frustules by marginal linking spines is indicated by the large arrow. Fig. 8 – External view of a terminal separation valve without marginal linking spines and reduced central connecting ribs.

Figs. 1–2 – LM; Figs. 3–8 – SEM. Scale bars: Figs. 1–6 = 10 µm; Figs. 7–8 = 1 µm. Figs. 1–6 – CAS 610954; Figs. 7–8 – CAS 615990.

PLATE 8

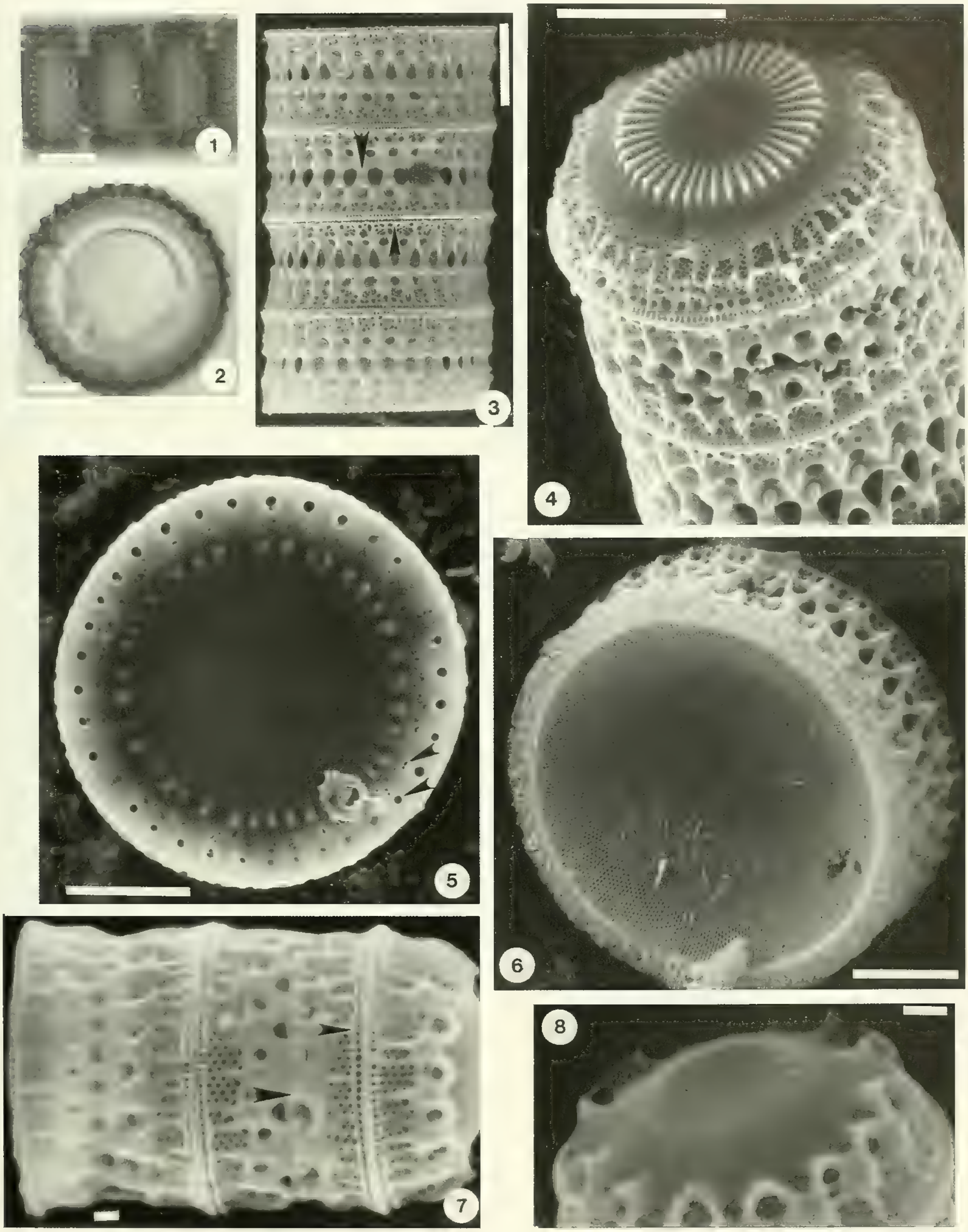

Plate 9

Figs. 1–4 – ***Actinoptychus packii***: Fig. 1 – Holotype CAS 1993; general view of valve. Fig. 2–3 – External views of valve face showing radial undulations that separate the valve face into 6 sectors (alternating 3 raised and 3 depressed). Elevated sectors are ornamented with numerous shallow depressions, whereas the depressed sectors are ornamented with small siliceous nodes. The undulating sectors are surrounded by a less undulating marginal zone on the valve face, which bears the external openings of the labiate processes (arrows). The border between the valve face and mantle includes a zone with narrow radial ribs that bear small spines. Porous canals are arranged in radial rows on the valve face and in a quincunx pattern on the valve mantle. Fig. 4 – Internal view of the valve face showing the central hyaline field, and the alternating depressed and elevated sectors of the valve face, quincunx rows of porous canals, hyaline curved and narrow fields in front of the convex sectors, and the slits of the labiate processes within small hyaline fields (arrows).

Fig. 1 – LM; Figs. 2–4 – SEM. Scale bars: Figs. 1–4 = 10 μm. Figs. 2–4 – CAS 610955.

PLATE 9

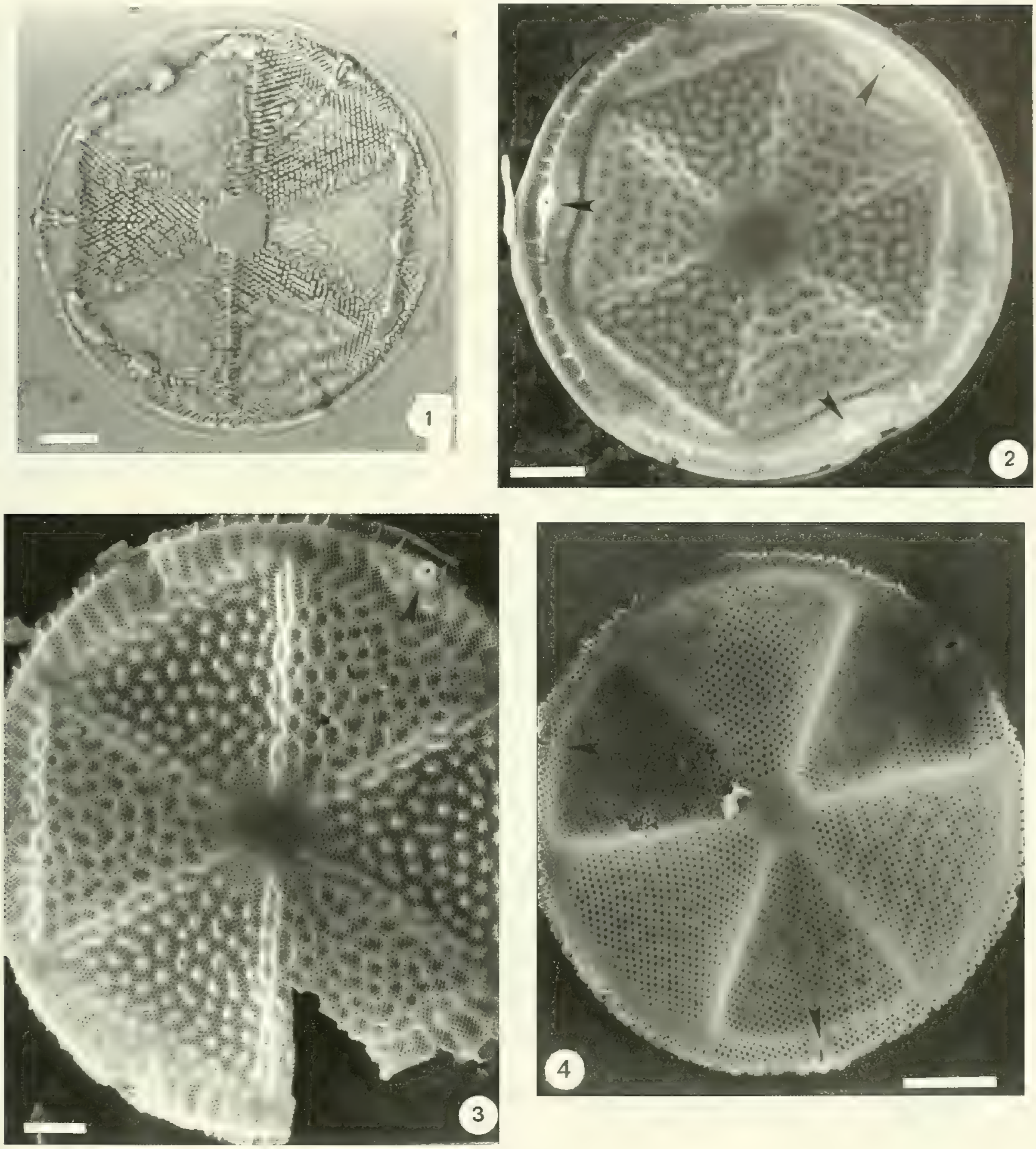

Plate 10

Figs. 1–4 – ***Actinoptychus taffii***: Fig. 1 – Holotype CAS 1995; general view of the valve with the focal plane on the surface of the elevated sectors and labiate processes at 3, 7, and 11 o'clock; note the quincunx arrangement of porous canals and sub-hexagonal packing of the surface ornamentation on the elevated sectors. Fig. 2 – External view of the valve face and narrow valve mantle showing the central hyaline field, the radial undulation that separates the valve face into six sectors, the radial and quincunx arrangement of porous canals and the net of anastomose ribs, and the opening of the labiate processes at the marginal center of the elevated undulations (arrows). Figs. 3–4 – Internal views of the valve; Fig. 3, valve face with radial undulations, , the radial and quincunx arrangement of porous canals, the central hexagonal hyaline field, the curved narrow hyaline fields toward the margin of the convex sectors, and the internal slits of labiate processes (arrows); Fig. 4, detail of Fig. 3 showing of the quincunx arrangement of porous canals and slit of labiate processes around by hyaline field; note the correspondence between the close-packing arrangement of the porous canals and the location of the external ornamentation of anastomose ribs (lighter sub-hexagonal areas).

Fig. 1 – LM; Figs. 2–4 – SEM. Scale bar: Figs. 1–3 = 10 µm; Fig. 4 = 1 µm. Figs. 2–4 – CAS 610954.

PLATE 10

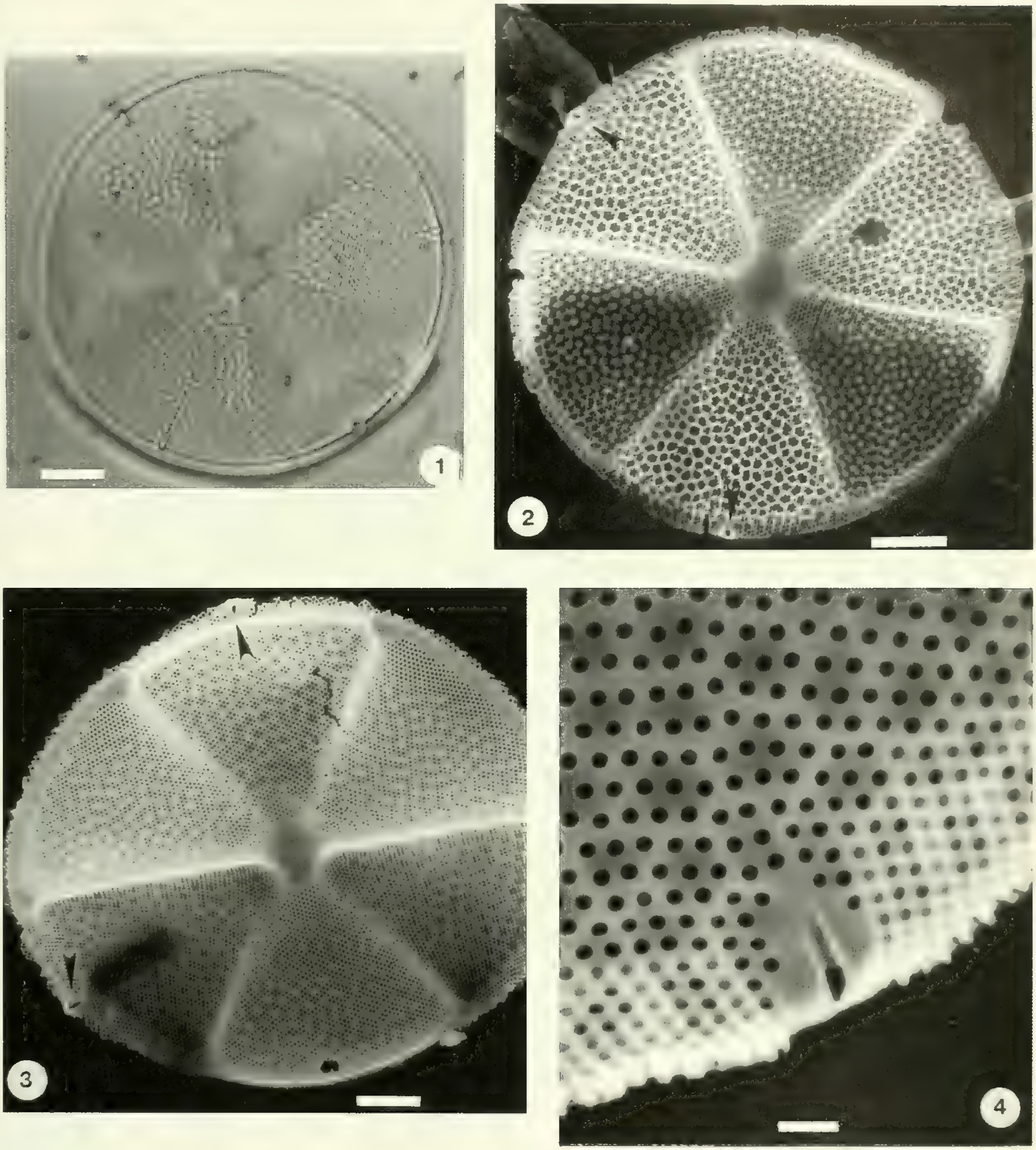

Plate 11

Figs. 1–5 – ***Centroporus californicus***: Figs. 1–2 – Holotype CAS 3387; valve in different focus. Figs. 3–5 Internal views of the valve. Fig. 3 – Valve face and valve mantle showing undulations of the valve. Fig. 4 – Central part of the valve face showing the irregular arrangement of porous canals in the center of the valve and the radial rows of porous canals in the bottom of the figure. Fig. 5 – Margin of the valve showing the radial rows of porous canals and the hyaline ray with an opening on the end (arrow).

Figs. 1–2 – LM; Figs. 3–5 SEM. Scale bars: Figs. 1–3 = 10 µm; Figs. 4–5 = 1 µm. Figs. 3–5 – CAS 615988.

PLATE 11

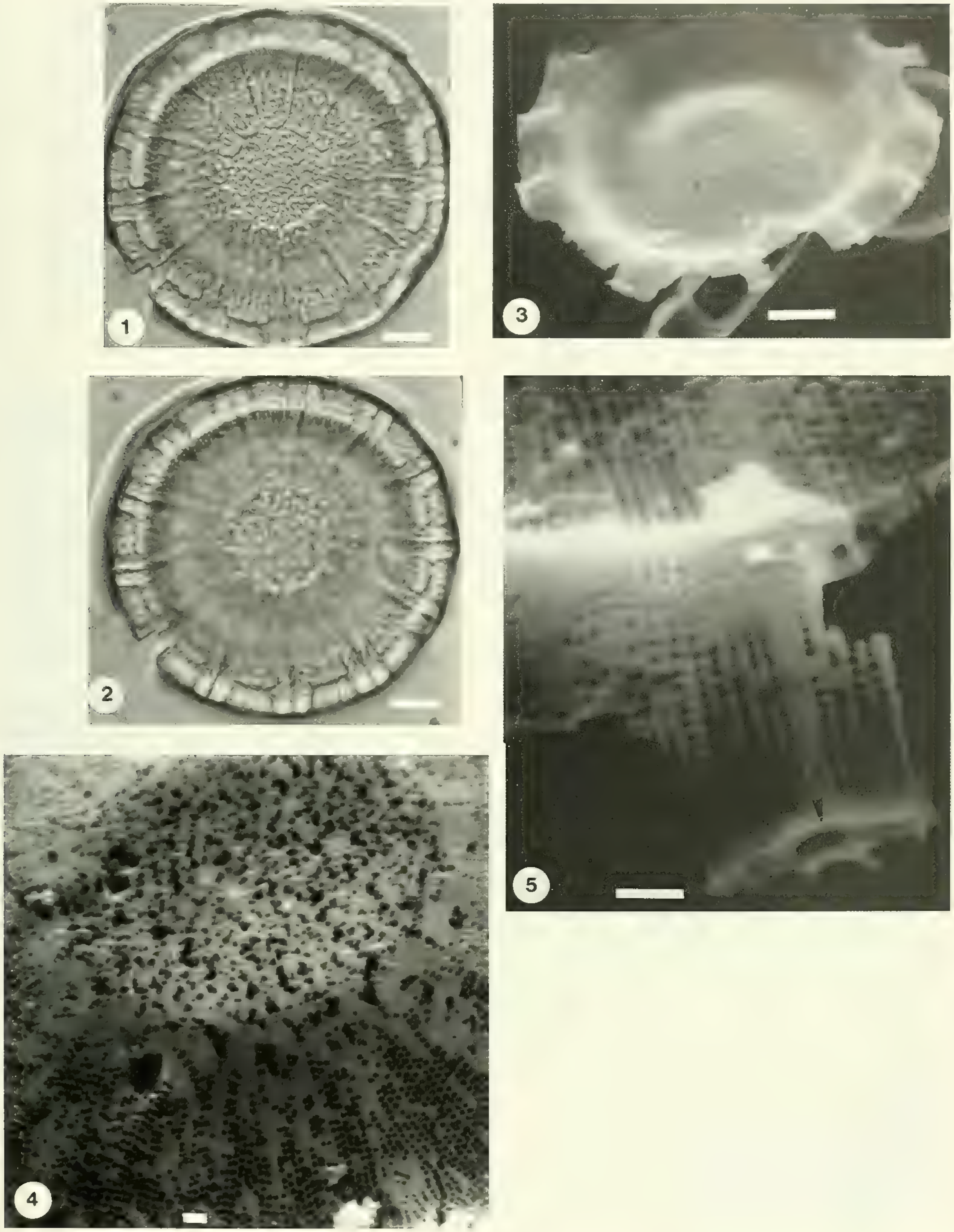

Plate 12

Figs. 1–6 – ***Debya californica***: Fig. 1– Holotype CAS 3403; general view of the valve. Figs. 2–4 – External views of the valve. Fig. 2 – Valve face and valve mantle showing radial and marginal undulations and the location of labiate processes (arrows). Fig. 3 – Detail of Fig. 2 showing the irregular arrangement of porous canal between the anastomose ribs. Fig. 4 – Detail of Fig. 2 showing porous canals and the system of anastomose ribs and the conical tube of the labiate process (arrow). Figs. 5–6 – Internal views of part of the valve face. Fig. 5 – Part of the valve face showing undulation of the valve and location of the labiate processes (arrows). Fig. 6 – Detail of Fig. 5 showing the arrangement of porous canals and labiate process with a curved slit (arrow).

