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Radiolaria : flux, ecology, and taxonomy in the Pacific and Atlantic

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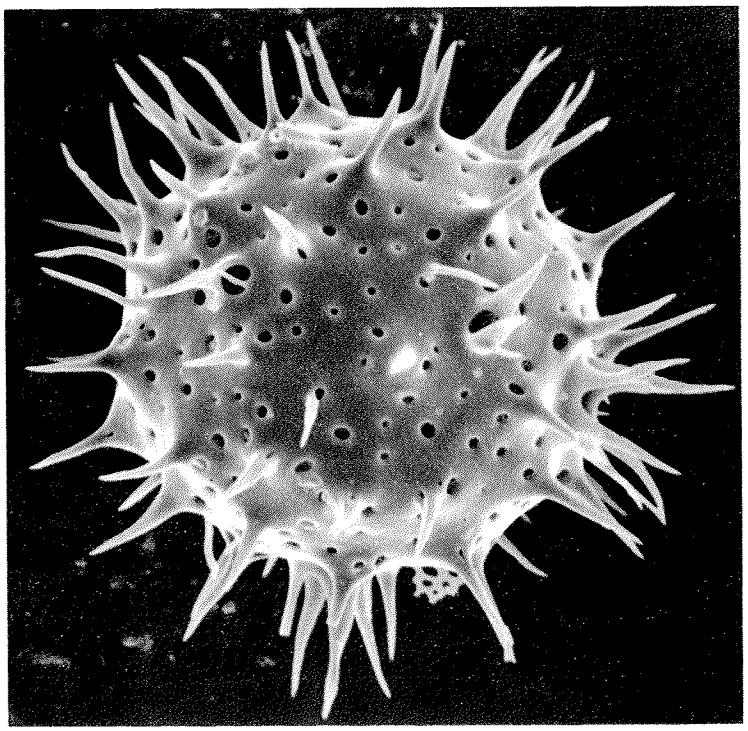
Flux, Ecology, and Taxonomy in the Pacific and Atlantic

Kozo Takahashi



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Explanation of Cover Photo: A scanning electron photomicrograph of *Acrosphaera spinosa* (Haeckel) *longispina* Takahashi collected at 4,280 m at PARFLUX sediment trap Station P_1 in the central tropical Pacific (see page 53 of text). *A. spinosa longispina* is a colonial radiolarian belonging to Suborder Spumellaria. The shell diameter of this specimen is 125 μm.

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Radiolaria:
Flux, Ecology, and Taxonomy in the Pacific and Atlantic

Kozo Takahashi

Abstract

Radiolarians settling through the oceanic water column were recovered from three stations (western tropical Atlantic, Station E; central tropical Pacific, Station P_1; and Panama Basin, Station PB) using PARFLUX sediment traps in moored arrays at several depths. The taxonomic diversity of the radiolarian assemblages in the sediment traps was very high. A total of 420 taxa (including 23 new taxa) were found at the three stations; of these 208 taxa were found at Station E. The polycystine radiolarians generally reach the sea floor with little change in abundance or species composition, although slight skeletal dissolution occurs during their descent through the water column. The phaeodarian radiolarians, on the other hand, are largely dissolved within the water column; only a few species reach the sea-floor and these dissolve rapidly at the sediment-water interface. Most radiolarian skeletons sink as individuals through deep water columns without being incorporated into large biogenic aggregates. Because significant numbers of nassellarian and phaeodarian species are deep-water dwelling forms, the diversity of radiolarians increases with increasing depth in the mesopelagic zone.

The vertical flux of the total radiolarians arriving at the trap depths (in $\times 10^3$ individuals $/m^2/day$) ranged from 16–24 at Station E, 0.6–17 at Station P_1, and 29–53 at Station PB. On the average 25% and 69% of the total radiolarian flux is transported by Spumellaria and Nassellaria, respectively, while 5% is carried by Phaeodaria. The supply of radiolarian silica (mg $SiO_2/m^2/day$) to each trap depth ranged from 2.5–4.0 at Station E, 0.9–3.2 at Station P_1, and 5.7–10.4 at Station PB. The Radiolaria appear to be a significantly large portion of the SiO_2 flux in the > 63 μm size fraction and thus play an important role in the silica cycle. When the radiolarian fluxes at the three stations are compared with Holocene radiolarian accumulation rates in the same areas it became apparent that several percent or less of the fluxes are preserved in the sediment in all cases and the rest must be dissolved on the sea-floor.

1 Introduction

Radiolaria are one of the major groups of marine planktonic protozoans belonging to the class Actinopoda. Their geometrically complex skeletons, where present, are composed of amorphous silica and are often aesthetically pleasing. Since Haeckel's (1887) time, modern Radiolaria have been known to represent quite diversified assemblages. About 200 radiolarian species, for instance, were reported from a single geographic area in the tropical Atlantic (Takahashi and Honjo, 1981). This is a remarkably high diversity in contrast with the total of about 40 present-day species of planktonic Foraminifera in the world oceans (Bé, 1977).

The highest standing stock of living Radiolaria is generally found in the vicinity of the thermocline (see e.g., Renz, 1976; Bishop et al., 1977, 1978; Takahashi and Ling, 1980). The major proportion of the population dwells in the upper several hundred meters of the pelagic realms, although there are some deep dwelling forms down to abyssal depths.

The quantitative world-wide distribution of living Radiolaria is not yet fully understood, however, the results of such biocoenosis can be seen in the underlain sediments (for example, as radiolarian oozes). The oozes generally occur more extensively in the equatorial siliceous belt of sediments than in other latitudinal regions, reflecting both siliceous productivity in the overlying water and carbonate dissolution on the sea-floor. In fact, Radiolaria are known to be the major siliceous component in suspension as well as in the sediments in the tropical regions (Lisitzin, 1971, 1972). High latitude siliceous belts are thought to be another major sink for radiolarian skeletons. However, Radiolaria are usually not present in high proportions in sediments because they are masked by diatoms.

There have been increasing numbers of recent studies concerning paleoenvironmental interpretations using radiolarian thanatocoenosis (e.g., Moore, 1978). Detailed studies of radiolarian production, sedimentation and preservation have only recently begun (e.g., Takahashi, 1981, 1983). The extent of preservation of radiolarians in marine sediments is known to be very small (e.g., Calvert, 1974; Heath, 1974; Takahashi and Honjo, 1981), and the thanatocoenosis is rarely proportional to the biocoenosis in the upper water layer (Renz, 1976). Preferential dissolution generally leaves only solution resistant taxa to be preserved. For this reason, estimating paleotemperatures, for instance, by using the thanatocoenosis without adequate information on preservation mechanisms may lead to inaccurate results.

Recent advancements in ocean experimental methods allow the deployment of large sediment traps for prolonged periods of time in pelagic environments (e.g., Wiebe et al., 1976; Honjo, 1978; Honjo et al., 1980). By studying sediment trap material collected over a three month period, Takahashi and Honjo (1981) documented the largest stock of radiolarian assemblages ever reported from the tropical Atlantic. Radiolarian samples collected by sediment traps are useful not only for a basic description of biocoenosis, but also for understanding the mechanisms of sedimentation, dissolution/preservation and silica cycling since the geochemistry of seawater is in part governed by particle-water interaction.

Despite many taxonomic works on fossil Radiolaria (e.g., Riedel, 1967a, 1971; Petrushevskaya, 1971d, 1981; Nigrini and Moore, 1979) the systematics of Recent Radiolaria is still in need of improvement. In this report Radiolarians from the PARFLUX sediment trap stations in the Atlantic and Pacific (Figure 1) were determined quantitatively and used for taxonomic emendations.

2 Samples and Methods

The sources of the samples used in this study are summarized in Table 1. Station E is located about 750 km from the Guyana Coast in a region where there is found very little seasonal variation in zooplankton productivity (e.g., Moore and Sander, 1977). The underlying Demerara Abyssal Plain has a gentle topography and is covered with silty clay. The North Equatorial Current flows in a northwesterly direction, but no deep current measurements have been reported in the study area. Station P_1 is located in the East Hawaii Abyssal Plain. The bottom sediment is consolidated clay with alternating thin ferro-manganese laminations (Honjo, 1980). Station PB, located in the Panama Basin, is characterized by high productivity and is relatively close to land (250 km from the nearest shoreline). Hydrography, geology, biology and physical oceanography are quite well known in this area

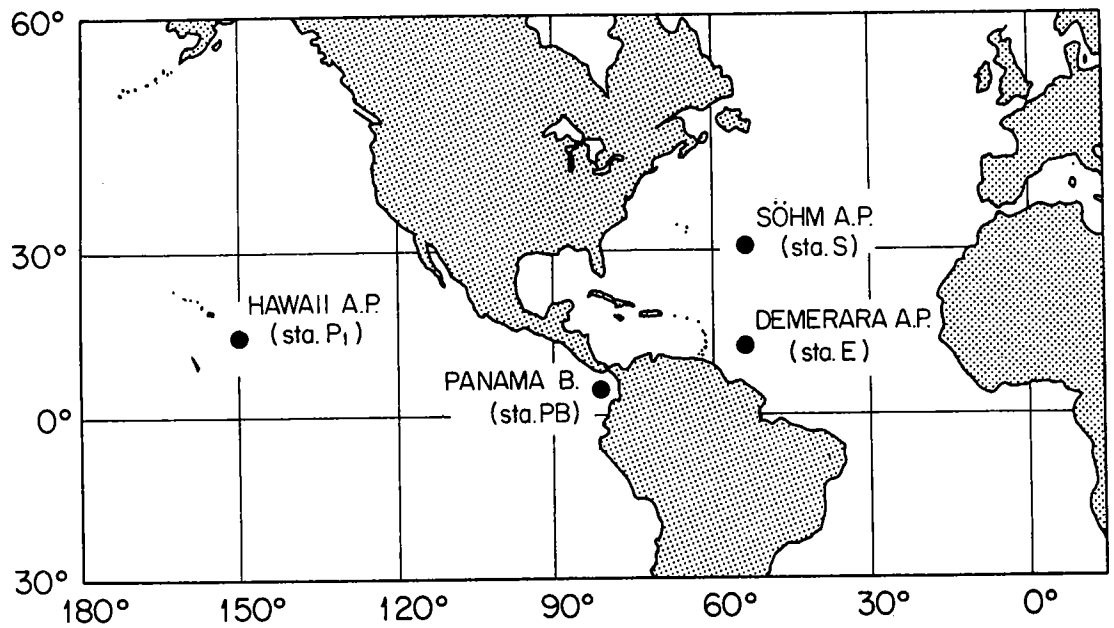

Figure 1: Locations of the PARFLUX sediment trap stations.

(e.g., Stevenson, 1970; van Andel, 1973; Kowsmann, 1973; Moore et al., 1973; Plank et al., 1973; Heath et al., 1974; Lonsdale, 1975, 1977; Swift, 1977; Swift and Wenkam, 1978).

The sediment trap arrays deployed at the above stations consisted of four or five PARFLUX Mark II traps with 1.5 m^2 opening (Honjo et al., 1980) (Table 1). The receiving cup was sealed by a time-controlled spring shutter prior to recovery.

The samples were wet sieved upon arrival in the laboratory with a 1 mm mesh screen and split into four aliquots by a Honjo-Erez precision rotary liquid splitter (Honjo, 1978). An aliquot of material finer than 1 mm was further split into several aliquots (Table 1). The resulting aliquot of the original sample was wet sieved through 250, 125 and 63 μm screens. When necessary the samples were split further into smaller aliquots prior to filtration (Table 2). Samples of less than 63 μm size fraction from Station E were separately prepared prior to establishment of the standard method: by diluting a 1/64 aliquot to 250 ml in a measuring flask using filtered seawater from the deep Sargasso Sea, and then a 2 ml aliquot was taken by using a pipet.

The above aliquots were filtered through a 47 mm type HA Millipore© grid filter with a nominal 0.45 μm pore size using a filtration funnel with a 19×42 mm rectangular opening. the residue was rinsed with distilled water, then dried at 50°C in an oven. Large foraminiferal and pteropod specimens in 1,000–250 μm and 250–125 μm size fractions were removed from the filter surface under a dissecting microscope. The dried filter sample was mounted on a standard glass slide after trimming off the excess margins. Drops of Cargile^R type B compound were applied to clear the sample filter. It took a few days for the bubbles to escape from all radiolarian shells prior to placing a cover glass over the sample area. Aliquot size and number of slides from the three stations which were used in this paper are summarized in Table 2.

Table 1: Summary of the sample sources from the PARFLUX sediment traps deployed in the Atlantic and Pacific.

	PARFLUX S_2	PARFLUX E	PARFLUX P_1	PARFLUX PB
Location	31°32.5′N, 55°55.4′W	13°30.2′N, 54°00.1′W	15°21.1′N, 151°28.5′W	5°21′N, 81°53′W
Ocean/Basin	Central Sargasso Sea/ Söhm Abyssal Plain	Tropical Atlantic/ Demerara Abyssal Plain	N. Central Pacific/ E. Hawaii Abyssal Plain	Tropical Pacific/ hemipelagic Panama Basin
Term	10/76–1/77	11/77–2/78	7/78–11/78	8/79–12/79
Duration	110 days	98 days	61 days	112 days
Trap Depth (m)	976 3,694	389 988 3,755 5,068	378 978 2,778 4,280 5,582	667 1,268 2,869 3,769 3,791
Anchor Depth	5,581 m	5,288 m	5,792 m	3,856 m

The slides were studied to identify radiolarian taxa and to count individuals to the species level under a transmission light microscope. Two or more of slides whose aliquot sizes are shown in Table 2 were used for the species identification. The number of slides used for counts is presented in Table 2. The counts were converted to the flux term; number of individual shells/m^2/day.

An abundant, medium sized radiolarian genus, *Pterocorys* (*P. campanula* Haeckel, Plate 42, figures 5–8, and *P. zancleus* (Miller), Plate 42, figures 1–4) was chosen in order to assess the range of errors induced during sample preparation, and the reproducibility of shell counting. The assessment was made by counting *Pterocorys* shells in a given slide. This taxon occurs mostly in 250–125 μm and 125–63 μm size fractions. The counting reproducibility by duplicate countings of an identical slide proved to be more than 90%. Statistical variability among four slides prepared from the coarse and medium size fractions is due to errors involving slide preparation including wet sieving and splitting. The standard deviation ranged from 0.14 to 0.26 at 95% confidence interval. The radiolarian species count applied in this paper is reproducible to better than 74%. All the microslides used for the present investigation are deposited permanently in the Sea-floor Sample Laboratory, Woods Hole Oceanographic Institution.

To prepare handpicked specimens for electron microscopy and dimension analyses, aliquots of 1/64 or 1/256 of wet samples from the sediment trap are sieved and desalted by the same method as above. Grid-imprinted, black-background, 47 mm HA Millipore© filters with a nominal 0.45 μm pore size are used to retain radiolarian samples. After drying, specimens of radiolarian taxa are handpicked using an ultrafine Japanese calligraphy brush. A portion of the picked specimens were mounted on an aluminum stub with a piece of

Table 2: Size of aliquot in each microslide relative to total sediment trap samples. Number of slides used for counts is shown in parentheses.

		Size Fraction			
Station:	**Depth (m)**	**1000–250 (μm)**	**250–125 (μm)**	**125–63 (μm)**	**< 63 (μm)**
E:	389	1/256 (1)	1/1024 (1)	1/1024 (1)	1/8000 (1)
	988	1/256 (1)	1/1024 (1)	1/1024 (1)	1/8000 (1)
	3755	1/256 (1)	1/1024 (1)	1/1024 (1)	1/8000 (1)
	5068	1/256 (1)	1/1024 (1)	1/1024 (1)	1/8000 (1)
		1/256[a] (1)	1/1024[a] (4)	1/1024[a] (4)	1/8000[a] (2)
PB:	667	1/4086 (2)	1/1024 (1)	1/1024 (1)	1/16384 (2)
	1268	1/1024 (1)	1/1024 (1)	1/1024 (1)	1/4096 (2)
	2869	1/4096 (2)	1/1024 (1)	1/1024 (1)	1/16384 (2)
	3769[b]	1/4096 (2)	1/4096 (2)	1/4096 (2)	1/16384 (2)
	3791	1/1024 (1)	1/1024 (1)	1/1024 (1)	1/16384 (2)

[a]For statistical assessment at each of the four depths at Station E.
[b]Studied only for Phaeodaria.

		Size Fraction		
Station:	**Depth (m)**	**1000–250 (μm)**	**250–63 (μm)**	**< 63 (μm)**
P_1:	378	1/256 (1)	1/256 (1)	1/256 (1)
	978	1/256 (1)	1/256 (1)	1/256 (1)
	2778	1/256 (1)	1/256 (1)	1/1024 (1)
	4280	1/256 (1)	1/256 (1)	1/1024 (1)
	5582	1/256 (1)	1/256 (1)	1/1024 (1)

double-sided adhesive tape and coated with carbon and then Pd-Au alloy film for scanning electron microscopy (SEM). Samples for transmission electron microscopy were prepared by the method described by Hurd et al. (1981).

Reflected light micrographs were taken at ×20 and ×40 magnification of a dissecting microscope for each taxa. The micrographs were converted to positive slides and projected onto an image digitizer (LW International) for measurements of length, width and maximum projected area.

After the photography, specimens were dried in a vacuum at 150°C for 2 days, then cooled in a desiccator for 10 minutes and quickly weighed. A Cahn 25 Automatic Electrobalance© was used in a room with humidity of less than 40%. The number of specimens needed for this varied significantly depending on weight/shell of different taxa. Details were reported elsewhere (Takahashi and Honjo, 1983).

3 Results and Discussion

3.1 Counts of Radiolarian Taxa

The majority of radiolarian specimens found in the slide samples were identified to the species level (Table 3, Section 6, Plates 1–63). A total of 420 taxa, including one new genus, 20 new species, and one new subspecies, were recognized from the three stations. Following are the total numbers of radiolarian taxa encountered at each trap station: Station E: 208; Station P_1: 217; Station PB: 225. The systematics of the taxa are given in a later section of this report. According to Casey (pers. comm., 1981), based on the published literature the best inference on total number of living radiolarian species in the world ocean is about 600. This report thus covers a majority of tropical radiolarian species.

Subclass Radiolaria are comprised of the following three suborders whose cumulative number of taxa encountered from all stations are shown in parenthesis: Spumellaria (175); Nassellaria (182); and Phaeodaria (63). The number of encountered taxa in Spumellaria, Nassellaria, and Phaeodaria in order are: Station P_1: 82, 113, 22; Station PB: 83, 111, 31 (for information on Station E, see Takahashi and Honjo, 1981). The number of taxa contained in the counting slides appeared to be less than that in slides used for species identification (Tables 2 and 3, Plates 1–63), due to the statistical discrepancy of using one or two slides for counting and one to four slides in each size fraction for species identification. When necessary (i.e., taxonomic division was not practical) several species were combined together as one group during census taking (Table 3). Spicules were not counted.

The radiolarian fluxes from the three stations were normalized to the number of individual shells/m^2/day for each taxon (Table 3). The size fractioned fluxes of radiolarian families from Stations P_1 and PB are presented in Table 4, and those from Station E are from Takahashi and Honjo (1981). Percentages of actual specimens counted in each slide are also given in Table 4. The fluxes of suborders are summarized in Table 5 and illustrated in Figure 2.

Table 3: The radiolarian (species) flux (number of shells/m^2/day) at three sediment trap stations. Data reported here include all size fractions from < 63 μm to 1mm–250 μm.

Sediment Trap Station	E				P_1					PB			
Depth (m)	389	988	3755	5068	378	978	2778	4280	5582	667	1268	2869	3791
Suborder SPUMELLARIA Ehrenberg													
Family COLLOSPHAERIDAE Müller													
Acrosphaera spinosa (Haeckel)	10	58	65	116	0	6	28	31	25	0	49	12	12
Acrosphaera murrayana (Haeckel)	0	0	0	0	0	0	0	6	0	12	43	104	67
Acrosphaera cyrtodon (Haeckel)	0	0	0	0	0	0	0	0	0	0	0	0	0
Clathrosphaera arachnoides Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Collosphaera tuberosa Haeckel	19	9	31	29	0	8	53	34	31	98	37	110	61
Collosphaera confossa Takahashi, n. sp. and *C. armata* Brandt	0	0	0	0	0	0	19	8	31	30	6	24	43
Collosphaera huxleyi Müller	5	46	107	38	3	17	65	53	56	0	0	18	18
Collosphaera macropora Popofsky	0	0	0	0	39	36	81	107	123	55	37	98	73
Collosphaera polygona Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Disolenia collina (Haeckel)	0	0	0	0	6	0	17	0	8	0	0	0	0
Disolenia zanguebarica (Ehrenberg)	0	0	0	0	3	11	14	36	31	0	24	6	0
Disolenia quadrata (Ehrenberg)	0	0	0	0	0	14	34	45	22	0	0	0	0
Disolenia sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0
Disolenia sp. B	0	0	0	0	3	0	0	0	0	0	0	18	0
Otosphaera tenuissima (Hilmers)	0	0	0	0	0	0	0	0	0	0	0	0	0
Otosphaera polymorpha Haeckel	40	29	40	29	0	14	75	53	95	24	6	18	18
Otosphaera auriculata Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Siphonosphaera magnisphaera Takahashi, n. sp.	0	0	0	0	6	0	8	11	14	18	0	0	6
Siphonosphaera sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0
Siphonosphaera martensi Brandt	0	0	0	0	14	34	95	73	28	6	6	48	18
Siphonosphaera sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0
Siphonosphaera sp. aff. *S. hippotis* (Haeckel)	0	0	0	0	0	0	0	0	0	0	0	0	0
Siphonosphaera socialis Haeckel	19	15	19	26	6	11	34	22	31	0	12	6	6
Total COLLOSPHAERIDAE	88	111	155	200	80	151	523	479	495	243	220	462	322
Family SPHAEROZOIDAE Haeckel													
Rhaphidozoum pandora Haeckel***	86	71	63	12	0	0	0	0	0	12	0	0	0
Total SPHAEROZOIDAE	86	71	63	12	0	0	0	0	0	12	0	0	0
Family ETHMOSPHAERIDAE Haeckel													
Plegmosphaera pachypila Haeckel	74	74	162	143	0	0	0	0	0	0	0	0	0
Plegmosphaera coelopila Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Plegmosphaera sp. aff. *P. lepticali* Renz	0	0	0	0	0	0	0	0	0	48	49	79	73
Plegmosphaera sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0
Plegmosphaera sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3 (continued)

Sediment Trap Station	E				P_1					PB			
Depth (m)	389	988	3755	5068	378	978	2778	4280	5582	667	1268	2869	3791
Plegmosphaera entodictyon Haeckel	0	0	0	0	0	0	0	0	0	61	110	213	140
Plegmosphaera oblonga Takahashi, n. sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Plegmosphaera lepticali Renz	21	0	15	18	0	0	20	17	8	0	0	0	0
Plegmosphaera pachyplegma Haeckel	0	0	0	0	0	0	0	0	0	0	18	12	0
Styptosphaera spongiacea Haeckel	0	0	0	0	0	0	3	28	20	24	30	91	134
Styptosphaera sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0
Styptosphaera sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0
Styptosphaera sp. C	0	0	0	0	0	0	0	0	0	0	0	0	0
Carposphaera capillacea Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Carposphaera sp. aff. *C. corypha* Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Total ETHMOSPHAERIDAE	95	74	177	161	0	0	23	45	28	133	207	395	347
Family ACTINOMMIDAE Haeckel emend. Riedel													
Subfamily ACTINOMMINAE Haeckel, emend. herein													
Centrocubus cladostylus Haeckel	3	0	3	14	0	0	0	0	0	0	0	0	0
Centrocubus octostylus Haeckel	0	0	0	0	0	0	11	0	3	0	0	0	0
Spongosphaera polycantha Müller	0	0	0	0	0	0	0	0	0	0	0	0	0
Spongosphaera sp. aff. *S. helioides* Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Spongosphaera streptacantha Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Spongosphaera ? sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0
Lychnosphaera regina Haeckel	0	0	0	0	0	0	0	0	0	0	6	0	6
Actinomma archadophorum Haeckel	56	40	56	65	0	0	36	22	17	110	116	152	91
Actinomma capillaceum Haeckel	0	0	0	0	0	0	0	0	0	24	6	0	0
Actinomma sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Trilobatum ? *acuferum* Popofsky	238	58	673	437	3	112	213	196	171	201	262	256	274
Acanthosphaera actinota (Haeckel)	49	33	81	62	0	28	45	42	62	122	73	140	122
Acanthosphaera tunis Haeckel	0	0	0	0	0	0	0	0	0	12	0	0	0
Acanthosphaera castanea Haeckel	0	0	0	0	0	0	17	22	3	0	0	0	0
Heliosphaera radiata Popofsky	10	15	12	9	0	0	3	0	0	0	0	0	0
Cladococcus viminalis Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladococcus abietinus Haeckel	0	3	18	2	0	0	3	0	0	12	6	0	0
Cladococcus scoparius Haeckel	5	2	7	14	0	8	14	8	8	49	43	61	61
Cladococcus cervicornis Haeckel	0	0	0	0	0	3	31	22	3	238	238	360	256
Arachnosphaera sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Arachnosphaera myriacantha Haeckel	21	12	37	23	0	3	3	3	3	49	55	110	104
Leptosphaera minuta ? Popofsky	0	0	0	0	0	0	0	0	0	0	0	0	0
Leptosphaera sp. group	38	45	72	138	0	0	62	42	31	18	6	0	0

Table 3 (continued)

Sediment Trap Station	E				P_1					PB			
Depth (m)	389	988	3755	5068	378	978	2778	4280	5582	667	1268	2869	3791
Actinosphaera tenella (Haeckel)	0	0	0	0	0	0	0	0	0	0	0	0	0
Actinosphaera acanthophora (Popofsky)	0	0	0	0	0	0	0	0	0	0	0	0	0
Actinosphaera capillacea (Haeckel)	0	0	0	0	0	0	0	0	0	0	0	55	91
Haliomma ? sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0
Haliomma sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0
Haliomma castanea Haeckel	0	0	0	0	0	3	8	3	6	0	24	6	43
Heliosoma spp. aff. *radians* Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Elatomma penicillus Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Haeckeliella macrodoras (Haeckel)	0	0	0	0	0	0	0	0	0	0	0	0	0
Astrosphaera hexagonalis Haeckel	5	5	16	0	0	0	20	14	0	164	152	268	305
Drymosphaera dendrophora Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphaeropyle mespilus ? Dreyer	0	0	0	0	0	0	0	0	0	0	0	0	0
Thecosphaera inermis (Haeckel)	251	58	409	194	0	6	6	59	8	0	18	12	6
Cromyomma villosum Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Xiphosphaera gaea Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Xiphosphaera tesseractis Dreyer	2	0	5	2	0	0	11	14	6	0	0	0	0
Staurolonche sp. A group	79	30	33	33	0	11	8	6	8	36	18	6	37
Staurolonche sp. B	2	16	19	14	0	0	0	3	0	12	0	0	6
Stauracontium sp.	9	0	0	0	0	0	0	0	0	0	12	43	12
Hexastylus triaxonius Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Hexastylus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hexalonche sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0
Hexalonche spp. B	47	42	139	80	6	8	14	8	14	18	61	73	91
Hexalonche amphisiphon Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Centrolonche hexalonche Popofsky	0	3	5	5	0	3	25	8	11	0	0	0	0
Centracontarium hexacontarium Popofsky	21	23	16	12	0	0	0	0	0	0	0	0	0
Hexacontium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hexacontium hostile Cleve	0	0	0	0	0	0	0	0	0	0	0	0	0
Hexacontium arachnoidale Hollande and Enjumet	0	0	0	0	0	0	0	0	0	0	0	0	0
Hexacontium axotrias Haeckel	22	33	71	21	3	67	131	156	112	153	134	134	177
Hexacontium sp. aff. *H. hostile* Cleve	0	0	0	0	0	0	0	0	0	0	0	0	0
Hexacontium heracliti (Haeckel)	0	0	0	0	0	0	0	3	0	6	6	6	6
Hexacontium hystricina (Haeckel)	0	0	0	0	0	0	0	0	0	0	0	0	0
Hexacromyum elegans Haeckel	0	16	5	7	0	0	3	0	0	0	6	0	30
Heterosphaera sp. A	0	0	0	0	8	17	47	22	36	0	37	55	73
Heterosphaera sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3 (continued)

Sediment Trap Station	E				P_1					PB			
Depth (m)	389	988	3755	5068	378	978	2778	4280	5582	667	1268	2869	3791
Cromyechinus sp. aff. *C. borealis* (Cleve)	0	3	0	0	0	0	0	0	0	0	0	0	0
Cromyechinus ? sp.	0	0	0	0	0	3	6	3	0	12	6	0	0
Cromyechinus borealis (Cleve)	0	0	0	0	0	3	0	6	3	0	0	0	0
Stomatosphaera sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0
Stomatosphaera sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0
Stomatosphaera sp. C	0	0	0	0	0	0	0	0	0	0	0	0	0
Stylacontarium bispiculum Popofsky	0	0	0	0	6	14	50	48	64	30	49	67	91
Stylosphaera ? sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0
Stylosphaera melpomene Haeckel	132	64	52	110	0	0	3	0	11	0	12	12	12
Stylosphaera ? sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0
Stylosphaera lithatractus Haeckel	0	7	89	166	0	3	28	6	6	0	61	91	79
Druppatractus ostracion Haeckel group	0	0	0	0	0	0	0	0	0	0	0	0	0
Ellipsoxiphium palliatum Haecker	0	0	0	0	0	0	0	0	6	0	0	0	0
Amphisphaera group	0	0	0	0	3	0	0	6	6	0	0	0	0
Azoprunum staurazonium Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Xiphatractus pluto (Haeckel)	0	2	57	26	0	6	0	0	8	0	0	6	0
Xiphatractus sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0
Xiphatractus spp. B	0	0	0	0	0	0	0	0	0	0	0	0	0
Druppatractus ? sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Dorydruppa bensoni new name	0	0	0	0	0	0	0	8	3	0	12	43	18
Total ACTINOMMINAE	990	510	1875	1434	29	298	798	730	609	1266	1419	1956	1997
Subfamily SATURNALINAE Deflandre													
Saturnalis circularis Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	18
Total SATURNALINAE	0	0	0	0	0	0	0	0	0	0	0	0	18
Total ACTINOMMIDAE	990	526	1643	1401	29	292	815	716	629	1399	1608	2339	2356
Family COCCODISCIDAE Haeckel, emend. Sanfilippo and Riedel													
Subfamily ARTISCINAE Haeckel, emend. Riedel													
Didymocyrtis tetrathalamus tetrathalamus (Haeckel)	125	177	197	176	0	67	201	224	241	54	73	146	104
D. tetrathalamus tetrathalamus (Haeckel) juvenile form	-	-	-	-	6	25	107	44	93	0	6	12	6
Didymocyrtis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Spongoliva ellipsoides Popofsky	15	18	5	0	3	6	8	8	0	0	0	55	12
Total COCCODISCIDAE	140	185	202	176	9	98	316	276	334	54	79	213	122

Table 3 (continued)

Sediment Trap Station	E				P_1					PB			
Depth (m)	389	988	3755	5068	378	978	2778	4280	5582	667	1268	2869	3791
Family PORODISCIDAE Haeckel, emend. Petrushevskaya and Kozlova													
Euchitonia elegans (Ehrenberg)	26	39	68	57	3	22	50	48	45	55	55	189	177
Euchitonia cf. *furcata* Ehrenberg	106	32	128	46	0	0	36	50	48	0	6	0	0
Euchitonia sp.	0	0	0	0	0	8	22	28	45	0	0	0	0
Amphirhopalum ypsilon Haeckel	0	0	7	3	0	0	0	0	0	12	6	18	37
Amphirhopalum straussii (Haeckel)	0	0	0	0	0	0	0	0	3	0	0	0	0
Stylodictya validispina Jørgensen	0	0	0	0	0	0	0	0	0	0	0	0	0
Stylodictya ? sp.	0	0	0	0	3	81	218	293	280	397	433	689	615
Stylodictya multispina Haeckel	0	0	0	0	0	3	3	22	25	0	0	0	18
Circodiscus spp. group	0	0	36	16	0	3	0	0	0	6	24	0	18
Stylochlamydium venustum (Bailey)	0	0	0	0	0	0	0	0	0	0	0	0	0
Stylochlamydium asteriscus Haeckel	121	72	55	91	8	20	109	129	76	153	122	287	219
Porodiscus micromma (Harting)	76	160	257	114	0	0	34	39	64	18	55	103	140
Total PORODISCIDAE	329	303	551	327	14	137	472	609	586	641	701	1286	1224
Family SPONGODISCIDAE Haeckel, emend. Riedel, and Petrushevskaya & Kozlova													
Spongobrachium sp.	0	0	0	0	0	0	0	14	8	0	0	0	0
Dictyocoryne profunda Ehrenberg	81	72	126	102	0	8	31	22	70	6	61	30	79
Dictyocoryne truncatum (Ehrenberg)	0	0	0	0	0	3	3	11	6	24	37	0	30
Spongodiscus sp. A	0	0	0	0	0	0	14	17	0	24	43	30	67
Spongodiscus biconcavus Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Spongodiscus resurgens Ehrenberg	*	*	*	*	0	0	3	0	17	49	67	110	98
Spongodiscus spp. B group	808*	929*	1337*	1498*	11	159	590	554	450	2304	1475	2810	2176
Spongotrochus glacialis Popofsky	*	*	*	*	0	25	45	64	48	104	122	135	152
Spongotrochus sp. A	44	45	73	14	0	0	0	0	20	0	0	0	0
Spongotrochus sp. B	0	0	0	0	0	0	11	6	8	0	0	0	0
Stylospongia huxleyi Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Spongurus cylindricus Haeckel	23	5	22	7	0	0	17	28	34	61	67	42	85
Spongopyle setosa Dreyer	0	0	0	0	0	3	8	6	8	61	67	42	24
Spongopyle osculosa Dreyer	0	0	0	0	0	0	0	0	0	0	0	0	0
Spongaster tetras tetras Ehrenberg	42	46	63	99	0	3	0	8	31	43	24	49	73
Spongaster pentas Riedel and Sanfilippo	0	0	0	0	0	0	6	39	36	0	0	6	30
Total SPONGODISCIDAE	998	1097	1621	1720	11	201	728	769	736	2676	1963	3254	2814

Table 3 (continued)

Sediment Trap Station	E				P_1					PB			
Depth (m)	389	988	3755	5068	378	978	2778	4280	5582	667	1268	2869	3791
Family MYELASTRIDAE Riedel													
Myelastrum quadrifolium Takahashi, n. sp.	0	0	0	0	0	0	0	0	0	0	0	0	6
Myelastrum trinibrachium Takahashi, n. sp.	0	0	0	0	0	0	0	0	0	0	0	24	24
Total MYELASTRIDAE	0	0	0	0	0	0	0	0	0	0	0	24	30
Family LARNACILLIDAE Haeckel													
Larnacalpis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Family PHACODISCIDAE Haeckel													
Heliodiscus ? sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Heliodiscus asteriscus Haeckel	3	2	2	13	6	3	11	6	14	67	24	79	49
Heliodiscus echiniscus Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Total PHACODISCIDAE	3	2	2	13	6	3	11	6	14	67	24	79	49
Family THOLONIIDAE Haeckel, emend. Campbell													
Tholoma metallasson Haeckel	0	0	0	0	0	0	0	0	0	6	67	0	0
Total THOLONIIDAE	0	0	0	0	0	0	0	0	0	6	67	0	0
Family PYLONIIDAE Haeckel													
Hexapyle dodecantha Haeckel	32	6	12	33	0	6	0	6	0	0	12	6	12
Hexapyle sp.	163	85	186	111	0	14	22	25	50	244	79	135	0
Octopyle stenozona Haeckel	53	56	72	37	0	6	31	34	73	323	171	91	134
Tetrapyle octacantha Müller	513	444	947	458	11	204	612	805	780	689	652	1280	1085
Total PYLONIIDAE	761	591	1217	639	11	230	665	870	903	1256	914	1512	1231
Family LITHELIIDAE Haeckel													
Larcopyle butschlii Dreyer	0	0	0	0	0	0	25	14	8	30	0	37	6
Larcopyle sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0
Larcopyle sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0
Discopyle elliptica Haeckel	0	0	0	0	0	3	78	11	3	24	0	24	37
Tholospira cervicornis Haeckel group	191	365	176	371	25	260	1013	1180	1063	1024	1201	1494	1347
Tholospira dendrophora Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Tholospira ? sp.	0	0	0	0	0	11	31	14	14	0	0	54	98
Lithelius minor ? Jørgensen	0	0	0	0	0	0	0	0	0	0	0	0	0
Larcospira quadrangula Haeckel	2	0	9	3	0	0	8	22	25	12	24	12	37
Total LITHELIIDAE	193	365	185	374	25	274	1155	1241	1113	1090	1225	1621	1525
Spumellaria undetermined	-	-	-	-	20	73	98	92	92	377	134	652	543
Total SPUMELLARIA	3688	3355	6155	5094	205	1465	4789	5117	4910	7809	6953	11454	10204

Table 3 (continued)

Sediment Trap Station	E				P_1					PB			
Depth (m)	389	988	3755	5068	378	978	2778	4280	5582	667	1268	2869	3791
Suborder NASSELLARIA Ehrenberg													
Family PLAGIACANTHIDAE Hertwig, emend. Petrushevskaya													
Subfamily PLAGIACANTHINAE Hertwig, emend. Petrushevskaya													
Tetraplecta pinigera Haeckel	0	0	0	0	6	14	48	36	17	91	104	231	226
Tetraplecta plectaniscus Haeckel	0	0	0	0	0	0	3	6	0	12	0	0	12
Tetraplecta corynephorum ? Jørgensen	0	0	0	0	0	0	0	0	0	0	0	0	0
Archiscenium quadrispinum ? Haeckel	17	86	158	152	0	0	0	6	0	37	0	0	6
Plectanium sp.	5	18	0	5	0	0	3	0	6	0	0	0	6
Protoscenium ? sp.	0	0	0	0	0	3	6	0	0	0	0	0	0
Clathromitra pterophormis Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladoscenium ancoratum Haeckel	123	320	267	419	22	162	235	330	243	1122	987	1865	1415
Semantis gracilis ? Popofsky	0	0	0	0	0	0	0	0	0	0	0	0	0
Deflandrella cladophora Jørgensen	0	0	0	0	0	6	20	25	17	0	0	0	0
Deflandrella sp.	75	239	129	83	0	17	25	28	25	0	0	0	0
Pseudocubus obeliscus Haeckel	83	131	167	113	0	20	20	34	45	311	165	213	140
Pseudocubus primordialis ? (Jørgensen)	0	0	0	0	0	0	0	0	0	0	0	0	0
Phormacantha hystrix (Jørgensen)	150	141	330	260	6	73	215	275	280	750	463	1578	701
Neosemantis distephanus Popofsky	39	43	19	98	3	11	34	39	36	79	91	147	110
Total PLAGIACANTHINAE	492	978	1070	1130	37	306	609	779	669	2402	1810	4034	2616
Subfamily LOPHOPHAENINAE Haeckel, emend. Petrushevskaya													
Acanthocorys cf. *variabilis* Popofsky	594	538	982	146	8	23	134	149	143	988	378	615	658
Lophophaena cf. *capito* Ehrenberg	21	17	36	28	3	109	632	495	498	1419	768	1292	743
Lophophaena decacantha (Haeckel) group	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophopaena circumtexta (Popofsky)	5	0	37	11	3	53	112	112	76	226	213	445	378
Lophophaena cylindrica (Cleve)	2445*	1283*	1925*	1570*	11	81	280	280	179	2681	1645	2907	2352
Peromelissa phalacra Haeckel	*	*	*	*	28	207	876	762	714	1097	762	1043	1012
Helotholus histricosa Jørgensen	313	251	238	120	0	0	14	0	14	0	0	115	61
Lithomelissa setosa Jørgensen	0	0	0	0	11	17	168	115	104	1907	926	1908	841
Peridium spinipes Haeckel	1251	2184	3114	2173	45	649	2314	2432	2046	7692	4468	7698	5517
Peridium sp.	6	96	41	47	3	14	39	50	72	0	30	116	73
Trisulcus triacanthus Popofsky	0	0	0	0	3	0	0	0	0	36	42	140	0
Total LOPHOPHAENINAE	4635	4369	6373	4095	115	1158	4569	4395	3846	16046	9232	16279	11635

Table 3 (continued)

Sediment Trap Station	E				P_1					PB			
Depth (m)	389	988	3755	5068	378	978	2778	4280	5582	667	1268	2869	3791
Subfamily SETHOPERINAE Haeckel, emend. Petrushevskaya													
Lithopilium reticulatum Popofsky	0	0	0	0	0	0	0	0	0	0	0	0	0
Clathrocanium insectum (Haeckel)	0	0	0	0	0	0	14	6	25	36	0	92	61
Clathrocanium coarctatum Ehrenberg	0	0	0	0	0	8	42	73	67	0	6	24	0
Clathrocanium diadema Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Callimitra emmae Haeckel	22	27	21	7	0	6	14	11	8	12	6	30	30
Callimitra annae Haeckel	2	3	19	0	0	3	8	0	6	6	0	0	0
Callimitra solocicribrata Takahashi, n. sp.	0	0	0	0	0	0	0	0	3	18	12	0	18
Clathrocorys giltschii Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Clathrocorys murrayi Haeckel	0	0	0	0	0	20	14	20	3	85	43	61	189
Total SETHOPERINAE	24	30	40	7	0	37	92	110	112	157	67	207	298
Total PLAGIACANTHIDAE	5151	5377	7483	5232	152	1501	5270	5284	4627	18605	11109	20520	14549
Family ACANTHODESMIIDAE Haeckel, emend. Riedel													
Zygocircus capulosus Popofsky	248	596	795	285	14	3	444	582	518	635	475	1085	1158
Zygocircus productus (Hertwig) group	453	436	634	431	0	0	260	20	0	146	122	164	207
Zygocircus cf. *piscicaudatus* Popofsky	0	0	0	0	0	0	0	0	0	0	0	0	0
Acanthodesmia vinculata (Müller)	108	91	69	54	6	45	126	115	148	304	274	829	366
Lophospyris juvenile form group	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophospyris pentagona (Ehrenberg) *quadriforis* (Haeckel)	0	0	0	0	6	76	168	232	140	597	439	512	427
Lophospyris pentagona pentagona (Ehrenberg)	20	35	60	72	0	22	48	78	42	183	165	134	195
Lophospyris pentagona (Ehrenberg) *hyperborea* (Jørgensen)	64	44	83	38	0	0	0	0	0	0	0	0	0
Lophospyris cheni Goll	0	0	0	0	0	0	0	0	0	0	0	0	0
Tripodospyris sp.	0	0	0	0	0	22	31	53	11	37	55	85	73
Phormospyris stabilis (Goll) *scaphipes* (Haeckel)	0	0	0	0	3	17	92	50	106	353	286	871	701
Phormospyris sp. aff. *L. pentagona hyperborea* (Jørgensen)	0	0	0	0	0	0	0	6	0	103	43	24	37
Phormospyris stabilis (Goll) *capoi* Goll	0	0	0	0	0	3	3	3	6	55	85	104	91
Phormospyris stabilis stabilis (Goll)	0	0	0	0	0	8	25	14	25	165	122	122	147
Phormospyris ? sp.	0	0	0	0	0	0	0	0	0	12	0	6	0
Dictyospyris sp. group	109	54	36	9	0	0	0	0	0	55	24	18	30
Nephrospyris renilla renilla Haeckel	0	0	0	0	0	0	0	0	0	0	0	12	0
Nephrospyris renilla Haeckel *lana* Goll	0	0	0	0	0	0	0	0	0	0	0	0	0
Androspyris reticulidisca Takahashi, n. sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Androspyris huxleyi (Haeckel)	0	0	0	0	0	0	0	0	0	12	12	30	0
Androspyris ramosa (Haeckel)	0	13	0	11	0	3	6	8	6	0	0	0	0
Cephalospyris cancellata Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3 (continued)

Sediment Trap Station	E				P_1					PB			
Depth (m)	389	988	3755	5068	378	978	2778	4280	5582	667	1268	2869	3791
Cantharospyris platybursa Haeckel	28	83	16	14	0	0	44	14	14	30	12	30	43
Cantharospyris cf. *clathrobursa* (Haeckel)	0	0	0	0	0	8	0	0	3	18	0	12	12
Tholospyris sp. group	0	0	0	0	0	95	260	342	235	195	201	366	421
Tholospyris baconiana baconiana (Haeckel)	0	0	0	0	0	0	0	0	0	0	0	0	0
Tholospyris baconiana variabilis Goll	0	0	0	0	0	0	3	14	0	49	6	30	43
Tholospyris macropora (Popofsky)	0	0	0	0	0	0	8	6	0	12	6	24	18
Liriospyris sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Liriospyris thorax (Haeckel) *laticapsa* Takahashi, n. subsp.	0	0	0	0	0	11	34	45	39	55	43	30	73
Liriospyris thorax thorax (Haeckel)	0	0	0	0	0	0	0	0	0	12	0	0	0
Liriospyris reticulata (Ehrenberg)	128	175	56	56	6	31	154	126	95	42	146	311	281
Total ACANTHODESMIIDAE	1158	1527	1749	970	35	344	1706	1708	1388	3070	2516	4799	4232
Family SETHOPHORMIDIDAE Haeckel, emend. Petrushevskaya													
Tetraphormis rotula (Haeckel)	0	6	98	57	0	28	53	78	48	103	37	61	122
Tetraphormis dodecaster (Haeckel)	0	0	0	0	3	17	25	45	28	183	219	304	165
Tetraphormis butschlii (Haeckel)	0	0	0	0	0	0	0	0	0	30	49	116	122
Theophormis callipilium Haeckel	0	0	0	0	0	3	17	20	14	0	30	24	37
Lampromitra schultzei (Haeckel)	0	0	0	18	0	0	0	0	0	12	0	0	0
Lampromitra cracenta Takahashi, n. sp.	0	0	0	0	0	11	22	36	17	30	18	67	43
Lampromitra cachoni Petrushevskaya	0	0	0	0	0	0	0	0	0	0	0	0	0
Lampromitra spinosiretis Takahashi, n. sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucecryphalus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucecryphalus gegenbauri Haeckel	46	30	50	43	0	25	67	48	31	183	122	146	49
Eucecryphalus europae (Haeckel)	0	0	0	0	0	0	3	11	0	0	0	24	49
Eucecryphalus clinatus Takahashi, n. sp.	0	0	0	0	0	3	0	11	0	182	146	189	274
Eucecryphalus tricostatus (Haeckel)*	28*	34*	49*	20*	6*	31*	70*	87*	70*	275*	158*	579*	616*
Eucecryphalus sestrodiscus (Haeckel)*	*	*	*	*	*	*	*	*	*	*	*	*	*
Corocalyptra cervus (Ehrenberg)	0	0	0	0	*	*	*	*	*	*	*	*	*
Phrenocodon clathrostomium Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Clathrocyclas sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Clathrocyclas monumentum (Haeckel)	0	0	0	0	0	0	0	11	11	0	0	0	0
Clathrocyclas cassiopejae Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Total SETHOPHORMIDIDAE	74	70	197	138	9	118	257	347	219	998	779	1510	1477

Table 3 (continued)

Sediment Trap Station	E				P_1					PB			
Depth (m)	389	988	3755	5068	378	978	2778	4280	5582	667	1268	2869	3791
Family THEOPERIDAE Haeckel, emend. Riedel													
Subfamily PLECTOPYRAMIDINAE Haecker, emend. Petrushevskaya													
Cornutella profunda Ehrenberg	64	141	367	160	6	73	294	316	359	537	287	543	464
Peripyramis circumtexta Haeckel	0	16	40	39	0	0	0	3	3	0	0	24	0
Litharachnium tentorium Haeckel and *L. eupilium* (Haeckel)	0	2*	5*	14*	0	6	8	8	6	0	0	24	91
L. tentorium Haeckel and *L. eupilium* (Haeckel) juvenile form	*	*	*	*	0	8	25	22	47	146	146	269	263
Total PLECTOPYRAMIDINAE	64	159	412	213	6	87	7	349	415	683	433	860	818
Subfamily EUCYRTIDIINAE Ehrenberg, emend. Petrushevskaya													
Archipilium sp. aff. *A. orthopterum* Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Archipilium macropus ? (Haeckel)	0	0	0	0	0	0	0	0	0	0	0	0	0
Pteroscenium pinnatum Haeckel	0	0	0	0	0	17	14	8	8	36	73	55	61
Pterocanium trilobum (Haeckel)	0	0	0	0	0	0	0	0	0	0	0	0	0
Pterocanium grandiporus Nigrini	0	0	0	0	0	6	31	22	14	55	67	54	55
Pterocanium praetextum praetextum (Ehrenberg)	207	158	102	88	3	0	25	145	143	30	49	152	91
Pterocanium praetextum (Ehrenberg) *eucolpum* Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Dictyophimus sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0
Dictyophimus crisiae Ehrenberg	0	2	48	49	0	6	109	118	84	342	165	183	268
Dictyophimus infabricatus Nigrini	0	0	0	0	0	0	0	0	0	0	0	0	0
Dictyophimus macropterus (Ehrenberg)	0	0	0	0	0	8	17	3	3	12	73	67	18
Dictyophimus sp. B	0	0	0	0	3	42	89	90	53	183	207	445	714
Pseudodictyophimus gracilipes (Bailey)	14	163	361	260	3	31	165	143	140	86	238	590	396
Dictyocodon elegans (Haeckel)	0	0	0	0	0	0	0	0	3	0	0	0	0
Dictyocodon palladius Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Conicavus tipiopsis Takahashi, n. sp.	0	0	0	0	0	0	0	0	0	0	0	12	0
Sethoconus myxobrachia Strelkov and Reshetnyak	0	0	0	0	0	0	0	0	0	0	0	0	0
Conarachnium polyacanthum (Popofsky)	0	0	0	0	0	3	6	0	8	18	6	24	12
Conarachnium parabolicum (Popofsky)	0	0	0	0	0	0	3	0	0	12	18	0	49
Conarachnium facetum (Haeckel)	0	0	0	0	0	0	0	0	0	0	0	0	0
Stichopilium bicorne Haeckel	0	0	0	0	0	11	20	14	8	214	85	98	110
Lithopera bacca Ehrenberg	14	15	27	37	0	6	28	6	0	0	0	0	0
Cyrtopera languncula Haeckel	0	15	46	31	0	0	14	8	17	0	12	61	43
Cyrtopera aglaolampa Takahashi, n. sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Stichophormis cf. *cornutella* Haeckel	0	54	7	2	0	0	8	0	3	0	0	24	6
Lophocorys undulata (Popofsky)	0	0	0	0	0	0	0	0	6	0	0	0	24
Theocorys veneris Haeckel	9	24	215	53	0	39	76	98	81	329	171	268	305
Theocorythium trachelium trachelium (Ehrenberg)	0	0	0	0	0	6	0	14	20	0	0	0	0

Table 3 (continued)

Sediment Trap Station	E				P_1					PB			
Depth (m)	389	988	3755	5068	378	978	2778	4280	5582	667	1268	2869	3791
Lipmanella dictyoceras (Haeckel)	0	0	0	0	0	0	0	0	0	0	0	0	0
Lipmanella pyramidale (Popofsky)	40*	69*	36*	19*	0	0	0	0	0	0	0	0	0
Lipmanella virchowii (Haeckel)	*	*	*	*	0	11	25	39	20	67	79	67	104
Lithostrobus hexagonalis Haeckel	0	0	0	0	0	0	25	3	3	36	30	24	43
Theocalyptra bicornis (Popofsky)	83	122	197	75	6	22	34	64	36	366	207	147	238
Theocalyptra davisiana davisiana (Ehrenberg)	0	0	0	0	0	0	0	6	17	0	0	0	0
Theocalyptra davisiana cornutoides (Petrushevskaya)	82	354	784	207	3	20	67	42	56	98	55	365	250
Total EUCYRTIDIINAE	449	976	1823	821	18	276	756	823	723	1884	1535	2636	2787
Total THEOPERIDAE	513	1135	2235	1034	24	363	1083	1172	1138	2567	1968	3496	3605
Family PTEROCORYTHIDAE Haeckel, emend. Riedel													
Tetracorethra tetracorethra (Haeckel)	0	0	0	0	3	22	481	25	36	12	18	12	18
Pterocorys zancleus (Müller)	2966*	2381*	2698*	1654*	14	243	854	663	563	195	238	165	152
Pterocorys campanula Haeckel	*	*	*	*	15	92	199	274	279	147	61	250	122
Pterocorys sp.	0	0	0	0	0	0	25	8	11	73	49	12	12
Eucyrtidium spp. A group	0	0	0	0	3	6	86	95	65	196	61	37	153
Eucyrtidium acuminatum (Ehrenberg)	0	0	0	0	0	3	11	11	11	55	43	67	73
Eucyrtidium hexagonatum Haeckel	0	0	0	0	0	0	31	17	11	97	104	97	98
Eucyrtidium anomalum Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucyrtidium sp. aff. *E. anomalum* (Haeckel)	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucyrtidium dictyopodium (Haeckel)	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucyrtidium hexastichum (Haeckel)	120	45	133	40	0	36	78	100	56	153	183	128	201
Anthocyrtidium zanguebaricum (Ehrenberg)	0	0	0	0	3	20	36	20	25	55	0	67	79
Anthocyrtidium ophirense (Ehrenberg)	9	37	122	79	0	8	67	36	42	146	61	67	37
Lamprocyclas maritalis Haeckel *polypora* Nigrini	0	0	0	0	0	0	0	0	3	0	0	0	0
Lamprocyclas maritalis maritalis Haeckel	0	0	0	0	0	0	11	0	6	0	0	0	0
Lamprocyclas ? hannai (Campbell and Clark)	0	0	0	0	0	0	0	0	0	0	18	6	6
Lamprocyrtis sp.	0	0	0	0	0	0	8	14	14	43	30	122	140
Lamprocyrtis nigriniae (Caulet)	0	0	0	0	0	0	0	0	0	0	6	30	0
Total PTEROCORYTHIDAE	3095	2463	2953	1773	38	430	1454	1263	1122	1172	872	1060	1091
Family ARTOSTROBIIDAE Riedel, emend. Foreman													
Spirocyrtis scalaris Haeckel	91	79	67	101	0	8	36	36	28	280	238	299	341
Spirocyrtis subscalaris Nigrini	0	0	0	0	14	64	280	361	202	1566	1048	1920	1482
Spirocyrtis sp. aff. *S. seriata* Jørgensen and *S. subscalaris* Nigrini	1496	629	653	660	0	0	0	0	0	0	0	0	0
Spirocyrtis ? platycephala (Ehrenberg) group	0	0	0	0	0	17	25	33	59	0	0	0	0
Artostrobus annulatus (Bailey)	0	0	0	0	3	22	25	30	73	67	67	451	488

Table 3 (continued)

Sediment Trap Station	E				P_1					PB			
Depth (m)	389	988	3755	5068	378	978	2778	4280	5582	667	1268	2869	3791
Botryostrobus aquilonaris (Bailey)	0	0	0	0	0	3	0	3	6	30	30	12	30
Phormostichoartus corbula (Harting)	0	30	17	17	0	39	51	92	44	146	98	147	208
Siphocampe nodosaria (Haeckel)	0	3	135	26	0	0	0	0	0	0	0	0	0
Siphocampe lineata (Ehrenberg)	0	0	0	0	0	81	185	425	196	878	543	464	658
Siphocampe arachnea (Ehrenberg)	0	0	0	0	0	0	0	0	0	0	0	0	0
Artobotrys borealis (Cleve)	0	0	0	0	8	0	56	22	64	842	329	786	244
Total ARTOSTROBIIDAE	1587	741	872	804	25	234	658	1002	672	3809	2353	4079	3451
Family CARPOCANIIDAE Haeckel, emend. Riedel													
Carpocanistrum sp.	9	69	72	7	0	31	129	121	196	97	49	103	43
Carpocanarium papillosum (Ehrenberg)	0	7	2	56	0	0	3	3	3	30	30	115	67
Total CARPOCANIIDAE	9	76	74	63	0	31	132	124	199	127	79	218	110
Family CANNOBOTRYIDAE Haeckel, emend. Riedel													
Acrobotrys teralans Renz	0	0	0	0	0	0	0	0	0	85	73	232	225
Acrobotrys tessarolobon Takahashi, n. sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Acrobotrys chelinobotrys Takahashi, n. sp.	0	0	0	0	3	31	131	126	47	353	299	524	390
Acrobotrys spp. A, B and C	123	76	126	68	-	-	-	-	-	-	-	-	-
Acrobotrys sp. C	-	-	-	-	3	3	25	14	11	6	18	6	18
Saccospyris preantarctica Petrushevskaya	0	0	0	0	0	0	0	0	0	0	0	0	0
Centrobotrys thermophila Petrushevskaya	0	0	0	0	6	3	34	39	31	0	0	0	0
Neobotrys quadrituberosa Popofsky	0	0	0	0	0	3	3	8	0	0	0	6	49
Botryocyrtis sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0
Botryocyrtis scutum (Harting)	226	167	212	111	6	78	129	215	238	353	256	365	402
Botryocyrtis elongatum Takahashi, n. sp.	0	0	0	0	14	28	20	42	56	238	177	219	73
Total CANNOBOTRYIDAE	349	243	338	179	32	146	322	444	383	1035	823	1352	1157
Family ARCHIPHORMIDIDAE Haeckel													
Arachnocalpis ? sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0
Arachnocalpis sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0
Arachnocalpis ? *ovatiretalis* Takahashi, n. sp.	0	0	0	0	0	6	0	3	3	0	6	0	37
Arachnocalpis ? sp. C	0	0	0	0	0	0	0	0	0	0	0	0	0
Arachnocalpis ellipsoides Haeckel	0	0	0	0	0	0	3	3	0	0	0	0	0
Total ARCHIPHORMIDIDAE	0	0	0	0	0	6	3	6	3	0	6	0	37
Nassellaria undetermined	-	-	-	-	28	143	300	185	212	555	287	1268	835
Total NASSELLARIA	11936	11637	15901	10192	343	3316	11175	11535	9963	31938	20792	38302	30635

Table 3 (continued)

Sediment Trap Station	E				P_1					PB				
Depth (m)	389	988	3755	5068	378	978	2778	4280	5582	667	1268	2869	3769	3791
Suborder PHAEODARIA Haeckel														
Family CHALLENGERIIDAE Murray, emend. herein														
Challengeron willemoesii Haeckel	128	110	62	36	6	3	0	0	0	122	30	18	24	6
Challengeron lingi Takahashi, n. sp.	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Challengeron radians Borgert	6	0	6	5	0	0	0	0	0	0	0	0	0	0
Challengeron tizardi (Murray)	0	0	0	0	0	0	0	0	0	0	6	6	0	0
Challengerosium balfouri (Murray)	6	2	0	0	0	0	0	0	0	0	0	0	0	0
Challengerosium avicularia Haecker	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Challengeranium diodon (Haeckel)	14	3	19	20	0	0	0	3	0	98	55	12	12	24
Protocystis sp. A	0	0	0	0	0	0	0	0	0	0	0	12	0	24
Protocystis harstoni (Murray)	2	11	0	3	0	0	0	0	0	0	0	0	0	0
Protocystis honjoi Takahashi, n. sp.	0	0	12	0	0	0	0	0	0	12	18	30	0	12
Protocystis tridentata Borgert	0	0	0	0	0	0	0	0	0	0	6	6	0	0
Protocystis auriculata Takahashi, n. sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protocystis aduncicuspis Takahashi, n. sp.	0	0	0	0	0	0	0	0	0	6	0	18	24	43
Protocystis sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protocystis sloggetti (Haeckel)	0	0	0	0	0	0	0	0	0	0	12	0	0	6
Protocystis murrayi (Haeckel)	0	0	0	0	0	0	0	0	0	0	0	6	0	0
Protocystis sp. C	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protocystis thomsoni (Murray)	0	7	2	2	0	0	0	0	0	0	0	0	0	0
Protocystis xiphodon (Haeckel)	135	64	36	40	0	0	0	3	0	43	24	0	0	0
Protocystis tritonis (Haeckel)	0	2	0	3	0	0	0	0	0	0	0	0	0	0
Protocystis naresi (Murray)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pharyngella gastrula Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Entocannula infundibulum Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total CHALLENGERIIDAE	291	199	137	109	6	3	6	6	0	281	151	108	60	115
Family MEDUSETTIDAE Haeckel, emend. herein														
Euphysetta elegans Borgert	8	86	96	93	0	0	6	0	0	0	49	116	73	85
Euphysetta staurocodon Haeckel	0	0	0	0	0	0	6	3	0	0	49	177	61	140
Euphysetta pusilla Cleve	407	229	188	21	0	0	0	0	0	0	0	0	0	0
Euphysetta lucani Borgert	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Medusetta ansata Borgert	73	15	59	53	3	20	3	3	0	6	24	24	49	0
Medusetta inflata Borgert	0	0	0	0	0	0	0	0	0	0	0	6	0	18
Medusetta sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total MEDUSETTIDAE	488	330	345	147	3	20	15	6	0	6	122	323	183	243

Table 3 (continued)

Sediment Trap Station	E				P_1					PB				
Depth (m)	389	988	3755	5068	378	978	2778	4280	5582	667	1268	2869	3769	3791
Family LIRELLIDAE Ehrenberg														
Borgertella caudata (Wallich)	252	62	149	180	3	62	190	120	47	811	524	994	549	658
Lirella baileyi Ehrenberg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lirella bullata (Stadum and Ling)	2	384	603	705	6	17	190	142	118	847	335	847	817	1024
Lirella melo (Cleve) and *L. tortuosa* Takahashi, n. sp.	0	7	380	199	0	0	25	59	22	427	85	286	158	165
Total LIRELLIDAE	254	453	1132	1084	9	79	405	321	187	2085	944	2127	1524	1847
Family POROSPATHIDIDAE Borgert, emend. Campbell														
Porospathis holostoma (Cleve)	0	0	8	0	0	0	3	3	0	0	18	12	49	18
Total POROSPATHIDIDAE	0	0	8	0	0	0	3	3	0	0	18	12	49	18
Family CASTANELLIDAE Haeckel														
Castanidium longispinum Haecker	-	-	-	-	0	0	0	0	0	122	98	244	98	128
Castanidium abundiplanatum Takahashi, n. sp.	-	-	-	-	0	0	0	0	0	12	0	37	12	12
Castanella spp.	-	-	-	-	0	3	0	0	0	0	0	0	0	0
Castanidium spp.	-	-	-	-	0	0	0	0	0	12	18	0	37	24
Castanarium spp.	-	-	-	-	0	0	0	0	0	12	12	37	24	18
Castanissa spp.	-	-	-	-	0	0	0	0	0	24	6	0	0	6
Castanellids group	7	3	0	2	-	-	-	-	-	-	-	-	-	-
Total CASTANELLIDAE	7	3	0	2	0	3	0	0	0	182	134	318	171	188
Family CIRCOPORIDAE Haeckel														
Haeckeliana porcellana Murray	0	2	0	2	0	3	0	0	0	0	0	0	0	0
Circoporus sexfuscinus Haeckel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Circoporus oxyacanthus Borgert	5	0	2	3	0	0	0	0	0	0	12	24	12	0
Circogonia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total CIRCOPORIDAE	5	2	2	5	0	3	0	0	0	0	12	24	12	0
Family CONCHARIIDAE Haeckel														
Conchellium capsula Borgert†	27	0	10	2	0	0	0	0	3	0	0	0	0	0
Conchellium tridacna Haeckel†	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Conchophacus diatomeus (Haeckel)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conchidium argiope Haeckel†	0	0	0	0	3	6	6	6	0	92	128	128	85	79
Conchidium caudatum (Haeckel)†	103	2	25	30	0	0	0	0	0	0	0	0	0	0
Conchopsis compressa Haeckel†	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Total CONCHARIIDAE	130	6	35	32	3	6	6	6	3	92	128	128	85	79

Table 3 (continued)

Sediment Trap Station	E				P_1					PB				
Depth (m)	389	988	3755	5068	378	978	2778	4280	5582	667	1268	2869	3769	3791
Family AULOSPHAERIDAE Haeckel														
Aulosphaerids group**	2	0	3	2	0	3	8	6	6	85	37	108	98	61
Total AULOSPHAERIDAE	2	0	3	2	0	3	8	6	6	85	37	108	98	61
Family AULACANTHIDAE Haeckel														
Aulographis stellata Haeckel, and *A. tetrancistra* Haeckel‡	-	-	-	-	0	0	0	6	0	0	12	30	49	24
Auloceros spathillaster Haeckel‡	-	-	-	-	0	0	0	0	0	0	0	0	0	0
Auloceros arborescens Haeckel *birameus* (Immermann)‡	-	-	-	-	0	0	0	3	0	280	73	177	122	116
Aulographonium bicorne Haecker‡	-	-	-	-	0	0	3	20	3	12	0	30	24	6
Aulospathis taumorpha ? Haeckel‡	-	-	-	-	0	3	6	6	12	24	0	6	49	49
Aulospathis variabilis Haeckel *bifurca* Haecker‡	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total AULACANTHIDAE	0	0	0	0	0	3	9	35	15	316	85	237	244	195
Total PHAEODARIA	1177	993	1662	1381	21	120	452	383	208	3047	1632	3385	2426	2746
Total RADIOLARIA	16801	15985	23718	16667	569	4901	16416	17035	15081	42794	29376	53141	-	43585

* These two or three taxa were counted together.
* Incomplete fragments were counted.
** Spicule swarms were counted.
† Each value was counted as one half (0.5) shell.
‡ Each tubule was counted.

Table 4: The size fractioned radiolarian flux (number of shells/m^2/day) in each family from the sediment trap Stations P_1 and PB. The proportion of counted specimens (%) with respect to the radiolarian flux is given in the bottom row of each station.

	Station/Depth (m)	P_1/378			P_1/978			P_1/2778			P_1/4280			P_1/5582		
	Size Fraction (μm)	1000–250	250–63	<63	1000–250	250–63	<63	1000–250	250–63	<63	1000–250	250–63	<63	1000–250	250–63	<63
Suborder	SPUMELLARIA															
Family	COLLOSPHAERIDAE	0	36	42	0	120	31	8	369	145	0	386	101	3	411	90
	SPHAEROZOIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ETHMOSPHAERIDAE	0	0	0	0	0	0	3	19	0	28	17	0	14	14	0
	ACTINOMMIDAE															
	ACTINOMMINAE	0	28	0	25	266	6	137	616	45	104	571	67	62	545	0
	SATURNALINAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	COCCODISCIDAE	3	6	0	6	90	3	8	263	45	14	241	22	8	280	45
	PORODISCIDAE	3	11	0	6	98	34	34	327	112	42	422	145	39	422	123
	SPONGODISCIDAE	3	8	0	6	123	73	11	302	414	48	400	325	28	529	179
	MYELASTRIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	LARNACILLIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PHACODISCIDAE	6	0	0	0	3	0	0	11	0	0	6	0	3	11	0
	THOLONIIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PYLONIIDAE	3	3	6	3	179	48	28	437	201	67	601	201	31	582	291
	LITHELIIDAE	3	14	8	6	238	31	39	935	179	62	1035	145	39	878	201
	SPUMELLARIA undet.	0	11	8	11	25	36	20	45	34	17	53	22	6	42	45
Total	SPUMELLARIA	21	117	64	63	1142	262	288	3324	1175	382	3718	1028	233	3714	974
Suborder	NASSELLARIA															
Family	PLAGIACANTHIDAE															
	PLAGIACANTHINAE	6	28	3	17	271	17	64	532	11	39	660	78	25	568	78
	LOPHOPHAENINAE	34	42	39	20	616	523	157	1838	2574	249	2051	2093	118	1914	1813
	SETHOPERINAE	0	0	0	6	31	0	11	81	0	8	101	0	0	101	111
Family	ACANTHODESMIIDAE	6	17	11	14	271	59	48	1021	638	84	985	638	39	946	403
	SETHOPHORMIDIDAE	3	6	0	11	106	0	31	227	0	67	280	0	39	179	0
	THEOPERIDAE															
	PLECTOPYRAMIDINAE	0	0	6	3	28	56	0	92	235	11	104	235	17	118	280
	EUCYRTIDIINAE	3	8	6	3	196	76	28	582	145	42	657	123	6	616	101
	PTEROCORYTHIDAE	8	22	8	8	392	34	31	1223	201	45	1097	123	25	1007	90
	ARTOSTROBIIDAE	0	6	20	0	56	179	0	187	470	20	213	772	6	218	448
	CARPOCANIIDAE	0	0	0	0	8	22	0	42	90	3	31	90	0	87	112
	CANNOBOTRYIDAE	14	6	11	3	64	78	3	126	190	20	168	257	3	168	213
	ARCHIPHORMIDIDAE	0	0	0	3	3	0	3	0	0	6	0	0	3	0	0
	NASSELLARIA undet.	3	11	14	0	64	78	11	64	224	17	56	112	14	64	134
Total	NASSELLARIA	77	146	118	88	2106	1122	387	6015	4778	611	6403	4521	295	5986	3683
Suborder	PHAEODARIA															
Family	CHALLENGERIIDAE	0	6	0	3	0	0	0	6	0	0	6	0	0	0	0
	MEDUSETTIDAE	0	3	0	0	20	0	0	14	0	0	6	0	0	0	0
	LIRELLIDAE	0	3	6	0	14	64	8	84	313	6	70	246	8	34	145
	POROSPATHIDIDAE	0	0	0	0	0	0	0	3	0	0	3	0	0	0	0
	CASTANELLIDAE	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
	CIRCOPORIDAE	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
	CONCHARIIDAE	0	3	0	3	3	0	0	6	0	0	6	0	0	3	0
	AULOSPHAERIDAE	0	0	0	3	0	0	8	0	0	3	3	0	6	0	0
	AULACANTHIDAE	0	0	0	0	3	0	3	6	0	28	6	0	6	8	0
Total	PHAEODARIA	0	15	6	12	40	64	19	122	313	37	100	246	20	45	145
Total	RADIOLARIA	92	278	188	163	3260	1448	694	9461	6266	1030	10221	5795	548	9745	4802
	% Counted Specimens	36	36	36	36	36	36	36	36	9	36	36	9	36	36	9

Table 4 (continued)

Station/Depth (m)		PB/667				PB/1268				PB/2869				PB/3791			
Size Fraction (μm)		1000–250	250–125	125–63	<63	1000–250	250–125	125–63	<63	1000–250	250–125	125–63	<63	1000–250	250–125	125–63	<63
Suborder	SPUMELLARIA																
Family	COLLOSPHAERIDAE	49	104	91	0	6	140	73	0	98	213	152	0	30	140	152	0
	SPHAEROZOIDAE	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ETHMOSPHAERIDAE	85	30	18	0	146	61	0	0	329	18	49	0	213	85	49	0
	ACTINOMMIDAE																
	ACTINOMMINAE	780	335	152	0	603	634	171	12	1146	597	213	0	896	786	317	0
	SATURNALINAE	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0
	COCCODISCIDAE	24	30	0	0	37	43	0	0	98	85	30	0	18	79	24	0
	PORODISCIDAE	122	201	122	195	91	384	189	37	512	396	280	98	140	396	542	146
	SPONGODISCIDAE	475	457	622	1122	219	738	664	341	573	536	1073	1073	183	561	1341	731
	MYELASTRIDAE	0	0	0	0	0	0	0	0	24	0	0	0	30	0	0	0
	LARNACILLIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PHACODISCIDAE	49	18	0	0	6	18	0	0	73	6	0	0	24	24	0	0
	THOLONIIDAE	0	0	6	0	12	49	6	0	0	0	0	0	0	0	0	0
	PYLONIIDAE	293	323	347	213	110	496	250	61	427	341	304	439	67	488	481	195
	LITHELIIDAE	366	500	226	0	146	853	226	0	646	604	323	49	201	749	573	0
	SPUMELLARIA undet.	146	30	55	146	24	43	6	61	158	85	18	390	67	67	165	244
Total	SPUMELLARIA	2401	2028	1639	1756	1400	3457	1585	512	4084	2881	2442	2049	1869	3393	3644	1316
Suborder	NASSELLARIA																
Family	PLAGIACANTHIDAE																
	PLAGIACANTHINAE	719	512	829	341	268	518	1000	24	1658	707	987	683	244	1042	1036	293
	LOPHOPHAENINAE	1914	1975	4846	7314	555	2469	4322	1890	2426	2359	5108	6388	421	1554	5906	3755
	SETHOPERINAE	61	79	18	0	6	55	6	0	49	49	61	49	18	91	189	0
	ACANTHODESMIIDAE	622	920	798	731	311	1091	969	146	1061	1128	1737	878	280	1073	1896	1073
	SETHOPHORMIDIDAE	207	457	189	146	165	408	207	0	549	652	311	0	329	670	475	0
	THEOPERIDAE																
	PLECTOPYRAMIDINAE	73	85	183	341	43	134	134	122	219	158	286	195	79	128	414	195
	EUCYRTIDIINAE	451	567	475	390	134	762	603	37	646	786	1012	195	262	750	1627	146
	PTEROCORYTHIDAE	195	390	445	146	91	433	347	0	256	366	439	0	91	238	664	98
	ARTOSTROBIIDAE	341	518	1048	1902	67	750	939	597	512	549	1164	1853	98	317	1621	1414
	CARPOCANIIDAE	24	49	55	0	6	18	43	12	37	177	0	0	0	0	110	0
	CANNOBOTRYIDAE	134	122	390	390	30	219	439	134	171	165	524	488	18	55	646	439
	ARCHIPHORMIDIDAE	0	0	0	0	0	6	0	0	0	0	0	0	0	18	18	0
	NASSELLARIA undet.	110	49	55	341	43	55	67	122	256	165	213	634	67	116	262	390
Total	NASSELLARIA	4851	5723	9331	12042	1719	6918	9076	30845	7840	7261	11842	11363	1907	5052	14864	7803

Station/Depth (m)		PB/667				PB/1268				PB/2869				PB/3769				PB/3791			
Size Fraction (μm)		1000–250	250–125	125–63	<63	1000–250	250–125	125–63	<63	1000–250	250–125	125–63	<63	1000–250	250–125	125–63	<63	1000–250	250–125	125–63	<63
Suborder	PHAEODARIA																				
Family	CHALLENGERIIDAE	85	110	37	49	12	79	49	12	37	49	24	0	0	37	24	0	12	67	37	0
	MEDUSETTIDAE	0	0	6	0	6	61	55	0	49	55	219	0	0	49	85	49	18	61	165	0
	LIRELLIDAE	73	49	207	1755	61	201	219	463	85	201	573	1268	24	24	256	1219	37	30	561	1219
	POROSPATHIDIDAE	0	0	0	0	0	18	0	0	0	12	0	0	0	0	49	0	6	6	6	0
	CASTANELLIDAE	183	0	0	0	134	0	0	0	305	12	0	0	158	12	0	0	183	0	6	0
	CIRCOPORIDAE	0	0	0	0	12	0	0	0	24	0	0	0	12	0	0	0	0	0	0	0
	CONCHARIIDAE	49	43	0	0	30	98	0	0	12	104	12	0	0	85	0	0	12	61	6	0
	AULOSPHAERIDAE	73	12	0	0	37	0	0	0	110	0	0	0	49	37	12	0	24	37	0	0
	AULACANTHIDAE	122	30	67	98	18	24	30	12	85	30	128	0	85	134	24	0	85	55	55	0
Total	PHAEODARIA	585	244	317	1902	310	481	353	487	707	463	956	1268	328	378	450	1268	377	317	836	1219
Total	RADIOLARIA	7837	7995	11287	15700	3429	10856	11014	4083	12631	10605	15240	14680	-	-	-	-	4153	8762	19344	10338
% Counted Specimens		8	16	16	2	16	16	16	8	8	16	16	2	8	8	8	2	16	16	16	2

Table 5: Summary of radiolarian (suborders) flux (number of shells/m^2/day) and ratios between suborders at the three sediment trap stations.

Station:	Depth (m)	Flux (no. shells/m^2/day) Spumellaria	(%[a])	Nassellaria	(%[a])	Phaeodaria	(%[a])	Total Radiolaria	N/S[b]	Ratio Ph/S[c]	Ph/P[d]
E:	389	3688	21	11936	72	1177	7	16801	3.2	0.32	0.075
	988	3355	21	11637	73	993	6	15985	3.5	0.30	0.066
	3755	6155	26	15901	67	1662	7	23718	2.6	0.27	0.075
	5068	5049	31	10192	61	1381	8	16667	2.0	0.27	0.091
P_1:	378	205	36	343	60	21	4	569	1.7	0.10	0.038
	978	1465	30	3316	68	120	2	4901	2.3	0.082	0.025
	2778	4789	29	11175	68	452	3	16416	2.3	0.094	0.028
	4280	5117	30	11535	68	383	2	17035	2.3	0.074	0.023
	5582	4910	33	9963	66	208	1	15081	2.0	0.042	0.014
PB:	667	7809	18	31938	75	3047	7	42794	4.1	0.39	0.077
	1268	6953	24	20792	71	1632	6	29376	3.0	0.23	0.059
	2869	11454	22	38302	72	3385	6	53141	3.3	0.30	0.068
	3769	-	-	-	-	2426	-	-	-	-	-
	3791	10204	23	30635	70	2746	6	43585	3.0	0.27	0.067

[a]% = (suborder flux/total radiolarian flux) x 100.
[b]N/S ratio = nassellarian flux/spumellarian flux
[c]Ph/S ratio = phaeodarian flux/spumellarian flux
[d]Ph/P = phaeodarian flux/polycystine flux

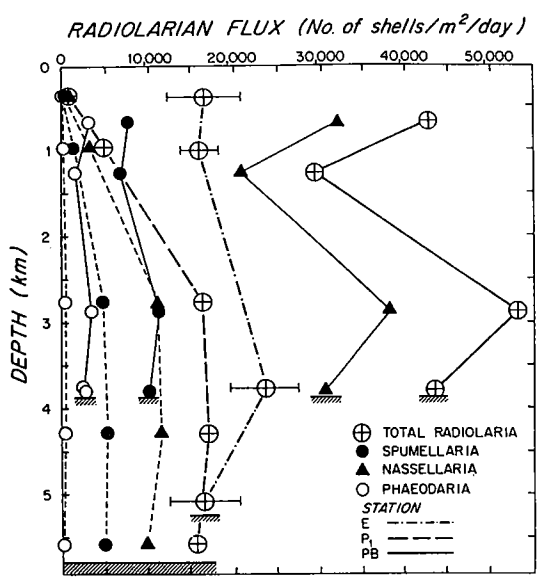

Figure 2: Vertical fluxes (number of shells/m^2/day) of Radiolaria and their suborders from Stations E, P_1 and PB. Horizontal bars on Station E data represent standard deviations at 95% confidence level for all data. Most data for Station E are presented in Figure 3 for better clarity.

3.2 Vertical Flux of Radiolaria and Suborders at Three Tropical Stations

Fluxes of the three suborders as well as total Radiolaria are more or less uniform throughout the trap depths at the three stations (Table 5, Figures 3 and 4), although there are minor fluctuations with depth. The fluxes at 3,755 m from Station E were greater than at other depths. This flux maximum at 3,755 m is also true for biogenic opal (Honjo, 1980) and planktonic foraminifera (Thunell and Honjo, 1981) from the same trap samples reflecting general larger material flux than other depths. The fluxes at 378 and 978 m from Station P_1 are anomalously less than those at deeper depths. This is probably due to exportation of the trapped samples by macro- and megaplankton such as euphausiids (Honjo, 1980). The fluxes from Station PB appear to fluctuate with depth. Biogenic opal flux from the same samples shows a trend similar to this (Honjo et al., 1982), and may be due to horizontal transport of particles.

Radiolarian shell flux as a whole showed no decreasing trend through the water column at any of the three stations (Tables 3, 4 and 5; Figures 2 and 3). Diversity index analysis of the samples from Station E indicated no significant change in polycystine assemblages below 1 km depth, suggesting little gain or loss during their descent (Figure 4). A significant increase in nassellarian diversity index from 389 m to 988 m was mainly due to input of deep dwelling forms and, partially, to more extensive *in situ* dissolution in the receiving cup at 389 m. The decrease in the spumellarian diversity index from the 389 m to 988 m sample is not readily explained: a possibility is the removal of relatively soluble forms in the 988 m trap sample. Phaeodarian diversity tends to fluctuate with depth, reflecting substantial change in assemblages due to dissolution and input of deep dwelling forms (Table 3).

The above arguments for sedimentation and dissolution of Radiolaria have been further substantiated by percent similarity index analysis on the data from Station E (Figure 5; Takahashi and Honjo, 1981). The data from each depth were computed against other depths in order to obtain the index between two depths. When the data from 389 m are compared with those from the lower depths, the index drastically decreased at 988 m for all suborders and stays rather uniform below 1 km depth for polycystines, but decreases further for phaeodarians. This trend in the mesopelagic zone is accounted for by the input of deep dwelling forms and/or the result of dissolution.

Although the composition of the polycystine radiolarian assemblages does not change with depth, their morphology appears to change with depth due to dissolution. A significant increase in shell fragmentation was noted with increasing depth; for instance, percentage of broken shells of *Pterocorys* (*P. campanula* Haeckel and *P. zancleus* (Müller)) from Station E generally increased with depth (Takahashi and Honjo, 1981). Although less significant than the above, a similar trend in shell fragmentation with depth was observed in Spumellaria, Nassellaria, Phaeodaria, as well as total Radiolaria (for details see Takahashi and Honjo, 1981). The continuous increase in shell fragmentation with depth suggests that dissolution begins at the onset of their descent through the water column. Percentages of broken shells at 389 m were slightly higher than at 988 m for most of the taxa. Field studies (Berger, 1968; Erez et al., 1982) and laboratory observations (Hurd, 1972, 1973; Hurd and Takahashi, 1983) demonstrated much higher dissolution rates of biogenic opal above about 400 m than below in the tropical Pacific, indicating that some of the trapped shells were

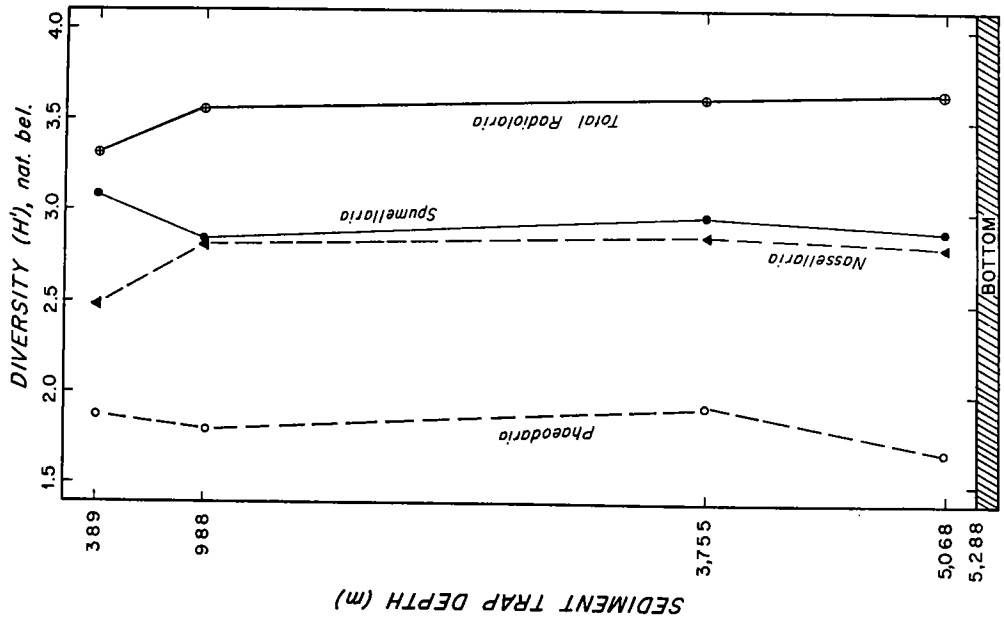

Figure 4: Diversity index (H'), natural bels, of Radiolaria and their suborders from Station E.

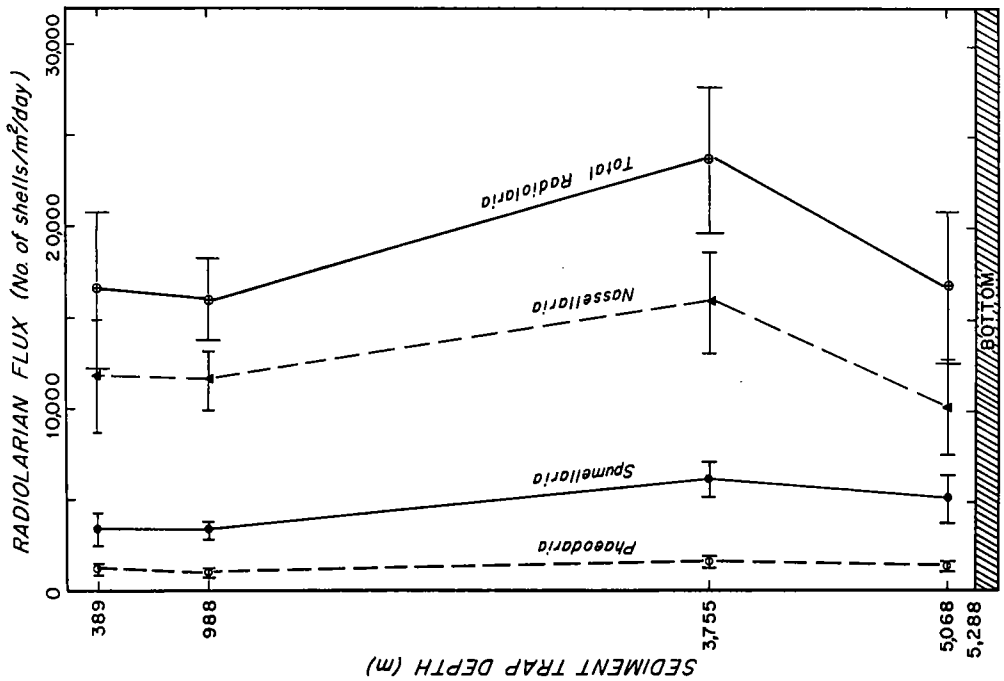

Figure 3: Vertical fluxes (number of shells/m^2/day) of Radiolaria and their suborders from Station E. Horizontal bars represent standard deviations at 95% confidence level.

dissolved within the sediment trap prior to retrieval. Thus, the higher percentage of broken shells at 389 m than at 988 m could be attributed to the trap *in situ* dissolution rather than during their descent through the water column. Generally, the above trend of increasing breakage with depth is also true in Phaeodaria, although the extent of shell breakage is much more substantial than that of polycystines.

The apparent decrease of the shells in biogenic aggregates with depth was probably due to disintegration/oxidation of the biogenic aggregates during their descent through the water column. The decrease was most significant between 389 m and 988 m. Disintegration of biogenic aggragates appears to occur more frequently in the mesopelagic than in the bathypelagic zone. A similar trend was observed on all suborders of Radiolaria.

Percent fluxes of each suborder in total radiolarian shell flux are presented in Table 5. The ratios between two suborders are illustrated in Figure 6: Nassellaria and Spumellaria (N/S), Phaeodaria/Spumellaria (Ph/S). Nassellaria contribute more than 60% of the total radiolarian flux counts at all stations and depths and hence is the predominant suborder. Except between 389 m and 988 m at Station E and 378 m and 978 m at Station P_1, the N/S ratio decreased with depth, indicating either an increase in relative spumellarian flux, or a relative decrease of the nassellarian flux, or both. The N/S ratios at Station E at 389 m and Station P_1 at 378 m were less than those at immediately lower depths. This difference is significant and is reasonable considering more input of deep water nassellarians than spumellarians between the top and second trap depths and *in situ* dissolution (Berger, 1968; Erez et al., 1982) within the receiving cups.

McMillen and Casey (1978) reported the standing stock of suspended Radiolaria skeletons using plankton tows from the surface to a few km deep in the Gulf of Mexico and Caribbean Sea. Their data indicated that the N/S ratio decreased three orders of magnitude from the surface to a few km depth. Petrushevskaya (1971a) showed that N/S ratio decreased from her plankton samples to the surface sediments at two stations in the central tropical Pacific. The decreasing trend in N/S ratio with depth within the water column appears to be universal. The reported N/S ratios in the bottom sediments (Berger and Soutar, 1970; Kowsmann, 1973; McMillen, 1979) were generally much lower than the present observations in the deepest trap samples from all the three stations suggesting poorer preservation of Nassellaria than Spumellaria in the sediments.

The flux of Phaeodaria was more or less uniform due to the constant addition of deep dwelling forms despite the elimination of many shells throughout the depths. The flux was between 6 and 8% in total Radiolaria at all depths at Stations E and PB. Of the total Radiolaria, only 1–4% of phaeodarian flux was observed at Station P_1. As stated previously, species composition of the phaeodarian flux changed significantly with depth (Table 3). The following species comprised the majority (ca. > 30 shells/m^2/day) of phaeodarian flux in the bathypelagic zone at Stations E and PB: *Protocystis xiphodon* (Haeckel), *Euphysetta elegans* Borgert, *E. pusilla* Cleve, *Medusetta ansata* Borgert, *Borgertella caudata* (Wallich), *Lirella melo* (Cleve), *L. bullata* (Stadum and Ling), *Challengeron willemoesii* (Haeckel), and *Conchidium caudatum* (Haeckel). Except for the last two species which were of medium size, all were of small size.

Fluxes of abundant phaeodarian species (> 40 shells/m^2/day at any depth) are illustrated in pertinent family groups (Figures 7–11). The unit of shells/m^2/day is kept for

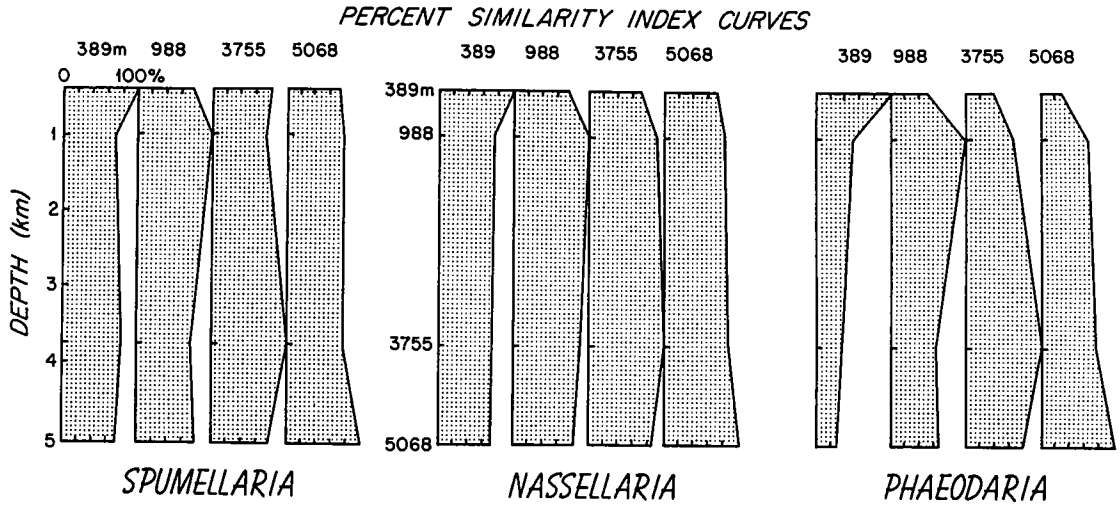

Figure 5: Percent similarity index curves for radiolarian suborders from Station E. The data from each depth were computed against other depths in order to obtain the index between two depths. See Takahashi and Honjo (1981) for detail information.