Fig. 1 – LM; Figs. 2–6 – SEM. Scale bars: Figs. 1–2, 5 = 10 µm; Figs. 3–4, 6 = 1 µm. Figs. 2–6 – CAS 610939.

PLATE 12

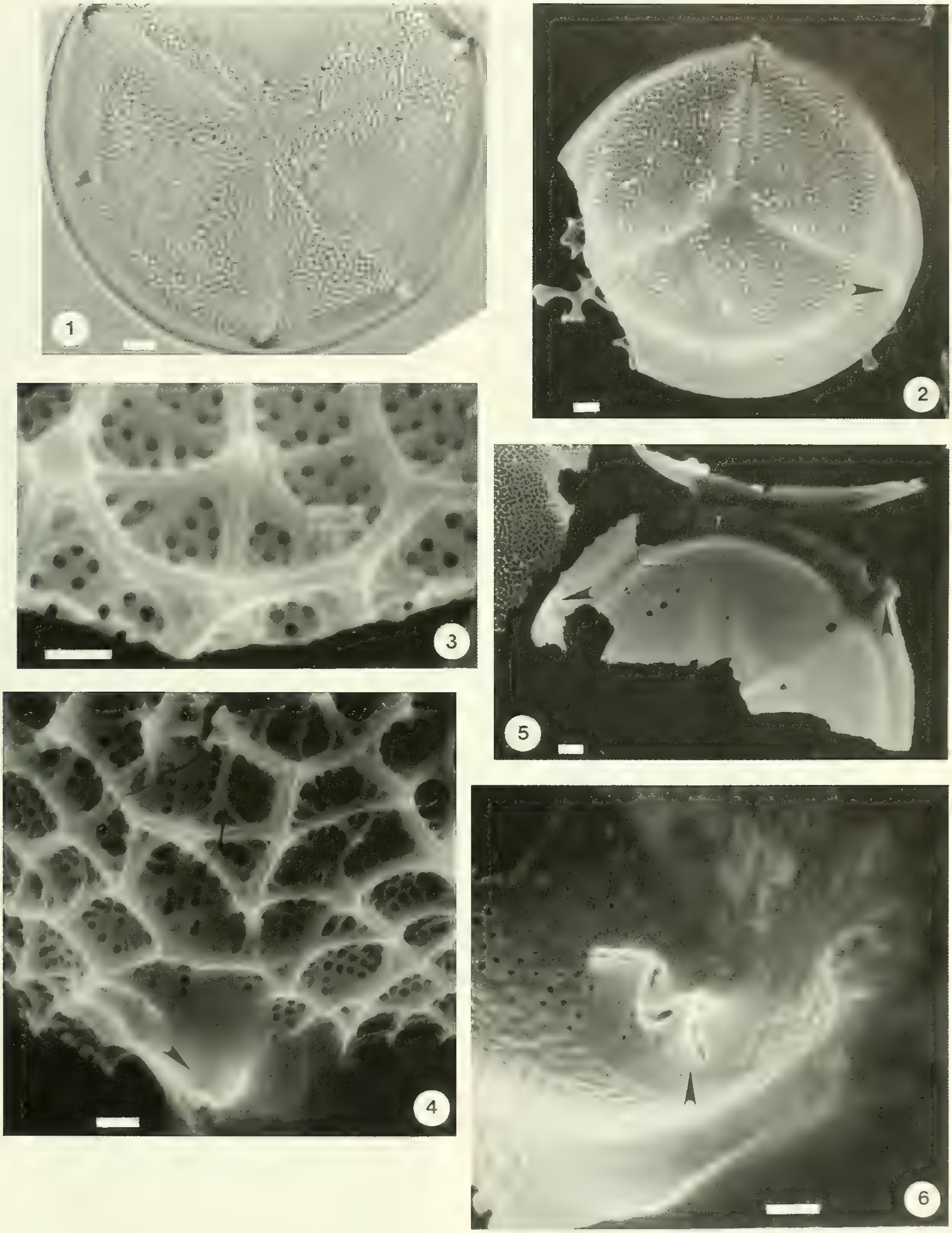

Plate 13

Figs. 1–7 – ***Gloriopthychus callidus***: Fig. 1 – Holotype CAS 2007; general view of the valve with focus on the elevated undulations. Fig. 2 – External view of the valve face showing undulations of the valve, the system of anastomose ribs, and the openings of the labiate processes (arrows). Figs. 3–5 – Internal views of the valve. Fig. 3 – Valve face showing undulations of the valve and the location of labiate processes (arrows). Fig. 4 – Detail of Fig. 3 showing the arrangement of porous canals on the valve face and a cross-section of the valve showing the passages of the porous canals in the basal siliceous layer. Fig. 5 – Detail of Fig. 3 showing the arrangement of porous canals at the valve margin, and the form of the labiate process with a curved slit. Fig. 6 – External view of a small, quadrate valve showing undulations of the valve face, the arrangement of the porous canals and the location of labiate processes (arrows). Fig. 7 – Part of the interior of the valve margin, showing the arrangement of porous canals and the slit of the labiate process (arrow).

Fig. 1 – LM. Figs. 2–7 – SEM. Scale bars: Figs. 1–3, 6 = 10 µm; Figs. 4–5, 7 = 1 µm. Figs. 2–5 – CAS 610954; Figs. 6–7 – CAS 610955.

PLATE 13

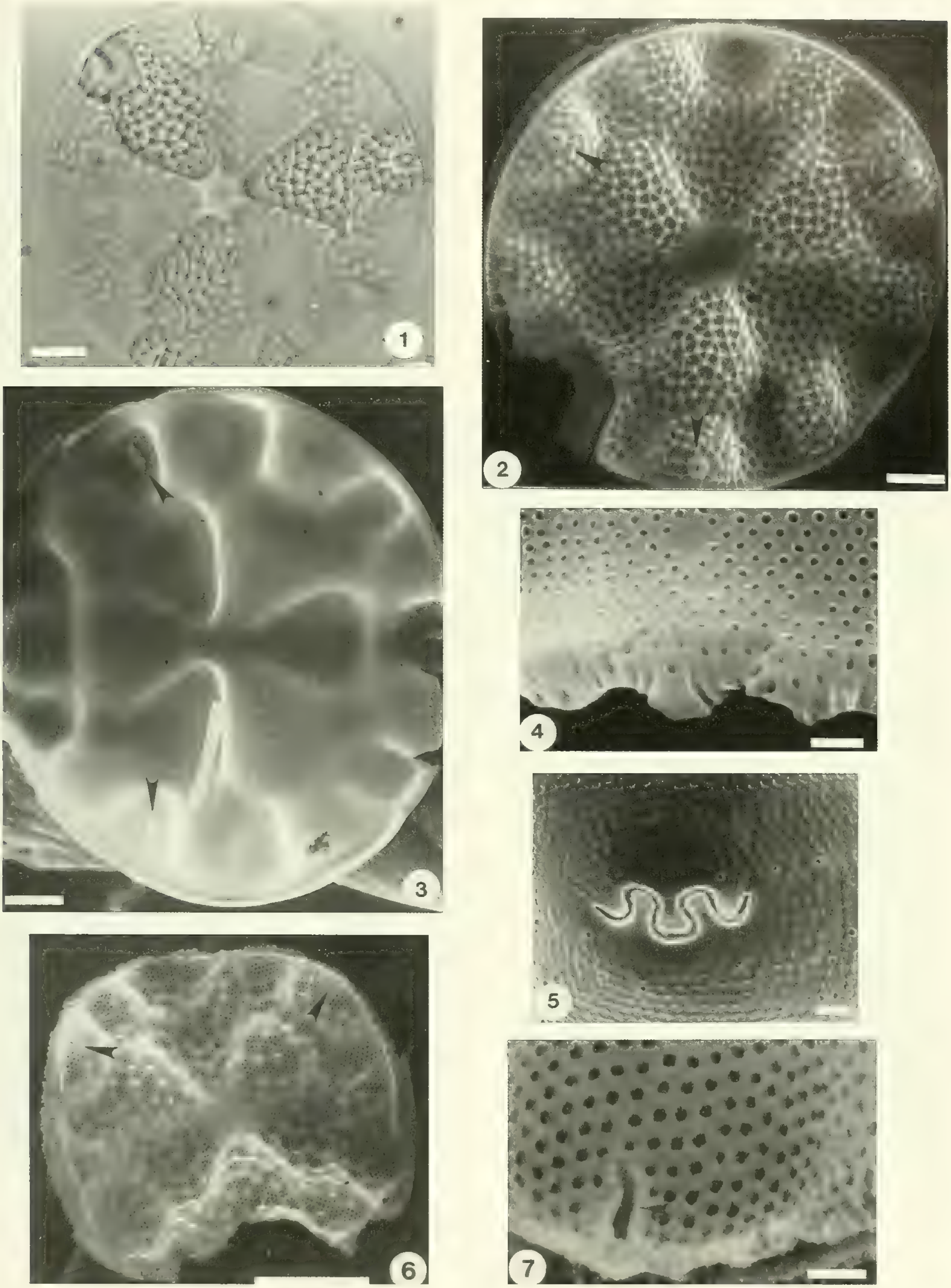

Plate 14

Figs. 1–5 – ***Haynaldia strigillata***: Fig. 1 – Valve. Figs. 2–3 – External views of the valve. Fig. 2 – External view of the valve face, showing the gentle undulation of the valve, the system of anastomose ribs and small spines. Fig. 3 – Detail of Fig. 2 showing the system of anastomose ribs near the valve margin and mantle. Figs. 4–5 – Internal views of the valve. Fig. 4 – Valve face showing the irregular arrangement of porous canals on the valve face, the zone of porous canals on the valve mantle, and the marginal ring of labiate processes (arrows). Fig. 5 – Detail of Fig. 4 showing scattered porous canals on the valve face and valve mantle, and the horseshoe shape of the labiate processes (arrows).

Fig. 1– LM; Figs. 2–5 – SEM. Scale bars: Figs. 1–5 = 10 µm. Figs. 1–5 – CAS 615990.

PLATE 14

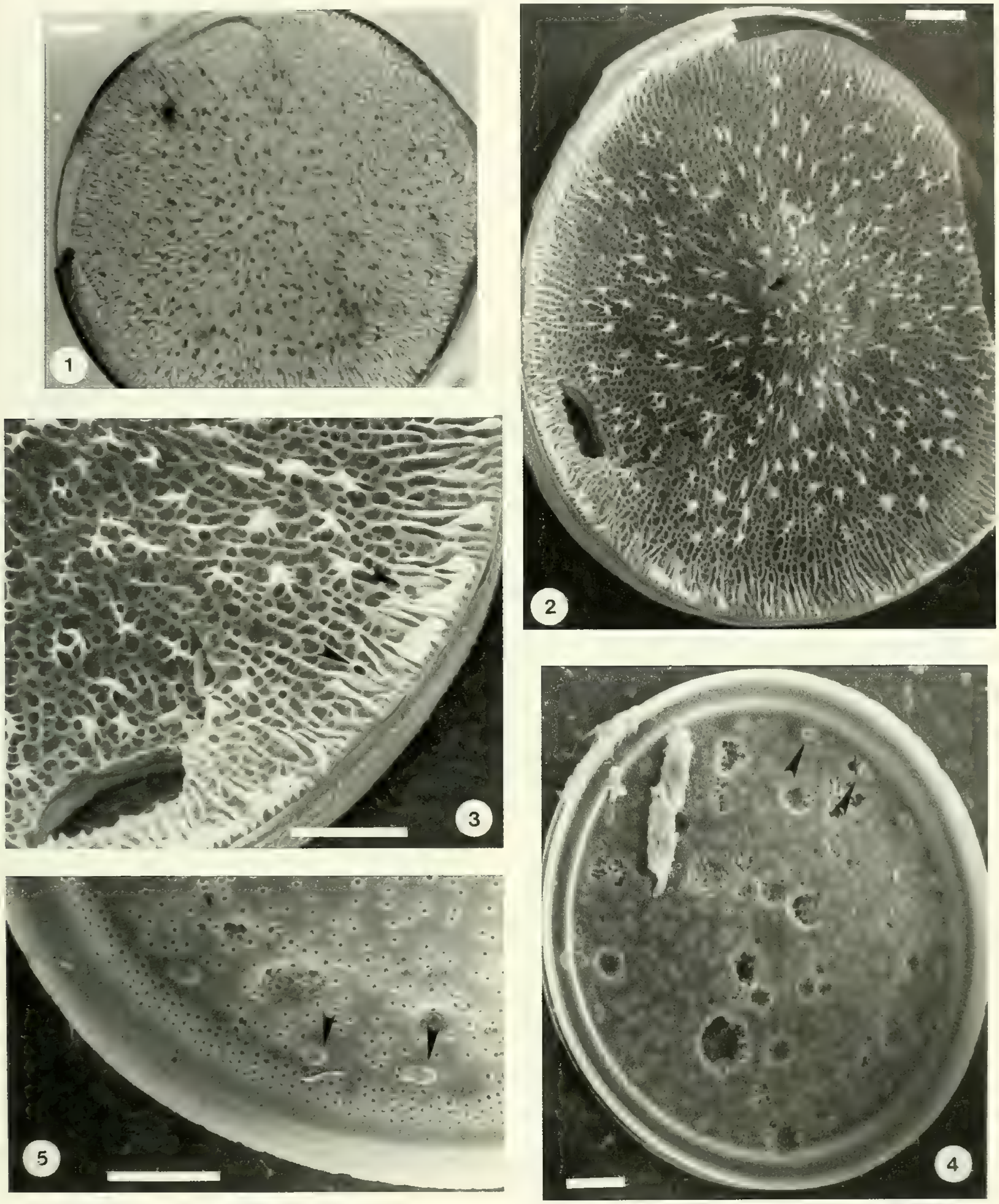

Plate 15

Figs. 1–5 – ***Hendeya dehiscens***: Fig. 1 – Holotype CAS 3446; general view of the valve; large arrow identifies the ocellus and small arrows identify the position of the labiate processes. Fig. 2 – Paratype CAS 3447; general view of the valve; arrows identify the location of the labiate processes. Figs. 3–5 – Internal views of the valve. Fig. 3 – Valve face showing undulations of the valve, location of the labiate processes (large arrows) and the ocellus (small arrows). Fig. 4 – Detail of Fig. 3, showing the arrangement of the porous canals and the tubercle which bears a labiate process with a slit (arrow). Fig. 5 – Detail of Fig. 3 showing the ocellus (arrow).

Figs. 1–2 – LM; Figs. 3–5 SEM. Figs. 1–3 = 10 μm; Figs. 4–5 = 1 μm. Figs. 3–5 – CAS 615990.

PLATE 15

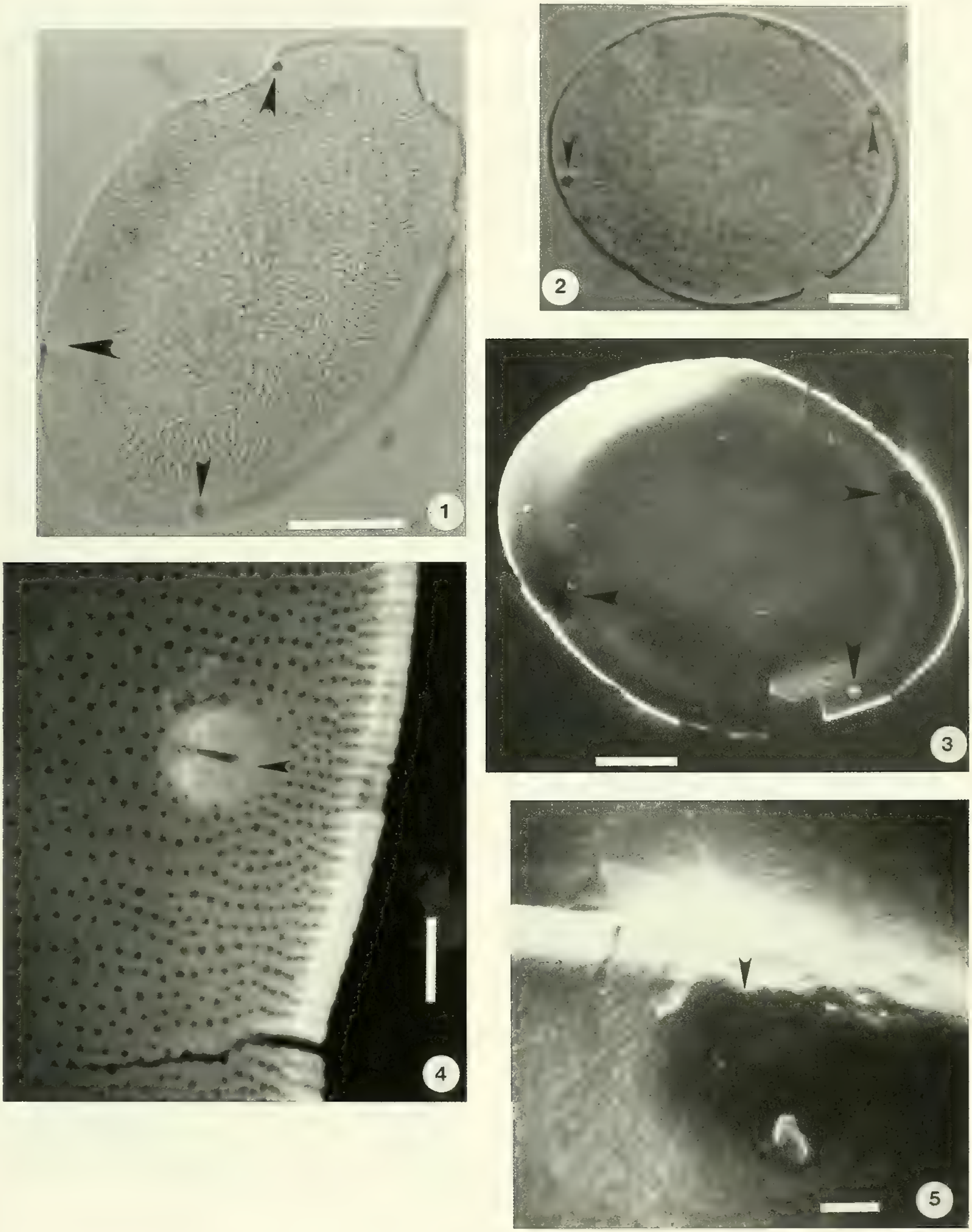

Plate 16

Figs. 1–6 – ***Coscinodiscus marginatus***: Fig. 1 – Hypotype CAS 3396; general view of the valve. Figs. 2–3 – External views of the valve. Fig. 2 – Valve mantle and valve face showing the arrangement of loculate areolae and the opening of the macro-labiate process (arrow). Fig. 3 – Detail of Fig. 2 showing a part of the broken uninterrupted cribrum of the marginal part of the valve face, and the external opening of the macro-labiate process (arrow). Figs. 4–6 – Interior views of the valve. Fig. 4 – Valve face and valve mantle showing the arrangement of the foramen of loculate areolae, and the location of the macro-labiate process (large arrow) and the marginal ring of labiate processes (small arrows). Fig. 5 – Detail of Fig. 4 showing the locula of the areolae (top right), the large foramen of the loculate areolae on the valve face and the smaller foramen on the valve mantle, and four labiate processes of the marginal ring (arrows). Fig. 6 – Detail of Fig. 4 showing the macro-labiate process (large arrow) and the labiate processes (small arrows).

Fig. 1 – LM; Figs. 2–6 – SEM. Scale bars: Figs. 1–2, 4 = 10 µm; Figs. 3, 5–6 = 1 µm. Figs. 2–6 – CAS 610954.

PLATE 16

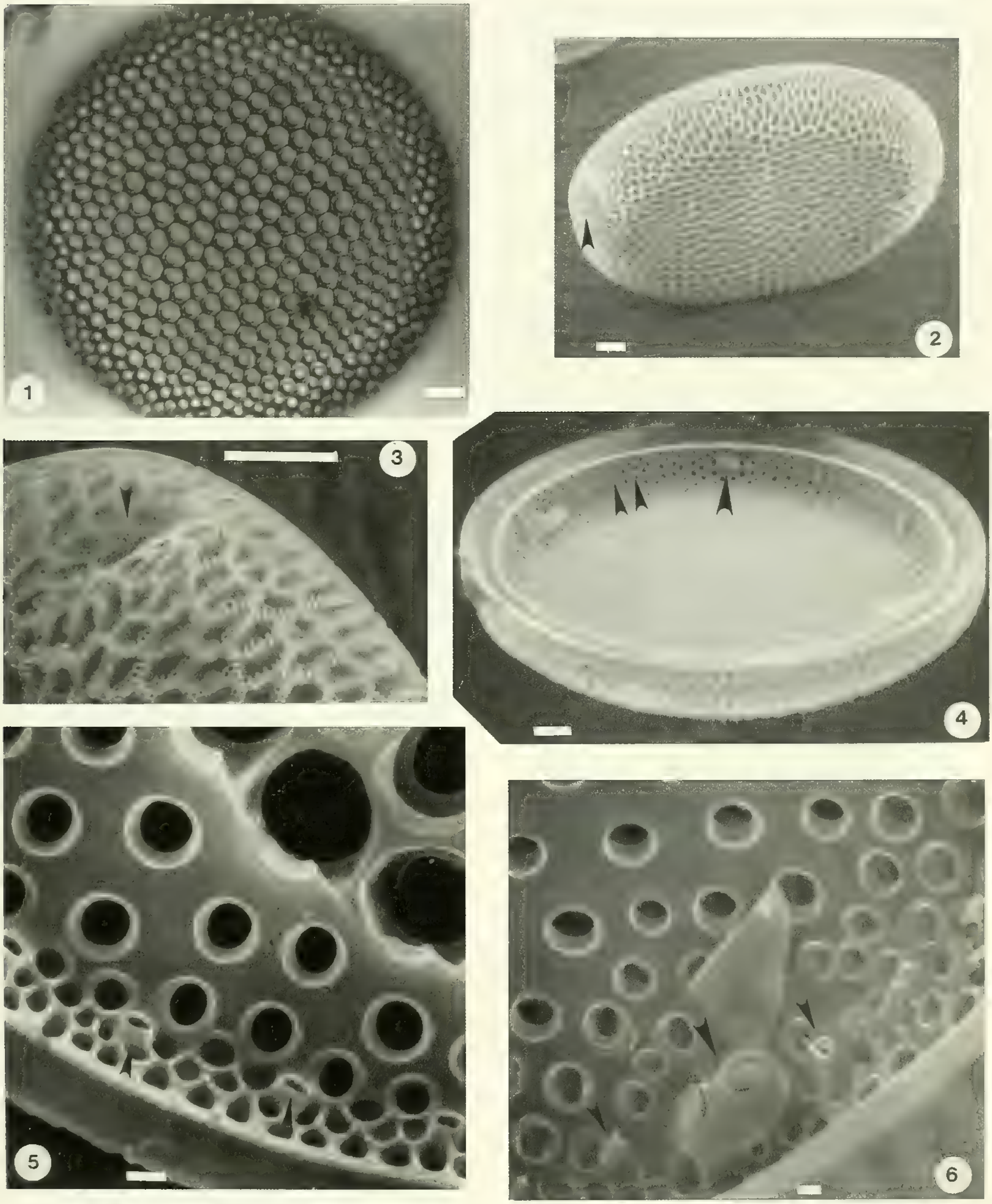

Plate 17

Figs. 1–6 – ***Aulacodiscus archangelskianus***: Figs. 1–4 – Views of the valve face showing morphological variability. Fig. 1 – Paratype CAS 1997. Fig. 2 – Paratype CAS 1998. Fig. 5 – External view of the valve face showing radial undulations with tubes of the labiate processes, the arrangement of loculate areolae and ribs between the valve face and valve mantle. Fig. 6 – Internal view of the valve face showing radial undulations with the labiate processes visible on the bottom of the depression (arrows) and arrangement of the foramen of loculate areolae on the valve face and valve mantle.

Figs. 1–4 – LM; Figs. 5–6 – SEM. Scale bar: Figs. 1–6 = 10 µm. Figs. 3–6 – CAS 610954.

PLATE 17

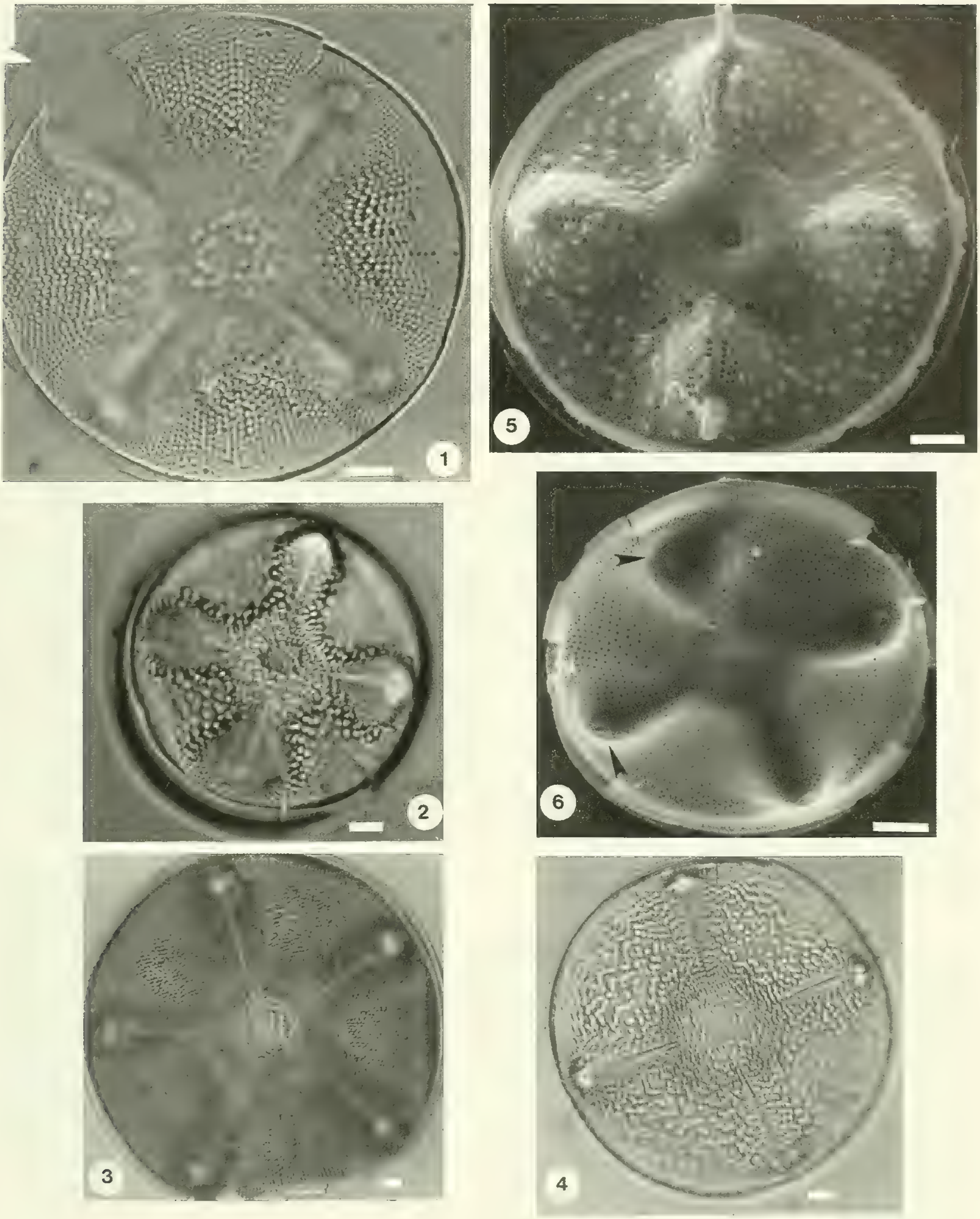

Plate 18

Figs. 1–6 – ***Rattrayella churchii***: Fig. 1 – Holotype CAS 3541, general view of the valve. Figs. 2–4 – External views of the valve. Fig. 2 – Valve showing undulations of the valve face, three marginal elevations with ocelli, marginal ring of spines and tubes of the labiate processes (arrows). Fig. 3 – Detail of Fig. 2 showing the uninterrupted cribrum with small tubercles, ocellus and part of the ring of marginal spines. Fig. 4 – Part of the valve margin with a broken cribrum to illustrate the structure of the loculate areolae with an external uninterrupted cribrum, tube of a labiate process (arrow) and marginal spines. Fig. 5 – Internal view of the valve showing undulations of the valve face, location of the ocelli (large arrows) and the location of labiate processes (small arrows). Fig. 6 – Detail of Fig. 5 showing the radial rows of foramen of the loculate areolae, two tubercle labiate processes (arrows) and the hyaline margin of the valve mantle.

Fig. 1 – LM; Figs. 2–6 – SEM. Scale bars: Figs. 1–2, 5 = 10 µm; Figs. 3–4, 6 = 1 µm. Figs. 2–6 – CAS 610954.

PLATE 18

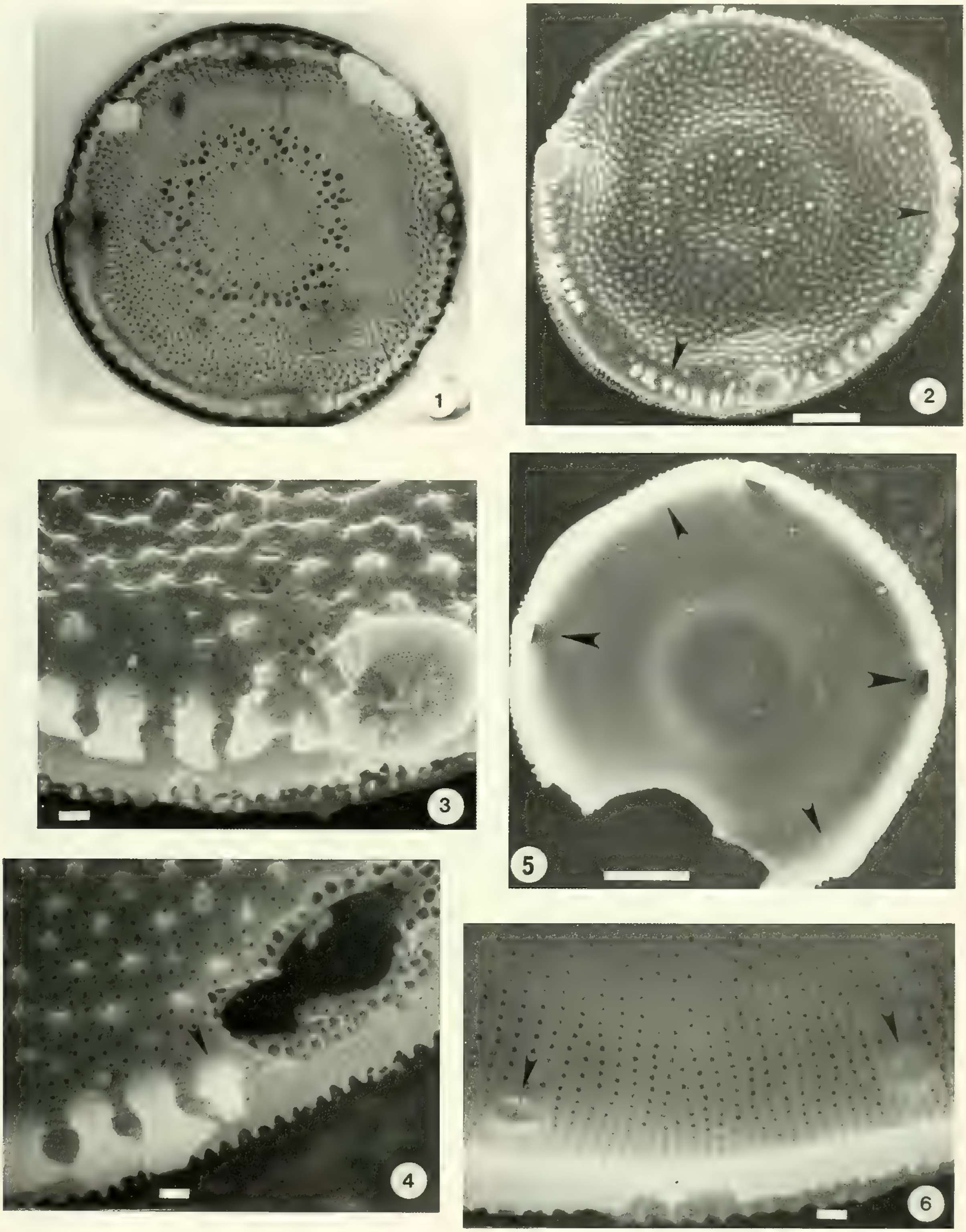

Plate 19

Figs. 1–5 – ***Stellarima distincta***: Fig. 1 – Holotype CAS 3391; general view of the valve. Figs. 2–3 – External views of the valve. Fig. 2 – Valve showing the arrangement of loculate areolae on the valve face and valve mantle, and location of the central, slit-form labiate process (arrow). Fig. 3 – Part of the valve face showing the honeycomb structure of the chamber of loculate areolae, and the location of the slit-form labiate process (arrow). Figs. 4–5 – Internal views of the valve. Fig. 4 – Valve showing the arrangement of foramen of the loculate areolae on the valve face, valve mantle, and the location of the labiate process (arrow). Fig. 5 – Detail of Fig. 4 showing the different sizes of foramen of the loculate areolae in the center of the valve face, and the slit of the labiate process (arrow).

Fig. 1– LM; Figs. 2–5 – SEM. Scale bars: Figs. 1–4 = 10 µm, Fig. 5 = 1 µm. Figs. 2–5 – CAS 610954.

PLATE 19

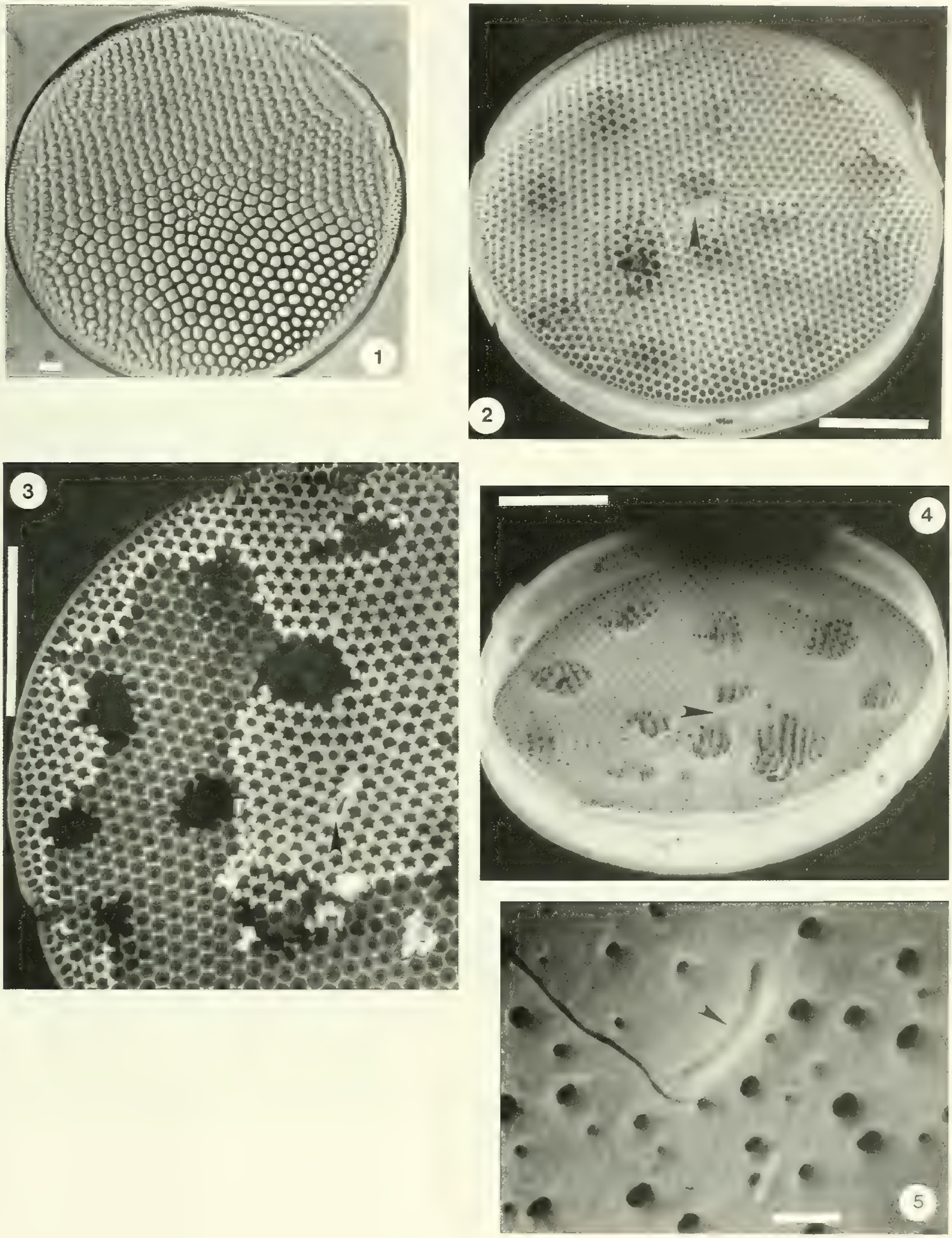

Plate 20

Figs. 1–6 – ***Stellarima steinyi***: Fig. 1 – Holotype CAS 2006; general view of the valve. Figs. 2–4 – External views of the frustule and valve. Fig. 2 – Frustule showing the epivalve (top) with epicingulum and hypovalve (bottom). Fig. 3 – Valve, showing the arrangement of loculate areolae in radial rows with a fasciculate pattern, small central hyaline field with a slit-form labiate process (arrow). Fig. 4 – Detail of Fig. 4 showing the arrangement of the loculate areolae with broken cribrum, and the slit of the labiate process (arrow). Figs. 5–6 – Internal views of the valve. Fig. 5 – Part of a broken valve, showing the cross-sectional form of the ovoid chamber of the loculate areolae, arrangement of foramen of the loculate areolae, and the labiate process (arrow). Fig. 6 – Part of the valve showing the arrangement of foramen of the loculate areolae, the central location of the labiate process with a slit (arrow), and the hyaline valve mantle (right).