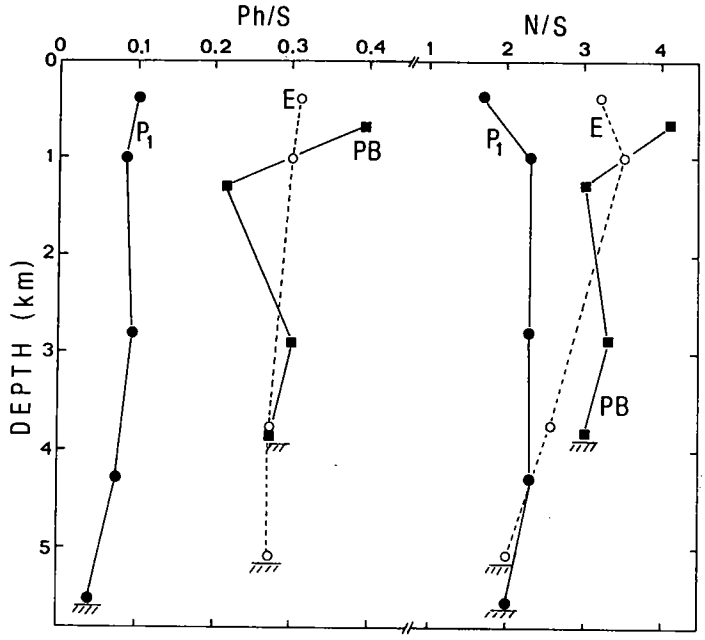

Figure 6: The Nassellaria/Spumellaria and Phaeoadaria/Spumellaria ratios from Stations E, P_1 and PB.

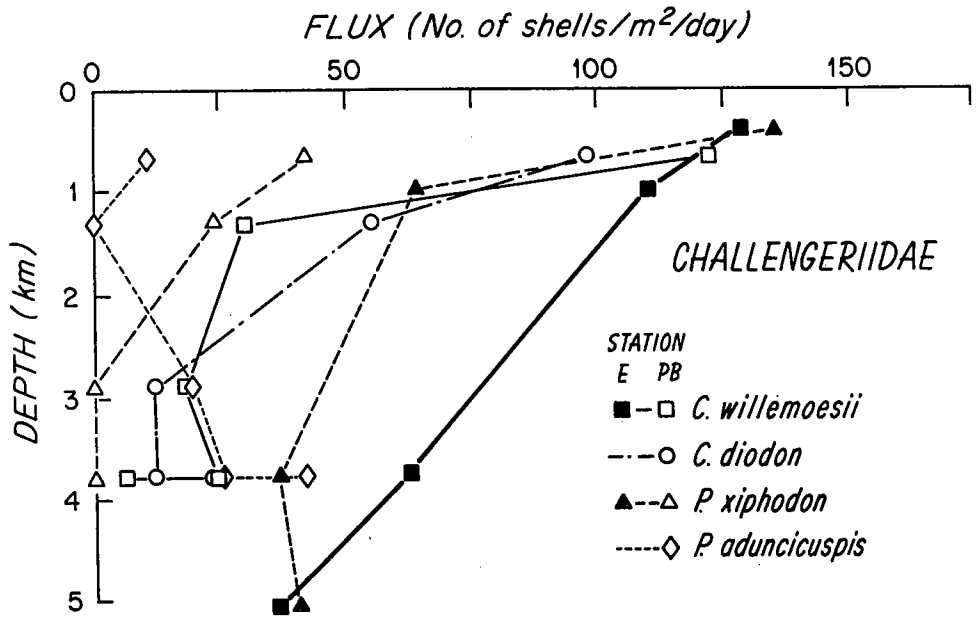

Figure 7: Vertical fluxes (number of shells/m^2/day) of Challengeriidae from Stations E and PB. This family represents a typical shallow dwelling group.

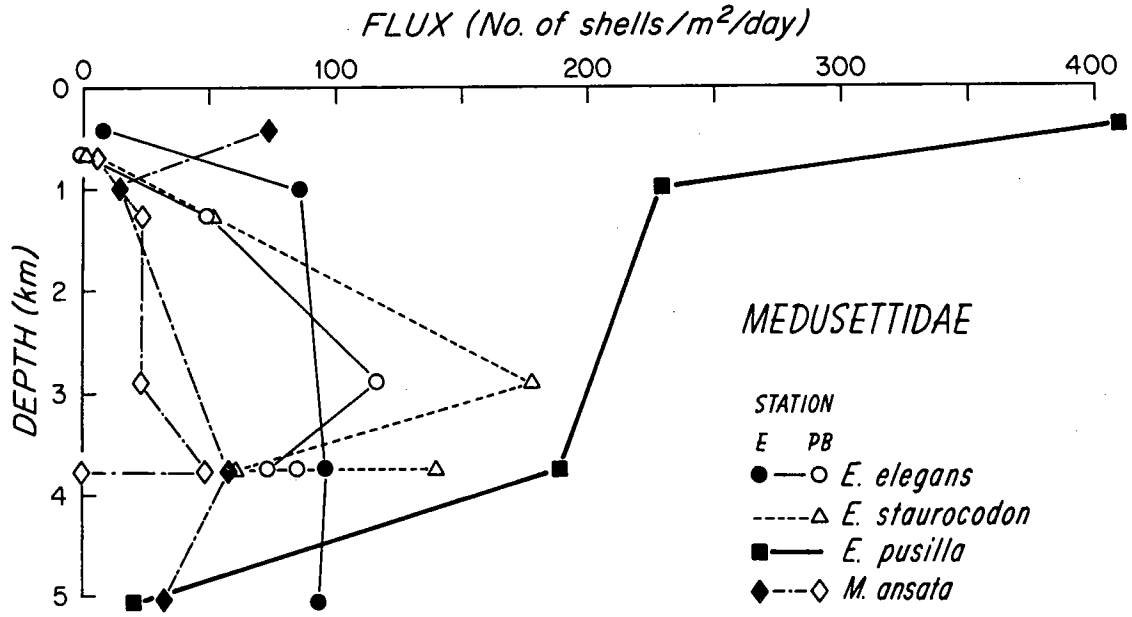

Figure 8: Vertical fluxes (number of shells/m^2/day) of Medusettidae from Stations E and PB. *Euphysetta pusilla* represents shallow dwelling species.

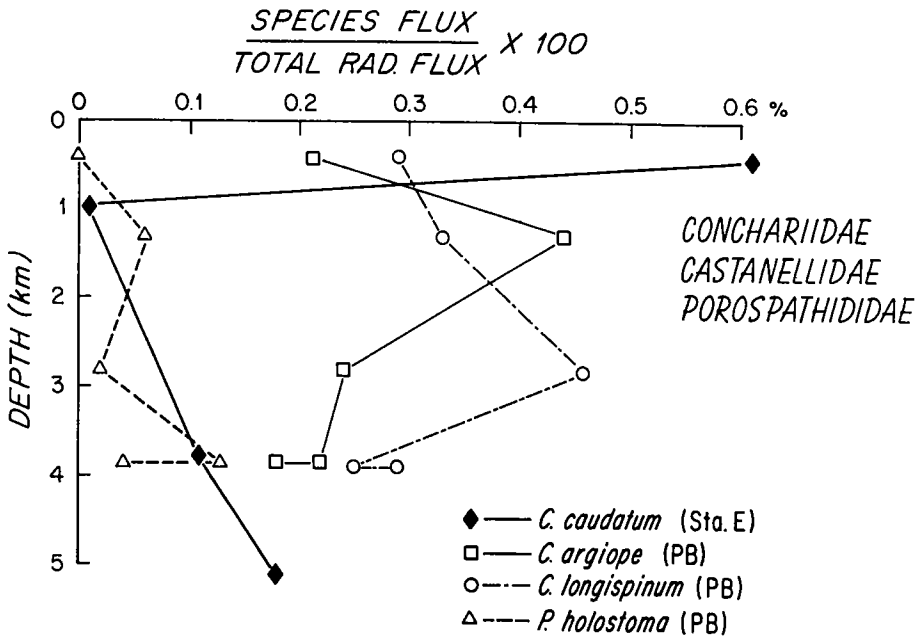

Figure 9: Vertical fluxes (% in total Radiolaria) of Conchariidae, Castanellidae and Porospathididae from Stations E and PB.

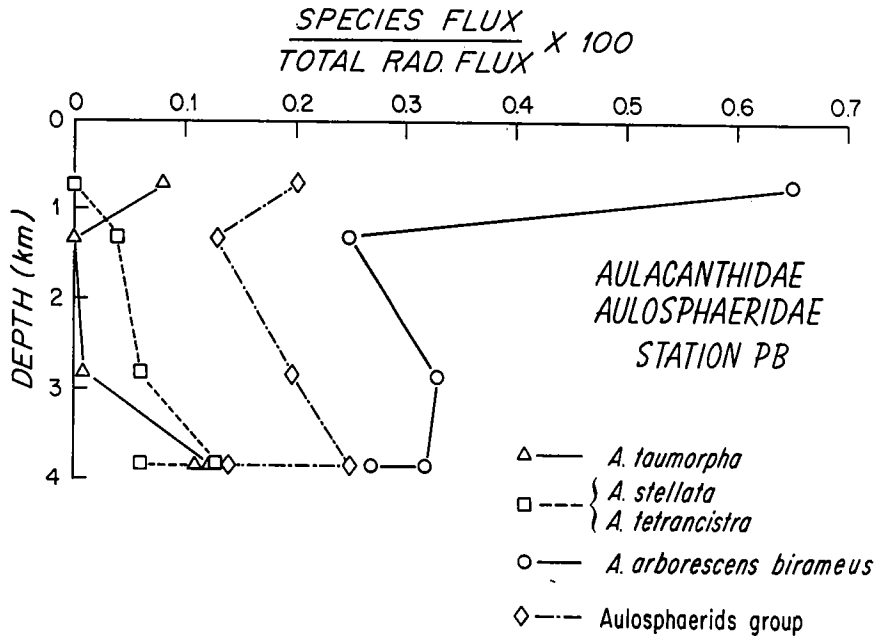

Figure 10: Vertical fluxes (% in total Radiolaria) of Aulacanthidae and Aulosphaeridae from Stations E and PB.

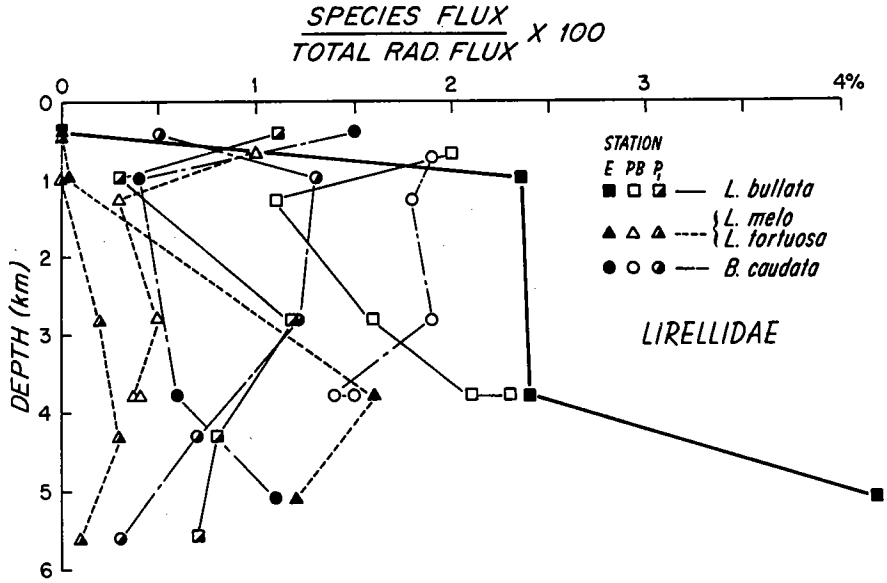

Figure 11: Vertical fluxes (% in total Radiolaria) of Lirellidae from Stations E, PB and P_1.

Challengeriidae, but converted to percentage for the rest of families in order to enhance their trend in flux. The flux of most Challengeriidae (Figure 7) and *Euphysetta pusilla* (Figure 8) evidently decreases with depth, suggesting that their source is above the shallowest traps and that dissolution is responsible for the observed decrease with depth. *Euphysetta elegans* (Figure 8) and *Lirella bullata* (Figure 11) tend to increase their fluxes with depth, suggesting increasing sources in deeper depths and compensating for the increase of dissolution with depth. Thus, actual fluxes may have increased more with depth than the apparent fluxes shown in Figures 7–11. These two types of fluxes with different living zonations are illustrated (Figure 12).

3.3 Comparison of the Radiolarian Fluxes with Accumulation Rates in the Holocene Sediments

Range of total radiolarian flux in the unit of $\times 10^3$ shells/m^2/day at each station was: Station E, 16.0–23.7; Station P_1, 0.6–17.0; Station PB, 29.4–53.1 (Table 5). Of these, the sum of the fluxes in the 1 mm-250 μm, 250–125 μm, and 125–63 μm size fractions in the unit of $\times 10^3$ shells/m^2/day at each station constituted: Station E, 8.7–13.4; Station P_1, 0.4–11.3; and Station PB, 25.3–38.5 (Table 4; Takahashi and Honjo, 1981). These correspond to 56–67% at Station E, 62–70% at Station P_1, and 63–86% at Station PB of the flux in all size fractions; the fine size (< 63 μm) fraction contained less than half of radiolarian flux at all the depths at all three stations.

The above total radiolarian fluxes can be compared with radiolarian accumulation rates in Holocene sediments cited in the literature in order to estimate the extent of preservation. When the above unit is converted to shells/cm^2/10^3 yrs. the flux is: 5.83–8.66$\times 10^5$ at

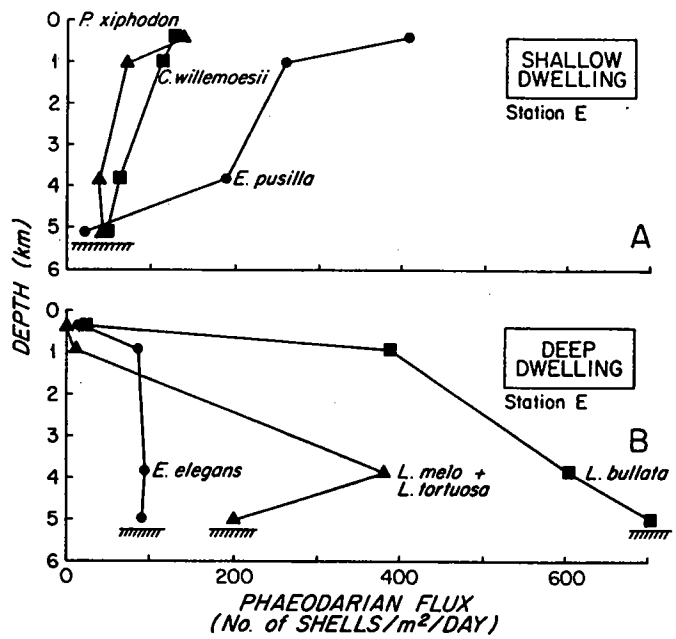

Figure 12: Representative Phaeodaria of shallow and deep dwelling species from Station E. The flux decrease of the shallow dwelling species with depth is caused by dissolution during sinking. The flux of deep dwelling species results from a mixture of shell production at depth and effect of dissolution.

Station E; 0.21–6.22$\times 10^5$ at Station P_1; and 10.72–19.40$\times 10^5$ at Station PB. Takahashi and Honjo (1981) estimated preservation to be 0.8% or less of the flux in Holocene sediments using the above flux from Station E, a sedimentation rate of < 0.9 g/cm^2/10^3 yr (Lisitzin, 1972) and radiolarian counts (Goll and Bjørklund, 1971).

Holocene accumulation rates of radiolarian skeletons from the Panama Basin have been estimated by Swift (1977) using counts of whole radiolarians in the > 63 μm size fraction (Kowsmann, 1973): (in the unit of $\times 10^3$ shells/cm^2/10^3 yrs) total Radiolaria: 104; Spumellaria: 82; and Nassellaria: 22. In order to compare radiolarian accumulation rates with the average vertical fluxes of Radiolaria (30.8$\times 10^3$ shells/m^2/day), including shells in the > 63 μm size fraction (Table 4), the rate unit is converted to $\times 10^3$ shells/cm^2/10^3 yr. This yields values of 1,123 for total Radiolaria, 281 for Spumellaria, and 787 for Nassellaria. The estimated total radiolarian preservation at Station PB is 9.3%. This is an order of magnitude higher than at equatorial Atlantic Station E where productivity is considerably lower (Figure 13). As can be predicted on the basis of the change in N/S ratio with progressive dissolution, more Spumellaria shells appear to be preserved than Nassellaria shells (29.2% vs. 2.8% of fluxes).

The sediment accumulation rate at Station P_1 has been estimated by Honjo to be 0.017 g/cm^2/10^3 yr (1982, in prep.). Renz (1976) reported radiolarian counts in > 35 μm size fraction per unit dry weight of surface sediments in a nearby region to be 1,400 shells/g. Based on this, only 0.004% of radiolarian shell flux is estimated to be preserved at Station P_1.

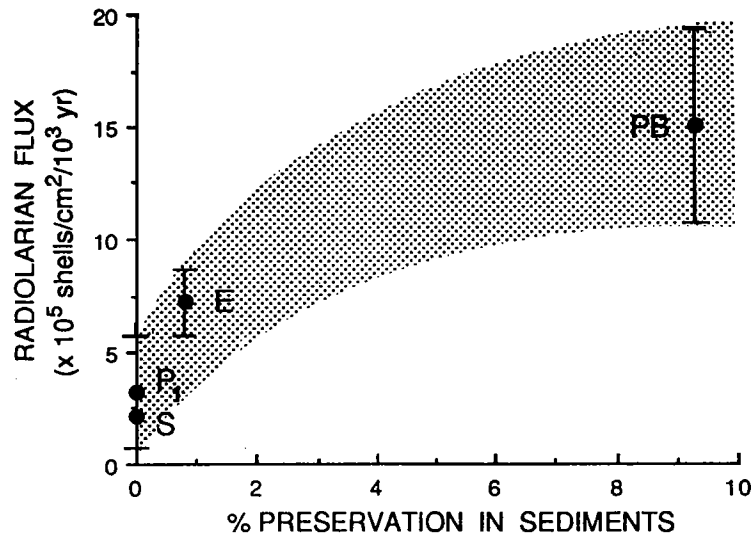

Figure 13: Plot of radiolarian flux vs. percent preservation in the surface sediments. Mean flux values are represented by solid circles and standard deviations are represented by horizontal bars.

Sediment trap samples from 976 m and 3,694 m at Station S were semi-quantitatively studied. As at the three other stations, the species composition of flux was similar between the two depths. The surficial bottom sediments obtained by a box core consisted mainly of clay minerals and only a few specimens of robust polycystines such as *Tetrapyle octacantha* were found in 5 g (wet weight) of sample suggesting significant dissolution of the radiolarian assemblage on the sea-floor.

A positive correlation exists between the radiolarian flux and percent preservation (Figure 13). It is clear that a sedimentary environment with higher rates of flux results in better preservation of radiolarians than does low flux areas. Whether the relationship is linear or logarithmic cannot be determined until more data points become available.

In conclusion, it can be stated that Radiolaria supplied to the ocean bottom are largely dissolved on the sea floor and only a few percent (maximum of 9.3% at Station PB) or less are preserved within the sediments. Judging from the above results from four stations, the extent of preservation appears to be in part proportional to the rate of sedimentation.

3.4 Radiolarian Dissolution in the Water Column

Since seawater is undersaturated with respect to biogenic silica (e.g., Cooper, 1952; Hurd, 1972), dissolution of biogenic silica occurs throughout the course of sedimentation. The extent of dissolution is dependent upon the taxa, since morphology, chemical composition and residence time in the water column can vary a great deal. A simplified view is illustrated in Figure 14. Extensive dissolution within the water column can eliminate most, if not all, of the descending population of dissolution susceptible taxa such as *Challengeron willemoesii*, a phaeodarian species (Table 3; Figure 7). On the other hand, species composition and abundance of polycystines are not significantly affected within the water column and only

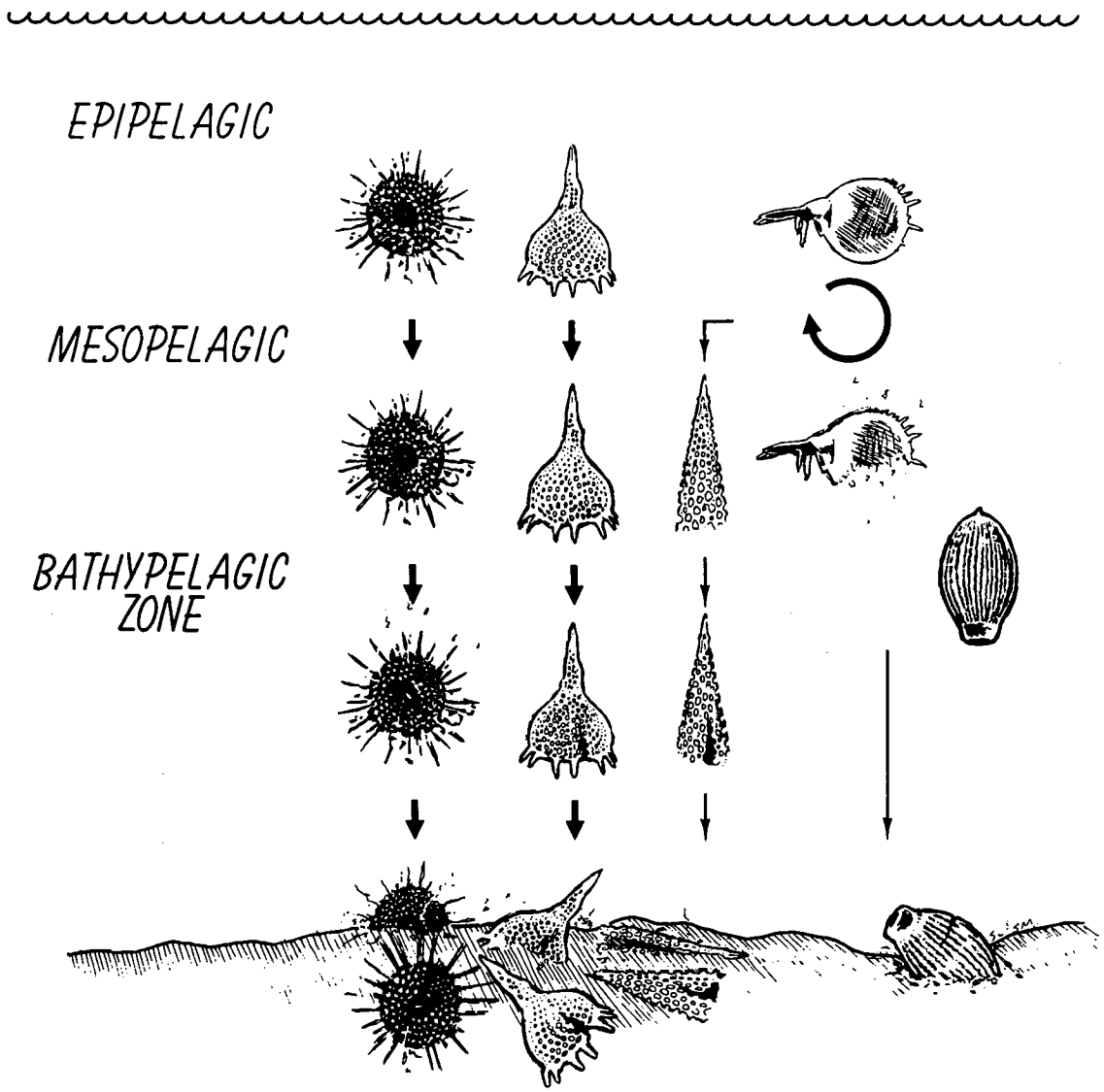

Figure 14: Simplified illustration depicting production depth, sinking, dissolution and preservation of Spumellaria, Nassellaria and Phaeodaria in a pelagic realm.

large amounts of statistical data (such as N/S ratio) can resolve a slight change (Figure 6). However, when individual shell morphology is examined, an increase of shell-breakage with depth is observed as stated earlier (e.g., genus *Pterocorys*). Polycystine skeletons from the sediment traps examined by TEM show that generally only about 0.1 μm or less of the surface layer is porous, apparently caused by dissolution (e.g., Plate 43, figures 10–11). Dissolution of 0.1 μm or less of the shell represents a small portion of the cross-sectional diameter, unless the skeletal elements are extremely thin such as in the case of *Myelastrum*. Skeletal thickness measurement of polycystine radiolarian skeletal elements using SEM micrographs show a mean diameter of 3.98 μm (S.D. - 2.80 μm, n = 12 taxa, 16 specimens, 2 to 3 measurements on each specimen). Therefore, the effect of dissolution on bulk morphology is generally insignificant in polycystines and this agrees well with the species counts (Table 3; Figures 2–4). Polycystines from the surface sediments are expected to have more porous skeletons than those from the trap samples since they have been exposed to seawater for a longer period of time. In fact, significantly porous radiolarian skeletons have been observed in Eocene through Recent sediment samples (Hurd et al., 1981).

Phaeodarian skeletons are different from their polycystine counterparts in detail. The phaeodarians recovered from plankton tow samples and dried on board ship at Station PB (Takahashi et al., 1983) showed small angular polygonal pores in the inner part of the skeletons but not in the solid surface layers which are 0.40–0.45 μm thick (Plate 47, figure 14; Plate 58, figure 1). With the exception of the angular pores, the skeletons looked relatively solid and uniform through cross-sectional examination, resembling the condition of their polycystine counterparts. Phaeodarian skeletons dissolve fairly quickly. The specimens recovered by the sediment traps did not show the original solid skeletal structure, but were significantly altered to a more porous state (e.g., Plate 47, figures 11, 12; Plate 53, figures 9, 10; Plate 59, figures 12, 13). The altered skeletons of several taxa consisted of a tubular structure (e.g., Plate 47, figure 12; Plate 58, figure 3; Plate 59, figures 12, 13) which may be due to growth features. Cross sections of challengeriid skeletons showed structures similar to amphorae (Greek wine bottles) (e.g., Plate 47, figures 8–13; Plate 48, figures 8–11; Plate 51, figures 10,11). The skeletal constituents of the amphorae (outer layer in the cross sections) must be more dissolution-resistant than the surrounding cementing parts (inner layers) because the inner layers dissolved first and the outer layers still remained. It is possible that the chemical and physical characteristics of the amphorae are similar to those of their polycystine counterparts since the ultrastructures of both are similar.

There are several phaeodarian taxa which were not found in the sediment trap samples but often are recovered from bottle castings or plankton net tows. These include *Euphysetta* sp. (Plate 63, figures 12, 13), *Medusetta robusta* Borgert (1902) and *Medusetta armata* Borgert (1901). It is apparent that such thin shells made of one or two layers of tubular skeletons (shown in the illustration) disintegrate quickly and hence are never found in trap samples. The fate of *Sticholonche*, classified now as *Heliozoa* (Cachon and Cachon, 1978), is similar to the above and has never been found as an intact shell but only as dispersed spines in trap samples (Takahashi and Ling, 1980). Aulosphaerids and aulacanthids are also readily disintegrated and only partial skeletons of the shells are recovered from the traps (Plate 63, figures 1–11).

3.5 Biogenic Opal Transport to the Deep-sea by Radiolarian Skeletons

The importance of radiolarian SiO_2 transport to the deep-sea at the equatorial Atlantic sediment trap station has been shown by Takahashi and Honjo (1981) based on microscopic counts combined with an inferred weight value. To further quantify the radiolarian SiO_2 flux it is necessary to combine radiolarian counts (Table 3), weight values (Takahashi and Honjo, 1983) and mean SiO_2 content in each suborder (Table 6). The details of the SiO_2 content data has been reported elsewhere (Takahashi, 1981). Choosing the weight values is most critical for estimation. Utilizing the data on 55 taxa (Tables 2–4; Plates 1–63) and taxonomic-morphological backgrounds, the most representative average values are chosen subjectively (Table 6).

Results show that spumellarian SiO_2 transport is generally 50% or more of the total radiolarian SiO_2 flux, and that nassellarians and phaeodarians follow them respectively at all stations. Phaeodarian SiO_2 transport is a few percent or less at Stations E and P_1, and approximately 20% at Station PB (Table 7). Some of the castanellids are rare but extremely large, and hence the introduction of a few specimens results in a significant contribution to the SiO_2 flux. Since the results in Table 7 were based on observations of microslides which did not always contain large and rare taxa due to the use of small aliquots in this study, phaeodarian flux results may be biased. The finding of a dense, large patch of monospecific *Castanidium longispinum* (whose size is 470±34 μm and weight is ca. 5 μg/shell) in the Gulf of Oman suggests its predominance under special conditions (Erez et al., 1982).

Radiolarian SiO_2 flux ranges from approximately 3 mg/m^2/day at Stations E and P_1 to 6–10 mg/m^2/day at Station PB. This is several factors higher than some of the previous estimates (e.g., Bishop et al., 1977). The radiolarian SiO_2 flux is compared to biogenic opal flux values (Honjo et al., 1982) and is expressed as a percentage of total biogenic SiO_2 (Table 7). That the percentages generally increase with depth suggests greater dissolution in the water column of other components, such as fragmented opal remains, than intact radiolarian skeletons. The radiolarian flux data from Station PB agrees well with size fractioned biogenic SiO_2 values. The radiolarian SiO_2 fluxes range from 22 to 30% of the total biogenic SiO_2 flux which is approximately equal to biogenic opal flux in the > 63 μm size fraction (Honjo, pers. comm., 1982). This suggests that the rest of the SiO_2 is transported by silicoflagellates, small diatoms (< 63 μm) and fragmented SiO_2 particles including radiolarian fragments which are < 63 μm. These values of 20 to 30% are approximately equivalent to the biogenic SiO_2 flux of the > 63 μm size fraction. Microscopically, radiolarian shells were the major biogenic silica component. Contributions of diatom frustules to biogenic SiO_2 flux at Stations PB and P_1 were insignificant. Large diatoms (> 63 μm) were minor components except at Station E where *Rhizosolenia styliformis*, a centric diatom, contributed approximately one quarter of the total SiO_2 flux. When weight values from Station PB are used the percentages of the estimated radiolarian SiO_2 flux obtained for Stations E and P_1 are too large (Takahashi, 1981). Microscopic examination indicates that some of the Panama Basin taxa are more robust and/or developed than the same taxa at other stations, probably reflecting nutrient conditions. For instance, patagium of *Euchitonia elegans* is generally present in samples from Station PB but absent in samples from Station P_1. Such a morphological difference, as well as composition difference in assemblages, results in

Table 6: Average weight and SiO_2 content data used for SiO_2 transport computations.

	Spumellaria	Nassellaria	Phaeodaria Castanellids + *Haeckeliana porcellana*	Others
Average weight for Station PB (μg/shell)	0.480	0.080	9.0	0.090
Average weight for Stations E and P_1 (μg/shell)	0.192	0.032	3.6	0.040
Mean SiO_2 content (%)	90.5 ± 4.7	98.4 ± 4.0	70.6 ± 13.0	

Table 7: An extent of SiO_2 transport to the deep-sea by radiolarians.

Station:	Depth (m)	SiO_2 flux for Total Radiolaria (mg/m²/day)	% SiO_2 Flux in Total Radiolaria for: Spumellaria	Nassellaria	Phaeodaria	$\frac{Rad.SiO_2}{BiogenicSiO_2} \times 100$ (%)
E:	389	1.07	59	35	6	15
	988	0.99	59	37	4	17
	3755	1.62	66	31	3	40
	5068	1.25	70	26	4	30
P_1:	378	0.05	74	25	0.8	13
	978	0.37	69	28	3.2	58
	2778	1.19	70	29	1.0	45
	4280	1.26	70	29	0.6	51
	5582	1.17	75	25	0.3	50
PB:	667	7.24	47	35	19	24
	1268	5.68	53	29	18	22
	2869	10.36	48	29	23	30
	3791	8.20	54	29	17	27

an overestimation of the percentages at Station E and Station P_1. Thus, it should be noted that the estimation of SiO_2 fluxes using radiolarians as particles can be applied best where weight data from the same samples are available. To estimate the percentage of radiolarian SiO_2 in the total SiO_2 fluxes at Stations E and P_1 (Table 7), 40% of the radiolarian weight values obtained from Station PB were used (Table 6).

3.6 Significance of Radiolarian Weights for Assessing Selective Preservation in the Sediments

Measured weight values are plotted against widths (Figure 15) for 33 taxa, and lengths (Figure 16) and projected areas (Figure 17) for 55 taxa. As noted by Takahashi and Honjo (1981), there is an order of magnitude or more difference between Quaternary radiolarian weights and those from sediment traps; Quaternary specimens from the central tropical Pacific weigh from 0.063 μg/shell (Moore, 1969) to 0.136 μg/shell (Takahashi and Honjo, 1981). These values correspond to the lower end of the weights presented in Figures 15–17.

Taxonomic and morphologic information on specimens from both sediment traps and bottom sediment provides an explanation for the differences in the weights of the two different assemblages (i.e., biocoenosis vs. thanatocoenosis). Phaeodarians and large-sized polycystines are generally absent in the sediment samples. Large, heavy polycystines are made of thin skeletal elements forming a network of spongy shells (e.g., *Conicavus tipiopsis* Takahashi, n. sp. and *Myelastrum trinibrachium* Takahashi, n. sp.). The state of preservation depends on skeletal thickness but not the size of a shell and thus those species whose skeletons are made of thin elements are likely to be dissolved on the sea-floor or soon after burial. Some of the phaeodarian shells are also significantly heavier (i.e., most of castanellids, *Haeckeliana porcellana* and *Conchopsis compressa*) than their polycystine counterparts. For example, a castanellid shell weighed 130.0 μg/shell (this value does not directly appear in Figures 15–17 since only mean values are illustrated). This value is approximately 2,000 times heavier than *Pterocorys zancleus* or *Pterocorys campanula*, typical polycystines, which were the most abundant taxa at Station E. Therefore, the heavy radiolarians play an important role in transporting and releasing silica and its associated elements in the deep-sea.

All of the above species were not reported from the sediments. Large-sized radiolarian shells greater than 450 μm are usually absent in Holocene sediments. From earlier discussion on N/S ratios, it is obvious that more nassellarians undergo dissolution than spumellarians. In these species, preservation, as well as skeletal weight loss is responsible for the smaller specimens found in Quaternary sediments than those in sediment traps.

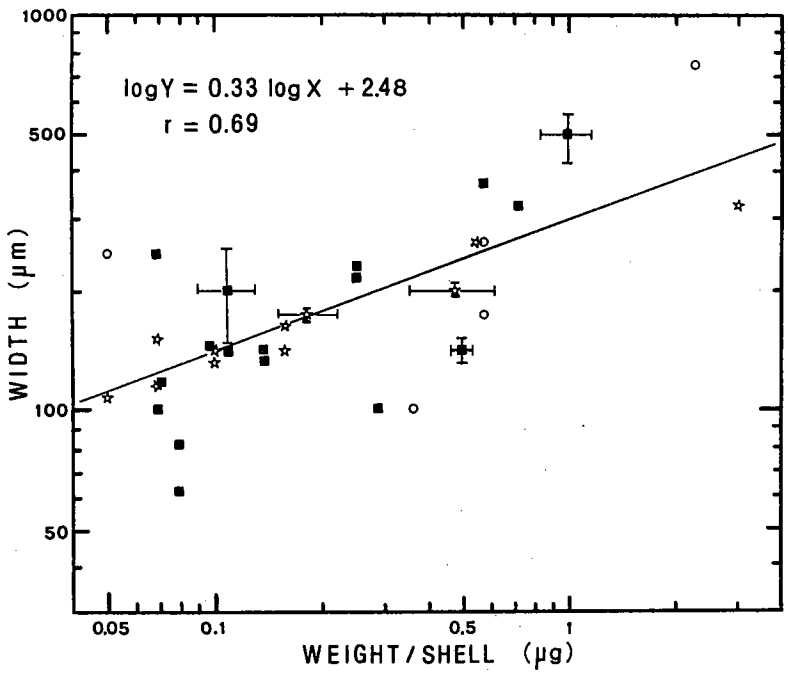

Figure 15: Plot of width vs. weight/shell. In the case of shells that have the same values in length and width they are represented as length (Figure 16) and thus not included here. Only representative standard deviations/analytical errors are given to several species for simplicity of the illustration in Figures 15–17. Symbols used are: • = Spumellaria; ■ = Nassellaria; ⋆ = Phaeodaria.

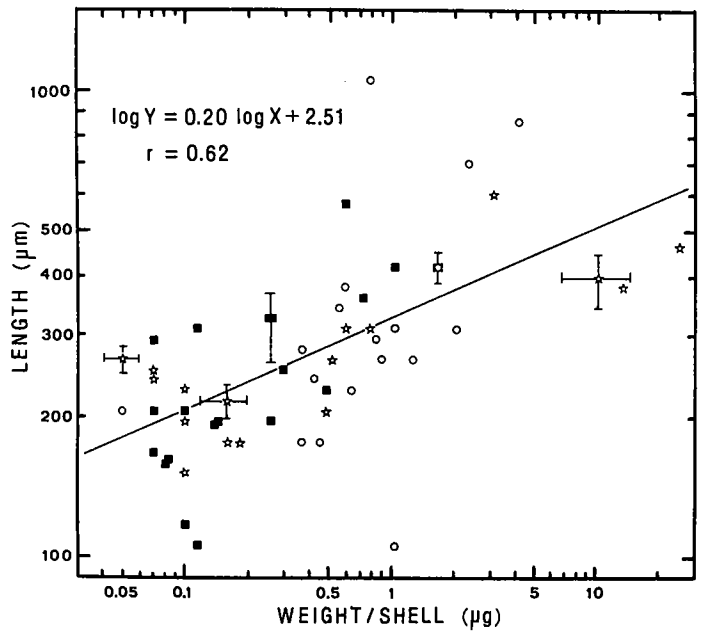

Figure 16: Plot of length vs. weight/shell. Each datum point represents individual species. Symbols used are: o = Spumellaria; □ = Nassellaria; ⋆ = Phaeodaria.

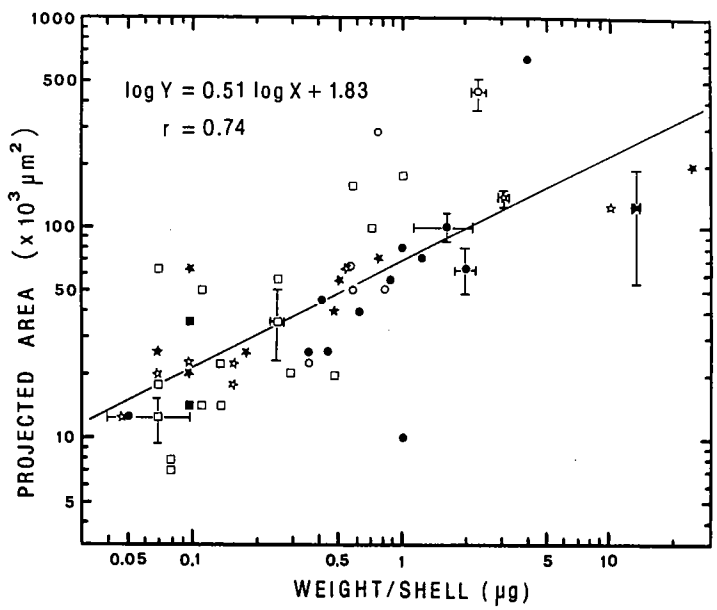

Figure 17: Plot of projected area vs. weight/shell. Symbols used are: o = Spumellaria; □ = Nassellaria; ⋆ = Phaeodaria. Open symbols = observed projected areas; filled symbols = computed projected areas.

4 Summary and Conclusions

1. Total number of radiolarian taxa encountered, combining all three stations, was 420: 175 Spumellaria; 182 Nassellaria; and 63 Phaeodaria. This includes 1 new genus, 20 new species, 1 new subspecies, 1 new name for a species, and 3 new names for subspecies. At Station E alone 208 taxa were found. Such a diversified marine community from the oceanic water column has never been reported previously.

2. The observed vertical flux of individual radiolarian shells in the unit of $\times 10^3$ shells/m^2 /day at each station was: Station E, 16 to 24; Station P_1, 0.6 to 17; and Station PB, 29 to 44. The radiolarian SiO_2 flux, estimated from the specimen counts, weight of shells and SiO_2 content, was 22 to 30% of total biogenic SiO_2 flux at Station PB. This range of values is essentially equal to all of the biogenic opal flux in the > 63 μm fraction at Station PB. The values for Stations P_1 and E were between 13 and 51%.

3. Fragmentation of radiolarian shells in the sediment traps is interpreted as a result of dissolution. An increase of percent broken shells with depth of *Pterocorys* and three other suborders suggests that slow dissolution of radiolarian shells takes place within the water column.

4. The fluxes of Nassellaria and Phaeodaria relative to Spumellaria decrease with depth, reflecting their higher dissolution susceptibility compared with Spumellaria.

5. Phaeodarians and dissolution-susceptible polycystines (e.g., *Myelastrum* and *Conicavus*), whose sizes are often large, transport a significant amount of SiO_2 to the deep-sea. They quickly release silica either in the water column or on the sea floor depending on their residence time in the water column. Thus, these shells play an important role in silica transport and recycling in the oceanic system.

6. From estimates of the radiolarian fluxes at the three stations and Holocene radiolarian accumulation rates in the same areas, several percent or less of the radiolarian fluxes are preserved in the sediments. A positive correlation is shown between the radiolarian flux and the percent preservation in the sediments.

5 Acknowledgments

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6 Systematics of Radiolaria

6.1 Introduction

The high-level classification followed herein is based mainly on that proposed by Riedel (1967a, 1967b, 1971a) for polycystines and by Haeckel (1887), Haecker (1908b) and Borgert (1901a, 1906, 1907, 1910, 1911) for phaeodarians with some emendations. A classification given by Takahashi and Honjo (1981) is slightly modified here. Synonymies of taxa include the original descriptions, those which reflect the current usage for polycystines, and relevant ones mainly from plankton and surface sediments. In the case of phaeodarians relatively little documentation has been accomplished thus far and available literature is much less than that for polycystines. Therefore, the author has attempted to list all references for phaeodarians where possible together with giving definitions of families and genera.

6.2 Classification Outline

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Suborder SPUMELLARIA Ehrenberg, 1875			53
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Aulospathis variabilis Haeckel *bifurca* Haecker	63	11	161

7 Systematics

Kingdom PROTISTA HAECKEL, 1866
Phylum SARCODINA HERTWIG AND LESSER, 1874
Class ACTINOPODA CALKINS, 1909
Subclass RADIOLARIA MÜLLER, 1858a
Order POLYCYSTINA EHRENBERG, 1838, emend. RIEDEL, 1967a
Suborder SPUMELLARIA EHRENBERG, 1875
Family COLLOSPHAERIDAE MÜLLER, 1858a

DEFINITION: Colonial spumellarians with lattice-shells (and one genus with no skeletal elements) (Riedel, 1971).

Genus *Acrosphaera* HAECKEL, 1881
Acrosphaera spinosa (Haeckel) *longispina* Takahashi, new name
Plate 1, figures 1, 4

Acrosphaera spinosa (Haeckel). - POPOFSKY, 1917, p. 253, text-fig. 16 (*partim*). - STRELKOV AND RESHETNYAK, 1971, p. 340, pl. 6, figs. 39, 41 (*partim*).

Polysolenia flammabunda (Haeckel). - NIGRINI, 1967, p. 15, pl. 1, fig. 2. - NIGRINI AND MOORE, 1979, p. S13, pl. 2, fig. 2.

Acrosphaera flammabunda (Haeckel). - JOHNSON AND NIGRINI, 1980, p. 116, pl. 1, fig. 1, text-fig. 3a.

DESCRIPTION: Shell smooth, polyhedron shape, with long radiated spines of up to 1/3 of shell diameter whose bases are elevated, with numerous circular to subcircular small pores of slightly variable size, with fewer number of large pores of about 3–5 times the small pore diameter. Number of spines is one on the small pore margin and up to several (and occasionally forming coronas) on the large pore margin.

REMARKS: Main differences of the present taxon from *A. spinosa coniculispira* and *A. spinosa coronula* are length and shape of spines and number of spines on the large pore margin. The author's concept of this subspecies is similar to that of Nigrini (1967) except elimination of forms close to *Choenicosphaera flammabunda* Haeckel. Popofsky (1917) and Strelkov and Reshetnyak (1971) lump these three taxa together; Nigrini (1967) and her co-workers split *A. spinosa longispina* from *A. spinosa coniculispina* but lump together *A. spinosa longispina* and *A. spinosa coronula*. It is important to note that both Popofsky (1917) and Strelkov and Reshetnyak (1971) describe different forms from one colony, although not necessarily in all of the groups presently in question. Such an observation of the colony is the key to improving the taxonomy of colonial Radiolaria. Thus, the four forms presented here may well be one taxon in the true biological sense, in which case splitting into several subspecies is invalid. However, until satisfactory information on the colonies of these groups is obtained, the author proposes to classify them as four different subspecies.

DERIVATION OF NAME: The Latin meaning long thorn.

Acrosphaera spinosa (Haeckel) *coniculispina* Takahashi, new name
Plate 1, figure 2

Collosphaera spinosa HAECKEL, 1860b, p. 845; 1862, p. 536, pl. 34, figs. 12, 13.

Acrosphaera spinosa (Haeckel). - BRANDT, 1885, p. 263, pl. 2, fig. 4; HAECKEL, 1887, p. 100. - STRELKOV AND RESHETNYAK, 1971, p. 340, pl. 5, figs. 33–38; pl. 6, figs. 40, 43 (*partim*). - JOHNSON AND NIGRINI, 1980, p. 119, pl. 1, fig. 3. - BOLTOVSKOY AND RIEDEL, 1980, p. 144, pl. 1, fig. 6. - TAKAHASHI AND HONJO, 1981, p. 144, pl. 1, fig. 6.

Polysolenia spinosa (Haeckel). - NIGRINI, 1967, p. 14, pl. 1, fig. 1. - NIGRINI AND MOORE, 1979, p. S19, pl. 2, fig. 5.

REMARKS: This form is the major component of the present species counts at all the three stations.

DERIVATION OF NAME: The name of this species is the Latin meaning conical thorn.

Acrosphaera spinosa (Haeckel) *flammabunda* Haeckel
Plate 1, figure 5

Choenicosphaera flammabunda HAECKEL, 1887, p. 103, pl. 8, fig. 5.

Acrosphaera spinosa (Haeckel). - POPOFSKY, 1917, p. 254, text-figs. 14, 15 (*partim*). - STRELKOV AND RESHETNYAK, 1971, p. 340, pl. 8, fig. 59 (*partim*).

REMARKS: Although this taxon is morphologically very different from *A. spinosa longispina* and *A. spinosa coniculispina*, they all may prove to be a single taxon with further investigation. This taxon is rare at all three stations.

Acrosphaera spinosa (Haeckel) *lappacea* (Haeckel)
Plate 1, figures 14, 16

Xanthiosphaera lappacea HAECKEL, 1887, p. 120, pl. 8, figs. 10, 11.

Polysolenia lappacea (Haeckel). - NIGRINI, 1967, p. 16, pl. 1, figs. 3a, 3b. - NIGRINI AND MOORE, 1979, p. S15, pl. 2, figs. 3a, 3b.

Acrosphaera lappacea (Haeckel). - JOHNSON AND NIGRINI, 1980, p. 119, pl. 1, fig. 2.

REMARKS: This taxon is very rare at all three stations and it did not appear in any of the counting slides.

Acrosphaera murrayana (Haeckel)
Plate 1, figures 3, 6–11

Choenicosphaera murrayana HAECKEL, 1887, p. 102, pl. 8, fig. 4; BENSON, 1966, p. 120, pl. 2, fig. 3.

Trypanosphaera brachysiphon CLEVE, 1900b, p. 13, pl. 6, fig. 3.

Polysolenia murrayana (Haeckel). - NIGRINI, 1968, p. 52, pl. 1, fig. 1a, 1b.

Acrosphaera murrayana (Haeckel). - POPOFSKY, 1917, p. 259, text-figs. 22, 23. - STRELKOV AND RESHETNYAK, 1971, p. 347, text-fig. 25.

REMARKS: This species is very abundant at the Panama Basin station. Shell diameter is 176 ± 18 μm (2 S.D.) (126 specimens), and its weight is 0.46 ± 0.01 μg (207 specimens). Specimens of two shells splitting apart have been occasionally observed (Plate 1, figures 3, 9, 10). An SEM view of this species' skeletal cross section (Plate 1, figure 11), typical of polycystine skeletons, shows solid silica in contrast to those of porous Phaeodaria (Plates 47–63).

Acrosphaera cyrtodon (Haeckel)
Plate 1, figures 12, 13

Odontosphaera cyrtodon HAECKEL, 1887, p. 102, pl. 5, fig. 6.

Acrosphaera cyrtodon (Haeckel). - STRELKOV AND RESHETNYAK, 1971, p. 344, pl. 7, fig. 51; pl. 8, fig. 54, text-fig. 24.

REMARKS: See Strelkov and Reshetnyak (1971) for a more complete synonymy.

Genus *Clathrosphaera* Haeckel, 1881
Clathrosphaera arachnoides Haeckel
Plate 1, figure 15

Clathrosphaera arachnoides HAECKEL, 1887, p. 119, pl. 8, fig. 7.

DESCRIPTION: Shell elliptical with many elevated cones, numerous straight strands connecting among the cones forming triangular to polygonal geometric network of outer sphere, pores numerous, mostly small and subcircular, a few large, quadrilateral pores.

Genus *Collosphaera* Müller, 1855
Collosphaera tuberosa Haeckel
Plate 2, figures 1–3

Collosphaera tuberosa HAECKEL, 1887, p. 97. - STRELKOV AND RESHETNYAK, 1971, p. 336, pl. 4, figs. 24, 25, text-fig. 22. - NIGRINI, 1970, p. 166, pl. 1, fig. 1, text-fig. 2; 1971, p. 445, pl. 34.1, fig. 1. - NIGRINI AND MOORE, 1979, p. S1, pl. 1, fig. 1. - JOHNSON AND NIGRINI, 1980, p. 119, pl. 1, fig. 8. - BOLTOVSKOY AND RIEDEL, 1980, p. 104, pl. 1, fig. 7. - TAKAHASHI AND HONJO, 1981, p. 144, pl. 1, fig. 2. See Strelkov and Reshetnyak (1971) and Nigrini (1971) for more synonymies.

Collosphaera confossa Takahashi, n. sp.
Plate 2, figures 4, 5

DESCRIPTION: Shell single lattice, thin-walled, smooth, spherical to slightly crumpled, with numerous circular to subcircular pores of variable size. Width of the interporous septa is about the same as average pore diameter. Number of pores is about 23 on the half perimeter of the shell and twice as many as that of *C. huxleyi*.

DIMENSION: Shell diameter: 125–225 μm.

TYPE LOCALITY: 15°21.1′N, 151°28.5′W; sediment trap at 5,582 m; collected during July–November, 1978.

REMARKS: This taxon is different from *C. huxleyi* in shell diameter variability, number and size of pores.

DERIVATION OF NAME: The name of this species is the Latin meaning full of holes.

Collosphaera armata Brandt
Plate 2, figures 6, 7, 12

Collosphaera armata BRANDT, 1905, p. 331, pl. 10, figs. 17, 18. - POPOFSKY, 1917, p. 246, pl. 14, fig. 1. - STRELKOV AND RESHETNYAK, 1971, p. 337, text-fig. 23.

Collosphaera huxleyi Müller
Plate 2, figures 8–11

Thalassicola punctata HUXLEY, 1851, p. 434, pl. 14, fig. 6 (*partim*).

Collosphaera huxleyi MÜLLER, 1855, p. 238; 1858a, p. 55, pl. 8, figs. 6–9. - POPOFSKY, 1917, p. 241, text-figs. 2, 3, pl. 13, figs. 1–9. - STRELKOV AND RESHETNYAK, 1971, p. 332, pl. 4, figs. 21, 23, text-figs. 19–21. - BOLTOVSKOY AND RIEDEL, 1980, p. 103, pl. 1, fig. 5. See Strelkov and Reshetnyak (1971) and Boltovskoy and Riedel (1980) for more synonymies.

Collosphaera macropora Popofsky
Plate 2, figures 13–18

Without a name. - HILMERS, 1906, pl., fig. 3.

Collosphaera macropora POPOFSKY, 1917, p. 247, text-figs. 5, 6, pl. 14, figs. 2a–2c. - STRELKOV AND RESHETNYAK, 1971, p. 337, pl. 4, figs. 30, 31. - BOLTOVSKOY AND RIEDEL, 1980, p. 103, pl. 1, fig. 6.

Collosphaera polygona Haeckel

? *Collosphaera huxleyi* Müller. - HAECKEL, 1862, pl. 34, fig. 5.

Collosphaera polygona HAECKEL, 1887, p. 96, pl. 5, fig. 13. - STRELKOV AND RESHETNYAK, 1971, p. 338, pl. 4, figs. 26, 27. - TAKAHASHI AND HONJO, 1981, p. 144, pl. 1, fig. 3.

Genus *Disolenia* Ehrenberg, 1860a
Disolenia collina (Haeckel)
Plate 3, figures 1, 5–7

Acrosphaera collina HAECKEL, 1887, p. 101, pl. 8, fig. 2. - BRANDT, 1905, pp. 334–335, pl. 9, figs. 14, 15; pl. 10, figs. 32, 33.

Solenosphaera collina (Haeckel). - HILMERS, 1906, pp. 41–44. - POPOFSKY, 1917, p. 250, pl. 14, fig. 3, text-fig. 10. - STRELKOV AND RESHETNYAK, 1971, p. 362, pl. 8, fig. 52.

Disolenia zanguebarica (Ehrenberg)
Plate 3, figures 2–4, 8, 9

Trisolenia zanguebarica EHRENBERG, 1872a, p. 321; 1872b, p. 149, pl. 10, fig. 11.

Solenosphaera zanguebarica (Ehrenberg). - BRANDT, 1905, p. 330, pl. 10, figs. 28–31. - POPOFSKY, 1917, p. 249, text-fig. 9. - STRELKOV AND RESHETNYAK, 1971, p. 360, pl. 10, figs. 74–76.

Disolenia zanguebarica (Ehrenberg). - NIGRINI, 1967, p. 20, pl. 1, fig. 6. - RENZ, 1976, p. 87, pl. 1, fig. 2. - NIGRINI AND MOORE, 1979, p. S5, pl. 1, fig. 3. - JOHNSON AND NIGRINI, 1980, p. 119, pl. 1, fig. 10. - BOLTOVSKOY AND RIEDEL, 1980, p. 105, pl. 1, fig. 11. - TAKAHASHI AND HONJO, 1981, p. 145, pl. 1, fig. 11.

Disolenia quadrata (Ehrenberg)
Plate 5, figures 1–5

Tetrasolenia quadrata EHRENBERG, 1872a, p. 320; 1872b, p. 301, pl. 10, fig. 20.

Solenosphaera variabilis HAECKEL, 1887, p. 113. - ? RIEDEL, 1953, p. 808, pl. 84, fig. 8.

Solenosphaera pandora HAECKEL, 1887, p. 113, pl. 7, figs. 10, 11. - STRELKOV AND RESHETNYAK, 1971, p. 362, pl. 10, figs. 77, 78.

Disolenia quadrata (Ehrenberg). - NIGRINI, 1967, p. 19, pl. 1, fig. 5. - NIGRINI AND MOORE, 1979, p. S3, pl. 1, fig. 2. - JOHNSON AND NIGRINI, 1980, p. 119, pl. 1, fig. 9.

Disolenia cf. *variabilis* (Haeckel). - BENSON, 1966, p. 123, pl. 2, fig. 5.

REMARKS: Bjørklund and Goll (1979, p. 1321, pl. 5, figs. 1–21) described a taxon, *Trisolenia megalactis megalactis* Ehrenberg, similar to this species. The author regards it as a different taxon from the present species because of distinct morphological differences of tubules and pore size of the shells. See the synonymy of *Otosphaera polymorpha* below.

Disolenia sp. A
Plate 5, figure 6

DESCRIPTION: Shell small with three large tubules of cylindrical shape and obliquely truncated. The shell is part of the three connecting tubules and has subcircular pores of finer than interporous septa. Pore size significantly increases (up to more than five times of the width of interporous septa) and becomes polygonal toward the terminal end of the tubules.

DIMENSIONS OF THE ILLUSTRATED SPECIMEN: Length of long axis: 150 μm; diameter of tubules: 30 μm.

REMARKS: This species occurs rarely at the three stations.

Disolenia sp. B

Disolenia sp. - TAKAHASHI AND HONJO, 1981, p. 145, pl. 1, fig. 10.

Genus *Otosphaera* Haeckel, 1887, emend. Nigrini, 1967
Otosphaera tenuissima (Hilmers)
Plate 3, figure 11

Solenosphaera tenuissima HILMERS, 1906, p. 48, pl., fig. 2. - POPOFSKY, 1917, p. 252, text-fig. 13.

Otosphaera polymorpha Haeckel
Plate 3, figures 12, 14, 15

Otosphaera polymorpha HAECKEL, 1887, p. 116, pl. 7, fig. 6. - NIGRINI, 1967, p. 23, pl. 1, fig. 8. - NIGRINI AND MOORE, 1979, p. 59, pl. 1, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 146, pl. 1, fig. 12.

? *Trisolenia megalactis megalactis* Ehrenberg. - BJØRKLUND AND GOLL, 1979, p. 1321, pl. 5, figs. 1–21.

Otosphaera auriculata Haeckel
Plate 3, figures 10, 13

Otosphaera auriculata HAECKEL, 1887, p. 116, pl. 7, fig. 5. - NIGRINI, 1967, p. 22, pl. 1, fig. 7. - NIGRINI AND MOORE, 1979, p. S7, pl. 1, fig. 4. - JOHNSON AND NIGRINI, 1980, p. 119, pl. 1, fig. 11.

Solenosphaera chierchiae BRANDT, 1905, p. 346, pl. 10, fig. 27. - STRELKOV AND RESHETNYAK, 1971, p. 363, pl. 8, figs. 55, 56.

Genus *Siphonosphaera* Müller, 1858a
Siphonosphaera magnisphaera Takahashi, n. sp.
Plate 4, figures 1, 3

DESCRIPTION: Shell large, spherical, with numerous subcircular to polygonal small pores and 10–17 large polygonal pores of 1/4–1/2 length of the shell diameter. Number of the small and large pores are ca. 30–40 and 2–4 respectively on the half meridian. The large pores form very short tubules.

DIMENSIONS: Shell diameter: 175–220 μm (6 specimens); large pore diameter: 12–64 μm (6 specimens).

TYPE LOCALITY: 15°21.1′N, 151°28.5′W; sediment trap at 378 m; collected during July–November, 1978.

REMARKS: This species has a relatively large shell for *Collosphaeridae*, and differs from *Siphonosphaera* sp.A (Plate 4, figure 2) in shell size and in number and shape of small and large pores.

DERIVATION OF NAME: The name of this species is the Latin meaning having the nature of a large sphere.

Siphonosphaera martensi Brandt
Plate 4, figures 4–5, 7–8

Siphonophaera martensi BRANDT, 1905, p. 339, pl. 9, figs. 9–12. - HILMERS, 1906, p. 80. - STRELKOV AND RESHETNYAK, 1971, p. 356, fig. 28. - BOLTOVSKOY AND RIEDEL, 1980, p. 104, pl. 1, fig. 8. - TAKAHASHI AND HONJO, 1981, p. 145, pl. 1, fig. 9.

Siphonosphaera tenera? Brandt. - POPOFSKY, 1917, p. 262, text-fig. 27 (*partim*).

REMARKS: The present taxon has pores of variable size which tend to protrude outward; some of the large ones form short straight or conical tubules. Many of the pores are much smaller than the width of the interporous septa. Thus, the present taxon is different from *S. macropora* Strelkov and Reshetnyak (1971, p. 357, text-fig. 29).

Siphonosphaera socialis Haeckel
Plate 4, figures 9–12, 15, 16

Siphonosphaera socialis HAECKEL, 1887, p. 106, pl. 6, figs. 1, 2. - HILMERS, 1906, p. 74. - POPOFSKY, 1917, p. 264, pl. 16, figs. 1–11; pl. 17, figs. 1–6, text-fig. 29. - STRELKOV AND RESHETNYAK, 1971, p. 353, pl. 8, fig. 60; pl. 9, fig. 72, text-fig. 27.

REMARKS: Specimens shown by Popofsky (1917) and Strelkov and Reshetnyak (1971) are the closest to the ones presented here. Haeckel's specimens of original *S. socialis* have larger pores than those shown by other workers. *S. cf. socialis* shown by Benson (1966: p. 121, pl. 2, fig. 4) is similar to the present taxon. *S. socialis* is preferred to *S. polysiphonia* because: 1) specimens observed here do not have as many prolonged tubules as the original *S. polysiphonia* Haeckel (as pointed out and illustrated by

Boltovskoy and Riedel, 1980); and 2) there are well illustrated descriptions of this taxon under *S. socialis* in the above synomymy. All of the specimens of this species observed under SEM have small numerous rectangular prisms or cubic crystals on the shell surface (e.g., Plate 4, figure 16). This is common to many collosphaerids but has never been observed on any other families under the identical desalting procedure. This may be due to the difference from other groups in the nature of the skeleton.

Siphonosphaera polysiphonia Haeckel

Siphonosphaera polysiphonia HAECKEL, 1887, p. 106. - NIGRINI, 1967, p. 18, pl. 1, figs. 4a, 4b. - RENZ, 1976, p. 89, pl. 1, fig. 7; NIGRINI AND MOORE, 1979, p. S21, pl. 1, figs. 6a, 6b. - JOHNSON AND NIGRINI, 1980, p. 119. - BOLTOVSKOY AND RIEDEL, 1980, p. 104, pl. 1, fig. 9. - TAKAHASHI AND HONJO, 1981, p. 145, pl. 1, fig. 8. See Boltovskoy and Riedel (1980) for an additional synonymy.

Siphonosphaera sp. aff. *S. hippotis* (Haeckel)
Plate 4, figures 13, 14

Siphonosphaera sp. aff. *S. hippotis* (Haeckel). - RENZ, 1976, p. 89, pl. 1, fig. 1.

DESCRIPTION: Shell smooth and thick, spherical, with 5–10 tubules of 1/6 to 1/4 length of shell diameter, pores much smaller and more abundant than those of *S. socialis*.

REMARKS: The present taxon is identical to that shown by Renz (1976).

Siphonosphaera sp. A
Plate 4, figure 2

DESCRIPTION: Shell small and smooth, spherical, with small and large circular to subcircular pores. Interporous septa is wider than large pore diameter. The small pores are much less abundant than those of *S. brachyporosa* and regularly distributed over the shell wall. The large pores form very short tubules of ca. 1/7 of the pore diameter. This species, although not the same, resembles to *S. brachysiphonia* Dumitrică (1978) in size and shape of the shell and large pores.

Siphonosphaera sp. B
Plate 4, figure 6

DESCRIPTION: Shell spherical, with many large pores of about equal width as interporous septa and fewer small pores of ca. 1/3 of the large pore diameter. There are usually 4–6 large and 1–3 small pores in half meridian. The rims of the large pores are elevated and forming short tubules of ca. 1/4 length of the pore diameter.

REMARKS: This species is different from *S. partinaria* and *S. cyathina* both described by Haeckel (1887) in height and shape (and size and number for the latter) of the tubules.

Family SPHAEROZOIDAE Haeckel, 1862

DEFINITION: Growth exclusively colonial.

Genus *Rhaphidozoum* Haeckel, 1862
Rhaphidozoum pandora Haeckel

Rhaphidozoum pandora HAECKEL, 1887, p. 49, pl. 4, fig. 6. - TAKAHASHI AND HONJO, 1981, p. 144, pl. 1, fig. 1.

Family ETHMOSPHAERIDAE Haeckel, 1862

DEFINITION: Without spines on shell surface.

REMARKS: Widely used name Liosphaeridae for this family is invalid. See Loeclich and Tappan (1961).

Genus *Plegmosphaera* Haeckel, 1881
Plegmosphaera pachypila Haeckel
Plate 5, figures 7–9

Plegmosphaera pachypila HAECKEL, 1887, p. 88.

Styptosphaera sp. - TAKAHASHI AND HONJO, 1981, p. 146, pl. 1, fig. 13.

Plegmosphaera coelopila Haeckel
Plate 5, figure 10

Plegmosphaera coelopila HAECKEL, 1887, p. 88.

Plegmosphaera lepticali Renz

Plegmosphaera lepticali RENZ, 1976, p. 115, pl. 1, fig. 14. - TAKAHASHI AND HONJO, 1981, p. 146, pl. 1, figs. 15, 16.

Plegmosphaera sp. aff. *P. lepticali* Renz
Plate 5, figure 11

? *Plegmosphaera lepticali* RENZ, 1976, p. 115, pl. 1, fig. 14.

DESCRIPTION: Shell ovate, smooth, with single layer of spongy meshwork.

Plegmosphaera entodictyon Haeckel
Plate 6, figures 8, 10, 11

Plegmosphaera entodictyon HAECKEL, 1887, p. 88. - HOLLANDE AND ENJUMET, 1960, p. 103, pl. 48, fig. 1. - BOLTOVSKOY AND RIEDEL, 1980, p. 106, pl. 1, fig. 16.

? *Styptosphaera spongiacea* Haeckel. - RENZ, 1976, p. 116, pl. 1, fig. 13.

REMARKS: A specimen shown in Plate 6, figure 8 has inside shell wall closed by a less dense lattice than those of figures 10–11.

Plegmosphaera oblonga Takahashi, n. sp.
Plate 6, figure 3

DESCRIPTION: Elongate hollow shell made of irregular polygonal spongy meshwork, without spines and with two large circular openings of different sizes on two opposite lateral sides. Either anterior or posterior half is slightly thicker in diamter than the other.

DIMENSIONS: (3 specimens) Shell length: 220–580 μm; width: 70–220 μm; radii of axes ratio: 1:2.6–3.0; diameter of lateral openings: 10–60 μm.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap at 667 m; collected during August–December 1979.

REMARKS: This species is rare in the Panama Basin. Wide size variation is observed.

DERIVATION OF NAME: The name of this species is the Latin meaning for having the nature of longer than broad.

Plegmosphaera pachyplegma Haeckel

Plegmosphaera pachyplegma HAECKEL, 1887, p. 89. - BOLTOVSKOY AND RIEDEL, 1980, p. 106, pl. 1, fig. 17.

Plegmosphaera sp. A
Plate 5, figure 14

DESCRIPTION: Shell ovate, surface smooth and hollow with irregular spongy meshwork. Thickness of the spongy layer is ca. 1/2 radius of the cavity. Radii of axes ratio 1:2.2.

Plegmosphaera sp. B
Plate 6, figure 1

DESCRIPTION: Shell, large, smooth and spherical with single layer of fine spongy meshwork.

Genus *Styptosphaera* Haeckel, 1881
Styptosphaera spongiacea Haeckel
Plate 6, figures 6, 7, 9

Styptosphaera spongiacea HAECKEL, 1887, p. 87.

Octodendron nidum TAN AND TCHANG, 1976, p. 233, text-fig. 10.

REMARKS: *S. spongiacea* shown by Renz (1976) has an inside cavity bounded by latticed wall and hence it should be placed in the genus *Plegmosphaera*.

Styptosphaera sp. A
Plate 6, figures 12–14

DIMENSIONS: Shell diameter (long axis) of the illustrated specimens: figure 12: 107 μm; figure 13: 190 μm; and figure 14: 34 μm.

REMARKS: This could be the juvenile form of *S. spongicea*.

Styptosphaera sp. B
Plate 5, figure 12

DESCRIPTION: Shell smooth and ovate with irregular polygonal meshwork on the surface which is connected to the central part with fine radial strands.

DIMENSIONS OF ILLUSTRATED SPECIMEN: Diameter of long axis: 240 μm; short axis: 183 μm.

Styptosphaera sp. C
Plate 5, figure 13

DESCRIPTION: Shell large and ovate with smooth surface. Very fine spongy meshwork, rather dense in the central part and loose in the subsurface layer.

DIMENSIONS OF ILLUSTRATED SPECIMEN: Diameter of long axis: 800 μm; short axis: 710 μm.

Genus *Carposphaera* Haeckel, 1881
Carposphaera capillacea Haeckel
Plate 6, figure 2

Thecosphaera capillacea HAECKEL, 1887, p. 81.

Carposphaera sp. aff. *C. corypha* Haeckel
Plate 9, figure 12

Spongoplegma antarcticum Haeckel. - KEANY, 1979, p. 53, pl. 2, fig. 1.

? *Carposphaera corypha* HAECKEL, 1887, p. 75.

REMARKS: Since specimens observed here as well as the one shown by Keany (1979) do not have spongy cortical shell, the generic name of this species is not *Spongoplegma*. This species is close to Haeckel's illustrated description of *Carposphaera corypha*, but its cortical shell thickness seems to be much thicker than the latter.

Family ACTINOMMIDAE Haeckel, 1862, emend. Sanfilippo and Riedel, 1980

DEFINITION: Solitary spumellarians with shells spherical or ellipsoidal or modifications of those shapes, but not discoidal, nor equatorially constricted ellipsoids, usually without internal spicules, generally much smaller than orosphaerids (Sanfilippo and Riedel, 1980).

Subfamily ACTINOMMINAE Haeckel, 1862
Genus *Centrocubus* Haeckel, 1887
Centrocubus cladostylus Haeckel

Centrocubus cladostylus HAECKEL, 1887, p. 278, pl. 18, fig. 1. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 4, fig. 1.

Centrocubus octostylus Haeckel
Plate 7, figure 1

Centrocubus octostylus HAECKEL, 1887, p. 278.

Genus *Spongosphaera* Ehrenberg, 1847b
Spongosphaera polycantha Müller
Plate 7, figures 2, 3, 5

Spongosphaera polycantha MÜLLER, 1858a, p. 32, pl. 4, figs. 1–4. - HAECKEL, 1887, p. 282. - HOLLANDE AND ENJUMET, 1960, pl. 46, fig. 1.

? *Spongosphaera streptacantha* ? Haeckel. - POPOFSKY, 1912, pl. 8, fig. 4.

Spongosphaera sp. aff. *S. helioides* Haeckel
Plate 7, figures 4, 7, 8

? *Spongosphaera helioides* HAECKEL, 1862, p. 456, pl. 12, figs. 11–13; 1887, p. 283.

REMARKS: This taxon is similar to *S. helioides*, but not the same because radial bi-spines are branching.

Spongosphaera streptacantha Haeckel
Plate 7, figure 6

Spongosphaera streptacantha HAECKEL, 1862, p. 455, pl. 26, figs. 1–3; 1887, p. 282. - MAST, 1910, p. 187. - POPOFSKY, 1912, p. 109, text-fig. 22. - HOLLANDE AND ENJUMET, 1960 ?, pl. 20, figs. 5–7; pl. 45, fig. 4; pl. 58, fig. 5. - TAN AND TCHANG, 1976, p. 234, text-fig. 11.

Spongosphaera ? sp. B
Plate 7, figure 9

DESCRIPTION: Shell large polyhedral and made of dense spongy meshwork with 20 thick branched radial spines. Bases of the spines are elevated and hence each shell surface plane becomes convex. Shell surface of pylome end is rather flat.

Genus *Lychnosphaera* Haeckel, 1881
Lychnosphaera regina Haeckel
Plate 7, figure 10

Lychnosphaera regina HAECKEL, 1887, p. 277, pl. 11, figs. 1–4.

Genus *Actinomma* Haeckel, 1860a, emend. Nigrini, 1967; Bjørklund, 1976b
Actinomma arcadophorum Haeckel
Plate 8, figures 8, 9, 11

Actinomma arcadophorum HAECKEL, 1887, p. 255, pl. 29, figs. 7, 8. - NIGRINI, 1967, p. 29, pl. 2, fig. 3. - NIGRINI AND MOORE, 1979, p. S29, pl. 3, fig. 4.

Actinomma capillaceum Haeckel
Plate 8, figure 10

Actinomma capillaceum HAECKEL, 1887, p. 255, p. 29, fig. 6.

Actinomma sp. aff. *A. arcadophorum* Haeckel and *A. medianum* Nigrini. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 2, fig. 4.

non *Actinimma capillaceum* NAKASEKO, 1959, p. 11, pl. 3, figs. 2a, 2b.

REMARKS: *Haliomma capillaceum* Haeckel (1862, p. 426, pl. 23, fig. 2; 1887, p. 236) is very similar to this taxon except for the absence of outer medullary shell.

Actinomma sp.
Plate 13, figure 11

Actinomma sp. B. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 2, fig. 6.

DESCRIPTION: Similar to *Heterosphaera*, sp. A (Plate 13, figures 9, 10), but this species lacks bi-spines and it has more and shorter main-spines than the former.

Genus *Trilobatum* Popofsky, 1912
Trilobatum ? acuferum Popofsky

Trilobatum acuferum POPOFSKY, 1912, p. 132, text-fig. 48. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 2, fig. 7.

Genus *Acanthosphaera* Ehrenberg, 1858
Acanthosphaera actinota (Haeckel)
Plate 8, figure 1

Heliosphaera actinota HAECKEL, 1860a, p. 803; 1862, p. 352, pl. 9, fig. 3; 1887, p. 218. - SCHRÖDER, 1909, p. 20, text-fig. 10.

Acanthosphaera tenuissima (Haeckel). - RENZ, 1976, p. 99, pl. 2, fig. 11.

Acanthosphaera sp. - HOLLANDE AND ENJUMET, 1960, p. 113, pl. 55, fig. 5 (only).

Acanthosphaera actinota (Haeckel). - BOLTOVSKOY AND RIEDEL, 1980, p. 107, pl. 1, fig. 19. - TAKAHASHI AND HONJO, 1981, p. 146, pl. 1, figs. 18, 19.

REMARKS: See Boltovskoy and Riedel (1980) for a more complete synonymy.

Acanthosphaera tunis Haeckel
Plate 8, figures 2, 3

Acanthosphaera tunis HAECKEL, 1887, p. 210.

Acanthosphaera castanea Haeckel
Plate 8, figures 4, 5

Acanthosphaera castanea HAECKEL, 1887, p. 211, pl. 26, fig. 3.

Genus *Heliosphaera* Haeckel, 1862
Heliosphaera radiata Popofsky

Heliosphaera radiata POPOFSKY, 1912, p. 98, text-fig. 10. - BENSON, 1966, p. 160, pl. 5, figs. 1, 2. - TAKAHASHI AND HONJO, 1981, p. 146, pl. 1, fig. 22.

Genus *Cladococcus* Müller, 1857
Cladococcus viminalis Haeckel
Plate 8, figures 6, 7

Cladococcus viminalis HAECKEL, 1862, pl. 14, figs. 2, 3. - BJØRKLUND, 1976a, pl. 1, figs. 10, 12.

Cladococcus abietinus Haeckel
Plate 10, figure 5

Cladococcus abietinus HAECKEL, 1887, p. 226, pl. 27, fig. 3. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 2, fig. 10.

Cladococcus scoparius Haeckel
Plate 10, figures 6, 7

Cladococcus scoparius HAECKEL, 1887, p. 225, pl. 27, fig. 2. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 2, fig. 11.

Cladococcus cervicornis Haeckel
Plate 10, figures 8–10

Cladococcus cervicornis HAECKEL, 1860a, p. 801; 1862, p. 370, pl. 14, figs. 4–6. - DREYER, 1913 (*partim*), p. 30, pl. 1, figs. 1, 5 (only). - BOLTOVSKOY AND RIEDEL, 1980, p. 110, pl. 2, fig. 5.

Elaphococcus cervicornis (Haeckel). - HAECKEL, 1887, p. 228. - BENSON, 1966, p. 172, pl. 6, fig. 1.

Elaphococcus gaussi POPOFSKY, 1912, p. 100, pl. 6, fig. 1.

Genus *Arachinosphaera* Haeckel, 1862
Arachnosphaera myriacantha Haeckel
Plate 10, figures 11, 12

Arachnosphaera myriacantha HAECKEL, 1862, p. 357, pl. 10, fig. 3, pl. 11, fig. 4; 1887, p. 268. - TAN AND TCHANG, 1976, p. 232, text-fig. 8.

Arachnosphaera hexasphaera POPOFSKY, 1912, p. 108, text-figs. 19–21. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 2, fig. 13.

Arachnosphaera sp.
Plate 7, figure 12

DESCRIPTION: Shells 7–8 concentric latticed sphere with branched spines of 1/2 of outermost shell diameter.

Genus *Leptosphaera* Haeckel, 1887
Leptosphaera minuta ? Popofsky
Plate 7, figure 11

? *Leptosphaera minuta* POPOFSKY, 1912, p. 104, text-fig. 14.

REMARKS: This species has two layers of fragile cortical shell whereas Popofsky described only one layer.

Leptosphaera sp. group

Leptosphaera sp. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, figs. 19, 20.

Genus *Actinosphaera* Hollande and Enjumet, 1960
Actinosphaera tenella (Haeckel)
Plate 9, figure 1

Haliomma tenellum HAECKEL, 1862, p. 428; 1887, p. 236.

Haliomma spinulosa aff. MÜLLER, 1858a, p. 40, pl. 4, fig. 7.

Actinosphaera capillaceum (Haeckel). - HOLLANDE AND ENJUMET, 1960 (*partim*), pl. 52, fig. 3 (only).

Actinosphaera acanthophora (Popofsky)
Plate 9, figures 2, 3

Haliomma acanthophora POPOFSKY, 1912, p. 101, text-fig. 13. - DUMITRICĂ, 1972, p. 832, pl. 20, figs. 1, 2.

Actinosphaera capillacea (Haeckel)
Plate 9, figures 4, 5

Haliomma capillaceum HAECKEL, 1862, p. 426, pl. 23, fig. 2; 1887, p. 236.

Haliomma erinaceum HAECKEL, 1862, p. 427, pl. 23, figs. 3, 4; 1887, p. 236.

Actinosphaera capillaceu (Haeckel). - HOLLANDE AND ENJUMET 1960 (*partim*), pl. 52, figs. 1, 2 (only).

Genus *Haliomma* Ehrenberg, 1838
Haliomma castanea Haeckel
Plate 9, figures 7, 11

Haliomma castanea HAECKEL, 1862, p. 428, pl. 24, fig. 4; 1887, p. 232.

Haliomma ? sp. A
Plate 8, figure 12

DESCRIPTION: Cortical shell thin, usually hexagonally meshed with spines of one kind which extend from thick and thorny medullary shell surface to outside of the cortical shell up to 1/3 of shell radius.

REMARKS: Medullary shell is tentatively considered to be one sphere under SEM observations.

Haliomma sp. B
Plate 12, figure 15

DESCRIPTION: Two concentric shells with circular pores of slightly different size. Some of the spines radiate from the inner shell.

REMARKS: This species is similar to *Cladococcus simplex* HAECKEL (1860a, p. 800), *Rhaphidococcus simplex* (Haeckel) (1862, p. 336, pl. 13, figures 5, 6), and *Acanthosphaera simplex* (Haeckel) (1887, p. 216). Differences are that the shell size is about one half of those described by Haeckel, and the spines are straight.

Genus *Heliosoma* Haeckel, 1881
Heliosoma spp. aff. *radians* Haeckel
Plate 9, figures 6, 8

Heliosoma radians HAECKEL, 1887, p. 240, pl. 28, fig. 3.

Genus *Elatomma* Haeckel, 1887
Elatomma penicillus Haeckel
Plate 9, figures 9, 10

Elatomma penicillus HAECKEL, 1887, p. 243.

Genus *Haeckeliella* Hollande and Enjumet, 1960
Haeckeliella macrodoras (Haeckel)
Plate 10, figures 1–4

Haeckeliella macrodoras (Haeckel). - HOLLANDE AND ENJUMET, 1960, p. 119, pl. 56, figs. 2–6.

? *Elatomma pinetum* HAECKEL, 1887, p. 242.

? *Cladococcus stalactites* HAECKEL ?, 1887, p. 227, pl. 27, fig. 4. - BENSON, 1966, p. 173, pl. 6, figs. 2, 3.

Genus *Astrosphaera* Haeckel, 1887
Astrosphaera hexagonalis Haeckel
Plate 11, figures 1–3

Astrosphaera hexagonalis HAECKEL, 1887, p. 250, pl. 19, fig. 4. - MAST, 1910, p. 174. - POPOFSKY, 1912, p. 105, text-fig. 16, pl. 8, fig. 2. - RENZ, 1976, p. 100, pl. 2, fig. 12. - TAN AND TCHANG, 1976, pp. 228–229, text-figs. 4a, 4b. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 2, fig. 12.

REMARKS: Generally bi-spines are very short but some specimens (e.g., Plate 11, figure 3) have long wavy bi-spines.

Genus *Drymosphaera* Haeckel, 1881
Drymosphaera dendrophora Haeckel
Plate 11, figure 4

Drymosphaera dendrophora HAECKEL, 1887, pp. 249–250, pl. 20, figs. 1, 1a, 1b. - TAN AND TCHANG, 1976, pp. 229–230, text-figs. 5a, 5b.

Genus *Sphaeropyle* Dreyer, 1889
Sphaeropyle mespilus ? Dreyer
Plate 11, figures 7, 8

? *Sphaeropyle mespilus* DREYER, 1889, p. 207, pl. 8, fig. 39.

REMARKS: See Dumitrică (1972) for a closely related species *Actinosphaera haackei* (Dreyer).

Genus *Thecosphaera* Haeckel, 1881
Thecosphaera inermis (Haeckel)
Plate 11, figure 9

Haliomma inerme HAECKEL, 1860a, p. 815.

Actinomma inerme HAECKEL, 1862, p. 440, pl. 24, fig. 5.

Thecosphaera inermis HAECKEL, 1887, p. 80.

Thecosphaera inermis (Haeckel). - BOLTOVSKOY AND RIEDEL, 1980, p. 114, pl. 3, fig. 6.

Genus *Cromyomma* Haeckel, 1881
Cromyomma villosum Haeckel
Plate 11, figures 10, 11

Cromyomma villosum HAECKEL, 1887, p. 261, pl. 30, fig. 2.

Genus *Xiphosphaera* Haeckel, 1881
Xiphosphaera gaea Haeckel
Plate 12, figures 1, 2

Xiphosphaera gaea HAECKEL, 1887, p. 123, pl. 14, fig. 5. - DREYER, 1913, p. 15, pl. 2, fig. 5.

Xiphosphaera tesseractis Dreyer
Plate 12, figures 3–5

Xiphosphaera tesseractis DREYER, 1913, p. 10, pl. 2, figs. 3, 3a, 4. - RENZ, 1976, p. 106, pl. 2, fig. 2. - MCMILLEN AND CASEY, 1978, pl. 1, fig. 18. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 9.

Genus *Staurolonche* Haeckel, 1881
Staurolonche sp. A group

Staurolonche group. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 3, fig. 7.

Staurolonche ? sp. B

Staurolonche ? sp. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 3, fig. 8

Genus *Stauracontium* Haeckel, 1881
Stauracontium sp.
Plate 12, figure 6

Genus *Hexastylus* Haeckel, 1881
Hexastylus triaxonius Haeckel
Plate 12, figures 7, 8

Hexastylus triaxonius HAECKEL, 1887, p. 175, pl. 21, fig. 2. - BENSON, 1966, p. 140, pl. 3, figs. 6, 7.

Hexastylus dictyotus HAECKEL, 1887, p. 76, pl. 21, figs. 8, 9.

Hexastylus sp.
Plate 12, figure 9

DESCRIPTION: Cortical shell spherical with mesh size of 3–4 times as wide as interporous bars. Six three-bladed spines of as long as shell diameter radiating from the cortical shell on perpendicular planes.

Genus *Hexalonche* Haeckel, 1881
Hexalonche amphisiphon Haeckel
Plate 12, figures 13, 14

Hexalonche amphisiphon HAECKEL, 1887, p. 182, pl. 25, fig. 2.

REMARKS: Specimens with more than 6 main-spines have been observed.

Hexalonche sp. A
Plate 11, figures 14, 15

DESCRIPTION: Two small concentric shells latticed with six equal-sized long main-spines (3–3.5 times of shell diameter), straight or slightly curved, and many bi-spines of 1.5 length of shell diameter.

Hexalonche sp. B
Plate 12, figures 10, 11

Hexancistra sp. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 10.

Genus *Centrolonche* Popofsky, 1912
Centrolonche hexalonche Popofsky

Centrolonche hexalonche POPOFSKY, 1912, pl. 1, fig. 1. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 18.

Genus *Centracontarium* Popofsky, 1912
Centracontarium hexacontarium Popofsky

Centracontarium hexacontarium POPOFSKY, 1912, p. 90, text-fig. 4. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 17.

Genus *Hexacontium* Haeckel, 1881
Hexacontium hostile Cleve
Place 13, figures 1, 2

Hexacontium hostile CLEVE, 1900a, p. 9, pl. 6, fig. 4. - SCHRÖDER, 1909, p. 14, text-fig. 6. - GOLL AND BJØRKLUND, 1971, p. 449, text-fig. 6. - BOLTOVSKOY AND RIEDEL, 1980, p. 112, pl. 2, fig. 13.

Hexacontium pachydermum JØRGENSEN, 1905, p. 115, pl. 8, figs. 31a, 31b. - BJØRKLUND, 1976, pl. 1, figs. 4–9. - KLING, 1977, pl. 1, fig. 18.

? *Hexacontium setosum* HAECKEL, 1887, p. 198. - CLEVE, 1900a, p. 9, pl. 5, fig. 6. - SCHRÖDER, 1909, p. 13, text-fig. 5.

Hexacontium arachnoidale Hollande and Enjumet

Hexacontium arachnoidale HOLLANDE AND ENJUMET, 1960, p. 96, pl. 53, fig. 1. - BJØRKLUND, 1976b, p. 118, pl. 1, figs. D–F. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 13.

Hexacontium axotrias Haeckel
Plate 13, figure 3

Hexacontium axotrias HAECKEL, 1887, p. 192, pl. 24, fig. 3. - BOLTOVSKOY AND RIEDEL, 1980, p. 112, pl. 2, fig. 11. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 14.

REMARKS: Size of the shell corresponds to Boltovskoy and Riedel (1980) but much smaller than that illustrated by Haeckel (1887).

Hexacontium heracliti (Haeckel)
Plate 15, figures 8, 9

Hexalonche heracliti HAECKEL, 1887, p. 187, pl. 22, fig. 7.

Hexacontium cf. *heracliti* (Haeckel). - BENSON, 1966, p. 158, pl. 4, figs. 8–10.

Hexacontium hystricina (Haeckel)
Plate 15, figure 10

Hexalonche hystricina Haeckel, 1887, p. 187, pl. 25, fig. 6. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 16.

REMARKS: Generic name is changed here because two medullary shells were commonly observed in the Pacific stations.

Hexacontium sp. aff. *H. hostile* Cleve
Plate 13, figure 6

REMARKS: This species is similar to *H. hostile* but has finer mesh.

Hexacontium sp.
Plate 12, figure 12

Genus *Hexacromyum* Haeckel, 1881
Hexacromyum elegans Haeckel
Plate 13, figures 4, 5, 7

Hexacromyum elegans HAECKEL 1887, p. 201, pl. 24, fig. 9. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 15.

REMARKS: Specimens with seven spines are rarely observed.

Genus *Heterosphaera* MAST, 1910
Heterosphaera sp. A
Plate 13, figures 9, 10

DESCRIPTION: Cortical shell very thick, rough surface with regular and circular pores of equal size as large as thickness of the interporous bars, with 7–9 three bladed radial main-spines of shell diameter, long and numerous bi-spines as long as 1.3 shell diameter.

Heterosphaera sp. B
Plate 13, figure 8

REMARKS: Similar to *Heterosphaera* sp. A, but has four denticles in the pores.

Genus *Cromyechinus* Haeckel, 1881
Cromyechinus borealis (Cleve)

Actinomma boreale CLEVE, 1899, p. 26, pl. 1, fig. 5c.

Chromyomma boreale (Cleve). - JØRGENSEN, 1900, p. 59.

Cromyechinus borealis (Cleve). - JØRGENSEN, 1905, p. 117, pl. 8, fig. 35; pl. 9, figs. 36–37. - BJØRKLUND, 1974, p. 20, figs. 5–7; 1976a, pl. 2, figs. 7–15. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 2, fig. 8.

Cromyechinus sp. aff. *C. borealis* (Cleve)
Plate 13, figure 13

Cromyechinus ? sp.
Plate 13, figure 12

Genus *Stomatosphaera* Dreyer, 1889
Stomatosphaera sp. A
Plate 13, figure 14

REMARKS: Cortical shell ellipsoidal and smooth with circular pores of unequal size.

Stomatosphaera sp. B
Plate 13, figure 15

REMARKS: This and the following, sp. C, resemble *S. dinoceras* Dreyer (1889, p. 211, pl. 10, fig. 76), the type species of this genus, but differ in size of shell and pores and cortical shell surface texture.

Stomatosphaera sp. C
Plate 13, figure 16

REMARKS: About twice as large as the above sp. B, otherwise similar to that.

Genus *Stylacontarium* Popofsky, 1912
Stylacontarium bispiculum Popofsky

Stylacontarium bispiculum POPOFSKY, 1912, pl. 2, fig. 2. - BENSON, 1966, p. 141, pl. 3, figs. 8–11. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 11.

Genus *Stylosphaera* Ehrenberg, 1847a
Stylosphaera melpomene Haeckel
Plate 14, figures 1, 2

Stylosphaera melpomene HAECKEL, 1887, p. 135, pl. 16, fig. 1. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 2, fig. 14.