Fig. 1 – LM; Figs. 2–6 – SEM. Scale bars: Figs. 1–3, 6 = 10 µm; Figs. 4–5 = 1 µm. Figs. 2–6 – CAS 610954.

PLATE 20

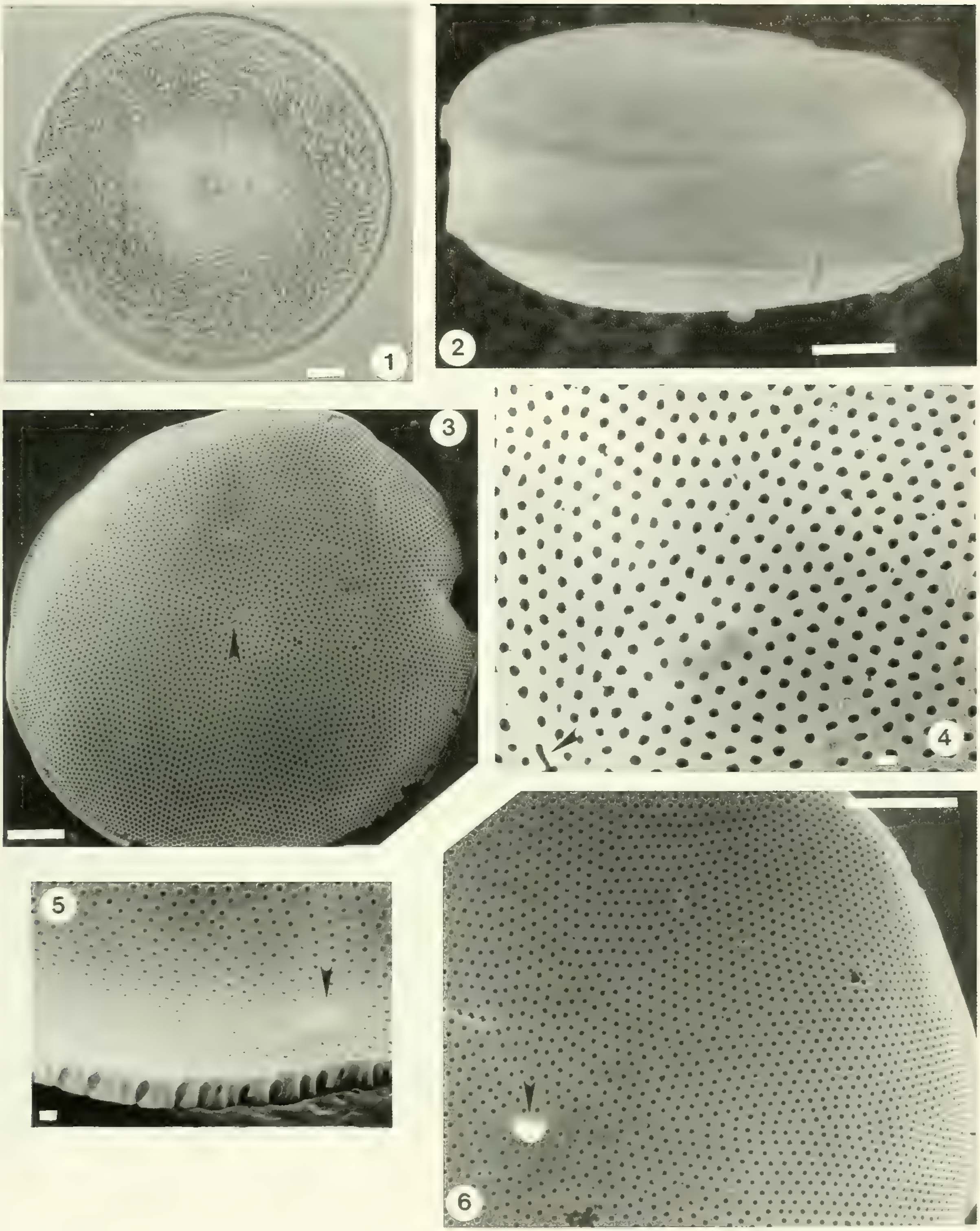

Plate 21

Figs. 1–6 – ***Azpeitiopsis morenoensis***: Fig. 1 – Holotype CAS 2004; general view of the valve showing radial fasciculate arrangement of loculate areolae, with rows of areolae in each fascicle parallel to the longest central row, and the central crescentric flexure of the valve. Figs. 2–3 – External views of the valve. Fig. 2 – Valve showing the arrangement of loculate areolae on the valve face, small central depression and the location of the external tube of the labiate process (arrow). Fig. 3 – Detail of Fig. 2 showing the central depression and tube of the labiate process. Figs. 4–6 – Internal views of the valve. Fig. 4 – Valve view showing the arrangement of foramen of the loculate areolae in radial rows on the valve face, radial and secondary crossing rows of foramen near the valve margin, one row small areolae on the valve mantle, and the internal slit of the labiate process on the central depression (arrow). Fig. 5. – Detail of Fig. 4 showing the foramen of loculate areolae and the slit of the labiate process. Fig. 6 – Part of a broken valve showing the form of the chamber of loculate areolae in the basal siliceous layer and part of the slit of the labiate process.

Fig. 1– LM; Figs. 2–6– SEM. Scale bars: Figs. 1–2, 4 = 10 µm; Figs. 3, 5–6 = 1 µm. Figs. 2–6 – CAS 610954.

PLATE 21

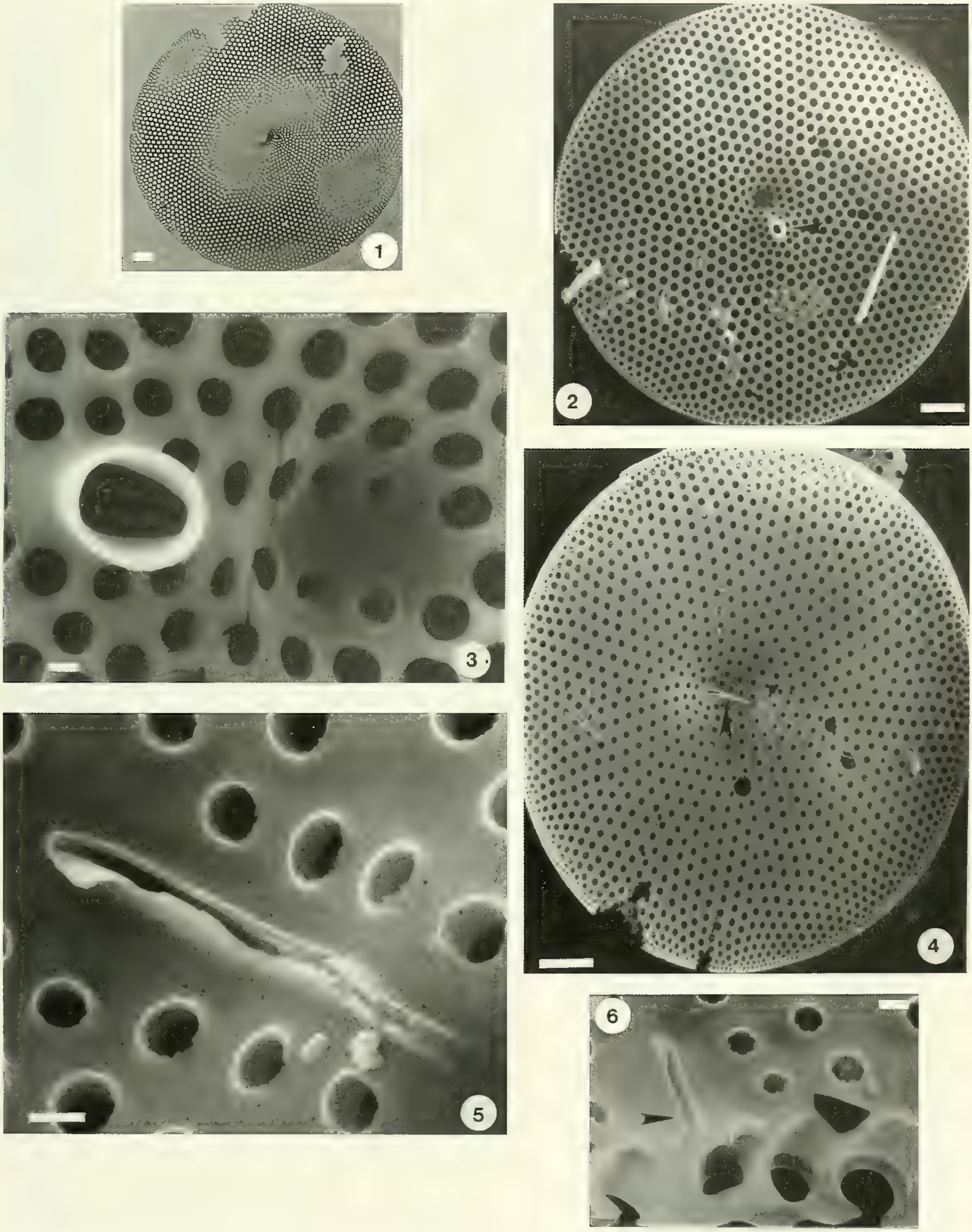

Plate 22

Figs. 1–5 – ***Pomphodiscus morenoensis***: Fig. 1 – Holotype CAS 34022; general view of the valve; arrow marks the location of the labiate process. Figs. 2–3 – External views of the valve. Fig. 2 – Valve view showing the arrangement of loculate areolae in radial rows, the convex wall of the central chamber with an ovoid opening (large arrow), the slit of the labiate process (small arrow), low marginal ridge, and two rows of smaller loculate areolae on the valve mantle. Fig. 3 – Detail of Fig. 2 showing the ovoid opening of the central chamber and the slit of the labiate process (arrow). Fig. 4 – Internal view of valve showing arrangement of foramen of loculate areolae on the valve face, convex wall of the central chamber with a small depression in the center of the valve, slit of the labiate process (arrow), and smaller rows of foramen on the valve mantle. Fig. 5 – Center of valve face showing the flattened tube of the labiate process with slit. Fig. 6 – ***Pomphodiscus craspedodiscoides*** – Holotype CAS 3397; general view of the valve showing the circular central chamber, labiate process (arrow), and radial fasciculate arrangement of areolae.

Figs. 1, 6 – LM; Figs. 2–5 – SEM. Scale bars: Figs. 1–2, 4, 6 = 10 μm; Figs. 3, 5 = 1 μm. Figs. 2–5 – CAS 610955.

PLATE 22

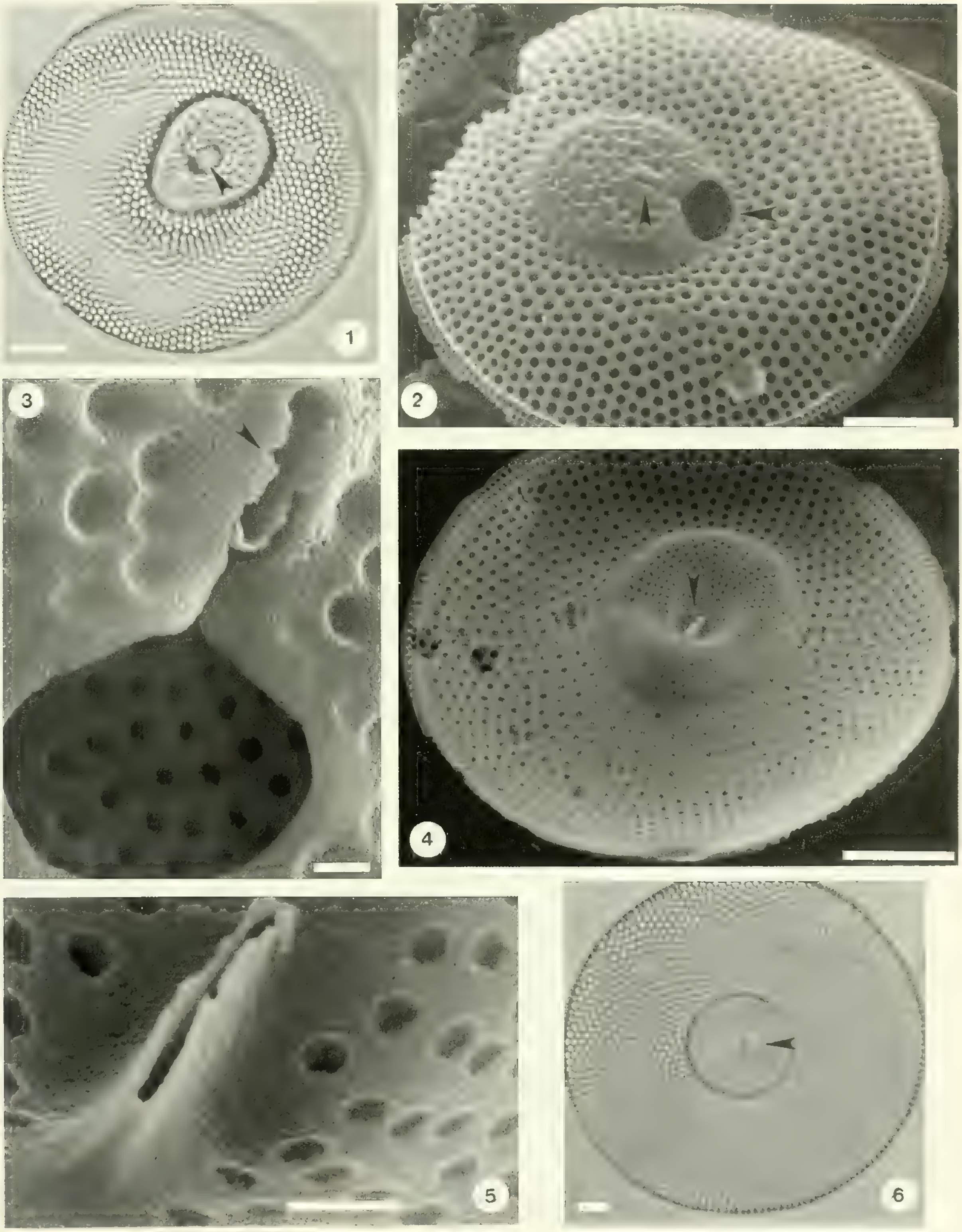

Plate 23

Figs. 1–6 – ***Trigonium hertleinii***: Figs. 1–2 – CAS Holotype 2041; general view of the valve in different focus. Fig. 1 – Focus on the margin part of valve face. Fig. 2 – Focus on the central part of valve face. Fig. 3 – Valve. Figs. 4–5 – External views of the valve. Fig. 4 – Valve showing the central round depression of the valve face, irregular arrangement of the loculate areolae, marginal part of valve with irregular rows of smaller loculate areolae, and the different sizes of the pseudocelli on the corners of valve (arrows). Fig. 5 – Detail of Fig. 4 showing the smaller size of the foramen of the loculate areolae (visible inside the holes) and the larger size of the opening with a broken velum; large pseudocellus with rows of smaller areolae. Fig. 6 – The same valve, internal view, showing the irregular arrangement of the foramen in the central part of the valve and the radial rows of foramen in the marginal part of the valve.

Figs. 1–3 – LM; Figs. 4–6 – SEM. Scale bars: Figs. 1–4, 6 = 10 µm; Fig. 5 = 1 µm. Figs. 3–6 – CAS 610954.