Stylosphaera lithatractus Haeckel

Stylosphaera lithatractus HAECKEL, 1887, pl. 16, figs. 4, 5. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 3, fig. 1.

Stylosphaera ? sp. A
Plate 11, figures 5, 6

REMARKS: Lacking in polar spines and thus the generic name is tentative.

Stylosphaera ? sp. B
Plate 14, figure 5

Genus *Druppatractus* Haeckel, 1887
Druppatractus ostracion Haeckel group
Plate 14, figures 3, 4

? *Druppatractus ostracion* HAECKEL, 1887, p. 326, pl. 16, figs. 8, 9

Genus *Ellipsoxiphium* Haeckel, 1887
Ellipsoxiphium palliatum Haecker
Plate 14, figures 11–17

Ellipsoxiphium palliatum HAECKER, 1908a, p. 441, pl. 84, fig. 587.

Druppatractus acquilonius Hays. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 3, fig. 5.

non *Ellipsoxiphus elegans* var. *palliatus* Haeckel, 1887, p. 296, pl. 14, fig. 7.

non *Druppatractus acquilonius* HAYS, 1970, p. 214, pl. 1, figs. 4, 5.

DESCRIPTION: Two medullary shells spherical to ellipsoidal. Inner cortical shell ellipsoidal and thick with circular pores of relatively uniform size which is about 2–2.5 times as large as the thickness of interporous bars. There are about ten pores on a half equator. Outer cortical shell extremely thin and delicate, consisting of a polygonal meshwork close to the inner cortical shell. The meshwork is connected everywhere with inner cortical shell's interporous bars and hence it resembles a form of bi-spines in poorly developed or extensively dissolved specimens. Polar spines dissimilar in length, having ratio of 1:2. The spines are cylindrical up to halfway and become conical distally. The bases of the spines are simply jointed with the inner cortical shell and almost not bladed.

DIMENSIONS: (12 specimens) Length of inner cortical shell major axis: 146 ± 22 μm (2 S.D.); range 148–207 μm. Length of inner cortical shell minor axis: 154 ± 17 μm (2 S.D.); range 136–179 μm. Length of major polar spine: 103 ± 12 μm (2 S.D.); range: 91–119 μm. Length of minor polar spine: 51 ± 7 μm (2 S.D.); range: 38–80 μm. Length of outer medullary shell major axis: 45–60 μm.

REMARKS: This species resembles *D. acquilonius* Hays (HAYS, 1970, p. 214, p. 1, figs. 4, 5. - KLING, 1971, p. 1086, pl. 1, figs. 5, 6. - LING, 1975, p. 717, pl. 1, figs. 17, 18; 1980, p. 367, pl. 1, fig. 1; *Stylacantarium acquilonium* (Hays) KLING, 1973, p. 634, pl. 1, figs. 17–20 and pl. 14, figs. 1–4. - LING, 1973, p. 777, pl. 1, figs. 6, 7) but length of the dissimilar polar spines is generally longer and ratio between the spines differs. Delicate meshwork of the outer cortical shell similar to this species has been recorded on some specimens of *D. acquilonius* (see Ling, 1975, pl. 1, figs. 17, 18; Kling, 1973, pl. 14, fig. 2). It is possible that *D. acquilonius* gave rise to the present species. The polar spines are always cylindro-conical, and not three-bladed, and thus the present species differs from *Ellipsoxiphus elegans* var. *palliatus* Haeckel (1887, p. 296, pl. 14, fig. 7).

Genus *Amphisphaera* Haeckel, 1881
Amphisphaera group
Plate 14, figures 6, 7

Amphisphaera group. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 3, fig. 3.

Genus *Axoprunum* Haeckel, 1887
Axoprunum stauraxonium Haeckel
Plate 14, figures 8–10

Axoprunum stauraxonium HAECKEL, 1887, p. 298, pl. 48, fig. 4. - HAYS, 1965, p. 170, pl. 1, fig. 3. - PETRUSHEVSKAYA AND KOZLOVA, 1972, p. 521, pl. 10, fig. 10. - NIGRINI AND MOORE, 1979, p. S57, pl. 7, figs. 2, 3.

? *Cromyatractus elegans* Dogel. - DUMITRICĂ, 1972, p. 834, pl. 20, fig. 8.

? *Amphisphaera cristata* Carnevale. - DUMITRICĂ, 1972, pp. 833–834, pl. 20, fig. 10.

REMARKS: Specimens observed here have thinner shell and smoother surface than those described by Hays (1965) and Nigrini and Moore (1979). Interconnecting rods between medullary and cortical shells lie in the equatorial plane as Petrushevskaya and Kozlova (1972) noted.

Genus *Xiphatractus* Haeckel, 1887
Xiphatractus pluto (Haeckel)
Plate 15, figures 1–3

Amphisphaera pluto HAECKEL, 1887, p. 144, pl. 17, figs. 7, 8.

? *Stylatractus neptunus* Haeckel, 1887, p. 328, pl. 17, fig. 6. - RIEDEL, 1958, p. 226, pl. 1, fig. 9.

Xiphatractus pluto (Haeckel). - BENSON, 1966, p. 184, pl. 7, figs. 14–17.

? *Xiphatractus cronos* (Haeckel). - BENSON, 1966, p. 182, pl. 7, figs. 12, 13.

? *Stylatractus* sp. - NIGRINI AND MOORE, 1979, p. S55, pl. 7, figs. 1a, 1b.

Xiphatractus sp. A
Plate 15, figure 4

? *Xiphatractus stahli* DREYER, 1889, p. 129, pl. 6, fig. 17.

Xiphatractus pluto ? (Haeckel). - TAKAHASHI AND HONJO, 1981, p. 147, pl. 3, fig. 4.

DESCRIPTION: Two medullary shells are slightly ellipsoidal. Cortical shell thick and thorny with dissimilar thick and short polar spines.

Xiphatractus sp. B
Plate 15, figures 6, 7

DESCRIPTION: Cortical shell single and medullary shell double. The cortical and outer medullary shells are ellipsoidal and made of hexagonal framework. The cortical shell has short bi-spines or conical projections at every intersection of interporous bars and has circular or hexagonal pores 2–4 times as large as the thickness of the interporous bars. The outer medullary shell has circular pores bounded by interporous bars of the same width as the pore diameter. Cortical-medullary interconnecting rods, which arise from every intersection of the medullary framework, lie in many planes. Two polar spines are short, smooth conical shape and dissimilar in length.

REMARKS: There are variations among specimens in pore size and shape as well as length of spines; these characteristics may correspond to more than one species.

Genus *Druppatractus* Haeckel, 1887
Druppatractus ? sp.
Plate 15, figure 5

REMARKS: This species is similar to *Druppatractus* ? sp. (Dumitrică, 1972, p. 833, pl. 20, fig. 5).

Genus *Dorydruppa* Vinassa de Regny, 1898
Dorydruppa bensoni Takahashi, new name
Plate 15, figures 11–14

? *Haliomma pyriformis* BAILEY, 1856, p. 2, pl. 1, fig. 29.

Druppatractus cf. *pyriformis* (Bailey). -BENSON, 1966, pp. 177–180, pl. 7, figs. 2–6.

DESCRIPTION: Medullary shell single and pear-shaped with circular pores of equal size and spines which become interconnecting rods when cortical shell is present. Cortical shell absent or single, usually thick but variable and rarely thick and hexagonally framed with single three-bladed polar spine of as long as length of the medullary shell main axis.

DIMENSIONS: (8 specimens): Length of cortical shell major axis: 74–91 μm; Length of medullary shell major axis: 47–58 μm; Length of medullary shell minor axis: 36–45 μm.

TYPE LOCALITY: 15°21.1′N, 151°28.5′W; sediment trap at 4,280 m; collected during July–November 1978.

REMARKS: Bailey (1856) illustrated a pear-shaped (*pyriformis*) shell which may or may not correspond to medullary shell of the present species. However, he did not illustrate nor describe for the cortical shell, hence Benson (1966) was the first to describe the species. *Druppatractus irregularis* Popofsky (1913, pp. 114–115, text-figs. 24–26. -BENSON, 1966, p. 180, pl. 7, figs. 7–11) has a pear-shaped medullary shell similar to the present species, but differs primarily in cortical mesh size.

DERIVATION OF NAME: This species is named after Dr. Richard N. Benson.

Subfamily SATURNALINAE Deflandre, 1953

DEFINITION: Spherical latticed or spongy shell, with two opposite spines joined by a ring. In some species, there are no spines and the ring (or two incomplete half-rings) joins the shell directly (Riedel, 1971).

Genus *Saturnalis* Haeckel, 1881, emend. Nigrini, 1967
Saturnalis circularis Haeckel
Plate 15, figures 15–18

Saturnalis circularis HAECKEL, p. 131. - NIGRINI, 1967, p. 25, pl. 1, fig. 9. - RENZ, 1976, p. 107, pl. 1, fig. 15. See Nigrini (1967) for a more complete synonymy.

Family COCCODISCIDAE Haeckel, 1862, emend. Sanfilippo and Riedel, 1980

DEFINITION BY SANFILIPPO AND RIEDEL (1980): Discoidal forms consisting of a lenticular cortical shell enclosing a small single or double medullary shell, and surrounded by an equatorial zone of spongy or concentrically-chambered structure, or forms with ellipsoidal cortical shell, usually equatorially constricted and enclosing a single or double medullary shell, the opposite poles of the shell generally bearing spongy columns and/or single or multiple latticed caps.

Subfamily ARTISCINAE Haeckel, 1881, emend. Riedel, 1967

DEFINITION: Ellipsoidal coccodiscids (Sanfilippo and Riedel, 1980).

Genus *Didymocyrtis* Haeckel, 1881, emend. Riedel, 1971
Didymocyrtis tetrathalamus tetrathalamus (Haeckel)
Plate 21, figures 1–14

Panartus tetrathalamus HAECKEL, 1887, p. 378, pl. 40, fig. 3. - NIGRINI, 1967, p. 30, pl. 2, figs. 4a–4d.

Ommatartus tetrathalamus (Haeckel). - RENZ, 1976, p. 107, pl. 1, fig. 6. - MCMILLEN AND CASEY, 1978, pl. 2, figs. 13a, 13b. - BOLTOVSKOY AND RIEDEL, 1980, p. 114, pl. 3, fig. 3. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 4, figs. 2–6 (including both subspp. A and B).

Ommatartus tetrathalamus tetrathalamus (Haeckel). - NIGRINI AND MOORE, 1979, p. S49, pl. 6, figs. 1a–1d. - JOHNSON AND NIGRINI, 1980, p. 121, pl. 1, fig. 17.

REMARKS: Major thick cortical-medullary interconnecting rods lie in the vicinity of equatorial plane and additional minor (thin) rods lie randomly. Development of delicate cortical lateral meshwork as well as polar caps varies significantly. Distinction of two separate forms (subspp. A and B) was possible only at Station E. Juvenile form (Plate 21, figure 1) of this species is counted separately and reported in the flux table. See Sanfilippo and Riedel (1980, p. 1010) for assignment of the generic name for this species.

Didymocyrtis sp.
Plate 21, figure 15

DESCRIPTION: Cortical shell ellipsoidal and not constricted in the equatorial plane, with coarser meshwork than that of *D. tetrathalamus* and a few short spines. Double medullary shells same as those of *D. tetrathalamus*.

Genus *Spongoliva* Haeckel, 1887
Spongoliva ellipsoides Popofsky
Plate 22, figures 15, 16

Spongoliva ellipsoides POPOFSKY, 1912, p. 117, text-fig. 28. - RENZ, 1976, p. 108, pl. 1, fig. 5.

Spongoliva cf. *ellipsoides* Popofsky. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 1, fig. 17.

? *Spongoliva* cf. *ellipsoides* Popofsky. - BENSON, 1966, p. 190, pl. 8, fig. 6.

Family PORODISCIDAE Haeckel, 1881, emend. Petrushevskaya and Kozlova, 1972
For a definition see Petrushevskaya and Kozlova (1972, p. 524.)
Genus *Euchitonia* Ehrenberg, 1860b, emend. Haeckel, 1887
Euchitonia elegans (Ehrenberg)
Plate 16, figures 1–6

Pteractis elegans EHRENBERG, 1872a, p. 319; 1872b, p. 299, pl. 8, fig. 3.

Euchitonia elegans (Ehrenberg). - HAECKEL, 1887, p. 535. - NIGRINI, 1967, p. 39, pl. 4, figs. 2a, 2b. - NIGRINI AND MOORE, 1979, p. S83, pl. 11, figs. 1a, 1b. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 2, fig. 7. - TAKAHASHI AND HONJO, 1981, pl. 149, pl. 5, fig. 2.

Euchitonia, sp. - RENZ, 1976 (*partim*) p. 93, pl. 3, fig. 2.

REMARKS: Morphology of the patagium varies considerably but that of main spongy arms is fairly consistent.

Euchitonia cf. *furcata* Ehrenberg
Plate 16, figure 8

Euchitonia furcata EHRENBERG, 1860a, p. 767; 1980b, p. 832; 1872a, p. 308; 1872b, p. 289, pl. 6 (III), fig. 6. - HAECKEL, 1887, p. 532. - LING AND ANIKOUCHINE, 1967, p. 1484, pls. 189, 190, figs. 1–2, 5–7. - NIGRINI AND MOORE, 1979, p. S85, pl. 11, figs. 2a, 2b. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 3, fig. 6.

REMARKS: This taxon is usually much smaller than *E. elegans* and its spongy arms are truncated at the terminal ends. A patagium is rarely seen. Thus, the present taxon may be a juvenile form of *E. furcata*. Completely developed *E. furcata* was not observed in my samples.

Euchitonia sp.
Plate 16, figures 9–11

DESCRIPTION: Shell spongy triangular and plate shaped with three short arms tapering toward terminal ends. The plate surface is slightly convex on both sides. Shell size much smaller than that of *E. elegans*. A central chamber surrounded by centric rings is about equal in size to that of *D. profunda*.

REMARKS: This taxon may well be a juvenile or poorly developed form of other species (e.g., *D. profunda*).

Genus *Amphirhopalum* Haeckel, 1881
Amphirhopalum ypsilon Haeckel
Plate 17, figures 1–3

Amphicraspedum wyvilleanum HAECKEL, 1887, p. 523, pl. 45, fig. 12

Amphirhopalum ypsilon HAECKEL, 1887, p. 522. - NIGRINI, 1967, p. 35, pl. 3, figs. 3a–3d. - LING, 1975, p. 725, pl. 14, fig. 2. - NIGRINI AND MOORE, 1979, pp. S75–S77, pl. 10, figs. 1a–1e. - BOLTOVSKOY AND RIEDEL, 1980, p. 117, pl. 3, fig. 16. - JOHNSON AND NIGRINI, 1980, p. 121, pl, 2, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 5, fig. 1.

Amphirhopalum straussii (Haeckel)
Plate 17, figure 4

Tessarastrum straussii HAECKEL, 1887, p. 547, pl. 45, fig. 8. - RENZ, 1976, p. 112, pl. 3, fig. 7.

Amphirhopalum cf. *Tessarastrum straussii* Haeckel. - JOHNSON AND NIGRINI, 1980, p. 121, pl. 2, fig. 4; pl. 5, figs. 1, 2.

Genus *Stylodictya* Ehrenberg, 1847a
Stylodictya validispina Jørgensen
Plate 19, figure 11

Stylodictya validispina JØRGENSEN, 1905, p. 119, pl. 10, figs. 40a, 40b. - NIGRINI AND MOORE, 1979, p. S103, pl. 13, figs. 5a, 5b.

Stylodictya multispina Haeckel
Plate 20, figures 5, 10, 12

Stylodictya multispina HAECKEL, 1860b, p. 842; 1862, p. 496, pl. 29, fig. 5. - RENZ, 1976, p. 111, pl. 3, fig. 13. - MCMILLEN AND CASEY, 1978, pl. 2, fig. 17. - BOLTOVSKOY AND RIEDEL, 1980, p. 118, pl. 4, figs. 4a–4b. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 5, fig. 10.

Stylodictya ? sp.
Plate 19, figures 12, 13

Genus *Circodiscus* Kozlova, 1972
Circodiscus sp. group
Plate 20, figures 6–9

Ommatodiscus murrayi Dreyer. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 5, fig. 11.

DESCRIPTION: Shell circular to elliptical and biconvex lenticular disc with a pylome, numerous very small pores, 2 to 4 central rings, and with or without spines.

REMARKS: Observed major differences among specimens are number of the central rings and presence/absence of marginal or lateral spines. *Porodiscus microporus* (Stohr) illustrated by Renz (1976, p. 109, pl. 3, fig. 15) is very similar to this group. *Ommatodiscus murrayi* Dreyer (1889, pl. 9, fig. 56) is included in this group. The generic name assigned here is that of Kozlova in Petrushevskaya and Kozlova (1972, p. 526).

Genus *Stylochlamydium* Haeckel, 1881
Stylochlamydium venustum (Bailey)
Plate 20, figure 11

Perichlamidium venustum BAILEY, 1856, p. 5, pl. 1, figs. 16, 17.

Stylochlamydium venustum (Bailey). - HAECKEL, 1887, p. 515. - LING ET AL., 1971, p. 711, pl. 1, figs. 7, 8, text-fig. 5. - RENZ, 1976, p. 110, pl. 3, fig. 11. - BOLTOVSKOY AND RIEDEL, 1980, p. 118, pl. 4, fig. 3.

Spongotrochus ? *venustum* (Bailey). - NIGRINI AND MOORE, 1979, p. S119, pl. 15, figs. 3a, 3b.

Stylochlamydium asteriscus Haeckel

Stylochlamydium asteriscus HAECKEL, 1887, p. 514, pl. 41, fig. 10. - RENZ, 1976, p. 109, pl. 3, fig. 12. - MCMILLEN AND CASEY, 1978, pl. 2, fig. 20. - BOLTOVSKOY AND RIEDEL, 1980, p. 118, pl. 4, fig. 2.

Genus *Porodiscus* Haeckel, 1881
Porodiscus micromma (Harting)
Plate 20, figures 13, 14

Flustrella micromma HARTING, 1863, p. 16, pl. 3, fig. 47.

Porodiscus micromma (Harting). - BOLTOVSKOY AND RIEDEL, 1980, p. 117, pl. 3, fig. 17. -TAKAHASHI AND HONJO, 1981, p. 149, pl. 5, figs. 7, 8.

Family SPONGODISCIDAE Haeckel, 1862, emend. Riedel, 1967a
and Petrushevskaya and Kozlova, 1972

DEFINITION: Discoidal, spongy or finely-chambered skeleton which is disposed irregularly or in a dense spiral, or in closely disposed spheres, with or without surficial pore-plate, often with radiating arms or marginal spines, and without a large central phacoid shell. The central chamber is usually not visible (Riedel, 1971; Petrushevskaya and Kozlova, 1972).

Genus *Spongobrachium* Haeckel, 1881
Spongobrachium sp.

Spongobrachium sp. -JOHNSON AND NIGRINI, 1980, p. 127, text-fig. 8f; pl. 2, fig. 13; pl. 5, fig. 3.

Genus *Dictyocoryne* Ehrenberg, 1860b
Dictyocoryne profunda Ehrenberg
Plate 16, figures 10, 12, 13, 15

Dictyocoryne profunda EHRENBERG, 1860a, p. 767; 1872a, p. 307; 1872b, p. 288, pl. 7, fig. 23. - HAECKEL, 1887, p. 592. - NIGRINI AND MOORE, 1979, p. S87, pl. 12, fig. 1. - BOLTOVSKOY AND RIEDEL, 1980, p. 115, pl. 3, fig. 10. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 2, fig. 9.

Hymeniastrum euclidis HAECKEL, 1887, p. 531, pl. 43, fig. 13. - BENSON, 1966, p. 222, pl. 12, figs. 1–3. - LING AND ANIKOUCHINE, 1967, p. 1488, pl. 191, fig. 3; pl. 192, fig. 3. - NIGRINI, 1970, p. 168, pl. 2, fig. 4, text-fig. 16. - NIGRINI AND MOORE, 1979, p. S91, pl. 12, fig. 3. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 2, fig. 11. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 5, figs. 3–5.

Dictyocoryne truncatum (Ehrenberg)
Plate 16, figure 14

Rhopalodictyum truncatum EHRENBERG, 1861b, p. 301. - HAECKEL, 1887, p. 589.

Dictyocoryne cf. *truncatum* (Ehrenberg). - BENSON, 1966, p. 235, pl. 15, fig. 1.

Dictyocoryne truncatum (Ehrenberg). - NIGRINI AND MOORE, 1979, p. S89, pl. 12, figs. 2a, 2b. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 2, fig. 10.

REMARKS: The specimen illustrated (Plate 16, figure 14) is an end member of the present population close to *D. profunda*. This species usually has much wider arms, which are truncated, and the corners are more rounded than in the illustrated specimen.

Genus *Spongodiscus* Ehrenberg, 1854
Spongodiscus resurgens Ehrenberg
Plate 19, figure 1

Spongodiscus resurgens EHRENBERG, 1854, p. 21, pl. 35B, fig. 16. - HAECKEL, 1887, p. 577. - PETRUSHEVSKAYA AND KOZLOVA, 1972, p. 528, pl. 21, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 4, fig. 11.

Spongodiscus resurgens resurgens Ehrenberg. - PETRUSHEVSKAYA AND BJØRKLUND, 1974, p. 40, text-fig. 6.

Spongodiscus biconcavus Haeckel
Plate 19, figures 4–6

Spongodiscus biconcavus HAECKEL, 1887, p. 577. - POPOFSKY, 1912, p. 143, pl. 6, fig. 2. - TAN AND TCHANG, 1976, p. 255, text-fig. 25.

Spongaster disymmetricus (Dogel). - PETRUSHEVSKAYA AND KOZLOVA, 1972, p. 528, pl. 21, fig. 14.

"Elliptical" spongodiscid. - MCMILLEN AND CASEY, 1978, pl. 3, fig. 13.

REMARKS: See Boltovskoy and Riedel (1980) for a more complete synonymy.

Spongodiscus sp. A
Plate 16, figure 7

Spongodiscus sp. aff. *S. resurgens* Ehrenberg. - RENZ, 1976, p. 96, pl. 3, fig. 10.

Spongodiscus sp. A. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 4, fig. 13.

Spongodiscus sp. B group
Plate 19, figures 2, 3

Genus *Spongotrochus* Haeckel, 1860b
Spongotrochus glacialis Popofsky
Plate 19, figure 10

Spongotrochus glacialis POPOFSKY, 1908, p. 228, pl. 26, fig. 8; pl. 27, fig. 1; pl. 28, fig. 2. - RIEDEL, 1958, p. 227, text-fig. 1; pl. 2, figs. 1, 2. - CASEY, 1971b, p. 337, pl. 23.1 , figs. 4, 5. - KEANY, 1979, p. 54, pl. 2, fig. 7; pl. 5, fig. 7. - BOLTOVSKOY AND RIEDEL, 1980, p. 117, pl. 3, fig. 15. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 4, fig. 17.

Spongotrochus arachnius Haeckel. - POPOFSKY , 1908, p. 227, pl. 26, figs. 5, 6, 6a, 7; pl. 28, fig. 1.

Spongotrochus multispinus Haeckel. - RENZ, 1976, p. 97, pl. 3, fig. 9.

Spongotrochus sp. A
Plate 19, figure 7

DESCRIPTION: Shell circular flat disc, with numerous fine spines arising from surface as well as edge of the disc, pores small and irregular, and without a pylome.

Spongotrochus sp. B. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 4, fig. 19.

Genus *Stylospongia* Haeckel, 1862

Stylospongia huxleyi Haeckel
Plate 19, figure 8

Stylospongia huxleyi HAECKEL, 1862, p. 473, pl. 28, fig.7.

Stylotrochus huxleyi (Haeckel). - HAECKEL, 1887, p. 586.

Genus *Spongurus* Haeckel, 1862

Spongurus cylindricus Haeckel
Plate 17, figures 6–9

Spongurus cylindricus HAECKEL, 1860b, p. 845; 1862, p. 465, pl. 27, fig. 1; 1887, p. 334. - DUMITRICĂ, 1972, p. 834, pl. 11, fig. 2; pl. 18, fig. 23.

Spongocore diplocylindrica HAECKEL, 1887, p. 346. - RENZ, 1976, p. 95, pl. 3, fig. 8.

Spongocore puella HAECKEL, 1887, p. 347, pl. 48, fig. 6. - BENSON, 1966, p. 187, pl. 8, figs. 1–3. - NIGRINI, 1970, p. 168, pl. 2, fig. 3. - CASEY, 1971b, p. 341, pl. 23.3, fig. 20. - NIGRINI AND MOORE, 1979, p. S69, pl. 8, figs. 5a–5c. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 4, fig. 20.

Spongocore cylindrica (Haeckel). - BOLTOVSKOY AND RIEDEL, 1980, p. 116, pl. 3, fig. 12.

REMARKS: The predated species name *cylindricus* should replace the widely used name *puella*, because the long spines of *cylindricus* are dissolved and consequently broken off and become like *puella*. See Dumitrică (1972) for use of the present generic name.

Genus *Spongopyle* Dreyer, 1889
Spongopyle setosa Dreyer
Plate 19, figure 9

Spongopyle setosa DREYER, 1889, p. 119, pl. 11, figs. 97, 98. - ? BOLTOVSKOY AND RIEDEL, 1980 (*partim*), p. 116, pl. 3, fig. 14.

Spongopyle osculosa Dreyer
Plate 20, figures 1–4

Spongopyle osculosa DREYER, 1889, p. 42, pl. 11, figs. 99, 100. - RIEDEL, 1958, p. 226, pl. 1, fig. 12. - NIGRINI AND MOORE, 1979, p. S115, pl. 15, fig. 1.

Genus *Spongaster* Ehrenberg, 1860b
Spongaster tetras tetras Ehrenberg
Plate 17, figures 10, 11

Spongaster tetras EHRENBERG, 1860b, p. 833; 1872b, p. 299, pl. 6, fig. 8. - HAECKEL, 1887, p. 597. - CASEY, 1971b, p. 341, pl. 23.3, figs. 18, 19. - GOLL AND BJØRKLUND, 1974, p. 64, text-fig. 14. - BOLTOVSKOY AND RIEDEL, 1980, p. 116, pl. 3, fig. 11.

Spongaster tetras tetras Ehrenberg. - NIGRINI, 1967, p. 41, pl. 5, figs. 1a, 1b; 1970, p. 169, pl. 2, fig. 7. - RENZ, 1976, p. 94, pl. 3, fig. 4. - NIGRINI AND MOORE, 1979, p. S93, pl. 13, fig. 1. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 2, fig. 13. - TAKAHASHI AND HONJO, 1981, 148, pl. 4, fig. 9. For a more complete synonymy see Nigrini (1967).

Spongaster pentas Riedel and Sanfilippo
Plate 17, figures 12–16

Spongaster pentas RIEDEL AND SANFILIPPO, 1970, p. 523, pl. 15, fig. 3; 1971, p. 1589, pl. 1D, figs. 5–7; 1978, p. 74, pl. 2, figs. 5–8. - MCMILLEN AND CASEY, 1978, pl. 3, fig. 14.

Spongaster cf. *pentas* Riedel and Sanfilippo. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 4, fig. 10.

DESCRIPTION: Spongy disc, typically pentagonal to hexagonal and often up to decagonal. Central area of the disc is elevated and forms a convex mound on one side and a concave depression on the other. The convex mound has much coarser spongy mesh than the rest of the area. The concave area has fine short spines perpendicular to disc plane.

Family MYELASTRIDAE Riedel, 1971

ORIGINAL DEFINITION: Spongodiscidae with arms much more delicately constructed than the small central area, which is the only part of the skeleton sufficiently robust to be preserved in sediments.

REMARKS: Subfamily Myelastrinae of Riedel (1971) is elevated to family level here.

Genus *Myelastrum* Haeckel, 1881, emend. herein

DEFINITION: Porodiscidae with three or four forked, spongy or chambered arms, without a patagium; shell bilaterally symmetric. In the case of three armed species, at least two arms of equal shape and length. In the case of four armed species, two equal anterior arms of different shape from the two equal posterior arms.

REMARKS: Haeckel's (1887) definition includes only four forked forms. An appearance of three forked species which is closely related to the four forked group necessitates either establishment of a new genus or emendation of the existing genus. I hereby propose to emend Haeckel's definition.

Myelastrum quadrifolium Takahashi, n. sp.
Plate 18, figures 1–6

DESCRIPTION; Shell large, spongy disc, uniformly very thin and delicate, with four major arms. Central rings similar to those of *Euchitonia*. All of the four arms are about equal in length and width. Anterior arms are bifurcated and form lobes with slight incisions. Posterior arms are trifurcated and form lobes with more conspicuous incisions than those of the anterior. Sagital incisions at the posterior end are deep and varying in width from one specimen to another, but the anterior one is shallow. Transverse incisions are shallow.

DIMENSIONS: Length: 704 ± 49 μm (2 S.D.) (n = 12 specimens); width: 757 ± 51 μm (2 S.D.) (n = 12); weight: 2.32 ± 0.16 μg (n = 13).

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap at 3,791 m; collected during August–December 1979.

REMARKS: The present species differs from *Myelastrum decaceros* Haeckel (1887, p. 554, pl. 47, fig. 7) in sagital and transverse incisions, width ratio between anterior and posterior arms and number of branched subarms. The delicate arms are often almost invisible in Cargile^R type B mounting medium, but the central rings are clearly visible.

DERIVATION OF NAME: The name of this species is the Latin meaning having the nature of four leaves.

Myelastrum trinibrachium Takahashi, n. sp.
Plate 18, figures 7–12

DESCRIPTION: Shell large, uniformly very thin, delicate spongy disc with three tapering arms. Central rings similar to those of *Euchitonia*. At least a pair of arms equal in shape and length, and the remaining one equal or slightly different in length (longer or shorter). Length of arms 2–6 times diameter of the outermost ring.

DIMENSIONS: Length between terminal ends of the two longest arms: 1027 ± 120 μm (2 S.D.) (n = 7 specimens); weight: 0.75 ± 0.13 μg (n = 16).

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap at 1,268 m; collected during August–December 1979.

REMARKS: The concentric central rings as well as three arms are generally slightly more conspicuous than those of *M. quadrifolium* in Cargile^R type B mounting medium. This species and *M. quadrifolium* are so thin and delicate that specimens are easily broken with the touch of a brush. Observations of skeletal cross sections under TEM show solid nature. However, the skeletons of the arms are so thin that only the central rings may be preserved in the bottom sediments.

DERIVATION OF NAME: The name of this species is the Latin meaning having the nature of three arms.

Family LARNACILLIDAE Haeckel, 1887

DEFINITION: Shell with open gates or annular constrictions; medullary shell trizonal.

Genus *Larnacalpis* Haeckel, 1887
Larnacalpis sp.
Plate 21, figures 16–18

Larnacalpis sp. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 1.

DESCRIPTION: Single ellipsoidal cortical shell connecting with outer medullary shell in manner similar to *Octopyle*, thus it looks as if constricted in equatorial plane in lateral view. Cortical shell pores 3–6 times as wide as interporous bars. Some specimens have two additional connecting bars to the medullary shell and/or a pylome with surrounding spines at one polar end. Medullary shell double.

Family PHACODISCIDAE Haeckel, 1881

DEFINITION: Single lenticular latticed cortical shell and single or double medullary shell; without chambered equatorial girdles.

Genus *Heliodiscus* Haeckel, 1862

Heliodiscus asteriscus Haeckel
Plate 23, figures 1–3

Heliodiscus asteriscus HAECKEL, 1887, p. 445, pl. 33, fig. 8. - NIGRINI, 1967, p. 32, pl. 3, figs. 1a, 1b; 1970, pl. 2, fig. 1. - RENZ, 1976, p. 92, pl. 2, fig. 1. - NIGRINI AND MOORE, 1979, p. 573, pl. 9, figs. 1, 2. - BOLTOVSKOY AND RIEDEL, 1980, p. 115, pl. 3, fig. 8. - JOHNSON AND NIGRINI, 1980, p. 121, pl. 2, fig. 2. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 4, figs. 7, 8.

Heliodiscus echiniscus Haeckel
Plate 23, figures 4–6

Heliodiscus echiniscus HAECKEL, 1887, p. 448, pl. 34, fig. 5. - NIGRINI, 1967, p. 34, pl. 3, figs. 2a, 2b. - JOHNSON AND NIGRINI, 1980, p. 121, pl. 2, fig. 3.

Heliodiscus asteriscoides HAECKER, 1907a, p. 22, fig. 7; 1908a, p. 444, pl. 83, figs. 578–580.

Heliodiscus ? sp.
Plate 22, figure 14

DESCRIPTION: Cortical shell bilaterally convex with numerous conical bispines and circular to subcircular unequal-sized pores of as wide as interporous bars. Major spines conical and thicker, but not much longer than the bi-spines, lie on the marginal edge. Shell size is about the same as *H. asteriscus* and *H. echiniscus*.

Family THOLONIIDAE Haeckel, 1887, emend. Campbell, 1954

DEFINITION: Cortical shell with 2 to 4 or more annular constrictions separated by 3 to 6 or more cupolas; constrictions in diagonal planes, cupolas in dimensive axes (Campbell, 1954).

Genus *Tholoma* Haeckel, 1887

Tholoma metallasson Haeckel
Plate 11, figures 12, 13

Tholoma metallasson HAECKEL, 1887, p. 672, pl. 10, fig. 13.

Cubotholus regularis Haeckel. - RENZ, 1976, p. 113, pl. 1, fig. 18.

Family PYLONIIDAE Haeckel, 1881

DEFINITION: Cortical shell latticed; with 2 to 4 or more symmetrically disposed gates (Campbell, 1954).

Genus *Hexapyle* Haeckel, 1881
Hexapyle dodecantha Haeckel

Hexapyle dodecantha HAECKEL, 1887, p. 569, pl. 48, fig. 16. - RENZ, 1976, p. 113, pl. 1, fig. 11. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 3.

Hexapyle sp.
Plate 23, figure 7

REMARKS: This species is about 1/4 size of *H. dodecantha*.

Genus *Octopyle* Haeckel, 1881
Octopyle stenozona Haeckel
Plate 23, figure 8

Octopyle stenozona HAECKEL, 1887, p. 652, pl. 9, fig. 11. - BENSON, 1966, p. 251, pl. 16, figs. 3, 4. - NIGRINI AND MOORE, 1979, p. S123, pl. 16, figs. 2a, 2b. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 7.

Genus *Tetrapyle* Müller, 1858b
Tetrapyle octacantha Müller
Plate 23, figures 9, 10

Tetrapyle octacantha MÜLLER, 1858b, p. 154; 1858a, p. 33, figs. 1–6. - BENSON, 1966, p. 245, pl. 15, figs. 3–10. - MCMILLEN AND CASEY, 1978, pl. 3, figs. 2a, 2b. - NIGRINI AND MOORE, 1979, p. S125, pl. 16, figs. 3a, 3b. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, figs. 5, 6.

Family LITHELIIDAE Haeckel, 1862

DEFINITION: Planispiral cortical shell.

Genus *Larcopyle* Dreyer, 1889
Larcopyle butschlii Dreyer
Plate 22, figures 1–4

Larcopyle butschlii DREYER, 1889, pl. 10, fig. 10. - BENSON, 1966, p. 280, pl. 19, figs. 3–5. - NIGRINI AND MOORE, 1979, p. S131, pl. 17, figs. 1a, 1b. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 5, fig. 15.

Larcopyle sp. A
Plate 22, figure 5

DESCRIPTION: Cortical shell ovate and about 1/2 size of *L. butschlii* with irregular circular to subcircular pores of as wide as interporous bars, numerous short spines lie every 2–3 interporous bars on the cortical shell, and a pylome surrounded by divergent long spines.

Larcopyle sp. B
Plate 22, figure 6

DESCRIPTION: Cortical shell smooth, ovate and same size as the above *Larcopyle* sp. A with irregular subcircular pores of smaller than interporous wall, conical spines much less than the species A, and a pylome surrounded by divergent spines.

Genus *Discopyle* Haeckel, 1887
Discopyle elliptica Haeckel

Discopyle elliptica HAECKEL, 1887, p. 573, pl. 48, fig. 20. - TAKAHASHI AND HONJO, 1981, pl. 150, pl. 5, fig. 14.

Genus *Tholospira* Haeckel, 1887
Tholospira cervicornis Haeckel group
Plate 22, figures 7–9, 12

Tholospira cervicornis HAECKEL, 1887, p. 700, pl. 49, fig. 5.

Tholospira cervicornis Haeckel group. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 5, figs. 16–18.

REMARKS: The present species group is fairly abundant throughout depths in our sediment trap stations.

Tholospira dendrophora Haeckel
Plate 22, figure 11

Tholospira dendrophora HAECKAL, 1887, p. 700, pl. 49, fig. 6.

Genus *Lithelius* Haeckel, 1862
Lithelius minor ? Jørgensen
Plate 22, figure 10

Lithelius minor JØRGENSEN, 1900, pp. 65–66, pl. 5, fig. 24. - BENSON, 1966, p. 262, pl. 17, figs. 9, 10; pl. 18, figs. 1–4.

Larcospira minor (Jørgensen), 1905, p. 121.

Genus *Larcospira* Haeckel, 1887
Larcospira quadrangula Haeckel
Plate 23, figures 11, 12

Larcospira quadrangula Haeckel, 1887, p. 696, pl. 49, fig. 3. - BENSON, 1966, p. 266, pl. 18, figs. 7, 8. - NIGRINI, 1970, p. 169, pl. 2, fig. 9, text-fig. 21. - NIGRINI AND MOORE, 1979, p. S133, pl. 17, fig. 2. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 2.

Suborder NASSELLARIA EHRENBERG, 1875
Family PLAGIACANTHIDAE HARTWIG, 1879, emend. PETRUSHEVSKAYA, 1971d

DESCRIPTION: Plagiacanthidae with conical or ovate skeleton. Thorax nearly reduced. The apical spine may form a columella or may approach the front wall of the cephalis. The vertical spine is nearly always present. In the cephalis are developed eucephalic and antecephalic lobes. They are separated by means of the apical arches which extend in the walls of the cephalis and make deep furrows (Petrushevskaya, 1971d).

Subfamily PLAGIACANTHINAE HERTWIG, 1879, emend. PETRUSHEVSKAYA, 1971d

DEFINITION: Plagiacanthidae with thorax reduced. The walls of the cephalis also may be reduced. In such cases the skeleton consists only of the spines and arches. The disposition of these elements, unlike all other nasselarian families, may vary within the limits of one species. The central capsule of the appoaxoplastique type (Petrushevskaya, 1971d).

Genus *Tetraplecta* HAECKEL, 1881, emend. herein

DEFINITION: Plagiacanthidae with 4 equal radial spines, arising from either one of 2 closely located central points. The skeletons form a tetrahedron.

Tetraplecta pinigera Haeckel
Plate 24, figures 1–5

Tetraplecta pinigera HAECKEL, 1887, p. 924, pl. 91, fig. 8.

Plectaniscus cortiniscus HAECKEL, 1887, p. 925, pl. 91, fig. 9.

REMARKS: A priority on genus *Tetraplecta* is given over *Plectaniscus* (Haeckel, 1887) since specimens observed here have 4 equal spines. Haeckel's *P. cortiniscus* has three equal and one short spine, but the short one may have been broken since I have observed many specimens like *P. cortiniscus* with four equal spines. Haeckel's two taxa, cited above, are apparently end members of the same species. The four main spines are cylindrical rods in the central area and become three-bladed towarded terminal ends, in contrast to Haeckel's description of all three-bladed spines.

Tetraplecta plectaniscus Haeckel
Plate 24, figure 7

Euscenium plectaniscus HAECKEL, 1887, p. 1146, pl. 98, fig. 1.

Cladoscenium sp. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 13.

Tetraplecta corynephorum ? Jørgensen
Plate 24, fig. 6

? *Plectanium trigeminium* HAECKEL, 1887, pl. 91, fig. 11.

Eucenium corynephorum JØRGENSEN, 1900, p. 77; 1905, p. 133, pl. 15, fig. 70. - BJØRKLUND, 1976a, pl. 7, fig. 1–4.

Genus *Archiscenium* Haeckel, 1881
Archiscenium quadrispinum ? Haeckel

Archiscenium quadrispinum HAECKEL, 1887, p. 1150, pl. 53, fig. 11. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 10, 11.

Genus *Plectanium* Haeckel, 1881
Plectanium sp.

Plectanium sp. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 8.

Genus *Protoscenium* Jørgensen, 1905

Protoscenium ? sp. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 9.

Genus *Clathromitra* Haeckel, 1881, emend. herein

DEFINITION: Plagoniidae with nearly a tetrahedron-shaped latticed shell; five prismatic, three-sided spines.

REMARKS: This genus is already classified under the present family by Riedel (1971).

Clathromitra pterophormis Haeckel
Plate 24, figure 8

Clathromitra pterophormis HAECKEL, 1887, p. 1219, pl. 57, fig. 8. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 16.

REMARKS: Observed specimens here are about twice as large as Haeckel's.

Genus *Cladoscenium* Haeckel, 1881
Cladoscenium ancoratum Haeckel
Plate 24, figures 9–14

Cladoscenium ancoratum HAECKEL, 1887, p. 1149, pl. 53, fig. 13. - GOLL, 1976, pl. 1, figs. 1–3, 6–8. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 14. - PETRUSHEVSKAYA AND KOZLOVA, 1979, p. 118, figs. 304, 476, 477.

REMARKS: Mesh size of the cephalis significantly varies among specimens. Some fully grown specimens have bi-spines nearly at terminal end of main spines completely connected to other bi-spines on other main spines (e.g., Plate 24, figure 10).

Genus *Semantis* Haeckel, 1887
Semantis gracilis ? Popofsky
Plate 24, figures 15, 16

Semantis gracilis POPOFSKY, 1908, p. 268, pl. 30, fig. 5; 1913, p. 298, pl. 28, fig. 7, 8.

DEFINITION: It lacks a cephalis but has two characteristic glasses-shaped openings formed by connecting skeleton between spines.

Genus *Deflandrella* Loeblich and Tappan, 1961
Deflandrella sp.

Campylacantha sp. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 12.

REMARKS: The generic name used here is that proposed by Loeblich and Tappan (1961, p. 227) which replaced *Campylacantha* Jørgensen, 1905.

Genus *Pseudocubus* Haeckel, 1887
Pseudocubus obeliscus Haeckel
Plate 26, figure 1

Pseudocubus obeliscus HAECKEL, 1887, p. 1010, pl. 94, fig. 11. - PETRUSHEVSKAYA, 1981, p. 92, text-figs. 58–64.

Obeliscus pseudocuboides POPOFSKY, 1913, pl. 29, figs. 4, 5. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 15.

REMARKS: Loeblich and Tappan (1961, p. 227) proposed a new generic name *Talariscus* for this group.

Pseudocubus primordialis ? (Jørgensen)
Plate 26, figure 2

Gonosphaera primordialis JØRGENSEN, 1905, p. 133, pl. 14, figs. 64–68. - BJØRKLUND, 1976a, pl. 9, figs. 7–10.

REMARKS: Generic name is changed because it should conform with that of *P. opeliscus*.

Genus *Phormacantha* Jørgensen, 1905
Phormacantha hystrix (Jørgensen)
Plate 26, figure 3

Peridium hystrix JØRGENSEN, 1900, p. 76.

Phormacantha hystrix (Jørgensen), 1905, p. 132, pl. 14, figs. 59–63. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, figs. 17–19.

Genus *Neosemantis* Popofsky, 1913
Neosemantis cladophora (Jørgensen)
Plate 24, figure 17

Neosemantis cladophora (Jørgensen). - GOLL, 1979, p. 385, pl. 4, fig. 16–19.

Campylacantha cladophora JØRGENSEN, 1905, p. 129, pl. 12, fig. 47. - BJØRKLUND, 1976a, pl. 6, fig. 1–6.

Neosemantis distephanus Popofsky
Plate 27, figure 12

Neosemantis distephanus POPOFSKY, 1913, p. 299, pl. 29, fig. 2. - PETRUSHEVSKAYA, 1971c, p. 152, figs. 77: I–III. - KLING, 1979, p. 309, pl. 1, figs. 15, 16. - BOLTOVSKOY AND RIEDEL, 1980, pl. 4, fig. 14. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, fig. 17.

Subfamily LOPHOPHAENINAE Haeckel, 1881, emend. Petrushevskaya, 1971d

DEFINITION: Plagiacanthidae with the skeleton consisting of two equal segments: cephalis and thorax. Cephalis with a large eucephalic lobe and a small antecephalic lobe which is not separated from the thorax (Petrushevskaya, 1971d).

Genus *Acanthocorys* Haeckel, 1881
Acanthocorys cf. *variabilis* Popofsky
Plate 25, figure 1

Acanthocorys variabilis POPOFSKY, 1913, p. 360, text-figs. 71, 72 (only).

Acanthocorys sp. aff. *A. variabilis* Popofsky. - RENZ, 1976, p. 155, pl. 6, fig. 20.

Acanthocorys cf. *variabilis* Popofsky. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, fig. 1.

Genus *Lophophaena* Ehrenberg, 1847b
Lophophaena cylindrica (Cleve)
Plate 25, figures 3–5

Acanthocorys variabilis POPOFSKY, 1913, p. 360, text-figs. 74–77 (only). - BENSON, 1966, p. 373, pl. 24, fig. 19.

Lophophaena cylindrica (Cleve). - PETRUSHEVSKAYA, 1971c, p. 117, fig. 61, IV–VI. - RENZ, 1976, p. 159, pl. 6, fig. 21. - TAKAHASHI AND HONJO, 1981, pl. 151, pl. 7, fig. 2.

Lophophaena decacantha (Haeckel) group
Plate 25, figures 2, 8, 10

Lithomelissa decacantha HAECKEL, 1887, p. 1208, pl. 56, fig. 2.

Lophophaena circumtexta (Popofsky)

Lampromitra circumtexta POPOFSKY, 1913, p. 346, pl. 32, fig. 1, text-fig. 53. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 6, fig. 23.

REMARKS: The author proposes to place the present species under this genus.

Lophophaena cf. *capito* Ehrenberg
Plate 25, figures 6–9

? *Lophophaena capito* EHRENBERG, 1873, p. 242; 1875, pl. 8, fig. 6.

Lophophaena cf. *capito* Ehrenberg. - BENSON, 1966, p. 378, pl. 24, figs. 22, 23; pl. 25, fig. 1. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 6, fig. 22.

Genus *Helotholus* Jørgensen, 1905
Helotholus histricosa Jørgensen

Helotholus histricosa JØRGENSEN, 1905, p. 137, pl. 16, figs. 86–88. - BENSON, 1966, p. 459, pl. 31. figs. 4–8. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, figs. 6, 7.

REMARKS: *Artostrobus joergenseni* Petrushevskaya illustrated by Bjørklund (1976a, pl. 11, figs. 12, 13) is similar to this species but different because its pores are in transverse rows.

Genus *Peromelissa* Haeckel, 1881
Peromelissa phalacra Haeckel
Plate 25, figures 11–15

Peromelissa phalacra HAECKEL, 1887, p. 1236, pl. 57, fig. 11. - MCMILLEN AND CASEY, 1978, pl. 4, fig. 20. - BOLTOVSKOY AND RIEDEL, 1980, p. 122, pl. 5, fig. 3. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, figs. 3–5.

Psilomelissa longispina CLEVE, 1900a, p. 10, pl. 4, fig. 4.

Psilomelissa phalacra (Haeckel). - POPOFSKY, 1908, p. 283, pl. 32, fig. 4.

Psilomelissa tricuspidata POPOFSKY, 1908, pl. 32, fig. 9.

Psilomelissa tricuspidata abdominalis POPOFSKY, 1908, pl. 33, fig. 4.

Lithomelissa monoceras POPOFSKY, 1913, p. 335, text-fig. 43, pl. 32, fig. 7. - RENZ, 1976, p. 158, pl. 6, fig. 12.

Lithomelissa setosa Jørgensen
Plate 25, figures 16–22

Lithomelissa setosa JØRGENSEN, 1900, p. 81, pl. 4, fig. 21; 1905, p. 135, pl. 16, figs. 81–83, pl. 18, figs. 108a, 108b. - BJØRKLUND, 1976a, pl. 8, figs. 1–13, pl. 11, figs. 19–23. - KLING, 1977, p. 217, pl. 1, fig. 2. - BOLTOVSKOY AND RIEDEL, 1980, p. 121, pl. 5, fig. 1.

REMARKS: For a more complete synonymy see Boltovskoy and Riedel (1980).

Genus *Peridium* Haeckel, 1887
Peridium spinipes Haeckel
Plate 26, figures 4–6

Peridium spinipes HAECKEL, 1887, p. 1154, pl. 53, fig. 9. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 6, fig. 20.

Peridium longispinum JØRGENSEN, 1905, p. 135, pl. 15, figs. 75–79; pl. 16, fig. 80. - BENSON, 1966, p. 359, pl. 23, fig. 27; pl. 24 (*partim*), figs. 1, 2 (only).

Psilomelissa calvata HAECKEL, 1887, p. 1209, pl. 56, fig. 3. - RENZ, 1976, p. 160, pl. 6, fig. 15.

Peridium sp.

Peridium sp. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 6, fig. 21.

REMARKS: One spine very long up to five times shell length; otherwise similar to *P. spinipes*.

Genus *Trisulcus* Popofsky, 1913
Trisulcus triacanthus Popofsky

Trisulcus triacanthus POPOFSKY, 1913, p. 354, text-fig. 59, 60. - RENZ, 1976, p. 161, pl. 6, fig. 10.

Subfamily SETHOPERINIDAE Haeckel, 1881, emend. Petrushevskaya, 1971d

DEFINITION: Plagiacanthidae with skeleton consisting of the cephalis surrounded by latticed plates built with branches of the spines. Three plates attached to a vertical spine and the cephalis and the remaining three plates which may be regarded as a thorax attached to divergent spines and the cephalis. Cephalis pyramidal.

Genus *Lithopilium* Popofsky, 1913
Lithopilium reticulatum Popofsky
Plate 26, figure 10

Lithopilium reticulatum POPOFSKY, 1913, p. 379, pl. 35, figs. 4, 5. - RENZ, 1976, p. 164, pl. 7, fig. 2.

Genus *Clathrocanium* Ehrenberg, 1860a
Clathrocanium insectum (Haeckel)
Plate 26, figures 7–9

Dictyoceras insectum HAECKEL, 1887, p. 1324, pl. 71, figs. 6, 7.

Corocalyptra columba (Haeckel). - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 16.

DESCRIPTION: Abdomen divided from the thorax by a constriction. The cephalis and spines similar to those of *C. coarctatum*. Abdominal mesh is very delicate and made of irregular polygons.

Clathrocanium coarctatum Ehrenberg
Plate 26, figures 11–13

Lychnocanium fenestratum EHRENBERG, 1860a, p. 767.

Clathrocanium coarctatum EHRENBERG, 1872a, p. 303; 1872b, p. 287, pl. 7, fig. 6.

Clathrocanium coarctatum HAECKEL, 1887, p. 1211. - POPOFSKY, 1913, p. 341, text-fig. 50.

Clathrocanium triomma HAECKEL, 1887, p. 1211, pl. 64, fig. 3.

Clathrocanium coronatum POPOFSKY, 1913, p. 342, pl. 33, fig. 1.

Clathrocanium cf. *coronatum* Popofsky. - BENSON, 1966, p. 394, pl. 26, figs. 1, 2.

Clathrocanium ornatum POPOFSKY, 1913, p. 343, pl. 33, fig. 2.

REMARKS: Apical horn straight, three-bladed and its branches are connected with fine strands extending from cephalis and thorax. The apical horn differs from a fenestrated and denticulate horn of *C. diadema* which is present at Station E.

Clathrocanium diadema Haeckel

Clathrocorona diadema HAECKEL, 1881, p. 431.

Clathrocanium diadema HAECKEL, 1887, p. 1212, pl. 64, fig. 2. - POPOFSKY, 1913, pl. 32, fig. 4. - MCMILLEN AND CASEY, 1978, pl. 5, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, fig. 8.

Genus *Callimitra* Haeckel, 1881
Callimitra emmae Haeckel
Plate 26, figure 14

Callimitra emmae HAECKEL, 1887, p. 1218, pl. 63, figs. 3, 4. - BENSON, 1966, p. 390, pl. 25, fig. 12. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, fig. 11.

REMARKS: This species differs from *C. annae* in absence of the marginal frame of dense geometric meshwork. Beams extending from cephalis toward margins commonly cross each other near the end.

Callimitra annae Haeckel
Plate 26, figure 15

Callimitra annae HAECKEL, 1887, p. 1217, pl. 63, fig. 2.

Callimitra agnesae HAECKEL, 1887, p. 1217, pl. 63, fig. 5.

Callimitra elisabethae HAECKEL, 1887, p. 1218, pl. 63, fig. 6. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, fig. 9, 10.

Callimitra sp. - RENZ, 1976, p. 162, pl. 7, fig. 1.

REMARKS: Note presence of a laterally extending tubule from a middle part of the cephalis. The cephalis is made of this solid sheet rather than meshwork. Transverse beams of this species rarely cross each other, whereas they commonly cross in *C. emmae*. The present species resembles the type species of this genus, *C. carolotae* Haeckel (1887, p. 1217, pl. 63, figs. 1, 7, 8), but differs in presence of basal marginal dense meshwork. Specimens like *C. carolotae* have not been observed here and hence it is not included in the synonymy. However, it is quite possible that it may become the name of this species depending on future studies. Sinking experiments show that specimens of this species typically settle in the water column upside down with respect to the orientation of the micrograph in the plate. This is common to most nassellarian species.

Callimitra solocicribrata Takahashi, n. sp.
Plate 27, figures 10, 11

DESCRIPTION: Cephalis hemispherical made of thin wall combined with meshwork similar to that of *C. annae*; a tubule on the cephalis similar to *C. giltschii*. Three vertical wings are made of much coarser irregular polygonal meshwork than those of *C. annae* and without conspicuous transverse beams. Thorax pyramidal in the upper half (cephalis side) and become cylindrical near the basal opening; mesh size finer than that of the vertical wings. Terminal ends of spines dented from the vertical wings.

DIMENSIONS: (6 specimens) Cephalis width: 40–80 μm; length between two terminal ends of divergent spines: 180–215 μm; height (top of apical horn to thorax opening): 235–380 μm; apical spine length: 132–182 μm.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 3,791 m; collected during August–December 1979.

REMARKS: Considerable difference in size has been observed.

DERIVATION OF NAME: The name of this species is the Latin meaning having the nature of a coarse sieve.

Genus *Clathrocorys* Haeckel, 1881
Clathrocorys giltschii Haeckel
Plate 26, figure 16; Plate 27, figures 1–3, 9

Clathrocorys giltschii HAECKEL, 1887, p. 1220, pl. 64, fig. 9.

Clathrocorys teuscheri HAECKEL, 1887, p. 1220, pl. 64, fig. 10.

Clathrocorys sp. - RENZ, 1976, p. 163, pl. 7, fig. 4a (*partim*).

REMARKS: This species is present at Stations P_1 and PB in the Pacific, but not at Station E in the Atlantic.

Clathrocorys murrayi Haeckel
Plate 27, figures 4–8

Clathrocorys murrayi HAECKEL, 1887, p. 1219, pl. 64, fig. 8. - POPOFSKY, 1913, p. 352, text-fig. 57, pl. 32, figs. 2, 3. - BENSON, 1966, p. 391, pl. 25, fig. 13–15.

Clathrocorys sp. - RENZ, 1976, p. 163, pl. 7, fig. 4b (*partim*).

Family ACANTHODESMIIDAE Haeckel, 1862, emend. Riedel, 1971

DEFINITION: Nassellaria possessing a sagital ring.

Genus *Zygocircus* Bütschli, 1882
Zygocircus capulosus Popofsky

Zygocircus capulosus POPOFSKY, 1913, p. 287, pl. 28, fig. 4. - RENZ, 1976, p. 169, pl. 8, fig. 6. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, fig. 12.

Zygocircus productus (Hertwig) group
Plate 27, figures 13, 14

Lithocircus productus HERTWIG, 1879, p. 197, pl. 12(7), fig. 4

Zygocircus productus (Hertwig). - PETRUSHEVSKAYA, 1971c, p. 281, fig. 16: II, 145: 10, 11. - BOLTOVSKOY AND RIEDEL, 1980, p. 121, pl. 4, fig. 17. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, figs. 13, 14.

Zygocircus cf. *piscicaudatus* Popofsky
Plate 27, figure 18

Zygocircus piscicaudatus POPOFSKY, 1913, p. 287, pl. 28, fig. 3.

Zygocircus sp. cf. *Z. piscicaudatus* Popofsky. - RENZ, 1976, p. 171, pl. 8, fig. 3. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, fig. 15.

Genus *Acanthodesmia* Müller, 1857
Acanthodesmia vinculata Müller
Plate 28, figures 6–8

Lithocircus vinculata MÜLLER, 1857, p. 484.

Acanthodesmia vinculata MÜLLER, 1858a, p. 30, pl. 1, figs. 4–7. - PETRUSHEVSKAYA, 1971c, p. 278, fig. 143, I–VII; 144, I–VI. - LING, 1972, p. 169, pl. 1, fig. 6. - BOLTOVSKOY AND RIEDEL, 1980, p. 120, pl. 4, fig. 12. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, figs. 18, 19.

Eucoronis nephrospyris HAECKEL, 1887, p. 977, pl. 82, fig. 5. - BENSON, 1966, p. 304, pl. 21, figs. 6–8.

Eucoronis angulata HAECKEL, 1887, p. 978, pl. 82, fig. 3.

Eucoronis challengeri HAECKEL, 1887, p. 978, pl. 82, fig. 4.

Giraffospyris angulata (Haeckel). - GOLL, 1969, p. 331, pl. 59, figs. 4, 6, 7, 9, text-figs. 2. - RENZ, 1976, p. 167, pl. 8, fig. 5. - NIGRINI AND MOORE, 1979, p. N11, pl. 19, figs. 2a–d, 3a–b.

Genus *Lophospyris* Haeckel, 1881, emend. Goll, 1977
Lophospyris juvenile form group
Plate 28, figures 1–4

REMARKS: This juvenile group includes at least *L. pentagona pentagona and L. pentagona hyperborea*, but not *L. pentagona quadriforis*.

Lophospyris pentagona (Ehrenberg) *quadriforis* (Haeckel), emend. Goll
Plate 28, figure 5

Semantrum quadrifore HAECKEL, 1887, p. 958, pl. 92, fig. 5.

Lophospyris pentagona quadriforis (Haeckel). - GOLL, 1977, pp. 398–400, pl. 13, figs. 1–13; pl. 14, figs. 1–3, 7, 10, 13.

REMARKS: For a more complete synonymy see Goll (1977).

Lophospyris pentagona pentagona (Ehrenberg) emend. Goll
Plate 28, figures 9–14

Ceratospyris pentagona EHRENBERG, 1872a, p. 303; 1872b, p. 302, pl. 15, fig. 15.

Ceratospyris allmersii HAECKEL, 1887, p. 1067, pl. 86, fig. 3.

Ceratospyris strasburgeri HAECKEL, 1887, p. 1067, pl. 86, fig. 2.

Ceratospyris polygona Haeckel. - BENSON, 1966, pp. 321–324, pl. 22, figs. 15, 16 (*partim*).

Ceratospyris sp. - NIGRINI, 1967, pp. 48, 49, pl. 5, fig. 6. - RENZ, 1976, p. 172, pl. 8, fig. 8.

Dorcadospyris pentagona (Ehrenberg). - Goll, 1969, pp. 338, 339, pl. 59, figs. 1–3, 5. - LING, 1972, p. 168, pl. 2, fig. 5.

Lophospyris pentagona pentagona (Ehrenberg). - GOLL, 1977, pp. 384, 398, pl. 10, fig. 1–7; pl. 11, figs. 1–3, 5. - NIGRINI AND MOORE, 1979, p. N15, pl. 19, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, figs. 20, 21.

Lophospyris pentagona (Ehrenberg) *hyperborea* (Jørgensen), emend. Goll
Plate 29, figures 1–3, 5–10

Ceratospyris hyperborea JØRGENSEN, 1905, pp. 130, 131, pl. 13, fig. 49. - GOLL AND BJØRKLUND, 1971, p. 449, text-fig. 7.

Ceratospyris polygona Haeckel. - POPOFSKY, 1913, pp. 305–308, pl. 30, fig. 1 (*partim*). - BENSON, 1966, pp. 321–324, pl. 22, figs. 17, 18 (*partim*).

Ceratospyris sp. A. - RENZ, 1976, p. 173, pl. 8, fig. 9.

Lophospyris pentagona hyperborea (Jørgensen), emend. GOLL, 1977, p. 400, pl. 14, figs. 4–6, 8–9, 11–12; pl. 15, figs. 1–12. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 7, figs. 22–26.

Lophospyris cheni Goll
Plate 29, figure 4

Lophospyris cheni GOLL, 1977, p. 402, pl. 11, fig. 4; pl. 12, figs. 1–7

Genus *Tripodospyris* Haeckel, 1881

Tripodospyris sp.

Tripodospyris sp. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 7, fig. 27.

Genus *Phormospyris* Haeckel, 1881, emend. Goll, 1977

Phormospyris stabilis (Goll) *scaphipes* (Haeckel)
Plate 29, figures 11, 12, 14

Tholospyris scaphipes (Haeckel). - GOLL, 1969, pp. 328, 329, pl. 58, figs. 1–6 (*partim*).

Tristylospyris scaphipes Haeckel. - BENSON, 1966, pp. 316–321, pl. 22, figs. 7, 9, 10.

Phormospyris stabilis scaphipes (Haeckel). - GOLL, 1977, p. 394, pl. 8, figs. 1–15; pl. 9, figs. 1–5.

REMARKS: For a more complete synonymy see Goll (1977).

Phormospyris sp. aff. *L. pentagona hyperborea* (Jørgensen)
Plate 29, figure 13

REMARKS: Characteristic spines on basal ring are conical and connected at the bases to adjacent other spines so that they become flaring. Usually specimens are robust.

Phormospyris stabilis (Goll) *capoi* Goll
Plate 29, figures 15–18

Rhodospyris sp. - BENSON, 1966, pp. 329–331, pl. 23, figs. 3–5.

Phormospyris stabilis capoi GOLL, 1977, p. 392, pl. 5, figs. 1, 2; pl. 6, figs. 1–13; pl. 7, figs. 1–9.

Phormospyris stabilis stabilis (Goll)
Plate 30, figures 2–5

Desmospyris anthocyrtoides (Bütschli). - BENSON, 1966, pp. 324–334, pl. 23, figs. 6–8.

Dendrospyris stabilis GOLL, 1968, pp. 1422–1423, pl. 173, figs. 16–18, 20.

Phormospyris stabilis (Goll) *stabilis* GOLL, 1977, p. 390, pl. 1, figs. 1–13; pl. 2, figs. 7–14. - KLING, 1979, p. 309, pl. 1, fig. 18.

REMARKS: For a more complete synonymy see Goll (1977).

Phormospyris ? sp.
Plate 30, figure 6

Genus *Dictyospyris* Ehrenberg, 1847b
Dictyospyris sp. group
Plate 30, figure 1

Dictyospyris sp. B. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 7, fig. 29.

Genus *Nephrospyris* Haeckel, 1881
Nephrospyris renilla renilla Haeckel
Plate 30, figures 7–9

Nephrospyris renilla HAECKEL, 1887, p. 1101, pl. 90, figs. 9, 10. - RENZ, 1976, p. 176, pl. 8, fig. 18.

Nephrodictyum renilla (Haeckel). - BENSON, 1966, pp. 302–304, pl. 21, fig. 5.

Nephrospyris renilla renilla Haeckel. - GOLL, 1980, p. 437, pl. 5, fig. 2.

Nephrospyris renilla Haeckel *lana* Goll
Plate 30, figure 10

Nephrospyris renilla lana GOLL, 1980, p. 438, pl. 5, fig. 1.

Genus *Androspyris* Haeckel, 1887
Androspyris reticulidisca Takahashi, n. sp.
Plate 30, figures 12–14

DESCRIPTION: Shell flat disc with two branching feet and a sagital ring of ca. 1/5–1/4 as long as longitudinal shell length; meshwork with pores of irregular and polygonal shape and increasing in size toward margin where a thick skeletal frame is present. An apical spine small when present.

DIMENSIONS: (20 specimens) Longitudinal length (excluding an apical spine and feet): 363 ± 45 μm (2 S.D.); width: 336 ± 19 μm (2 S.D.).

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 3,791 m; collected during August–December 1979.

REMARKS: This species has finer mesh size and a proportionlly smaller sagital ring than does *A. huxleyi*. The former is discoidal and has a thick marginal frame, whereas the latter is lenticular and does not have such a thick frame.

DERIVATION OF NAME: The name of this species is the Latin meaning a net-like disc.

Androspyris huxleyi (Haeckel)
Plate 30, figures 15, 16

Lamprospyris huxleyi HAECKEL, 1887, p. 1094, pl. 89, fig. 14.

Androspyris huxleyi (Haeckel). - GOLL 1980, p. 436, pl. 4, figs. 4, 5.

Androspyris ramosa (Haeckel)
Plate 31, figures 1, 2

Tholospyris ramosa HAECKEL, 1887, p. 1079, pl. 89, fig. 3.

? *Tholospyris cupola* HAECKEL, 1887, p. 1080, pl. 89, fig. 4.

Tholospyris fornicata POPOFSKY, 1912, p. 309, pl. 30, fig. 2. - RENZ, 1976, p. 177, pl. 8, fig. 15. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 7, fig. 30.

? *Tripospyris semantis* HAECKEL, 1887, p. 1026, pl. 84, fig. 2.

? *Tripospyris diomma* HAECKEL, 1887, p. 1026, pl. 84, fig. 5.

REMARKS: Under the present observation *A. ramosa* and *T. fornicata* are indistinguishable.

Genus *Cephalospyris* Haeckel, 1881
Cephalospyris cancellata Haeckel
Plate 31, figures 3, 4

Cephalospyris cancellata HAECKEL, 1887, p. 1035, pl. 83, fig. 10.

Genus *Cantharospyris* Haeckel, 1887
Cantharospyris platybursa Haeckel
Plate 31, figure 5

Cantharospyris platybursa HAECKEL, 1887, p. 1051, pl. 53, fig. 7. - RENZ, 1976, p. 171, pl. 8, fig. 10. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 7, fig. 32.

Cantharospyris cf. *clathrobursa* (Haeckel)

Tessarospyris clathrobursa HAECKEL, 1887, p. 1045, pl. 53, fig. 8.

Cantharospyris cf. *clathrobursa* (Haeckel). - TAKAHASHI AND HONJO, 1981, p. 152, pl. 7, fig. 32.

Genus *Tholospyris* Haeckel, 1881, emend. Goll, 1969
Tholospyris sp. group
Plate 27, figures 15–17

REMARKS: The following taxa are included in this group: un-named transition specimens between *Tholospyris baconiana spinula* and *Tholospyris rhombus* (Goll, 1972a, pl. 15, figs. 1–11); *Tholospyris rhombus* (Haeckel) (Goll, 1972a, p. 455, pl. 16, figs. 1–11); *Tholospyris* sp. (TAKAHASHI AND HONJO, 1981, p. 152, pl. 7, fig. 16).

Tholospyris baconiana baconiana (Haeckel)
Plate 31, figures 6, 7

Tricolospyris baconiana HAECKEL, 1887, p. 1098, pl. 88, fig. 8.

Tholospyris baconiana baconiana (Haeckel). - GOLL, 1972a, p. 451, pl. 1, figs. 7–9; pl. 2, figs. 1–8; pl. 4, figs. 1–4; pl. 5, figs. 1–3.

Tholospyris baconiana (Haeckel) *variabilis* Goll
Plate 31, figure 8

Tholospyris baconiana variabilis GOLL, 1972a, p. 452, pl. 8, figs. 1–8; pl. 9, figs. 1–12.

Tholospyris baconiana baconiana (Haeckel). - TAKAHASHI AND HONJO, 1981, p. 151, pl. 8, fig. 3.

Tholospyris macropora (Popofsky)
Plate 31, figure 9

Phormospyris macropora POPOFSKY, 1913, p. 310, pl. 30, fig. 3.

Tholospyris baconiana cf. *variabilis* Goll. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 8, fig. 4.

Genus *Liriospyris* Haeckel, 1881, emend. Goll, 1968
Liriospyris thorax (Haeckel) *laticapsa* Takahashi, n. subsp.
Plate 31, figures 10, 11, 13

Amphispyris toxarium Haeckel. - BENSON, 1966, pp. 293–297, pl. 20, figs. 3, 5–6 (*partim*).

DESCRIPTION: Sagital ring thick and similar shape to that of *L. thorax thorax* (Haeckel) whose cross section looks like a clover leaf; the ring is proportionally smaller compared to *L. reticulata* and as long as 1/3 of shell height. Major branches from the sagital ring thick and branch further and spread out fine surface meshwork made of irregular polygons with pores of equal to 3 times as broad as sagital ring thickness. The meshwork forms crests between and branches on lateral side. The meshwork wraps the sagital rings and branch system. Shape of the shell is more or less a rectangular prism and length/width ratio is similar to reciprocal of that of *L. reticulata*.

DIMENSIONS: (8 specimens) Length: 160–280 μm; width: 195–360 μm; width/length ratio: 1.15–1.35.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 3,791 m; collected during August–December 1979.

DERIVATION OF NAME: The name of this subspecies is the Latin meaning a wide box.

REMARKS: The present taxon is separated from counterpart *L. thorax thorax* largely on the basis of wider but shorter shape than the latter.

Liriospyris thorax thorax (Haeckel)
Plate 31, figure 12

Amphispyris thorax HAECKEL, 1887, p. 1096, pl. 88, fig. 4.

Liriospyris reticulata (Ehrenberg)
Plate 31, figures 14–16

Dictyospyris reticulata EHRENBERG, 1872a, p. 307; 1872b, p. 289, pl. 10, fig. 19.

Amphispyris costata HAECKEL, 1887, p. 1097, pl. 88, fig. 3. - NIGRINI, 1967, p. 45, pl. 5, fig. 4. - MCMILLEN AND CASEY, 1978, pl. 5, fig. 9. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 8, figs. 1, 2.

Amphispyris reticulata (Ehrenberg). - NIGRINI, 1967, p. 44, pl. 5, fig. 3.

Liriospyris reticulata (Ehrenberg). - GOLL, 1968, p. 1429, pl. 176, figs. 9, 11, 13; 1972b, p. 967, pl. 71, fig. 1. - NIGRINI AND MOORE, 1979, p. N13, pl. 19, figs. 4a–4b. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 3, fig. 2.

REMARKS: For a complete synonymy see Goll (1968).

Liriospyris sp.
Plate 30, figure 11

DESCRIPTION: Similar to *L. thorax laticapsa* including shape, size and position of sagital ring and its branches, but differs in mesh size and robust outer framework which is the extension of the sagital branches which encloses the mesh.

Family SETHOPHORMIDIDAE Haeckel, 1881, emend. Petrushevskaya, 1971d

DEFINITION: Plagiacanthoidea with flat cephalic skeleton. Thorax, if present, in the shape of an umbrella. Cephalis large, in the form of a tent; with thin walls. The walls of the cephalis are separated from those of the thorax by arches. Pores on the cephalis and on the thorax are different in size and shape (Petrushevskaya, 1971d).

Genus *Tetraphormis* Haeckel, 1881
Tetraphormis rotula (Haeckel)
Plate 32, figures 1–3

Sethophormis rotula HAECKEL, 1887, p. 1246, pl. 57, fig. 9. - RENZ, 1976, p. 166, pl. 7, fig. 14. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 8, fig. 6 (non. fig. 7).

REMARKS: *Sethophormis* is a junior objective synonym of *Tetraphormis*; the genus *Sethophormis* is not listed in Haeckel (1881).

Tetraphormis dodecaster (Haeckel)
Plate 32, figure 7

Sethophormis dodecaster HAECKEL, 1887, p. 1248, pl. 56, fig. 12.

Sethophormis cf. *dodecaster* Haeckel. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 8, fig. 8.

Tetraphormis butschlii (Haeckel)
Plate 32, figure 6

Dictyophimus butschlii HAECKEL, 1887, p. 1201, pl. 60, fig. 2. - TAKAHASHI AND HONJO, 1981, pl. 8, fig. 14.

REMARKS: The three divergent spines are usually long as Haeckel illustrated. The author proposes to place this species in the genus *Tetraphormis*.

Genus *Theophormis* Haeckel, 1881
Theophormis callipilium Haeckel
Plate 32, figures 9–12

Theophormis callipilium HAECKEL, 1887, p. 1367, pl. 70, figs. 1–3.

Sethophormis umbrella HAECKEL, 1887, p. 1248, pl. 70, figs. 4, 5.

Sethophormis aurelia HAECKEL, 1887, p. 1248, pl. 55, fig. 3. - RENZ, 1976, p. 165, pl. 7, fig. 16.

REMARKS: Some specimens show faint radial ribs especially in basal view. The number and curvature of the ribs vary among the specimens. Illustrations of *T. callipilium* by Haeckel represent the best for this taxon and hence the name is selected here.

Genus *Lampromitra* Haeckel, 1881
Lampromitra schultzei (Haeckel)
Plate 32, figures 4, 5

Eucecryphalus schultzei HAECKEL, 1862, p. 309, pl. 5, figs. 16–19; 1887, p. 1216.

Lampromitra coronata HAECKEL, 1887, p. 1214, pl. 60, fig. 7.

? *Sethophormis pentalactis* HAECKEL, 1887, p. 1244, pl. 56, fig. 5. - RENZ, 1976, p. 165, pl. 7, fig. 7. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 8, fig. 5.

(non) *Lampromitra coronata* Haeckel. - KEANY, 1979, p. 56, pl. 4, fig. 10; pl. 5, fig. 14.

Lampromitra cracenta Takahashi, n. sp.
Plate 32, figure 8

Lampromitra cf. *coronata* Haeckel. - BENSON, 1966, p. 452, pl. 30 (*partim*), figs. 9, 10 (only).

DESCRIPTION: Cephalis cap-shaped with small pores. Thorax with three ribs which penetrate the perimeter and form spines and with coarse irregular polygonal mesh; marginal mesh forms a zone of fine mesh with small circular to subcircular pores. Number of short spines on the perimeter is about 30 and they are conical. The perimeter of the thorax is an irregularly curved circle.

DIMENSION: (5 specimens) Thorax diameter: 153–164 μm.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 3,791 m; collected during August–December 1979.

REMARKS: *L. petrushevskayae* Dumitrică (1972, p. 837, pl. 23, figs. 6, 7) is different from this species. This species is rare at Station PB.

DERIVATION OF NAME: The name of this species is the Latin meaning graceful.

Lampromitra cachoni Petrushevskaya
Plate 33, figures 2, 3

Lampromitra ? sp. - DZINORIDZE ET AL., 1976, pl. 33, fig. 10.

Lampromitra cachoni PETRUSHEVSKAYA AND KOZLOVA 1979, p. 128, text-figs. 362, 363, 497.

? *Lampromitra erosa* CLEVE, 1900, p. 10, pl. 4, figs. 2, 3. - DUMITRICĂ, 1972, p. 838, pl. 24, figs. 8. 9.

Lampromitra spinosiretis Takahashi, n. sp.
Plate 34, figures 1, 2, 7

Helotholus histricosa Jørgensen. - BENSON, 1966, p. 459, pl. 31 (*partim*), figs. 6, 7 (only).

DESCRIPTION: Cephalis hemispherical with several short and long spines of up to thorax length and with circular pores. Thorax conical net-shaped and similar to *L. cachoni* but has coarser circular to hexagonal meshwork. Radial ribs absent in most specimens. The margin of the thorax thorny.

DIMENSIONS: (8 specimens) Thorax diameter: 175–280 μm; diameter of pores next to marginal thorns: 20–35 μm.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 3,791 m; collected during August–December 1979.

REMARKS: This species has a slightly convex cone, coarse mesh and many spines on the cephalis, whereas *L. cachoni* has a flatter and slightly concave cone, fine mesh and a few short spines on the cephalis.

DERIVATION OF NAME: The name of this species is the Latin meaning a thorny net.

Genus *Eucecryphalus* Haeckel, 1860
Eucecryphalus tricostatus (Haeckel)
Plate 33, figures 4, 6

Theopilium tricostatum HAECKEL, 1887, p. 1322, pl. 70, fig. 6. - POPOFSKY, 1913, p. 375, pl. 37, fig. 6. - BENSON, 1966, p. 444, pl. 30, figs. 1, 2. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 8, fig. 12.

? *Corocalyptra elisabethae* HAECKEL, 1887, p. 1323, pl. 59, fig. 10.

? *Corocalyptra agnesae* HAECKEL, 1887, p. 1323, pl. 59, fig. 3.

REMARKS: The author proposes to put this taxon into the present genus.

Eucecryphalus sestrodiscus (Haeckel)
Plate 33, figures 5, 7, 8

Cecryphalium sestrodiscus HAECKEL, 1887, p. 1399, pl. 58, fig. 1.

Theocalyptra sp. - RENZ, 1976, p. 137, pl. 5, fig. 13.

Eucecryphalus gegenbauri Haeckel
Plate 33, figures 13–15

Eucecryphalus gegenbauri HAECKEL, 1860b, p. 836; 1862, p. 308, pl. 5, fig. 12–15; 1887, p. 1222. - HERTWIG, 1879, p. 76, pl. 8, figs. 5, 5a, 5b.

Clathrocyclas danaes HAECKEL, 1887, p. 1388, pl. 59, figs. 13, 14. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 8, fig. 13.

Clathrocyclas alcmenae HAECKEL, 1887, p. 1388, pl. 59, fig. 6.

? *Clathrocyclas latonae* HAECKEL, 1887, p. 1389, pl. 59, fig. 7.

Clathrocyclas ionis HAECKEL, 1887, p. 1389, pl. 59, fig. 9.

Corocalyptra gegenbauri (Haeckel). - POPOFSKY, 1913, p. 384, pl. 34, figs. 1, 2.

Theocalyptra gegenbauri BOLTOVSKOY AND RIEDEL, 1980, p. 126, pl. 5, fig. 18 (*partim*).

REMARKS: Mesh size and morphology of the outermost circle varies significantly.

Eucecryphalus europae (Haeckel)
Plate 34, figures 5, 6

Clathrocyclas europae HAECKEL, 1887, p. 1388, pl. 59, figs. 11, 12.

Eucecryphalus clinatus Takahashi, n. sp.
Plate 35, figures 1, 2

Eucecryphalus sp. - BENSON, 1966, p. 450, pl. 30, figs. 6, 7. - RENZ, 1976, p. 130, pl. 5, fig. 3.

DESCRIPTION: Cephalis hemispherical with small pores and spines. The thorax smooth and characteristically beret-shaped with regular hexagonal meshwork whose pores are 2–5 times as wide as interporous bars. There are 11–14 rows of pores in thorax in the longest meridian.

DIMENSIONS: (11 specimens) Minimum diameter: 120–145 μm; maximum diameter: 150–175 μm.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 2,869 m; collected during August–December 1979.

REMARKS: This species is abundant at Station PB.

DERIVATION OF NAME: The name of this species is the Latin meaning slanted.

Eucecryphalus sp.
Plate 33, figure 1

REMARKS: This species resembles *T. gegenbauri* but differs in detail of marginal meshwork.

Genus *Coracalyptra* Haeckel, 1887
Corocalyptra cervus (Ehrenberg)
Plate 33, figures 9–12

Eucyrtidium cervus EHRENBERG, 1872b, p. 291, pl. 9, fig. 21.

Corocalyptra cervus (Ehrenberg). - POPOFSKY, 1913, p. 383, pl. 34, fig. 3. - BENSON, 1966, p. 447, pl. 30, figs. 3–5. - RENZ, 1976, p. 129, pl. 5, fig. 2.

REMARKS: For a more complete synonymy see Benson (1966).

Genus *Phrenocodon* Haeckel, 1887
Phrenocodon clathrostomium Haeckel
Plate 34, figures 3, 4

Phrenocodon clathrostomium HAECKEL, 1887, p. 1434, pl. 70, figs. 7, 8.

Genus *Clathrocyclas* Haeckel, 1881
Clathrocyclas monumentum (Haeckel)
Plate 34, figures 9–11

Calocyclas monumentum HAECKEL, 1887, p. 1385, pl. 73, fig. 9. - RENZ, 1976, p. 128, pl. 5, fig. 1.

Clathrocyclas ? sp. - BENSON, 1966, p. 457, pl. 31, figs. 2, 3.

REMARKS: The apical spine is a conical rod but not three-bladed. The author proposes to put this species in the present genus because it resembles many species of *Clathrocyclas* (e.g., *C. cassiopejae* listed below), although it does not look very much like the type species of the genus, *C. principessa* Haeckel (1887, p. 1386, pl. 74, fig. 7).

Clathrocyclas cassiopejae Haeckel
Plate 34, figures 12–14

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

Clathrocyclas sp.
Plate 34, figure 8

DESCRIPTION: Cephalis cap-shaped with small apical spine and fine pores. Thorax conical, dilated and made of very thick skeleton. Pores on the thorax circular and smaller than interporous bars adjacent to cephalis and increasing their size and become elliptical toward the dilated opening.

Family THEOPERIDAE Haeckel, 1881, emend. Riedel, 1967a

DEFINITION BY RIEDEL (1967a): Cephalis relatively small, approximately spherical, often poreless or sparsely perforate, the internal spicule homologous with that of plagoniids, reduced to a less conspicuous structural element than in the latter group.

Subfamily PLECTOPYRAMIDINAE Haecker, 1908a, emend. Petrushevskaya, 1971d

DEFINITION BY PETRUSHEVSKAYA (1971d): Eucyrtidiidae with a small dome-shaped cephalis and a vast thorax. Cephalis consists of the encephalic part only, poreless. Thorax sometimes with the upper part poreless. The pores on its middle and lower part quadrangular, disposed in longitudinal rows. Internal spines nearly reduced.

Genus *Cornutella* Ehrenberg, 1838
Cornutella profunda Ehrenberg
Plate 35, figures 3–9

Cornutella profunda EHRENBERG, 1858, p. 31. - NIGRINI, 1967, p. 60, pl. 6, figs. 5a–5c. - RENZ, 1976, p. 149, pl. 7, fig. 11. - KLING, 1979, p. 309, pl. 1, fig. 21. - BOLTOVSKOY AND RIEDEL, 1980, p. 123, pl. 5, fig. 6. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 8, fig. 9.

REMARKS: Significant variations in skeletal thickness and apical spine length have been observed.

Genus *Peripyramis* Haeckel, emend. Riedel, 1958
Peripyramis circumtexta Haeckel
Plate 35, figures 10–13

Peripyramis circumtexta HAECKEL, 1887, p. 1162, pl. 54, fig. 5. - RIEDEL, 1958, p. 231, pl. 2, figs. 8, 9. - BENSON, 1966, p. 426, pl. 29, fig. 4. - NIGRINI AND MOORE, 1979, p. N29, pl. 21, figs. 4a, 4b. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 8, figs. 10, 11.

Genus *Litharachnium* Haeckel, 1860b
Litharachnium tentorium Haeckel
Plate 35, figures 14–18

Litharachnium tentorium HAECKEL, 1860b, p. 836; 1862, p. 281, pl. 4, figs. 7–10. - CASEY, 1971, p. 341, pl. 23.3, fig. 11. - RENZ, 1976, p. 150, pl. 7, fig. 6. - BOLTOVSKOY AND RIEDEL, 1980, p. 125, pl. 5, fig. 14.

Litharachnium eupilium (Haeckel)
Plate 36, figures 1–4

Sethophormis eupilium HAECKEL, 1887, p. 1247, pl. 56, fig. 9.

REMARKS: This species is placed in *Litharachnium* because of its affinity to *L. tentorium*.

Subfamily EUCYRTIDIINAE Ehrenberg, 1847b, emend. Petrushevskaya, 1971d

DEFINITION BY PETRUSHEVSKAYA (1971d): Eucyrtidiidae with a cephalis in which only the encephalic part is well developed. Very often it looks like a ball with thick, rough walls. The apical spine forms an apical horn, and the vertical spine may form a small occipital horn. Sometimes they are followed by tubes. the dorsal and lateral spines form the so-called feet. The post-thoracic segments may be reduced or consist only of the abdomen. The pores are numerous, disposed in a checkerboard order.

Genus *Archipilium* Haeckel, 1881
Archipilium macropus ? (Haeckel)
Plate 36, figure 6

Sethopilium macropus HAECKEL, 1887, p. 1203, pl. 97, fig. 9.

Archipilium spp. aff. *A. macropus* (Haeckel). - PETRUSHEVSKAYA AND KOZLOVA, 1972, p. 553 (*partim*), pl. 29, figs. 13, 14.

Archipilium sp. aff. *A. orthopterum* Haeckel
Plate 36, figures 5, 7

See *Archipilium orthopterum* HAECKEL, 1887, p. 1139, pl. 98, fig. 7.

Genus *Pteroscenium* Haeckel, 1881
Pteroscenium pinnatum Haeckel
Plate 36, figures 8, 9

Pteroscenium pinnatum HAECKEL, 1887, p. 1152, pl. 53, figs. 14–16.

Verticillata hexacantha POPOFSKY, 1913, p. 282, text-fig. 11. - BENSON, 1966, p. 397, pl. 26, fig. 3. - RENZ, 1976, p. 161, pl. 6, fig. 5.

Genus *Pterocanium* Ehrenberg, 1847a
Pterocanium trilobum (Haeckel)
Plate 36, figures 10, 11

Dictyopodium trilobum HAECKEL, 1860b, p. 839.

Pterocanium trilobum (Haeckel). - NIGRINI, 1967, p. 71, pl. 7, figs. 3a, 3b. - KLING, 1979, p. 311, pl. 2, fig. 13. - NIGRINI AND MOORE, 1979, p. N45, pl. 23, figs. 4a–4c. - BOLTOVSKOY AND RIEDEL, 1980, p. 126, pl. 5, fig. 15. - JOHNSON AND NIGRINI, 1980, p. 129, pl. 3, fig. 12. - (non RENZ, 1976, p. 135, pl. 5, fig. 17).

Pterocanium grandiporus Nigrini
Plate 36, figures 12, 13

Pterocanium grandiporus NIGRINI, 1968, p. 57, pl. 1, fig. 7. - NIGRINI AND MOORE, 1979, p. N47, pl. 23, fig. 5.

Pterocanium praetextum praetextum (Ehrenberg)
Plate 36, figures 15–18

Lychnocanium praetextum EHRENBERG, 1872a, p. 316; 1872b, p. 297, pl. X, fig. 2.

Pterocanium praetextum (Ehrenberg). - HAECKEL, 1887, p. 1330. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, figs. 5, 6.

Pterocanium praetextum praetextum (Ehrenberg). - NIGRINI, 1967, p. 68, pl. 7, fig. 1. - NIGRINI AND MOORE, 1979, p. N41, pl. 23, fig. 2. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 3, fig. 10.

Pterocanium praetextum (Ehrenberg) aff. *eucolpum* Haeckel
Plate 36, figure 14

Pterocanium eucolpum HAECKEL, 1887, p. 1322, pl. 73, fig. 4.

Pterocanium praetextum (Ehrenberg) *eucolpum* Haeckel. - NIGRINI, 1967, p. 70, pl. 7, fig. 2. - KLING, 1979, p. 311, pl. 2, figs. 14–16. - NIGRINI AND MOORE, 1979, p. N43, pl. 23, fig. 3. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 3, fig. 11.

Genus *Dictyophimus* Ehrenberg, 1847a
Dictyophimus crisiae Ehrenberg
Plate 37, figure 2

Dictyophimus crisiae EHRENBERG, 1854a, p. 241. - NIGRINI, 1967, p. 66, pl. 6, figs. 7a, 7b. - NIGRINI AND MOORE, 1979, p. N33, pl. 22, figs. 1a, 1b. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 3, fig. 9.

Pterocorys hirundo HAECKEL, 1887, p. 1318, pl. 71, fig. 4. - LING ET AL., 1971, p. 715, pl. 2, figs. 8, 9.

? *Pterocorys* sp. - BENSON, 1966, p. 412, pl. 28, fig. 4 (*partim*).

Dictyophimus infabricatus Nigrini
Plate 37, figures 3–5

Dictyophimus infabricatus NIGRINI, 1968, p. 56, pl. 1, fig. 6. - NIGRINI AND MOORE, 1979, p. N37, pl. 22, fig. 5.

Dictyophimus macropterus (Ehrenberg)
Plate 39, figures 8–11

Lithomelissa macroptera EHRENBERG, 1875, p. 78 (*partim*), pl. 3, figs. 9–10 (only).

Carpocanarium sp. - RIEDEL AND SANFILIPPO, 1971, p. 1599, pl. II, fig. 21. - RENZ, 1976, p. 117, pl. 4, fig. 4.

REMARKS: Some specimens show characteristic shell surface ornamentation like ripple marks (e.g., Plate 39, figure 9).

Dictyophimus sp. A
Plate 37, figure 1

DESCRIPTION: Cephalis nearly spherical with very fine pores and a stout conical apical horn of 2–3 times its length. Three divergent wing-like spines three-sided (but not bladed) with grooves. Stout, slightly curved downward and slightly longer than thorax's transverse diameter. Thorax conical with small regular circular pores of narrower than its interporous bars and with numerous accessory spines. Abdomen stout and nearly cylindrical with large circular to hexagonal pores of 4–6 times its interporous bar thickness.

Dictyophimus sp. B
Plate 39, figure 12

Pterocorys cf. *columba* Haeckel. - BENSON, 1966, p. 414, pl. 28, fig. 7.

REMARKS: Three divergent spines extending obliquely downward from the thorax are as long as the length from tip of apical spine to end of abdomen. This species resembles illustrations of *P. hirundo* and *D. insectum* by Haeckel (1887, pl. 71, figs. 4, 5).

Genus *Pseudodictyophimus* Petrushevskaya, 1971c
Pseudodictyophimus gracilipes (Bailey)
Plate 37, figures 12–14

Dictyophimus gracilipes BAILEY, 1856, p. 4, pl. 1, fig. 8. - HAECKEL, 1887, p. 1197. - CLEVE, 1899, p. 29, pl. 2, fig. 2. - POPOFSKY, 1908, p. 274, pl. 30, figs. 12, 13; pl. 31, figs. 15; pl. 34, fig. 6. - RIEDEL, 1958, p. 233, text-fig. 5, pl. 3, fig. 5. - BOLTOVSKOY AND RIEDEL, 1980, p. 124, pl. 5, fig. 8.

Pseudodictyophimus gracilipes (Bailey). - PETRUSHEVSKAYA, 1971c, p. 93, fig. 48: I, IV, V. - BJØRKLUND, 1976a, pl. 9, figs. 1–5; pl. 11, figs. 6, 7. - KLING, 1979, p. 309, pl. 1, figs. 23, 24. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, figs. 3, 4.

Genus *Dictyocodon* Haeckel, 1881
Dictyocodon elegans (Haeckel)
Plate 37, figures 6, 7, 9

Artopilium elegans HAECKEL, 1887, p. 1440, pl. 75, fig. 1.

Pterocanium cf. *elegans* (Haeckel). - BENSON, 1966, p. 403, pl. 27, figs. 1, 2.

REMARKS: The author proposes to place this species in the present genus because of the observed morphology shown in the plate, including many teminal feet.

Dictyocodon palladius Haeckel
Plate 37, figures 8, 10, 11

Dictyocodon palladius HAECKEL, 1887, p. 1335, pl. 71, figs. 12, 13. - RENZ, 1976, p. 121, pl. 4, fig. 16.

REMARKS: Observed specimens have always two large, cephalic spines similar to those of *D. elegans*. The thorax is not constricted as that of *D. elegans* and always smooth without any accessory spines. The terminal feet are very delicate and usually poorly preserved. The present species and the above *D. elegans* are members of the most fragile nassellarians.

Genus *Conicavus* Takahashi, new genus

DEFINITION: Conical shell semi-enclosed with very fine irregular, polygonal and non-segmented meshwork, one or two apical horns, three or more basal feet made of the meshwork, one or two apical openings. Basal end of the shell is enclosed by the mesh but has a few large basal pores. Sagital ring absent.

REMARKS: The present genus differs from *Cephalospyris* Haeckel (1881) in the absence of a sagital ring and many other features. The type species is *C. tipiopsis* Takahashi, , n. sp. Position of this genus is uncertain and hence it is tentatively assigned to the present family.

DERIVATION OF NAME: The name of this genus is the Latin meaning a conical cage.

Conicavus tipiopsis Takahashi, n. sp.
Plate 38, figures 1–6

DESCRIPTION: Shell conical with semi-enclosed irregular and very fine meshwork; numerous triangular to polygonal irregular pores. Sagital ring and constriction absent. A characteristic apical opening is located on a right or left side of the apical part next to one or two conical apical horns and forms a triangular cavity which has occasionally a frame extending from one of the apical horns. A few circular to oval basal pores vary considerably in size from 1/10 to 1/3 of the shell width. Three to four feet are made of the meshwork, ca. 1/8 of the shell length and extending parallel to a plane of the cone.

DIMENSIONS: Length (31 specimens): 567 ± 89 μm (2 S.D.); width (36 specimens): 372 ± 42 μm.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 3,791 m; collected during August–December 1979.

REMARKS: This species is large in size and commonly observed at Station PB, but poor preservation in the sediments is expected due to its fragile skeleton.

DERIVATION OF NAME: The name of this species is a dimunitive of the word tipi (var. of tepee) because of its characteristic shape.

Genus *Sethoconus* Haeckel, 1881
Sethoconus myxobrachia Strelkov and Reshetnyak
Plate 38, figures 7, 8

Sethoconus myxobrachia Strelkov and Reshetnyak. - RENZ, 1976, p. 136, pl. 5, fig. 4.

Genus *Conarachnium* Haeckel, 1881
Conarachnium polyacanthum (Popofsky)
Plate 39, figures 1–4

Lophocorys polyacantha POPOFSKY, 1913, p. 400, text-fig. 122. - BENSON, 1966, p. 494, (*partim*), pl. 34, fig. 3 (only). - KLING, 1979, p. 309, pl. 1, fig. 27.

REMARKS: Thorax length and extent of constriction varies significantly. This and the following two species are apparently closely related and thus the same generic name *Conarachnium* is assigned for them.

Conarachnium parabolicum (Popofsky)
Plate 39, figures 5, 6

? *Sethoconus anthocyrtis* HAECKEL, 1887, p. 1296, pl. 62, fig. 21.

? *Periarachnium periplectum* HAECKEL, 1887, p. 1297, pl. 55, fig. 11.

Lampromitra parabolica POPOFSKY, 1913, p. 348, text-fig. 54. - RENZ, 1966, p. 122, pl. 4, fig. 14.

Conarachnium facetum (Haeckel)
Plate 39, figure 7

Sethoconus facetus HAECKEL, 1887, p. 1296, pl. 55, fig. 1.

Genus *Stichopilium* Haeckel, 1881
Stichopilium bicorne Haeckel
Plate 39, figures 13–19

Stichopilium bicorne HAECKEL, 1887, p. 1437, pl. 77, fig. 9. - BENSON, 1966, p. 422, pl. 29, figs. 1, 2. - RENZ, 1976, p. 125, pl. 4, fig. 9. - KLING, 1979, p. 311, pl. 2, figs. 11, 12. - NIGRINI AND MOORE, 1979, p. N91, pl. 26, figs. 1a, 1b. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 11.

Genus *Lithopera* Ehrenberg, 1847a
Lithopera bacca Ehrenberg
Plate 40, figures 1, 2

Lithopera bacca EHRENBERG, 1872a, p. 314. - NIGRINI, 1967, p. 54, pl. 6, fig. 2. - RENZ, 1976, p. 133, pl. 5, fig. 12. - KLING, 1979, p. 309, pl. 2, figs. 4–7. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 3, fig. 8. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 13.

Lithopera ananassa HAECKEL, 1887, p. 1234, pl. 57, fig. 3.

Genus *Cyrtopera* Haeckel, 1881
Cyrtopera languncula Haeckel
Plate 40, figures 3–6

Cyrtopera languncula HAECKEL, 1887, p. 1451, pl. 75, fig. 10. - BENSON, 1966, p. 510, pl. 35, figs. 3, 4. - CASEY, 1971b, pl. 23.1, fig. 10. - RENZ, 1976, p. 120, pl. 4, fig. 7. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 14.

Cyrtopera aglaolampa Takahashi, n. sp.
Plate 40, figures 7–8

DESCRIPTION: Cephalis spherical with a conical stout apical horn 2–3 times its length and with very small pores. There are 6–8 abdominal segments of equal length which gradually increase their width toward the last abdominal chamber. The chamber is ca. 4–6 times as wide as cephalic diameter. Constrictions between the segments are equal to or less than those in *C. languncula*. There are a few short spines on the thorax as well as on the basal side of the last chamber. Four to five abdominal ribs attached on the wall and extending out of the last chamber and become feet which are as long as the chamber's length and slightly curved inward. Pores circular and small in the thorax and gradually increase their size and become hexagonal toward the last chamber. The last chamber's pores are as wide as 2–3 times the thickness of interporous bars.

DIMENSIONS: (5 specimens) Length (cephalis to last chamber): 220–270- μm; width (last chamber): 120–195 μm.

TYPE LOCALITY: 15°21.1′N, 151°28.5′W; sediment trap depth 2,778 m; collected during July–November 1978.

REMARKS: The apical spines are usually straight and not curved as those of *C. languncula*.

DERIVATION OF NAME: The name of this species if from the Greek meaning a beautiful lamp.

Genus *Stichophormis* Haeckel, 1881
Stichophormis cf. *cornutella* Haeckel

? *Stichophormis cornutella* HAECKEL, 1887, p. 1455, pl. 75, fig. 9.

? *Stichophormis novena* HAECKEL, 1887, p. 1455, pl. 79, fig. 9.

Stichophormis cf. *cornutella* Haeckel. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 15.

Genus *Lophocorys* Haeckel, 1881
Lophocorys undulata (Popofsky)
Plate 40, figures 9, 10

Artopilium undulatum POPOFSKY, 1913, p. 405, pl. 36, figs. 4, 5.

Lophocorys polyacantha Popofsky. - BENSON, 1966, p. 494 (*partim*), pl. 34, figs. 1, 2 (only).

? *Stichopilium anocor* RENZ, 1976, p. 124, pl. 5, fig. 10.

REMARKS: *Artopilium* is a junior objective synonym of *Triacartus*, whose type species, *A. elegans*, does not resemble this species. The type species of *Stichopilium, S. bicorne*, does not resemble this species either. *Lophocorys* is tentatively used here, although the generic assignment is uncertain.

Genus *Theocorys* Haeckel, 1881
Theocorys veneris Haeckel
Plate 40, figures 11–14

Theocorys veneris HAECKEL, 1887, p. 1415, pl. 69, fig. 5. - BENSON, 1966, p. 492, pl. 33, figs. 12, 13. - RENZ, 1976, p. 137, pl. 5, fig. 11. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 17.

Genus *Theocorythium* Haeckel, 1887
Theocorythium trachelium trachelium (Ehrenberg)
Plate 40, figures 15, 16

Eucyrtidium trachelius EHRENBERG, 1872a, p. 312; 1972b, p. 293, pl. 7, fig. 8.

Calocyclas amicae HAECKEL, 1887, p. 1382, pl. 74, fig. 2.

Calocyclas vestalis HAECKEL, 1887, p. 1382, pl. 74, fig. 3.

Theocyrtis trachelius (Ehrenberg). - HAECKEL, 1887, p. 1405.

Theocorythium trachelium trachelium (Ehrenberg). - NIGRINI, 1967, p. 79, pl. 8, fig. 2; pl. 9, fig. 2. - JOHNSON AND NIGRINI, 1980, p. 135, text-fig. 13e, pl. 4, fig. 3.

Theocorythium trachelium (Ehrenberg). - RENZ, 1976, p. 147, pl. 6, fig. 13. - RIEDEL AND SANFILIPPO, 1978, p. 76, pl. 9, fig. 17.

Genus *Lipmanella* Loeblich and Tappan, 1961
Lipmanella dictyoceras (Haeckel)
Plate 40, figure 17

Lithornithium dictyoceras HAECKEL, 1860b, p. 840.

Dictyoceras acanthicum JØRGENSEN, 1900, p. 84; 1905, p. 140, pl. 17, fig. 101a; pl. 18, fig. 101b. - BENSON, 1966, p. 417, pl. 28, figs. 8–10.

Dictyoceras xiphephorum JØRGENSEN, 1900, p. 84, pl. 5, fig. 25; 1905, p. 140.

Lithopilium sphaerocephalum POPOFSKY, 1913, p. 380, pl. 35, fig. 2, 3. - RENZ, 1976, p. 123, pl. 4, fig. 8.

Lipmanella dictyoceras (Haeckel). - KLING, 1973, p. 636, pl. 4, figs. 24–26; 1977, p. 217, pl. 2, fig. 2; 1979, p. 309, pl. 2, fig. 8. - PETRUSHEVSKAYA AND KOZLOVA, 1979, p. 137.

Lipmanella pyramidale (Popofsky)
Plate 40, figure 18

Theopilium pyramidale POPOFSKY, 1913, p. 376, pl. 37, fig. 1. - RENZ, 1976, p. 126, pl. 4, fig. 13.

Dictyoceras pyramidale (Popofsky). - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 9.

Lipmanella virchowii (Haeckel)
Plate 40, figures 19–21

Dictyoceras virchowii HAECKEL, 1862, p. 333, pl. 8, figs. 1–5. - TAN AND TCHANG, 1976, p. 285, text-fig. 63. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, figs. 7, 8.

Dictyoceras neglectum CLEVE, 1900a, p. 7, pl. 4, fig. 5. - POPOFSKY, 1913, pl. 34, fig. 4. - RENZ, 1976, p. 121, pl. 4, fig. 10.

Dictyoceras prismaticum TAN AND TCHANG, 1976, p. 185 (*partim*), text-figs. 64, 65a, 65c (only).

Genus *Lithostrobus* Bütschli, 1882
Lithostrobus hexagonalis Haeckel
Plate 41, figures 1–3

Lithostrobus hexagonalis HAECKEL, 1887, p. 1475, pl. 79, fig. 20. - RENZ, 1976, p. 123, pl. 5, fig. 15. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 10.

Lithostrobus cf. *hexagonalis* Haeckel. - BENSON, 1966, p. 508, pl. 35, figs. 1, 2.

Genus *Theocalyptra* Haeckel, 1881
Theocalyptra bicornis (Popofsky)
Plate 41, figures 4–6, 8–11

Pterocorys bicornis POPOFSKY, 1908, p. 208, pl. 34, figs. 7, 8.

Clathrocyclas alcmanae Haeckel. - POPOFSKY, 1913, pl. 37, fig. 4.

Theocalyptra bicornis (Popofsky). - RIEDEL, 1958, p. 240, pl. 4, fig. 4. - NIGRINI AND MOORE, 1979, p. N53, pl. 24, fig. 1. - LING, 1980, p. 369, pl. 2, fig. 3.

Theocalyptra davisiana davisiana (Ehrenberg). - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, figs. 19, 20.

Theocalyptra davisiana davisiana (Ehrenberg)
Plate 41, figure 7

Cycladophora ? davisiana EHRENBERG, 1861b, p. 297; 1872b, pl. 2, fig. 11.

Theocalyptra davisiana (Ehrenberg). - RIEDEL, 1958, p. 239, pl. 4, figs. 2, 3, text-fig. 10. - BENSON, 1966, p. 441 (*partim*), pl. 29, figs. 14, 15 (only). - NIGRINI AND MOORE, 1979, p. N59, pl. 24, figs. 2a, 2b.

Cycladophora davisiana davisianad Ehrenberg. - MORLEY, 1980, p. 206, pl. 1, figs. 1–5.

Theocalyptra davisiana cornutoides (Petrushevskaya)
Plate 41, figures 12–16

Halicaliptra ? *cornuta* BAILEY, 1856, p. 5, pl. 1, figs. 13, 14 (*nomen oblitum*).

Theocalyptra davisiana (Ehrenberg). - BENSON, 1966, p. 441 (*partim*), pl. 29, fig. 16 (only).

Cycladophora davisiana Ehrenberg *cornutoides* PETRUSHEVSKAYA, 1967, pl. 70, figs. 1–3. - LING ET AL., 1971, p. 714, pl. 2, figs. 6, 7. - MORLEY, 1980, p. 206, pl. 1, figs. 7–10.

? *Cycladophora davisiana semeloides* Petrushevskaya. - MORLEY, 1980, p. 206, pl. 1, figs. 11–14.

Theocalyptra davisiana cornutoides (Petrushevskaya). - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 18.

Family PTEROCORYTHIDAE Haeckel, 1881, emend. Riedel, 1967a

DEFINITION BY RIEDEL (1967a): Cephalis subdivided into three lobes by two obliquely downwardly directed lateral furrows arising from the apical spine, in the manner described for *Anthocytidium cineraria* Haeckel and *Calocyclas virginis* Haeckel by Riedel (1959).

Genus *Tetracorethra* Haeckel, 1881, emend. Petrushevskaya, 1971c
Tetracorethra tetracorethra (Haeckel)
Plate 41, figures 17, 18

Tetraspyris tetracorethra HAECKEL, 1887, p. 1044, pl. 53, fig. 19.

Tetracorethra tetracorethra (Haeckel). - RENZ, 1976, p. 145, pl. 6, fig. 23.

Genus *Pterocorys* Haeckel, 1881
Pterocorys zancleus (Müller)
Plate 42, figures 1–4

Eucyrtidium zanclaeum MÜLLER, 1858a, p. 41, pl. 6, figs. 1–3.

Theoconus zancleus. - BENSON, 1966, p. 482, pl. 33, fig. 4 (not fig. 5).

Pterocorys zancleus (Müller). - NIGRINI AND MOORE, 1979, p. N89, pl. 25, figs. 11a, 11b. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, figs. 1–3.

REMARKS: The present species is distinguished from *P. campanula* by its short conical apical spine, rounded thorax and abdomen and absent or very small wings.

Pterocorys campanula Haeckel
Plate 42, figures 5–8

Pterocorys campanula HAECKEL, 1887, p. 1316, pl. 71, fig. 3. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, figs. 4, 5.

Genus *Eucyrtidium* Ehrenberg, 1847a
Eucyrtidium acuminatum (Ehrenberg)
Plate 42, figures 9, 10, 16, 17, 20

Lithocampe acuminatum EHRENBERG, 1844, p. 84.

Eucyrtidium acuminatum (Ehrenberg). - EHRENBERG, 1854, p. 43, pl. 22, fig. 27. - POPOFSKY, 1913, p. 406, text-fig. 127. - NIGRINI, 1967, p. 81, pl. 8, figs. 3a, 3b. - RENZ, 1976, p. 130, pl. 5, fig. 5. - NIGRINI AND MOORE, 1979, p. N61, pl. 24, figs. 3a, 3b. - JOHNSON AND NIGRINI, 1980, p. 129, text-fig. 11d, pl. 3, fig. 15.

Eusyringium siphonostoma HAECKEL, 1887, p. 1499, pl. 80, fig. 14. - BENSON, 1966, p. 498, pl. 34, figs. 6–9.

? *Eusyringium cannostoma* HAECKEL, 1887, p. 1499, pl. 80, fig. 13.

Stichopilium rapaeformis POPOFSKY, 1913, p. 404, text-fig. 126.

REMARKS: Specimens shown by Benson (1966) are very close to the specimens observed under the transmission light microscope in this study. Thoracic ribs form small wings extended from cephalis, attached on the thorax and terminate in the first abdominal segment. A significant variation in skeletal thickness has been observed.

Eucyrtidium hexagonatum Haeckel
Plate 42, figures 18, 19

Eucyrtidium hexagonatum HAECKEL, 1887, p. 1489, pl. 80, fig. 11. - NIGRINI, 1967, p. 83, pl. 8, figs. 4a, 4b. - RENZ, 1976, p. 132, pl. 5, fig. 6. - NIGRINI AND MOORE, 1979, p. N63, pl. 24, figs. 4a, 4b. - JOHNSON AND NIGRINI, 1980, p. 129, text-fig. 11e, pl. 3, fig. 16.

Eusyringium siphonostoma Haeckel. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, fig. 7.

Eucyrtidium cienkowskii HAECKEL, 1887, p. 1493, pl. 80, fig. 9.

REMARKS: A specimen illustrated by Boltovskoy and Riedel (1980, p. 124, pl. 5, fig. 9) has a much wider thorax than those observed here and thus is excluded from the above synonymy.

Eucyrtidium anomalum (Haeckel)
Plate 42, figures 11–14

Lithocampe anomala HAECKEL, 1860, p. 839.

Eucyrtidium anomalum HAECKEL, 1862, p. 323, pl. 7, figs. 11–13. - BENSON, 1966, p. 496, pl. 34, figs. 4, 5. - DUMITRICĂ, 1972, pl. 7, fig. 11. - RENZ, 1976, p. 131, pl. 5, fig. 8. - MCMILLEN AND CASEY, 1978, pl. 4, fig. 5.

Eucyrtidium dictyopodium (Haeckel)
Plate 42, figure 21

Stichopodium dictyopodium HAECKEL, 1887, p. 1447, pl. 75, fig. 6.

Eucyrtidium hexastichum (Haeckel)
Plate 42, figure 22

Lithostrobus hexastichus HAECKEL, 1887, p. 1470, pl. 80, fig. 15. - BENSON, 1966, p. 506 (*partim*), pl. 34, figs. 15, 16 (only).

Stichopilium annulatum POPOFSKY, 1913, p. 403, pl. 37, figs. 2, 3.

Eucyrtidium hexastichum (Haeckel). - PETRUSHEVSKAYA, 1971c, p. 221, fig. 99. - RENZ, 1976, p. 132, pl. 5, fig. 9. - BOLTOVSKOY AND RIEDEL, 1980, p. 124, pl. 5, fig. 10. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 12.

Eucyrtidium sp. aff. *E. anamalum* (Haeckel)
Plate 42, figure 15

REMARKS: Thorax much smaller than that of *E. anomalum*.

Eucyrtidium sp. A group
Plate 38, figures 11–13

Eucyrtidium sp. - JOHNSON, 1974, pl. 10, figs. 17, 18.

Genus *Anthocyrtidium* Haeckel, 1881
Anthocyrtidium zanguebaricum (Ehrenberg)
Plate 41, figures 19–22

Anthocyrtis zanguebarica EHRENBERG, 1872a, p. 301; 1872b, p. 285, pl. 9, fig. 12.

Anthocyrtium zanguebaricum (Ehrenberg). - HAECKEL, 1887, p. 1277.

Anthocyrtis ovata HAECKEL, 1887, p. 1272, pl. 62, fig. 13.

Sethocyrtis oxycephalis HAECKEL, 1887, p. 1299, pl. 62, fig. 9.

Anthocyrtium oxycephalis (Haeckel). - BENSON, 1966, p. 468, pl. 32, figs. 3–5.

Anthocyrtidium zanguebaricum (Ehrenberg). - NIGRINI, 1967, p. 58, pl. 6, fig. 4. - RENZ, 1976, p. 143, pl. 6, fig. 18. - NIGRINI AND MOORE, 1979, p. N69, pl. 25, fig. 2. - JOHNSON AND NIGRINI, 1980, p. 129, text-fig. 12b, pl. 3, fig. 19. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 21.

Anthocyrtidium ophirense (Ehrenberg)
Plate 43, figures 1–7

Anthocyrtis ophirense EHRENBERG, 1872a, p. 301; 1872b, p. 285, pl. 9, fig. 13.

Anthocyrtidium cineraria HAECKEL, 1887, p. 1278, pl. 62, fig. 16.

Anthocyrtidium ophirense (Ehrenberg). - NIGRINI, 1967, p. 56, pl. 6, fig. 3. - RENZ, 1976, p. 143, pl. 6, fig. 25. - NIGRINI AND MOORE, 1979, p. N67, pl. 25, fig. 1. - KLING, 1979, p. 309, pl. 2, fig. 21. - JOHNSON AND NIGRINI, 1980, p. 129, text-fig. 12a, pl. 3, fig. 18. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 9, fig. 22.

REMARKS: Based on TEM, skeletons of this species are very little dissolved in the water column (Plate 43, figures 10–11) as are many other polycystines.

Genus *Lamprocyclas* Haeckel, 1881
Lamprocyclas maritalis Haeckel *polypora* Nigrini
Plate 43, figures 12, 15

Lamprocyclas maritalis Haeckell *polypora* NIGRINI, 1967, p. 76, pl. 7, fig. 6. - KLING, 1979, p. 309, pl. 2, fig. 25. - NIGRINI AND MOORE, 1979, p. N77, pl. 25, fig. 5. - JOHNSON AND NIGRINI, 1980, p. 129, text-fig. 12e, pl. 3, fig. 22.

Lamprocyclas maritalis maritalis Haeckel
Plate 43, figures 8–11, 13, 14

Lamprocyclas maritalis maritalis Haeckel. - NIGRINI, 1967, p. 74, pl. 7, fig. 5. - NIGRINI AND MOORE, 1979, p. N75, pl. 25, fig. 4. - JOHNSON AND NIGRINI, 1980, p. 129, text-fig. 12d, pl. 3, fig. 21. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 9, fig. 26.

Lamprocyclas maritalis HAECKEL, 1887, p. 1390, pl. 79, figs. 13, 14.

Genus *Lamprocyrtis* Kling, 1973
Lamprocyrtis ? *hannai* (Campbell and Clark)

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

? *Lamprocyclas junonis* (Haeckel) group. - PETRUSHEVSKAYA AND KOZLOVA, 1972, p. 545, pl. 36, fig. 8.

Calocyclas hannai CAMPBELL AND CLARK, 1944, p. 48, pl. 6, figs. 21, 22.

Lamprocyrtis ? *hannai* (Campbell and Clark). - KLING, 1973, p. 638, pl. 5, figs. 12–14; pl. 12, figs. 10–14. - NIGRINI AND MOORE, 1979, p. N83, pl. 25, fig. 8. - JOHNSON AND NIGRINI, 1980, p. 135, pl. 3, fig. 25.

Lamprocyclas ? *hannai* (Campbell and Clark). - TAKAHASHI AND HONJO, 1981, p. 154, pl. 9, fig. 25.

Lamprocyrtis nigriniae (Caulet)
Plate 43, figures 17–19

Conarachnium ? sp. - NIGRINI, 1968, p. 56 (*partim*), pl. 1, fig. 5a (only).

Conarachnium nigriniae CAULET, 1971, p. 3, pl. 3, figs. 1–4; pl. 4, figs. 1–4.

Lamprocyrtis haysi KLING, 1973, p. 639, pl. 5, figs. 15, 16; pl. 15, figs. 1–3. - SANFILIPPO AND RIEDEL, 1974, p. 1022, pl. 3, figs. 9, 10. - RIEDEL AND SANFILIPPO, 1978, p. 69, pl. 5, fig. 9.

Lamprocyrtis nigriniae Caulet. - NIGRINI AND MOORE, 1979, p. N81, pl. 25, fig. 7. - KLING, 1979, p. 309, pl. 2, fig. 26. - JOHNSON AND NIGRINI, 1980, p. 129, text-fig. 13a, pl. 3, fig. 24.

Lamprocyrtis sp.
Plate 43, figure 16

Conarachnium ? sp. - NIGRINI, 1968, p. 56 (*partim*), pl. 1, fig. 5b (only).

REMARKS: This taxon differs from *L. nigriniae* in its larger conical thorax and more hexagonal pores. However, it may be combined with the latter pending future studies.

Family ARTOSTROBIIDAE Riedel, 1967b, emend. Foreman, 1973

DEFINITION: Radiolarians with six collar pores, a well-developed vertical tube, no appendages, and the pores of at least one major segment arranged in transverse rows. They may have a smooth or ridged surface, and the last segment is not flared (Forman, 1973).

Genus *Spirocyrtis* Haeckel, 1881
Spirocyrtis scalaris Haeckel
Plate 44, figure 1, 2

Spirocyrtis scalaris HAECKEL, 1887, p. 1509, pl. 76, fig. 14. - RENZ, 1976, p. 142, pl. 6, fig. 1. - NIGRINI, 1977, pl. 2, fig. 12. - JOHNSON AND NIGRINI, 1980, p. 135, text-fig. 14e, pl. 4, fig. 9. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, fig. 15.

Spirocyrtis subscalaris Nigrini
Plate 44, figures 3–6

Spirocyrtis subscalaris NIGRINI, 1977, p. 259, pl. 3, figs. 1, 2. - LING, 1980, p. 368, pl. 2, fig. 21.

Spirocyrtis ? *platycephala* (Ehrenberg) group
Plate 44, figures 7, 8

Lithomitra platycephala ? (Ehrenberg). - BJØRKLUND, 1976a, p. 1124, pl. 11, figs. 17, 18.

REMARKS: Pores are much larger and the angle of the siphon is larger than those of *S. subscalaris*.

Spirocyrtis sp. aff. *S. seriata* Jørgensen and *S. subscalaris* Nigrini

Spirocyrtis seriata JØRGENSEN, 1905, p. 140, pl. 18, figs. 102–104. - BJØRKLUND, 1976a, pl. 10, figs. 7–12.

Spirocyrtis subscalaris NIGRINI, 1977, p. 259, pl. 3, figs. 1, 2.

Spirocyrtis sp. aff. *S. seriata* Jørgensen and *S. subscalaris* Nigrini. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, fig. 16.

Genus *Artostrobus* Haeckel, 1887
Artostrobus annulatus (Bailey)
Plate 38, figures 9, 10

Cornutella ? *annulata* BAILEY, 1856, p. 3, pl. 1, figs. 5a, 5b.

Artostrobus annulatus (Bailey). - HAECKEL, 1887, p. 1481. - RENZ, 1976, p. 117, pl. 4, fig. 5. - LING, 1975, p. 731, pl. 13, fig. 10. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, fig. 8.

Genus *Botryostrobus* Haeckel, 1887
Botryostrobus aquilonaris (Bailey)
Plate 44, figures 9–13

Eucyrtidium aquilonaris BAILEY, 1856, p. 4, pl. 1, fig. 9.

Eucyrtidium tumidium BAILEY, 1856, p. 5, pl. 1, fig. 11.

Botryostrobus aquilonaris (Bailey). - NIGRINI, 1977, p. 246, pl. 1, fig. 1. - NIGRINI AND MOORE, 1979, p. N99, pl. 27, fig. 1. - KLING, 1979, p. 309, pl. 2, fig. 18. - JOHNSON AND NIGRINI, 1980, p. 135, text-fig. 14a, pl. 4, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, figs. 9, 10.

REMARKS: Variations in pore size, shell surface texture and position of the largest post-cephalic segment have been observed. For a more complete synonymy see Nigrini (1977).

Genus *Phormostichoartus* Campbell, 1951, emend. Nigrini, 1977
Phormostichoartus corbula (Harting)
Plate 44, figures 14–16

Lithocampe corbula HARTING, 1863, p. 12, pl. 1, fig. 21.

Siphocampe corbula (Harting). - NIGRINI, 1967, p. 85, pl. 8, fig. 5. - RIEDEL AND SANFILIPPO, 1971, p. 1601, pl. 1H, figs. 18–25; 1978, p. 73, pl. 9, fig. 7. - RENZ, 1976, p. 141, pl. 6, fig. 8.

Phormostichoartus corbula (Harting). - NIGRINI, 1977, p. 252, pl. 1, fig. 10. - JOHNSON AND NIGRINI, 1980, p. 135, text-fig. 14c, pl. 4, fig. 7. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, figs. 13, 14.

Genus *Siphocampe* Haeckel, 1887
Siphocampe nodosaria (Haeckel)

Lithomitra nodosaria HAECKEL, 1887, p. 1484, pl. 79, fig. 1. - PETRUSHEVSKAYA AND KOZLOVA, 1972, pl. 24, figs. 29, 30.

Lithomitra eruca HAECKEL, 1887, p. 1485, pl. 79, fig. 3. - PETRUSHEVSKAYA AND KOZLOVA, 1972, p. 539, pl. 24, figs. 32, 33.

Siphocampe nodosaria (Haeckel). - NIGRINI, 1977, p. 256, pl. 3, fig. 11. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, figs. 11, 12.

Siphocampe lineata (Ehrenberg)
Plate 44, figures 17–20

Lithocampe lineata EHRENBERG, 1838, p. 130 (*partim*).

Eucyrtidium lineatum (Ehrenberg). - EHRENBERG, 1847, p. 43 (*partim*); 1854, pl. 22, fig. 26.

Tricolocampe cylindrica HAECKEL, 1887, p. 1412, pl. 66, fig. 21.

Siphocampe lineata (Ehrenberg) group. - NIGRINI, 1977, p. 256, pl. 3, figs. 9, 10. - JOHNSON AND NIGRINI, 1980, p. 135, text-fig. 14d, pl. 4, fig. 8.

REMARKS: For a more complete synonymy see Nigrini (1977).

Siphocampe arachnea (Ehrenberg)
Plate 44, figures 21–23

Eucyrtidium lineatum arachneum Ehrenberg, 1861b, p. 299.

Lithomitra vanhoffeni POPOFSKY, 1908a, p. 296, pl. 36, fig. 9.

Lithomitra arachnea (Ehrenberg). - RIEDEL, 1958, p. 242, pl. 4, figs. 7, 8. - PETRUSHEVSKAYA, 1966, p. 232, text-fig. 7(4); 1971b, text-fig. 22.4b; 1975, p. 586, pl. 10, figs. 13–17.

REMARKS: Genus *Siphocampe* is assigned here in order to conform with the generic namne of other species in this group.

Genus *Artobotrys*
Artobotrys borealis (Cleve)
Plate 44, figure 24; Plate 45, figures 1–3

Theocorys borealis CLEVE, 1899, p. 33, pl. 3, fig. 5.

Artobotrys borealis (Cleve). - BJØRKLUND, 1976, p. 1124, pl. 11, figs. 24–27.

Family CARPOCANIIDAE Haeckel, 1881, emend. Riedel, 1967b

DEFINITION: Cephalis small, not sharply distinguished in contour from thorax, and tending to be reduced to a few bars within top of thorax (Riedel, 1971).

Genus *Carpocanistrum* Haeckel, 1887
Carpocanistrum flosculum Haeckel
Plate 45, figures 4, 6–7

Carpocanistrum flosculum HAECKEL, 1887, p. 1171, pl. 52, fig. 9.

Carpocanium verecundum HAECKEL, 1887, p. 1284, pl. 52, fig. 12, 13.

Carpocanium petalospyris Haeckel. - BENSON, 1966, p. 434 (*partim*), text-fig. 25, pl. 29, fig. 10 (only).

Carpocanium spp. - NIGRINI, 1970, p. 171 (*partim*), pl. 4, figs. 5, 6.

Carpocanistrum spp. - DUMITRICĂ, 1972, p. 838, pl. 14, fig. 4; pl. 15, figs. 11, 12; pl. 24, figs. 1, 3, 6. - RENZ, 1976, p. 151, pl. 6, fig. 4. - NIGRINI AND MOORE, 1979, p. N23 (*partim*), pl. 21, figs. 1b, 1c. - JOHNSON AND NIGRINI, 1980, p. 127 (*partim*), text-fig. 9f, pl. 3, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 155, pl. 10, figs. 21, 22.

REMARKS: Pore size varies. Terminal teeth present on the peristome in well developed specimens.

Carpocanistrum cephalum Haeckel
Plate 45, figures 5, 12

Carpocanistrum cephalum HAECKEL, 1887, p. 1171, pl. 52, fig. 10.

Carpocanistrum evacuatum HAECKEL, 1887, p. 1172, pl. 52, fig. 11.

Carpocanium petalospyris Haeckel. - BENSON, 1966, p. 434 (*partim*), pl. 29, fig. 9 (only).

Carpocanium sp. - BENSON, 1966, p. 438, pl. 29, figs. 11, 12.

Carpocanium sp. A. - NIGRINI, 1968, p. 55, pl. 1, fig. 4. - NIGRINI AND MOORE, 1979, p. N25, pl. 21, fig. 2.

REMARKS: This species is distinguished by its cylindrical shape rather than amphora-shaped counterparts in the present genus. Present species differs from *Cryptopora ornata* Ehrenberg (see Sanfilippo and Riedel, 1973, p. 530, pl. 35, figs. 3, 4).

Carpocanistrum favosum (Haeckel)
Plate 45, figure 8

Sethamphora favosa HAECKEL, 1887, p. 1252, pl. 57, fig. 4.

Carpocanistrum ? odysseus Haeckel. - DUMITRICĂ, 1972, p. 838, pl. 15, fig. 10; pl. 24, fig. 2.

REMARKS: Basal opening rather small surrounded by terminal teeth whose surface is smooth. Shell surface rough caused by numerous rounded denticles. This species should not be confused with *Carpocanopsis favosa* (Haeckel) (Sanfilippo et al., 1973, p. 224, pl. 6, figs. 7, 8).

Carpocanistrum coronatum (Ehrenberg)
Plate 45, figure 10

Carpocanium coronatum EHRENBERG, 1875, p. 66, pl. 5, fig. 7.

Carpocanistrum sp. D. - LING, 1975, p. 730, pl. 12, fig. 6.

Carpocanistrum spp. - NIGRINI, 1970, p. 171 (*partim*), pl. 4, fig. 4 (only). - NIGRINI AND MOORE, 1979, p. N23 (*partim*), pl. 21, fig. 1a (only).

REMARKS: Pores smaller and more in number than in the relative species shown in Plate 45. The number is ca. 16–18 in an equatorial half meridian.

Carpocanistrum acutidentatum Takahashi, n. sp.
Plate 45, figures 9, 13–15

DESCRIPTION: Shell thick and ovate with cephalis completely hidden, pores elongate but occasionally subcircular and smaller than longitudinal crests. There are ca. 14–18 such crests in a half meridian. Peristome surrounded by ca. 12–16 sharp conical teeth of 1/4 to 3/4 shell length which are straight or inwardly curved near the terminal end. One tooth is connected with 1–3 crests.

DIMENSIONS: (11 specimens) Shell length (exclusive of teeth): 87–110 μm; tooth length: 24–71 μm; transverse width: 80–96 μm.

TYPE LOCALITY: 15°21.1′N, 151°28.5′W; sediment trap depth 4,280 m; collected during July–November 1978.

REMARKS: The present species differs from *C. flosculum* Haeckel primarily in pore shape and in the presence of the strong crests.

DERIVATION OF NAME: The name of this species is the Latin meaning sharp tooth.

Carpocanistrum sp.
Plate 45, figure 11

REMARKS: This taxon resembles some specimens shown by Riedel and Sanfilippo (1971, see pl. 2F).

Genus *Carpocanarium* Haeckel, 1887, emend. Nigrini and Moore, 1979
Carpocanarium papillosum (Ehrenberg)
Plate 45, figures 16, 17

Eucyrtidium papillosum EHRENBERG, 1872a, p. 310; 1872b, p. 293, pl. 7, fig. 10.

Dictyocryphalus papillosus (Ehrenberg). - HAECKEL, 1887, p. 1307. - RIEDEL, 1958, p. 236, pl. 3, fig. 10, text-fig. 8. - NIGRINI, 1967, p. 63, pl. 16, fig. 6. - LING, 1975, p. 731, pl. 13, fig. 10. - RENZ, 1976, p. 139, pl. 6, fig. 9.

Carpocanarium papillosum (Ehrenberg) group. - NIGRINI AND MOORE, 1979, p. N27, pl. 21, fig. 3. - JOHNSON AND NIGRINI, 1980, p. 127, text-fig. 10a, pl. 3, fig. 6.

Carpocanarium papillosum (Ehrenberg). - TAKAHASHI AND HONJO, 1981, p. 155, pl. 10, fig. 17.

Family CANNOBOTRYIDAE Haeckel, 1881, emend. Riedel, 1967a

DEFINITION BY RIEDEL (1967a): Cephalis consisting of two or more unpaired lobes, only one of which is homologous with the cephalis of theoperids.

Genus *Acrobotrys* Haeckel, 1881
Acrobotrys teralans Renz
Plate 45, figures 18, 19

Acrobotrys cf. *disolenia* Haeckel. - BENSON, 1966, p. 339, text-fig. 21, pl. 23, figs. 13, 14.

Gen. et sp. indet. - RIEDEL AND SANFILIPPO, 1971, pl. 1J, figs. 17, 18.

Acrobotrys teralans RENZ, 1976, p. 152, pl. 7, fig. 8.

? *Neobotrys* sp. - TAN AND TCHANG, 1976, p. 273, text-fig. 46.

Acrobotrys tessarolobon Takahashi, n. sp.
Plate 45, figure 20

DESCRIPTION: Cephalis quadrilobate with a single tubule projecting laterally. The cephalic lobes of unequal size and shape. Main cephalic lobe spherical and exposing nearly half of its surface area and with fine circular pores and thick skeleton. A polar lobe of the cephalis is conical in shape and characteristically projecting straight poleward. It has fine circular pores much smaller than the interporous septae. The largest lobe lies between the conical polar lobe and post-cephalic lobe. A collar constriction forms an upside down wide angle "V" and has a few fine spines. Postcephalic lobe cylindrical and with circular pores which are at least latitudinally regularly arranged and with a large basal opening. There is no wing.

DIMENSIONS: (3 specimens) Length: 95–110 μm; breadth (including the tubule): 85–98 μm.

TYPE LOCALITY: 15°21.1′N, 151°28.5′W; sediment trap depth 978 m; collected during July–November 1978.

REMARKS: This species differs from *A. teralans* in number and shape of the cephalic lobes and its absence of wings.

DERIVATION OF NAME: The name of this species is Greek meaning four lobes.

Acrobotrys chelinobotrys Takahashi, n. sp.
Plate 45, figures 22–24

Botryopyle dictyocephalus Haeckel group. - RENZ, 1976, p. 154, pl. 7, fig. 10.

Acrobotrys sp. A. - TAKAHASHI AND HONJO, 1981, p. 155, pl. 10, fig. 18.

DESCRIPTION: Cephalis trilobate with a single tapering tubule which is laterally or obliquely (toward postcephalic side) projecting. The three cephalic lobes unequal in size and shape. The central lobe of the cephalis is spherical, exposing 1/4 of its surface of outside and having the thickest skeleton and the smallest pore size among all of the lobes. A collar stricture between the cephalic lobes and a postcephalic lobe makes an arch. The postcephalic lobe nearly cylindrical but tapering toward basal opening. Both cephalis and thorax are made of meshwork with subcircular irregular pores whose diameter varies from 1–4 times the interporous bars. There is no wing.

DIMENSION: (11 specimens) Length: 80–105 μm; breadth (excluding the tubule): 40–60 μm.

TYPE LOCALITY: 15°21.1′N, 151°28.5′W; sediment trap depth 978 m; collected during July–November 1978.

REMARKS: This species apparently differs from the *Botryopyle dictyocephalus* group illustrated by Riedel and Sanfilippo (1971, p. 1602, pl. 1J, fig. 21–26) typically in presence of a tubule.

DERIVATION OF NAME: The name of this species is from Greek meaning netted cluster of grapes.

Acrobotrys sp. C

Acrobotrys sp. C. - TAKAHASHI AND HONJO, 1981, p. 155, pl. 10, fig. 20.

Genus *Saccospyris* Haecker, 1908b
Saccospyris preantarctica Petrushevskaya
Plate 45, figure 21

Saccospyris preantarctica PETRUSHEVSKAYA, 1975, p. 589, pl. 13, fig. 19, 20.

REMARKS: The present finding of this species indicates that it has long range at least back to Miocene. This species resembles *Bisphaerocephalus minutus* Popofsky (1908a, pl. 33, fig. 9).

Genus *Centrobotrys* Petrushevskaya, 1965
Centrobotrys thermophila Petrushevskaya
Plate 46, figures 1, 2

Androspyris aptenodytes Haeckel. - POPOFSKY, 1913, p. 294, text-figs. 17, 18.

Centrobotrys thermophila PETRUSHEVSKAYA, 1965, p. 115. - NIGRINI, 1967, p. 49, text-fig. 26, pl. 5, fig. 7. - RIEDEL AND SANFILIPPO, 1971, p. 1602, pl. 1J, figs. 27–31; pl. 2J, fig. 19; pl. 3F, fig. 14. - RENZ, 1976, p. 155, pl. 7, fig. 15.

Genus *Neobotrys* Popofsky, 1913
Neobotrys quadrituberosa Popofsky
Plate 46, figure 3

Neobotrys quadrituberosa POPOFSKY, 1913, pp. 320–321, pl. 30, fig. 4.

Genus *Botryocyrtis* Ehrenberg, 1860b
Botryocyrtis scutum (Harting)
Plate 46, figures 6, 7

Haliomma scutum HARTING, 1863, p. 11, pl. 1, fig. 18.

Botryocyrtis caput serpentis EHRENBERG, 1872a, p. 301; 1872b, p. 287, pl. 10, fig. 21.

? *Lithobotrys homunculus* POPOFSKY, 1913, p. 317, pl. 31, figs. 5, 6.

Botryopyle erinaceus POPOFSKY, 1913, p. 319, text-figs. 28, 28a.

Botryocyrtis scutum (Harting). - NIGRINI, 1967, p. 52, pl. 6, figs. 1a–1c. - NIGRINI AND MOORE, 1979, p. N105, pl. 28, figs. 1a, 1b. - TAKAHASHI AND HONJO 1981, p. 155, pl. 10, figs. 23, 24.

Botryocyrtis elongatum Takahashi, n. sp.
Plate 46, figures 8, 9

DESCRIPTION: Cephalis trilobate with spherical lobes of increasing size from one side to another, a few spines longer than lobes, rough surface and very small pores. Thorax elongate and cylindrical and 2–3 times of cephalic length with fine spines and pores, rough surface in the anterior half and becomes porous and smooth in the posterior half which looks hyaline under the transmission light microscope. There is no segmentation in the thorax.

DIMENSIONS: (8 specimens) Length: 65–160 μm; width: 35–64 μm.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 3,769 m; collected during August–December 1979.

REMARKS: This species is common at Stations P_1 and PB.

DERIVATION OF NAME: The name of this species is the Latin meaning prolonged.

Botryocyrtis sp. A
Plate 46, figures 4, 5

DESCRIPTION: Cephalis trilobate with very fine pores, spines and rough surface. Thorax cylindrical and short with irregular circular pores.

REMARKS: This could be a juvenile form of *B. scutum*.

Family ARCHIPHORMIDIDAE Haeckel, 1881

DEFINITION: Phaenocalpida with the basal mouth of the shell open (Haeckel, 1887).

Genus *Arachnocalpis* Haeckel, 1881
Arachnocalpis ellipsoides Haeckel
Plate 46, figure 17

Arachnocalpis ellipsoides HAECKEL, 1887, p. 1172, pl. 98, fig. 13.

Arachnocalpis ? *ovatiretalis* Takahashi, n. sp.
Plate 46, figures 12–14

DESCRIPTION: Shell ovate with a fragile thin mesh composed of polygons and a basal opening at one pole, without an apical horn, spines, ribs and a sagital ring. Usually one pole is slightly protruded from the ellipsoidal perimeter but some specimens have smooth poles. The polygons of the network are mostly triangular. There are two kinds of interconnecting networks: thin and thick ones. Size of the polygons is ca. 1–4 times thickness of the thicker mesh.

DIMENSIONS: (8 specimens) Length: 175–290 μm; width: 105–205 μm; mean length/width ratio: 1.62 ± 0.16.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 667 m; collected during August–December 1979.

REMARKS: Position of this species is uncertain because no closely related species to this has been reported and thus the present assignment is tentative.

DERIVATION OF NAME: The name of this species is the Latin meaning having the nature of an egg-shaped net.

Arachnocalpis ? sp. A
Plate 46, figure 10

DESCRIPTION: Large ellipsoidal shell with fine spongy and fragile network composed of irregular size polygons and without an apical horn, spines, and sagital ring.

REMARKS: This species is very rare. The systematic position of this taxon is uncertain.

Arachnocalpis sp. B
Plate 46, figure 11

Arachnocalpis ? sp. C
Plate 46, figure 16

DESCRIPTION: Shell elongate fragile spongy network with tubules associated with 7–10 large pores.

REMARKS: Very rare and systematic position is uncertain.

Order TRIPLYEA Hertwig, 1879
Suborder PHAEODARIA Haeckel, 1879
Family CHALLENGERIIDAE Murray, 1876, emend. herein

DEFINITION: Shell ovate or lens-shaped with a mouth and peristome and is usually provided with oral teeth, but without articulated feet. Surface of the shell usually smooth with numerous regularly arranged pores and some species bear a zone of dimples causing alveolate surface. Skeletal unit of shell made of amphora structure cemented with soluble silica.

REMARKS: The above emendation is based on the following: 1) information on surface morphology (i.e., smooth and/or dimpled surfaces); 2) SEM-TEM information on micro- and ultra-skeletal structures; 3) finding of a form without oral teeth (i.e., *C. lingi* Takahashi, n. sp.). This family is characterized by alveolate internal skeletal morphology which is commonly composed of amphora-shaped structure.

Genus *Challengeron* Haeckel, 1887

DEFINITION: Challengeriida without pharynx. Shell smooth without dimples. Marginal spines present in well developed individuals. Oral teeth may be present or absent.

REMARKS: All of the species studied here have amphorae of similar size and shape as basic unit of skeletal structure.

Challengeron willemoesii Haeckel
Plate 47, figures 1–14

Challengeron willemoesii HAECKEL, 1887, p. 1659, pl. 99, fig. 13. - BORGERT, 1911, p. 456, pl. 34, figs. 4–6. - TAKAHASHI AND HONJO, 1981, p. 155, pl. 10, figs. 25, 29.

Challengeron rottenburgi BORGERT, 1892, p. 182, pl. 6, fig. 1; 1911, p. 458, pl. 35, figs. 1, 2. - HAECKER, 1906a, p. 301, pl. 6, fig. 1, text-figs. f, k.

Challengeron armatum BORGERT, 1901a, p. XV33, fig. 39; 1911, p. 454, pl. 34, figs. 7–9.

Challengeron gracile BORGERT, 1911, p. 458, pl. 35, figs. 6, 7.

Challengeron gracilimum BORGERT, 1911, p. 459, pl. 35, figs. 3–5.

Challengeron walwini WOLFENDEN, 1902, p. 359, pl. 2, figs. 1, 1a.

? *Challengeron wyvillei* HAECKEL, 1887, p. 1660, pl. 99, fig. 15.

Challengeron sp. LING AND TAKAHASHI, 1977, p. 208, pl. 1, figs. 1–5.

REMARKS: The concept of this species herein is somewhat broader than that of Borgert. Based on examinations of several tens of specimens, the author believes that intra-species morphological variations of the present species occur to such an extent that previous authors separated this group into several species. The variations observed include size and shape of the shell, length, number and arrangement of spines (i.e., alternation of longer and shorter ones). However, the angle between 2 pairs of divergent teeth is consistent. Splitting of ovate forms from compressed ellipsoidal forms was possible, but this may or may not be natural. Forms with sabre-shaped terminal teeth such as those of *Challengeron wyvillei* Haeckel (1887, p. 1660, pl. 99, fig. 15) have not been recognized from the present study areas (Haeckel's specimens were from the eastern tropical Atlantic).

Micro- and ultra-structural studies shown in Plate 47 reveal that the basic unit of skeleton is a regularly arranged amphora-shaped structure cemented by relatively soluble silica. This structure is common to all of the 17 species studied in the present family except *Challengeranium diodon* (Haeckel) as shown in Plates 47–52.

Challengeron lingi Takahashi, n. sp.
Plate 48, figures 1–5

DESCRIPTION: Shell ovate to compressed ellipsoid, usually with spines along longitudinal rim. Shell wall smooth with regularly arranged numerous pores which are one open end of amphora structure common to all of the species in the present family. Peristome smooth without teeth and the mouth opens obliquely.

DIMENSIONS: Length 240 ± 30 (2 S.D.) μm (6 specimens); width: 159 ± 33 μm (7 specimens); weight: 0.07 ± 0.01 μg (15 specimens).

TYPE LOCALITY: 5°21′N, 81°53′W; depth of sediment traps 3,769 m and 3,791 m; collected during August–December 1979.

REMARKS: The present species is closely related to *C. willemoesii*. Absence of oral teeth is the major difference from the latter. More than 30 specimens observed showed smooth peristome as shown in Plate 48 without any exceptions.

DERIVATION OF NAME: This species is dedicated to Professor Hsin Yi Ling who inspired the present study.

Challengeron radians Borgert
Plate 48, figure 6

Challengeron radians BORGERT, 1903, p. 743, text-fig. J; 1911, p. 453, pl. 34, fig. 3. - TAKAHASHI AND HONJO, 1981, p. 155, pl. 11, figs. 1, 2.

Challengeron tizardi (Murray)
Plate 48, figures 13–16

Challengeria tizardi MURRAY, 1885, p. 226, pl. A, figs. 7–7b.

Challengeron tizardi (Murray). - HAECKEL, 1887, p. 1656.

Protocystis tizardi (Murray). - HAECKER, 1908b, p. 266, pl. 50, figs. 405, 406.

REMARKS: Size of this species is fairly uniform based on 20 specimens; it is close to Murray's and larger than Haeckel's specimens. Dimensions obtained from Takahashi and Honjo (in prep.): length 340 ± 25 (2 S.D.) μm (5 specimens); width: 272 ± 30 μm (8 specimens); weight: 0.54 ± 0.16 (2 S.D.) μg (18 specimens).

Genus *Challengerosium* Haeckel, 1887, emend. herein

DEFINITION: Challengeriidae with marginal spines, oral teeth and two different kinds (smooth and dimpled) of surfaces on a lens-shaped shell.

TYPE SPECIES: *Challengerosium avicularia* Haecker, 1906a.

REMARKS: Subgenus *Challengerosium* of Haeckel (1887) is herein elevated and separated from *Challengeron* in analogous manner with what Haecker (1906a) proposed for *Heliochallengeron* for presence of alveolate girdle zone in *H. channeri* (Murray).

Challengerosium balfouri (Murray)
Plate 48, figures 7–10

Challengeria balfouri MURRAY, 1885, p. 226, pl. A, fig. 10.

Challengeron balfouri (Murray). - HAECKEL, 1887, p. 1655. - BORGERT, 1901a, p. XV31, fig. 37; 1911, p. 449, pl. 33, figs. 5–9. - WOLFENDEN, 1902, p. 360, pl. 2, figs. 2, 2a, 3, 3a. - TAKAHASHI AND HONJO, 1981, p. 155, pl. 11, figs. 5, 6. See Borgert (1911) for additional references.

Protocystis balfouri (Murray). - HAECKER, 1908b, p. 268, pl. 50, fig. 395.

REMARKS: Surface texture of the shell of two kinds: smooth on lateral sides; alveolate on sagital plane. Microstructure study using SEM shows no significant difference in internal amphora structure in both smooth and rough surface areas of the shell wall. These two kinds of surface morphologies also exist in *C. avicularia*.

Challengerosium avicularia Haecker
Plate 49, figures 1–13

Challengerosium avicularia HAECKER, 1906a, p. 300, pl. 11, fig. 8.

Challengeron avicularia (Haecker). - BORGERT, 1911, p. 466.

? *Challengeria bethelli* MURRAY, 1885, pl. A, fig. 6.

? *Challengerosium bethelli* (Murray). - HAECKER, 1906a, p. 299, text-fig. F, h.

REMARKS: Contrast between smooth and dimpled rough surfaces is clear in most specimens observed under SEM, except some determined to be affected by dissolution. The number of marginal spines is generally close to 10; occasionally 2 or 3 spines. None of the specimens here has as many spines as *C. bethelli* (Murray) shown by Murray (1885) and Haecker (1906a).

Genus *Protocystis* Wallich, 1869, emend. herein

DEFINITION: Challengeriidae without pharynx, with none or up to several oral teeth and without marginal spines.

REMARKS: Wallich (1869), Borgert (1901a, 1911) and Haecker (1906a) defined the present genus having one or several oral teeth. However, appearance of specimens with peristome without oral teeth necessitated this emendation. Generic classification of the present genus as well as *Challengeron* and *Challengerosium* may be artificial and hence it may require further emendations in the future work.

DESCRIPTION: Shell lens-shaped, without marginal spines. Compressed sides of shell relatively smooth and girdle zone of alveolate surface. Peristome smooth without teeth.

Protocystis harstoni (Murray)

Challengeria harstoni MURRAY, 1885, p. 226, pl. A, fig. 14a (not fig. 14). - HAECKEL, 1887, p. 1650.

Protocystis harstoni (Murray). - BORGERT, 1901a, p. XV28, fig. 30. - BJØRKLUND, 1976a, pl. 12, fig. 5. - DUMITRICĂ, 1973, p. 755, pl. 8, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 11, fig. 11.

? *Protocystis harstoni* (Murray). - HAECKER, 1908b, p. 49, text-fig. 150. - BORGERT, 1911, p. 436, text-fig. 4a. - STADUM AND LING, 1969, p. 483, pl. 1, figs. 1–3. - BJØRKLUND, 1976a, pl. 12, figs. 6, 7.

Protocystis natuiloides BORGERT, 1903, p. 738, text-figs. Da, Db.

Protocystis antarctica SCHRÖDER, 1913, pl. 21, fig. 1.

? *Challengeria zetlandica* WOLFENDEN, 1902, p. 361, pl. 2, fig. 5. See Borgert (1911) for additional references.

REMARKS: Specimens shown by Haecker (1908), Borgert (1911), Stadum and Ling (1969) and Bjørklund (1976a, p. 12, figs. 6, 7 of the Cleve collection) are different in angle, length and shape of peristome from the rest in the references listed above and the examined specimens. The former can be classified as a subspecies of the present species.

Protocystis honjoi Takahashi, n. sp.
Plate 50, figures 1, 2

Protocystis sp. TAKAHASHI AND HONJO, 1981, p. 156, pl. 11, figs. 8, 9.

DESCRIPTION: Shell lens-shaped and circular, with two characteristic wing-like oral teeth on the peristome. Shell surface texture of two kinds: rough girdle zone and smooth compressed sides. Contrast between the two surface textures is not as marked as in *Challengerosium*.

DIMENSIONS: (12 specimens) Shell diameter: 147 ± 13 (2 S.D.) μm; weight: 0.10 ± 0.05 μg (4 specimens).

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 2,869 m; collected during August–December 1979.

REMARKS: This species is closely related to *P. gravida* Borgert (1903, p. 741, figs. Ga, Gb) and *P. macleari* (Murray) (1885, p. 226, pl. A, fig. 3; Haeckel, 1887, p. 1651). Specimens from the Pacific are slightly larger than those of the Atlantic (Takahashi and Honjo, 1981).

DERIVATION OF NAME: This species is dedicated to Dr. Susumu Honjo for his contribution to this work in recovery of the samples.

Protocystis tridentata Borgert
Plate 50, figure 3

Protocystis tridentata BORGERT, 1903, p. 743, text-fig. H; 1911, p. 444, pl. 32, fig. 7. - HAECKER, 1906, p. 294, 295; 1908b, p. 266, pl. 50, fig. 404.

Protocystis auriculata Takahashi, n. sp.
Plate 50, figures 4–7

DESCRIPTION: Shell lens-shaped and extending toward posterior end where peristome exists, with two ear-shaped winged teeth. The wings extend perpendicular to sagital plane. The teeth as long as 1/2 to 2/3 of transverse shell diameter.

DIMENSIONS: (8 specimens) Transverse shell diameter: 98 ± 9 (2 S.D.) μm.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 2,869 m; collected during August–December 1979.

DERIVATION OF NAME: The name of this species is the Latin meaning having the nature of ear.

Protocystis aduncicuspis Takahashi, n. sp.
Plate 50, figures 8–10

DESCRIPTION: Shell compressed and semi-triangular, with two divergent oral teeth on peristome causing a sharp bend on girdle circumference. Girdle zone is covered by dimples causing rough surface.

DIMENSIONS: Transverse shell diameter: 139 ± 21 (2 S.D.) μm (13 specimens); longitudinal length including teeth: 174 ± 12 μm (6 specimens).

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 3,791 m; collected during August–December 1979.

REMARKS: Shape of the peristome and teeth thickness vary.

DERIVATION OF NAME: The name of this species is the Latin meaning having the nature of bent and pointed ends.

Protocystis sloggetti (Haeckel)
Plate 50, figures 12–15

Challengeron harstoni MURRAY, 1885, p. 226, pl. A, fig. 14 (*nomen oblitum*).

Challengeria sloggetii HAECKEL, 1887, pp. 1649, 1650, pl. 99, fig. 4.

Protocystis sloggetii (Haeckel). - HAECKER, 1906, pp. 297, 298; 1908b, p. 271, pl. 50, figs. 401, 402. - BORGERT, 1911, p. 435, text-fig. 3.

REMARKS: Bifurcated oral teeth vary in thickness and length. Shape of compressed triangular lenticular shell is consistent and less round than the previous workers report.

Protocystis murrayi (Haeckel)
Plate 50, figures 16–18, Plate 51, figures 1–3

Challengeria aldrichi MURRAY, 1885, pl. A, fig. 4 (*nomen oblitum*).

Challengeria murrayi HAECKEL, 1887, p. 1653, pl. 99, fig. 1.

Protocystis murrayi (Haeckel). - HAECKER, 1906a, p. 299, text-fig. F, g; 1908b, pp. 272, 273, pl. 50, figs. 409, 411, text-fig. 29, g. - BORGERT, 1911, p. 445, text-figs. 11a, 11b.

? *Protocystis thyroma* HAECKER, 1906, p. 299, pl. 6, fig. 6.

Protocystis thomsoni (Murray)
Plate 51, figure 5

Challengeria thomsoni MURRAY, 1885, pl. A, figs. 2, 2a. - HAECKEL, 1887, p. 1650.

Protocystis thomsoni (Murray). - HAECKER, 1906a, p. 291, text-fig. Fb; 1908b, p. 261, pl. 49, figs. 388–389, text-fig. 29b. - BORGERT, 1911, p. 440, text-figs. 7a, 7b. - RESHETNYAK, 1955, p. 98, pl. 1, figs. 1, 2. - LING, 1966, p. 206, pl. 1, figs. 1–11; pl. 2, figs. 1–7. - LING AND TAKAHASHI, 1977, p. 209, pl. 2, figs. 1–6. - TAKAHASHI AND HONJO, 1981, p. 155 (partim), pl. 11, fig. 4.

Protocystis bicornis BORGERT, 1901a, p. XV29, text-fig. 32, pl. 33, figs. 3, 4.

Protocystis xiphodon (Haeckel)
Plate 52, figures 1–3

Challengeria naresii MURRAY dwarf variety, pl. A, fig. 1b (*nomen oblitum*).

Challengeria xiphodon HAECKEL, 1887, p. 1648. - HAECKER, 1908b, p. 260, pl. 49, figs. 378–381.

Protocystis xiphodon (Haeckel). - BORGERT, 1901a, p. XV27, fig. 28; 1903, p. 738; 1911, p. 433, pl. 31, figs. 5–7. - JØRGENSEN, 1905, p. 141. - STADUM AND LING, 1969, p. 483, pl. 1, figs. 4, 5. - BJØRKLUND, 1976, pl. 12, fig. 4. - TAN AND TCHANG, 1976, p. 297, text-fig. 78. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 11, fig. 14. See Borgert (1911) for additional references.

REMARKS: This is the smallest species among the one-toothed trio of *Protocystis* (including *P. tritonis* and *P. naresi*) whose shell is compressed ovate tapering toward the oral tooth. Ratio of mouth/shell diameter is the largest among the trio.

Protocystis tritonis (Haeckel)
Plate 52, figures 4, 5

Challengeria tritonis HAECKEL, 1887, p. 1649, pl. 99, fig. 5. - WOLFENDEN, 1902, p. 360, pl. 2, fig. 4.

Protocystis tritonis (Haeckel). - BORGERT, 1901a, p. XV28, fig. 29; 1911, p. 434, pl. 31, figs. 8, 9. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 11, fig. 13.

Protocystis naresi (Murray)
Plate 52, figures 6–8

Challengeria naresii MURRAY, 1885, p. 226, pl. A, figs. 1, 1a–1e. - HAECKEL, 1887, p. 1648.

Challengeria naresi Murray. - HAECKER, 1906a, p. 290, text-figs. A, Fa; 1908b, p. 258, pl. 48, fig. 370, pl. 49, fig. 377, pl. 52, figs. 429, 430, text-figs. 27, 28. - RESHETNYAK, 1955, p. 95, pl. 1, fig. 62.

Protocystis naresi (Murray). - BORGERT, 1911, p. 432, text-fig. 2. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 52, fig. 12.

REMARKS: This is the largest of the *Protocystis* one-toothed trio whose longer axis of compressed oval shell diameter ranges from 480 to 680 μm. Mouth is relatively small compared to the former two species of the trio. Examination of microstructure shows this species has elongated amphorae (Plate 52, figure 9), but otherwise very similar to all other species of the family Challengeridae studied.

Protocystis sp. A
Plate 49, figures 14, 15

Protocystis sp. B
Plate 50, figure 11

DESCRIPTION: Shell spherical, with two divergent teeth having similar angle to those of *P. aduncicuspis*. Specimen shown in the plate is 205 μm in shell diameter.

Protocystis sp. C
Plate 51, figure 4

DESCRIPTION: Shell strongly compressed, with winged teeth similar to those of *P. murrayi* (Haeckel), but extending beyond shell thickness.

Genus *Pharyngella* Haeckel, 1887

ORIGINAL DEFINITION: Challengerida with a pharynx, and with one or more teeth on the mouth, but without marginal spines (Haeckel, 1887).

Pharyngella gastrula Haeckel
Plate 51, figures 6–14

Pharyngella gastrula HAECKEL, 1887, p. 1662, pl. 99, fig. 18. - BORGERT, 1901, p. 34, text-fig. 41; 1903, p. 746, text-fig. N; 1911, p. 461, pl. 31, figs. 3, 4. - HAECKER, 1906, p. 303.

Protocystis thomsoni (Murray). - TAKAHASHI AND HONJO, 1981, p. 155 (partim), pl. 11, fig. 3.

REMARKS: Presence of characteristic pharynx separates the present species from *Protocystis thomsoni* (Murray).

Genus *Entocannula* Haeckel, 1879

DEFINITION BY HAECKEL (1887): Challengerida with a pharynx, without teeth on the mouth, and without marginal spines.

Entocannula infundibulum Haeckel
Plate 52, figures 9, 10

Challengeria bromleyi MURRAY, 1885, pl. A, fig. 5 (*nomen oblitum*).

Entocannula infundibulum HAECKEL, 1887, p. 1661, pl. 99, fig. 19. - BORGERT, 1903, pp. 745, 746, text-fig. M; 1911, p. 460, pl. 31, fig. 1. - HAECKER, 1906a, pp. 303, 304; 1908b, p. 279, pl. 51, fig. 425.

Genus *Challengeranium* Haecker, 1908b

ORIGINAL DEFINITION: Shell ovate. Peristome with two fenestrated perforations. Two oral spines. An apical spine often surrounded by secondary spines (Haecker, 1908b, translated by the author).

Challengeranium diodon (Haeckel)
Plate 52, figures 11–16

Challengeron diodon HAECKEL, 1887, p. 1654, pl. 99, fig. 6. - BORGERT, 1901a, p. 30, fig. 34; 1911, p. 448, pl. 33, figs. 10, 11. - JØRGENSEN, 1905, p. 141. - BJØRKLUND, 1974, p. 28, fig. 10; 1976a, pl. 12, figs. 8–11. - TAKAHASHI AND HONJO, 1981, p. 155, pl. 12, figs. 1–3. See Borgert (1911) for additional references.

Challengeron narthorsti CLEVE, 1899, pl. 1, figs. 9a, 9b.

Challengeron heteracanthum JØRGENSEN, 1900, pl. 3, figs. 16, 17.

REMARKS: The microstructure of this species appears to be very different from other Challengerida in the presence of: 1) dimpled surface; 2) clusters of small pores associated with individual amphora (inner shell surface); and 3) thin and delicate amphorae which are different in shape from other species of the family. Thus, the author prefers to choose Haecker's separate classification of the present genus from *Challengeron*. Texture of outer shell surface resembles that of *E. elegans*. Overall shape is closer to Medusettidae than to Challengeriidae. Compare this species with other species of the same genus (i.e., *C. torquatum* Dumitrică, 1965, p. 251, figs. 1, 2, 7). Apparently this species has intermediate morphology between Challengeriidae and Medusettidae and a new assignment to a separate family is possible in future investigations. Therefore, the present classification should be considered as tentative.

Family MEDUSETTIDAE Haeckel, 1887

DEFINITION: Phaeodaria with an ovate, hemispherical or cap-shaped shell of alveolate, smooth or smooth with raised-striae texture, and with articulate hollow feet on the peristome.

REMARKS: Shell surface texture has been observed to be variable depending on species. Observations of microstructures show significant variations between species of the present family and they are very different from amphorae of the family Challengeriidae. As Phaeodaria, shells of this family are small as compared to those of families Porospathidae and Lirellidae.

Genus *Euphysetta* Haeckel, 1887

ORIGINAL DESCRIPTION BY HAECKEL (1887): Medusettida with four articulate feet on the peristome, one odd very large, and three small or rudimentary feet.

Euphysetta elegans Borgert
Plate 53, figures 1–10

Euphysetta elegans BORGERT, 1902, p. 569, text-fig. F; 1906, p. 154, pl. 11, figs. 7–9. - HAECKER, 1904a, p. 138; 1906a, p. 273; 1908b, p. 307, pl. 53, figs. 435, 438. - DUMITRICĂ, 1973, p. 756, pl. 5, fig. 8; pl. 6, figs. 1–3; pl. 12, fig. 8. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 12, figs. 4, 5.

REMARKS: Lengths of an apical spine and odd large foot appear to vary. The specimens observed here always have three small feet and thus differ from *E. amphicodon* HAECKEL, (1887, p. 1670, pl. 118, fig. 3). Microstructure shown in Plate 53 demonstrates layers of circular pores.

Euphysetta staurocodon Haeckel
Plate 53, figures 11–14

Euphysetta staurocodon HAECKEL, 1887, p. 1670, pl. 118, fig. 2.

REMARKS: Shell is usually much smaller and shell surface is more finely alveolate than that of *E. elegans*. The form studied here always has a large foot extending toward terminal end but is not bent as described by Haeckel (1887).

Euphysetta pusilla Cleve
Plate 53, figure 15

Euphysetta pusilla CLEVE, 1900a, p. 7, pl. 3, fig. 16; 1900b, p. 160. - BORGERT, 1902, p. 567, fig. D; 1906, p. 152, pl. 11, figs. 1–3. - DUMITRICĂ, 1973, p. 756, pl. 9, fig. 6, pl. 12, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 12, fig. 8.

REMARKS: The author also observed a few specimens with an apical spine, as noted by Borgert (1906).

Euphysetta lucani Borgert
Plate 54, figures 10–12

Euphysetta lucani BORTERT, 1892, p. 181, pl. 6, fig. 8; 1901a, p. 37, fig. 45; 1901b, p. 242, pl. 11, fig. 4; 1906, p. 151, pl. 6, figs. 4–6. - HAECKER, 1908b, p. 306, pl. 53, figs. 436, 439, 442. - DUMITRICĂ, 1973, p. 756, pl. 9, fig. 1; pl. 12, fig. 6. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 11, fig. 7.

REMARKS: Microstructure shows a regularly arranged single layer of ovate-shaped amphorae cemented with silica. The morphology of the internal skeleton is very close to that of Challengeriidae. The amphorae are slightly different in shape (elongate) from those of Challengeriidae.

Genus *Medusetta* Haeckel, 1887

ORIGINAL DEFINITION BY HAECKEL (1887): Medusettida with four equidistant articulate feet of equal size on the peristome.

Medusetta ansata Borgert
Plate 54, figures 1–7

Medusetta ansata BORGERT, 1902, p. 564, fig. B; 1906, p. 146, pl. 12, figs. 1, 2. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 12, figs. 6, 7.

REMARKS: Two different forms exist: one has an ovate shell with feet extending obliquely and abruptly bent at the branching joints (Plate 54, figures 1–5); the other has an elongated shell with a foot gently curved toward the terminal end (Plate 54, figures 6–7). At Atlantic Site E, only the former form was found; both forms were found at Pacific sediment trap sites P_1 and PB. A cross section of the microstructure shows one layer of square to rectangular shaped pores bounded by outer and inner shell walls.

Medusetta inflata Borgert

Medusetta inflata BORGERT, 1902, p. 563, fig. A; 1906, p. 146, pl. 11, figs. 10, 11. - CLEVE, 1903, p. 354. - HAECKER, 1908b, p. 305, pl. 53, fig. 437. - DUMITRICĂ, 1973, p. 756, pl. 13, fig. 1. - TAN AND TCHANG, 1976, p. 297, text-fig. 79. - TAKAHASHI AND HONJO, 1981, p. 157, pl. 12, fig. 11.

Medusetta sp. A
Plate 54, figures 8, 9

DESCRIPTION: Shell longitudinally compressed spherical with four bifurcated feet on the peristome of large mouth. Alveolate shell surface similar to that of *E. elegans*. Other than shown in Plate 54, figures 8–9, presence/absence of apical spines remains to be further examined upon collection of more specimens.

Medusetta sp. B
Plate 63, figures 12, 13

DESCRIPTION: Shell smooth hemispherical cap with four equal articulate feet which have many spines. No apical spine has been observed.

REMARKS: The above cited figures are TEM partial cross sections. Note that skeletons shown here collected from plankton tows are made of one layer of very thin tubes. This species has never been found before in the sediment trap samples.

Family LIRELLIDAE Ehrenberg, 1872c

REMARKS: Present family represents the most abundant Phaeodaria in the deep sea water column, although diversity is low. Only two genera and three species were encountered.

Genus *Borgertella* Dumitrică, 1973

REMARKS: See Dumitrică (1973) for diagnosis of this genus.

Borgertella caudata (Wallich)
Plate 54, figures 13–17, Plate 55, figures 1–6

Cadium caudatum WALLICH, 1869, pl. 3, figs. 7–10. - BÜTSCHLI, 1882, pl. 32, fig. 15a.

Cadium inauris BORGERT, 1903, p. 747, fig. O; 1910, p. 402, pl. 30, figs. 4–10.

Borgertella caudata (Wallich). - DUMITRICĂ. 1973, p. 755, pl. 8, figs. 6–8; pl. 12, figs. 13–17. - LING, 1975, p. 732, pl. 13, fig. 24. - TAKAHASHI AND HONJO, 1981, p. 157, pl. 12, fig. 12.

Genus *Lirella* Ehrenberg, 1872c

REMARKS: Species of the present genus are characterized by a small ovate or ellipsoidal shell with straight or curved wavy lines of furrows and crests.

Lirella baileyi Ehrenberg
Plate 55, figure 7

Cadium marinum BAILEY, 1856, p. 3, pl. 1, fig. 2.

Lirella baileyi EHRENBERG, 1872c, p. 248, pl. 3, fig. 29a, 29b. - LOEBLICH AND TAPPAN, 1961, p. 231, 232. - LING, 1973, pp. 781, 782; 1975, p. 732, pl. 13, fig. 28. - LING AND TAKAHASHI, 1977, p. 209, pl. 3, figs. 1–3.

Lirella marina (Bailey). - DUMITRICĂ, 1973, p. 755, pl. 6, fig. 8; pl. 8, fig. 8; pl. 12, figs. 10–12.

REMARKS: About 60–70 longitudinal striae terminate without reaching the tapered ends and form smooth surfaces. See Loeblich and Tappan (1961) for a discussion on generic names.

Lirella bullata (Stadum and Ling)
Plate 55, figures 8–11

Cadium bullatum STADUM AND LING, 1969, p. 484, pl. 1, figs. 9–14.

Lirella bullata (Stadum and Ling). - LING, 1975, p. 732, pl. 13, fig. 29. - TAKAHASHI AND HONJO, 1981, p. 157, pl. 13, figs. 1–2.

Lirella melo (Cleve)
Plate 55, figures 12–18, Plate 56, figures 1–8

Beroetta melo CLEVE, 1899, p. 27, pl. 1, fig. 8.

Cadium melo (Cleve). - BORGERT, 1901a, p. XV50, fig. 58; 1910, p. 401, pl. 30, figs. 3–5. - JØRGENSEN, 1905, p. 142, pl. 18, fig. 13. - HAECKER, 1908b, p. 282, pl. 52, fig. 415. - SCHRÖDER, 1913, p. 168, text-fig. 10. - STADUM AND LING, 1969, p. 484, pl. 1, figs. 6–8. - DUMITRICĂ, 1973, p. 755, pl. 7, figs. 3, 4; pl. 12, fig. 9. - TAKAHASHI AND HONJO, 1981, p. 157, pl. 12, figs. 13, 14, 16.

REMARKS: Several forms of peristome have been observed: 1) smooth and significantly protruded; 2) smooth, short and non-protruded; and 3) slightly obliquely open. Also two different kinds of microstructures have been recognized (Plate 56, figures 2–4, 6–8). Even within a specimen the two kinds of microstructures have been observed. There are perhaps secondary features due to dissolution judging from observations of other species from plankton tows.

Lirella tortuosa Takahashi, n. sp.
Plate 55, figures 19, 20, Plate 56, figures 9–11

DESCRIPTION: Shell ovate, with 25–35 coiled longitudinal striae and crests, with a short apical spine, and with peristome open straight.

DIMENSIONS: (12 specimens) Length: 105 ± 5 μm; width 67 ± 3 μm.

TYPE LOCALITY: 15°21.1′N, 151°28.5′W; sediment trap depth 4,280 m; collected during July–November 1978.

REMARKS: Both right and left coiled specimens have been observed.

DERIVATION OF TIME: The name of this species is the Latin meaning twisted.

Family POROSPATHIDIDAE Borgert, 1901a

DEFINITION: Shell covered by paneled or tubulated surface or covered by trizonal meshwork; radial spines on all sides.

Genus *Porospathis* Haeckel, 1879

Porospathis holostoma (Cleve)
Plate 57, figures 1–8

Polypetta holostoma CLEVE, 1899, p. 32, pl. 3, figs. 4a, 4b; 1900b, p. 180.

Porospathis holostoma (Cleve). - BORGERT, 1901a, p. 48, figs. 56, 56a; 1903, p. 752; 1910, p. 387, pl. 29, figs. 1–8, pl. 30, figs. 1, 2. - HAECKER, 1908b, p. 240, pl. 48, figs. 371–376; pl. 49, figs. 392, 393. - SCHRØDER, 1913, p. 166, text-fig. 9. - RESHETNYAK, 1955, p. 95, fig. 66 (in plate); 1966, p. 166, fig. 52. - STADUM AND LING, 1969, p. 485, pl. 1, figs. 16–18. - DUMITRICĂ, 1973, p. 754, pl. 5, figs. 1, 2, 6. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 11, fig. 15.

Porospathis sp. aff. *P. holostoma* (Cleve). - DUMITRICĂ, 1972, p. 842, pl. 15, fig. 14.

Family CASTANELLIDAE Haeckel, 1879

DEFINITION BY HAECKEL (1887): Phaeodaria with a spherical or subspherical shell, exhibiting ordinary lattice-work, with circular or roundish pores. Radial spines without circles of basal pores. Mouth of the shell large, usually circular and armed with teeth. Central capsule eccentric, placed in the aboral half of the shell-cavity.

The following systematics originally given by Haeckel (1887) and Haecker (1908b) and emended by Kling (1966) represent generic classification criteria for the present family.

A. Shells with pores distributed over the entire shell wall.

Main Spines	Mouth	Species
absent	without teeth or other ornamentation	*Castanarium*
absent	with teeth	*Castanella*
unbranched	without teeth or other ornamentation	*Castanidium*
branched	without teeth or other ornamentation	*Castanopsis*
unbranched	with teeth	*Castanissa*
branched	with teeth	*Castanea*
usually present, (absent in some specimens)	with thickened rim, blunt protuberances, or raised collar-shaped rim.	*Castanura*

B. Shell with some pore positions occupied by enclosed, hollow spaces - *Circocastanea*.

REMARKS: Biogeography of the present family in the eastern North Pacific has been given by Kling (1966).

Genus *Castanidium* Haeckel, 1879
Castanidium longispinum Haecker
Plate 57, figures 9–13, Plate 58, figures 1–4

Castanidium longispinum HAECKER, 1908b, pp. 163, 164, pl. 37, figs. 285, 286; pl. 38, figs. 290, 291; pl. 40, fig. 296. - SCHRÖDER, 1913, p. 151. - KLING, 1966, p. 115, pl. 5, figs. m–r; 1971, p. 664, pl. 2, figs. 5–7.

DESCRIPTION: Shell spherical, with unbranched main-spines and numerous short by-spines of uniform length, with small pores circular to polygonal shape, with usually one main-spine on the rim of a small mouth. Main-spine slightly wavy and as long as shell diameter. Shell diameter of the specimens observed here range from 310–450 μm and surface plankton tow samples from the Gulf of Oman (collected by J. Erez) range from 390–510 μm (470 $\pm$ 34μm; n = 40 specimens).

REMARKS: The above ranges of shell diameter are much smaller than that observed by Kling (1966: 240–630 μm). Mouth size is similar to Kling (1966) but smaller than that of Haecker (1908b). Cross-sections of intervening bars show rectangular shape as Kling (1966) noted.

Castanidium abundiplanatum Takahashi, n. sp.
Plate 58, figures 5–8

DESCRIPTION: Shell relatively small for Castanellidae, without by-spines, with slightly wavy main-spines, mouth usually with one main-spine on the rim, pores circular to polygonal. Bases of the main-spines fenestrated, shell wall often elevated there and forming polyhedral shell. Length of the main-spines up to 1/2 as long as shell diameter.

DIMENSIONS: Shell diameter 308 ± 21 μm (2 S.D.) (18 specimens); weight: 0.80 ± 0.02 μg (22 specimens).

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 1,268 m; collected during August–December 1979.

REMARKS: The present species has a narrow size range and is distinctly smaller than *C. longispinum*. Specimens of two shells dividing are occasionally observed.

DERIVATION OF NAME: The name of this species is the Latin meaning having the nature of copious planes.

Castanidium sp.
Plate 58, figure 10

DESCRIPTION: Shell polyhedral, with very large pores of 1/4 to 1/5 of shell diameter combined with a few small pores of skeleton thickness, main-spines as long as 1/2 of shell diameter whose bases are elevated causing the shell shape, by-spines of equal or shorter length than pore diameter.

Genus *Castanissa* Haeckel, 1879
Castanissa circumvallata Schmidt
Plate 58, figure 9

Castanissa circumvallata SCHMIDT, 1907, p. 301, fig. 6; 1908, p. 257, pl. 20, fig. 6. - KLING, 1966, p. 123, pl. 3, figs. a–h; 1971, p. 665, pl. 4, figs. 1–4. - TAKAHASHI AND HONJO, 1981, p. 157, pl. 13, fig. 4.

Castanissa similis SCHMIDT, 1908, p. 257, pl. 20, fig. 5.

REMARKS: Specimen illustrated here has more developed teeth than those shown by the previous workers, although by-spines are broken off thus not showing well in the illustration.

Genus *Castanella* Haeckel, 1879
Castanella aculeata Schmidt
Plate 58, figure 11, 13, Plate 59, figure 1

Castanella aculeata SCHMIDT, 1907, p. 299, fig. 4; 1908, p. 250, pl. 18, fig. 6. - KLING, 1966, p. 110, pl. 2, figs. j–o.

Castanella macropora (Borgert)
Plate 58, figure 12

Castanidium macroporum Schmidt, 1908, p. 252, pl. 19, fig. 2.

DESCRIPTION: Shell small for Castanellidae, pores circular and of unequal size, by-spines 1/10 length of shell diameter and variable in thickness, mouth circular and 1/5 to 1/4 length of shell diameter with divergently curved conical teeth.

REMARKS: According to Schmidt (1908), main spines of his *Castanidium macroporum* were broken off, but his illustration suggests that the main spines could well be thicker by-spines. The author believes that *macropora* should be placed in *Castanella* rather than *Castanidium* because of absence of main spines.

Castanella sloggetti Haeckel
Plate 59, figure 2

Castanella sloggetti HAECKEL, 1887, p. 1683. - BORGERT, 1903, p. 750. - HAECKER, 1908b, p. 157, pl. 34, figs. 260, 261.

REMARKS: Teeth observed here are four compared to more than five shown by the previous workers. The present species resembles *Castanella maxima* SCHMIDT (1907, p. 297, fig. 1; 1908, p. 251, pl. 18, fig. 8. - SCHRÖDER, 1913, p. 148), although the size of the latter is ca. 1 mm.

Castanella balfouri Haeckel
Plate 58, figure 3

Castanella balfouri HAECKEL, 1887, p. 1683. - SCHMIDT, 1908, p. 249, pl. 18, fig. 3.

Family CIRCOPORIDAE Haeckel, 1879

DEFINITION: Phaeodaria with a spherical or polyhedral shell, exhibiting peculiar solid porcellaneous structure, with a stellate circle of radial pores around the base of the hollow radial spines. Mouth usually with teeth. Surface of the shell tabulate, paneled or dimpled. Central capsule eccentric, placed in the aboral half of the shell cavity (Haeckel, 1887).

Genus *Haeckeliana* Haeckel, 1887

ORIGINAL DEFINITION: Circoporida with spherical shell of a peculiar dimpled, porcellaneous structure, and with a variable number of simple radial main spines which are usually not regularly arranged.

Haeckeliana porcellana Murray
Plate 59, figures 4–13

Haeckeliana porcellana Murray. - HAECKEL, 1887, p. 1701, pl. 114, fig. 6. - HAECKER, 1908b, p. 182, text-fig. 20, pl. 20, fig. 117. - SCHRÖDER, 1913, pp. 155, 156. - KLING, 1966, p. 137, pl. 8, figs. i–n.

Haeckeliana maxima HAECKEL, 1887, p. 1701, pl. 114, fig. 5.

Haeckeliana murrayi HAECKEL, 1887, p. 1702.

Haeckeliana geotheana HAECKEL, 1887, p. 1702, pl. 114, fig. 3.

Haeckeliana darwiniana HAECKEL, 1887, p. 1702, pl. 114, figs. 1, 2. - TAKAHASHI AND HONJO, 1981, p. 157, pl. 13, figs. 7, 8.

Haeckeliana labradoriana BORGERT, 1901, p. 43, fig. 51; 1909, pp. 330, 331, pl. 24, figs. 1–3.

REMARKS: Some specimens entirely lack in by-spines and thus shell surface appears very smooth in contrast to other thorny specimens. The author accepts classification by Kling (1966) which involves combining Haeckel's six species of *Haeckeliana* shown in the above synonymy. Cross-sectional microstructures show several different layers including the innermost part of polygons made of tubes (Plate 59, figures 10, 12).

Genus *Circoporus* Haeckel, 1879

DEFINITION BY HAECKEL (1887): Circoporida with a spherical or regularly octahedral shell, composed of eight congruent, triangular plates, with six corners from which arise six radial spines, opposite in pairs in three diameters, perpendicular one to another.

Circoporus sexfuscinus Haeckel
Plate 60, figures 1, 3, 5

Circoporus sexfuscinus HAECKEL, 1887, p. 1695, pl. 115, fig. 1. - BORGERT, 1901b, pp. 243, 244, pl. 11, fig. 7; 1909, pp. 336, 337, pl. 24, figs. 4, 5, pl. 25, figs. 5–7. - HAECKER, 1908b, p. 186, pl. 20, figs. 174, 175.

REMARKS: This species has six major radial spines which are divergently three-forked at the terminal ends, in contrast to the straight terminal ends of *C. oxyacanthus*.

Circoporus oxyacanthus Borgert
Plate 60, figures 2, 4, 6–13

Circoporus oxyacanthus BORGERT, 1902, pp. 571, 572, fig. Hb; 1903, p. 753; 1909, pp. 335, 336, pl. 25, figs. 1–4. - HAECKER, 1908b, p. 185, pl. 20, fig. 173. - TAKAHASHI AND HONJO, 1981, p. 157, pl. 15, figs. 6, 7.

Genus *Circogonia* Haeckel, 1887

ORIGINAL DEFINITION: Circoporida with a regular icosahedral shell, composed of twenty congruent, triangular plates, with twelve corners, from which arise twelve radial spines.

Circogonia sp.
Plate 60, figures 9, 10

DESCRIPTION: Shell icosahedral, smooth and delicate, with twelve equal hollow major spines whose bases are fenestrated with 4–6 oval pores and well elevated so that each plate of shell becomes convex, mouth circular with several small spines.

Family CONCHARIIDAE Haeckel, 1879

DEFINITION: Phaeodaria with a bivalved lattice-shell, which is spherical or lenticular, and composed of two equal or unequal boat-shaped valves, a dorsal and a ventral. The valves bear neither an apical latticed cupola or glea, nor hollow radial tubes. The central capsule is placed in the aboral half of the shell-cavity, and so enclosed between both valves that its three openings lie in the open frontal fissure between them (the astropyle on the oral pole of the main axis, the two parapylae on both sides of its aboral pole, at right and left) (Haeckel, 1887).

The following is the synopsis of the genera of Conchariidae originally presented by Haeckel (1887) and emended by Haecker (1908b) and Campbell (1954) and further emended herein:

Valves	Aboral Hinge	Genus
I. Subfamily CONCHARIINAE Lateral edges of the two valves smooth, without teeth; valves without sagittal keel, nearly hemispherical or slightly compressed.	Without horns	*Concharium*
(as above)	With two horns, one on each valve.	*Conchasma*
II. Subfamily CONCHIDIINAE Lateral edges of the two valves dentate, with a series of prominent teeth on both sides; valves without sagittal keel, nearly hemispherical or slightly compressed.	Without horns	*Conchellium*
(as above)	With two horns; no apical horn.	*Conchidium*
(as above)	With two horns; apex with horn.	*Conchonia*
(as above)	No horn; diatom-like texture.	*Conchocystis*
(as above)	Like *Conchocystis*, but slit-like pores.	*Conchophacus*
III. Subfamily CONCHOPSIDINAE Lateral edges of the two valves dentate, with a series of prominent teeth on both sides; valves with a sharp sagittal keel, strongly compressed on both sides, boat-shaped.	Without horns	*Conchopsis*
(as above)	With two horns, one on each valve.	*Conchasma*

REMARKS: Skeletal cross sections for this family represent similar morphology in all of the species examined here (e.g., Plates 61, 62).

Genus *Conchellium* Haeckel, 1887
Conchellium capsula Borgert
Plate 61, figures 1–5, 7, 8, 10

Conchellium capsula BORGERT, 1907, p. 208, pl. 17, fig. 1–4. - TAKAHASHI AND HONJO, 1981, p. 157, pl. 14, figs. 1–4.

REMARKS: This species has smoother shell surface, thinner skeleton and smaller shell size than those of *Conchellium tridacna* Haeckel. Measurements on longer axis of shell diameter represent 264 ± 11 μm based on 11 specimens.

Conchellium tridacna Haeckel
Plate 61, figures 6, 9, 11

Conchellium tridacna HAECKEL, 1887, p. 1720, pl. 123, figs. 7, 7a.

REMARKS: This species is different from *C. capsula* in shell size, skeletal thickness and shell surface texture. The shell size ranges from 350–500 μm in longer axis and the surface texture is rough (Plate 61, figure 9) as described in Haeckel (1887).

Genus *Conchophacus* Haecker, 1906b
Conchophacus diatomeus (Haeckel)
Plate 61, figure 12

Concharium diatomeum HAECKEL, 1887, p. 1717, pl. 123, fig. 1. - BORGERT, 1901b, p. 244.

Conchidium diatomeum (Haeckel). - HAECKER, 1906b, p. 34.

Conchophacus diatomeus (Haeckel). - BORGERT, 1907, p. 212, pl. 15, figs. 5–8. - TAKAHASHI AND HONJO, 1981, pl. 15, fig. 2.

Genus *Conchidium* Haeckel, 1887
Conchidium argiope Haeckel
Plate 62, figures 1, 2

Conchidium argiope HAECKEL, 1887, p. 1722, pl. 124, figs. 7–9. - BORGERT, 1903, pp. 755, 756, text-fig. R; 1907, p. 209, pl. 16, figs. 1–4.

REMARKS: Shell smaller than *C. caudatum* and it lacks a window at the base of the short horn. Dimensions from the Panama Basin samples: shell length 196 ± 14 μm (n = 19); width 138 ± 6 μm (n = 4).

Conchidium caudatum (Haeckel)
Plate 62, figures 3–8

Conchoceras caudatum HAECKEL, 1887, p. 1727, pl. 24, fig. 15. - HAECKER, 1905, p. 351; 1906b, p. 34, fig. 1; 1908b, pp. 331, 332, pl. 58, fig. 457, pl. 60, figs. 467–468.

Conchidium caudatum (Haeckel). - BORGERT, 1903, p. 756, fig. 5; 1907, p. 210, pl. 16, figs. 5–7. - TAKAHASHI AND HONJO, 1981, p. 158, pl. 14, figs. 5–7.