PLATE 23

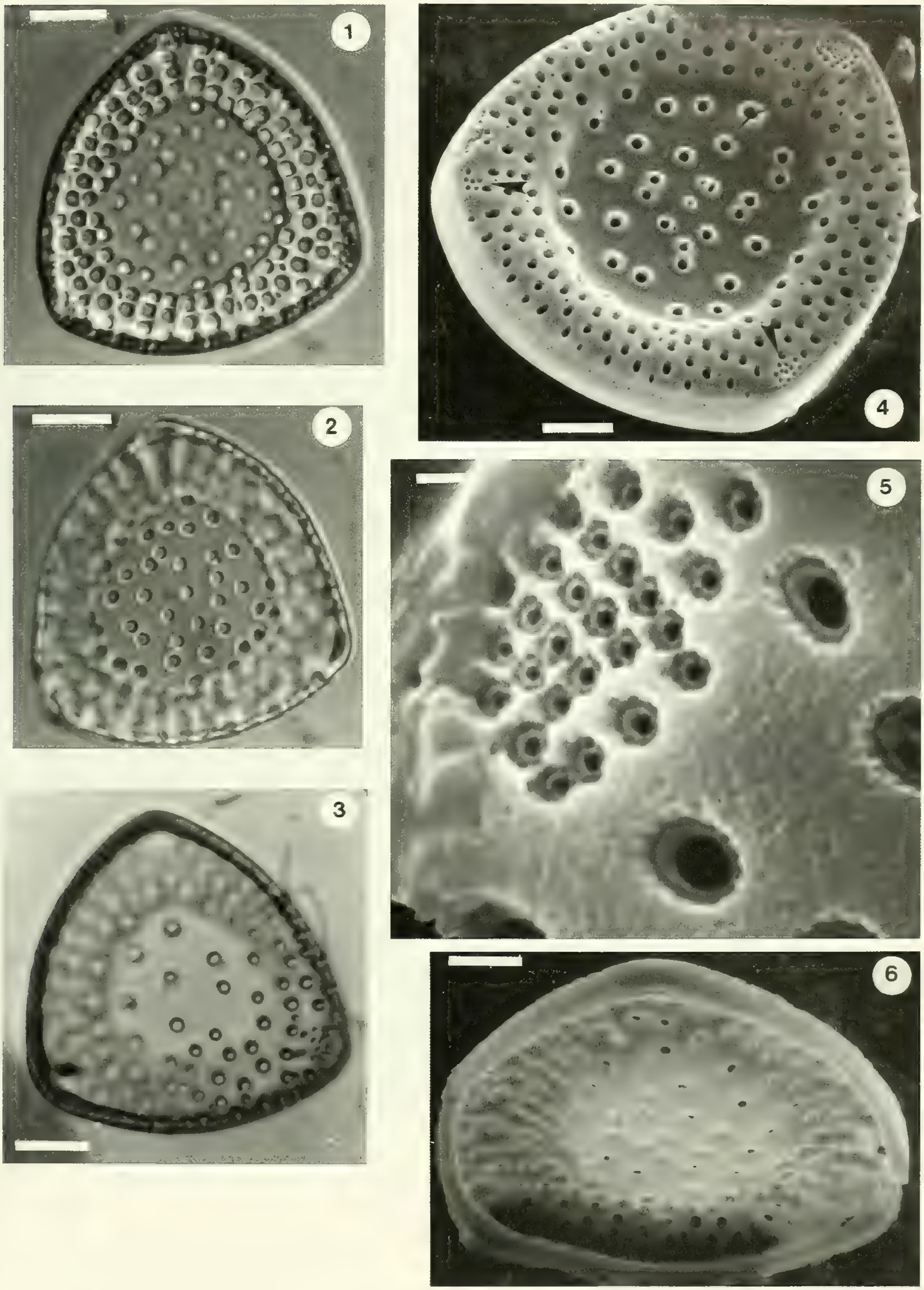

Plate 24

Figs. 1–5 – ***Sphynctolethus monstrosus***: Fig. 1 – Holotype CAS 2034; general view of the valve face. Fig. 2 – Two valves connected in a colony. Fig. 3 – External view of the valve with a broken valve face showing the polar elevations with ocelli, marginal ridge, radial arrangement of poroid areolae and vertical rows porous canal on valve mantle. Fig. 4 – Internal view of the valve showing undulations of the valve face, location of the marginal ridge, arrangement of poroid areolae in radial rows, and the central location of the labiate process (arrow). Fig. 5 – Detail of Fig. 4 showing the foramen of poroid areolae and porous canal in central part of valve and the tuberculate labiate process with a slit (arrow). Fig. 6 – ***Hemiaulus polymorphus***: General view of the valve.

Figs. 1, 6 – LM; Figs. 2–5 – SEM. Scale bars: Figs. 1–4, 6 = 10 μm; Fig. 5 = 1 μm. Figs. 2, 4–5 – CAS 610954; Fig. 6 – CAS 610955.

PLATE 24

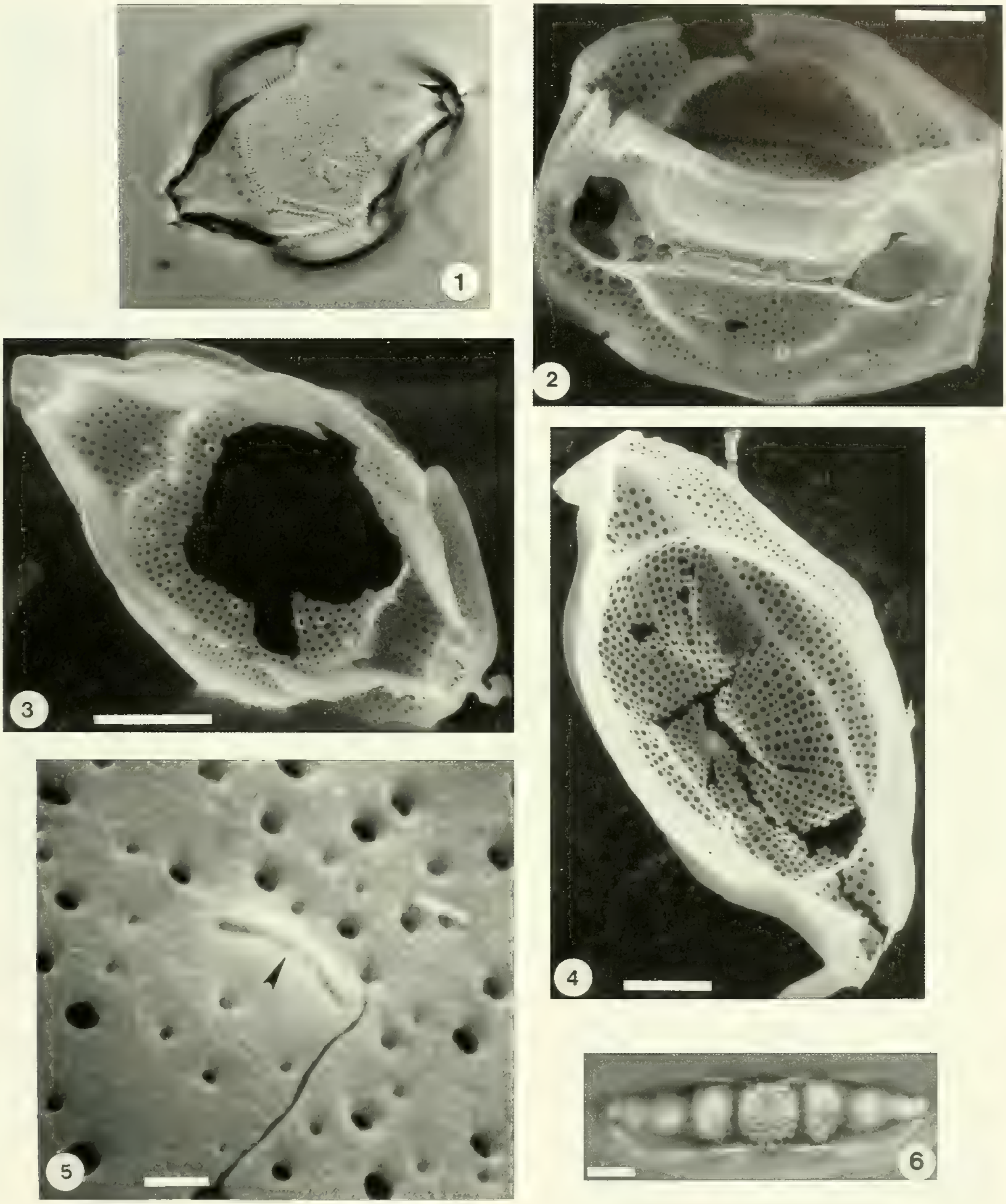

Plate 25

Figs. 1–3 – ***Hemiaulus polymorphus***: Fig. 1 – Girdle view of two frustules connected by horns of the linking apparatus with short spines, external tubes of the labiate processes are visible in the center of the top an bottom valves. Fig. 2 – External view of the valve showing the arrangement of poroid areolae, polar horns, marginal ridge, and the opening of the central labiate process (arrow). Fig. 3 – Internal oblique view of the valve showing undulations of the valve face separated by pseudosepta and the location of the labiate process (arrow). Figs. 4–6 – ***Trinacria aries***: Fig. 4 – Plesiotype CAS 2042 is at right; two valves. Fig. 5 – External view of the valve showing the irregular arrangement of poroid areolae on the valve face and the horizontal rows of poroid areolae on the valve mantle, polar elevations bear pseudoocelli and small spines, low marginal ridge. Fig. 6 – Internal view of the valve showing the arrangement of the foramen of poroid areolae on the valve face, and the location of the labiate process with a slit (arrow).

Fig. 4 – LM; Figs. 1–3, 5–6 – SEM. Scale bars; Figs. 1–6 = 10 µm. Figs. 1–2 – CAS 615978; Figs. 4–5 – CAS 610955.

PLATE 25

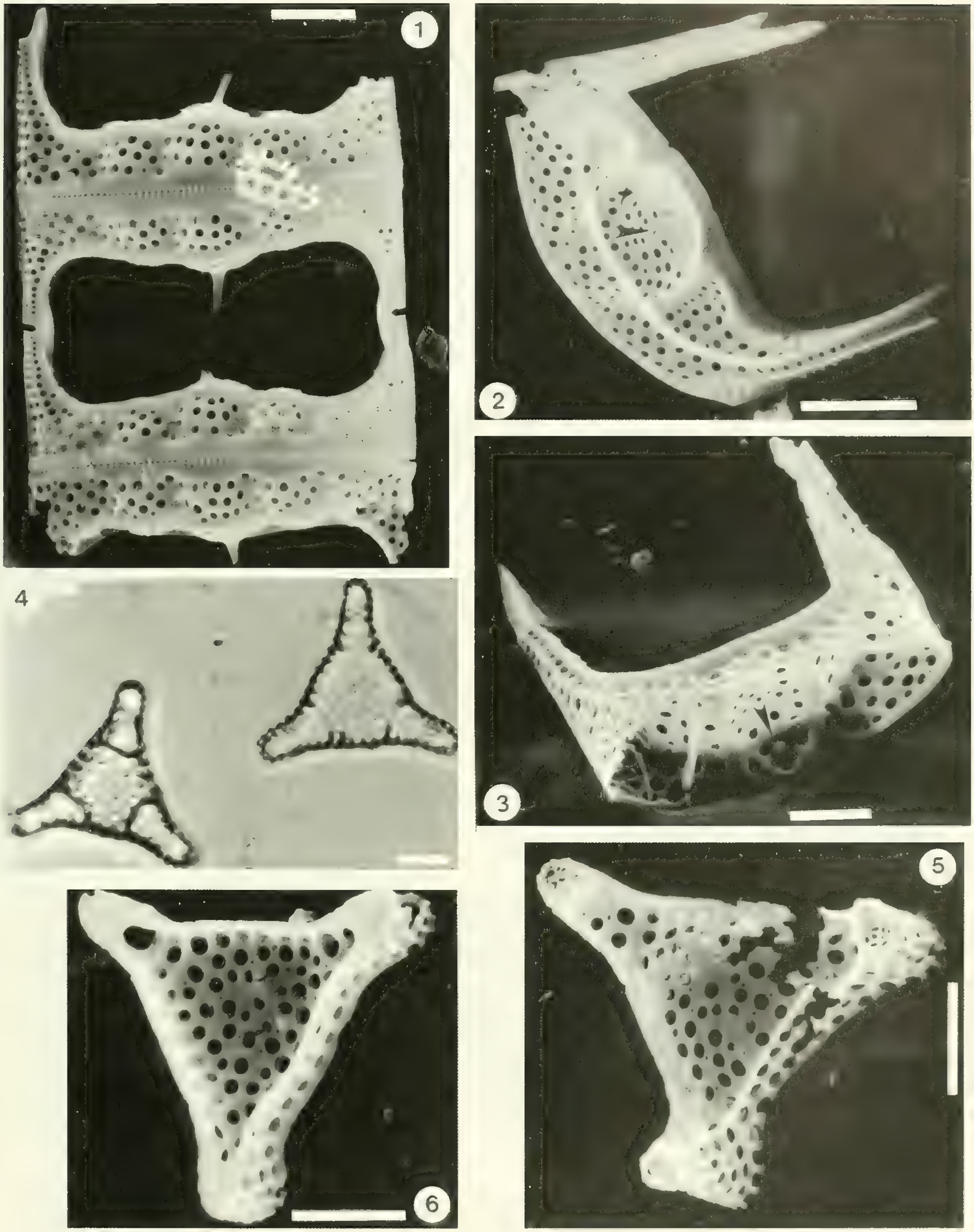

Plate 26

Figs. 1–4 – ***Trinacria insipiens***: Figs. 1, 3 – External views of valves showing polar elevation with pseudoocelli and small spines, arrangement of poroid areolae in radial rows on the valve face, the tube of the labiate processes (arrows), and a marginal ridge. Figs. 2, 4 – Internal views of the valves showing the arrangement of the foramen of poroid areolae in radial rows on the valve face, one row of larger poroid areolae on the valve mantle, and the location of labiate processes with a slit (arrow). Figs. 5–6 – ***Medlinia mucronata***: Fig. 5 – Plesiotype CAS 2051; general view of the valve. Fig. 6 – External view of the valve showing the irregular rows of poroid areolae on the valve face, low marginal ridge, one row of larger poroid areolae on the valve mantle, and the location of the external tube (broken) of the labiate process (arrow).

Fig. 5 – LM; Figs. 1–4, 6 – SEM. Scale bars: Figs. 1–6 = 10 μm.

PLATE 26

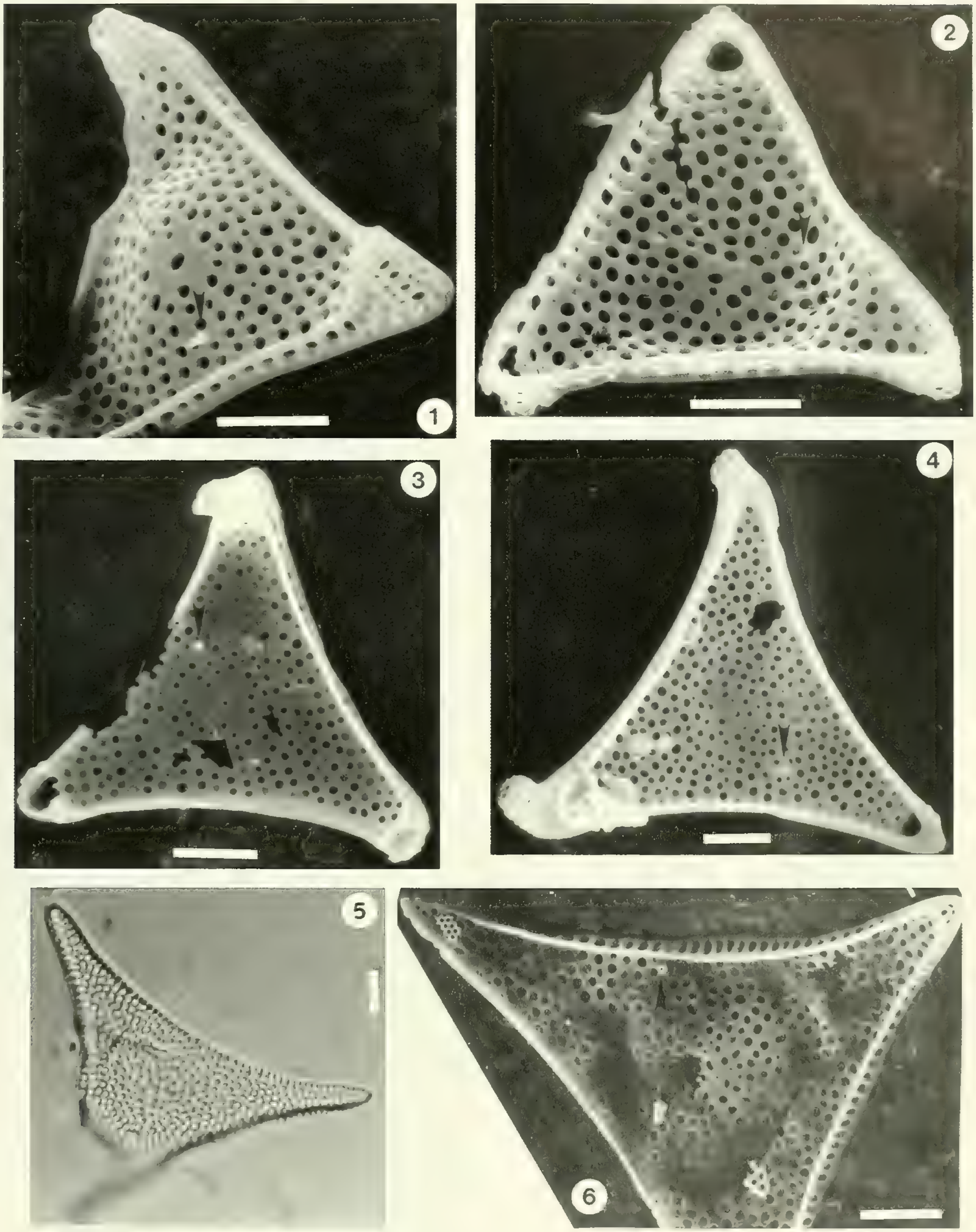

Plate 27

Figs. 1–3 – ***Euodiella tristictia***: Fig. 1 – Holotype CAS 2052, general view of the valve with focus on the elevations and the central part of the valve. Fig. 2 – External view of the valve showing undulations of valve face, the arrangement of poroid areolae in radial rows on the valve face, small isolated porous canals between the rows of poroid areolae, small elevations at the angles, the marginal ridge, scattered slit of the labiate process (small arrow), and two pseudoocelli located on the valve mantle (large arrows at the bottom). Fig. 3 – Internal view of valve showing undulations of the valve, arrangement of the foramen of poroid areolae in radial rows on the valve face and vertical rows of poroid areolae on the valve mantle, and the tubercle labiate process with a slit (arrow). Figs. 4–6 – ***Medlinia deciusii***: Fig. 4 – General views of two valves on slide CAS 201069; valve on the right is syntype specimen CAS 2044. Fig. 5 – External view of the valve showing the irregular arrangement of poroid areolae on the valve face, polar elevations, and the location of tube of the labiate process (arrow). Fig. 6 – Internal view of the valve showing the irregular arrangement of the foramen of poroid areolae on the valve face and the linear rows of poroid areolae on the valve mantle, and the location of labiate process (arrow).

Figs. 1, 4 – LM; Figs. 2–3, 5–6 – SEM. Scale bars: Figs. 1–6 = 10 μm. Figs. 2–3, 5–6 – CAS 610955.