REMARKS: Formation of the keel is considered to be incomplete here since it does not reach aboral end and also its thickness is comparable to many other longitudinal lines (although it is elevated and forms a conspicuous crest in the posterior part). Thus, the present species should be placed in *Conchidium* rather than *Conchoceras*.

Genus *Conchopsis* Haeckel, 1887
Conchopsis compressa Haeckel
Plate 62, figures 9–16

Conchopsis compressa HAECKEL, 1887, p. 1725, pl. 125, figs. 7, 8. - TAKAHASHI AND HONJO, 1981, p. 158, pl. 14, figs. 8–10; pl. 15, fig. 1.

Conchopsis aspidium HAECKEL, 1887, p. 1726, pl. 125, figs. 1, 2.

Conchopsis barca BORGERT, 1907, pp. 215, 216, pl. 17, figs. 5–7.

DESCRIPTION: Lenticular shell composed of strongly compressed bivalves, with narrow smooth keels, about 32–42 teeth on one side of each valve, pores circular near the hinge and slitlike shape in the rest of the shell, shell surface rough at highly magnified view. Length and thickness of teeth are variable even in the same specimen.

REMARKS: The following closely related species were excluded in the above synonymy since specimens like them were not found: *C. orbicularis* (type species of the genus), *C. carinata, C. lenticula, C. navicula*, and *C. pilidium*, all described by Haeckel (1887). The criteria used in the above classification by the author are: 1) number and location of teeth; 2) width of keels; 3) shape of valves in lateral view; and 4) whether pores are surrounded by hexagonal framework.

Family AULOSPHAERIDAE Haeckel, 1862

DEFINITION BY HAECKEL (1887): Phaeodaria with a large spherical or subspherical (rarely spindle-shaped) articulated shell, which is composed of hollow tangential tubes. Nodal points of the loose network stellate, with a nodal cavity and astral septa. Meshes either triangular or polygonal. Hollow radial spines arise usually at the nodal points of the surface. No peculiar mouth in the shell. Central capsule tripylean, placed in the centre of the shell.

Genus *Aularia* Haeckel, 1887

ORIGINAL DESCRIPTION: Aulosphaerida with triangular meshes in the network, the tangential tubes of which form a simple smooth lattice-sphere. No radial tubes at the nodal points.

Aularia ternaria Haeckel
Plate 63, figures 1, 2

Aularia ternaria HAECKEL, 1887, p. 1621, pl. 111, fig. 2.

Family AULACANTHIDAE Haeckel, 1862

DEFINITION BY HAECKEL (1887): Phaeodaria with an incomplete skeleton, composed of numerous hollow radial tubes, which pierce the spherical calymma and touch with their proximal ends the surface of the tripylean central capsule.

Genus *Aulographis* Haeckel, 1879

DEFINITION BY HAECKEL (1887): Aulacanthida with a veil of tangential needles, and with radial tubes, which bear no lateral branches, but at the distal end a verticil of simple terminal branches.

Aulographis stellata Haeckel
Plate 63, figure 3

Aulographis stellata HAECKEL, 1887, p. 1578, pl. 103, figs. 23a–23c. - HAECKER, 1908b, pp. 41, 42, pl. 1, figs. 4–7; pl. 2, fig. 19; pl. 42, figs. 313, 314. - TIBBS, 1976, p. 31.

Aulographis tetrancistra Haeckel
Plate 63, figure 10

Aulographis tetrancistra HAECKEL, 1887, p. 1581, pl. 103, fig. 22. - TIBBS, 1976, p. 32, text-figs. 6, 7.

Genus *Auloceros* Haeckel, 1887

ORIGINAL DEFINITION: Aulacanthidae with a veil of tangential needles, and with radial tubes, which bear no lateral branches, but at the distal end a verticil of ramified or forked terminal branches.

Auloceros spathillaster Haeckel
Plate 63, figure 4

Auloceros spathillaster HAECKEL, 1887, p. 1585, pl. 102, fig. 12.

Auloceros arborescens Haeckel *birameus* (Immermann)
Plate 63, figure 9

Auloceros arborescens HAECKEL, 1887, p. 1584, pl. 102, figs. 11, 13.

Auloceros spathillaster (Haeckel) var. *birameus* IMMERMANN, 1804, p. 51, pl. 5, fig. 10.

Auloceros arborescens birameus (Immermann). - HAECKER, 1908b, p. 53, pl. 3, figs. 21–25, 34, 35; pl. 10, fig. 102.

Genus *Aulographonium* Haeckel, 1887

ORIGINAL DEFINITION: Terminal branch of the radial tubes armed with numerous lateral denticles, and with terminal spathillae (or whorls of small radial teeth).

REMARKS: This genus was elevated from the original subgenus to the present level by Haecker (1908b).

Aulographonium bicorne Haecker
Plate 63, figures 5, 6

Aulocoryne candelabrum IMMERMANN, 1804, p. 59, pl. 6, figs. 5–7.

Aulographonium bicorne HAECKER, 1908b, pp. 69–70, pl. 1, fig. 1; pl. 6, fig. 57. - TIBBS, 1976, p. 42.

REMARKS: Although this species has five to seven dentate terminal branches, it has the name *bicorne*.

Genus *Aulospathis* Haeckel, 1887

ORIGINAL DESCRIPTION: Aulacanthidae with a veil of tangential needles, and with radial tubes, which bear two verticils of branches, a distal verticil of terminal branches, and a proximal verticil of lateral branches.

Aulospathis taumorpha Haeckel
Plate 63, figures 7, 8

Aulospathis taumorpha HAECKEL, 1887, p. 1577, pl. 103, fig. 16.

Aulospathis variabilis Haeckel *bifurca* Haeckel
Plate 63, figure 11

Aulospathis bifurca HAECKEL, 1887, p. 1586, pl. 104, figs. 1–5. - BORGERT, 1901a, p. XV8, text-fig. 6.

Aulospathis variabilis bifurca HAECKER, 1904a, pp. 125–127, text-fig. 2; 1908b, pp. 86, 87, pl. 6, figs. 63–67; pl. 7, figs. 72–75. - TIBBS, 1976, p. 49, text-fig. 20.

Aulospathis variabilis grandis TIBBS, 1976, p. 50, text-figs. 21, 22.

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Plates

PLATE 1

Suborder: Spumellaria
Family: Collosphaeridae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Acrosphaera spinosa* (Haeckel) *longispina* Takahashi, new name	P_1: 4280	SEM	× 260
2	*Acrosphaera spinosa* (Haeckel) *coniculispina* Takahashi, new name	P_1: 5582	SEM	× 300
3	*Acrosphaera murrayana* (Haeckel) Two shells linked together.	PB: 3791	LM	× 210
4	*Acrosphaera spinosa* (Haeckel) *longispina* Takahashi, new name	P_1: 5582	LM	× 210
5	*Acrosphaera spinosa* (Haeckel) *coronula* Takahashi, new name	P_1: 2778	LM	× 210
6	*Acrosphaera murrayana* (Haeckel)	PB: 1268	LM	× 210
7	*Acrosphaera murrayana* (Haeckel)	P_1: 4280	SEM	× 230
8	*Acrosphaera murrayana* (Haeckel)	PB: 3791	SEM	× 220
9	*Acrosphaera murrayana* (Haeckel) Two shells linked together.	PB: 3769	SEM	× 120
10	*Acrosphaera murrayana* (Haeckel) Same specimen; some of the spines are still linked.	PB: 3769	SEM	× 880
11	*Acrosphaera murrayana* (Haeckel) A typical skeletal cross section which is common to most, if not all, polycystines.	PB: 3769	SEM	× 4700
12	*Acrosphaera cyrtodon* (Haeckel)	P_1: 978	SEM	× 440
13	*Acrosphaera cyrtodon* (Haeckel)	PB: 3769	LM	× 210
14	*Acrosphaera spinosa* (Haeckel) *lappacea* (Haeckel)	PB: 3769	LM	× 210
15	*Clathrosphaera arachnoides* Haeckel	P_1: 4280	SEM	× 370
16	*Acrosphaera spinosa lappacea* (Haeckel)	P_1: 4280	SEM	× 340

SEM: Scanning Electron Micrograph
TEM: Transmission Electron Micrograph
LM: Transmission Light Micrograph
RLM: Reflection Light Micrograph

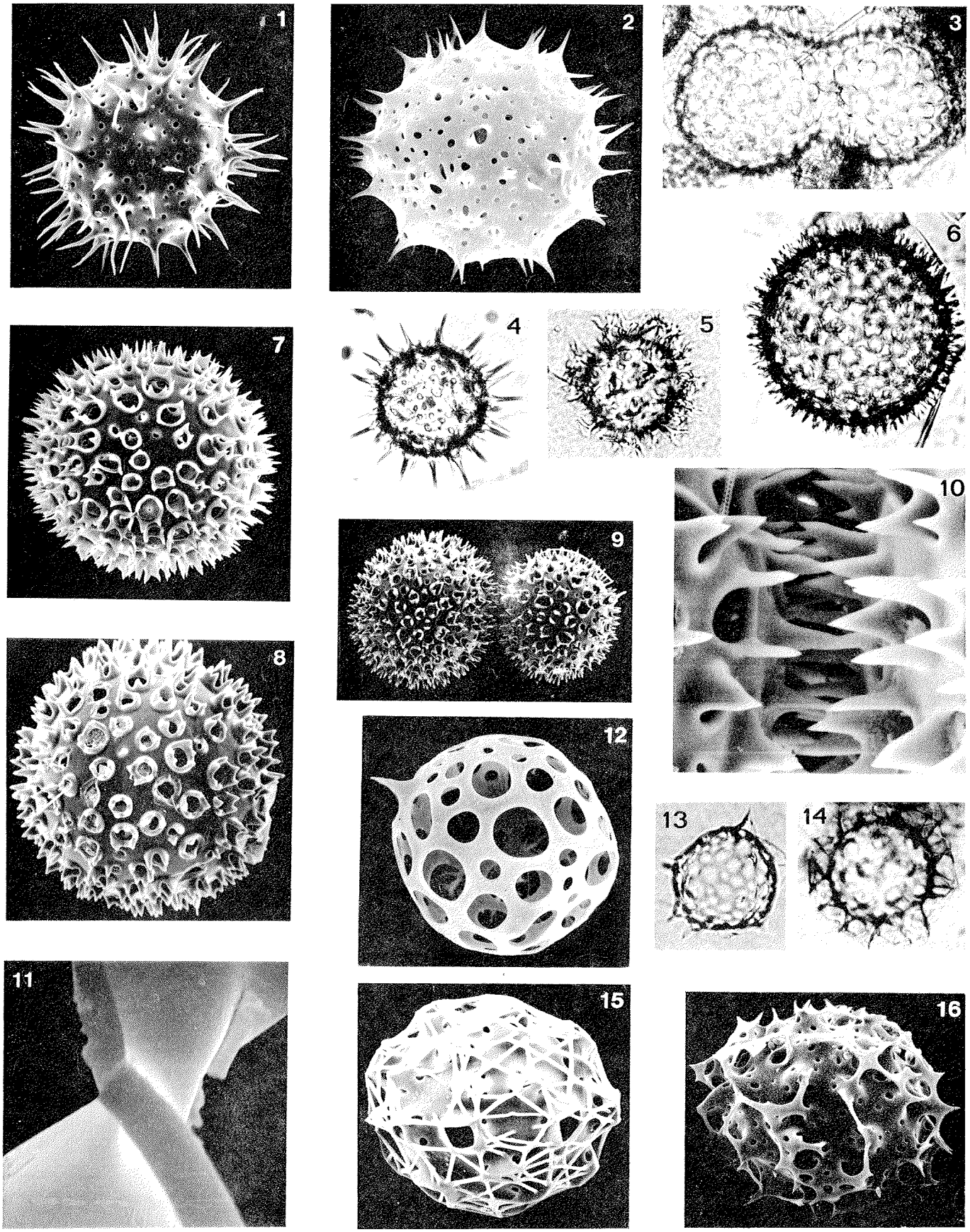
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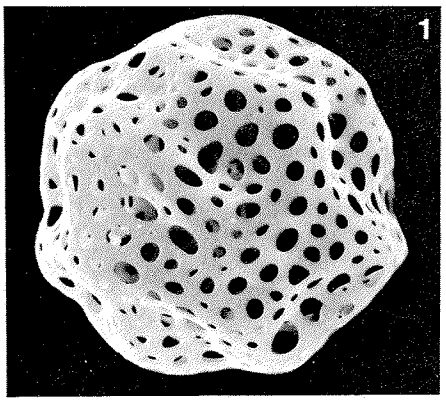
PLATE 2

Suborder: Spumellaria
Family: Collosphaeridae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Collosphaera tuberosa* Haeckel	P_1: 5582	SEM	×280
2	*Collosphaera tuberosa* Haeckel	PB: 2869	LM	×210
3	*Collosphaera tuberosa* Haeckel	P_1: 5582	LM	×210
4	*Collosphaera confossa* Takahashi, n. sp. Holotype	P_1: 5582	SEM	×215
5	*Collosphaera confossa* Takahashi, n. sp. Paratype	P_1: 2778	LM	×210
6	*Collosphaers armata* Brandt	PB: 2869	LM	×210
7	*Collosphaera armata* Brandt	P_1: 5582	LM	×210
8	*Collosphaera huxleyi* Müller	P_1: 4280	SEM	×210
9	*Collosphaera huxleyi* Müller	PB: 2869	LM	×210
10	*Collosphaera huxleyi* Müller	P_1: 978	LM	×210
11	*Collosphaera huxleyi* Müller	P_1: 2778	LM	×210
12	*Collosphaera armata* Brandt	PB: 3769	SEM	×350
13	*Collosphaera macropora* Popofsky	P_1: 4280	LM	×210
14	*Collosphaera macropora* Popofsky Two shells linked together.	P_1: 978	SEM	×520
15	*Collosphaera macropora* Popofsky	P_1: 4280	SEM	×370
16	*Collosphaera macropora* Popofsky Same specimen as figure 14.	P_1: 978	SEM	×2,200
17	*Collosphaera macropora* Popofsky	P_1: 978	SEM	×940
18	*Collosphaera macropora* Popofsky A group of shells probably derived from a colony.	P_1: 2778	LM	×240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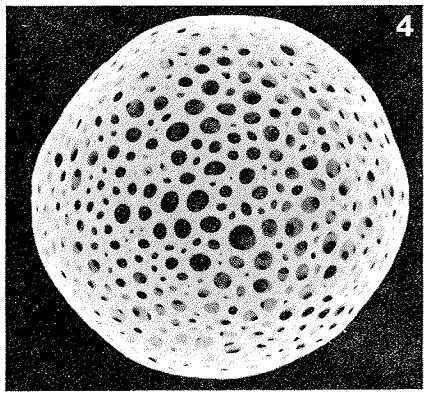
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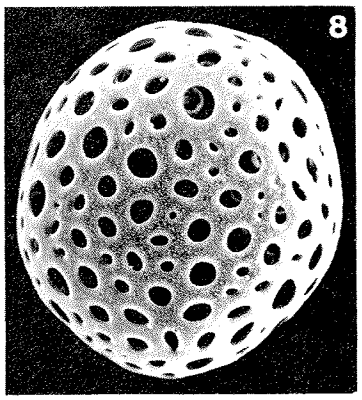
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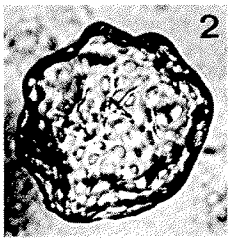
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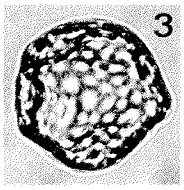
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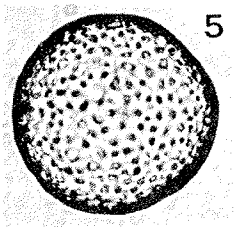
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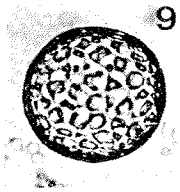
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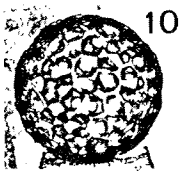
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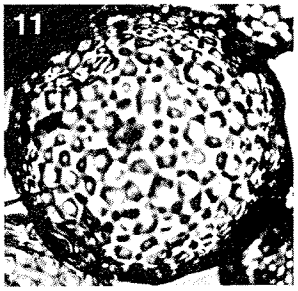
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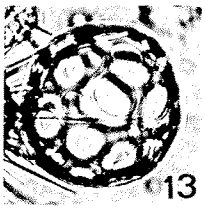
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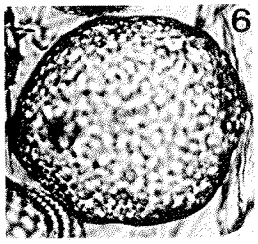
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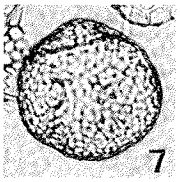
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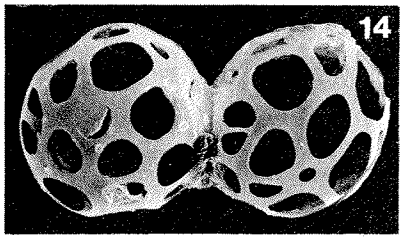
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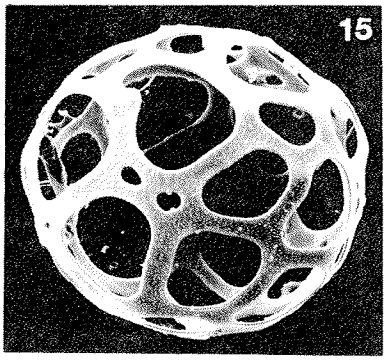
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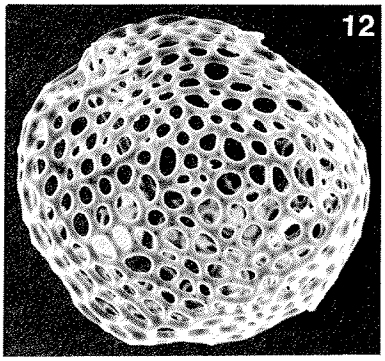
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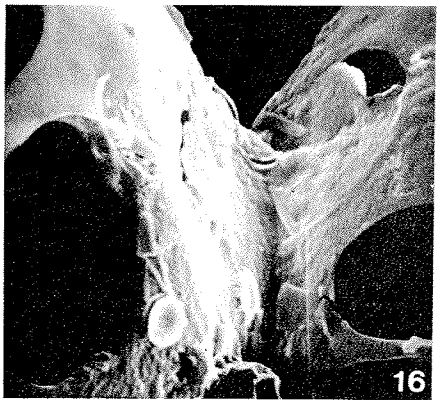
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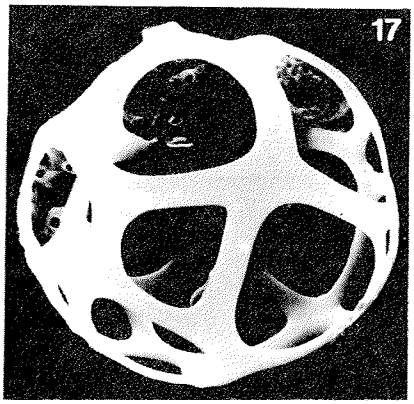
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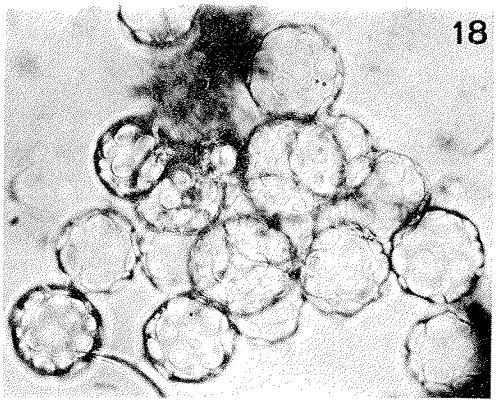
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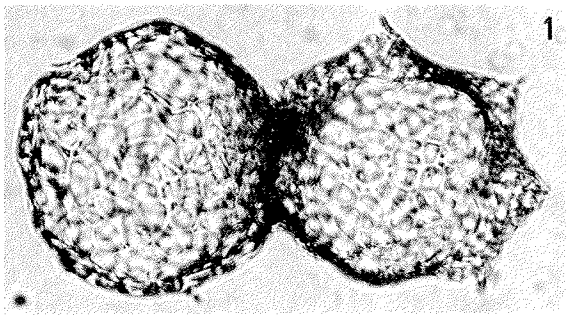
PLATE 3

Suborder: Spumellaria
Family: Collosphaeridae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Disolenia collina* (Haeckel) Two shells linked together.	P_1: 378	LM	×210
2	*Disolenia zanguebarica* (Ehrenberg) Two shells linked together.	P_1: 978	LM	×210
3	*Disolenia zanguebarica* (Ehrenberg) Two shells linked together.	PB: 3769	SEM	×230
4	*Disolenia zanguebarica* (Ehrenberg) Same specimen.	PB: 3769	SEM	×1,650
5	*Disolenia collina* (Haeckel)	P_1: 5582	SEM	×226
6	*Disolenia collina* (Haeckel)	P_1: 5582	SEM	×230
7	*Disolenia collina* (Haeckel)	P_1: 5582	SEM	×226
8	*Disolenia zanguebarica* (Ehrenberg)	P_1: 4280	SEM	×450
9	*Disolenia zanguebarica* (Ehrenberg)	P_1: 4280	LM	×210
10	*Otosphaera auriculata* Haeckel A specimen without spines.	P_1: 5582	SEM	×340
11	*Otosphaera tenuissima* (Hilmers)	P_1: 978	SEM	×520
12	*Otosphaera polymorpha* Haeckel	PB: 2869	LM	×210
13	*Otosphaera auriculata* Haeckel	P_1: 4280	SEM	×350
14	*Otosphaera polymorpha* Haeckel	P_1: 5582	LM	×210
15	*Otosphaera polymorpha* Haeckel	P_1: 2778	LM	×210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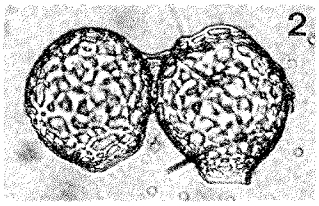
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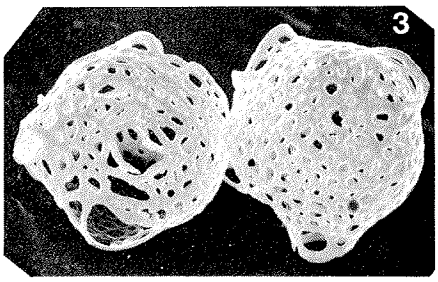
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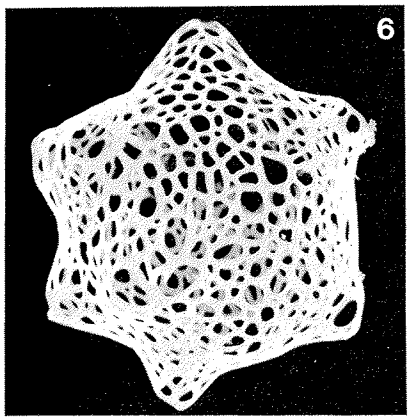
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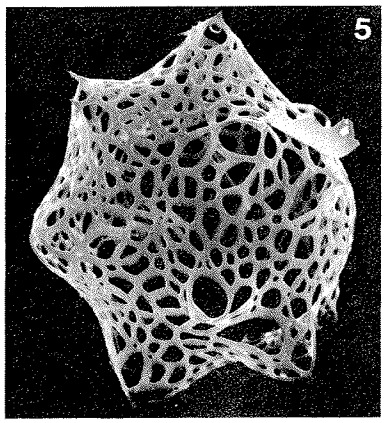
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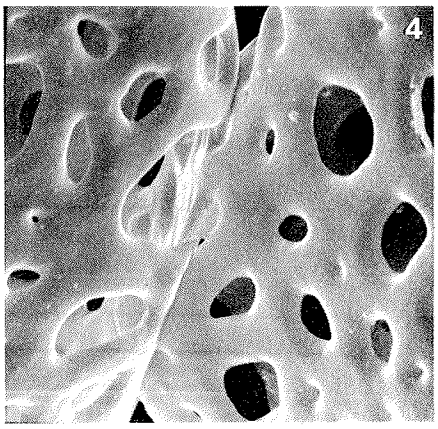
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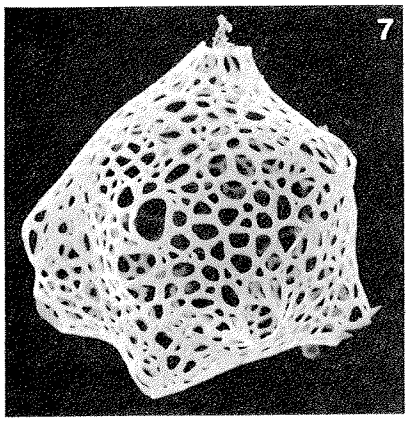
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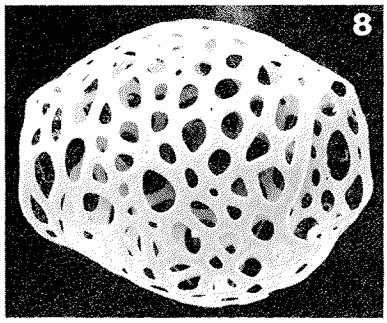
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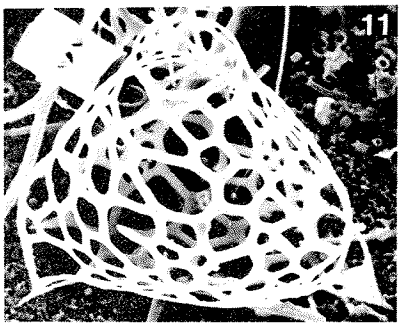
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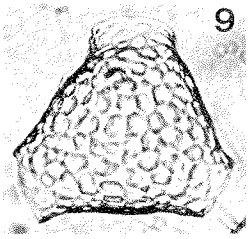
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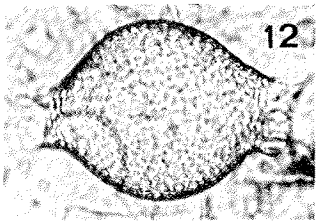
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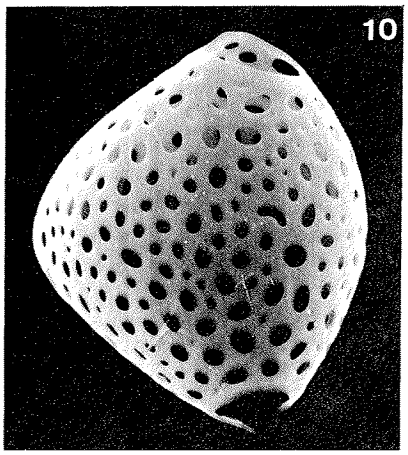
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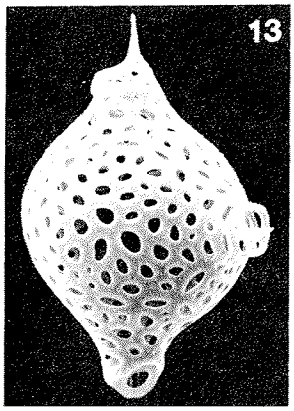
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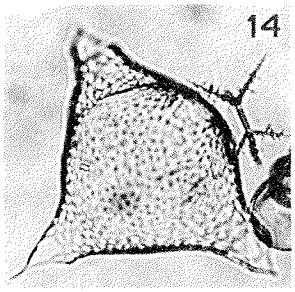
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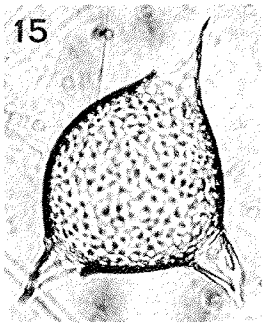
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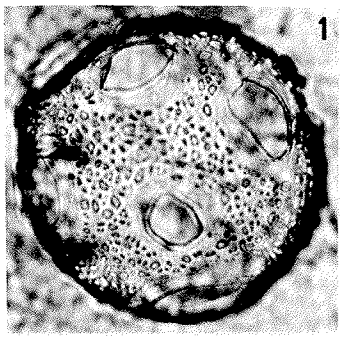
PLATE 4

Suborder: Spumellaria
Family: Collosphaeridae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Siphonosphaera magnisphaera* Takahashi, n. sp. Paratype	PB: 2869	LM	×210
2	*Siphonosphaera* sp. A	P_1: 4280	SEM	×550
3	*Siphonosphaera magnisphaera* Takahashi, n. sp. Holotype	p_1: 378	LM	×210
4	*Siphonosphaera martensi* Brandt	P_1: 2778	LM	×210
5	*Siphonosphaera martensi* Brandt	P_1: 2778	LM	×210
6	*Siphonosphaera* sp. B	P_1: 978	SEM	×550
7	*Siphonosphaera martensi* Brandt	P_1: 4280	SEM	×560
8	*Siphonosphaera martensi* Brandt	P_1: 4280	SEM	×480
9	*Siphonosphaera socialis* Haeckel	P_1: 4280	SEM	×390
10	*Siphonosphaera socialis* Haeckel	P_1: 4280	SEM	×280
11	*Siphonosphaera socialis* Haeckel	P_1: 978	SEM	×250
12	*Siphonosphaera socialis* Haeckel Two shells linked together.	P_1: 978	LM	×210
13	*Siphonosphaera* sp. aff. *S. hippotis* (Haeckel)	P_1: 2778	LM	×210
14	*Siphonosphaera* sp. aff. *S. hippotis* (Haeckel)	P_1: 2778	LM	×210
15	*Siphonosphaera socialis* Haeckel	P_1: 4280	SEM	×370
16	*Siphonosphaera socialis* Haeckel Same specimen. Note presence of many rectangular prisms to cubic crystals on the surface, which are absent in specimens of other families with identical desalting preparation.	P_1: 4280	SEM	×2,760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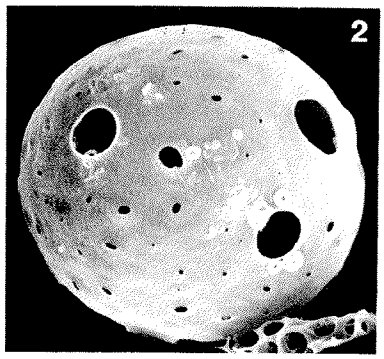
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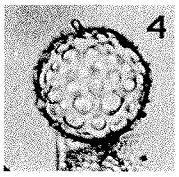
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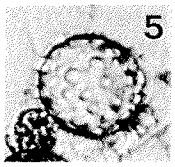
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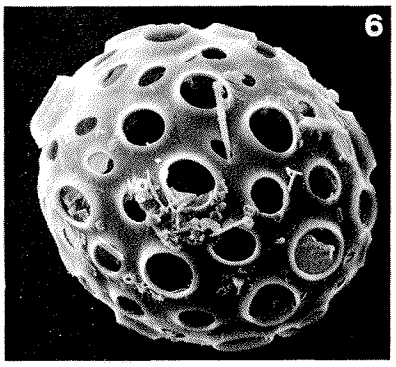
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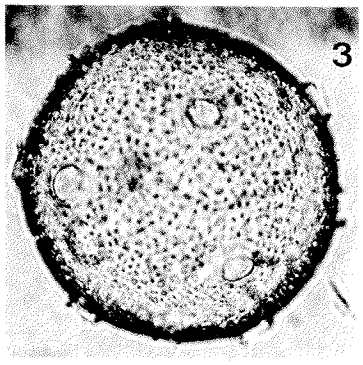
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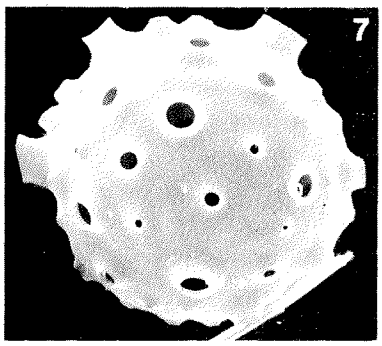
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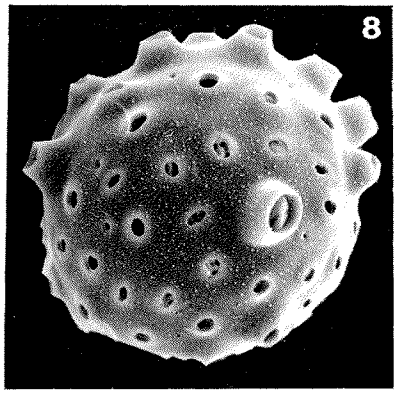
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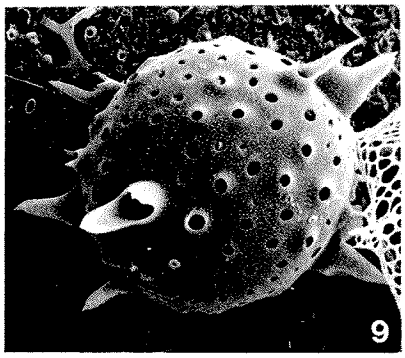
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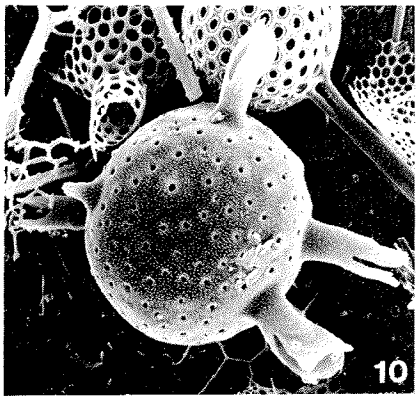
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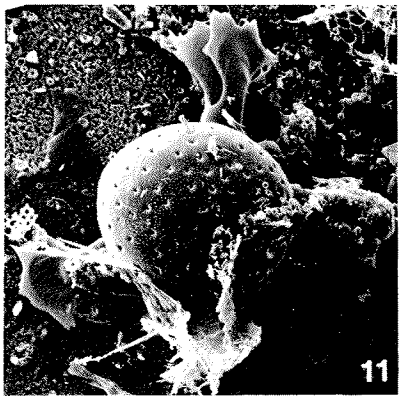
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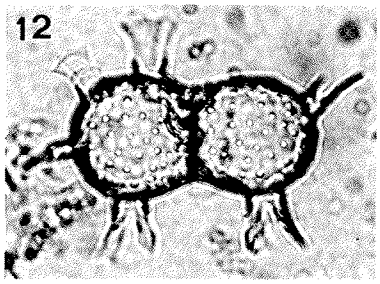
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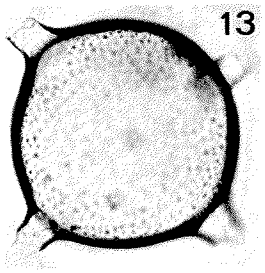
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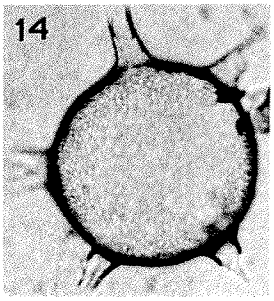
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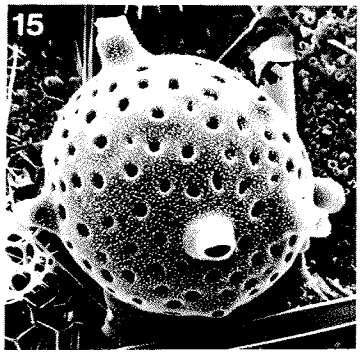
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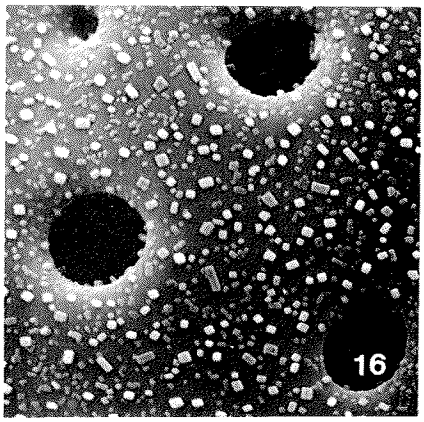
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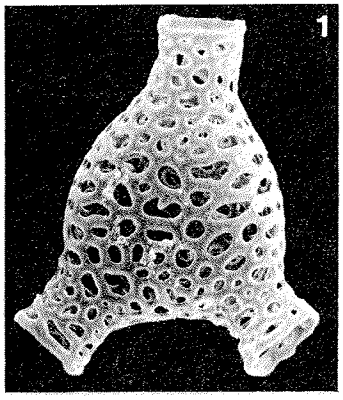
PLATE 5

Suborder: Spumellaria
Families: Collosphaeridae, Ethmosphaeridae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Disolenia quadrata* (Ehrenberg)	P_1: 4280	SEM	×340
2	*Disolenia quadrata* (Ehrenberg)	P_1: 4280	SEM	×340
3	*Disolenia quadrata* (Ehrenberg)	P_1: 5582	SEM	×280
4	*Disolenia quadrata* (Ehrenberg)	P_1: 2778	LM	×210
5	*Disolenia quadrata* (Ehrenberg)	P_1: 4280	SEM	×340
6	*Disolenia* sp. A	P_1: 4280	SEM	×340
7	*Plegmosphaera pachypila* Haeckel	E: 389	LM	×150
8	*Plegmosphaera pachypila* Haeckel	PB: 3791	LM	×154
9	*Plegmosphaera pachypila* Haeckel	PB: 1268	LM	×162
10	*Plegmosphaera coelopila* Haeckel	P_1: 5582	SEM	×154
11	*Plegmosphaera* sp. aff. *P. lepticali* Renz	P_1: 2778	SEM	×260
12	*Styptosphaera* sp. B	PB: 667	SEM	×210
13	*Styptosphaera* sp. C	PB: 3769	SEM	×55
14	*Plegmosphaera* sp. B	PB: 3769	LM	×160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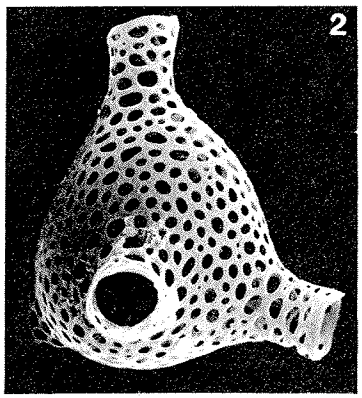
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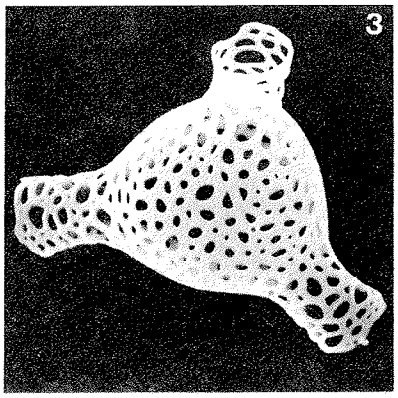
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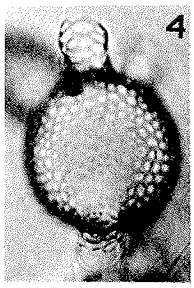
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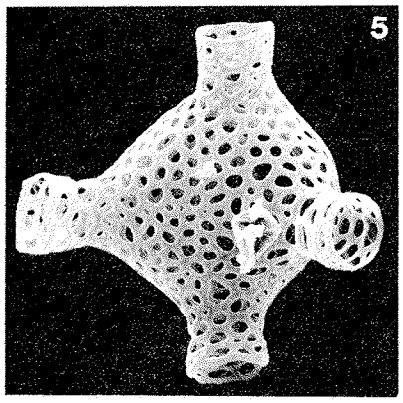
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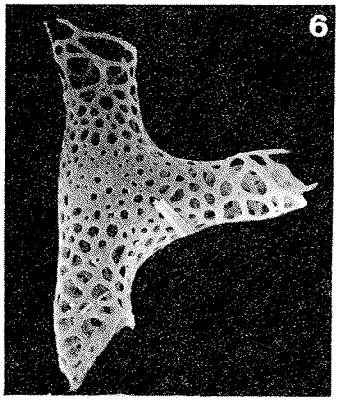
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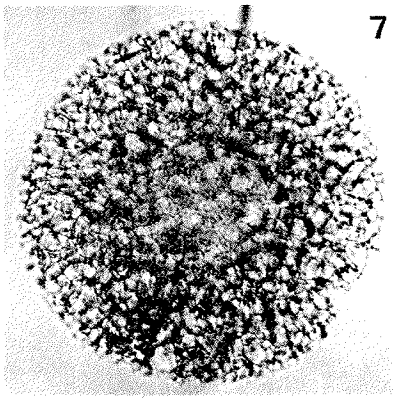
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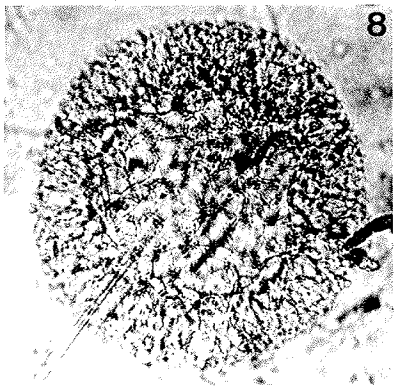
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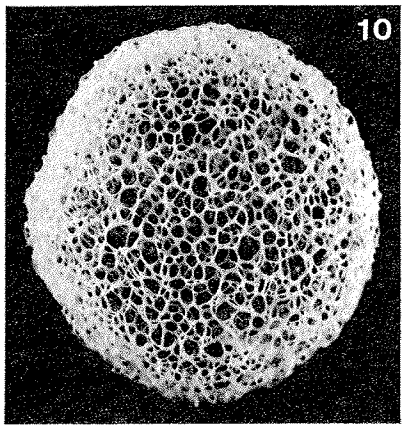
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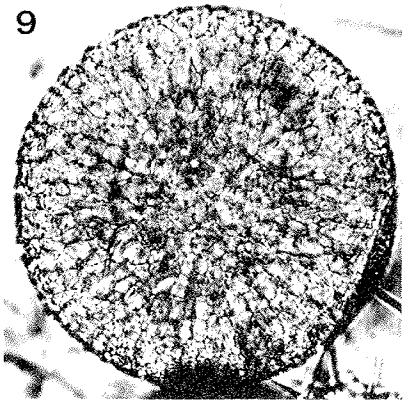
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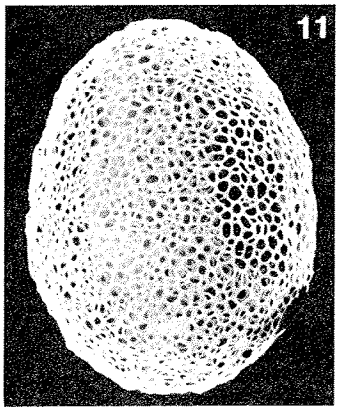
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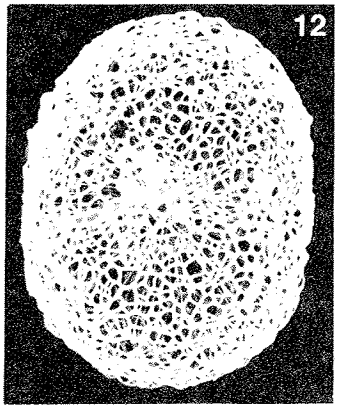
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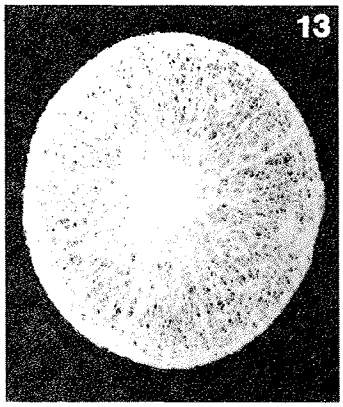
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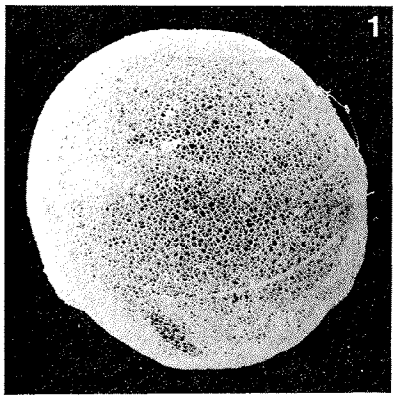
14

PLATE 6

Suborder: Spumellaria
Family: Ethmosphaeridae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Plegmosphaera* sp. B	PB: 3769	SEM	×55
2	*Carposphaera capillacea* Haeckel	P_1: 5582	SEM	×110
3	*Plegmosphaera oblonga* Takahashi, n. sp. Paratype	PB: 3791	SEM	×220
4	*Plegmosphaera oblonga* Takahashi, n. sp. Holotype	PB: 667	SEM	×105
5	*Plegmosphaera oblonga* Takahashi, n. sp. Same specimen; an enlarged view of the opening.	PB: 667	SEM	×280
6	*Styptosphaera spongiacea* Haeckel	PB: 3769	LM	×210
7	*Styptosphaera spongiacea* Haeckel	PB: 2869	LM	×210
8	*Plegmosphaera entodictyon* Haeckel	PB: 3791	SEM	×290
9	*Styptosphaera spongiacea* Haeckel	P_1: 4280	LM	×105
10	*Plegmosphaera entodictyon* Haeckel	P_1: 2778	LM	×210
11	*Plegmosphaera entodictyon* Haeckel	P_1: 5582	SEM	×190
12	*Styptosphaera* sp. A	P_1: 978	SEM	×440
13	*Styptosphaera* sp. A	P_1: 5582	SEM	×250
14	*Styptosphaera* sp. A	PB: 3769	SEM	×1,270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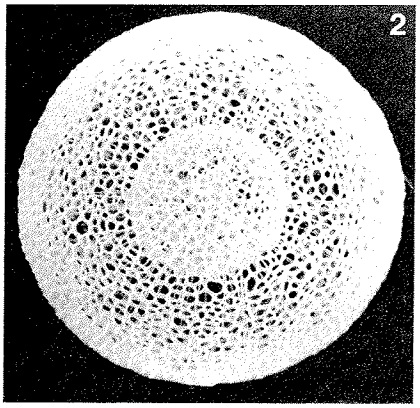
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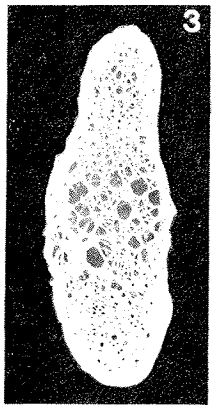
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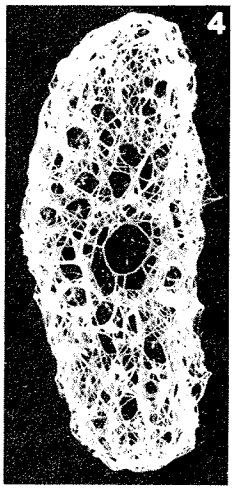
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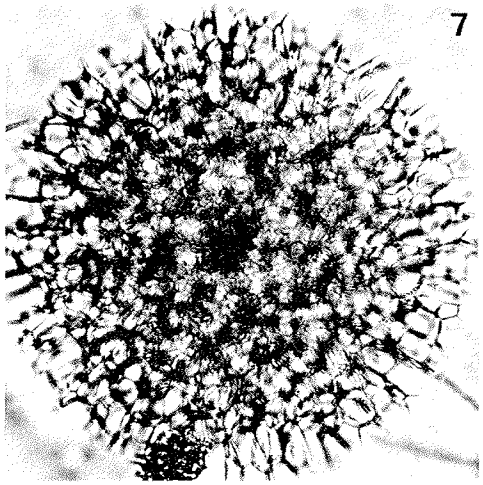
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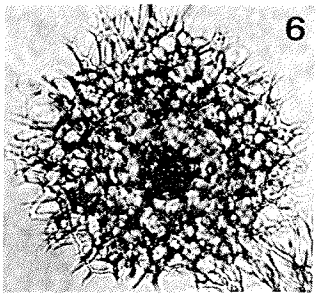
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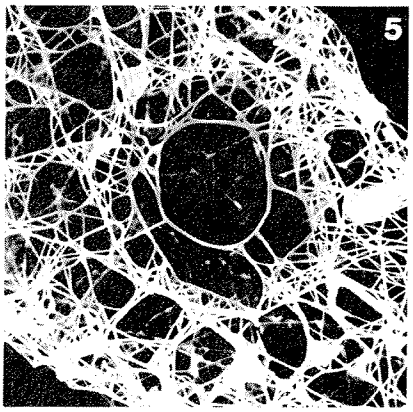
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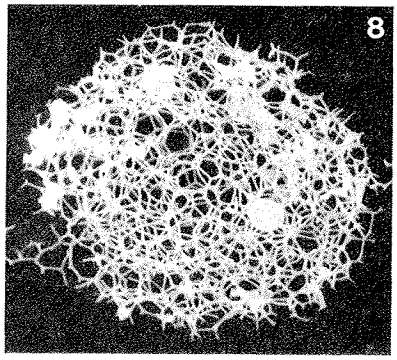
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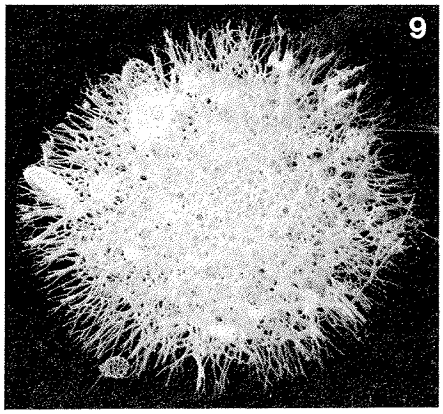
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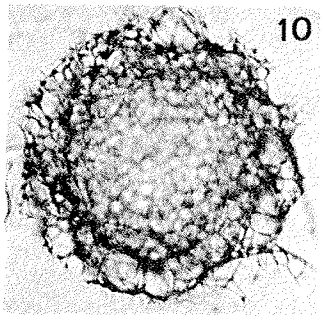
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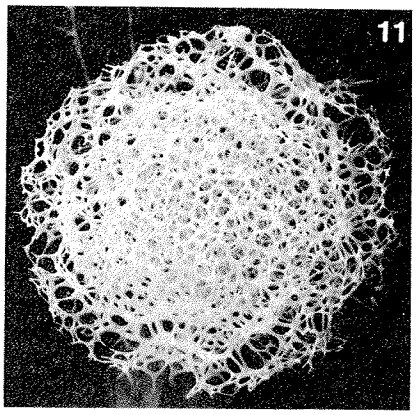
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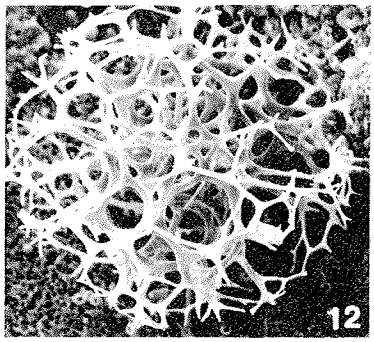
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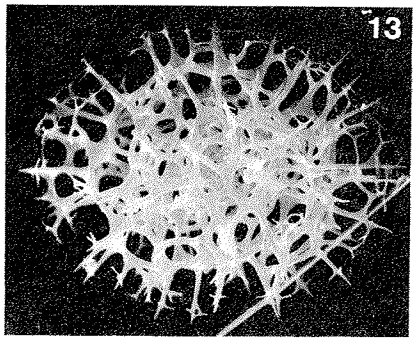
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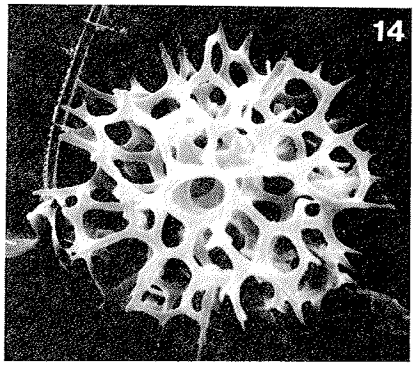
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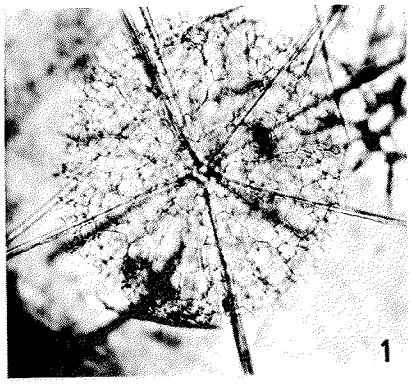
PLATE 7

Suborder: Spumellaria
Family: Actinommidae; Subfamily: Actinomminae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Centrocubus octostylus* Haeckel	PB: 1268	LM	×104
2	*Spongosphaera polycantha* Müller	PB: 3769	LM	×106
3	*Spongosphaera polycantha* Müller	P_1: 5582	SEM	×165
4	*Spongosphaera* sp. aff. *S. helioides* Haeckel	PB: 3791	LM	×130
5	*Spongosphaera polycantha* Müller	PB: 667	SEM	×66
6	*Spongosphaera streptacantha* Haeckel	PB: 2778	SEM	×28
7	*Spongosphaera* sp. aff. *S. helioides* Haeckel	P_1: 2778	SEM	×36
8	*Spongosphaera* sp. aff. *S. helioides* Haeckel	P_1: 2778	SEM	×40
9	*Spongosphaera* ? sp. B	P_1: 2778	SEM	×40
10	*Lychnosphaera regina* Haeckel	PB: 667	LM	×66
11	*Leptosphaera minuta* Popofsky	P_1: 2778	SEM	×280
12	*Arachnosphaera* sp.	P_1: 2778	LM	×158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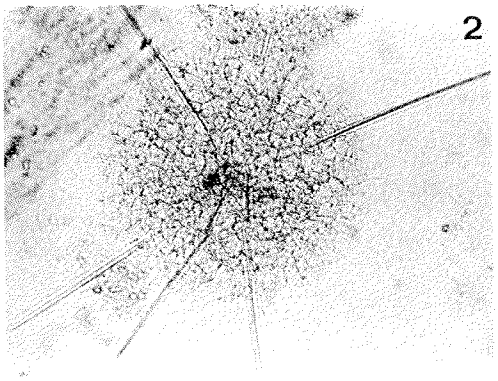
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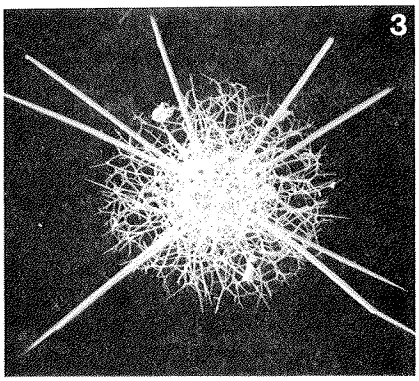
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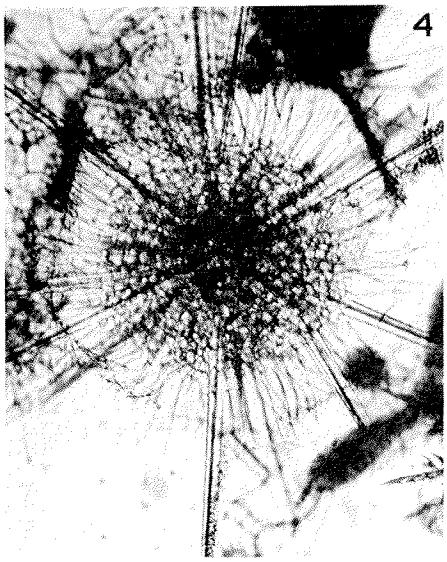
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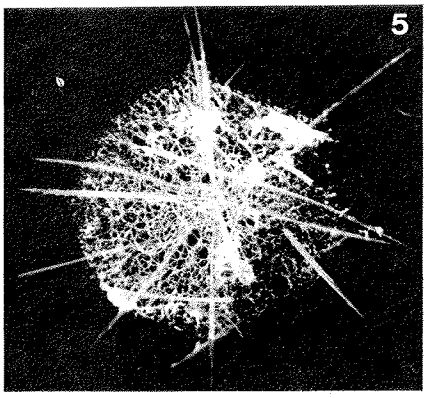
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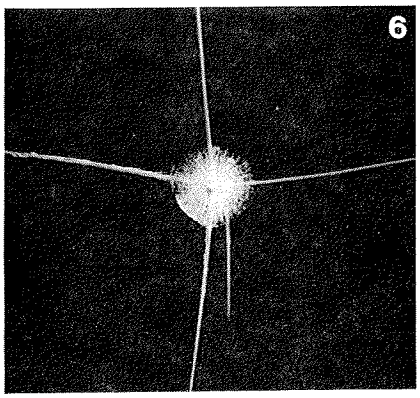
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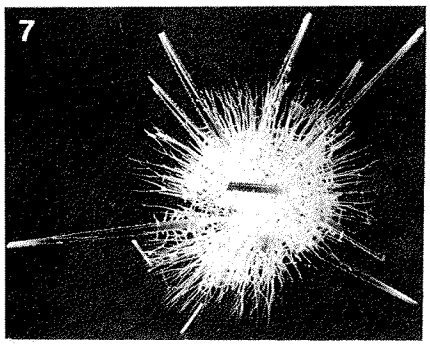
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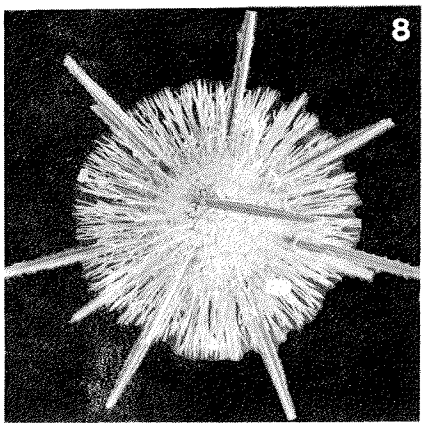
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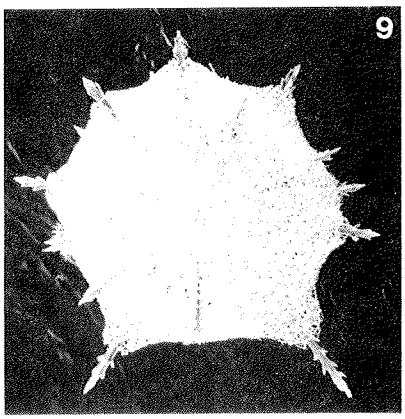
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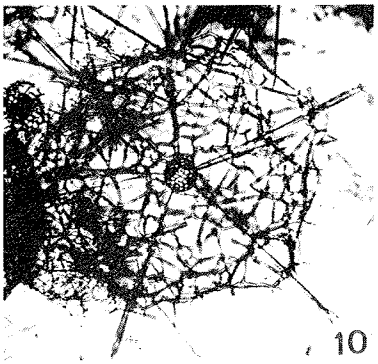
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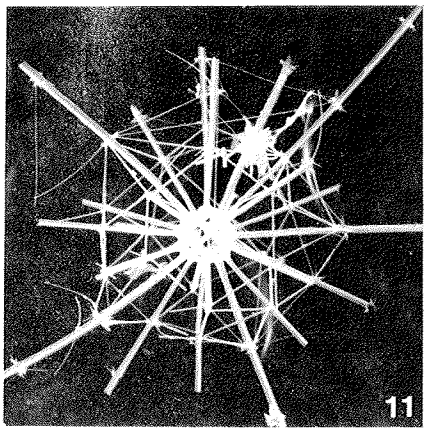
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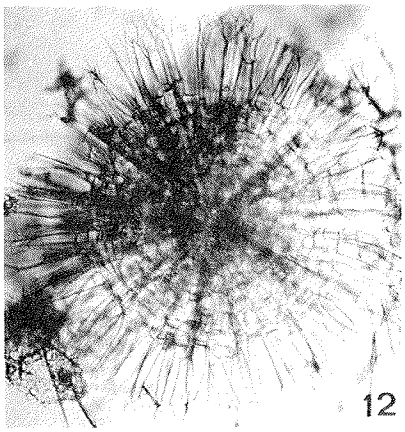
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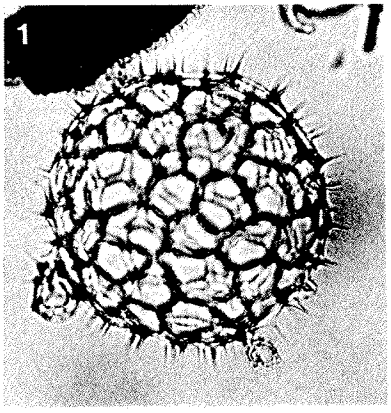
PLATE 8

Suborder: Spumellaria
Family: Actinommidae; Subfamily: Actinomminae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Acanthosphaera actinota* (Haeckel)	P_1: 5582	LM	×210
2	*Acanthosphaera tunis* Haeckel	PB: 667	LM	×210
3	*Acanthosphaera tunis* Haeckel	PB: 667	LM	×210
4	*Acanthosphaera castanea* Haeckel	P_1: 5582	SEM	×165
5	*Acanthosphaera castanea* Haeckel	P_1: 2778	LM	×210
6	*Cladococcus viminalis* Haeckel	P_1: 2778	LM	×210
7	*Cladococcus viminalis* Haeckel	P_1: 978	SEM	×200
8	*Actinomma arcadophorum* Haeckel	PB: 1268	LM	×210
9	*Actinomma arcadophorum* Haeckel	P_1: 5582	SEM	×165
10	*Actinomma capillaceum* Haeckel	P_1: 4280	SEM	×150
11	*Actinomma arcadophorum* Haeckel	P_1: 4280	SEM	×140
12	*Haliomma* ? sp. A	P_1: 4280	SEM	×440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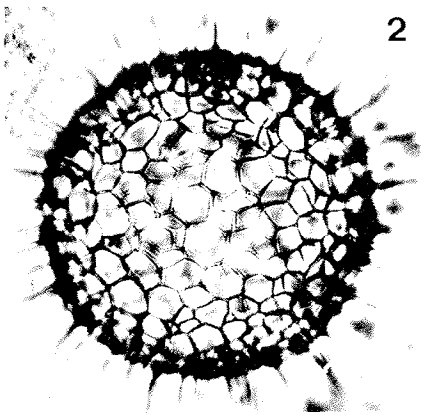
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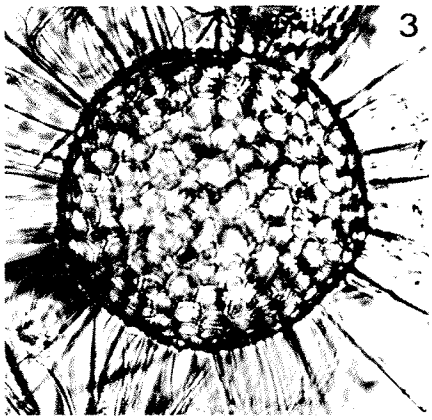
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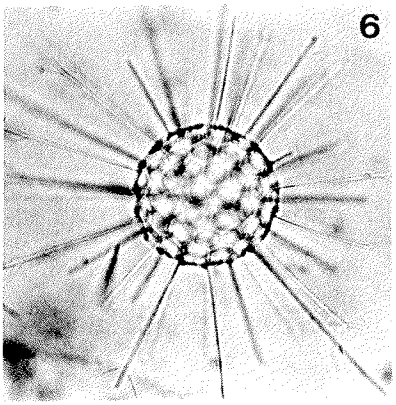
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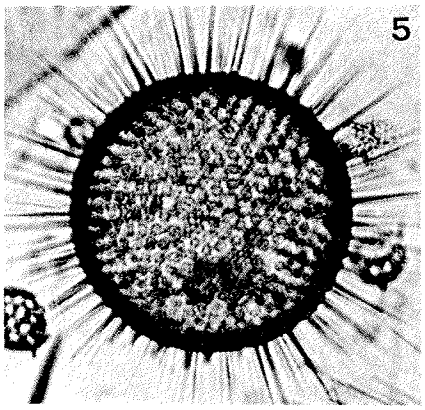
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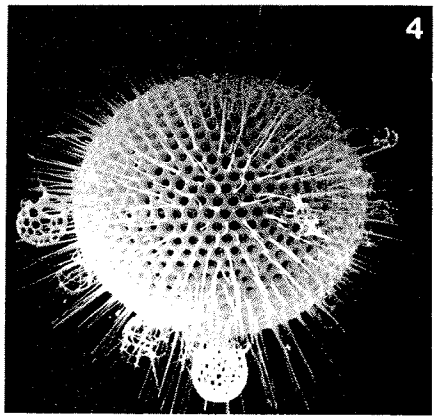
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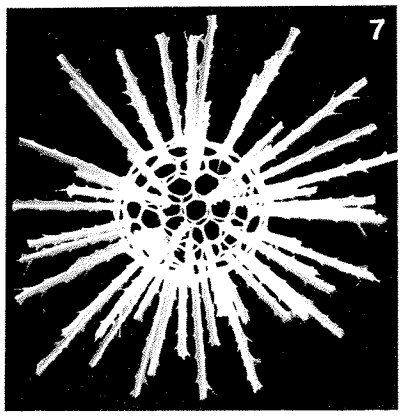
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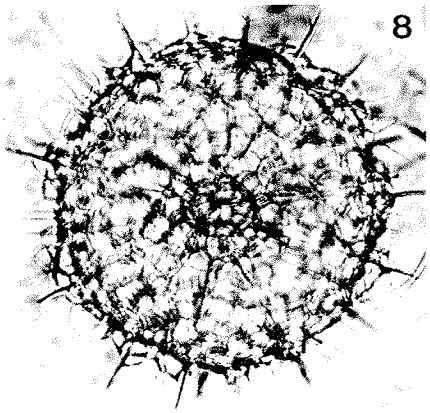
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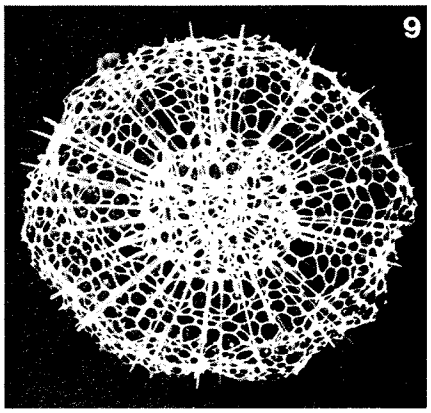
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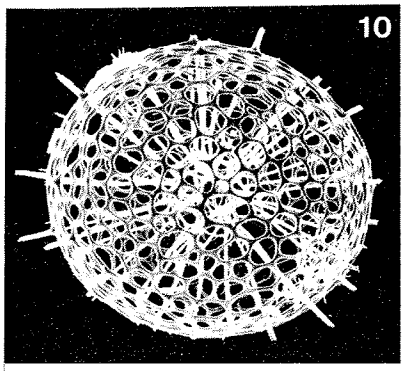
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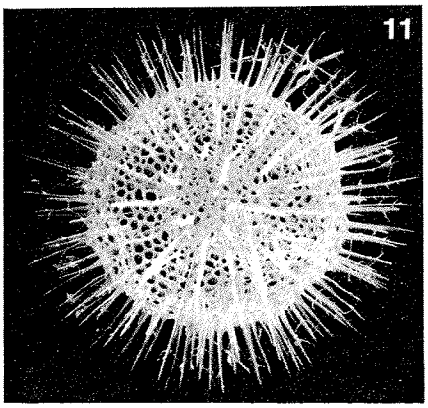
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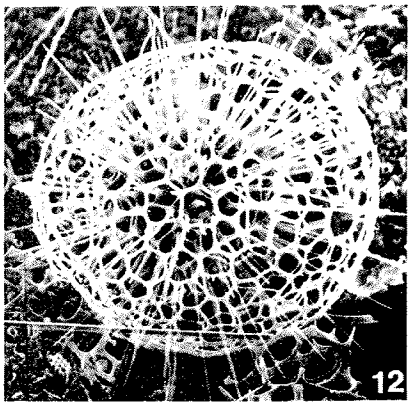
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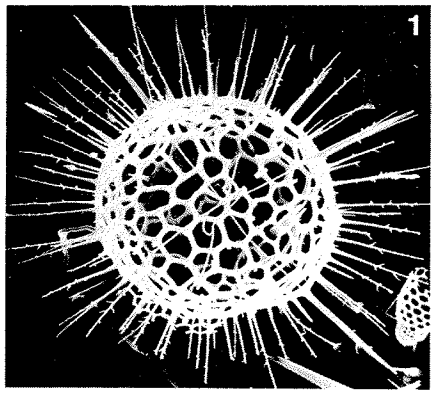
PLATE 9

Suborder: Spumellaria
Family: Actinommidae; Subfamily Actinomminae
Family: Ethmosphaeridae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Actinosphaera tenella* (Haeckel)	P_1: 4280	SEM	×165
2	*Actinosphaera acanthophora* (Popofsky) Specimen broken to show the medullary shell.	PB: 1268	SEM	×180
3	*Actinosphaera acanthophora* (Popofsky)	PB: 3791	SEM	×160
4	*Actinosphaera capillacea* (Haeckel)	P_1: 4280	SEM	×180
5	*Actinosphaera capillacea* (Haeckel)	PB: 3791	LM	×210
6	*Heliosoma* sp.	P_1: 4280	SEM	×440
7	*Haliomma castanea* Haeckel	P_1: 4280	SEM	×440
8	*Heliosoma* sp.	P_1: 378	LM	×210
9	*Elatomma penicillus* Haeckel	P_1: 5582	SEM	×150
10	*Elatomma penicillus* Haeckel	PB: 1268	LM	×210
11	*Haliomma castanea* Haeckel	E: 988	LM	×210
12	*Carposphaera* sp. aff. *C. corypha* Haeckel	P_1: 5582	LM	×210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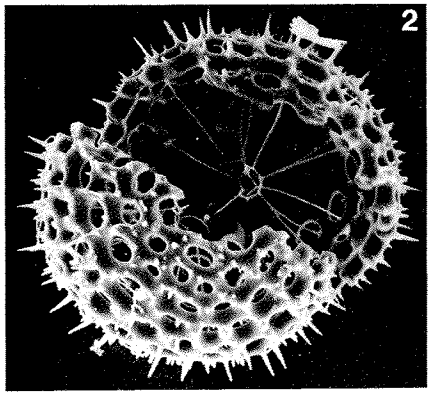
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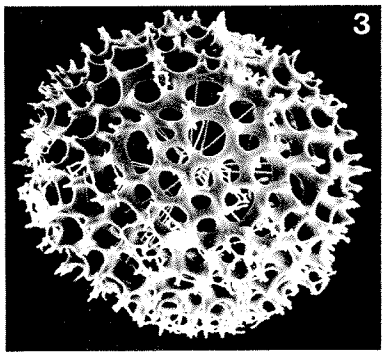
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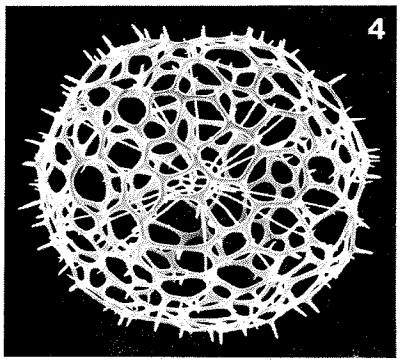
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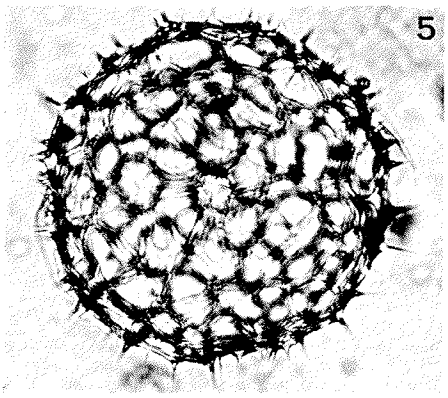
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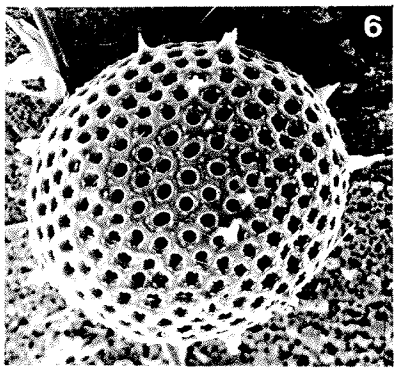
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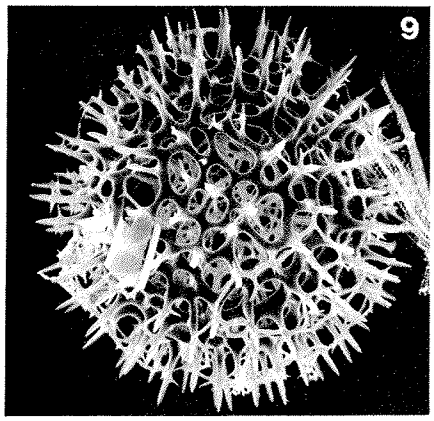
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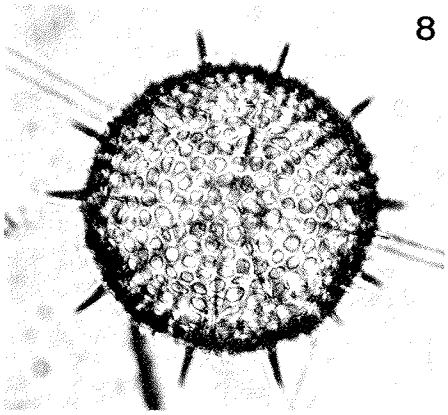
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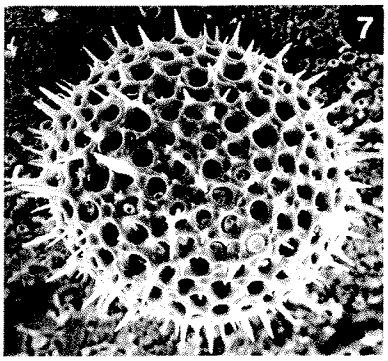
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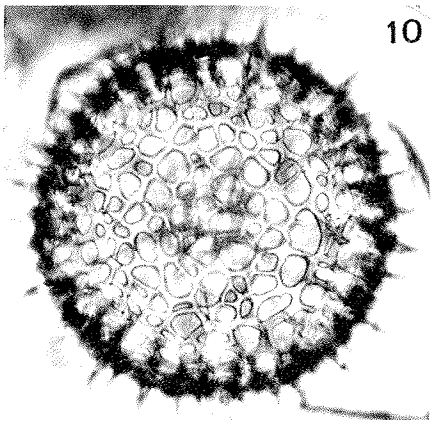
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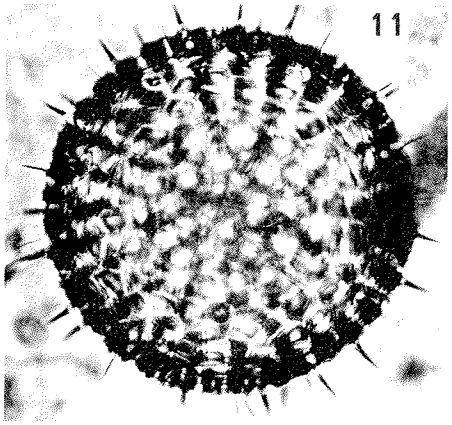
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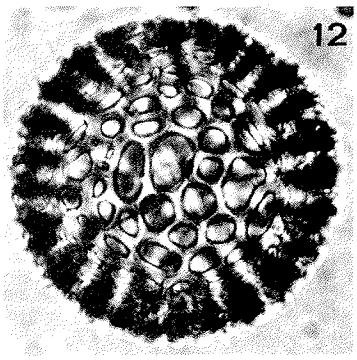
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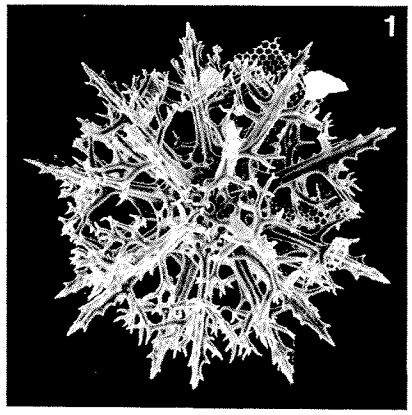
PLATE 10

Suborder: Spumellaria
Family: Actinommidae; Subfamily: Actinomminae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Haeckeliella macrodoras* (Haeckel)	P_1: 978	SEM	×110
2	*Haeckeliella macrodoras* (Haeckel) Detail of inner medullary shell.	P_1: 978	SEM	×350
3	*Haeckeliella macrodoras* (Haeckel)	P_1: 378	LM	×210
4	*Haeckeliella macrodoras* (Haeckel)	P_1: 978	SEM	×110
5	*Cladococcus abietinus* Haeckel	PB: 667	LM	×152
6	*Cladococcus scoparius* Haeckel	PB: 3769	LM	×160
7	*Cladococcus scoparius* Haeckel	P_1: 978	SEM	×140
8	*Cladococcus cervicornis* Haeckel	P_1: 4280	SEM	×190
9	*Cladococcus cervicornis* Haeckel	PB: 3769	LM	×210
10	*Cladococcus cervicornis* Haeckel	PB: 2869	LM	×210
11	*Arachnosphaera myriacantha* Haeckel	PB: 3791	LM	×132
12	*Arachnosphaera myriacantha* Haeckel	P_1: 5582	SEM	×105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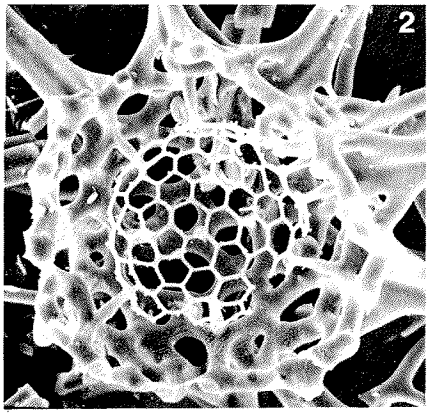
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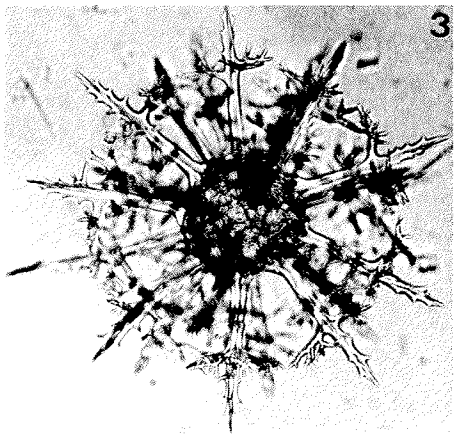
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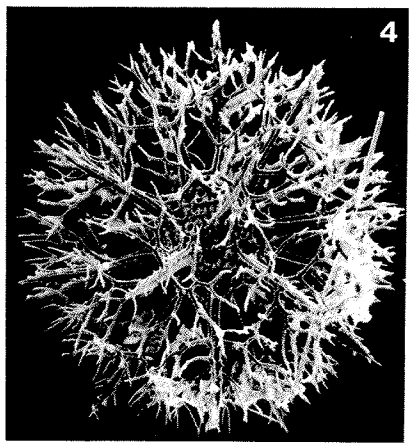
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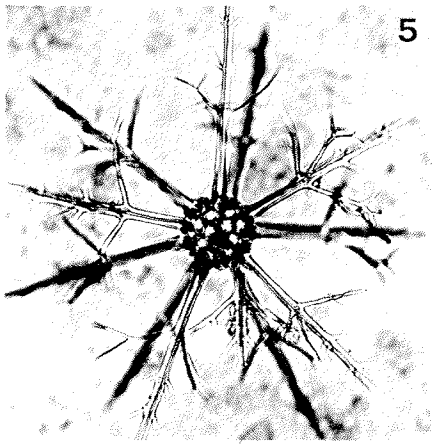
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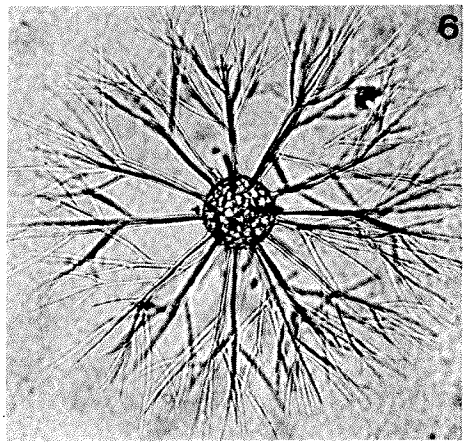
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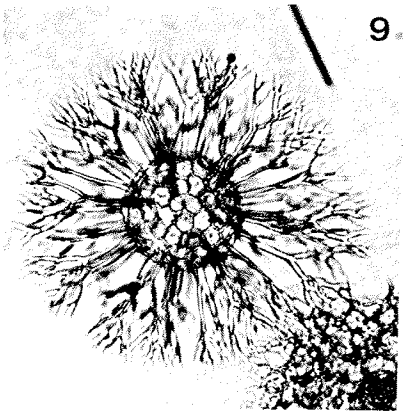
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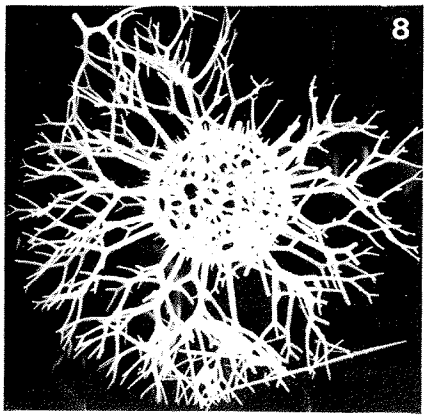
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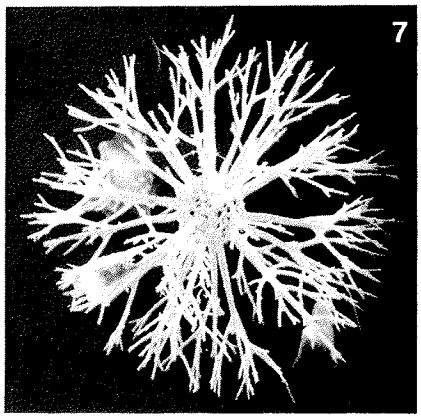
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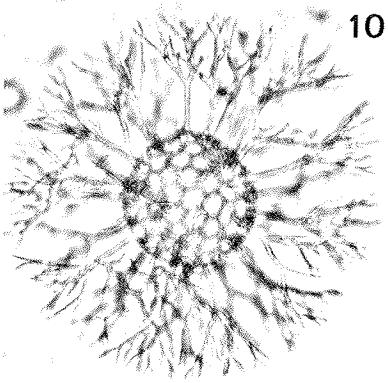
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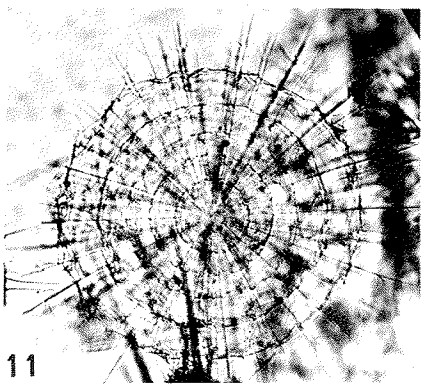
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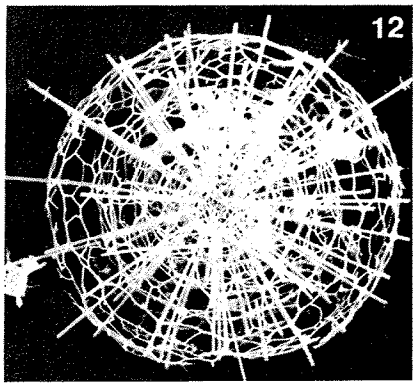
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PLATE 11

cSuborder: Spumellaria
Family: Actinommidae; Subfamily: Actinomminae
Family: Tholoniidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Astrosphaera hexagonalis* Haeckel	PB: 667	SEM	×120
2	*Astrosphaera hexagonalis* Haeckel	PB: 3791	LM	×158
3	*Astrosphaera hexagonalis* Haeckel A form with long wavy bi-spines.	PB: 1268	LM	×133
4	*Drymosphaera dendrophora* Haeckel	PB: 3769	LM	×120
5	*Stylosphaera* ? sp. A	P_1: 978	SEM	×500
6	*Stylosphaera* ? sp. A	P_1: 2778	SEM	×440
7	*Sphaeropyle mespilus* ? Dreyer	PB: 2869	LM	×210
8	*Sphaeropyle mespilus* ? Dreyer	P_1: 378	LM	×210
9	*Thecosphaera inermis* (Haeckel)	P_1: 4280	SEM	×440
10	*Cromyomma villosum* Haeckel	PB: 2869	LM	×210
11	*Cromyomma villosum* Haeckel	PB: 3769	LM	×210
12	*Tholoma metallasson* Haeckel	P_1: 2778	LM	×210
13	*Tholoma metallasson* Haeckel	PB: 3791	LM	×210
14	*Hexalonche* sp. A	P_1: 2778	LM	×210
15	*Hexalonche* sp. A	PB: 3769	LM	×210

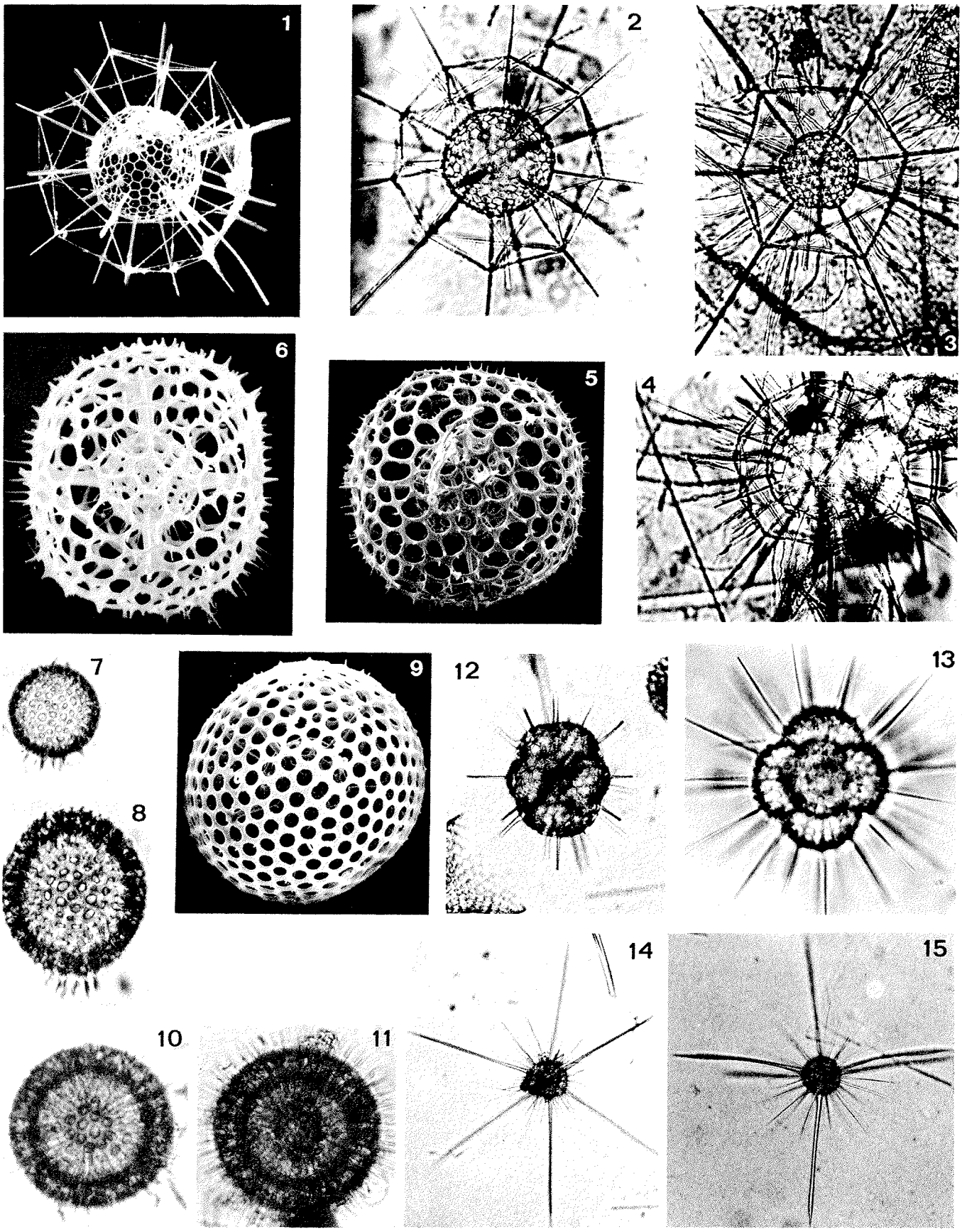
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PLATE 12

Suborder: Spumellaria
Family: Actinommidae; Subfamily: Actinomminae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Xiphosphaera gaea* Haeckel	P_1: 4280	SEM	×330
2	*Xiphosphaera gaea* Haeckel	P_1: 2778	LM	×130
3	*Xiphosphaera tesseractis* Dreyer	P_1: 5582	SEM	×140
4	*Xiphosphaera tesseractis* Dreyer	PB: 3769	LM	×150
5	*Xiphosphaera tesseractis* Dreyer	P_1: 4280	SEM	×280
6	*Stauracontium* sp.	P_1: 2778	LM	×126
7	*Hexastylus triaxonius* Haeckel	PB: 3791	LM	×210
8	*Hexastylus triaxonius* Haeckel	PB: 3791	SEM	×165
9	*Hexastylus* sp.	P_1: 4280	SEM	×440
10	*Hexalonche* sp. B	P_1: 4280	SEM	×550
11	*Hexalonche* sp. B	P_1: 978	SEM	×660
12	*Hexacontium* sp.	P_1: 5582	SEM	×360
13	*Hexalonche amphisiphon* Haeckel	P_1: 4280	SEM	×130
14	*Hexalonche amphisiphon* Haeckel	P_1: 4280	SEM	×180
15	*Haliomma* sp. B	P_1: 978	SEM	×440

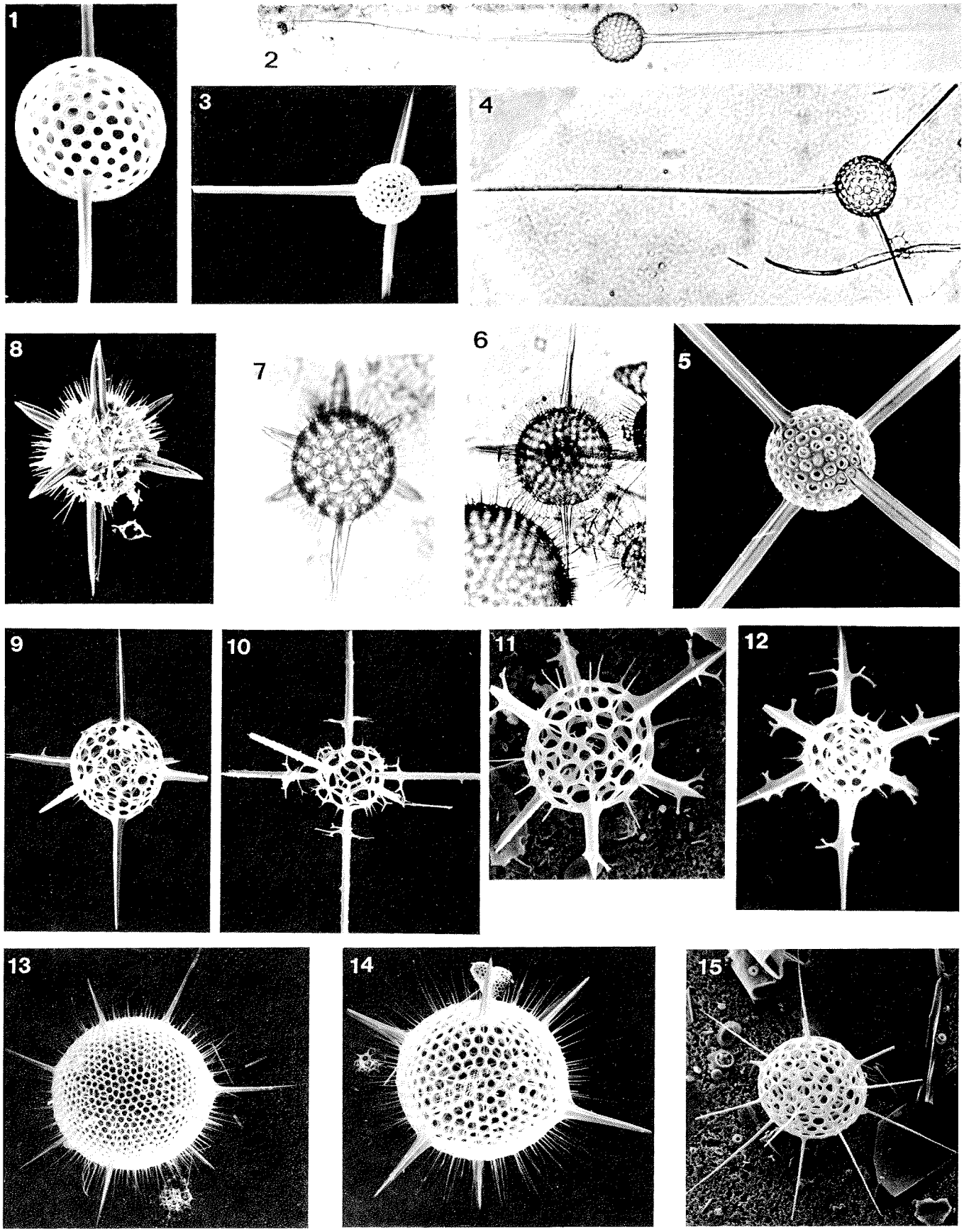
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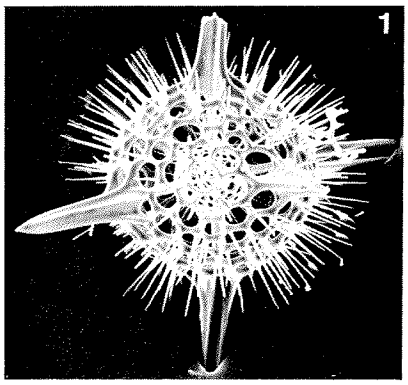
PLATE 13

Suborder: Spumellaria
Family: Actinommidae; Subfamily: Actinomminae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Hexacontium hostile* Cleve	P_1: 4280	SEM	×220
2	*Hexacontium hostile* Cleve	PB: 2869	LM	×210
3	*Hexacontium axotrias* Haeckel	P_1: 5582	LM	×210
4	*Hexacromyum elegans* Haeckel	E: 389	LM	×210
5	*Hexacromyum elegans* Haeckel A specimen with 7 radial spines.	E: 389	LM	×210
6	*Hexacontium* sp. aff. *H. hostile* Cleve	P_1: 4280	SEM	×180
7	*Hexacromyum elegans* Haeckel	P_1: 4280	SEM	×230
8	*Heterosphaera* sp. B	P_1: 4280	SEM	×250
9	*Heterosphaera* sp. A	PB: 3791	LM	×210
10	*Heterosphaera* sp. A	P_1: 2778	LM	×210
11	*Actinomma* sp.	P_1: 5582	LM	×210
12	*Cromyechinus* ? sp.	P_1: 4280	SEM	×130
13	*Cromyechinus* sp. aff. *C. borealis* (Cleve)	P_1: 978	LM	×210
14	*Stomatosphaera* sp. A	P_1: 978	SEM	×340
15	*Stomatosphaera* sp. B	P_1: 4280	SEM	×210
16	*Stomatosphaera* sp. C	PB: 3769	SEM	×170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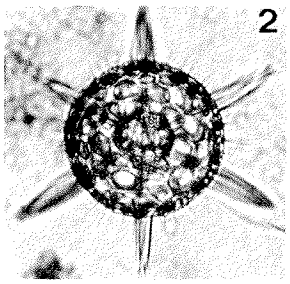
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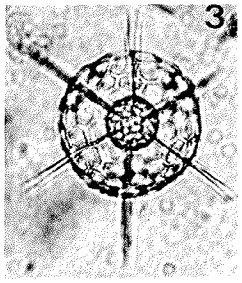
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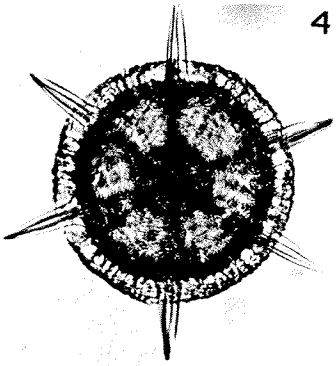
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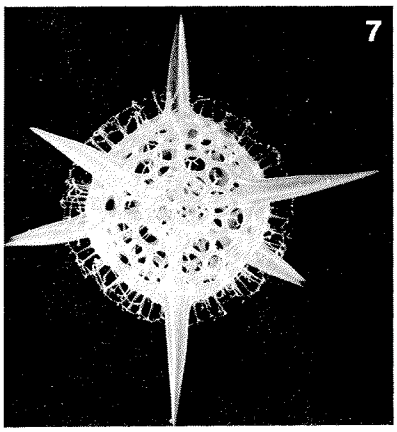
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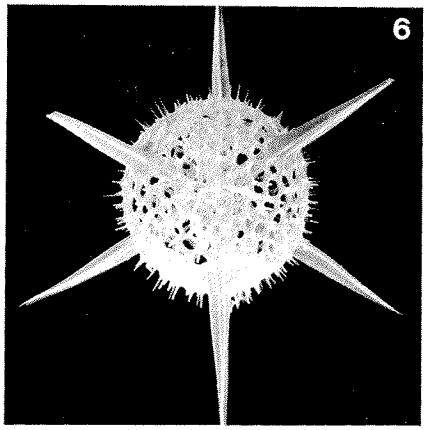
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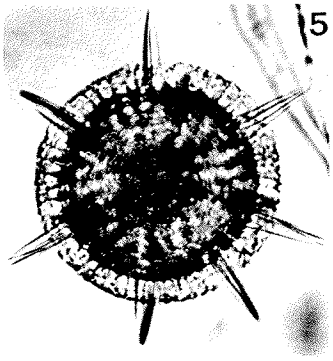
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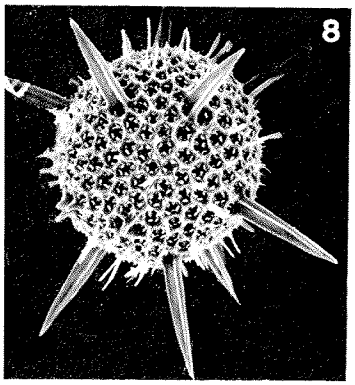
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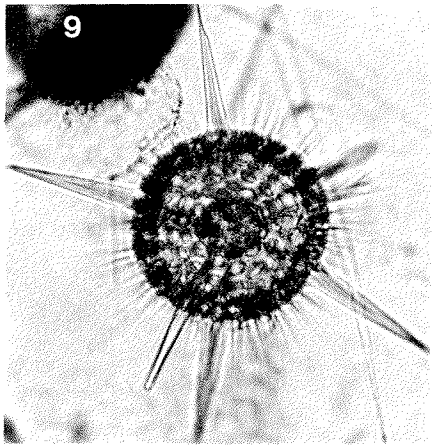
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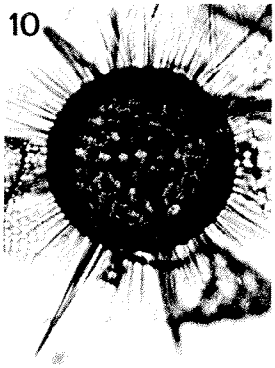
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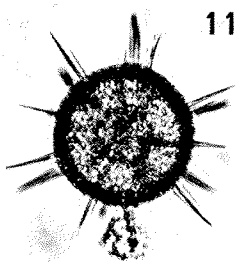
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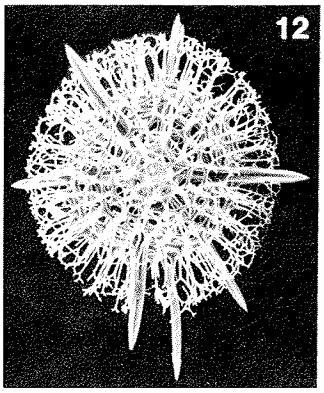
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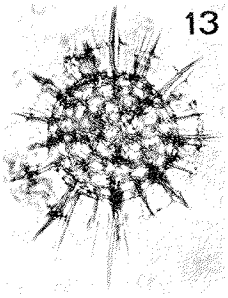
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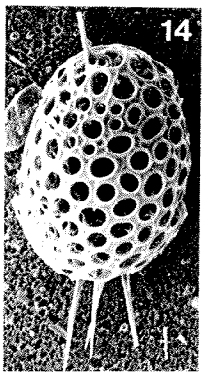
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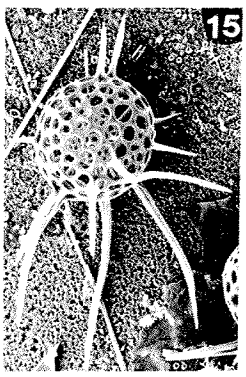
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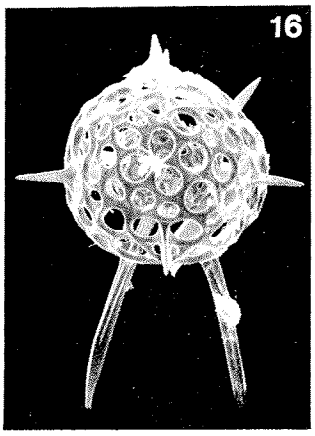
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PLATE 14

Suborder: Spumellaria
Family: Actinommidae; Subfamily: Actinomminae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Stylosphaera melpomene* Haeckel	PB: 2869	LM	×210
2	*Stylosphaera melpomene* Haeckel	PB: 3769	LM	×210
3	*Druppatractus ostracion* Haeckel group	PB: 3769	LM	×210
4	*Druppatractus ostracion* Haeckel group	P_1: 4280	LM	×210
5	*Stylosphaera* ? sp. B	P_1: 4280	SEM	×250
6	*Amphisphaera* group	P_1: 5582	SEM	×140
7	*Amphisphaera* group	P_1: 5582	LM	×140
8	*Axoprunum stauraxonium* Haeckel	PB: 3769	LM	×210
9	*Axoprunum stauraxonium* Haeckel	P_1: 5582	LM	×210
10	*Axoprunum stauraxonium* Haeckel	P_1: 5582	SEM	×165
11	*Ellipsoxiphium palliatum* Haecker	P_1: 5582	SEM	×140
12	*Ellipsoxiphium palliatum* Haecker	P_1: 4280	SEM	×165
13	*Ellipsoxiphium palliatum* Haecker	PB: 3791	LM	×210
14	*Ellipsoxiphium palliatum* Haecker	P_1: 4280	SEM	×165
15	*Ellipsoxiphium palliatum* Haecker	PB: 3791	LM	×210
16	*Ellipsoxiphium palliatum* Haecker	P_1: 5582	LM	×210
17	*Ellipsoxiphium palliatum* Haecker	E: 3755	LM	×210

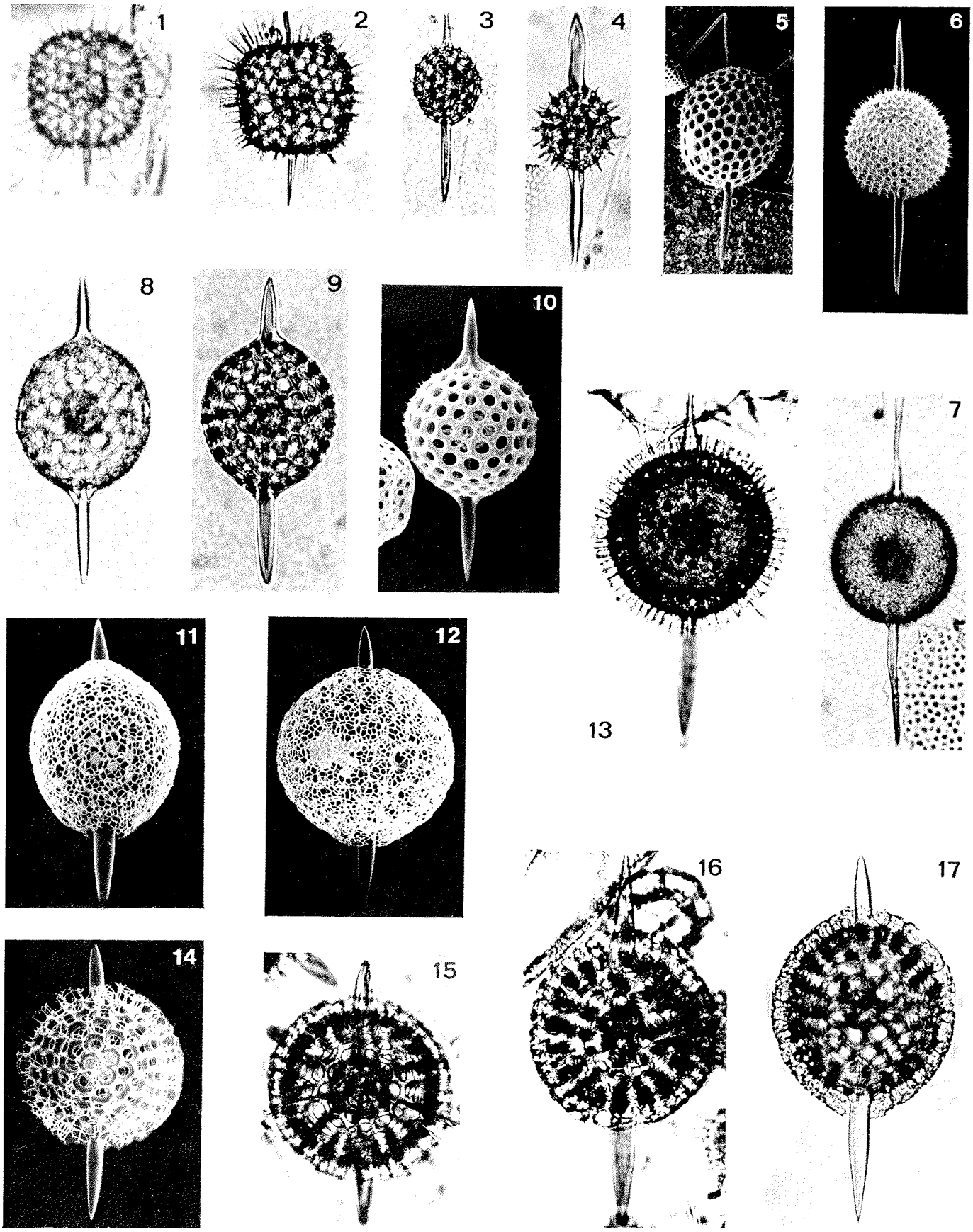
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PLATE 15

Suborder: Spumellaria
Family: Actinommidae; Subfamilies: Actinomminae, Saturnalinae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Xiphatractus pluto* (Haeckel)	P_1: 5582	LM	×210
2	*Xiphatractus pluto* (Haeckel)	P_1: 978	LM	×210
3	*Xiphatractus pluto* (Haeckel)	P_1: 5582	LM	×210
4	*Xiphatractus* sp. A	E: 988	LM	×210
5	*Druppatractus* ? sp.	P_1: 5582	SEM	×200
6	*Xiphatractus* sp. B	P_1: 4280	SEM	×250
7	*Xiphatractus* sp. B	P_1: 4280	SEM	×440
8	*Hexacontium heracliti* (Haeckel)	PB: 3791	LM	×210
9	*Hexacontium heracliti* (Haeckel)	PB: 2869	LM	×210
10	*Hexacontium hystricina* (Haeckel)	PB: 2869	SEM	×230
11	*Dorydruppa bensoni* Takahashi, new name	PB: 2869	LM	×210
12	*Dorydruppa bensoni* Takahashi, new name A pear-shaped medullary shell.	PB: 2869	LM	×210
13	*Dorydruppa bensoni* Takahashi, new name A specimen with thin cortical shell.	P_1: 4280	LM	×210
14	*Dorydruppa bensoni* Takahashi, new name A pear-shaped medullary shell.	PB: 3791	SEM	×550
15	*Saturnalis circularis* Haeckel	PB: 3791	LM	×210
16	*Saturnalis circularis* Haeckel	P_1: 4280	SEM	×210
17	*Saturnalis circularis* Haeckel A close-up of the cortical shell. Note presence of fragile outer cortical meshwork.	PB: 2869	SEM	×380
18	*Saturnalis circularis* Haeckel	PB: 2869	SEM	×170

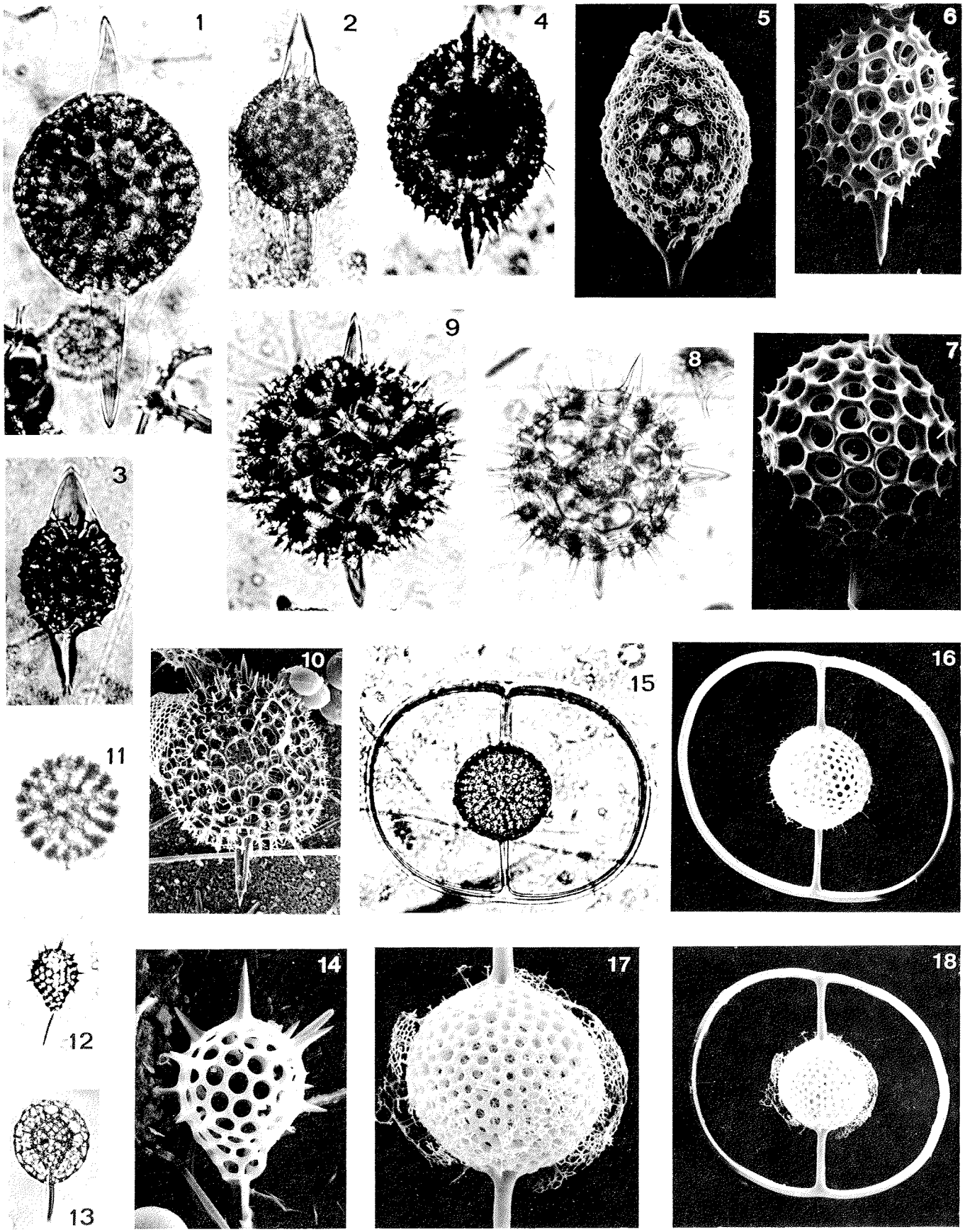
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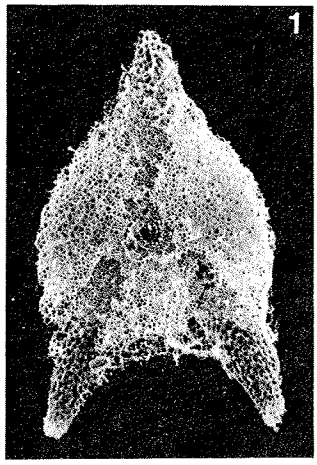
PLATE 16

Suborder: Spumellaria
Families: Porodiscidae, Spongodiscidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Euchitonia elegans* (Ehrenberg)	P_1: 978	SEM	×120
2	*Euchitonia elegans* (Ehrenberg)	P_1: 5582	SEM	×120
3	*Euchitonia elegans* (Ehrenberg) A specimen without a patagium.	PB: 3791	SEM	×80
4	*Euchitonia elegans* (Ehrenberg)	P_1: 2778	LM	×100
5	*Euchitonia elegans* (Ehrenberg)	PB: 3769	LM	×105
6	*Euchitonia elegans* (Ehrenberg) A specimen with a well developed patagium.	PB: 3769	LM	×105
7	*Spongodiscus* sp. A	P_1: 4280	SEM	×430
8	*Euchitonia* cf. *furcata* Ehrenberg	P_1: 4280	SEM	×240
9	*Euchitonia* sp.	PB: 2869	LM	×210
10	*Dictyocoryne profunda* Ehrenberg	P_1: 5582	LM	×210
11	*Euchitonia* sp.	P_1: 4280	SEM	×280
12	*Dictyocoryne profunda* Ehrenberg A specimen with a well developed patagium.	PB: 3791	LM	×210
13	*Dictyocoryne profunda* Ehrenberg	PB: 1268	SEM	×110
14	*Dictyocoryne truncatum* (Ehrenberg)	PB: 1268	SEM	×180
15	*Dictyocoryne profunda* Ehrenberg	P_1: 2778	SEM	×160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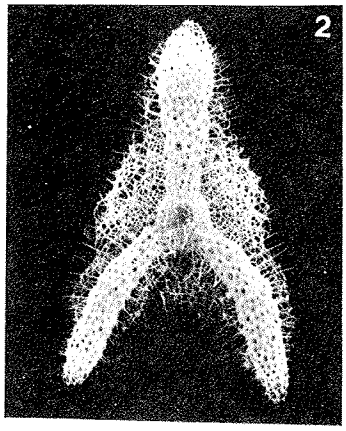
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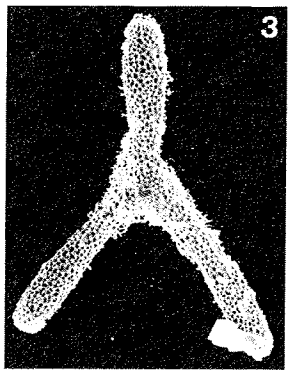
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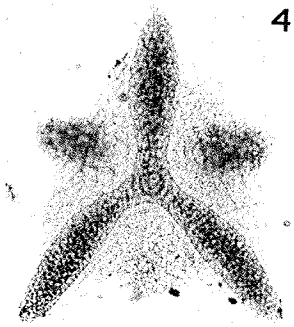
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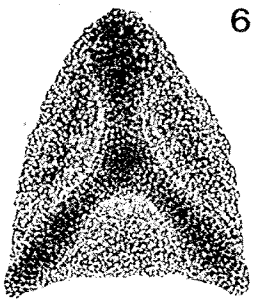
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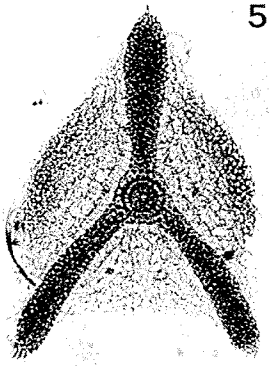
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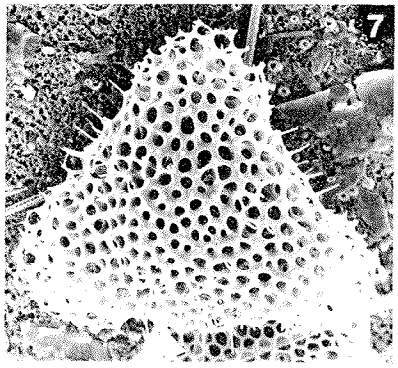
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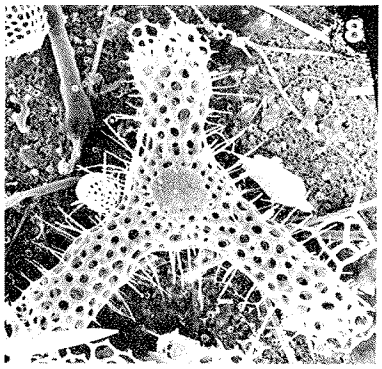
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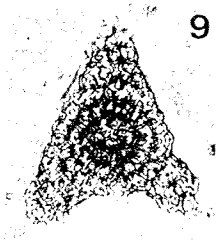
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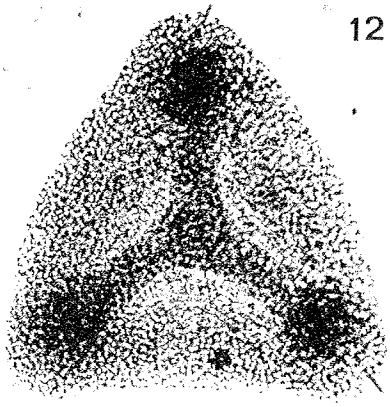
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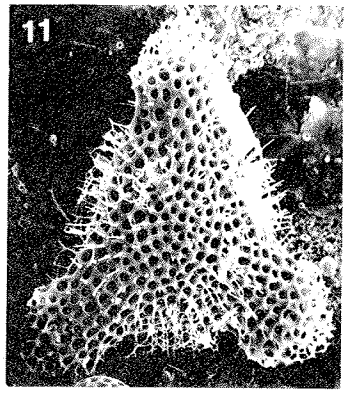
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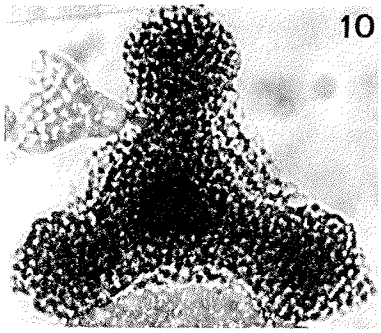
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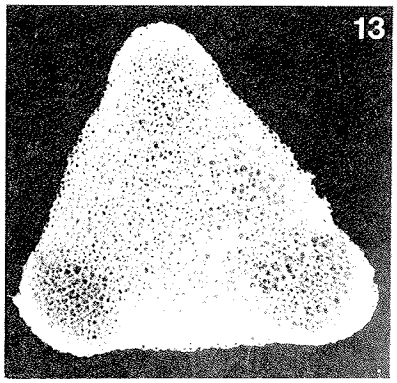
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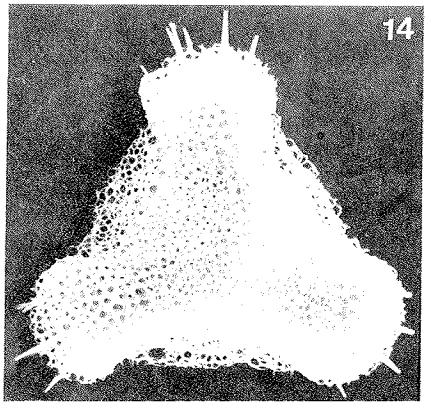
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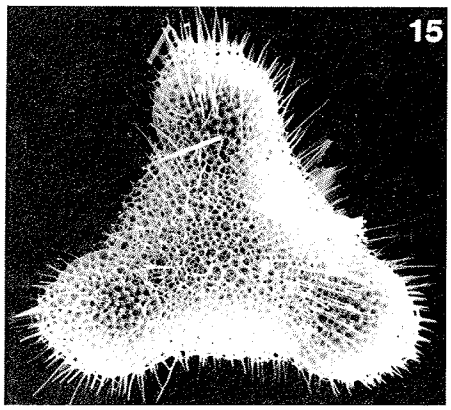
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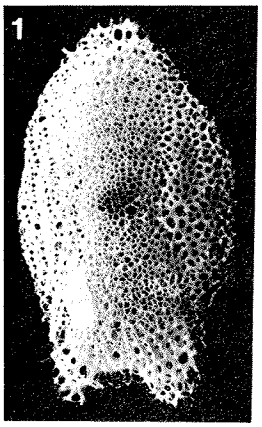
PLATE 17

Suborder: Spumellaria
Families: Porodiscidae, Spongodiscidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Amphirhopalum ypsilon* Haeckel	P_1: 5582	SEM	×180
2	*Amphirhopalum ypsilon* Haeckel	PB: 3791	LM	×210
3	*Amphirhopalum ypsilon* Haeckel	PB: 3791	LM	×210
4	*Amphirhopalum straussii* (Haeckel)	P_1: 5582	LM	×210
5	*Spongurus cylindricus* (Haeckel)	P_1: 4280	LM	×210
6	*Spongurus cylindricus* (Haeckel)	P_1: 5582	SEM	×165
7	*Spongurus cylindricus* (Haeckel)	P_1: 5582	LM	×210
8	*Spongurus cylindricus* (Haeckel)	P_1: 978	SEM	×190
9	*Spongurus cylindricus* (Haeckel)	PB: 3791	LM	×210
10	*Spongaster tetras tetras* Ehrenberg	PB: 978	SEM	×340
11	*Spongaster tetras tetras* Ehrenberg	PB: 3769	LM	×190
12	*Spongaster pentas* Riedel and Sanfilippo	PB: 2869	LM	×210
13	*Spongaster pentas* Riedel and Sanfilippo Oblique ventral view.	P_1: 5582	SEM	×230
14	*Spongaster pentas* Riedel and Sanfilippo Oblique ventral view.	P_1: 5582	SEM	×230
15	*Spongaster pentas* Riedel and Sanfilippo Oblique ventral view.	P_1: 5582	SEM	×210
16	*Spongaster pentas* Riedel and Sanfilippo Oblique dorsal view.	P_1: 5582	SEM	×200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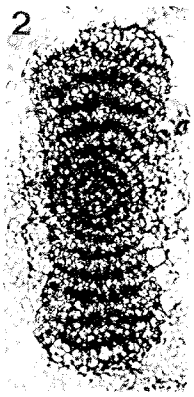
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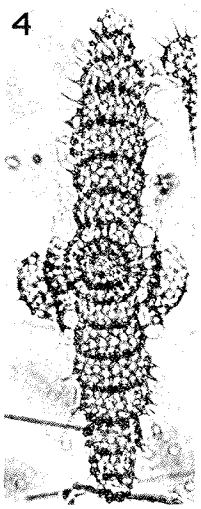
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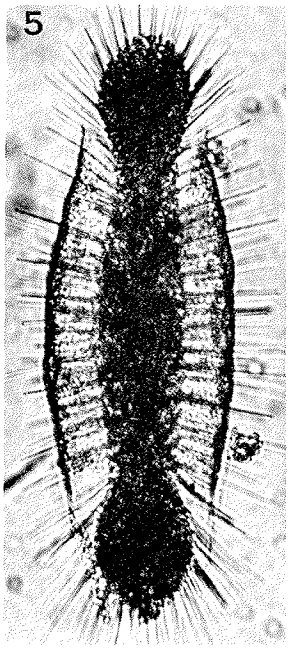
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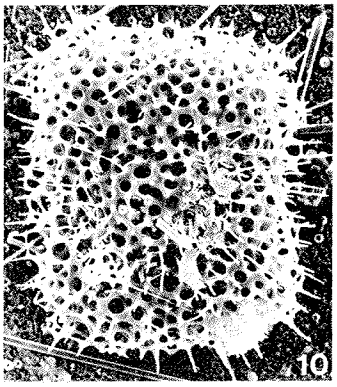
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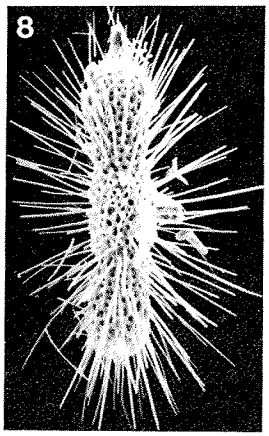
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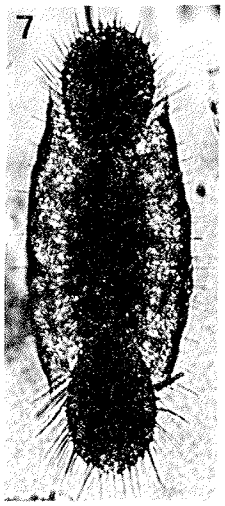
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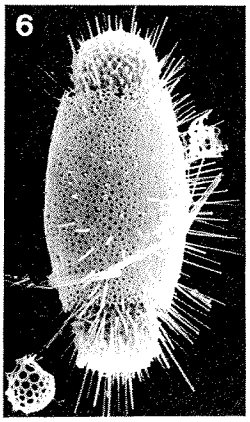
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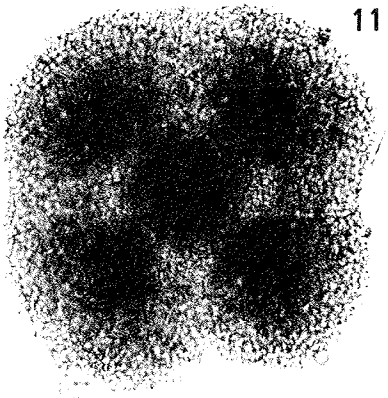
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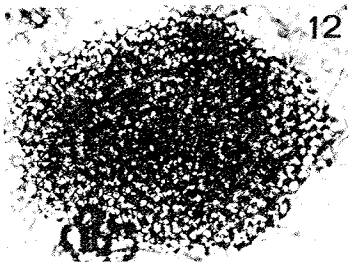
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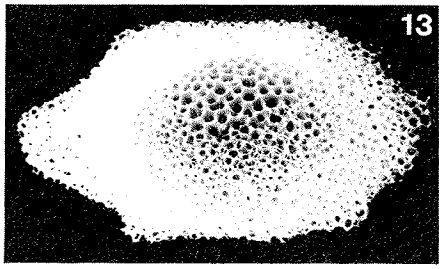
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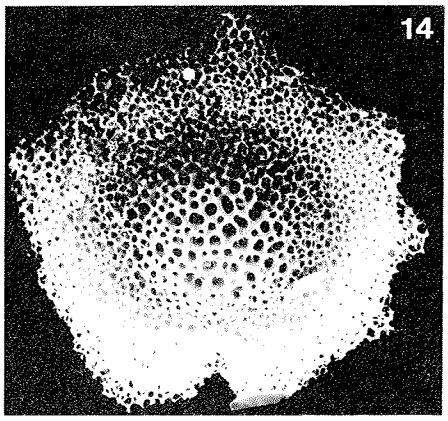
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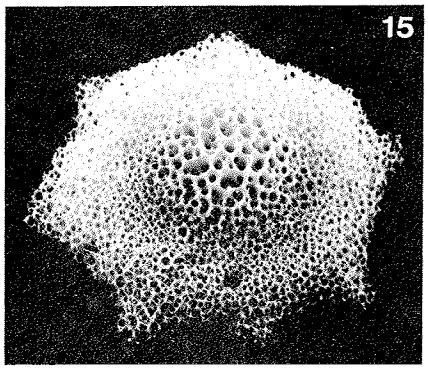
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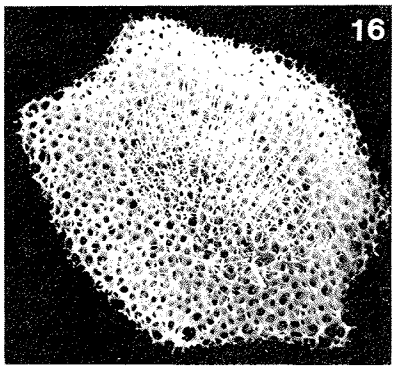
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PLATE 18

Suborder: Spumellaria
Family: Myelastridae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Myelastrum quadrifolium* Takahashi, n. sp.	PB: 3791	SEM	×55
2	*Myelastrum quadrifolium* Takahashi, n. sp. Holotype	PB: 3791	RLM	×64
3	*Myelastrum quadrifolium* Takahashi, n. sp. Paratype	PB: 3791	RLM	×64
4	*Myelastrum quadrifolium* Takahashi, n. sp. Oblique view.	PB: 3791	SEM	×50
5	*Myelastrum quadrifolium* Takahashi, n. sp. Paratype	PB: 667	SEM	×50
6	*Myelastrum quadrifolium* Takahashi, n. sp. Same specimen; detail of central area	PB: 667	SEM	×500
7	*Myelastrum trinibrachium* Takahashi, n. sp. Paratype	PB: 1268	SEM	×38
8	*Myelastrum trinibrachium* Takahashi, n. sp.	PB: 3791	RLM	×64
9	*Myelastrum trinibrachium* Takahashi, n. sp. Paratype	P_1: 4280	SEM	×50
10	*Myelastrum trinibrachium* Takahashi, n. sp. Holotype	PB: 1268	SEM	×33
11	*Myelastrum trinibrachium* Takahashi, n. sp. A cross section of a skeletal element of spongy meshwork. For comparisons, see plates 43, 47, 53, 56, 58–63.	PB: 3769	TEM	×67,000
12	*Myelastrum trinibrachium* Takahashi, n. sp. Paratype	DOMES B: 56	LM	×185

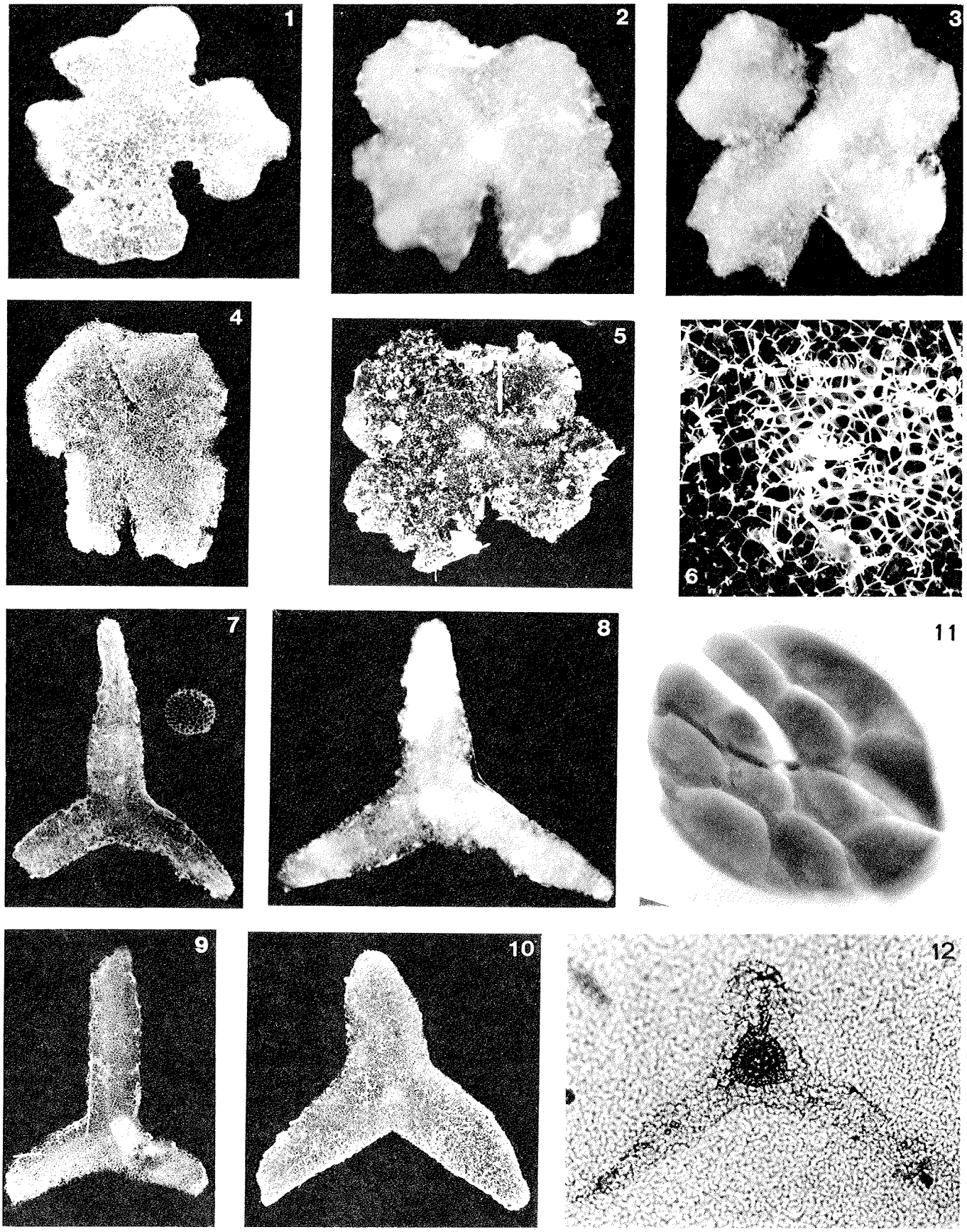
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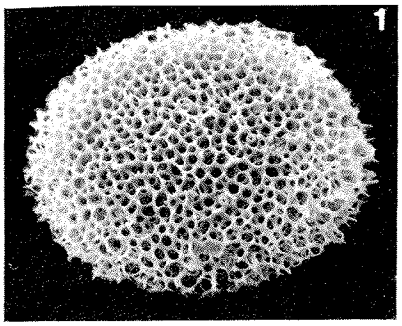
PLATE 19

Suborder: Spumellaria
Families: Spongodiscidae, Porodiscidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Spongodiscus resurgens* Ehrenberg	P_1: 978	SEM	×270
2	*Spongodiscus* spp. B group	P_1: 5582	SEM	×450
3	*Spongodiscus* spp. B group	P_1: 978	SEM	×440
4	*Spongodiscus biconcavus* Haeckel	P_1: 5582	SEM	×150
5	*Spongodiscus biconcavus* Haeckel	PB: 1268	SEM	×150
	Same specimen, oblique view.			
6	*Spongodiscus biconcavus* Haeckel	PB: 3769	LM	×157
7	*Spongotrochus* sp. A	P_1: 5582	SEM	×154
8	*Stylospongia huxleyi* Haeckel	P_1: 4280	SEM	×280
9	*Spongopyle setosa* Dreyer	P_1: 5582	LM	×210
10	*Spongotrochus glacialis* Popofsky	PB: 3791	LM	×210
11	*Stylodictya validispina* Jørgensen	P_1: 978	LM	×210
12	*Stylodictya* ? sp.	PB: 3791	LM	×210
13	*Stylodictya* ? sp.	PB: 3791	LM	×210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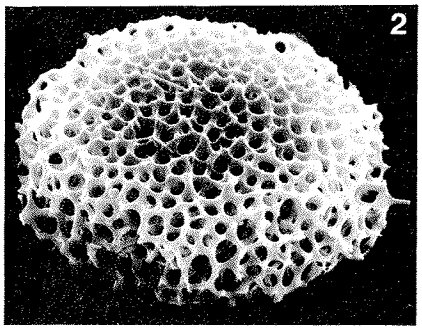
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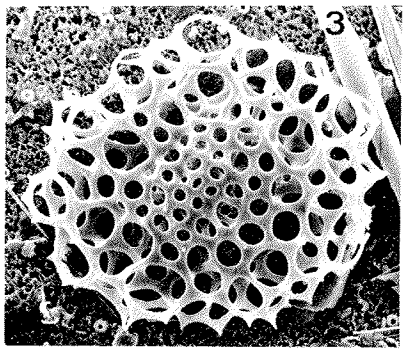
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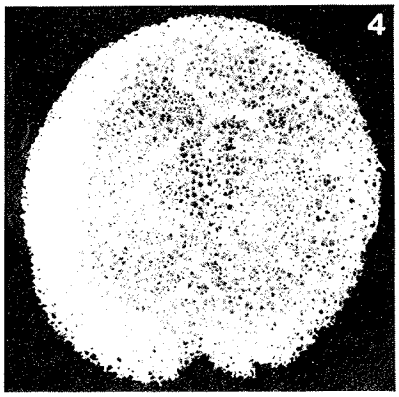
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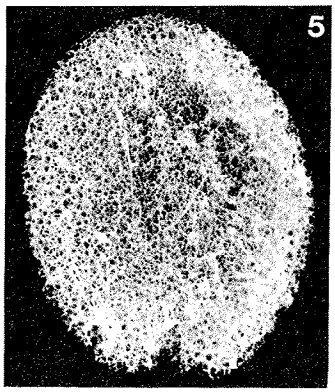
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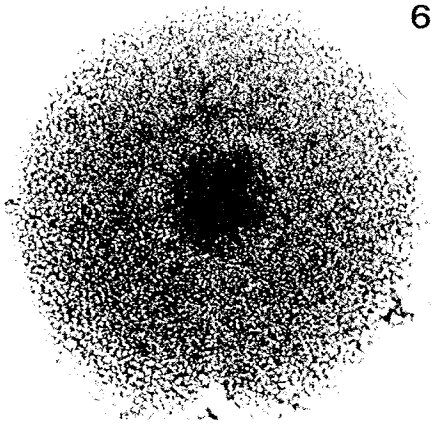
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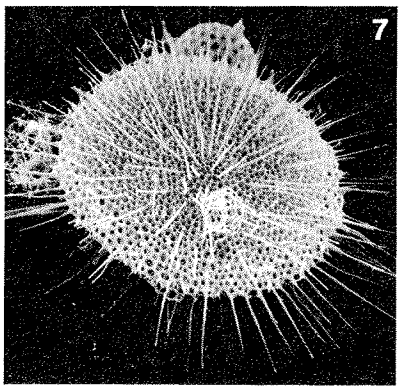
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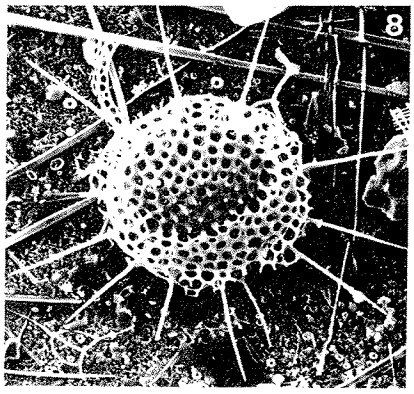
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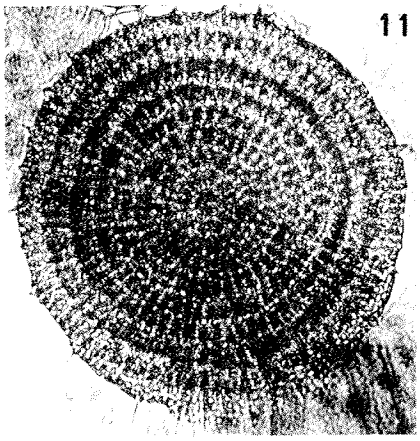
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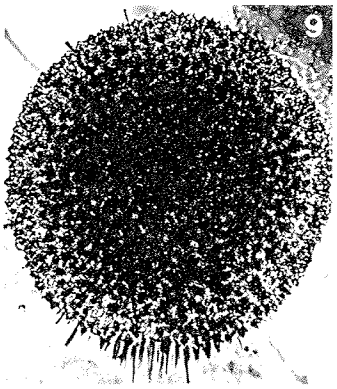
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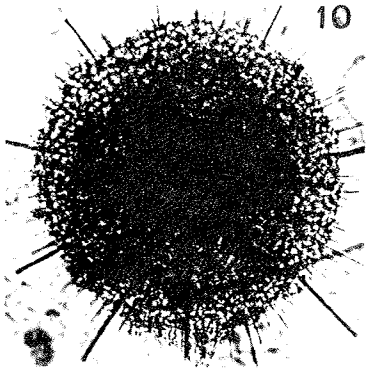
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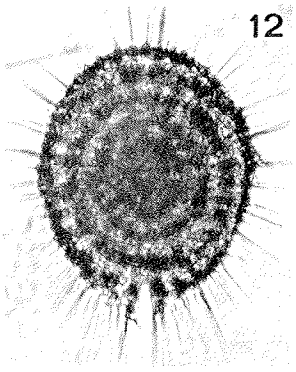
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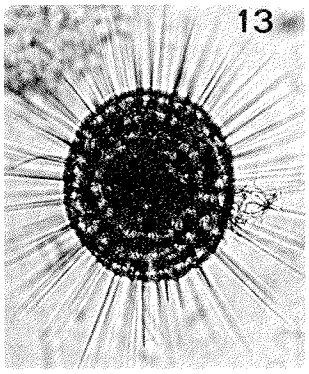
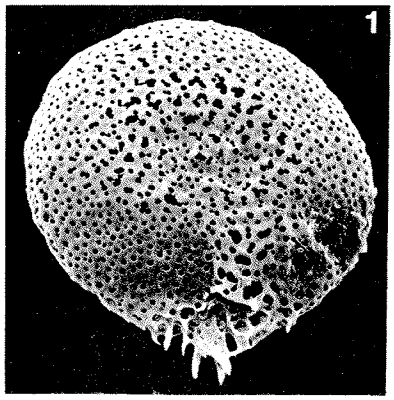

13

PLATE 20

Suborder: Spumellaria
Families: Spongodiscidae, Porodiscidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Spongopyle osculosa* Dreyer	P_1: 978	SEM	×390
2	*Spongopyle osculsa* Dreyer	PB: 1268	SEM	×200
3	*Spongopyle osculosa* Dreyer	PB: 3769	LM	×210
4	*Spongopyle osculosa* Dreyer	PB: 1268	SEM	×180
5	*Stylodictya multispina* Haeckel A specimen with broken surface membrane.	P_1: 978	SEM	×180
6	*Circodiscus* spp. group	PB: 667	SEM	×165
7	*Circodiscus* spp. group Apical view.	P_1: 2778	LM	×210
8	*Circodiscus* spp. group	P_1: 2778	LM	×210
9	*Circodiscus* spp. group	P_1: 978	LM	×210
10	*Stylodictya multispina* Haeckel	P_1: 5582	LM	×210
11	*Stylochlamydium venustum* (Bailey)	P_1: 978	LM	×210
12	*Stylodictya multispina* Haeckel	PB: 3769	LM	×210
13	*Porodiscus micromma* (Harting)	P_1: 5582	LM	×210
14	*Porodiscus micromma* (Harting)	P_1: 5582	LM	×210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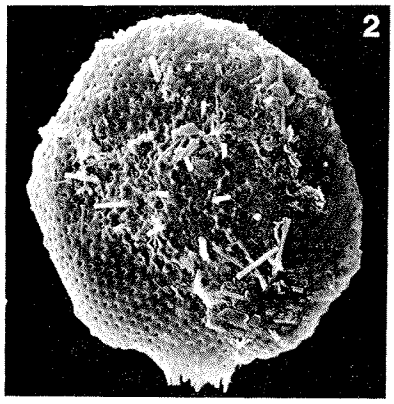
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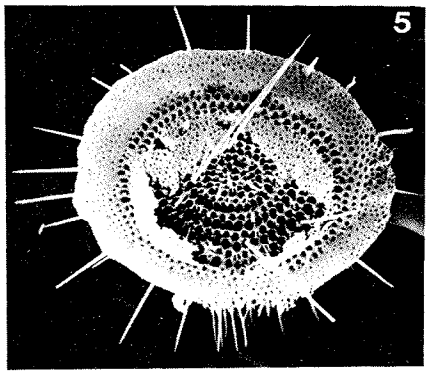
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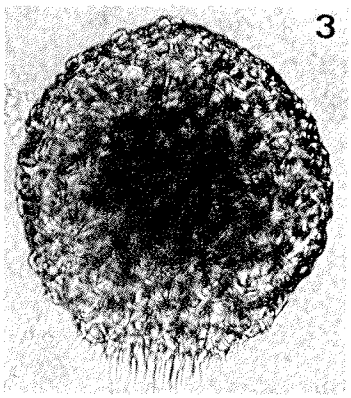
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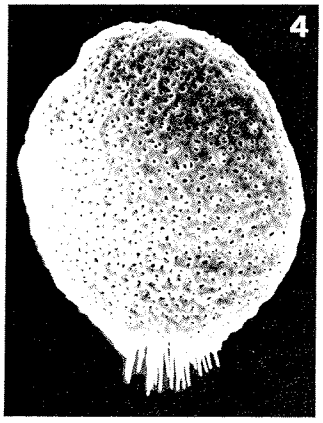
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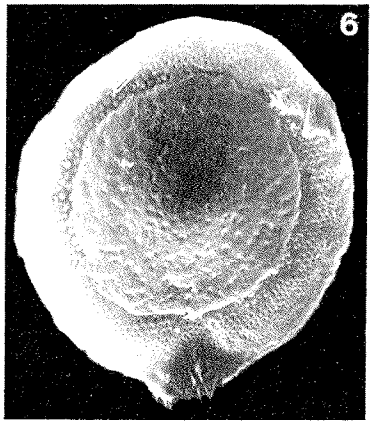
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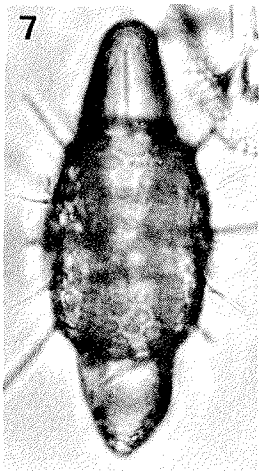
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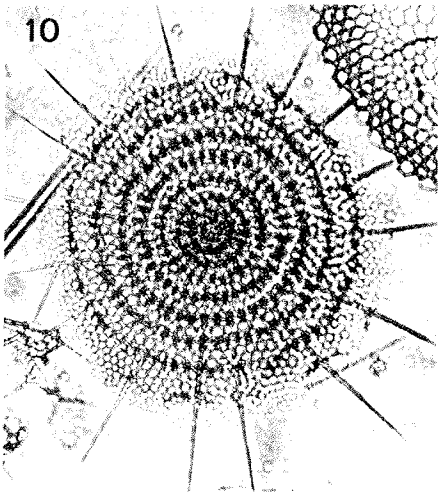
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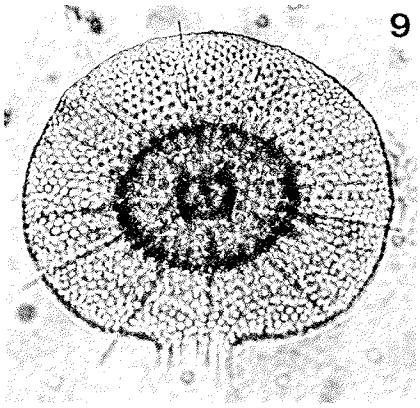
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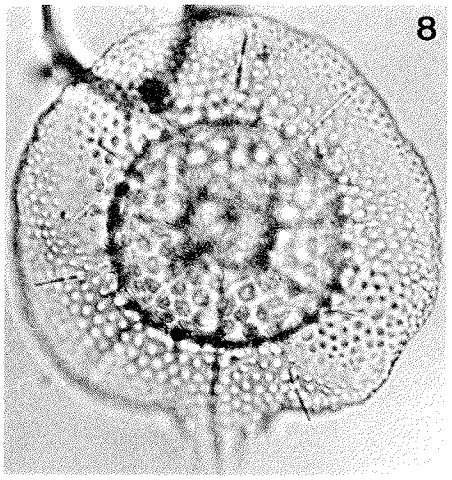
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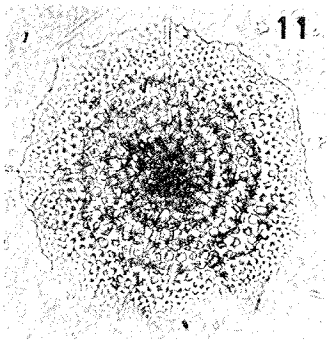
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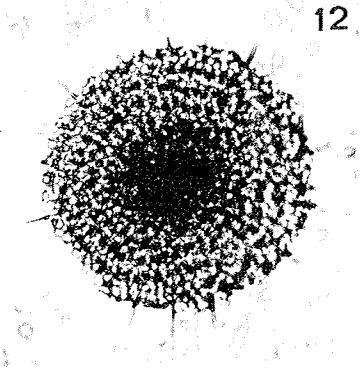
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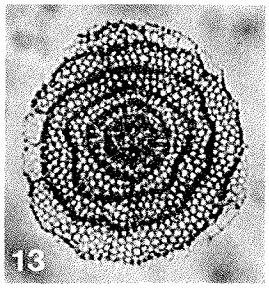
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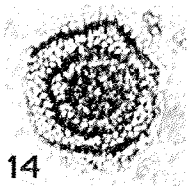
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PLATE 21

Suborder: Spumellaria
Families: Collosphaeridae, Larnacillidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Didymocyrtis tetrathalamus tetrathalamus* (Haeckel) juvenile form Oblique view of a specimen having only equatorial part. Note that cortical-medullary interconnecting bars lie in the vicinity of an equatorial plane.	P_1: 4280	SEM	×550
2	*Didymocyrtis tetrathalamus tetrathalamus* (Haeckel), Oblique lateral view.	P_1: 4280	SEM	×440
3	*Didymocyrtis tetrathalamus tetrathalamus* (Haeckel), Oblique polar view.	P_1: 4280	SEM	×440
4	*Didymocyrtis tetrathalamus tetrathalamus* (Haeckel), Lateral view.	P_1: 4280	SEM	×440
5	*Didymocyrtis tetrathalamus tetrathalamus* (Haeckel), Polar view of an incompletely developed specimen.	P_1: 5582	LM	×210
6	*Didymocyrtis tetrathalamus tetrathalamus* (Haeckel), Lateral view of an incompletely developed specimen.	P_1: 5582	LM	×210
7	*Didymocyrtis tetrathalamus tetrathalamus* (Haeckel)	PB: 2869	LM	×210
8	*Didymocyrtis tetrathalamus tetrathalamus* (Haeckel), A specimen with well developed outer cortical mesh.	PB: 667	LM	×210
9	*Didymocyrtis tetrathalamus tetrathalamus* (Haeckel)	P_1: 4280	SEM	×260
10	*Didymocyrtis tetrathalamus tetrathalamus* (Haeckel), Oblique polar view.	P_1: 978	SEM	×400
11	*Didymocyrtis tetrathalamus tetrathalamus* (Haeckel)	P_1: 5582	SEM	×220
12	*Didymocyrtis tetrathalamus tetrathalamus* (Haeckel), A specimen with well developed polar caps.	P_1: 5582	SEM	×215
13	*Didymocyrtis tetrathalamus tetrathalamus* (Haeckel)	P_1: 4280	SEM	×170
14	*Didymocyrtis tetrathalamus tetrathalamus* (Haeckel)	P_1: 4280	SEM	×280
15	*Didymocyrtis* sp.	PB: 2869	LM	×210
16	*Larnacalpis* sp., Frontal view.	PB: 2869	LM	×210
17	*Larnacalpis* sp., Lateral view.	PB: 2869	LM	×210
18	*Larnacalpis* sp., Frontal view.	PB: 3769	SEM	×170

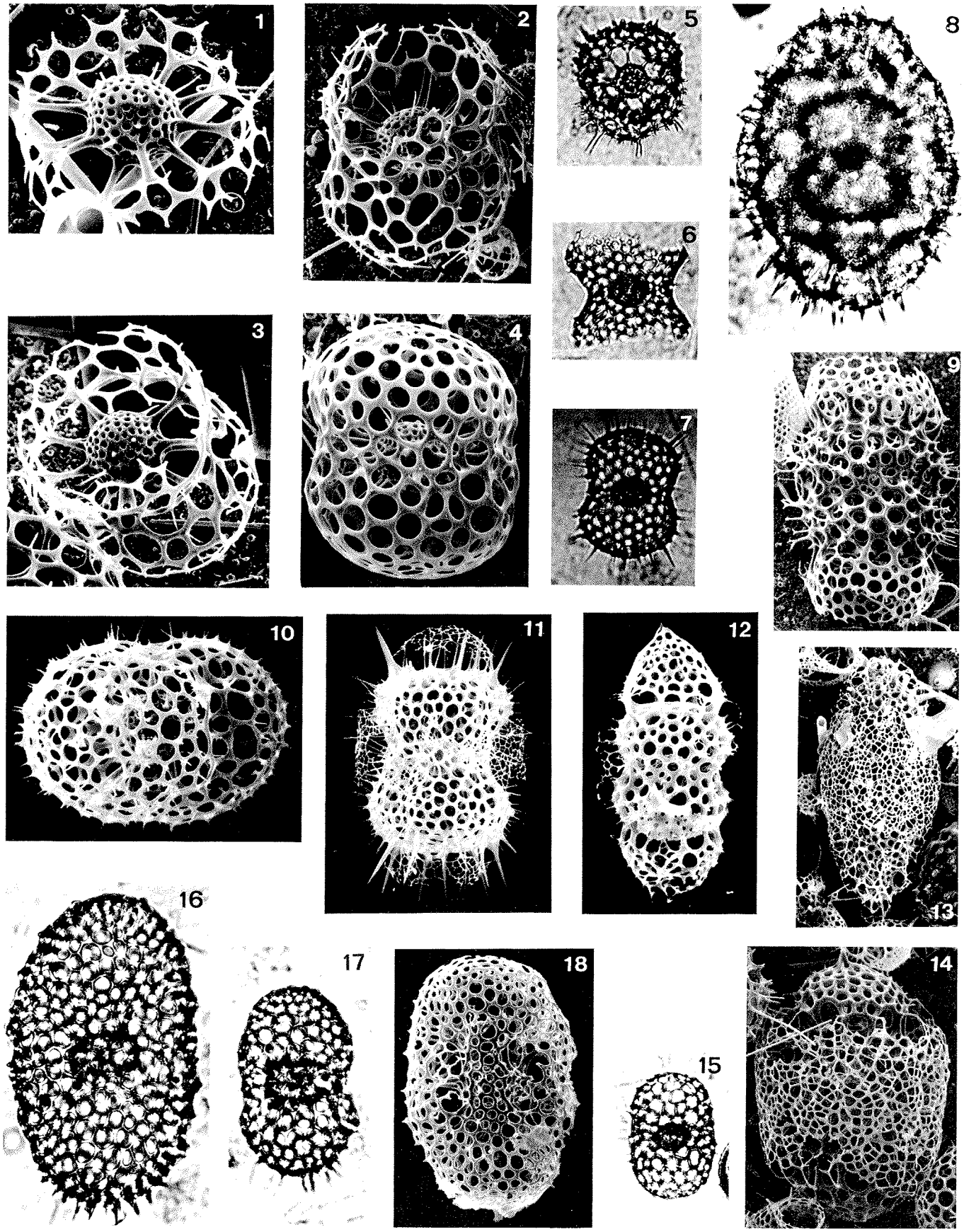
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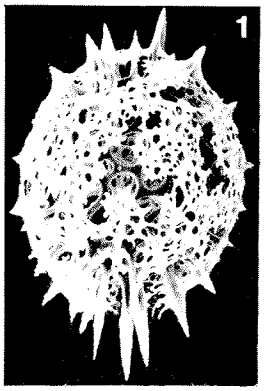
PLATE 22

Suborder: Spumellaria
Families: Litheliidae, Phacodiscidae, Actinommidae, Coccodiscidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Larcopyle butschlii* Dreyer	P_1: 4280	SEM	×280
2	*Larcopyle butschlii* Dreyer	E: 389	LM	×210
3	*Larcopyle butschlii* Dreyer	PB: 3791	LM	×210
4	*Larcopyle butschlii* Dreyer	PB: 3791	LM	×210
5	*Larcopyle* sp. A	P_1: 978	SEM	×450
6	*Larcopyle* sp. A	PB: 3791	SEM	×440
7	*Tholospira cervicornis* Haeckel group	PB: 2869	LM	×210
8	*Tholospira cervicornis* Haeckel group	PB: 3791	LM	×210
9	*Tholospira cervicornis* Haeckel group	PB: 2869	LM	×210
10	*Lithelius minor* ? Jørgensen	PB: 667	LM	×210
11	*Tholospira dendrophora* Haeckel	PB: 3791	LM	×210
12	*Tholospira cervicornis* Haeckel group	PB: 2869	LM	×210
13	*Actinommidae* gen. et sp. indet.	P_1: 5582	SEM	×350
14	*Heliodiscus* ? sp. Oblique view.	P_1: 5582	SEM	×165
15	*Spongoliva ellipsoides* Popofsky	PB: 667	LM	×210
16	*Spongoliva ellipsoides* Popofsky	PB: 3769	LM	×210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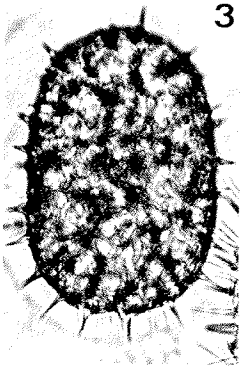
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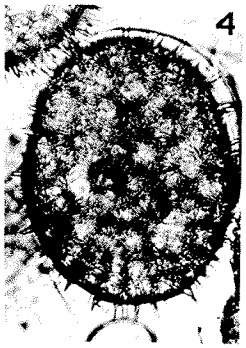
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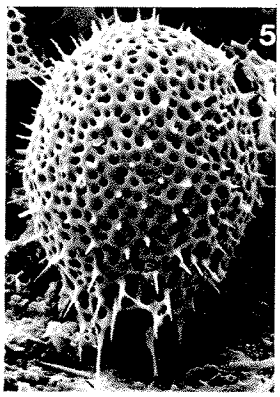
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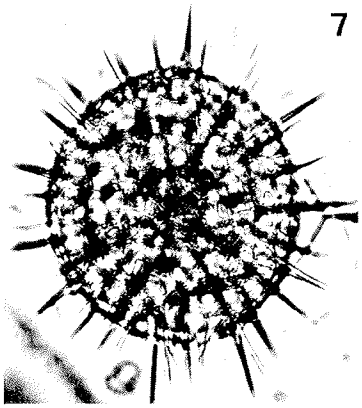
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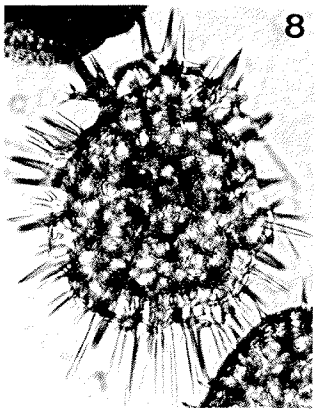
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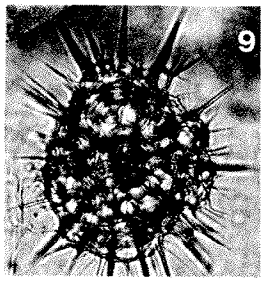
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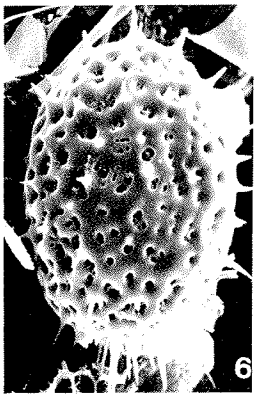
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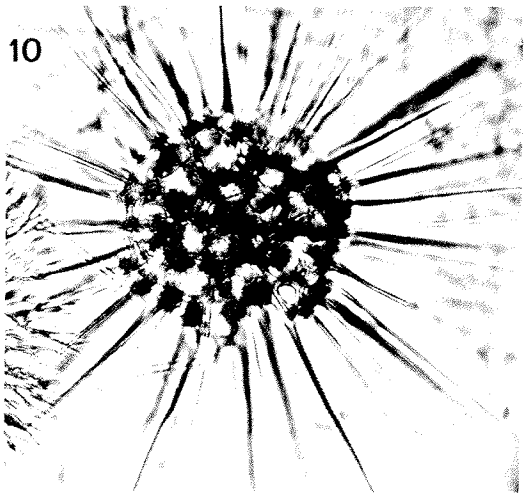
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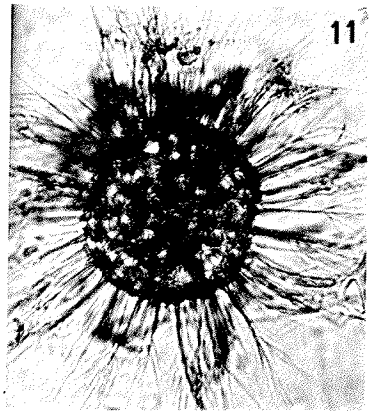
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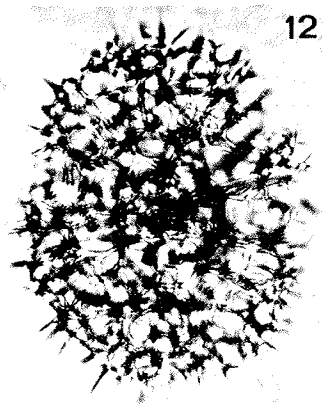
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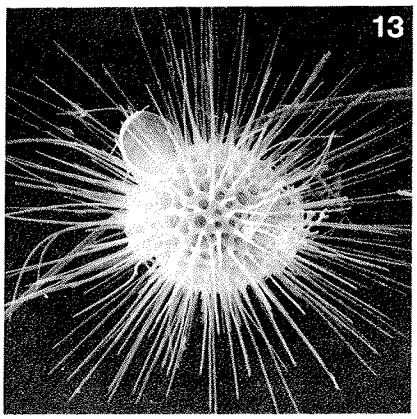
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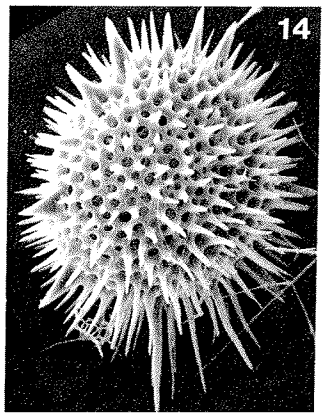
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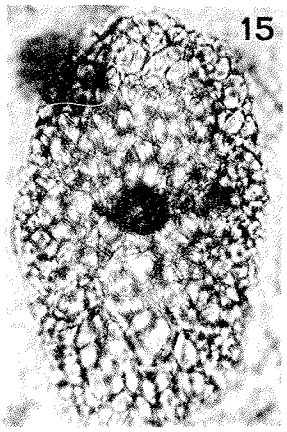
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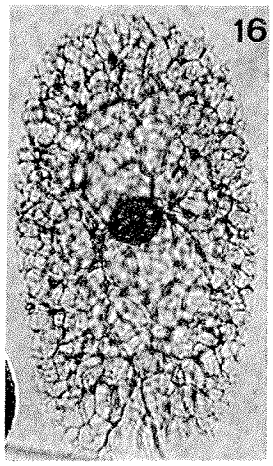
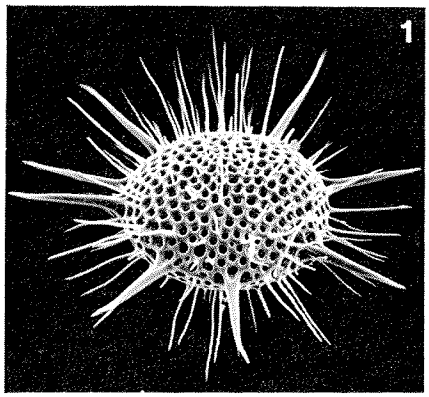

16

PLATE 23

Suborder: Spumellaria
Families: Phacodiscidae, Pyloniidae, Litheliidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Heliodiscus asteriscus* Haeckel Oblique view.	P_1: 978	SEM	×165
2	*Heliodiscus asteriscus* Haeckel	PB: 1268	LM	×210
3	*Heliodiscus asteriscus* Haeckel	PB: 667	LM	×210
4	*Heliodiscus echiniscus* Haeckel	P_1: 5582	SEM	×215
5	*Heliodiscus echiniscus* Haeckel	P_1: 4280	SEM	×210
6	*Heliodiscus echiniscus* Haeckel Oblique edge view.	PB: 667	LM	×210
7	*Hexapyle* sp.	P_1: 4280	SEM	×960
8	*Octopyle stenozona* Haeckel Frontal view.	P_1: 2778	SEM	×330
9	*Tetrapyle octacantha* Müller Frontal view.	PB: 3769	LM	×210
10	*Tetrapyle octacantha* Müller Polar view.	E: 389	SEM	×315
11	*Larcospira quadrangula* Haeckel Orientation illustrating the apparent double spiral arrangement of girdles.	P_1: 5582	SEM	×154
12	*Larcospira quadrangula* Haeckel Orientation perpendicular to figure 11.	P_1: 978	SEM	×180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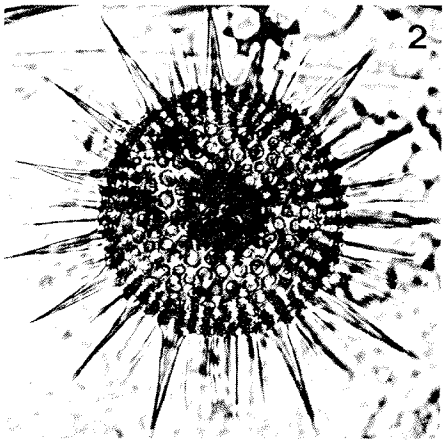
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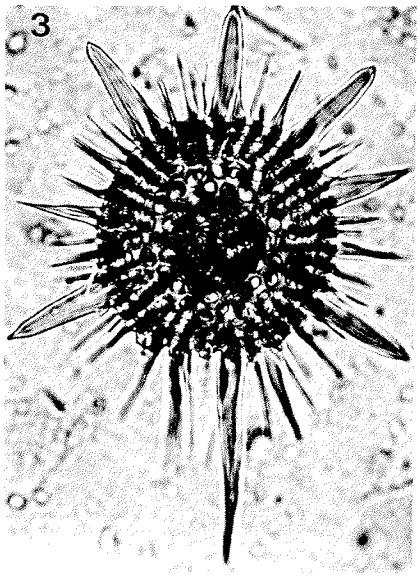
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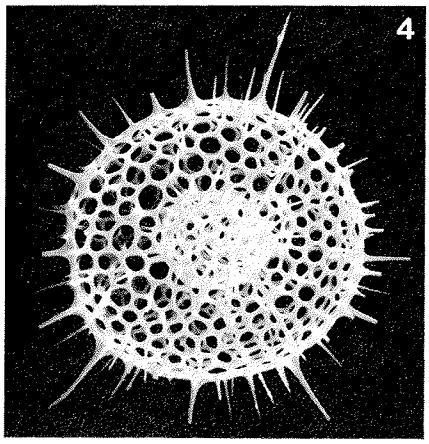
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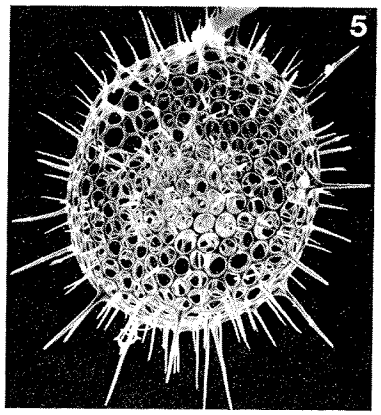
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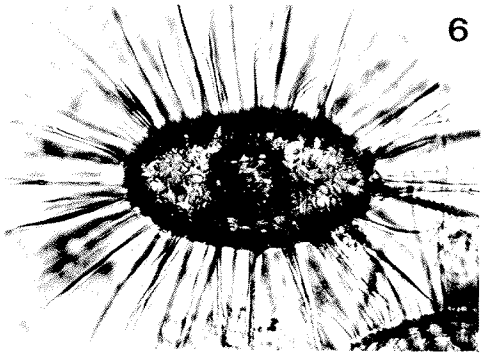
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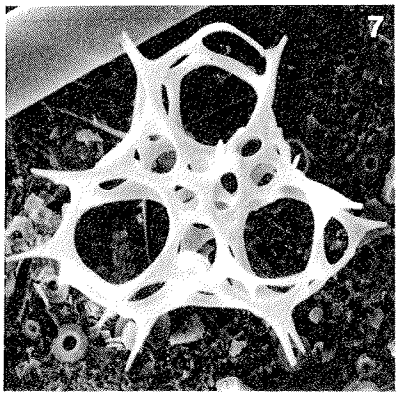
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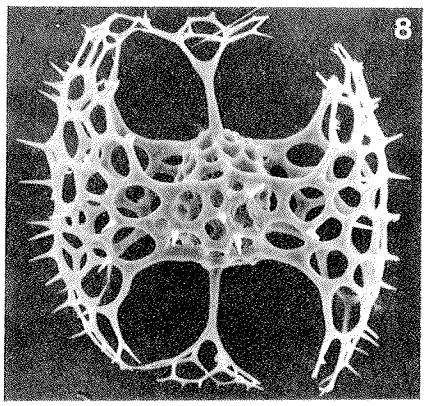
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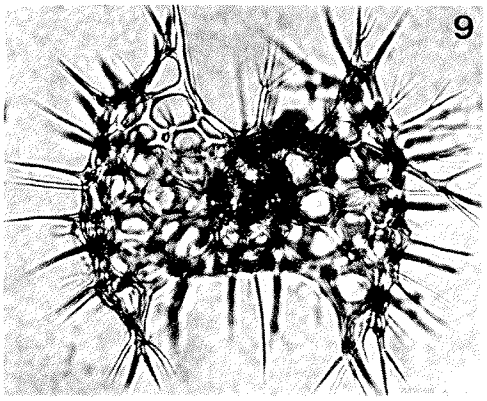
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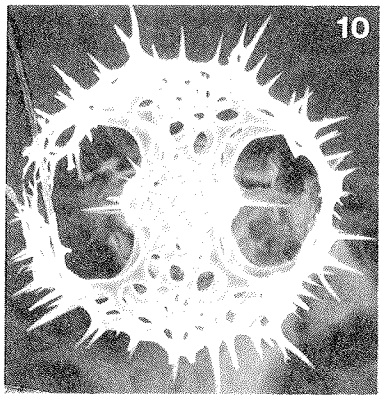
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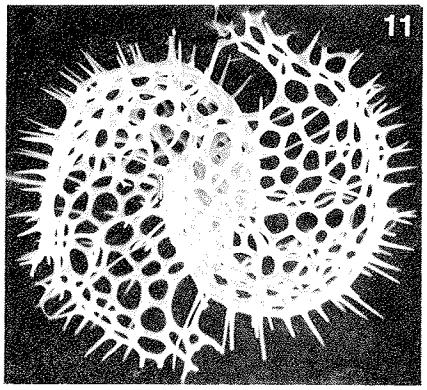
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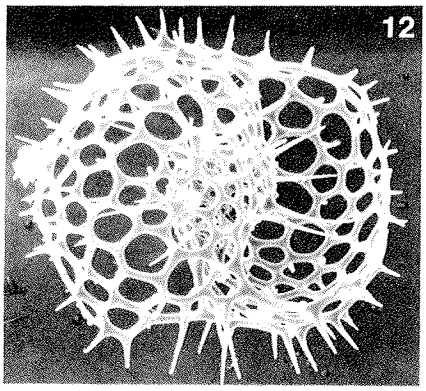
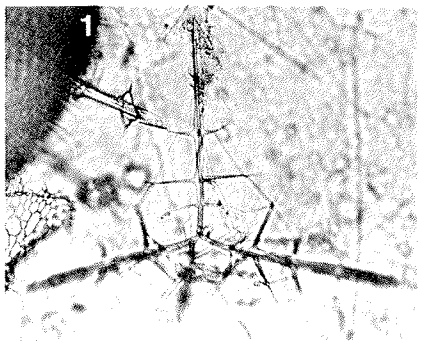

12

PLATE 24

Suborder: Nassellaria
Family: Plagiacanthidae; Subfamily: Plagiacanthinae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Tetraplecta pinigera* Haeckel	PB: 3791	LM	×160
2	*Tetraplecta pinigera* Haeckel	P_1: 978	SEM	×290
3	*Tetraplecta pinigera* Haeckel Detail of central part; note that the skeleton is cylindrical rod.	P_1: 4280	SEM	×1,100
4	*Tetraplecta pinigera* Haeckel	P_1: 4280	SEM	×150
5	*Tetraplecta pinigera* Haeckel	P_1: 4280	LM	×210
6	*Tetraplecta corynephorum* ? Jørgensen	PB: 1268	LM	×105
7	*Tetraplecta plectaniscus* Haeckel	E: 5068	LM	×210
8	*Clathromitra pterophormis* Haeckel	P_1: 5582	SEM	×120
9	*Cladoscenium ancoratum* Haeckel	PB: 3791	SEM	×440
10	*Cladoscenium ancoratum* Haeckel	P_1: 5582	LM	×210
11	*Cladoscenium ancoratum* Haeckel	PB: 2869	LM	×210
12	*Cladoscenium ancoratum* Haeckel	PB: 2869	LM	×210
13	*Cladoscenium ancoratum* Haeckel	PB: 2869	LM	×210
14	*Cladoscenium ancoratum* Haeckel	PB: 2869	LM	×210
15	*Semantis gracilis* ? Popofsky	PB: 3769	SEM	×1,100
16	*Semantis gracilis* ? Popofsky	P_1: 4280	SEM	×1,000
17	*Neosemantis cladophora* (Jørgensen)	P_1: 5582	SEM	×72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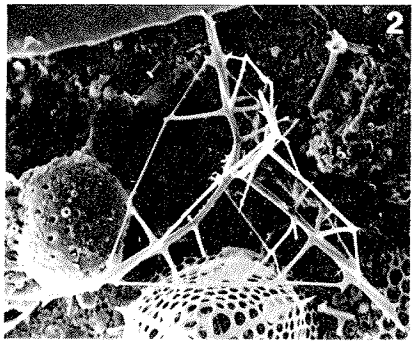
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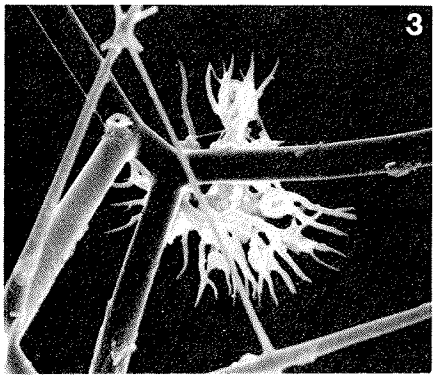
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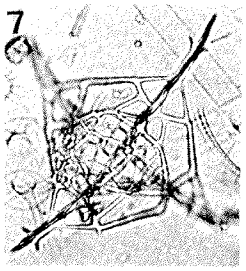
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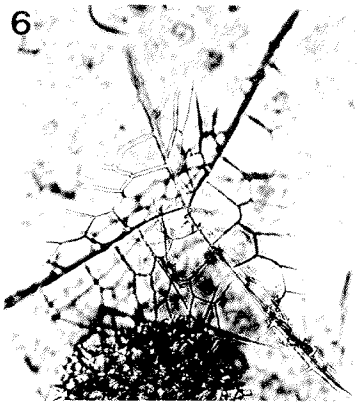
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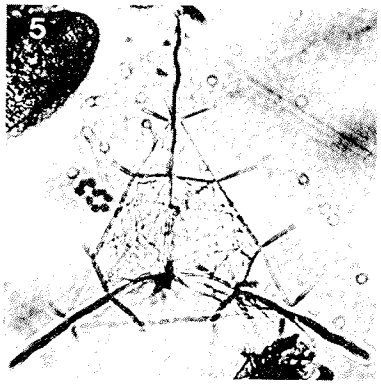
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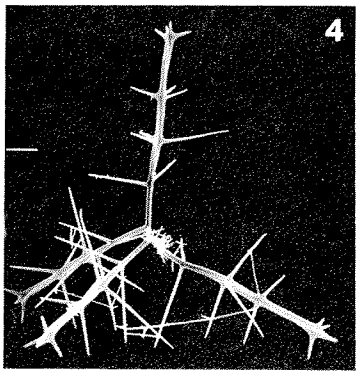
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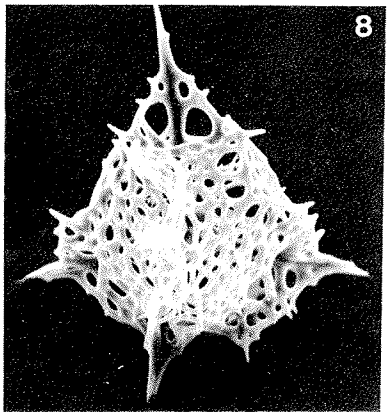
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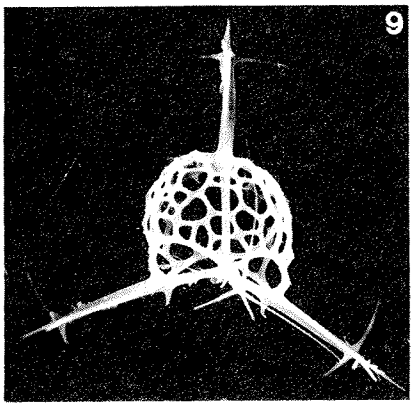
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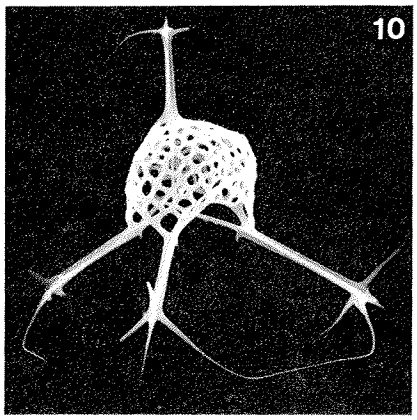
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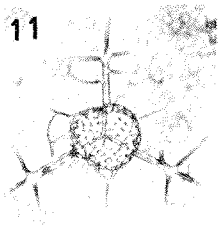
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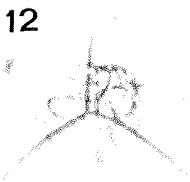
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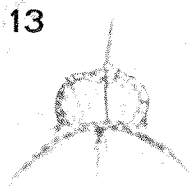
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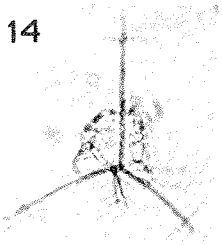
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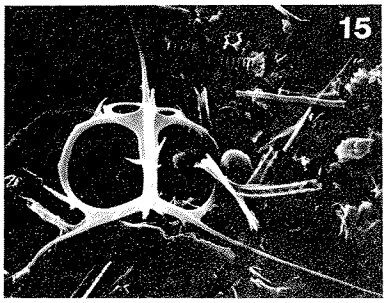
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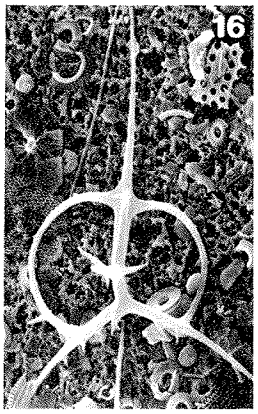
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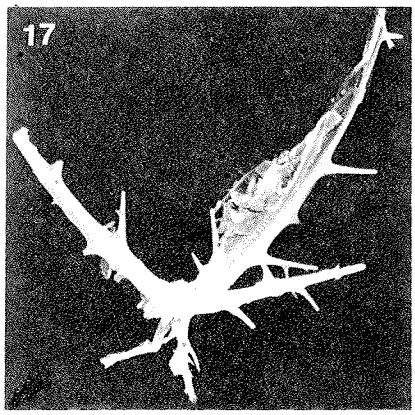
17

PLATE 25

Suborder: Nassellaria
Family: Plagiacanthidae; Subfamily: Lophophaeninae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Acanthocorys* cf. *variabilis* Popofsky	PB: 2869	LM	×210
2	*Lophophaena decacantha* (Haeckel) group	PB: 1268	LM	×210
3	*Lophophaena cylindrica* (Cleve)	P_1: 4280	SEM	×440
4	*Lophophaena cylindrica* (Cleve)	P_1: 4280	SEM	×500
5	*Lophophaena cylindrica* (Cleve)	PB: 3791	LM	×210
6	*Lophophaena* cf. *capito* Ehrenberg	PB: 3769	LM	×210
7	*Lophophaena* cf. *capito* Ehrenberg	P_1: 4280	SEM	×300
8	*Lophophaena* cf. *capito* Ehrenberg	P_1: 2778	SEM	×300
9	*Lophophaena* cf. *capito* Ehrenberg	PB: 1268	SEM	×250
10	*Lophophaena decacantha* (Haeckel) group	PB: 3791	LM	×210
11	*Peromelissa phalacra* Haeckel	P_1: 4280	SEM	×340
12	*Peromelissa phalacra* Haeckel	PB: 2869	LM	×210
13	*Peromelissa phalacra* Haeckel	PB: 2869	LM	×210
14	*Peromelissa phalacra* Haeckel	P_1: 978	SEM	×500
15	*Peromelissa phalacra* Haeckel	P_1: 4280	SEM	×520
16	*Lithomelissa setosa* Jørgensen	PB: 2869	LM	×210
17	*Lithomelissa setosa* Jørgensen	PB: 2869	LM	×210
18	*Lithomelissa setosa* Jørgensen	PB: 3769	SEM	×1,400
19	*Lithomelissa setosa* Jørgensen	PB: 3769	SEM	×1,100
20	*Lithomelissa setosa* Jørgensen	PB: 3769	SEM	×1,710
21	*Lithomelissa setosa* Jørgensen	PB: 2869	LM	×210
22	*Lithomelissa setosa* Jørgensen	P_1: 2778	LM	×210

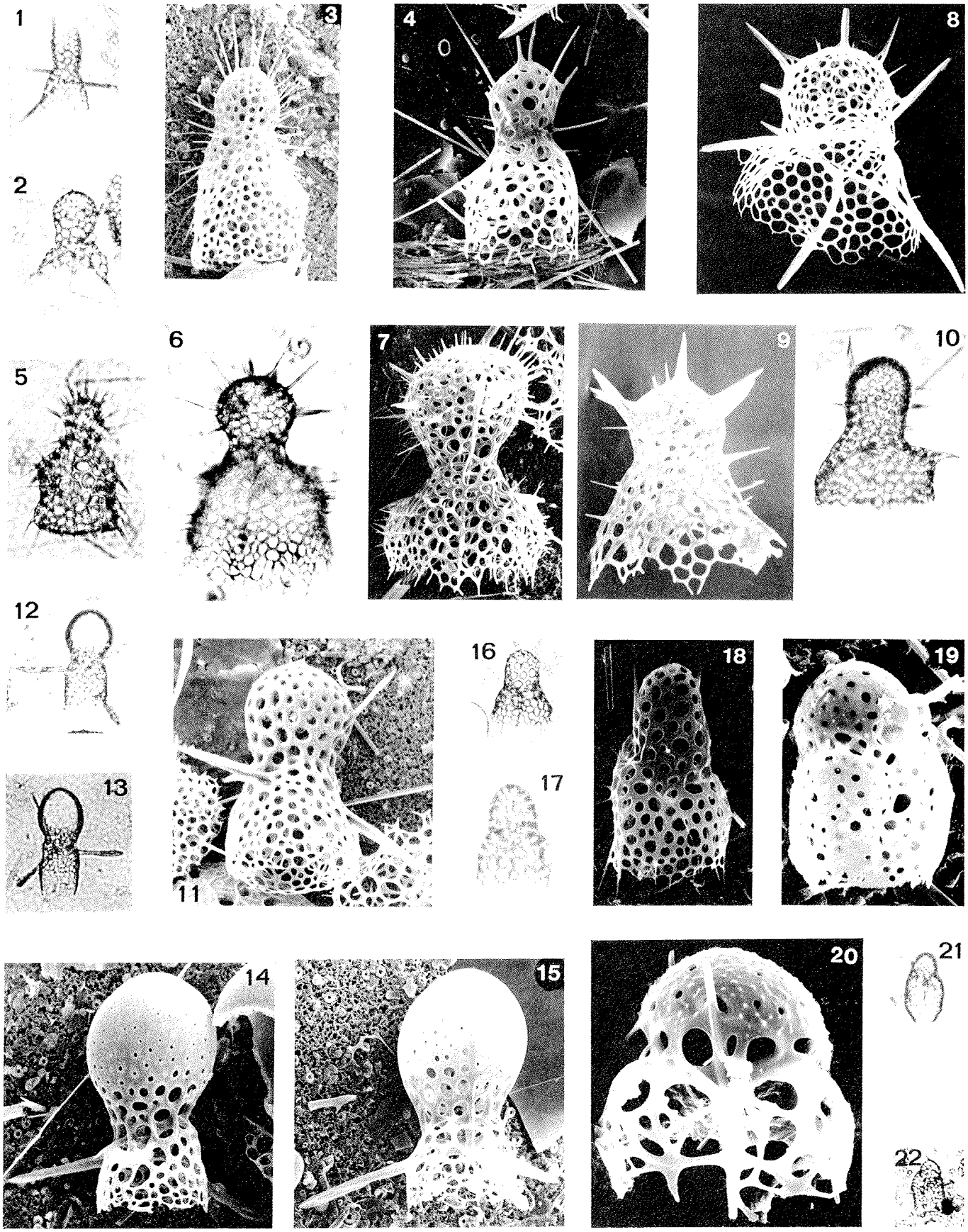
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PLATE 26

Suborder: Nassellaria
Family: Plagiacanthidae; Subfamilies: Plagiacanthinae, Sethoperinae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Pseudocubus obeliscus* Haeckel	P_1: 4280	SEM	×720
2	*Pseudocubus primordialis* ? (Jørgensen)	PB: 3769	SEM	×1,100
3	*Phormacantha hystrix* Jørgensen	P_1: 5582	SEM	×1,200
4	*Peridium spinipes* Haeckel	PB: 3769	SEM	×660
5	*Peridium spinipes* Haeckel	PB: 3769	LM	×210
6	*Peridium spinipes* Haeckel	PB: 3769	SEM	×500
7	*Clathrocanium insectum* (Haeckel)	PB: 2869	LM	×210
8	*Clathrocanium insectum* (Haeckel)	P_1: 4280	SEM	×230
9	*Clathrocanium insectum* (Haeckel)	P_1: 5582	SEM	×290
10	*Lithopilium reticulatum* Popofsky	P_1: 5582	SEM	×190
11	*Clathrocanium coarctatum* Ehrenberg	P_1: 4280	SEM	×440
12	*Clathrocanium coarctatum* Ehrenberg	P_1: 4280	SEM	×440
13	*Clathrocanium coarctatum* Ehrenberg	P_1: 4280	SEM	×390
14	*Callimitra emmae* Haeckel	P_1: 4280	SEM	×165
15	*Callimitra annae* Haeckel	P_1: 4280	SEM	×160
16	*Clathrocorys giltschii* Haeckel	PB: 1268	SEM	×190

Note presence of a cephalic tubule.