PLATE 27

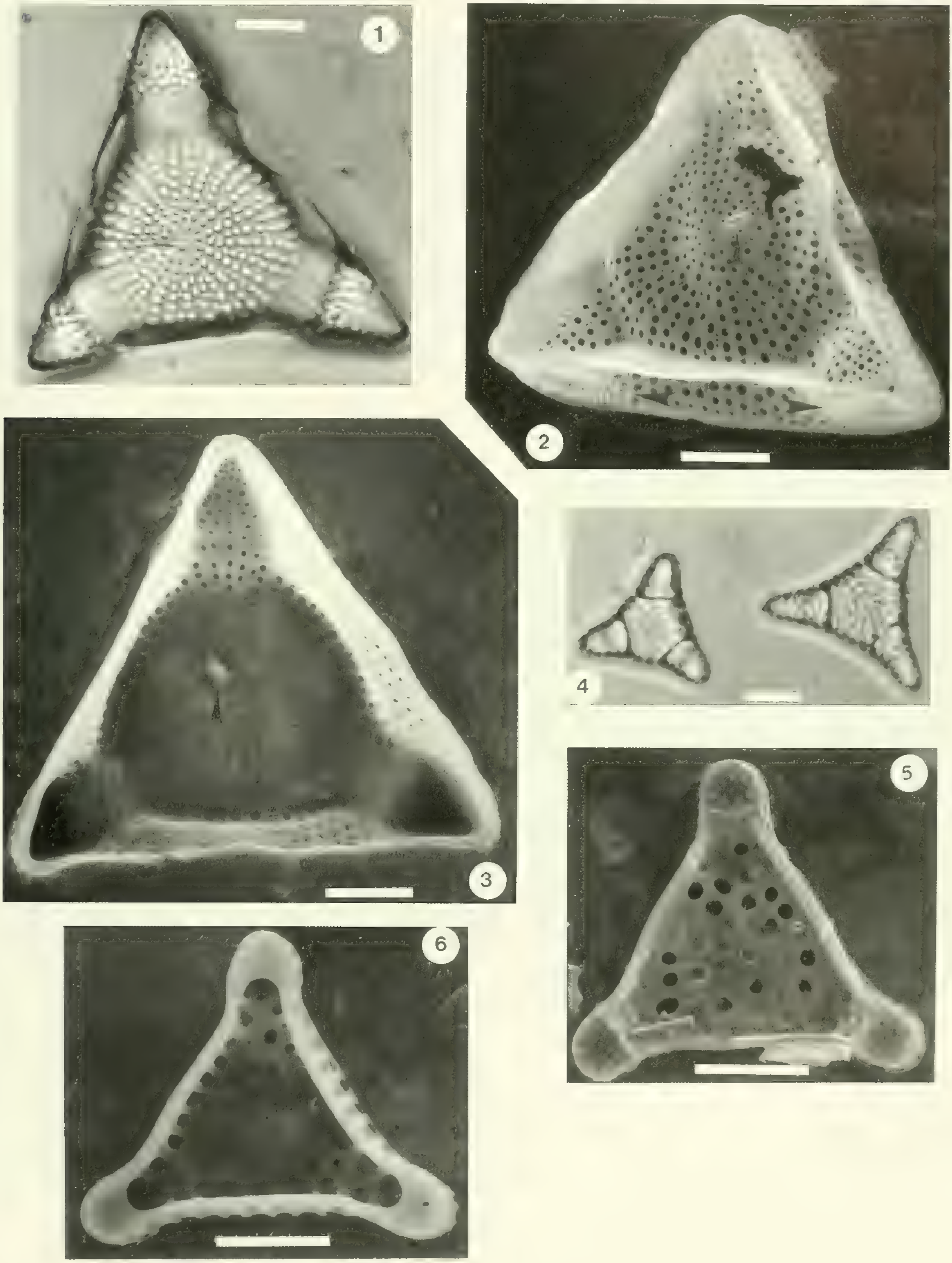

Plate 28

Figs. 1–5 – ***Euodiella bicornigera***: Fig. 1 – Holotype CAS 2039; general view of the valve. Figs. 2–3 – External views of the valve. Fig. 2 – Valve view showing two polar elevations with pseudoocelli, marginal ridge, arrangement of poroid areolae in radial rows with a focal center of the rows near the rounded corner that lacks an elevation and bears the flattened tube of the labiate process (arrow). Fig. 3 – Detail of Fig. 2 showing the cribrum of poroid areolae, the pseudoocelli on the polar elevation, and part of the marginal ridge. Figs. 4–5 – Internal views of the valve. Fig. 4 – Valve view showing the arrangement of the foramen of poroid areolae of the valve face, tubercle labiate process (arrow), and the external and internal structure of the poroid areolae on the valve mantle. Fig. 5 – Detail of Fig. 4 showing the tuberculate labiate process with a slit.

Fig. 1 – LM; Figs. 2–5 – SEM. Scale bars: Figs. 1–2, 4 = 10 μm; Figs. 3, 5 = 1 μm. Figs. 2–5 – CAS 610954.

PLATE 28

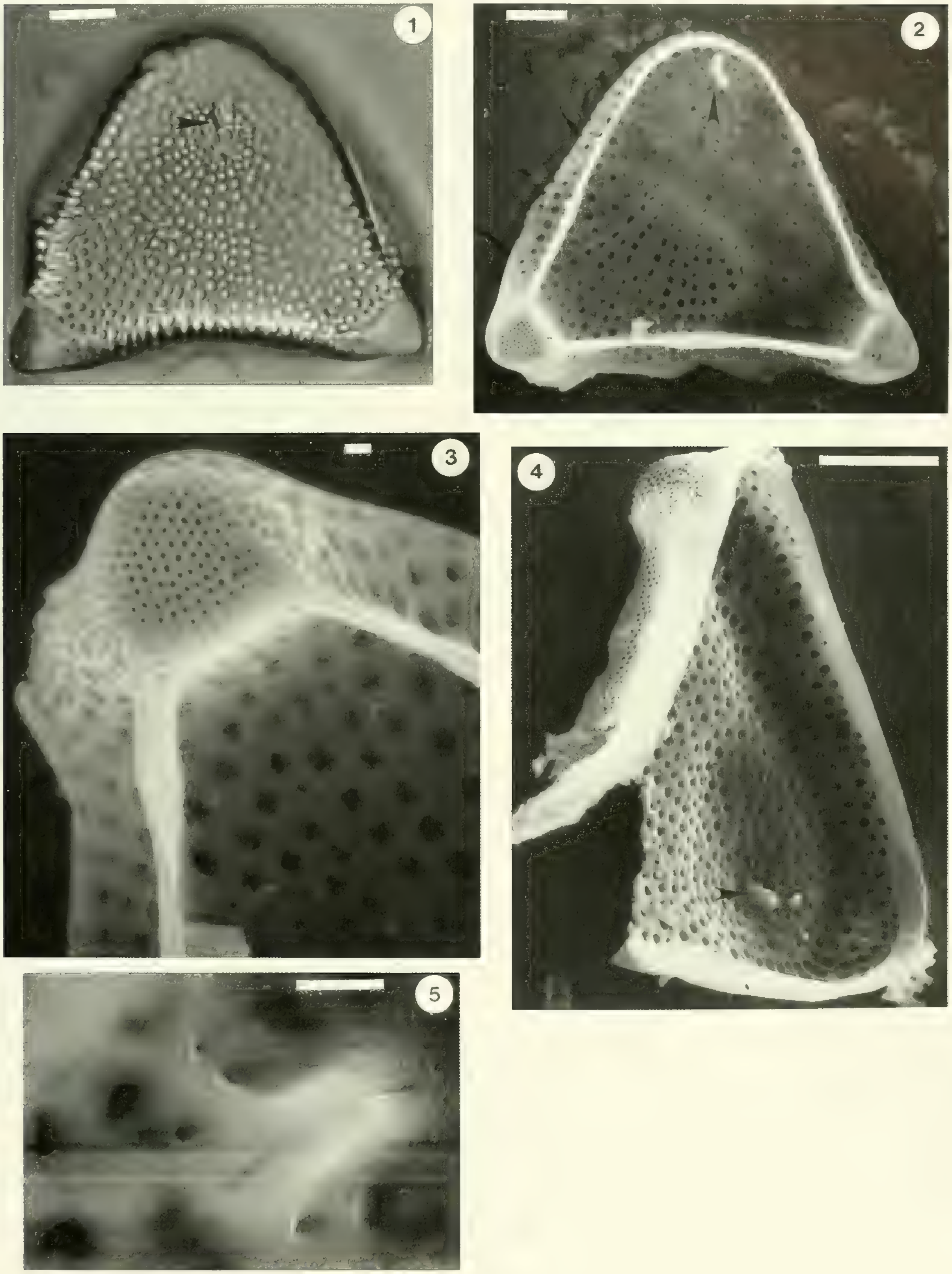

Plate 29

Figs. 1–5 – ***Sheshukovia excavata***: Fig. 1 – Plesiotype CAS 2047; general view of the valve face. Figs. 2–4 – External views of two valves, showing the arrangement of poroid areolae in radial rows, polar elevations with pseudoocelli, marginal ridge, and the location of labiate processes (arrows). Fig. 3 – Detail of Fig. 2 showing part of the valve, a polar elevation with a pseudoocelli, the radial rows of poroid areolae on the valve face, marginal ridge, one row of larger poroid areolae on the valve mantle, and external tubes of the labiate processes (arrows). Fig. 5 – Internal view of the valve showing the arrangement of the foramen of poroid areolae, and the location of labiate processes (arrows).

Fig. 1 – LM; Figs. 2–5 – SEM. Scale bars: Figs. 1–5 = 10 μm. Figs. 2–5 – CAS 610954.

PLATE 29

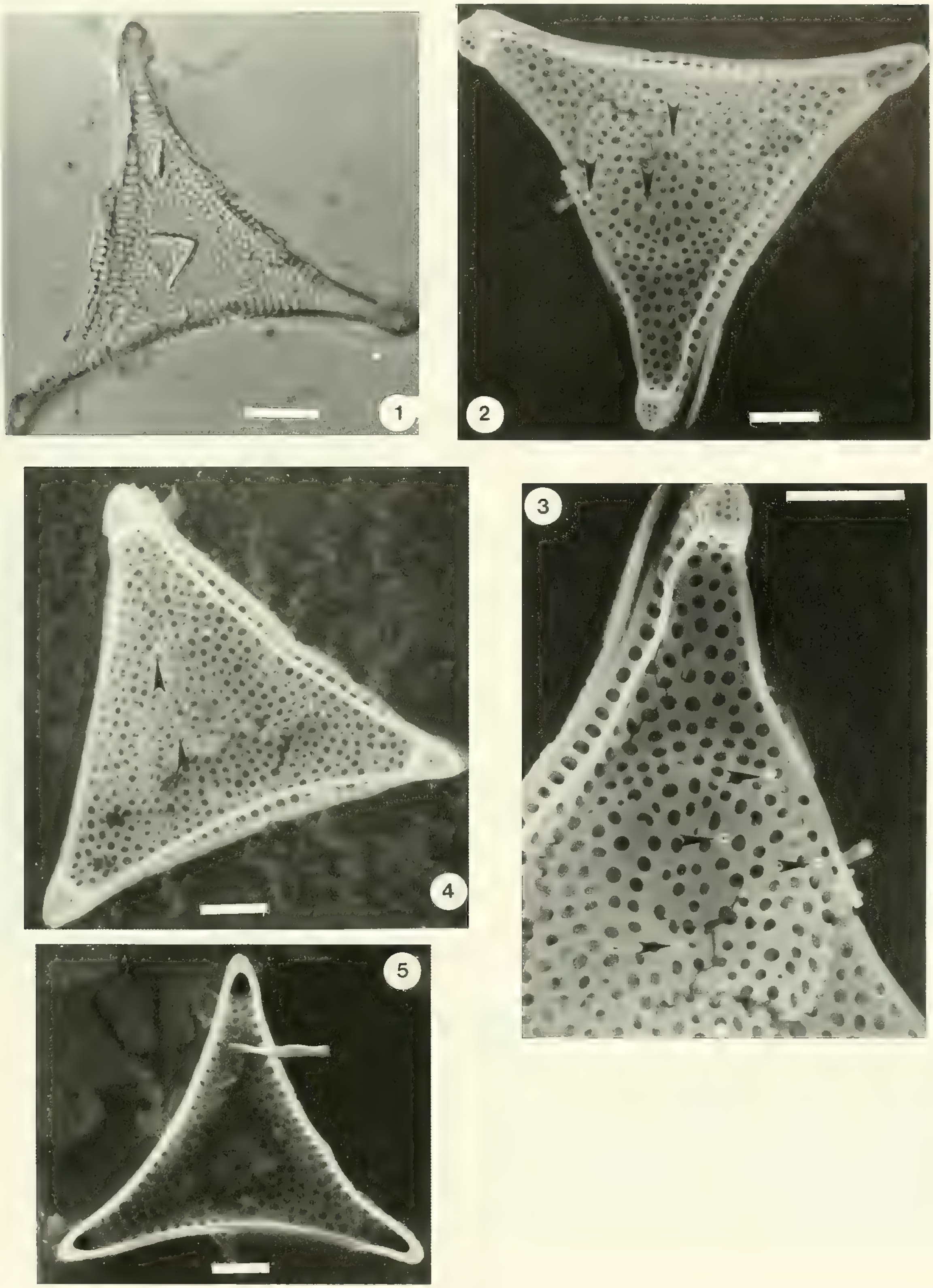

Plate 30

Figs. 1–5 – ***Pseudostictodiscus picus***: Figs. 1–2 – Holotype CAS 2011; valve in different focus, Fig. 1 focus is on the central part of the valve and in Fig. 2 the focus is on the margin of the valve. Fig. 3 – External views of the valve showing the central concave depression of the valve face with a central hyaline field, the irregular radial rows of poroid areolae, slit of the labiate process (small arrow), the marginal part of valve face bears radial rows of poroid areolae, a narrow circular ridge separates the central and marginal parts of valve face, narrow hyaline edge of the valve mantle with two small angular projections (large arrows). Fig. 4 – Internal view of the valve showing the central hyaline field, the elongate foramen of poroid areolae that are arranged radially near the margin of central elevation, slit of the labiate process (small arrow), radial rows of foramen on the margin of valve face, and two small angular projections on the edge of valve mantle (large arrows). Fig. 5 – Girdle view of the mantle showing the elevation of the central part of the valve face and the irregular rows of poroid areolae on the steep valve mantle.

Figs. 1–2 – LM; Figs. 3–5 – SEM. Scale bars: Figs. 1–5 = 10 µm. Figs. 3–5 – CAS 610939.

PLATE 30

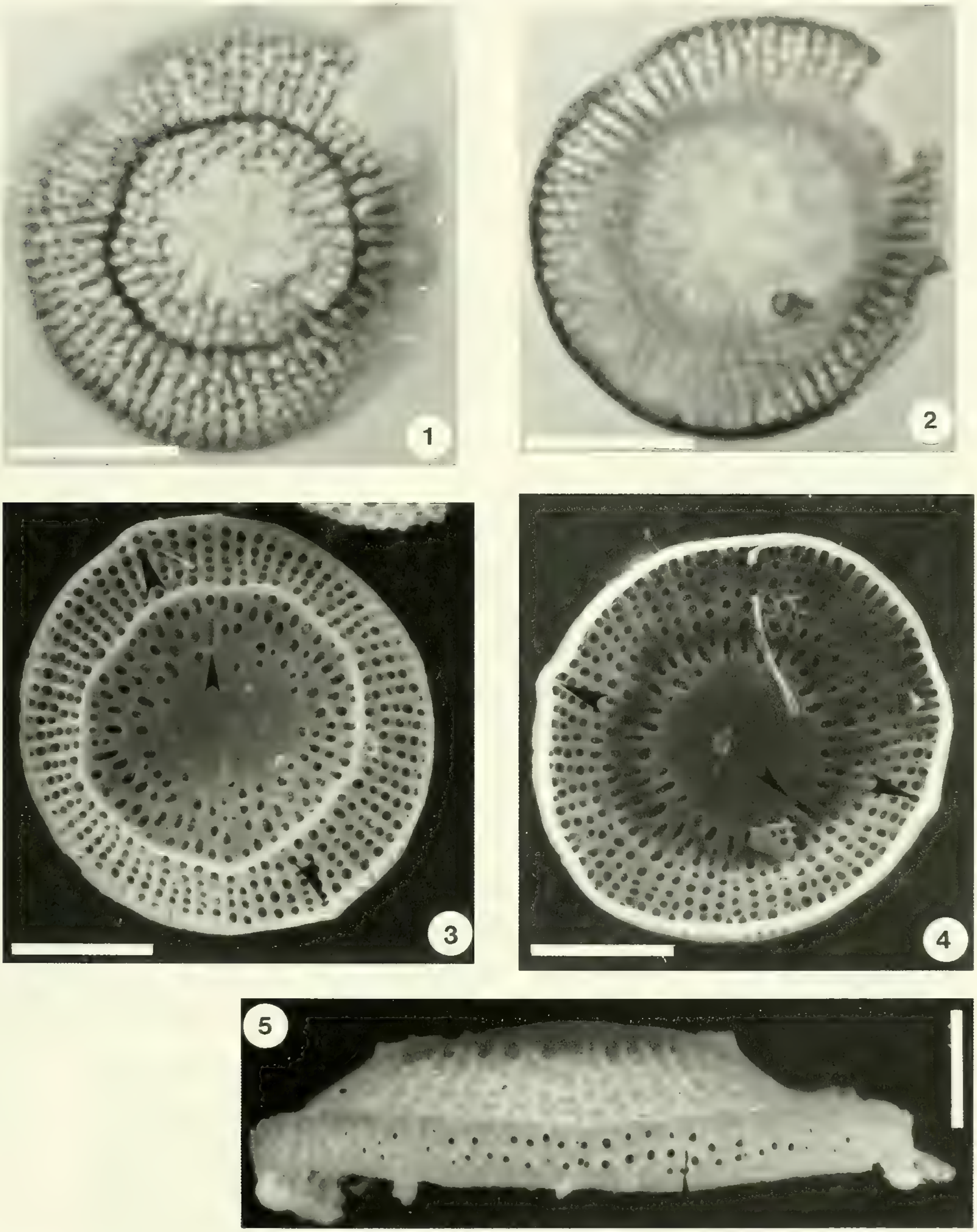

Plate 31

Figs. 1–5 – ***Arachnoidiscus ehrenbergii***: Fig. 1 – Hypotype CAS 3356, general view of the valve. Fig. 2 – External view of part of the valve showing the central hyaline field surrounded by a ring of labiate processes , and radial rows of poroid areolae with small vola. Figs 3–5 – Internal views of valves. Fig. 3 – System of central round hub which connects the radial ribs, short secondary ribs are restricted to the margin area, foramen of poroid areolae, and a ring of labiate processes that surround the hyaline center of the valve (arrow). Fig. 4 – Part of the valve showing the system of radial ribs, rows of foramen of poroid areolae and central hyaline field with ring of slit labiate processes (arrow). Fig. 5 – Detail of Fig. 4 showing central hyaline field with ring of slits labiate processes.

Fig. 1 – LM; Figs. 2–5 – SEM. Scale bars: Figs. 1–4 = 10 µm; Fig. 5 = 1 µm. Fig. 2 – CAS 610939; Fig. 3 – CAS 615990; Figs. 4–5 – CAS 610954.

PLATE 31

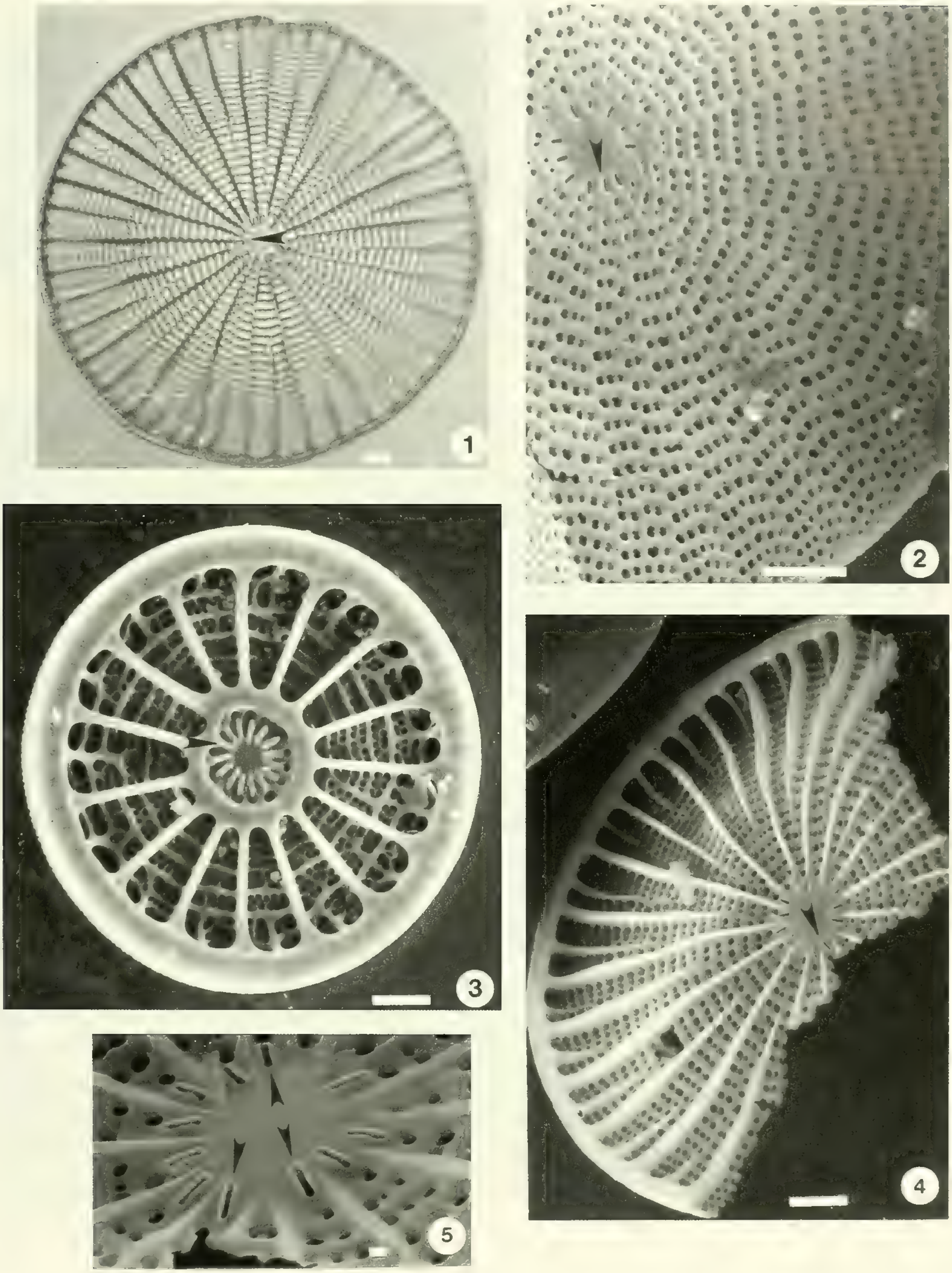

Plate 32

Figs. 1–7 – ***Benetorus fantasmus***: Fig. 1 – Holotype CAS 2000, general view of the valve, showing the radial rows of poroid areolae outside of the central ring-shaped chamber, position of the 'isthmus' marked by the arrow. Fig. 2 – Valve view, arrows indicate the location of the isthmus. Figs. 3–5 – External views of the valve. Fig. 3 – Valve view showing the mid-radius ring-shaped hyaline chamber with an 'isthmus' (large arrow), the central part of the valve face perforated by porous channels, radial rows of poroid areolae on the valve face, marginal ridge, the valve mantle with one rows of porous canals, and the tube of the labiate process (small arrow). Fig. 4 – Broken part of the valve showing a cross-section of the poroid areolae with a small rota (arrow). Fig. 5 – Part of the ring-shaped chamber with a broken external hyaline layer exposing the internal layer of the chamber (perforated by porous canals), and the opening of the labiate process (arrow). Figs. 6–7 – Internal views of the valve. Fig. 6 – valve view showing undulations of the of valve face, the central part of the valve with porous canals, the wall of the ring-shaped chamber perforated by pores that continued as foramen of poroid areolae on the valve face, and the labiate process (arrow). Fig. 7 – Detail of Fig. 6 showing the labiate process with a slit surrounded by a hyaline field and two linear pores.

Figs. 1–2 – LM; Figs. 3–7 – SEM. Scale bar: Figs. 1–3, 6 = 10 µm; Figs. 4–5, 7 = 1 µm. Figs. 2–5 – CAS 610955; Figs. 6–7 – CAS 615990.

PLATE 32

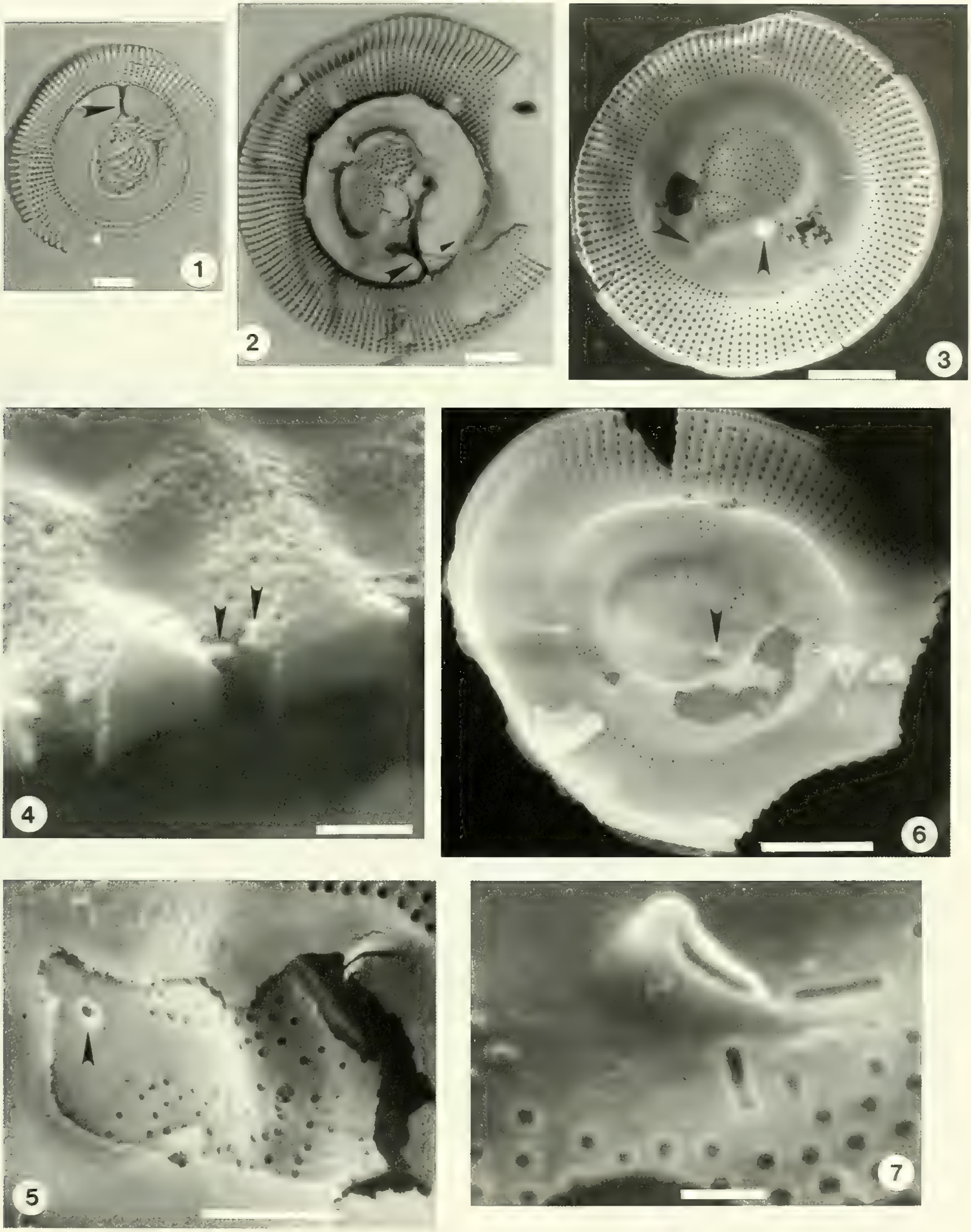

Plate 33

Figs. 1–5 – ***Acanthodiscus paterus***: Fig. 1 – Holotype CAS 3416; view of part of the valve. Figs. 2–3 – External views of a valve. Fig. 2 – Valve showing the hyaline valve face and ring of short ribs oriented radially on the valve margin. Fig. 3 – Detail of Fig. 2 showing the marginal part of the valve and features of the ornamentation. Figs. 4–5 – Internal views of parts valves. Fig. 4 – Part of the valve margin showing the hyaline and non-perforate structure of the basal siliceous layer. Fig. 5 – Part of the valve face and valve mantle showing the hyaline structure of both.

Fig. 1– LM; Figs. 2–5 – SEM. Scale bars: Figs. 1–3, 5 = 10 μm; Fig. 4 = 1 μm. Figs. 2–3, 5 – CAS 610954; Fig. 4 – CAS 610939.

PLATE 33

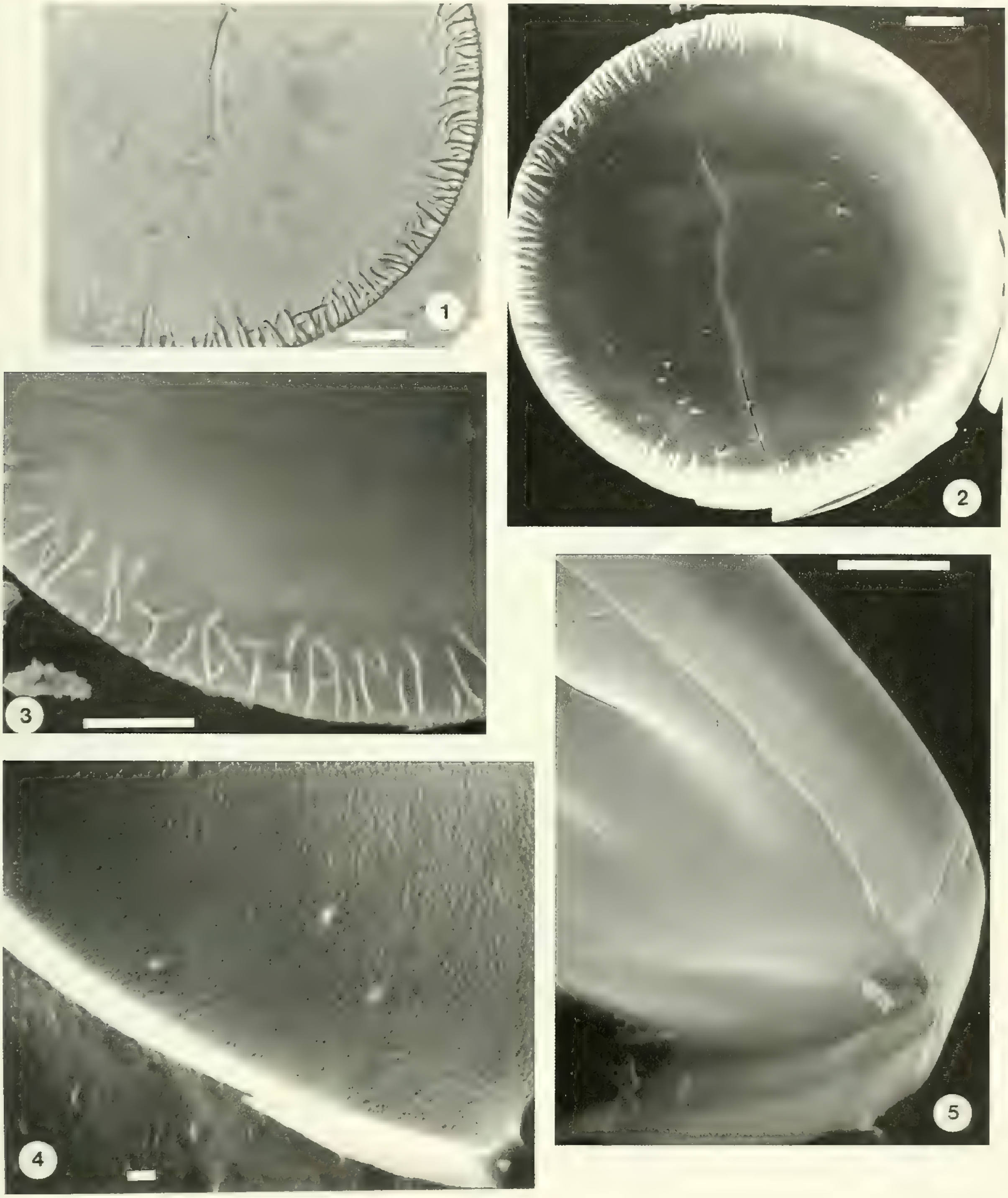

Plate 34

Figs. 1–4 – ***Acanthodiscus immaculatus***: Fig. 1 – Holotype CAS 2003; general view of the valve. Fig. 2 – External view of the valve showing the hyaline non-perforate structure of the valve face and valve mantle. Figs. 3–4 – Internal view of the valve at different magnification showing the hyaline nature of the basal siliceous layer.

Fig. 1 – LM; Figs. 2–4 SEM. Scale bars: Figs. 1–3 = 10 μm; Fig. 4 = 1 μm. Figs. 2–4 – CAS 610955.

PLATE 34

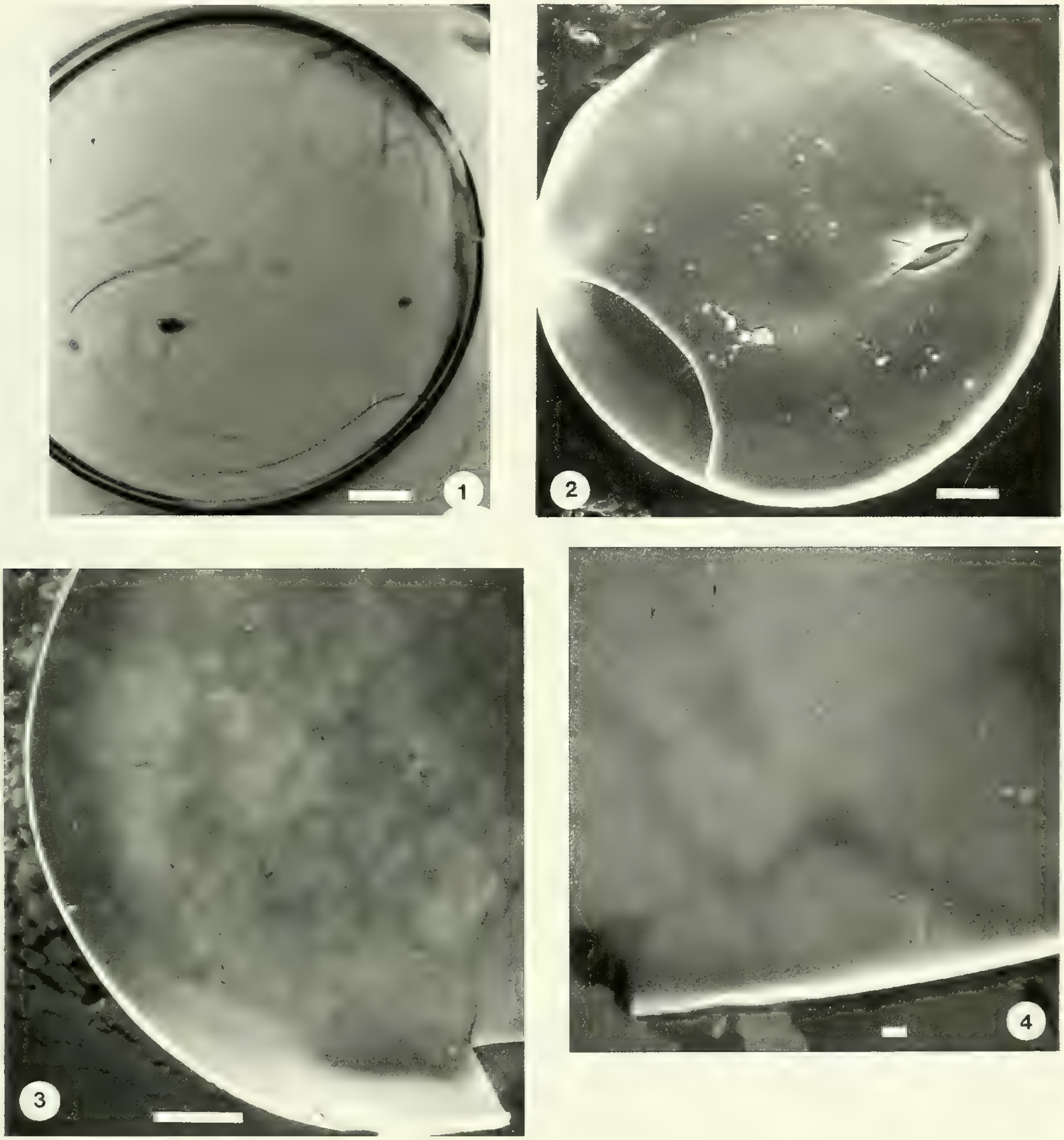

Plate 35

Figs. 1–2 – ***Pseudopyxilla russica***: Girdle view of a valve showing the hyaline structure of the mantle and valve face. Fig. 3 – ***Pseudopyxilla*** sp.: Girdle view showing the hyaline structure of the mantle and part of the valve face that is perforated by porous canals (arrow). Figs. 4–6 – ***Odontotropis galleonis***: Fig. 4 – Holotype CAS 2028; girdle view showing the epivalve (lower valve) with a perforate mantle and the hypovalve (upper valve). Fig. 5 – Epivalve with a trapezium-shaped longitudinal costa. Fig. 6 – Hypovalve with longitudinal costa, two curved spines and scattered small spines on the valve face.

Fig. 4 – LM; Figs. 1–3, 5–6 – SEM. Scale bars: Figs. 1–6 = 10 µm. Figs. 1–2 – CAS 610955; Fig. 3 – CAS 610954; Figs. 5–6 – CAS 610939.