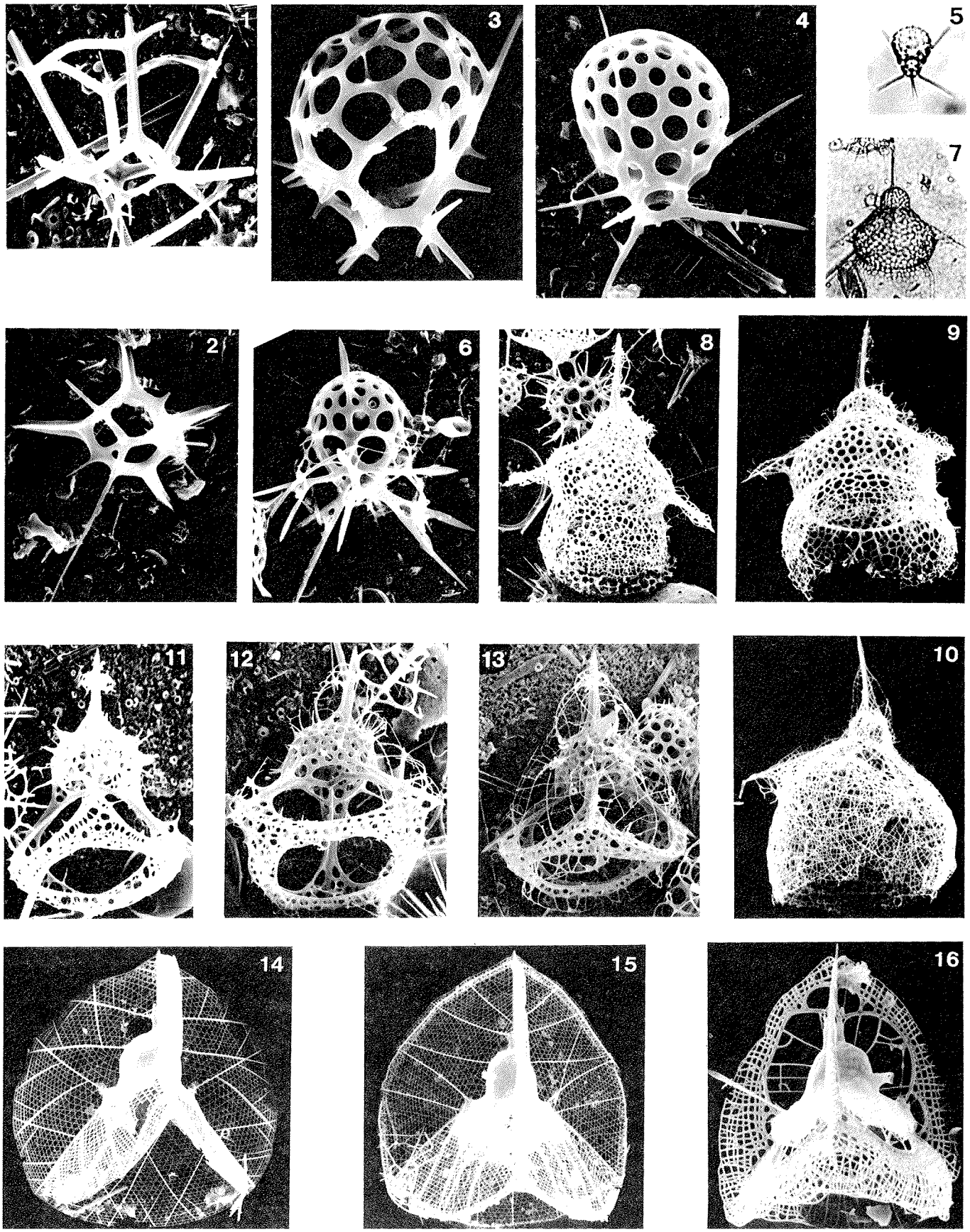
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PLATE 27

Suborder: Nassellaria
Family: Plagiacanthidae; Subfamilies: Plagiacanthinae, Sethoperinae
Family: Acanthodesmiidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Clathrocorys giltschii* Haeckel	PB: 2869	LM	×210
2	*Clathrocorys giltschii* Haeckel	PB: 1268	SEM	×165
3	*Clathrocorys giltschii* Haeckel Same specimen; detail of the cephalis and cephalic tubule.	PB: 1268	SEM	×390
4	*Clathrocorys murrayi* Haeckel	PB: 2869	LM	×210
5	*Clathrocorys murrayi* Haeckel	PB: 3791	LM	×210
6	*Clathrocorys murrayi* Haeckel	PB: 2869	LM	×210
7	*Clathrocorys murrayi* Haeckel	P_1: 4280	SEM	×250
8	*Clathrocorys murrayi* Haeckel	P_1: 2778	SEM	×260
9	*Clathrocorys giltschii* Haeckel	PB: 3791	LM	×210
10	*Callimitra solocicribrata* Takahashi, n. sp. Paratype	PB: 3791	LM	×210
11	*Callimitra solocicribrata* Takahashi, n. sp. Holotype	PB: 3791	LM	×210
12	*Neosemantis distephanus* Popofsky	P_1: 4280	SEM	×520
13	*Zygocircus productus* (Hertwig) group	P_1: 978	SEM	×440
14	*Zygocircus productus* (Hertwig) group	PB: 2869	LM	×210
15	*Tholospyris* sp. group	PB: 2869	LM	×210
16	*Tholospyris* sp. group	PB: 2869	LM	×210
17	*Tholospyris* sp. group	P_1: 978	SEM	×440
18	*Zygocircus* sp. *piscicaudatus* Popofsky	P_1: 4280	SEM	×560

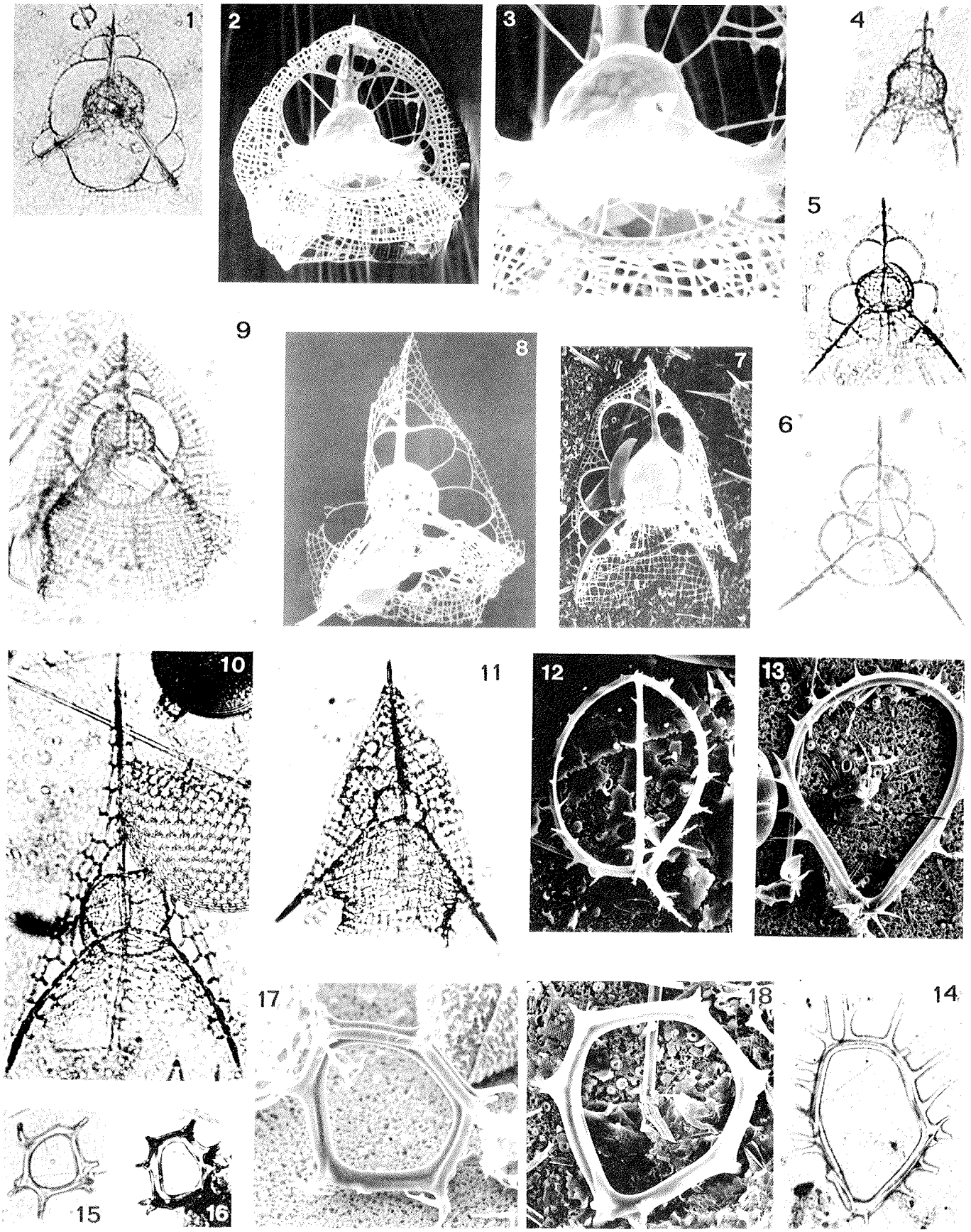
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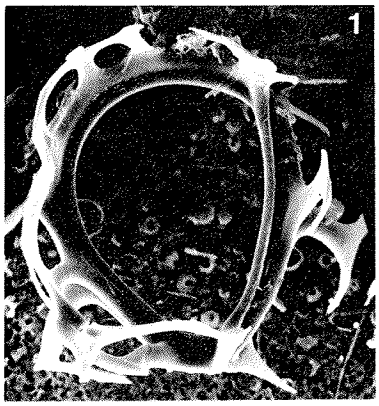
PLATE 28

Suborder: Nassellaria
Family: Acanthodesmiidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Lophospyris* juvenile form group	P_1: 4280	SEM	×630
2	*Lophospyris* juvenile form group	P_1: 5582	SEM	×400
3	*Lophospyris* juvenile form group	P_1: 4280	SEM	×440
4	*Lophospyris* juvenile form group	P_1: 4280	SEM	×330
5	*Lophospyris pentagona quadriforis* (Haeckel), emend. Goll	P_1: 4280	SEM	×390
6	*Acanthodesmia vinculata* Müller	P_1: 3791	SEM	×180
7	*Acanthodesmia vinculata* Müller	P_1: 978	SEM	×180
8	*Acanthodesmia vinculata* Müller	PB: 2869	LM	×210
9	*Lophospyris pentagona pentagona* (Ehrenberg), emend. Goll	PB: 3791	LM	×210
10	*Lophospyris pentagona pentagona* (Ehrenberg), emend. Goll	PB: 2869	LM	×210
11	*Lophospyris pentagona pentagona* (Ehrenberg), emend. Goll	PB: 2869	LM	×210
12	*Lophospyris pentagona pentagona* (Ehrenberg), emend. Goll	P_1: 4280	SEM	×200
13	*Lophospyris pentagona pentagona* (Ehrenberg), emend. Goll	P_1: 2778	SEM	×300
14	*Lophospyris pentagona pentagona* (Ehrenberg), emend. Goll	P_1: 5582	SEM	×300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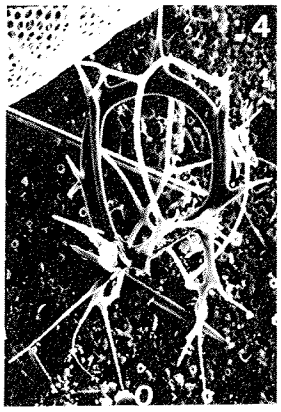
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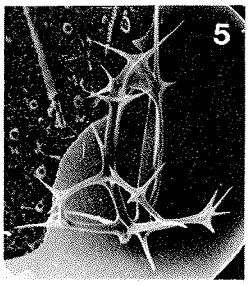
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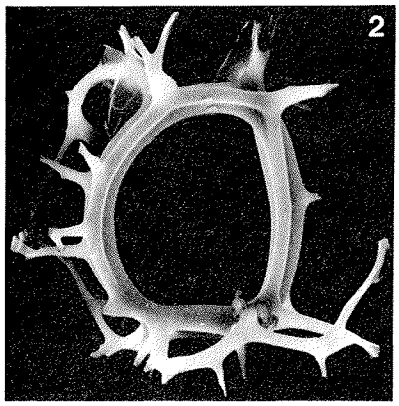
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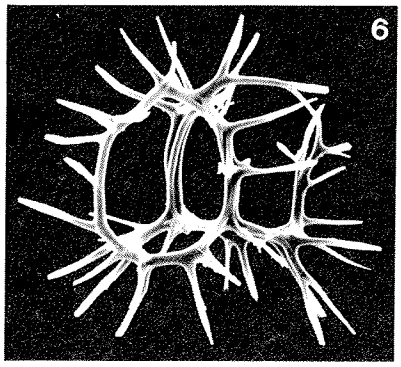
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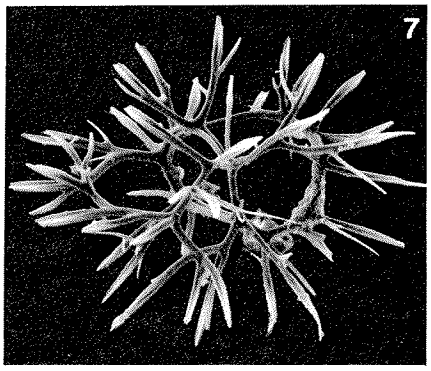
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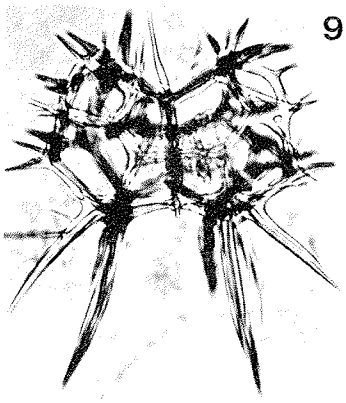
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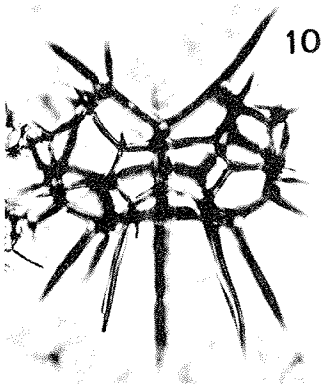
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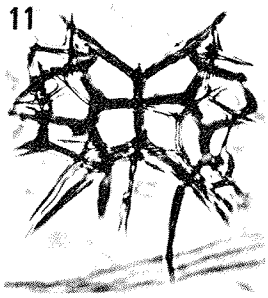
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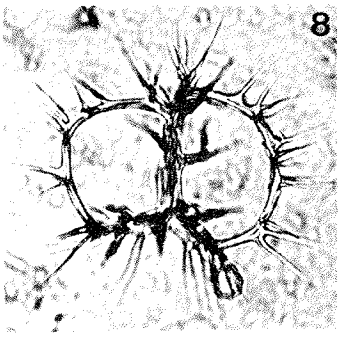
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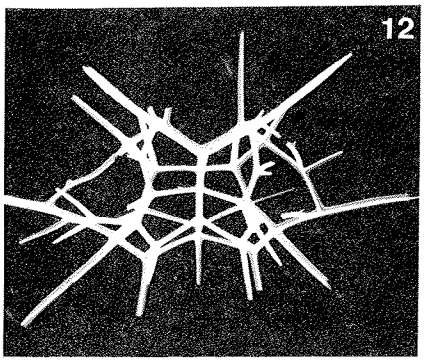
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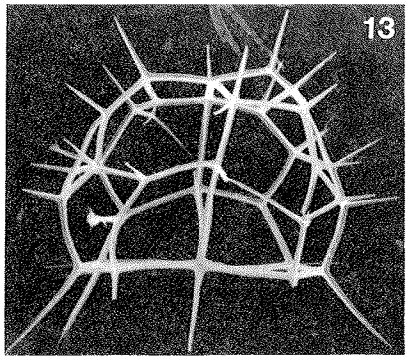
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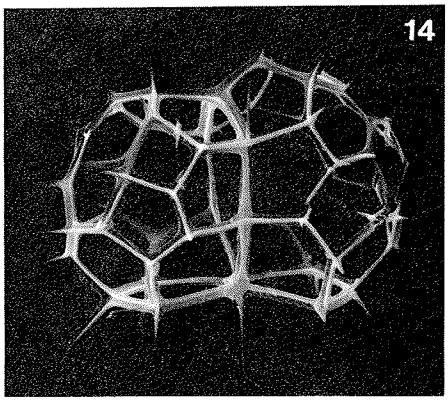
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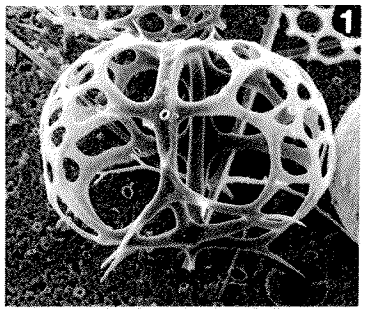
PLATE 29

Suborder: Nassellaria
Family: Acanthodesmiidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll	P_1: 4280	SEM	×360
2	*Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll	P_1: 4280	SEM	×360
3	*Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll	PB: 2869	LM	×210
4	*Lophospyris cheni* Goll	PB: 3791	LM	×210
5	*Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll	P_1: 978	SEM	×210
6	*Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll	P_1: 4280	SEM	×470
7	*Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll	PB: 3791	LM	×210
8	*Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll Apical view	PB: 2869	LM	×210
9	*Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll	P_1: 5582	LM	×210
10	*Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll	PB: 2869	LM	×210
11	*Phormospyris stabilis scaphipes* (Haeckel)	P_1: 4280	SEM	×500
12	*Phormospyris stabilis scaphipes* (Haeckel)	PB: 3791	SEM	×720
13	*Phormospyris* sp. aff. *L. pentagona hyperborea* (Jørgensen)	P_1: 978	SEM	×440
14	*Phormospyris stabilis scaphipes* (Haeckel)	P_1: 978	SEM	×770
15	*Phormospyris stabilis capoi* Goll	PB: 3769	LM	×210
16	*Phormospyris stabilis capoi* Goll	P_1: 4280	SEM	×280
17	*Phormospyris stabilis capoi* Goll	P_1: 2778	LM	×210
18	*Phormospyris stabilis capoi* Goll	P_1: 2778	LM	×210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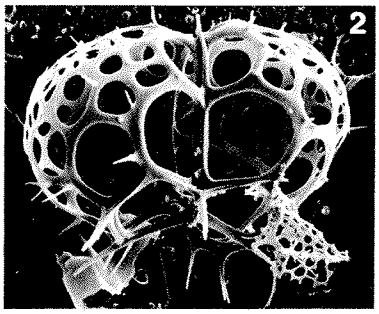
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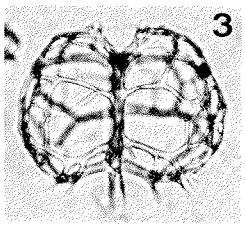
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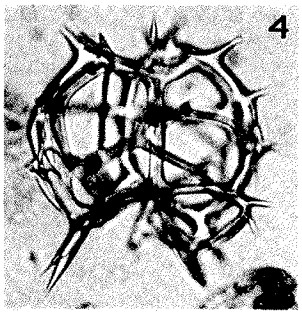
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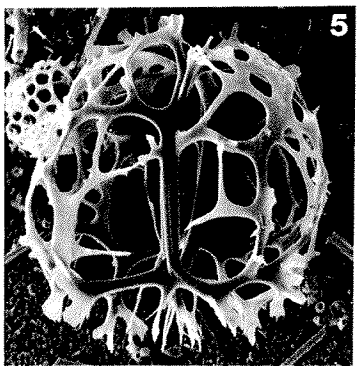
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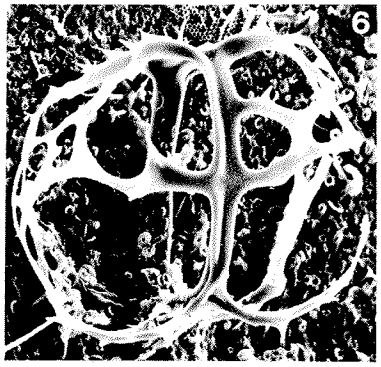
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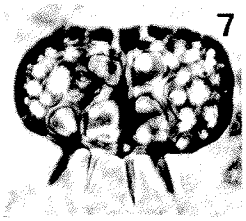
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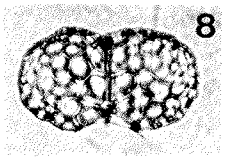
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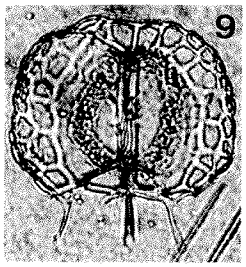
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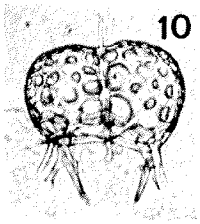
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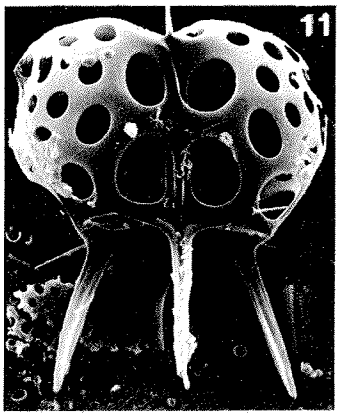
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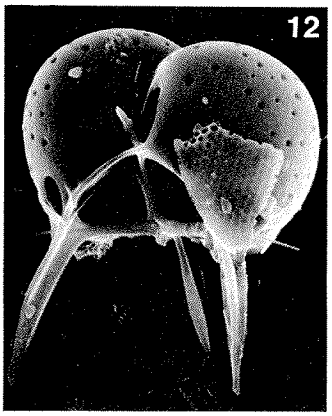
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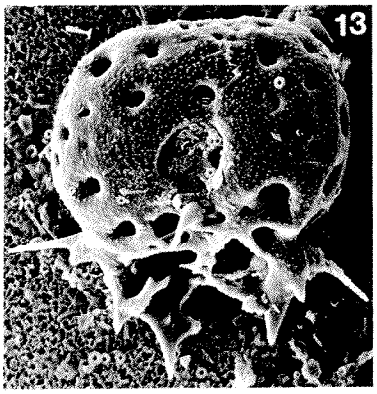
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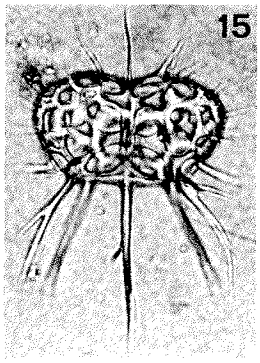
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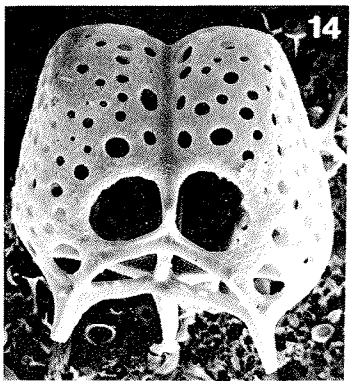
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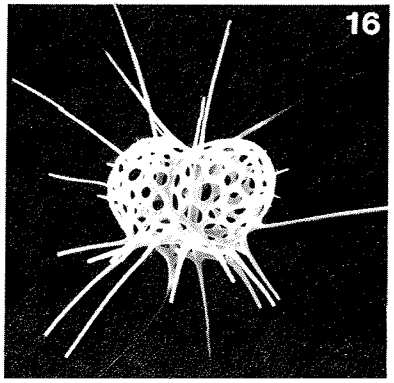
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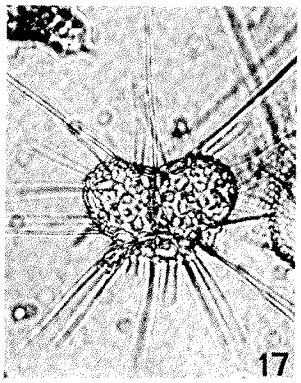
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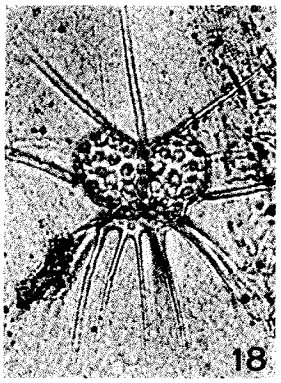
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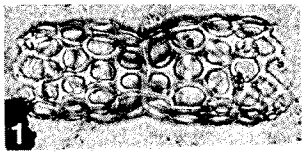
PLATE 30

Suborder: Nassellaria
Family: Acanthodesmiidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Dictyospyris* sp. group	PB: 3791	LM	×210
2	*Phormospyris stabilis stabilis* (Goll)	P_1: 2778	LM	×210
3	*Phormospyris stabilis stabilis* (Goll)	PB: 2869	LM	×210
4	*Phormospyris stabilis stabilis* (Goll)	P_1: 2778	LM	×210
5	*Phormospyris stabilis stabilis* (Goll)	P_1: 4280	SEM	×390
6	*Phormospyris* ? sp.	PB: 3769	LM	×210
7	*Nephrospyris renilla renilla* Haeckel	PB: 3769	LM	×106
8	*Nephrospyris renilla renilla* Haeckel	PB: 3769	SEM	×80
9	*Nephrospyris renilla renilla* Haeckel A specimen with only a central part.	P_1: 4280	LM	×210
10	*Nephrospyris renilla lana* Goll	PB: 3791	RLM	×80
11	*Liriospyris* sp.	PB: 3769	SEM	×140
12	*Androspyris reticulidisca* Takahashi, n. sp. Holotype	PB: 3791	LM	×160
13	*Androspyris reticulidisca* Takahashi, n. sp. Paratype	PB: 667	SEM	×110
14	*Androspyris reticulidisca* Takahashi, n. sp.	PB: 3791	RLM	×80
15	*Androspyris huxleyi* (Haeckel)	PB: 3791	RLM	×80
16	*Androspyris huxleyi* (Haeckel)	PB: 667	LM	×157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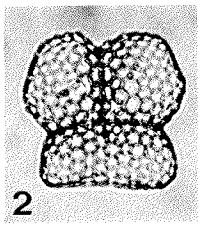
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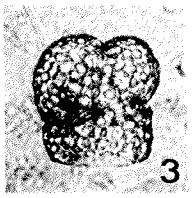
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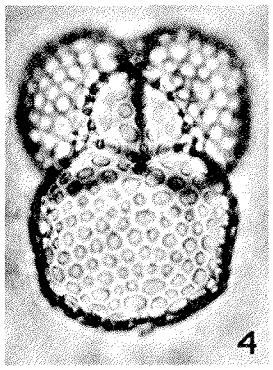
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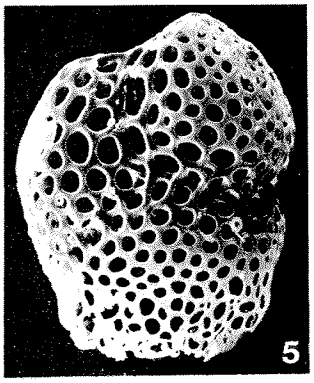
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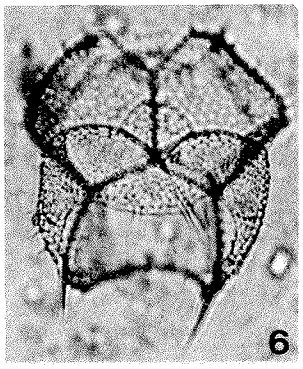
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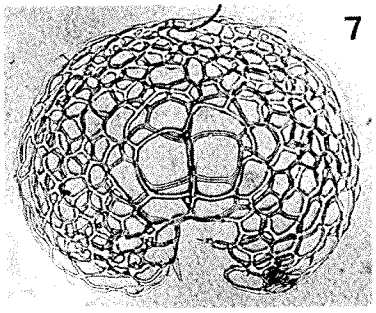
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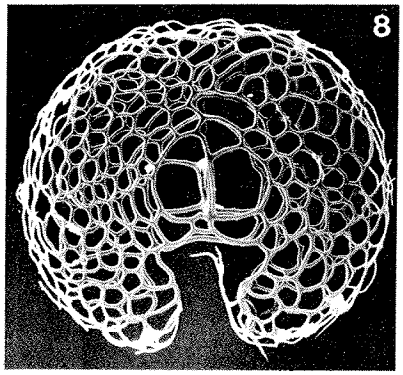
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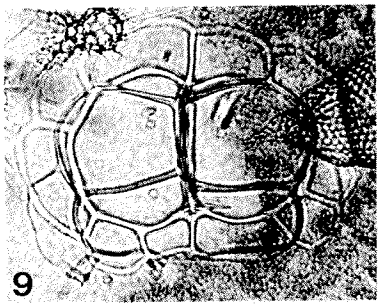
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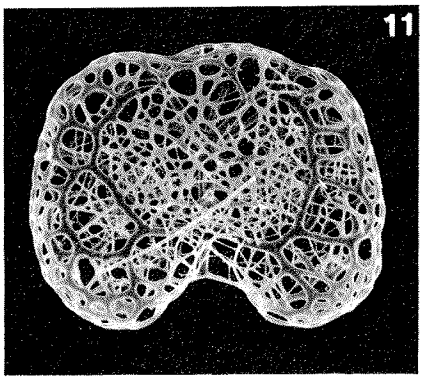
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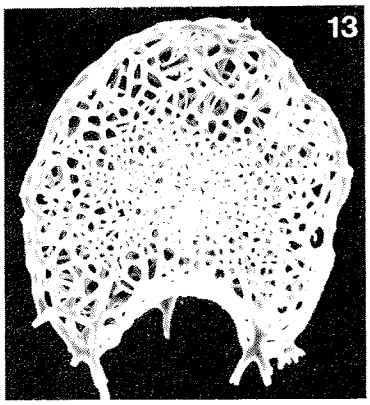
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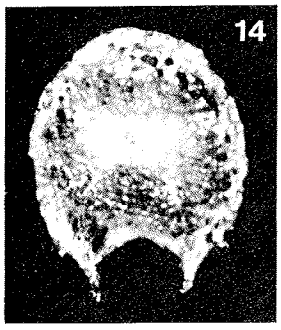
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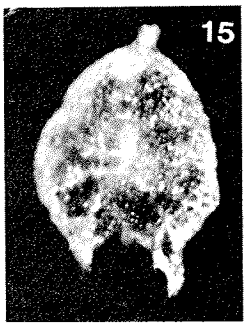
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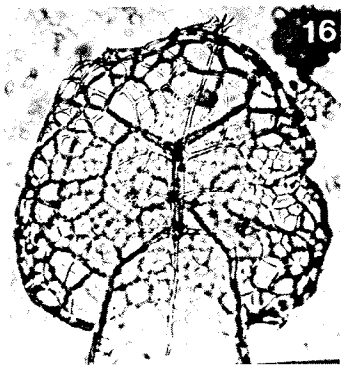
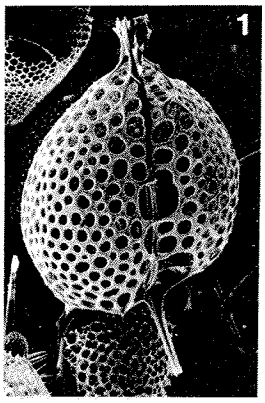

16

PLATE 31

Suborder: Nassellaria
Family: Acanthodesmiidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Androspyris ramosa* (Haeckel)	P_1: 4280	SEM	×220
2	*Androspyris ramosa* (Haeckel)	P_1: 4280	SEM	×250
3	*Cephalospyris cancellata* Haeckel	PB: 3791	LM	×170
4	*Cephalospyris cancellata* Haeckel	PB: 2869	LM	×210
5	*Cantharospyris platybursa* Haeckel	PB: 2869	LM	×210
6	*Tholospyris baconiana baconiana* Goll	PB: 2869	LM	×210
7	*Tholospyris baconiana baconiana* Goll	PB: 3769	LM	×210
8	*Tholospyris baconiana variabilis* Goll	E: 389	LM	×210
9	*Tholospyris macropora* (Popofsky)	E: 389	LM	×210
10	*Liriospyris thorax* (Haeckel) *laticapsa* Takahashi, n. subsp. Paratype	PB: 1268	LM	×210
11	*Liriospyris thorax* (Haeckel) *laticapsa* Takahashi, n. subsp. Holotype	PB: 3791	LM	×210
12	*Liriospyris thorax thorax* (Haeckel)	PB: 1268	SEM	×250
13	*Liriospyris thorax* (Haeckel) *laticapsa* Takahashi, n. subsp.	PB: 667	SEM	×130
14	*Liriospyris reticulata* (Ehrenberg)	P_1: 4280	SEM	×250
15	*Liriospyris reticulata* (Ehrenberg)	P_1: 4280	SEM	×350
16	*Liriospyris reticulata* (Ehrenberg)	P_1: 4280	SEM	×250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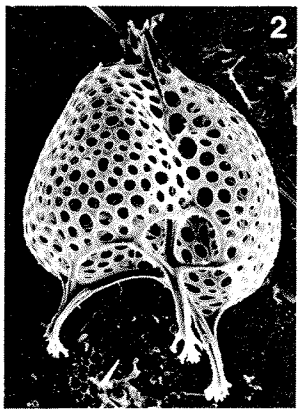
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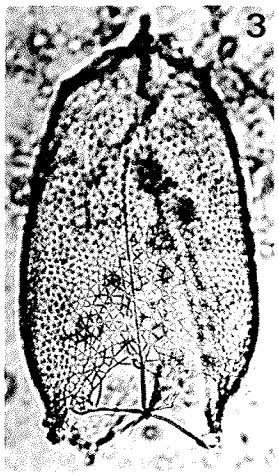
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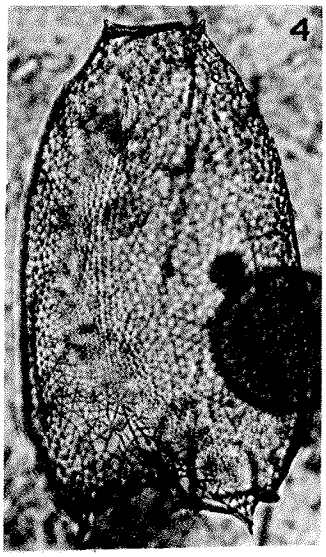
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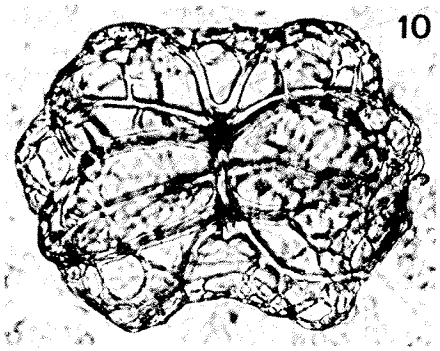
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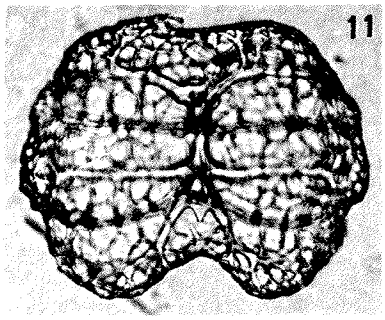
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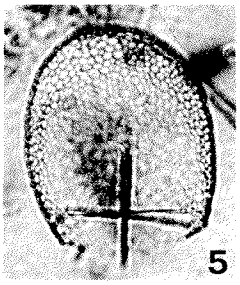
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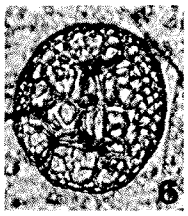
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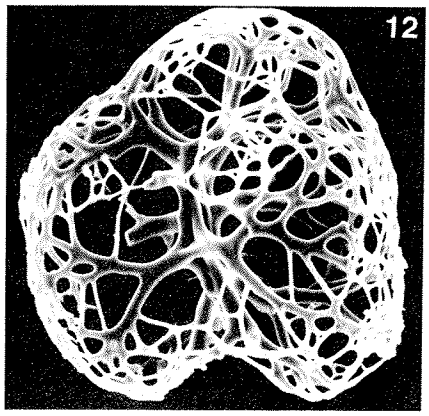
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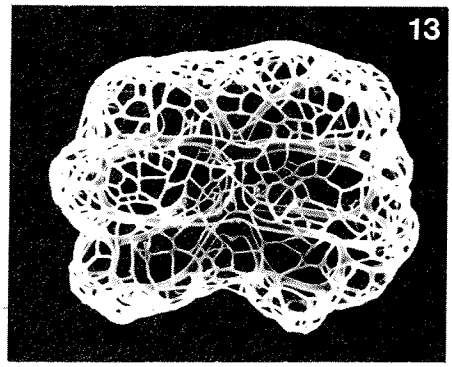
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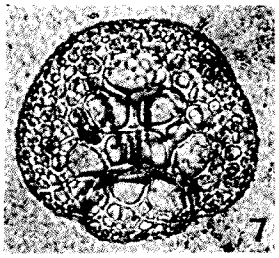
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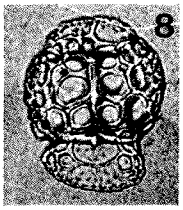
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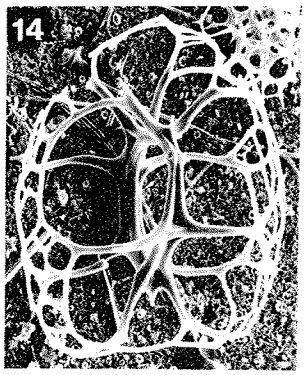
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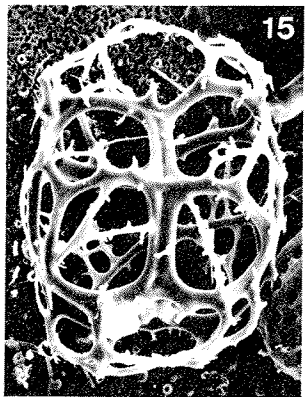
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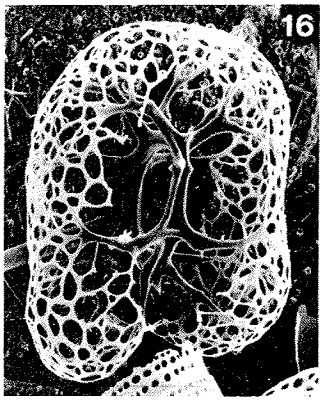
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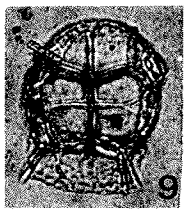
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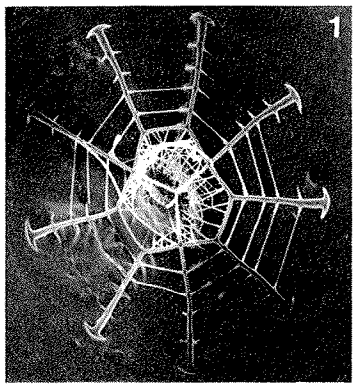
PLATE 32

Suborder: Nassellaria
Family: Sethophormididae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Tetraphormis rotula* (Haeckel)	P_1: 4280	SEM	×180
2	*Tetraphormis rotula* (Haeckel)	P_1: 5582	LM	×210
3	*Tetraphormis rotula* (Haeckel)	P_1: 5582	LM	×210
4	*Lampromitra schultzei* (Haeckel)	P_1: 4280	SEM	×180
5	*Lampromitra schultzei* (Haeckel)	PB: 3791	LM	×210
6	*Dictyophimus butschlii* Haeckel	P_1: 2778	LM	×210
7	*Tetraphormis dodecaster* (Haeckel)	PB: 3791	SEM	×340
8	*Lampromitra cracenta* Takahashi, n. sp.	PB: 3791	LM	×210
9	*Theophormis callipilium* Haeckel Oblique basal view.	P_1: 4280	SEM	×100
10	*Theophormis callipilium* Haeckel Apical view.	P_1: 5582	SEM	×120
11	*Theophormis callipilium* Haeckel Basal view.	PB: 3791	LM	×153
12	*Theophormis callipilium* Haeckel Apical view.	P_1: 5582	LM	×210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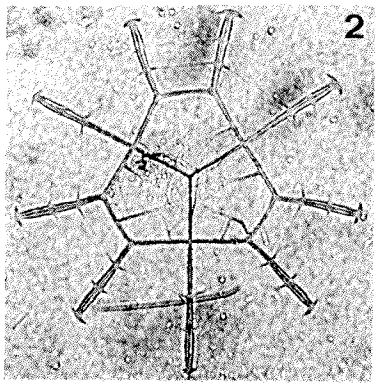
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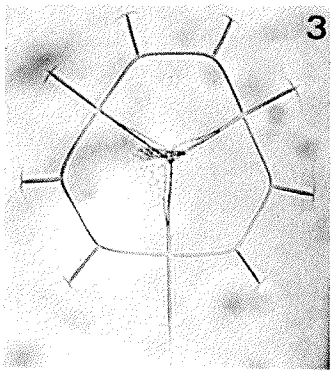
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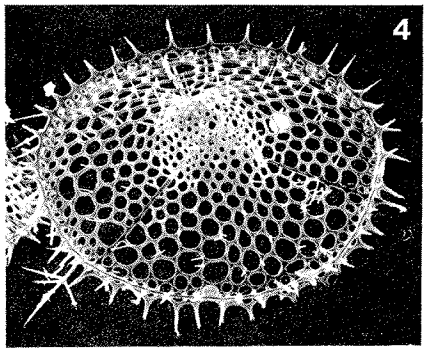
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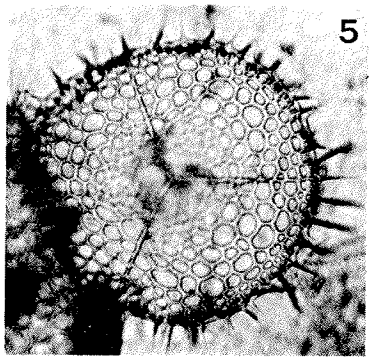
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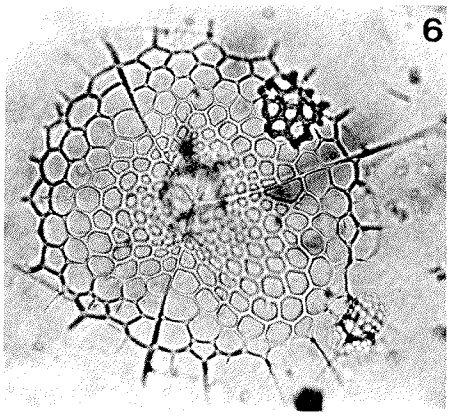
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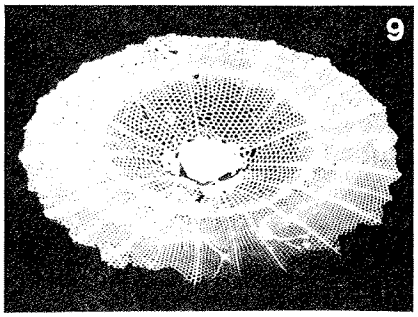
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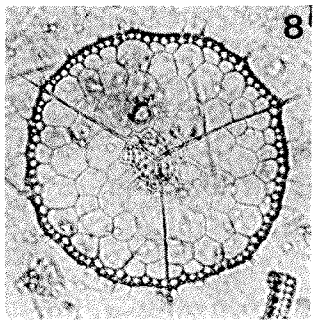
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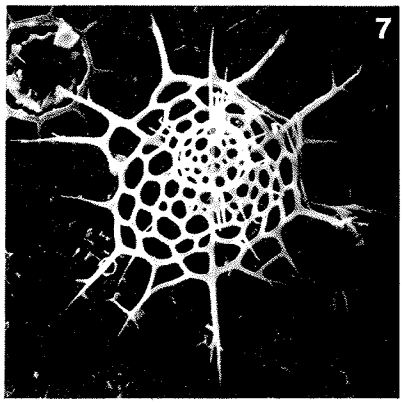
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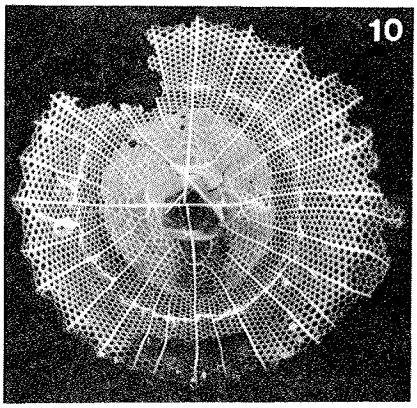
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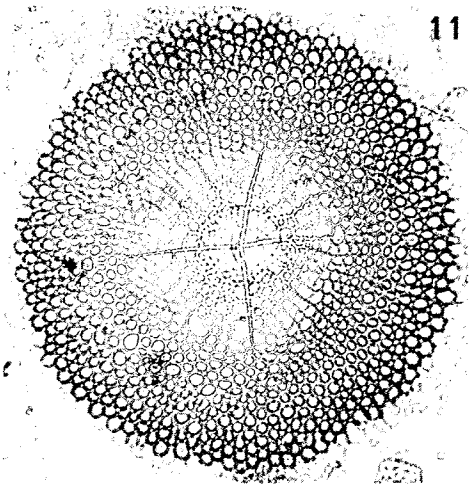
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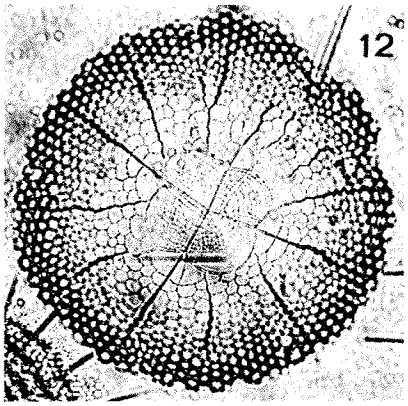
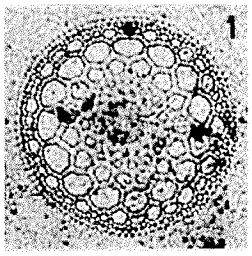

12

PLATE 33

Suborder: Nassellaria
Family: Sethophormididae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Eucecryphalus* sp.	PB: 1268	LM	×210
2	*Lampromitra cachoni* Petrushevskaya	PB: 2869	LM	×210
3	*Lampromitra cachoni* Petrushevskaya	PB: 3791	LM	×210
4	*Eucecryphalus tricostatus* (Haeckel)	PB: 2869	LM	×210
5	*Eucecryphalus sestrodiscus* (Haeckel)	PB: 3791	LM	×210
6	*Eucecryphalus tricostatus* (Haeckel) Oblique apical view.	PB: 1268	SEM	×200
7	*Eucecryphalus sestrodiscus* (Haeckel)	P_1: 2778	SEM	×220
8	*Eucecryphalus sestrodiscus* (Haeckel)	P_1: 4280	SEM	×340
9	*Corocalyptra cervus* (Ehrenberg)	PB: 3791	LM	×210
10	*Corocalyptra cervus* (Ehrenberg)	PB: 2869	SEM	×280
11	*Corocalyptra cervus* (Ehrenberg)	P_1: 4280	SEM	×250
12	*Corocalyptra cervus* (Ehrenberg)	P_1: 2778	SEM	×220
13	*Eucecryphalus gegenbauri* Haeckel	P_1: 978	LM	×210
14	*Eucecryphalus gegenbauri* Haeckel	P_1: 978	LM	×210
15	*Eucecryphalus gegenbauri* Haeckel	PB : 3791	SEM	×450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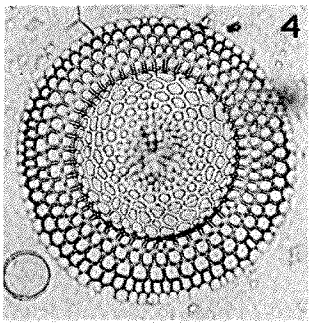
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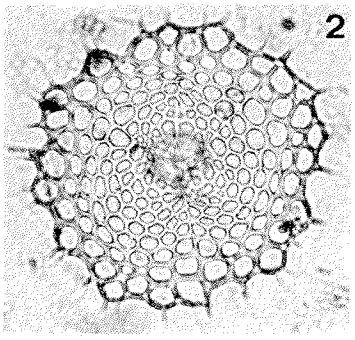
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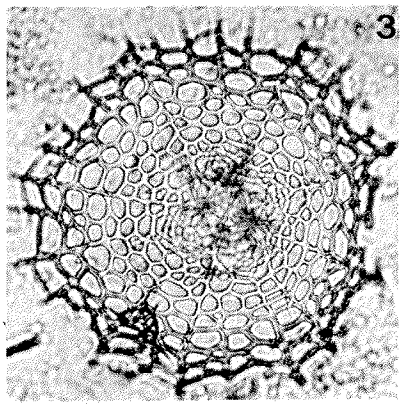
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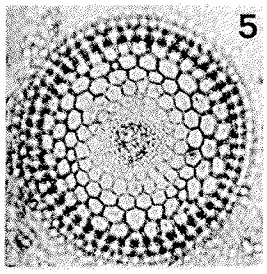
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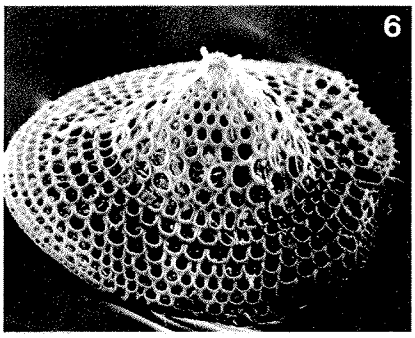
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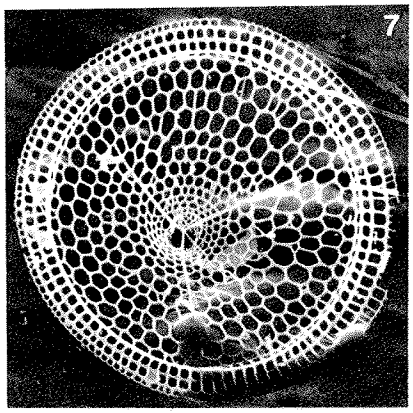
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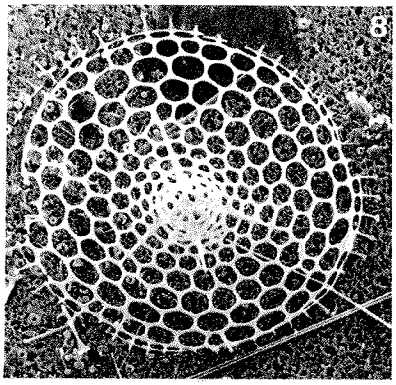
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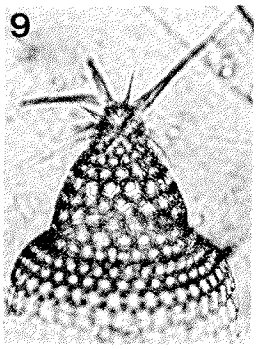
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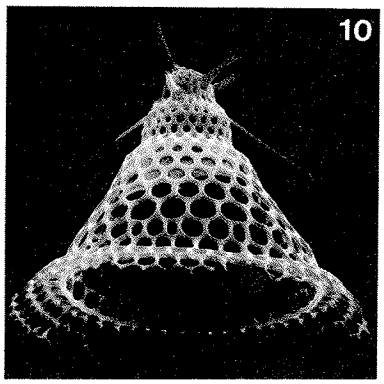
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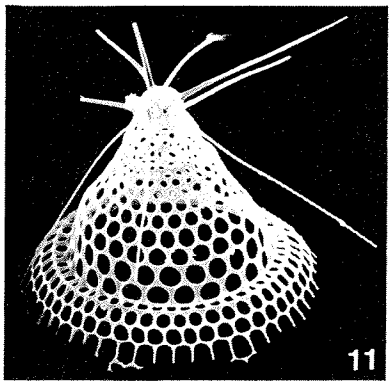
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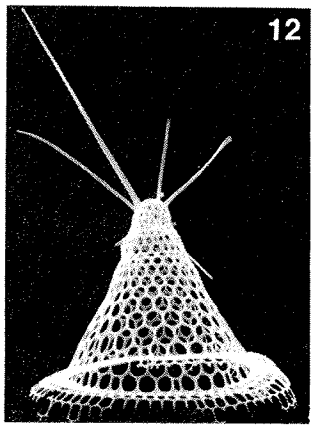
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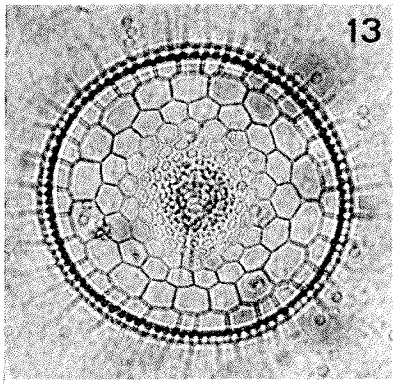
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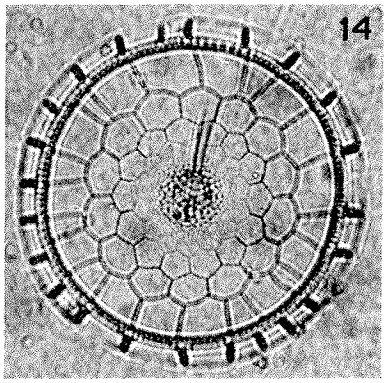
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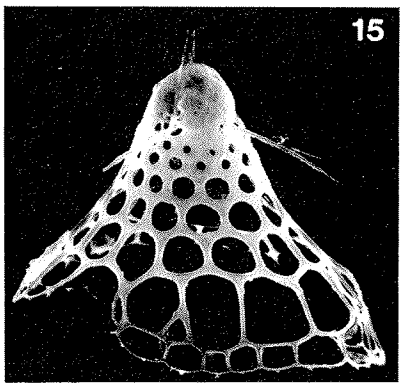
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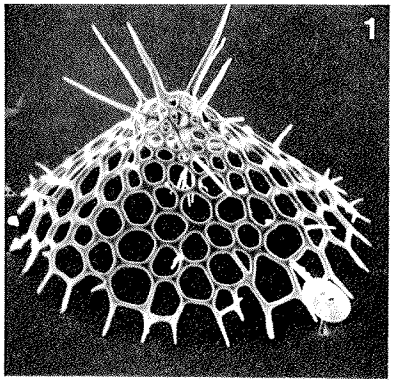
PLATE 34

Suborder: Nassellaria
Family: Sethophormididae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Lampromitra spinosiretis* Takahashi, n. sp. Holotype	PB: 3791	SEM	×165
2	*Lampromitra spinosiretis* Takahashi, n. sp. Paratype	PB: 3791	LM	×210
3	*Phrenocodon clathrostomium* Haeckel	P_1: 4280	LM	×210
4	*Phrenocodon clathrostomium* Haeckel	PB: 3769	LM	×210
5	*Eucecryphalus europae* (Haeckel)	PB: 3791	LM	×210
6	*Eucecryphalus europae* (Haeckel)	P_1: 5582	LM	×210
7	*Lampromitra spinosiretis* Takahashi, n. sp.	PB: 2869	LM	×210
8	*Clathrocyclas* sp.	P_1: 4280	SEM	×280
9	*Clathrocyclas monumentum* (Haeckel)	P_1: 2778	LM	×210
10	*Clathrocyclas monumentum* (Haeckel)	P_1: 4280	LM	×210
11	*Clathrocyclas monumentum* (Haeckel)	P_1: 2778	LM	×210
12	*Clathrocyclas cassiopejae* Haeckel Lateral view.	P_1: 4280	SEM	×150
13	*Clathrocyclas cassiopejae* Haeckel Apical view.	P_1: 5582	SEM	×220
14	*Clathrocyclas cassiopejae* Haeckel Oblique apical view.	P_1: 5582	SEM	×220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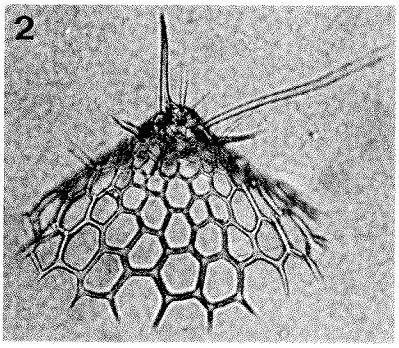
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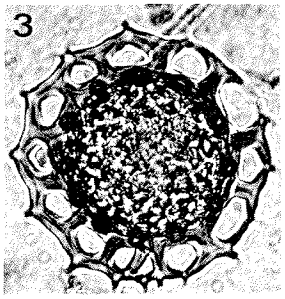
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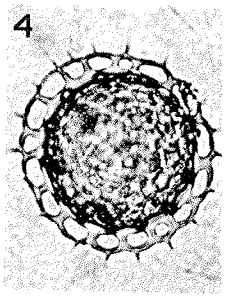
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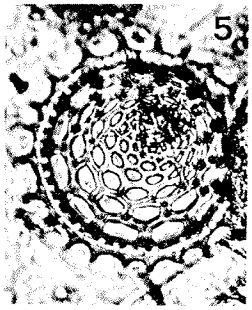
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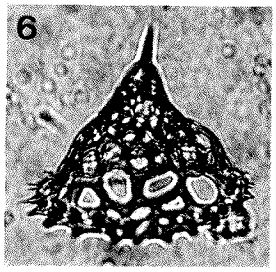
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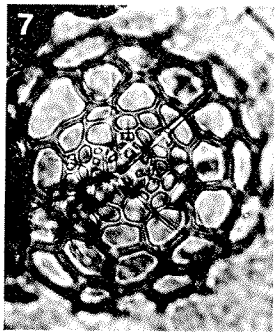
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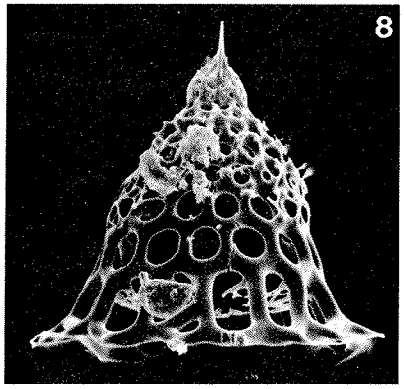
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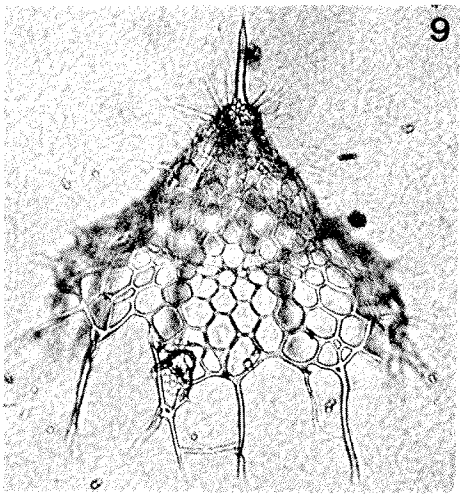
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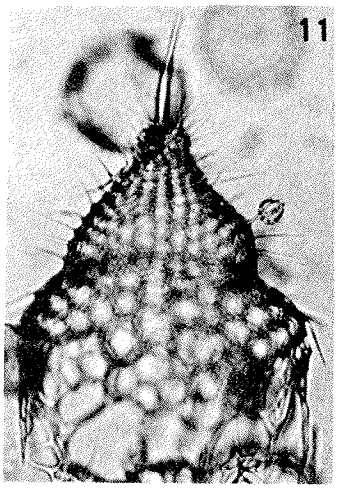
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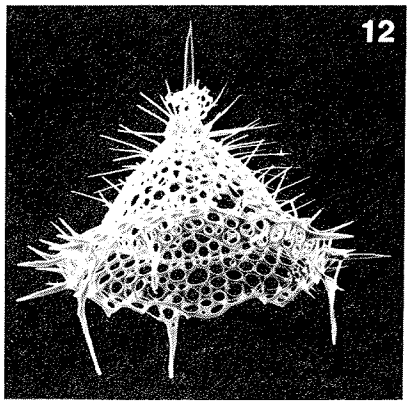
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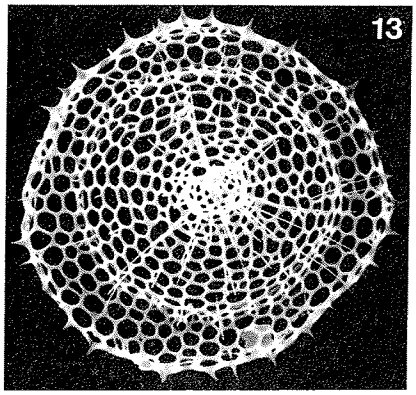
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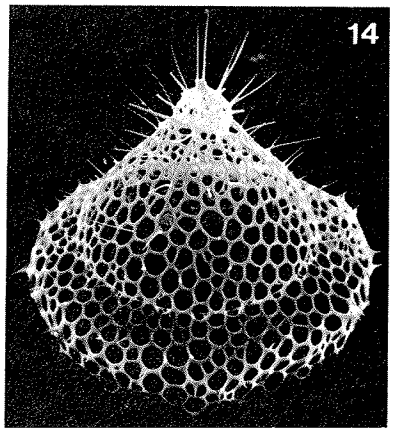
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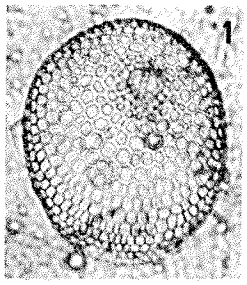
PLATE 35

Suborder: Nassellaria
Family: Sethophormididae
Family: Theoperidae; Subfamily: Plectopyramidinae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Eucecryphalus clinatus* Takahashi, n. sp. Holotype	PB: 2869	LM	×210
2	*Eucecryphalus clinatus* Takahashi, n. sp. Paratype	PB: 2869	LM	×210
3	*Cornutella profunda* Ehrenberg	E: 988	LM	×210
4	*Cornutella profunda* Ehrenberg A specimen with a long thick apical horn.	P_1: 4280	LM	×210
5	*Cornutella profunda* Ehrenberg	PB: 3769	SEM	×280
6	*Cornutella profunda* Ehrenberg Detail of shell surface.	PB: 3769	SEM	×2040
7	*Cornutella profunda* Ehrenberg Same specimen.	PB: 3769	SEM	×330
8	*Cornutella profunda* Ehrenberg	P_1: 2778	LM	×210
9	*Cornutella profunda* Ehrenberg A specimen with thick skeleton.	P_1: 978	LM	×210
10	*Peripyramis circumtexta* Haeckel A specimen with long ribs.	P_1: 2778	SEM	×80
11	*Peripyramis circumtexta* Haeckel	E: 988	LM	×210
12	*Peripyramis circumtexta* Haeckel Apical view.	E: 5068	LM	×210
13	*Peripyramis circumtexta* Haeckel	P_1: 5582	SEM	×180
14	*Litharachnium tentorium* Haeckel	PB: 2869	LM	×210
15	*Litharachnium tentorium* Haeckel Apical view.	PB: 3791	LM	×210
16	*Litharachnium tentorium* Haeckel Apical view.	PB: 3769	SEM	×83
17	*Litharachnium tentorium* Haeckel Oblique view.	P_1: 5582	SEM	×150
18	*Litharachnium tentorium* Haeckel Lateral view.	P_1: 2778	LM	×210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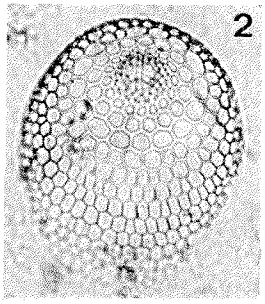
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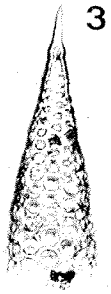
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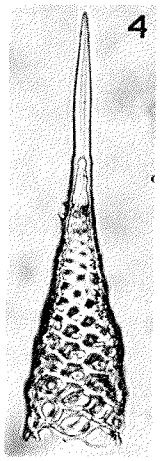
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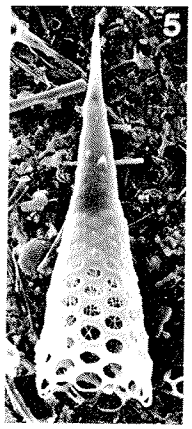
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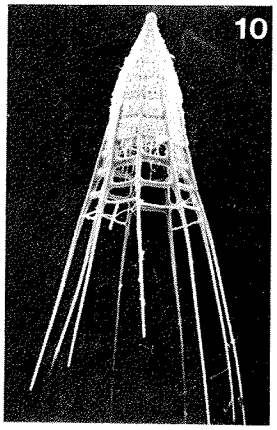
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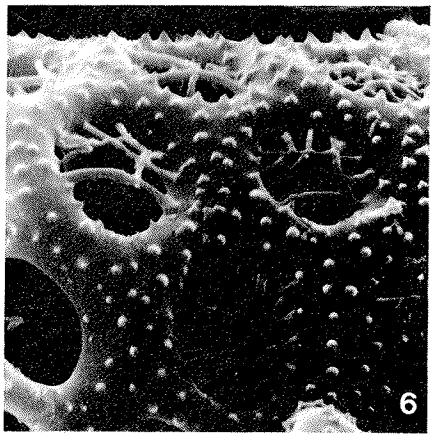
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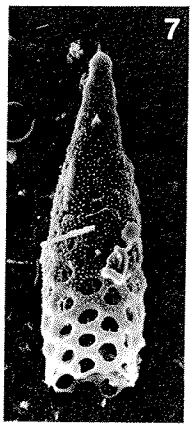
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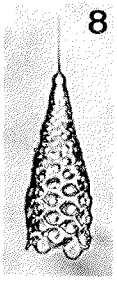
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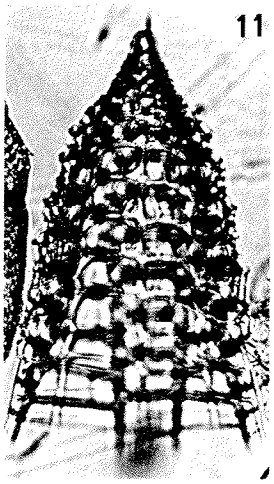
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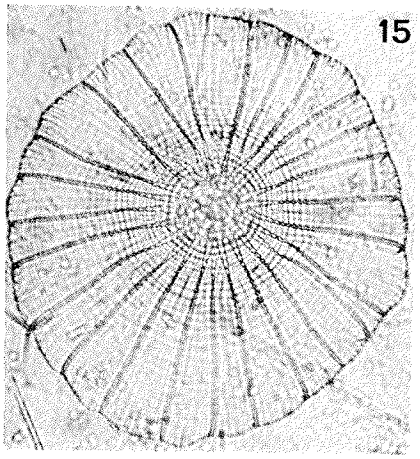
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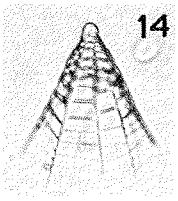
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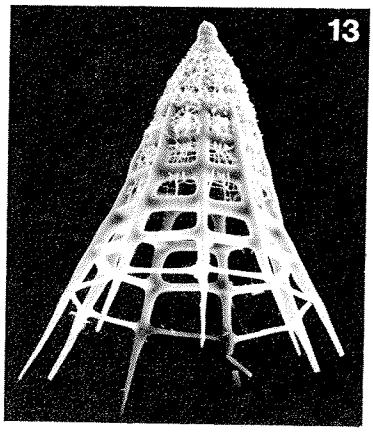
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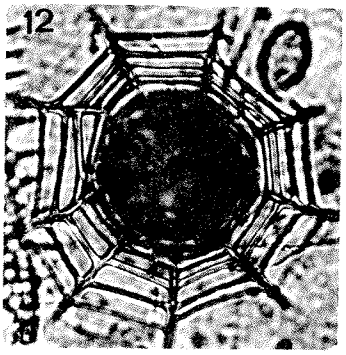
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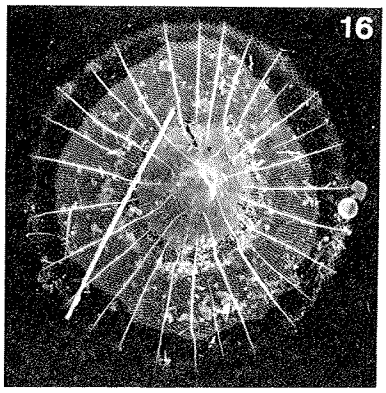
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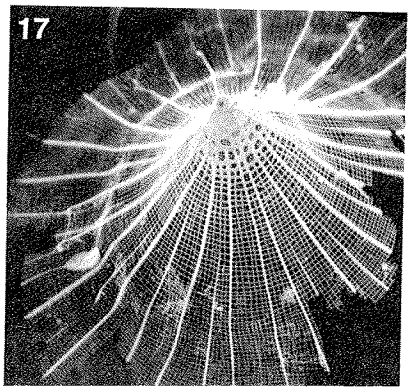
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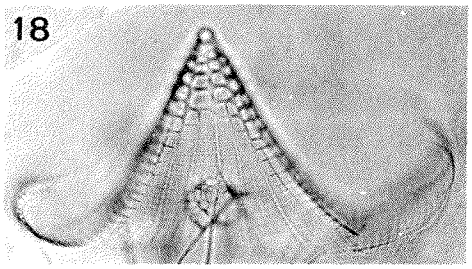
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PLATE 36

Suborder: Nassellaria
Family: Theoperidae; Subfamilies: Plectopyramidinae, Eucyrtidiinae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Litharachnium eupilium* (Haeckel) Apical view.	PB: 3769	LM	×210
2	*Litharachnium eupilium* (Haeckel) Apical view.	PB: 3769	LM	×210
3	*Litharachnium eupilium* (Haeckel) Lateral view.	PB: 1268	SEM	×220
4	*Litharachnium eupilium* (Haeckel) Oblique lateral view.	PB: 3791	LM	×210
5	*Archipilium* sp. aff. *A. orthopterum* Haeckel	P_1: 4280	SEM	×370
6	*Archipilium macropus* ? (Haeckel)	PB: 3769	LM	×210
7	*Archipilium* sp. aff. *A. orthopterum* Haeckel	P_1: 4280	SEM	×430
8	*Pteroscenium pinnatum* Haeckel	PB: 667	LM	×210
9	*Pteroscenium pinnatum* Haeckel	PB: 3791	SEM	×140
10	*Pterocanium trilobum* (Haeckel)	P_1: 4280	SEM	×230
11	*Pterocanium trilobum* (Haeckel)	P_1: 5582	SEM	×130
12	*Pterocanium grandiporus* Nigrini	PB: 3791	LM	×210
13	*Pterocanium grandiporus* Nigrini	PB: 3791	LM	×210
14	*Pterocanium praetextum* (Ehrenberg) *eucolpum* Haeckel	PB: 1268	SEM	×154
15	*Pterocanium praetextum praetextum* (Ehrenberg)	E: 389	LM	×210
16	*Pterocanium praetextum praetextum* (Ehrenberg)	P_1: 5582	LM	×210
17	*Pterocanium praetextum praetextum* (Ehrenberg)	P_1: 5582	LM	×210
18	*Pterocanium praetextum praetextum* (Ehrenberg)	P_1: 5582	SEM	×220

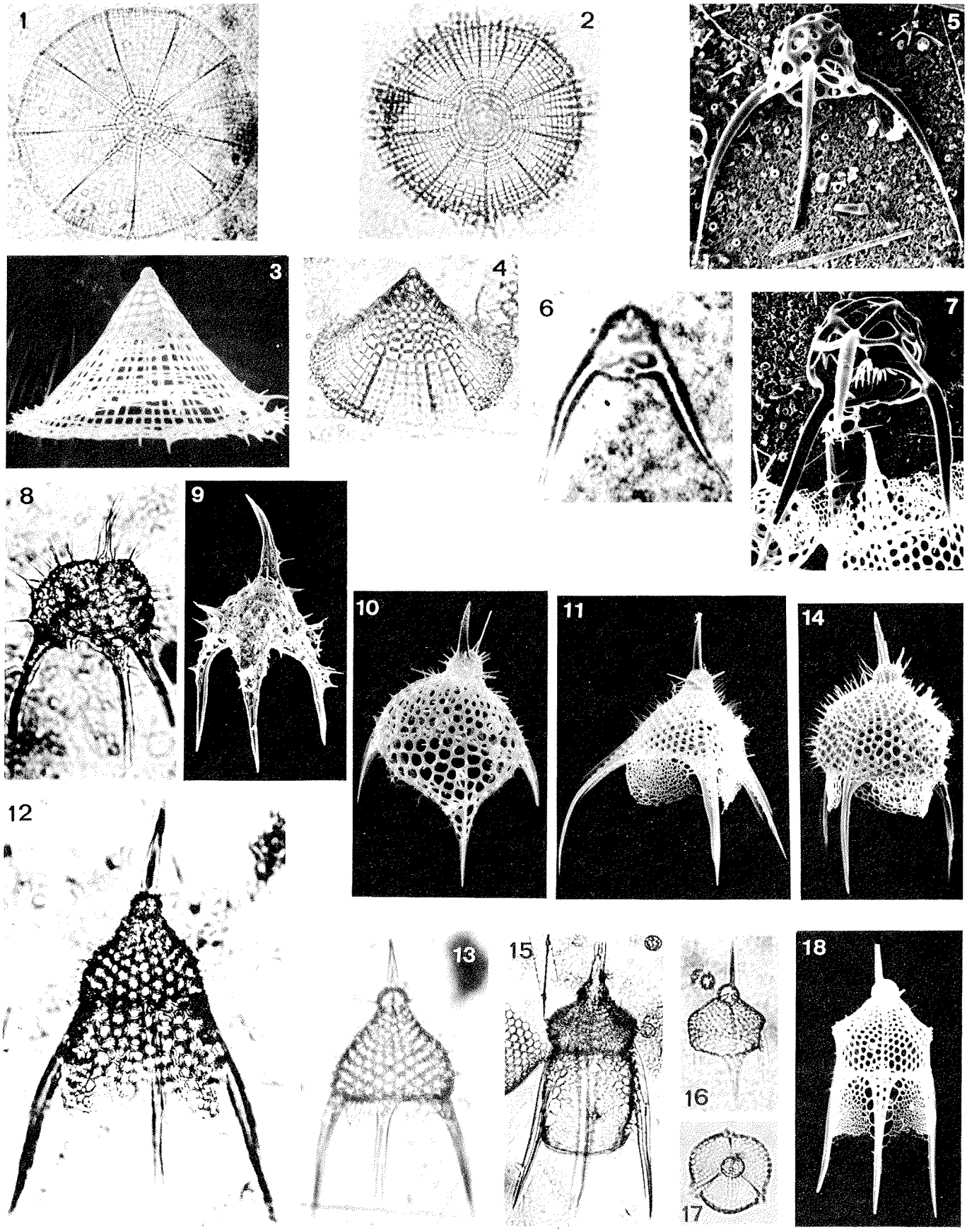
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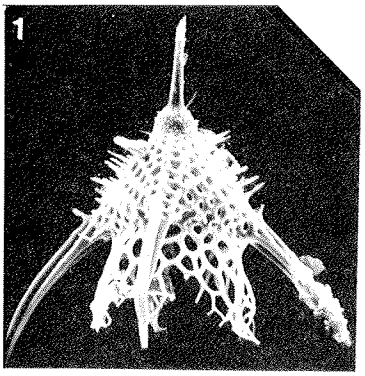
PLATE 37

Suborder: Nassellaria
Family: Theoperidae; Subfamily: Eucyrtidiinae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Dictyophimus* sp. A	PB: 667	SEM	×120
2	*Dictyophimus crisiae* Ehrenberg	P_1: 4280	SEM	×130
3	*Dictyophimus infabricatus* Nigrini	P_1: 978	SEM	×230
4	*Dictyophimus infabricatus* Nigrini	PB: 3791	LM	×210
5	*Dictyophimus infabricatus* Nigrini	PB: 2869	SEM	×220
6	*Dictyocodon elegans* (Haeckel)	PB: 3769	LM	×210
7	*Dictyocodon elegans* (Haeckel)	P_1: 5582	SEM	×154
8	*Dictyocodon palladius* Haeckel One spine on the cephalis broken off.	P_1: 2778	SEM	×180
9	*Dictyocodon elegans* (Haeckel)	P_1: 5582	SEM	×100
10	*Dictyocodon palladius* Haeckel	P_1: 4280	SEM	×130
11	*Dictyocodon palladius* Haeckel	PB: 2869	SEM	×105
12	*Pseudodictyophimus gracilipes* (Bailey)	PB: 3769	SEM	×610
13	*Pseudodictyophimus gracilipes* (Bailey)	P_1: 4280	SEM	×350
14	*Pseudodictyophimus gracilipes* (Bailey)	PB: 3769	LM	×210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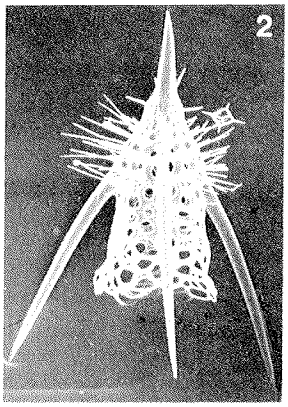
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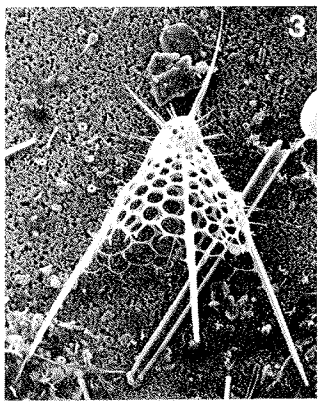
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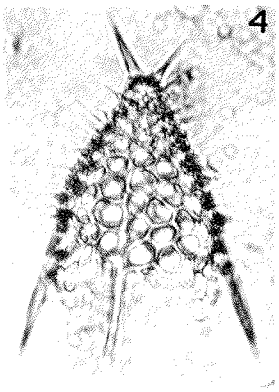
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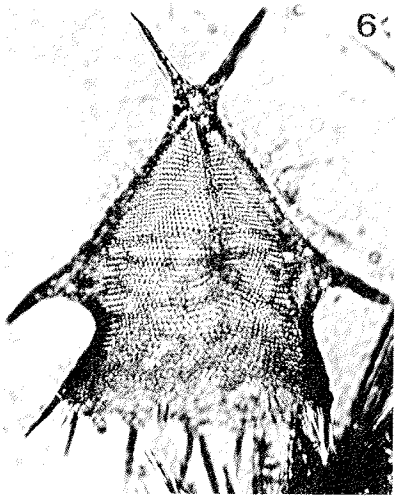
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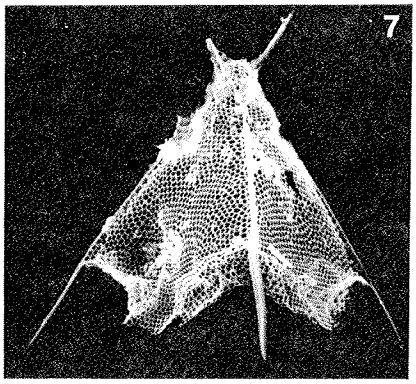
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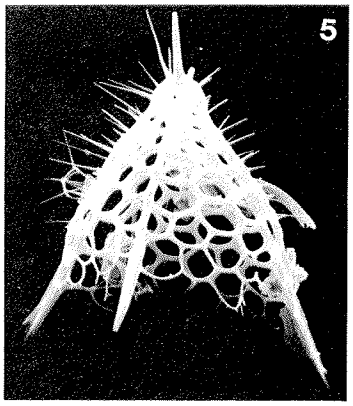
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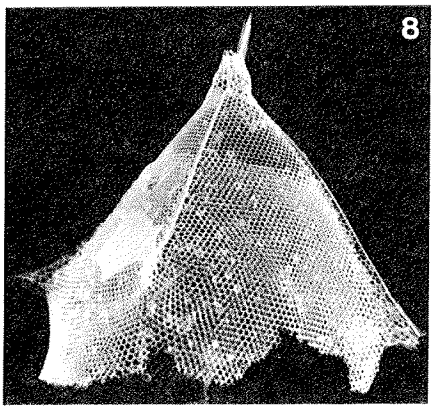
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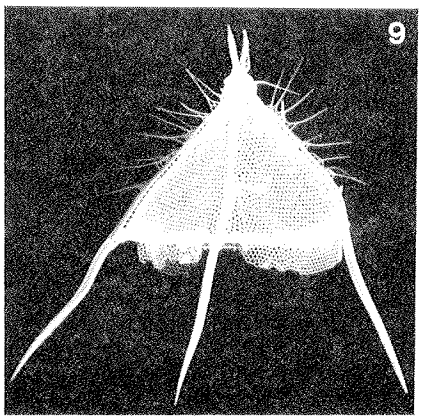
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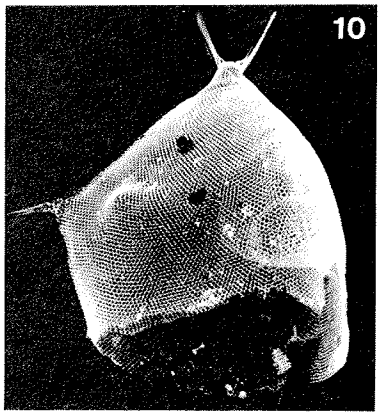
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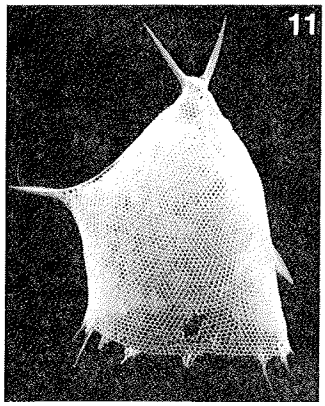
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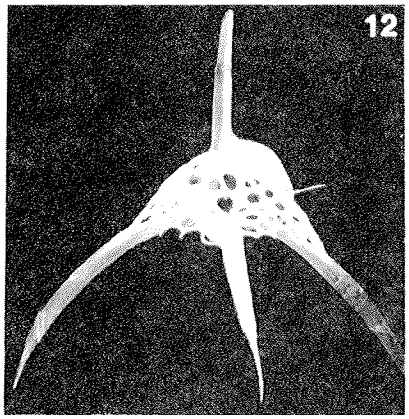
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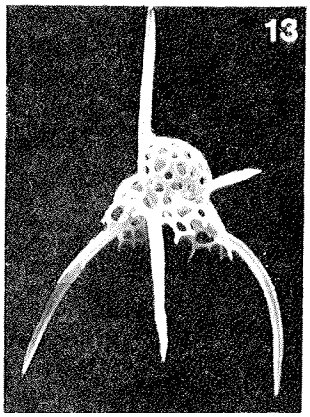
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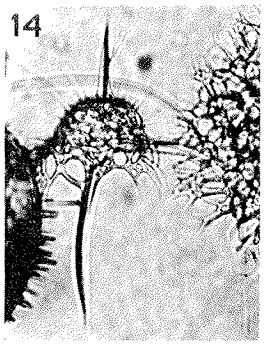
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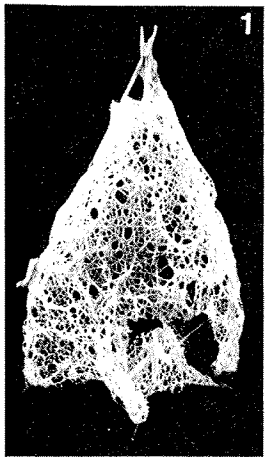
PLATE 38