PLATE 35

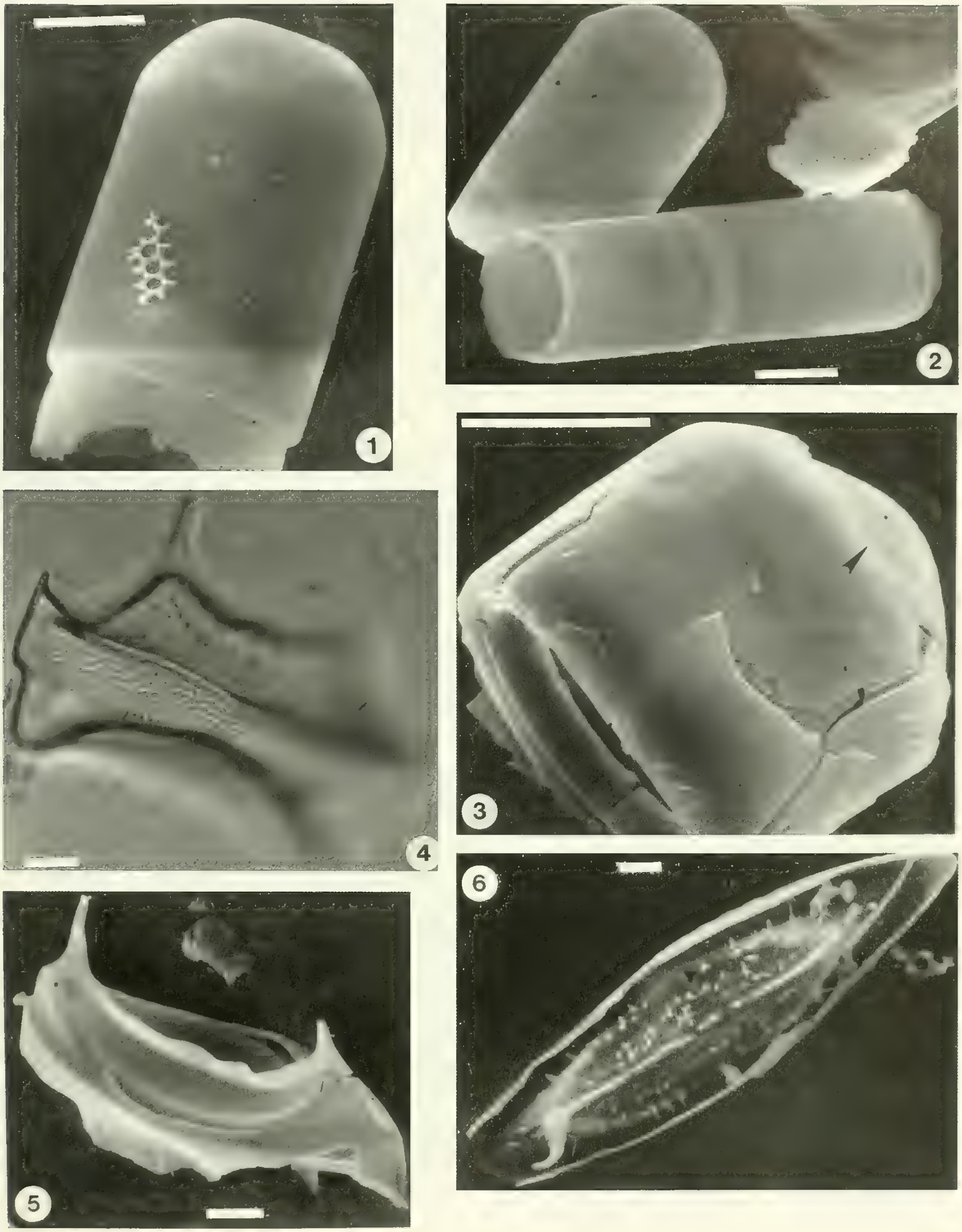

Plate 36

Figs. 1–5 – ***Kentrodiscus blandus***: Fig. 1 – Holotype CAS 3409; girdle view of a frustule; epivalve is funnel-shaped and hypovalve is circular, slightly convex and covered with scattered small spines. Figs. 2–5 – External views of the frustule and valve. Fig. 2 – Girdle view of a frustule showing the hyaline epivalve with a long conical elevation that bears longitudinal ribs and a zone of porous canals near the margin, and the low convex hypovalve with small spines (bottom right). Figs. 3–4 – Epivalve in different positions showing the central conical elevation with longitudinal curved ribs and the location of a slit labiate? process (arrow). Fig. 5 – Detail of Fig. 4 showing the slit of a labiate? process located on the top of the elevation (arrow). Figs. 6–7 – ***Kentrodiscus andersonii***: Fig. 6 – Holotype CAS 2016; girdle view of a frustule. Fig. 7 – External view of a frustule showing the girdle and epivalve/hypovalve with a system of spines.

Figs. 1, 6 – LM; Figs. 2–5, 7 – SEM. Scale bars: Figs. 1–4, 6–7 = 10 μm. Fig. 5 = 1 μm. Figs. 2–5 – CAS 610955; Figs. 6–7 – CAS 610954.

PLATE 36

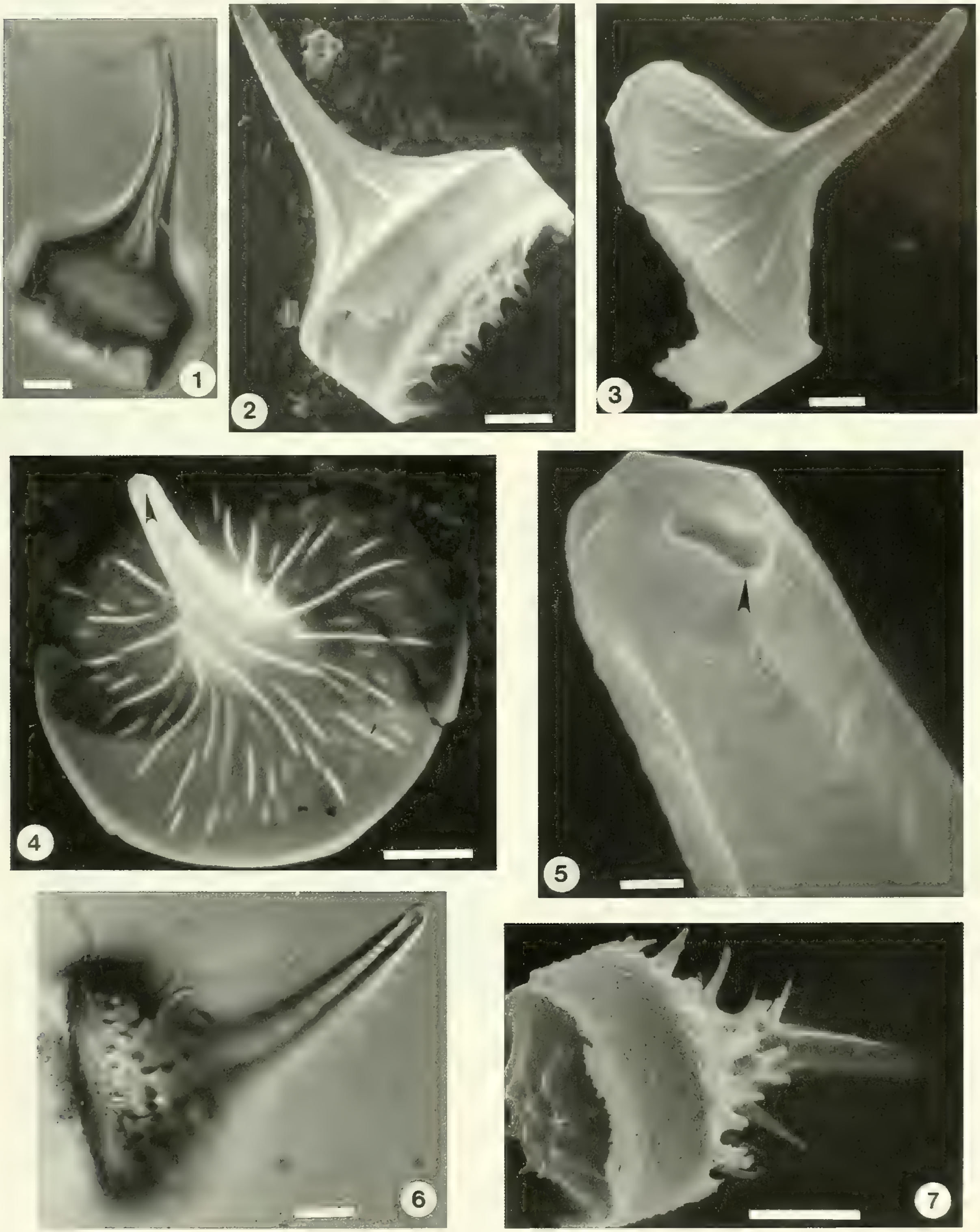

Plate 37

Figs. 1–5 – ***Kentrodiscus aculeatus***: Fig. 1 – Holotype CAS 2015; girdle view of a frustule. Figs. 2–3 – External views of a frustule showing the epivalve (top) and hypovalve (bottom) bearing small spines on the valve faces and the conical elevation of the hypovalve. Figs. 4–5 – Internal views of the epivalve showing the hyaline basal siliceous layer.

Fig. 1 – LM; Figs. 2–5 – SEM. Scale bars: Figs. 1–5 = 10 µm. Fig. 2 – CAS 610939; Figs. 3–5 – CAS 610954.

PLATE 37

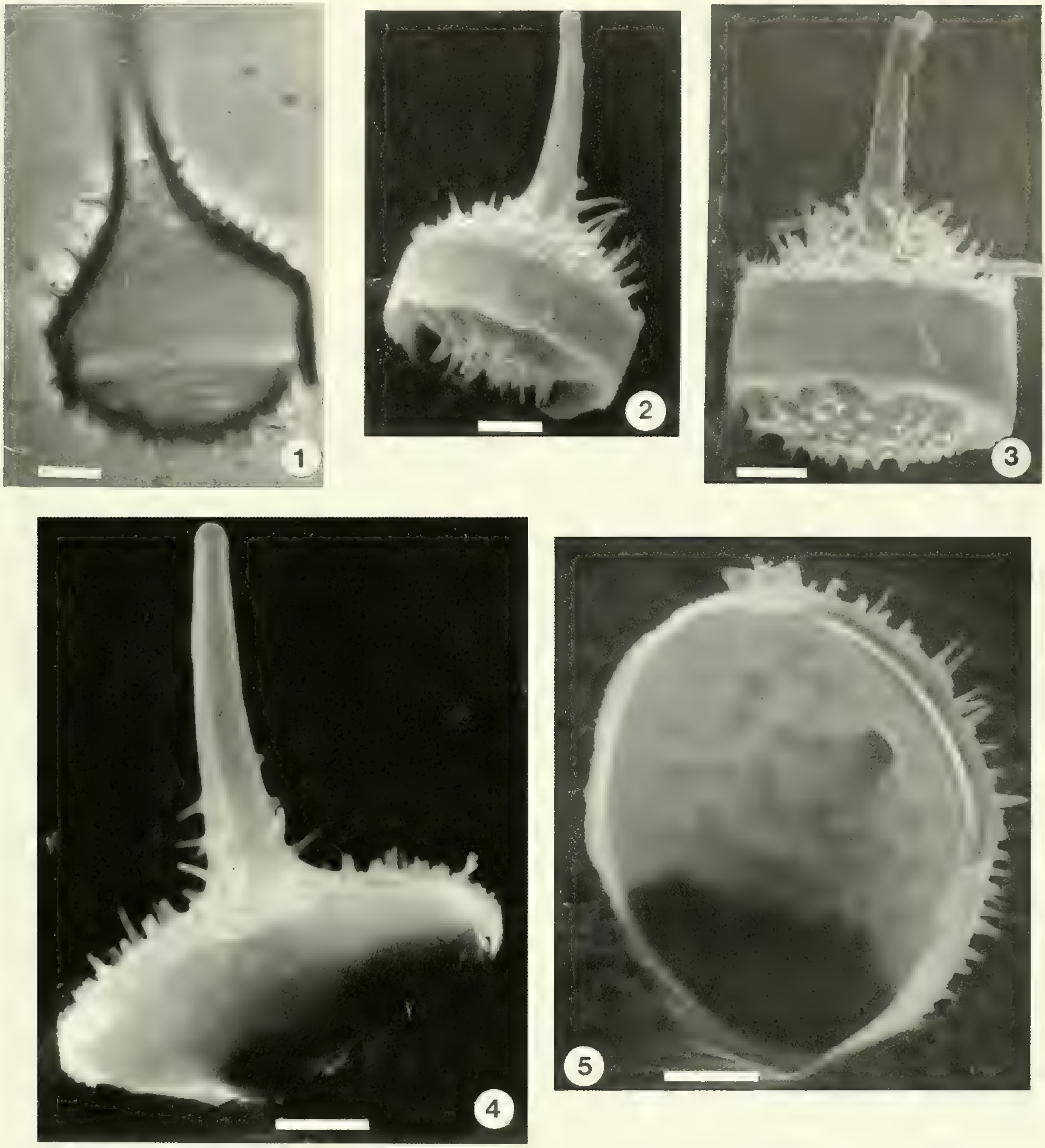

Plate 38

Figs. 1–7 – ***Liradiscus ovalis***: Figs. 1–2 – Valve of the same specimen in different focus. Fig. 1 – Focus on the valve margin. Fig. 2 – Focus on the center of the valve face. Figs. 3, 5, 7 – External views of the valve face valve showing the system of anastomose ribs on the valve face. Figs. 4, 6 – Internal views of valve showing the hyaline basal siliceous layer and the marginal ring of short teeth.

Figs. 1–2 – LM; Figs. 3–7 – SEM. Scale bars: Figs. 1–7 = 10 μm. Figs. 1–7 – CAS 1144.

PLATE 38

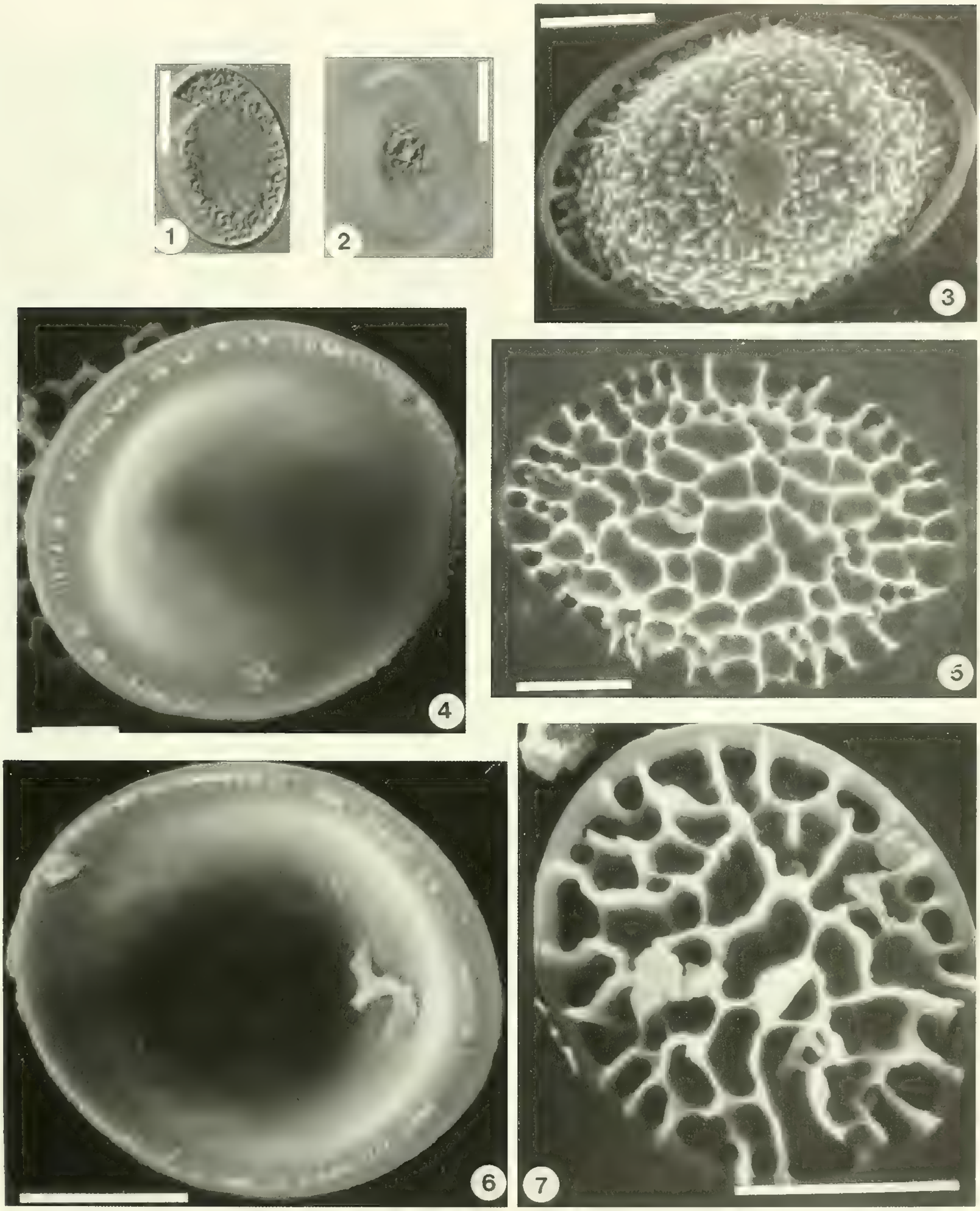

Plate 39

Figs. 1–5 – ***Xanthiopyxis grantii***: Figs. 1–2 – Holotype CAS 2054; Valve views of the same specimen in different focus. Fig. 1 – Focus on the valve margin. Fig. 2 – Focus on the valve face. Figs. 3–4 – External views of the valves. Fig. 3 – valve view showing the arrangement of spines on the valve face. Fig. 4 – valve view showing the irregular perforations of the valve face by porous canal and presence of small spines. Fig. 5 – Internal view of the valve. Figs. 6–7 – ***Pterotheca evermannii***: Fig. 6 – Holotype CAS 2033; girdle view of cylindrical epivalve with an hyaline tapering spine with lateral extensions near the apex. Fig. 7 – External girdle view showing the hyaline structure of the basal siliceous layer. Figs. 8, 9 – ***Pterotheca crucifera***: Fig. 8 – Holotype CAS 2030; girdle view of epivalve with an hyaline terminal spine bearing costae with lateral extensions. Fig. 9 – External girdle view of the epivalve showing the hyaline structure of basal siliceous layer with sub-radial costae on the valve face. Figs. 10–11 – ***Micrampulla parvula***: Fig. 10 – Holotype CAS 2025; side view. Fig. 11 – External side view showing a system of anastomose ribs on the inflated part of the cell, and the hyaline structure of the cylindrical part of the cell.

Figs. 1–2, 6, 8, 10 – LM; Figs. 3–5, 7, 9, 11 – SEM. Scale bars: Figs. 1–11 = 10 μm. Fig. 3 – CAS 615990; Figs. 4–5 – CAS 610954; Figs. 6, 9 – CAS 610955; Fig. 11 – CAS 610939.

PLATE 39