Suborder: Nassellaria
Family: Theoperidae; Subfamily: Eucyrtidiinae
Families: Pterocorythidae, Artostrobiidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Conicavus tipiopsis* Takahashi, n. sp. Paratype	PB: 1268	SEM	×66
2	*Conicavus tipiopsis* Takahashi, n. sp.	PB: 3791	RLM	×80
3	*Conicavus tipiopsis* Takahashi, n. sp. a–c: specimens with 3 feet; d: a specimen with 4 feet.	PB: 3791	RLM	×80
4	*Conicavus tipiopsis* Takahashi, n. sp. Holotype	PB: 3791	LM	×92
5	*Conicavus tipiopsis* Takahashi, n. sp. Paratype	PB: 3769	LM	×66
6	*Conicavus tipiopsis* Takahashi, n. sp. Paratype	PB: 667	SEM	×100
7	*Sethoconus myxobrachia* Strelkov and Reshetnyak	P_1: 2778	LM	×100
8	*Sethoconus myxobrachia* Strelkov and Reshetnyak	PB: 3769	LM	×60
9	*Artostrobus annulatus* (Bailey)	E: 988	LM	×210
10	*Artostrobus annulatus* (Bailey)	E: 988	LM	×210
11	*Eucyrtidium* spp. A group	P_1: 2778	LM	×210
12	*Eucyrtidium* spp. A group	P_1: 5582	LM	×210
13	*Eucyrtidium* spp. A group	PB: 3791	LM	×390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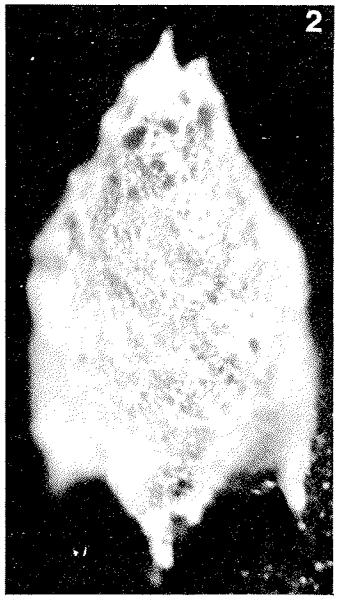
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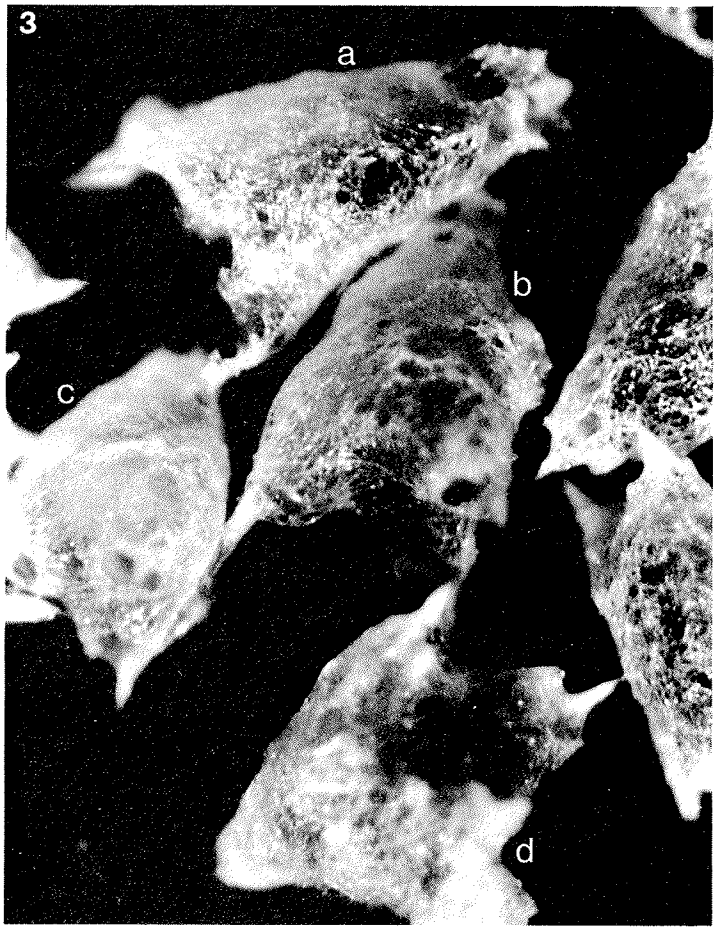
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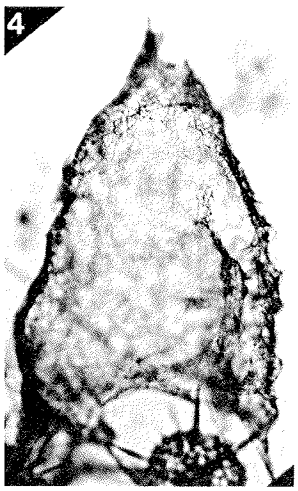
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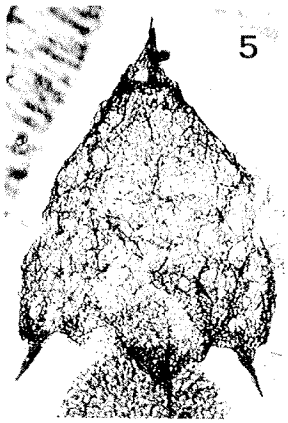
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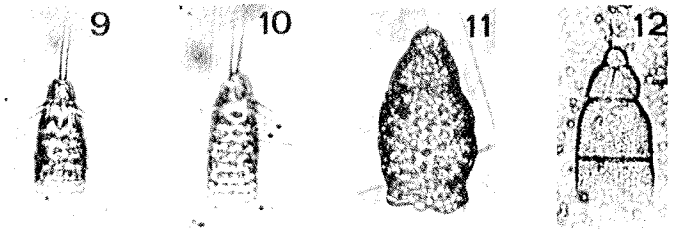
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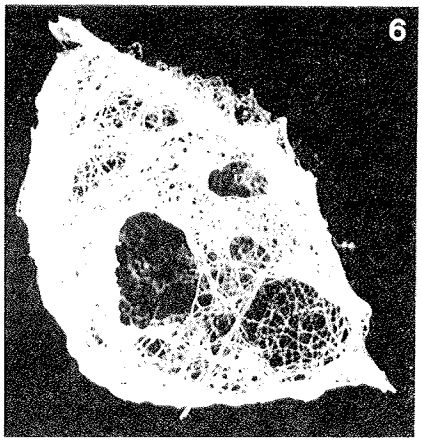
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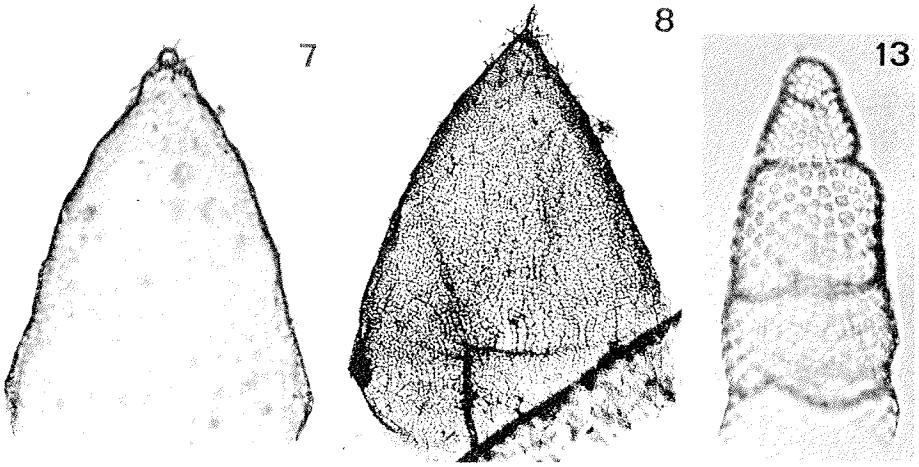
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PLATE 39

Suborder: Nassellaria
Family: Theoperidae; Subfamily: Eucyrtidiinae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Conarachnium polyacanthum* (Popofsky)	P_1: 2778	LM	×240
2	*Conarachnium polyacanthum* (Popofsky)	P_1: 4280	SEM	×120
3	*Conarachnium polyacanthum* (Popofsky)	PB: 2869	LM	×210
4	*Conarachnium polyacanthum* (Popofsky)	PB: 3791	LM	×210
5	*Conarachnium parabolicum* (Popofsky)	P_1: 5582	SEM	×100
6	*Conarachnium parabolicum* (Popofsky)	PB: 3769	LM	×156
7	*Conarachnium facetum* (Haeckel)	P_1: 5582	SEM	×165
8	*Dictyophimus macropterus* (Ehrenberg)	P_1: 4280	SEM	×550
9	*Dictyophimus macropterus* (Ehrenberg)	P_1: 978	SEM	×440
10	*Dictyophimus macropterus* (Ehrenberg)	PB: 3769	LM	×210
11	*Dictyophimus macropterus* (Ehrenberg)	P_1: 5582	LM	×210
12	*Dictyophimus* sp. B	P_1: 4280	SEM	×340
13	*Stichopilium bicorne* Haeckel	PB: 3769	LM	×210
14	*Stichopilium bicorne* Haeckel	PB: 3791	LM	×210
15	*Stichopilium bicorne* Haeckel	PB: 1268	SEM	×220
16	*Stichopilium bicorne* Haeckel	P_1: 4280	LM	×210
17	*Stichopilium bicorne* Haeckel	PB: 3769	LM	×210
18	*Stichopilium bicorne* Haeckel	PB: 3791	SEM	×230
19	*Stichopilium bicorne* Haeckel	P_1: 4280	SEM	×250

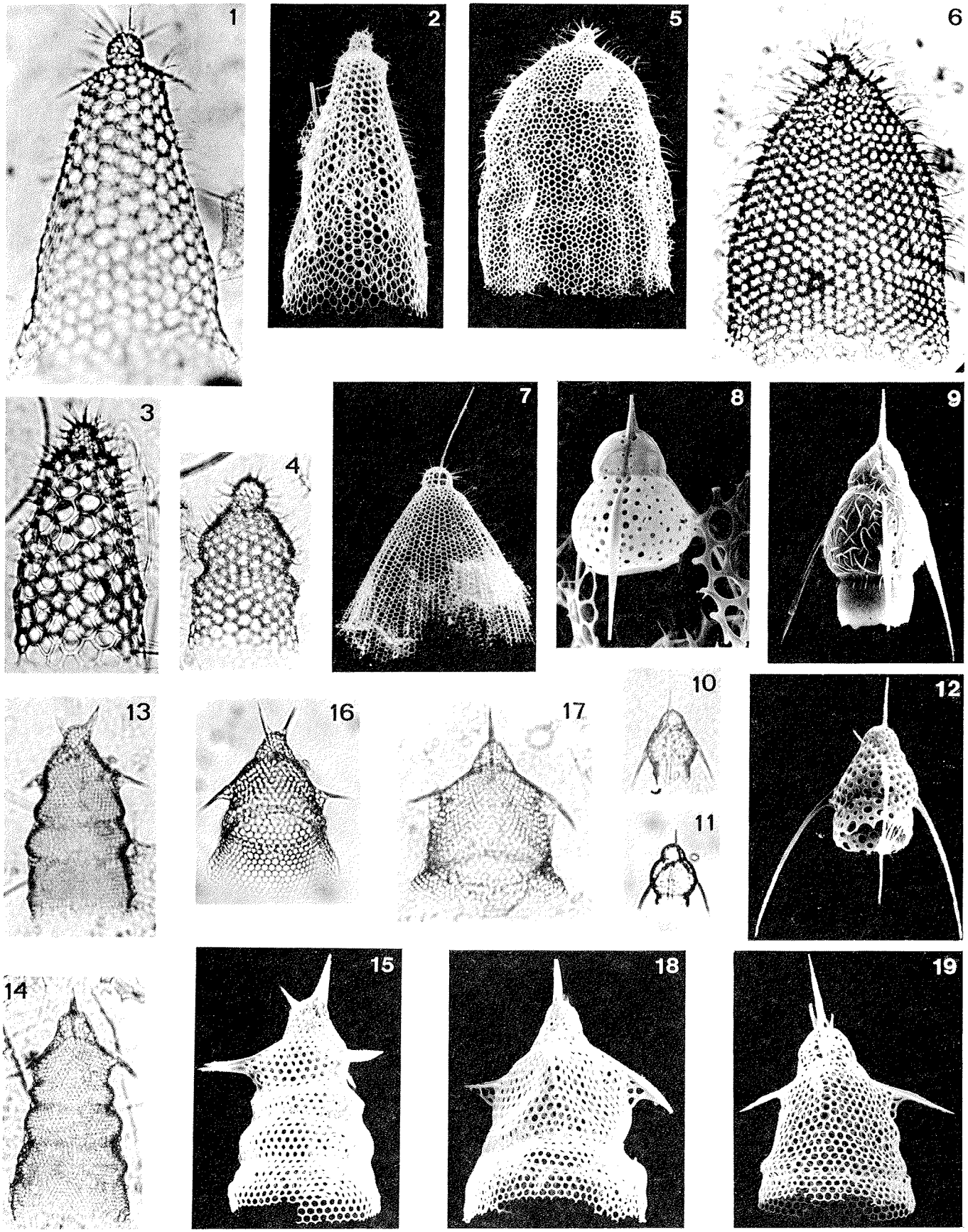
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PLATE 40

Suborder: Nassellaria
Family: Theoperidae; Subfamily: Eucyrtidiinae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Lithopera bacca* Ehrenberg	P_1: 4280	SEM	×390
2	*Lithopera bacca* Ehrenberg	P_1: 4280	SEM	×230
3	*Cyrtopera languncula* Haeckel	PB: 3769	SEM	×190
4	*Cyrtopera languncula* Haeckel	PB: 3769	SEM	×140
5	*Cyrtopera languncula* Haeckel	P_1: 4280	SEM	×440
6	*Cyrtopera languncula* Haeckel	PB: 3791	LM	×210
7	*Cyrtopera aglaolampa* Takahashi, n. sp. Holotype	P_1: 2778	LM	×210
8	*Cyrtopera aglaolampa* Takahashi, n. sp. Paratype	PB: 3769	SEM	×120
9	*Triacartus undulatum* (Popofsky)	P_1: 4280	SEM	×280
10	*Triacartus undulatum* (Popofsky)	PB: 2869	LM	×210
11	*Theocorys veneris* Haeckel	P_1: 4280	SEM	×440
12	*Theocorys veneris* Haeckel	PB: 3791	SEM	×370
13	*Theocorys veneris* Haeckel	PB: 2869	LM	×210
14	*Theocorys veneris* Haeckel	PB: 2869	LM	×210
15	*Theocorythium trachelium trachelium* (Ehrenberg)	P_1: 5582	SEM	×240
16	*Theocorythium trachelium trachelium* (Ehrenberg)	P_1: 978	LM	×210
17	*Lipmanella dictyoceras* (Haeckel)	PB: 2869	LM	×210
18	*Lipmanella pyramidale* (Popofsky)	P_1: 5582	SEM	×280
19	*Lipmanella virchowii* (Haeckel)	PB: 2869	LM	×210
20	*Lipmanella virchowii* (Haeckel)	PB: 2869	LM	×210
21	*Lipmanella virchowii* (Haeckel)	PB: 2869	LM	×210

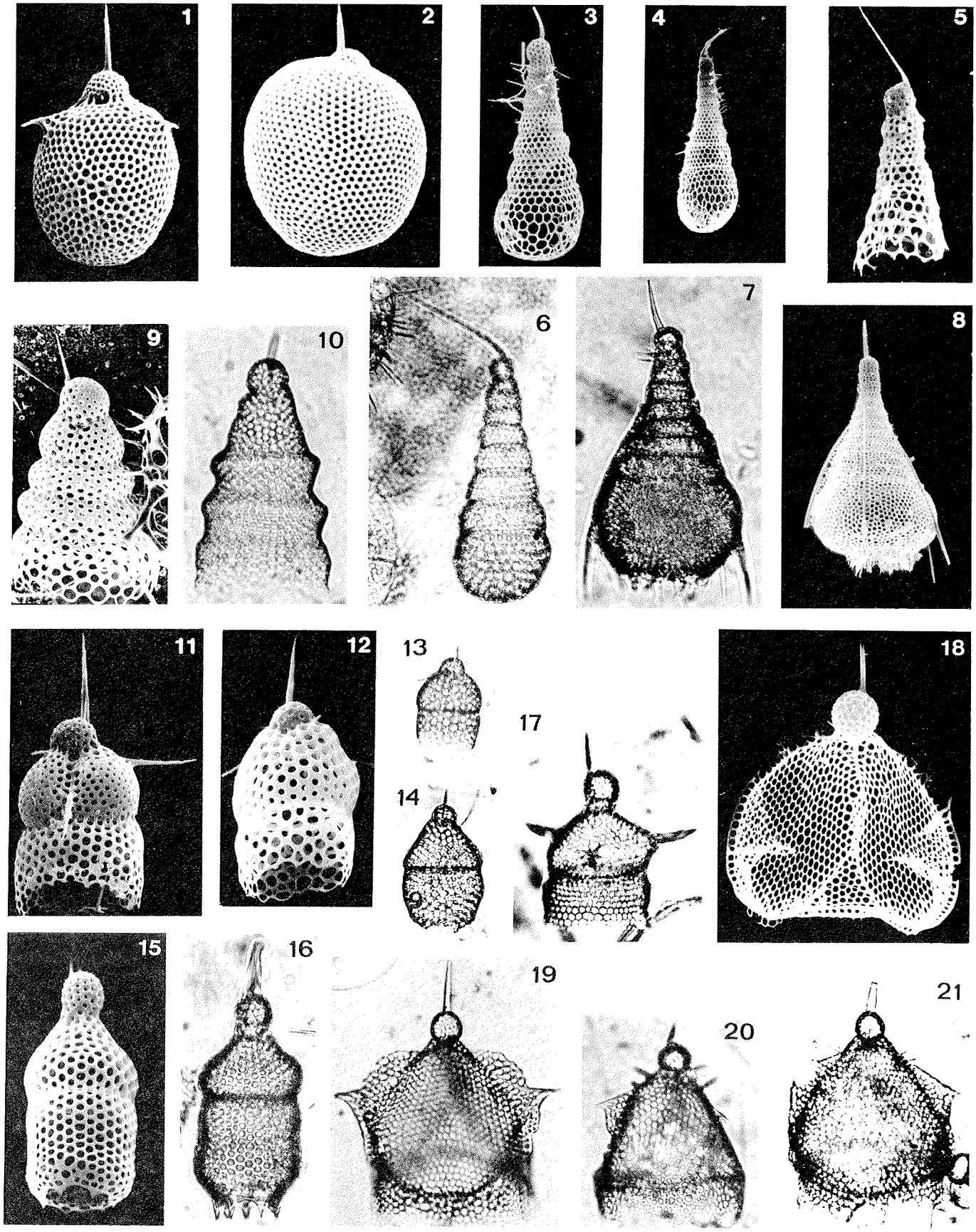
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PLATE 41

Suborder: Nassellaria
Family: Theoperidae; Subfamily: Eucyrtidiinae
Family: Pterocorythidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Lithostrobus hexagonalis* Haeckel	PB: 667	LM	×210
2	*Lithostrobus hexagonalis* Haeckel	P_1: 5582	SEM	×220
3	*Lithostrobus hexagonalis* Haeckel	PB: 3791	SEM	×165
4	*Theocalyptra bicornis* (Popofsky)	E: 988	LM	×210
5	*Theocalyptra bicornis* (Popofsky)	P_1: 378	LM	×210
6	*Theocalyptra bicornis* (Popofsky)	E: 988	LM	×210
7	*Theocalyptra davisiana davisiana* (Ehrenberg)	PB: 3791	LM	×210
8	*Theocalyptra bicornis* (Popofsky)	P_1: 5582	LM	×210
9	*Theocalyptra bicornis* (Popofsky)	P_1: 4280	SEM	×550
10	*Theocalyptra bicornis* (Popofsky)	P_1: 4280	SEM	×440
11	*Theocalyptra bicornis* (Popofsky)	P_1: 4280	SEM	×390
12	*Theocalyptra davisiana cornutoides* (Petrushevskaya)	PB: 3791	LM	×210
13	*Theocalyptra davisiana cornutoides* (Petrushevskaya)	P_1: 5582	LM	×210
14	*Theocalyptra davisiana cornutoides* (Petrushevskaya)	P_1: 4280	SEM	×830
15	*Theocalyptra davisiana cornutoides* (Petrushevskaya)	P_1: 4280	SEM	×440
16	*Theocalyptra davisiana cornutoides* (Petrushevskaya)	P_1: 4280	SEM	×360
17	*Tetracorethra tetracorethra* (Haeckel)	PB: 3769	LM	×85
18	*Tetracorethra tetracorethra* (Haeckel)	P_1: 5582	SEM	×154
19	*Anthocyrtidium zanguebaricum* (Ehrenberg)	PB: 2869	LM	×210
20	*Anthocyrtidium zanguebaricum* (Ehrenberg)	P_1: 4280	SEM	×230
21	*Anthocyrtidium zanguebaricum* (Ehrenberg)	PB: 3791	SEM	×250
22	*Anthocyrtidium zanguebaricum* (Ehrenberg)	P_1: 4280	SEM	×360

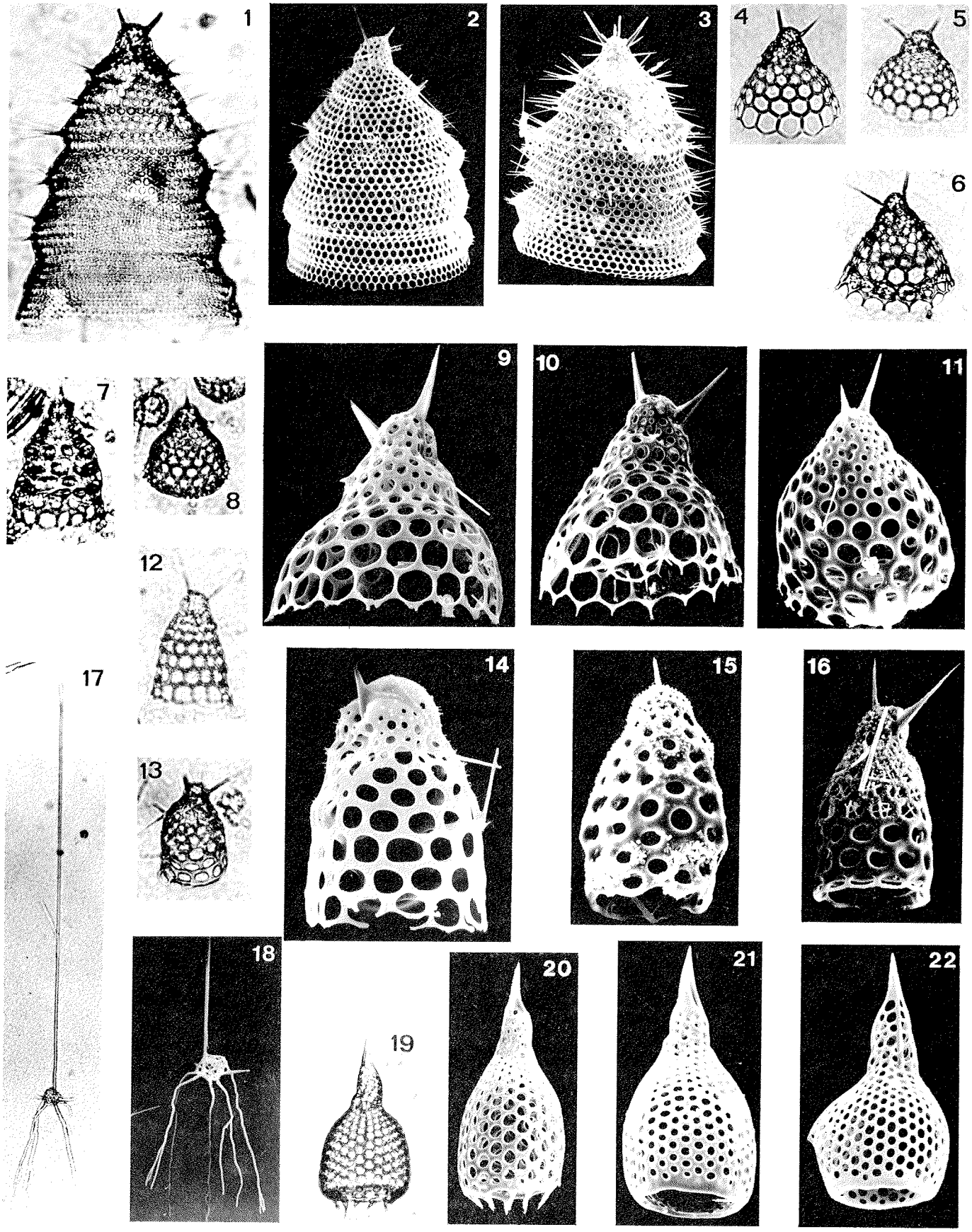
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PLATE 42

Suborder: Nassellaria
Family: Pterocorythidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Pterocorys zancleus* (Müller)	P_1: 5582	SEM	×300
2	*Pterocorys zancleus* (Müller)	P_1: 4280	SEM	×440
3	*Pterocorys zancleus* (Müller)	P_1: 4280	SEM	×300
4	*Pterocorys zancleus* (Müller)	P_1: 4280	LM	×210
5	*Pterocorys campanula* Haeckel	P_1: 978	SEM	×580
6	*Pterocorys campanula* Haeckel	PB: 667	LM	×210
7	*Pterocorys campanula* Haeckel	PB: 3769	LM	×210
8	*Pterocorys campanula* Haeckel	P_1: 4280	SEM	×220
9	*Eucyrtidium acuminatum* (Ehrenberg)	PB: 1268	SEM	×180
10	*Eucyrtidium acuminatum* (Ehrenberg)	PB: 1268	SEM	×165
11	*Eucyrtidium anomalum* (Haeckel)	P_1: 5582	SEM	×220
12	*Eucyrtidium anomalum* (Haeckel)	PB: 2869	LM	×210
13	*Eucyrtidium anomalum* (Haeckel)	PB: 3769	LM	×210
14	*Eucyrtidium anomalum* (Haeckel)	P_1: 4280	LM	×210
15	*Eucyrtidium* sp. aff. *E. anomalum* (Haeckel)	P_1: 5582	LM	×210
16	*Eucyrtidium acuminatum* (Ehrenberg)	P_1: 4280	SEM	×250
17	*Eucyrtidium acuminatum* (Ehrenberg)	P_1: 4280	SEM	×250
18	*Eucyrtidium hexagonatum* Haeckel	P_1: 5582	SEM	×220
19	*Eucyrtidium hexagonatum* Haeckel	PB: 2869	LM	×210
20	*Eucyrtidium acuminatum* (Ehrenberg)	PB: 3769	LM	×210
21	*Eucyrtidium dictyopodium* (Haeckel)	P_1: 5582	SEM	×165
22	*Eucyrtidium hexastichum* (Haeckel)	PB: 3769	LM	×210

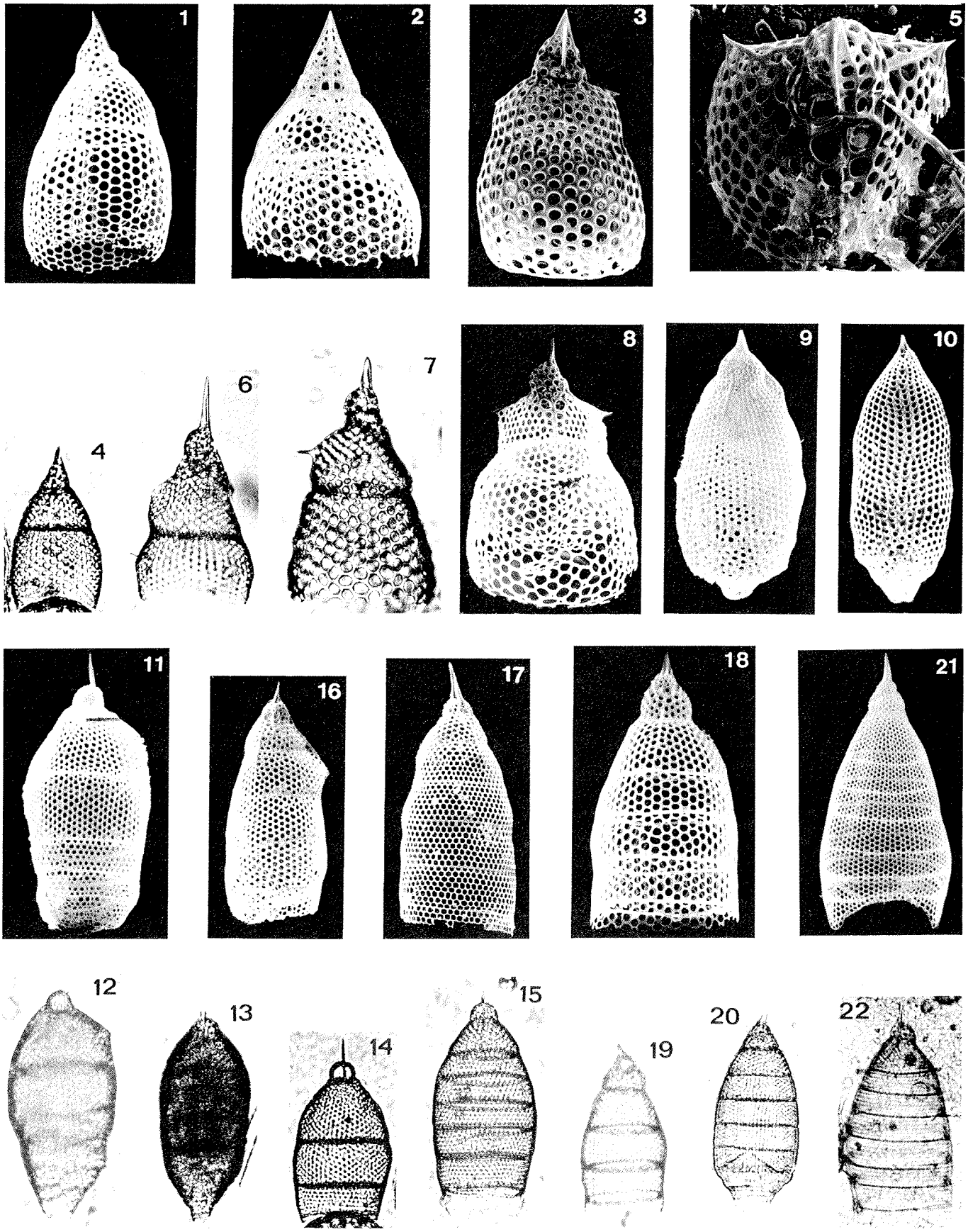
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PLATE 43

Suborder: Nassellaria
Family: Pterocorythidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Anthocyrtidium ophirense* (Ehrenberg)	PB: 2869	LM	×210
2	*Anthocyrtidium ophirense* (Ehrenberg)	P_1· 5582	SEM	×200
3	*Anthocyrtidium ophirense* (Ehrenberg)	P_1: 4280	SEM	×230
4	*Anthocyrtidium ophirense* (Ehrenberg)	PB: 3791	SEM	×165
5	*Anthocyrtidium ophirense* (Ehrenberg)	P_1: 4280	SEM	×220
6	*Anthocyrtidium ophirense* (Ehrenberg)	P_1: 978	LM	×210
7	*Anthocyrtidium ophirense* (Ehrenberg)	P_1: 4280	SEM	×340
8	*Lamprocyclas maritalis maritalis* Haeckel	P_1: 4280	SEM	×170
9	*Lamprocyclas maritalis maritalis* Haeckel	E: 3755	LM	×210
10	*Lamprocyclas maritalis maritalis* Haeckel A skeletal cross section of an interporous bar showing uniform and solid features with little dissolution on the margin. The conchoidal fractures are due to sectioning.	P_1: 2778	TEM	×19,200
11	*Lamprocyclas maritalis maritalis* Haeckel A more progressed stage of dissolution than the above (figure 10) showing porous marginal area.	P_1: 5582	TEM	×52,200
12	*Lamprocyclas maritalis polypora* Nigrini	PB: 3791	LM	×210
13	*Lamprocyclas maritalis maritalis* Haeckel	E: 5068	LM	×210
14	*Lamprocyclas maritalis maritalis* Haeckel	PB: 3791	SEM	×180
15	*Lamprocyclas maritalis polypora* Nigrini	PB: 3791	LM	×210
16	*Lamprocyrtis* sp.	PB: 3791	LM	×210
17	*Lamprocyrtis nigriniae* (Caulet)	PB: 2869	LM	×210
18	*Lamprocyrtis nigriniae* (Caulet)	PB: 2869	LM	×210
19	*Lamprocyrtis nigriniae* (Caulet)	PB: 3769	LM	×210

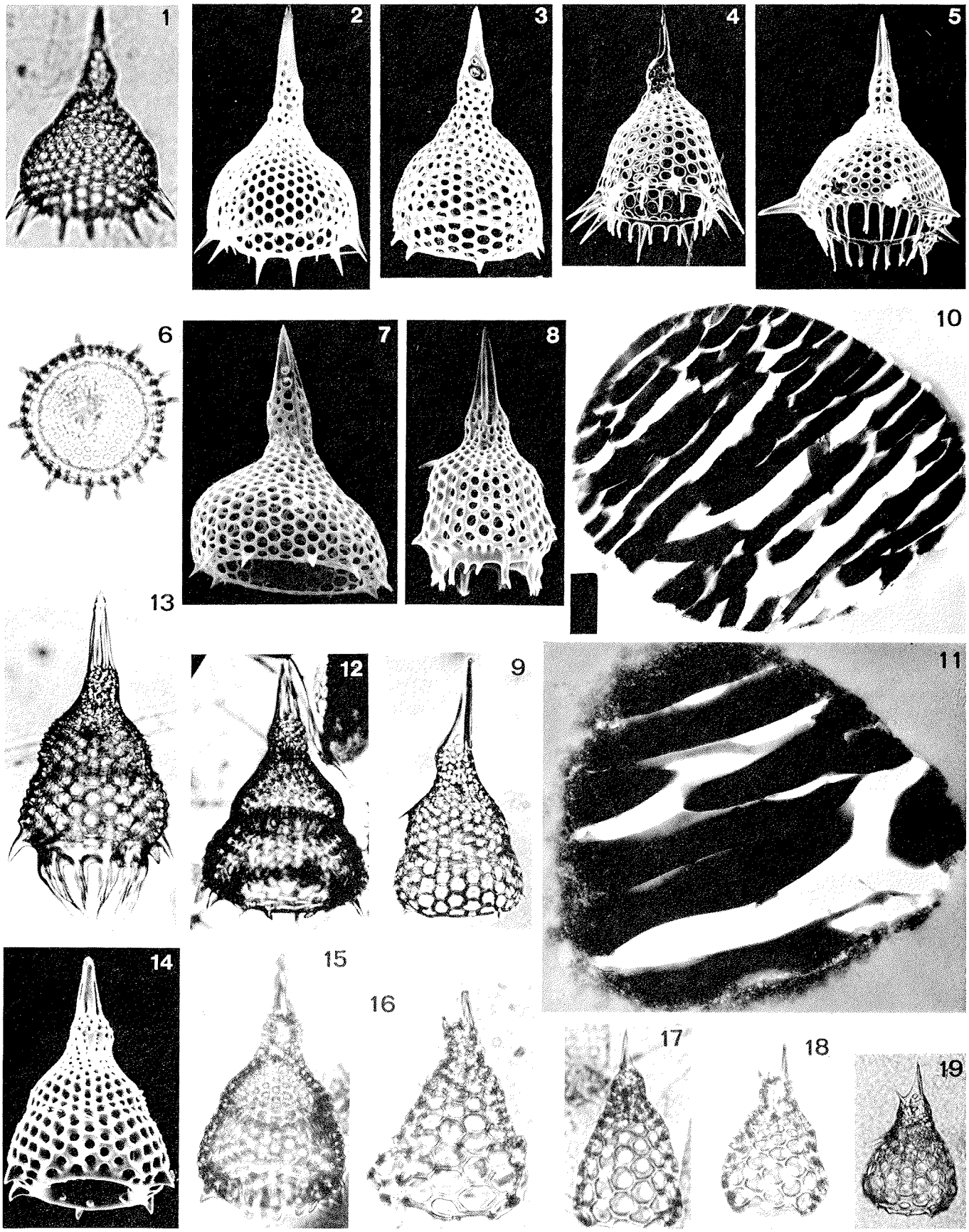
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PLATE 44

Suborder: Nassellaria
Family: Artostrobiidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Spirocyrtis scalaris* Haeckel	E: 389	LM	×210
2	*Spirocyrtis scalaris* Haeckel	PB: 1268	SEM	×200
3	*Spirocyrtis subscalaris* Nigrini	PB: 3791	SEM	×330
4	*Spirocyrtis subscalaris* Nigrini	PB: 1268	SEM	×330
5	*Spirocyrtis subscalaris* Nigrini An inside view of purposely broken specimen.	PB: 3769	SEM	×440
6	*Spirocyrtis subscalaris* Nigrini	PB: 3791	LM	×210
7	*Spirocyrtis ? platycephala* (Ehrenberg) group	PB: 3791	LM	×210
8	*Spirocyrtis ? platycephala* (Ehrenberg) group	P_1: 5582	LM	×210
9	*Botryostrobus aquilonaris* (Bailey)	E: 5068	LM	×210
10	*Botryostrobus aquilonaris* (Bailey)	PB: 2869	LM	×210
11	*Botryostrobus aquilonaris* (Bailey)	P_1: 978	SEM	×370
12	*Botryostrobus aquilonaris* (Bailey)	PB: 3791	SEM	×250
13	*Botryostrobus aquilonaris* (Bailey) Specimen with rough surface.	PB: 1268	SEM	×390
14	*Phormostichoartus corbula* (Harting)	PB: 2869	LM	×210
15	*Phormostichoartus corbula* (Harting)	PB: 2869	LM	×210
16	*Phormostichoartus corbula* (Harting)	P_1: 4280	SEM	×420
17	*Sithocampe lineata* (Ehrenberg)	PB: 1268	SEM	×280
18	*Sithocampe lineata* (Ehrenberg)	PB: 3769	SEM	×250
19	*Sithocampe lineata* (Ehrenberg)	PB: 2869	LM	×210
20	*Sithocampe lineata* (Ehrenberg) Same specimen as in figure 17; detail of surface texture.	PB: 1268	SEM	×880
21	*Sithocampe arachnea* (Ehrenberg)	PB: 3769	SEM	×410
22	*Sithocampe arachnea* (Ehrenberg)	PB: 3769	SEM	×520
23	*Sithocampe arachnea* (Ehrenberg)	PB: 2869	LM	×210
24	*Artobotrys borealis* (Cleve)	P_1: 978	SEM	×660

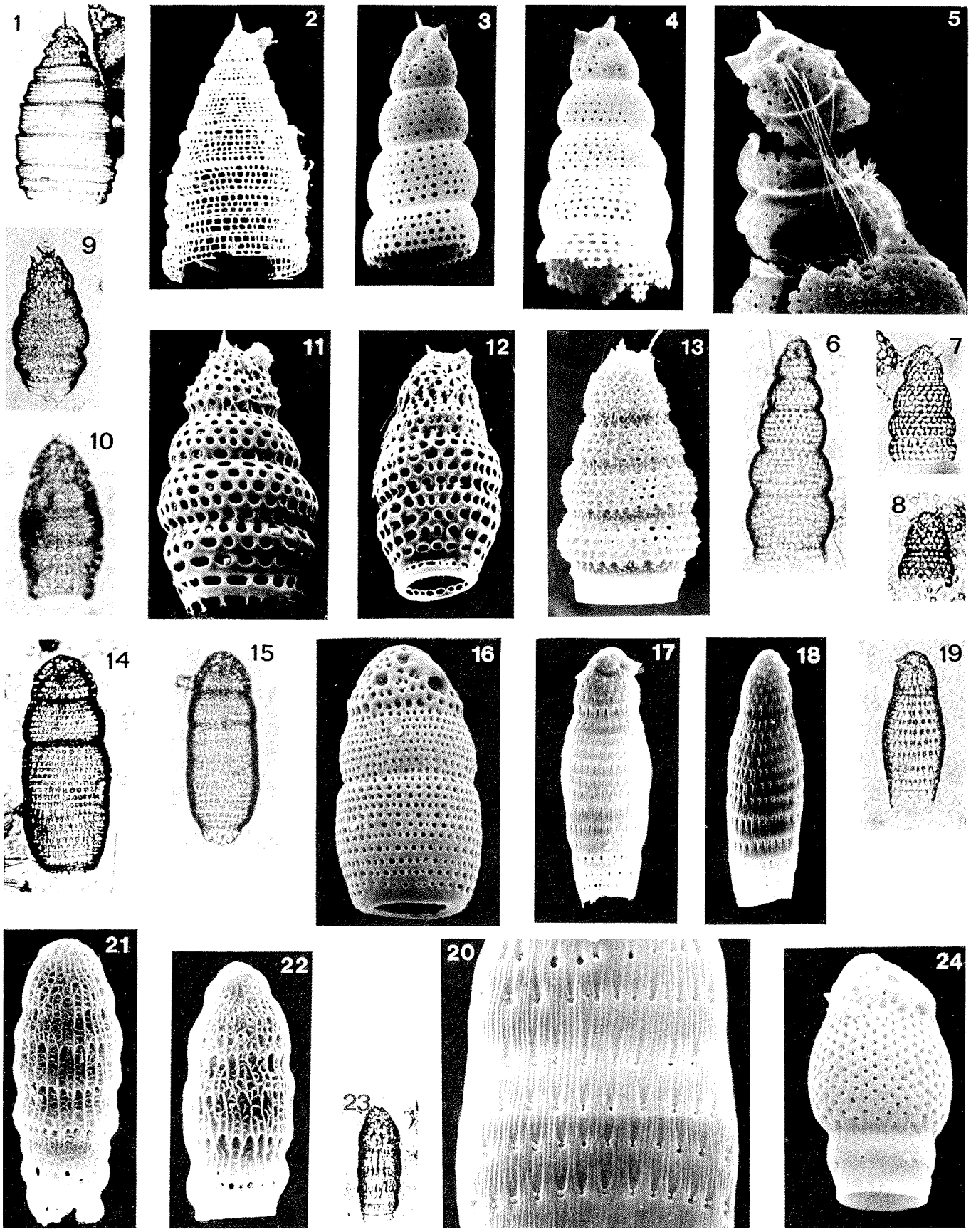
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PLATE 45

Suborder: Nassellaria
Families: Artostrobiidae, Carpocaniidae, Cannobotryidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Artobotrys borealis* (Cleve)	PB: 3769	SEM	×610
2	*Artobotrys borealis* (Cleve)	PB: 2869	LM	×405
3	*Artobotrys borealis* (Cleve)	PB: 2869	LM	×210
4	*Carpocanistrum flosculum* Haeckel	P_1: 4280	SEM	×470
5	*Carpocanistrum cephalum* Haeckel	P_1: 5582	SEM	×450
6	*Carpocanistrum flosculum* Haeckel	P_1: 4280	SEM	×550
7	*Carpocanistrum flosculum* Haeckel	P_1: 5582	SEM	×470
8	*Carpocanistrum favosum* (Haeckel)	P_1: 978	SEM	×470
9	*Carpocanistrum acutidentatum* Takahashi, n. sp.	P_1: 4280	SEM	×440
10	*Carpocanistrum coronatum* Haeckel	P_1: 5582	LM	×210
11	*Carpocanistrum* sp.			
12	*Carpocanistrum cephalum* Haeckel	P_1: 5582	LM	×210
13	*Carpocanistrum acutidentatum* Takahashi, n. sp. Holotype	P_1: 4280	SEM	×340
14	*Carpocanistrum acutidentatum* Takahashi, n. sp. Paratype	PB: 1268	SEM	×300
15	*Carpocanistrum acutidentatum* Takahashi, n. sp. Paratype	PB: 1268	SEM	×330
16	*Carpocanarium papillosum* (Ehrenberg)	PB: 3791	LM	×210
17	*Carpocanarium papillosum* (Ehrenberg)	PB: 2869	LM	×210
18	*Acrobotrys teralans* Renz	PB: 2869	LM	×210
19	*Acrobotrys teralans* Renz	PB: 2869	LM	×210
20	*Acrobotrys tessarolobon* Takahashi, n. sp.	P_1: 978	SEM	×450
21	*Saccospyris preantarctica* Petrushevskaya	P_1: 4280	SEM	×630
22	*Acrobotrys chelinobotrys* Takahashi, n. sp. Paratype	P_1: 4280	SEM	×550
23	*Acrobotrys chelinobotrys* Takahashi, n. sp. Paratype	PB: 3769	LM	×210
24	*Acrobotrys chelinobotrys* Takahashi, n. sp. Holotype	P_1: 978	LM	×210

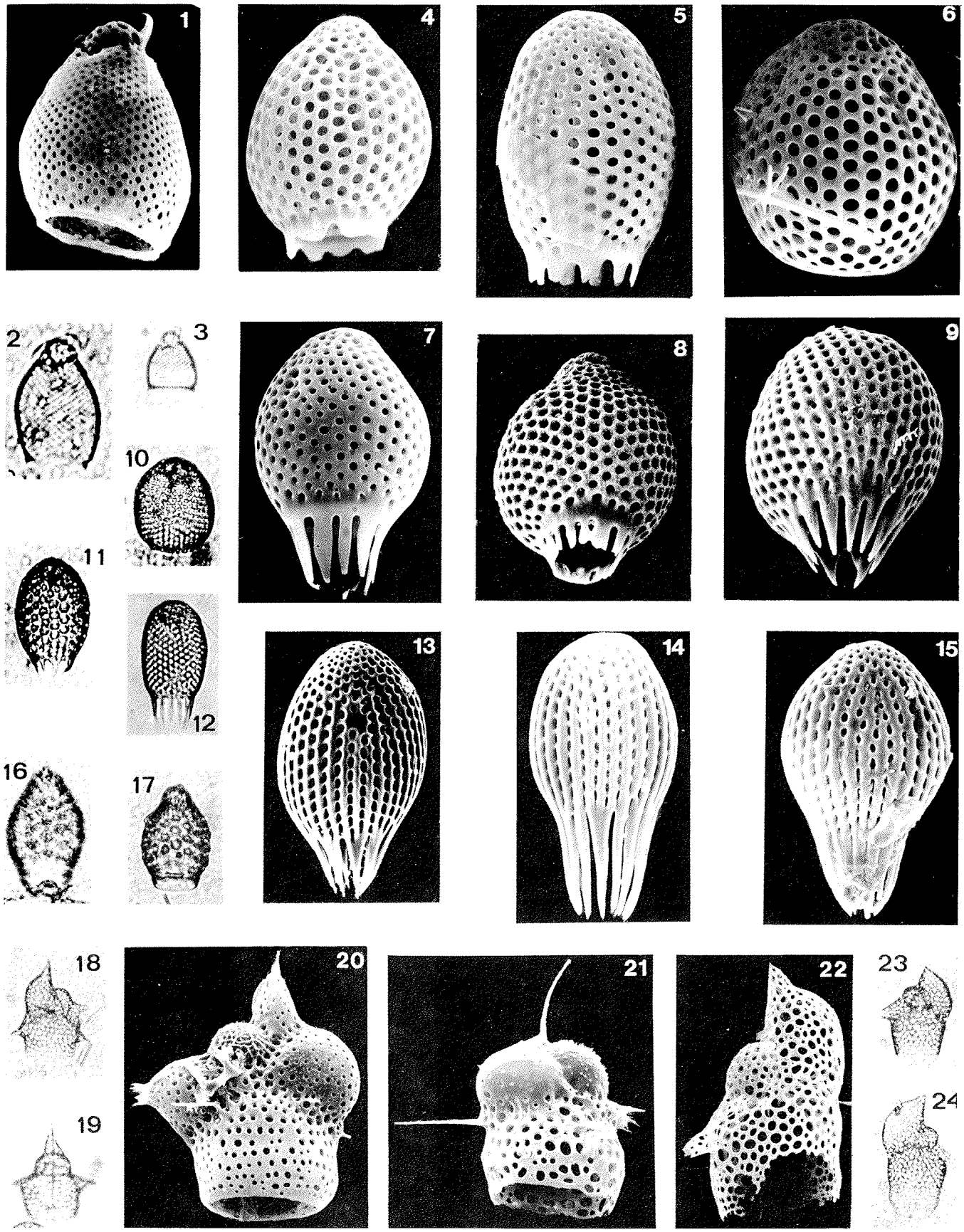
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PLATE 46

Suborder: Nassellaria
Families: Cannobotryidae, Archiphormididae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Centrobotrys thermophila* Petrushevskaya	P_1: 4280	SEM	×350
2	*Centrobotrys thermophila* Petrushevskaya	P_1: 4280	LM	×210
3	*Neobotrys quadrituberosa* Popofsky	PB: 2869	LM	×210
4	*Botryocyrtis* sp. A	P_1: 4280	SEM	×580
5	*Botryocyrtis* sp. A	P_1: 978	SEM	×660
6	*Botryocyrtis scutum* (Harting)	PB: 2869	LM	×210
7	*Botryocyrtis scutum* (Harting)	P_1: 5582	LM	×210
8	*Botryocyrtis elongatum* Takahashi, n. sp. Holotype	PB: 3769	LM	×210
9	*Botryocyrtis elongatum* Takahashi, n. sp. Paratype	P_1: 4280	SEM	×230
10	*Arachnocalpis* ? sp. A	PB: 1268	LM	×84
11	*Arachnocalpis* sp. B	PB: 3769	LM	×210
12	*Arachnocalpis* ? *ovatiretalis* Takahashi, n. sp. Paratype	PB: 3769	LM	×210
13	*Arachnocalpis* ? *ovatiretalis* Takahashi, n. sp. Paratype	PB: 3791	LM	×210
14	*Arachnocalpis* ? *ovatiretalis* Takahashi, n. sp. Holotype	PB: 667	SEM	×180
15	*Arachnocalpis ellipsoides* ? Haeckel Probably a deformed or broken specimen.	P_1: 2778	LM	×210
16	*Arachnocalpis* ? sp. C	P_1: 2778	LM	×210
17	*Arachnocalpis ellipsoides* Haeckel	P_1: 2778	LM	×210
18	A typical view of a portion of untreated filtered sample (250–63 μm fraction). Note predominance of Radiolaria over diatoms and Foraminifera in this size fraction.	P_1: 4280	SEM	×80

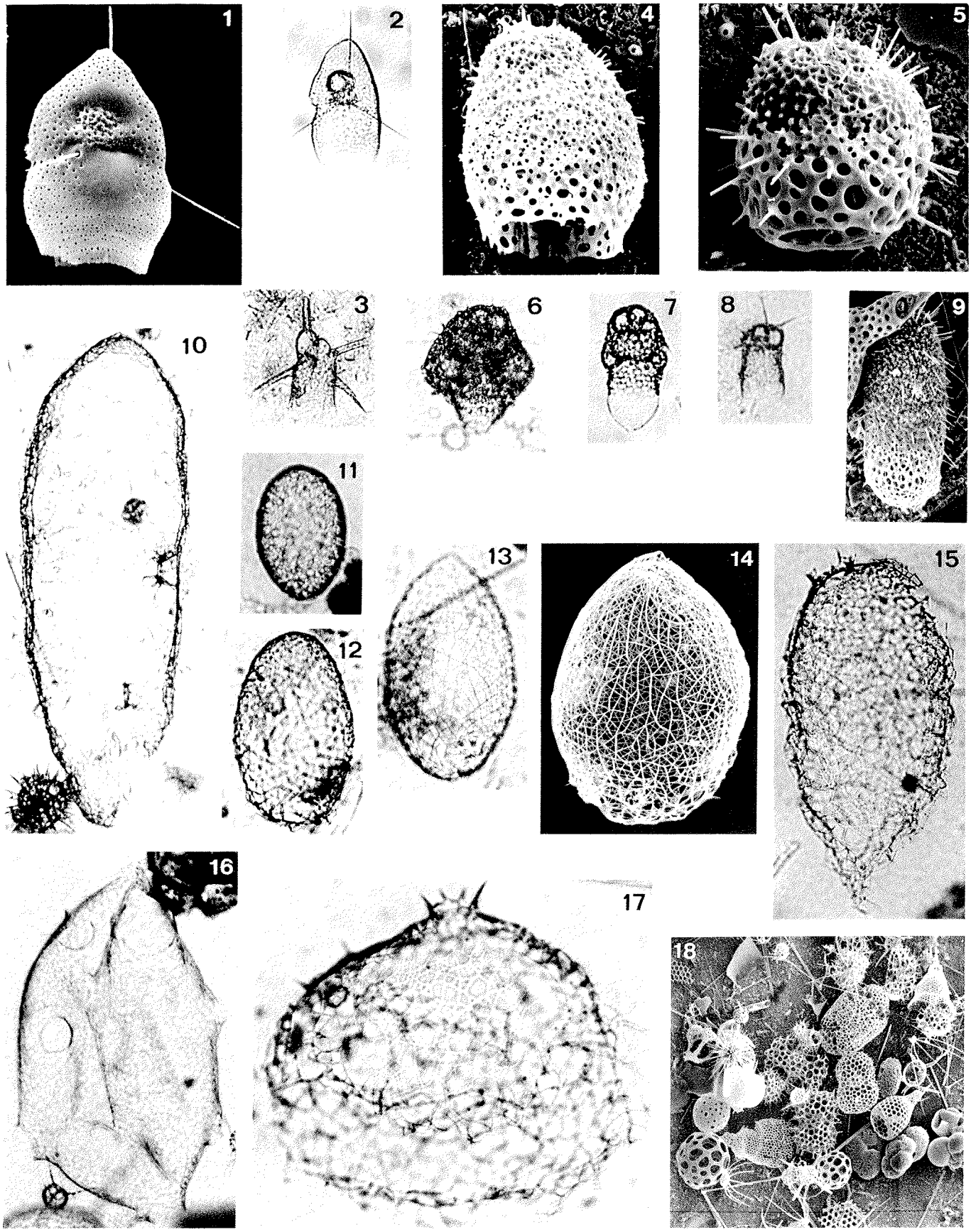
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PLATE 47

Suborder: Phaeodaria
Family: Challengeriidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Challengeron willemoesii* Haeckel Ovate form; lateral view.	PB: 667	SEM	×120
2	*Challengeron willemoesii* Haeckel Ovate form; oblique dorsal view.	PB: 667	SEM	×100
3	*Challengeron willemoesii* Haeckel Ovate form; lateral view.	E: 988	LM	×210
4	*Challengeron willemoesii* Haeckel Ovate form; lateral view,	E: 988	LM	×210
5	*Challengeron willemoesii* Haeckel Ellipsoidal form; lateral view.	PB: 1268	LM	×210
6	*Challengeron willemoesii* Haeckel Ellipsoidal form; lateral view.	P_1: 2778	SEM	×190
7	*Challengeron willemoesii* Haeckel Ellipsoidal form; lateral view. Specimen purposely broken for observation of microstructure.	PB: 1268	SEM	×215
8	*Challengeron willemoesii* Haeckel An extensively dissolved specimen. Note skeletal microstructure.	PB: 3791	SEM	×330
9	*Challengeron willemoesii* Haeckel Same specimen; outside surface.	PB: 3791	SEM	×800
10	*Challengeron willemoesii* Haeckel Same specimen; inside and outside surfaces of amphora structure are shown.	PB: 3791	SEM	×2,600
11	*Challengeron willemoesii* Haeckel Typical sediment trap specimen showing solid unit of amphorae and porous cementing unit between amphorae; cross section and inside surface.	PB: 1268	SEM	×3,400
12	*Challengeron willemoesii* Haeckel A section of figure 11; note the porous area is composed of tubes.	PB: 667	TEM	×11,900
13	*Challengeron willemoesii* Haeckel Relatively undissolved specimen showing indistinguishable porocity between amphorae and cementing units.[a]	P_1: 978	SEM	×2,400
14	*Challengeron willemoesii* Haeckel Cross section of undissolved specimen.[b]	PB: 0–100 plankton tow	TEM	×20,100

[a]Notice how necks of amphorae secure themselves with inside surface membrane.
[b]Note that pores (ca. 50–500 angstom in diameter) are distributed in the part corresponding to the cementing units of figures 8–12, but not on surfaces of amphorae nor outside of shell; conchoidal fractures are artifact due to sectioning.

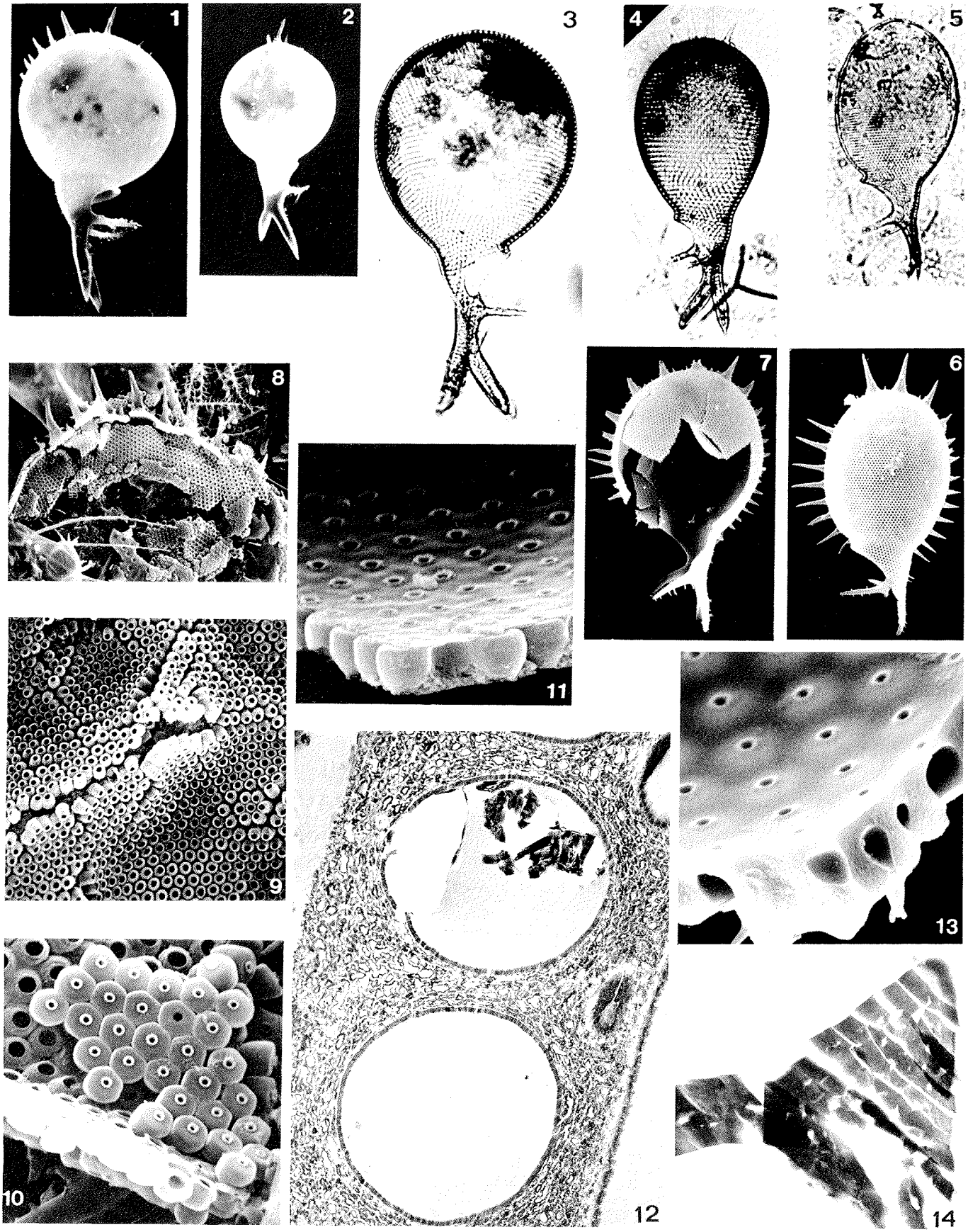
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PLATE 48

Suborder: Phaeodaria
Family: Challengeriidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Challengeron lingi* Takahashi, n. sp. Ovate form; oral view.	P_1: 378	SEM	×385
2	*Challengeron lingi* Takahashi, n. sp. Paratype Ovate form; oblique oral view.	PB: 2869	SEM	×230
3	*Challengeron lingi* Takahashi, n. sp. Holotype Ovate form; oblique ventral view.	P_1: 978	SEM	×180
4	*Challengeron lingi* Takahashi, n. sp. Paratype Ovate form; lateral view.	P_1: 2778	LM	×210
5	*Challengeron lingi* Takahashi, n. sp. Paratype Ellipsoidal form; lateral view.	P_1: 978	SEM	×220
6	*Challengeron radians* Borgert	E: 389	LM	×210
7	*Challengerosium balfouri* (Murray)	E: 389	LM	×210
8	*Challengerosium balfouri* (Murray) Microstructure composed of amphorae, outside and inside surface layers and porous cement.	E: 389	SEM	×5,760
9	*Challengerosium balfouri* (Murray) Ventral view with alveolate stripe on the sagital margin.	E: 389	SEM	×140
10	*Challengerosium balfouri* (Murray) Lateral view with alveolate zone on the marginal edge.	E: 389	SEM	×190
11	*Challengeron tizardi* (Murray) Microstructure showing regularly arranged amphorae cemented with porous silica.	PB: 1268	SEM	×2,100
12	*Challengeron tizardi* (Murray) Specimen purposely broken for microstructural observations.	PB: 1268	SEM	×140
13	*Challengeron tizardi* (Murray) Lateral view.	PB: 1268	LM	×160
14	*Challengeron tizardi* (Murray) Lateral view.	PB: 1268	SEM	×120
15	*Challengeron tizardi* (Murray) Same specimen; oblique apical view.	PB: 1268	SEM	×120
16	*Challengeron tizardi* (Murray) Same specimen; ventral view.	PB: 1268	SEM	×120

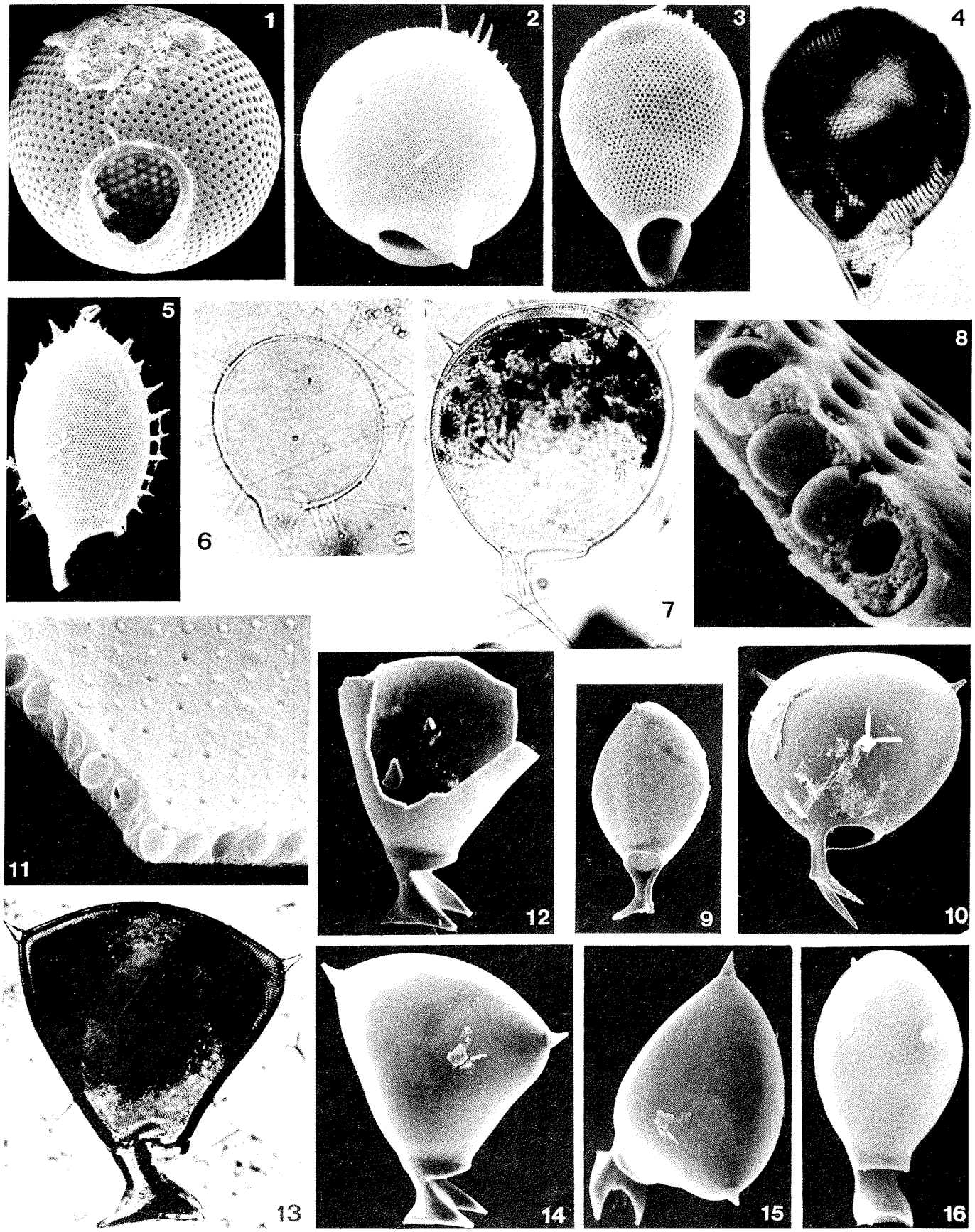
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PLATE 49

Suborder: Phaeodaria
Family: Challengeriidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Challengerosium avicularia* Haecker Ventral view.	P_1: 2778	SEM	×215
2	*Challengerosium avicularia* Haecker Lateral view.	P_1: 978	SEM	×215
3	*Challengerosium avicularia* Haecker Lateral view.	P_1: 2778	SEM	×210
4	*Challengerosium avicularia* Haecker Lateral view.	P_1: 2778	LM	×210
5	*Challengerosium avicularia* Haecker Lateral view.	P_1: 2778	SEM	×220
6	*Challengerosium avicularia* Haecker Same specimen; oblique lateral view.	P_1: 2778	SEM	×200
7	*Challengerosium avicularia* Haecker Oblique lateral view.	P_1: 2778	LM	×210
8	*Challengerosium avicularia* Haecker Lateral view of specimen with two spines.	P_1: 2778	SEM	×240
9	*Challengerosium avicularia* Haecker Specimen with pores connected with outside surface; considered to be dissolved.	P_1: 4280	SEM	×250
10	*Challengerosium avicularia* Haecker A specimen without spines.	P_1: 2778	LM	×210
11	*Challengerosium avicularia* Haecker Microstructure near oral teeth. Note amphoral structure predominant in main body of shell does not extend to teeth.	P_1: 2778	SEM	×830
12	*Challengerosium avicularia* Haecker Two different kinds of surfaces; alveolate marginal zone and smooth central zone.	P_1: 978	SEM	×1,000
13	*Challengerosium avicularia* Haecker Cross-sectional microstructure showing the same morphology in the alveolate and smooth zones.	P_1: 2778	SEM	×2,150
14	*Protocystis* sp. A	P_1: 978	SEM	×280
15	*Protocystis* sp. A	P_1: 978	SEM	×280

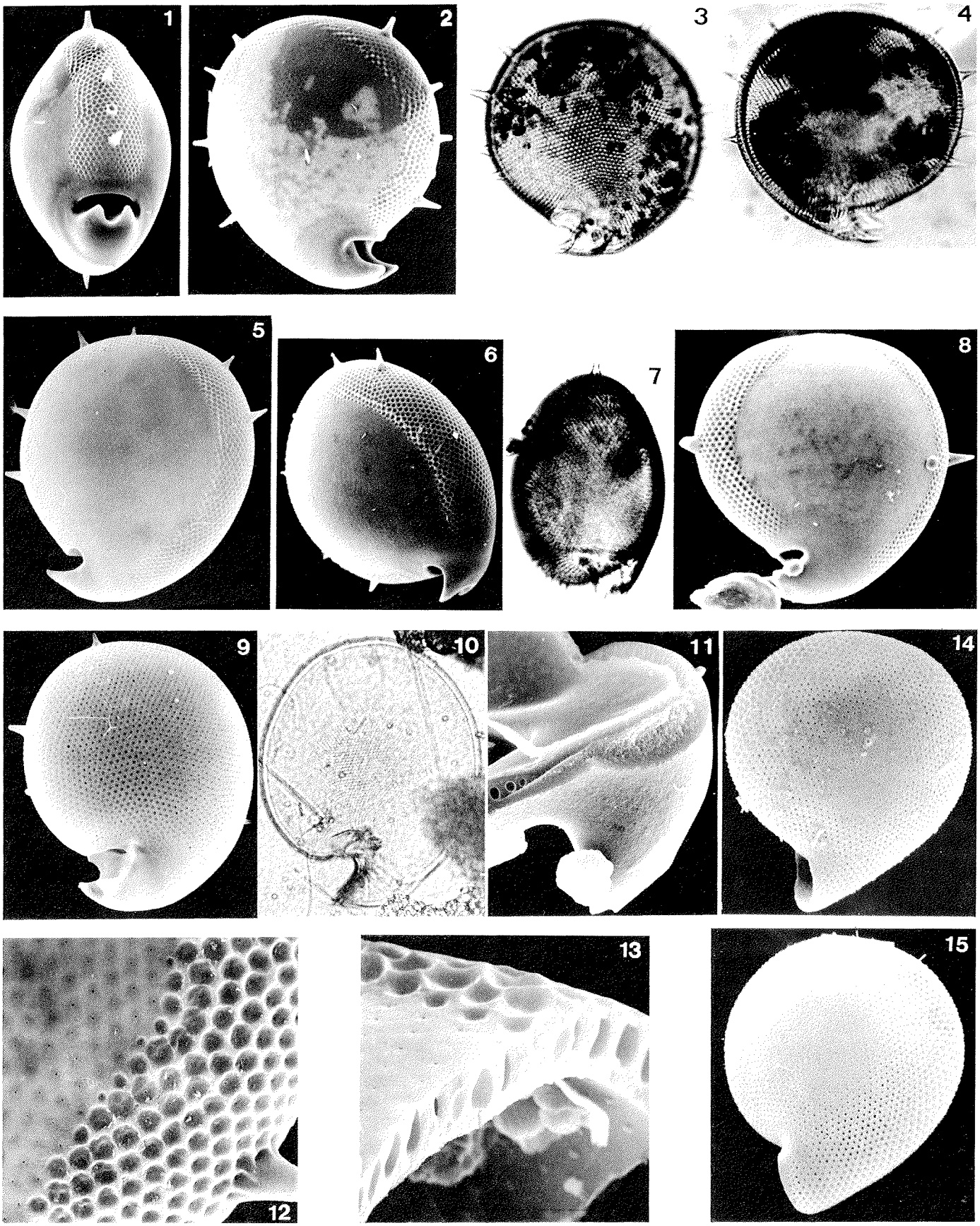
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PLATE 50

Suborder: Phaeodaria
Family: Challengeriidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Protocystis honjoi* Takahashi, n. sp. Paratype	PB: 1268	SEM	×280
2	*Protocystis honjoi* Takahashi, n. sp. Holotype	PB: 2869	LM	×210
3	*Protocystis tridentata* Borgert A specimen with blue tint.	PB: 2869	LM	×210
4	*Protocystis auriculata* Takahashi, n. sp. Paratype; oblique ventral view.	PB: 1268	SEM	×440
5	*Protocystis auriculata* Takahashi, n. sp. Paratype; lateral view.	PB: 1268	SEM	×440
6	*Protocystis auriculata* Takahashi, n. sp. Holotype; lateral view.	PB: 2869	LM	×210
7	*Protocystis auriculata* Takahashi, n. sp. Paratype; oblique ventral view.	PB: 2869	LM	×210
8	*Protocystis aduncicuspis* Takahashi, n. sp. Paratype	PB: 3791	SEM	×220
9	*Protocystis aduncicuspis* Takahashi, n. sp. Holotype	PB: 3791	LM	×210
10	*Protocystis aduncicuspis* Takahashi, n. sp.	PB: 2869	LM	×210
11	*Protocystis* sp. B	PB: 3791	SEM	×165
12	*Protocystis sloggetti* (Haeckel)	PB: 1268	LM	×210
13	*Protocystis sloggetti* (Haeckel)	P_1: 978	SEM	×120
14	*Protocystis sloggetti* (Haeckel) A purposely broken specimen. Note many spherical organic aggregates inside of the shell.	PB: 1268	SEM	×160
15	*Protocystis sloggetti* (Haeckel) A specimen with broken teeth.	PB: 1268	SEM	×250
16	*Protocystis murrayi* (Haeckel) Ventral view.	P_1: 2778	LM	×210
17	*Protocystis murrayi* (Haeckel) Microstructure showing a cross section of amphorae and outside. surface.	P_1: 2778	SEM	×2,500
18	*Protocystis murrayi* (Haeckel) Same specimen; amphorae buried in siliceous cement and pores are open.	P_1: 2778	SEM	×3,600

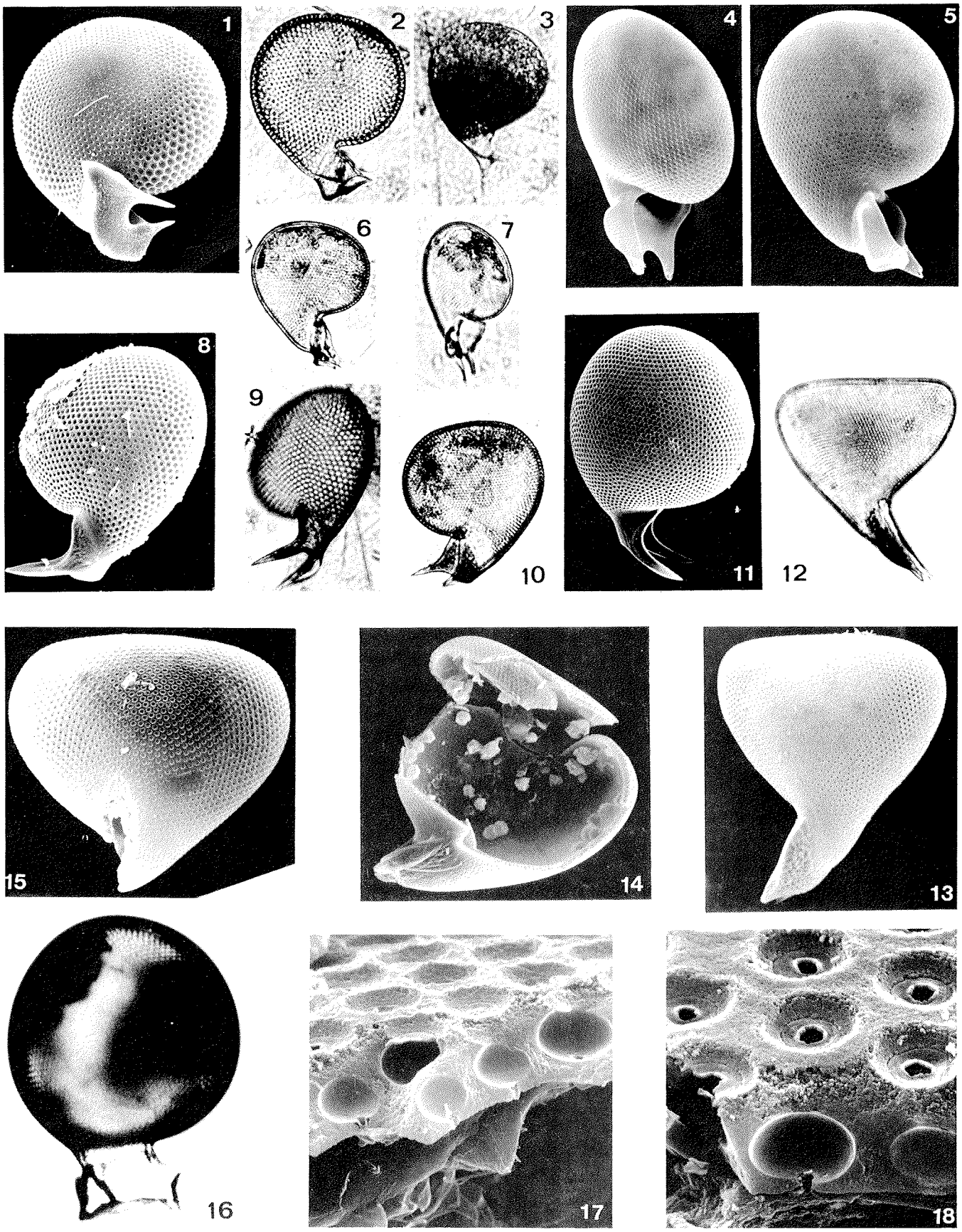
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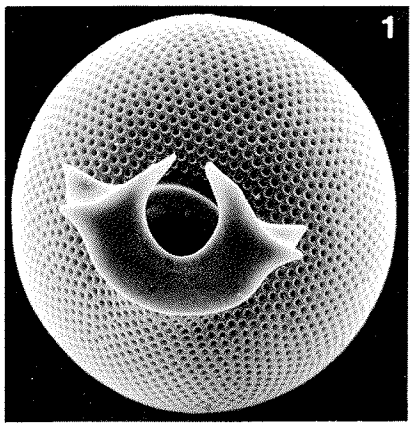
PLATE 51

Suborder: Phaeodaria
Family: Challengeriidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Protocystis murrayi* (Haeckel) Oral view.	P_1: 2778	SEM	×230
2	*Protocystis murrayi* (Haeckel) Ventral view.	P_1: 2778	SEM	×180
3	*Protocystis murrayi* (Haeckel) Lateral view.	P_1: 2778	SEM	×160
4	*Protocystis* sp. C Lateral view.	P_1: 2778	LM	×210
5	*Protocystis thomsoni* (Murray) Lateral view.	E: 988	LM	×210
6	*Pharyngella gastrula* Haeckel Dorsal view.	E: 988	SEM	×100
7	*Pharyngella gastrula* Haeckel Lateral view.	E: 988	SEM	×90
8	*Pharyngella gastrula* Haeckel Dorsal view.	E: 988	LM	×210
9	*Pharyngella gastrula* Haeckel Inside view showing detail of a pharynx.	E: 988	SEM	×320
10	*Pharyngella gastrula* Haeckel Microstructure showing amphorae and partially peeled off inside surface membrane.	E: 988	SEM	×9,000
11	*Pharyngella gastrula* Haeckel Microstructure showing amphorae and outside surface.	E: 988	SEM	×3,200
12	*Pharyngella gastrula* Haeckel Lateral view of a pharynx.	E: 988	SEM	×340
13	*Pharyngella gastrula* Haeckel Same specimen, microstructure of the peristome.	E: 988	SEM	×1,400
14	*Pharyngella gastrula* Haeckel Same specimen, an enlarged view. of figures 12–13. Note that this structure is a lateral cross section of amphorae which are slightly different in size and shape from those in main part of the shell.	E: 988	SEM	×3,000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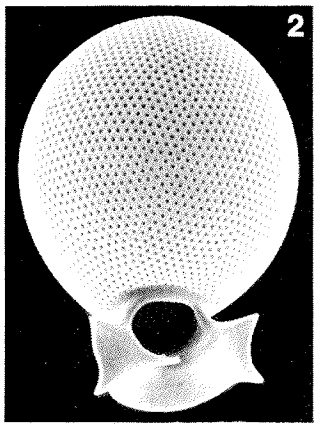
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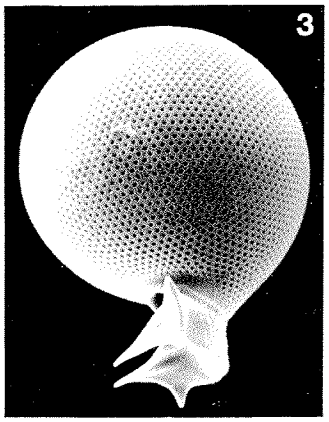
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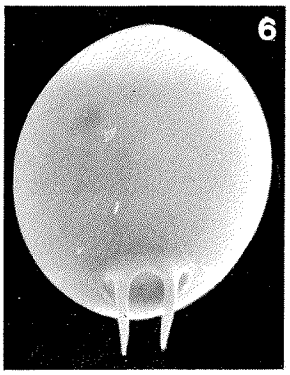
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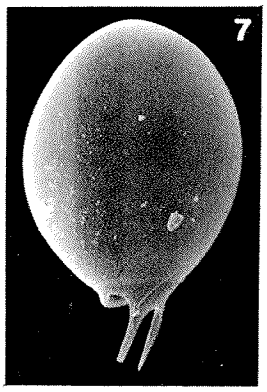
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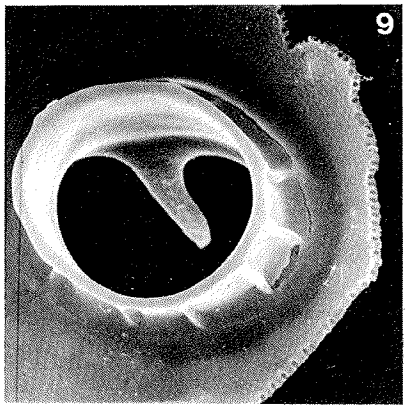
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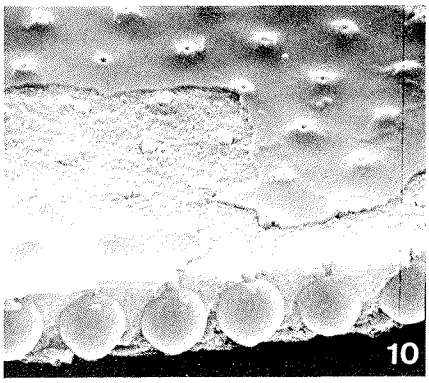
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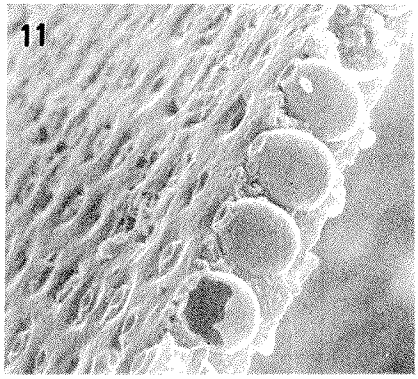
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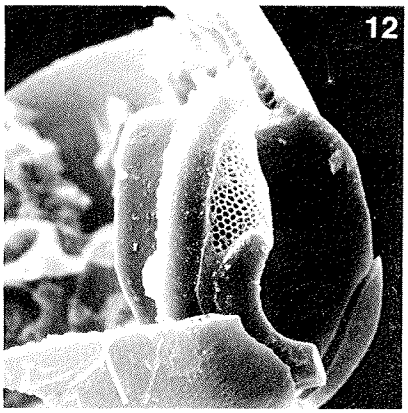
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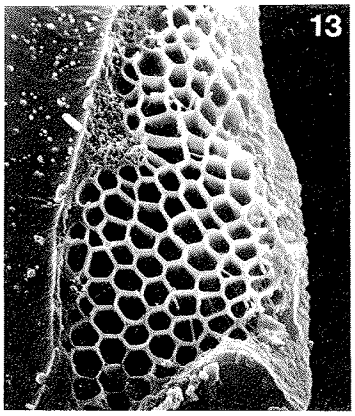
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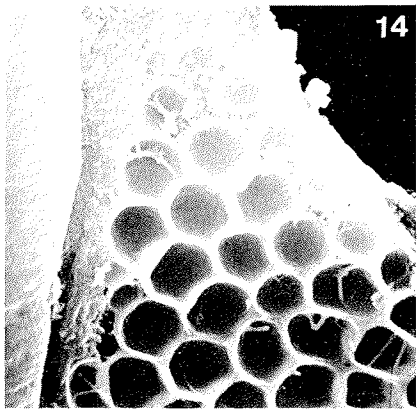
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PLATE 52

Suborder: Phaeodaria
Family: Challengeriidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Protocystis xiphodon* (Haeckel)	PB: 1268	SEM	×220
2	*Protocystis xiphodon* (Haeckel)	PB: 1268	LM	×210
3	*Protocystis xiphodon* (Haeckel) View from inside of a broken specimen showing amphorae and their necks securing themselves to inside surface membrane.	PB: 1268	SEM	×4,700
4	*Protocystis tritonis* (Haeckel)	E: 389	LM	×210
5	*Protocystis tritonis* (Haeckel)	E: 389	LM	×210
6	*Protocystis naresi* (Murray) Lateral view.	E: 988	SEM	×47
7	*Protocystis naresi* (Murray) Microstructure showing amphorae which are slightly more elongated than those in other 16 species of Challengeriidae.	E: 988	SEM	×3,600
8	*Protocystis naresi* (Murray) Oblique oral view.	E: 988	SEM	×75
9	*Entocannula infundibulum* Haeckel	PB: 1268	LM	×160
10	*Entocannula infundibulum* Haeckel	PB: 3769	SEM	×110
11	*Challengeranium diodon* (Haeckel) Microstructure showing delicate amphorae which have many small pores connected with inside of the shell.	PB: 1268	SEM	×4,000
12	*Challengeranium diodon* (Haeckel) Shell surface is alveolate and very different from all other Challengeriidae studied here; dorsal view.	PB: 1268	SEM	×900
13	*Challengeranium diodon* (Haeckel) Lateral view.	PB: 1268	LM	×210
14	*Challengeranium diodon* (Haeckel) Oblique ventral view.	PB: 389	LM	×210
15	*Challengeranium diodon* (Haeckel) Ventral view.	PB: 667	LM	×210
16	*Challengeranium diodon* (Haeckel) Ventral view.	E: 988	SEM	×385

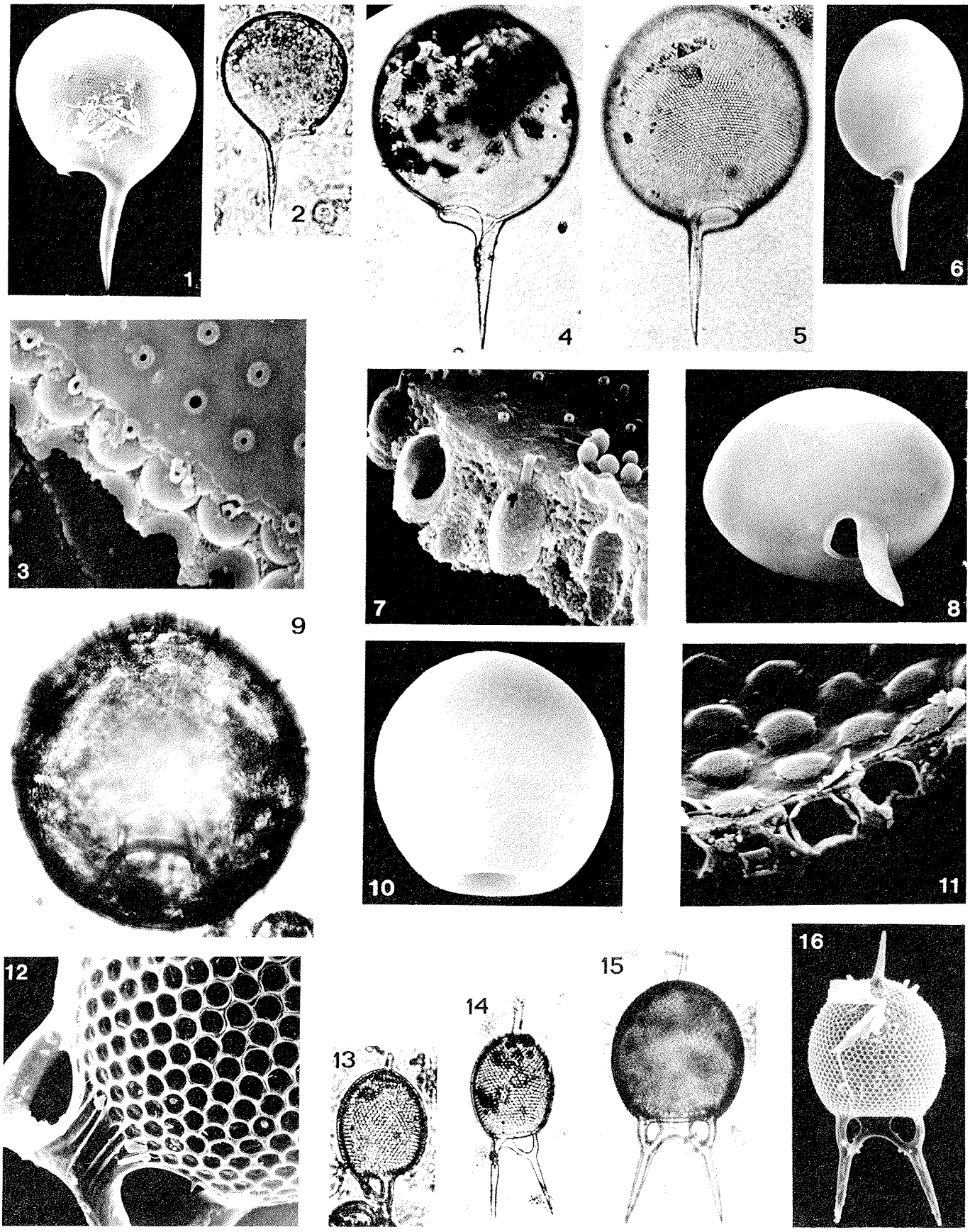
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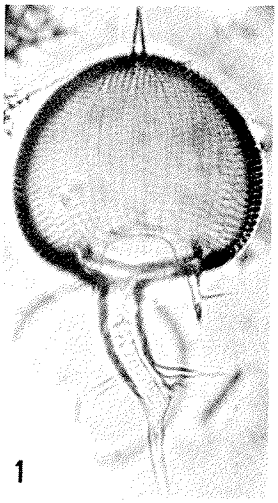
PLATE 53

Suborder: Phaeodaria
Family: Medusettidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Euphysetta elegans* Borgert Ventral view.	P_1: 2778	LM	×210
2	*Euphysetta elegans* Borgert Lateral view.	PB: 2869	LM	×210
3	*Euphysetta elegans* Borgert Oblique lateral view.	P_1: 978	SEM	×280
4	*Euphysetta elegans* Borgert Oblique ventral view.	P_1: 2778	SEM	×230
5	*Euphysetta elegans* Borgert Ventral view.	P_1: 978	SEM	×290
6	*Euphysetta elegans* Borgert Specimen with long apical horn and a foot; ventral view.	E: 3755	SEM	×320
7	*Euphysetta elegans* Borgert Specimen with long apical horn and a foot; lateral view.	PB: 2869	LM	×210
8	*Euphysetta elegans* Borgert Cross section across oblique transverse plane including base of large foot. Specimen ashed at 50°C for one hour.	PB: 2869	TEM	×1,300
9	*Euphysetta elegans* Borgert Microstructure showing two layers of large pores, additional layers of small pores and inside shell surface.	PB: 1268	SEM	×4,460
10	*Euphysetta elegans* Borgert Micro- and ultrastructures showing circular pores and alveolate outside surface. Note porosity varies from one part to another; wavy lines are artifact of the sectioning.	PB: 1268	TEM	×6,700
11	*Euphysetta staurocodon* Haeckel A small specimen with blue tint; lateral view.	PB: 2869	LM	×210
12	*Euphysetta staurocodon* Haeckel A large specimen with spherical shells and blue tint; lateral view.	P_1: 2778	LM	×210
13	*Euphysetta staurocodon* Haeckel Lateral view.	PB: 3769	SEM	×410
14	*Euphysetta staurocodon* Haeckel A specimen with blue tint; ventral view.	PB: 2869	LM	×210
15	*Euphysetta pusilla* Cleve	E: 389	LM	×850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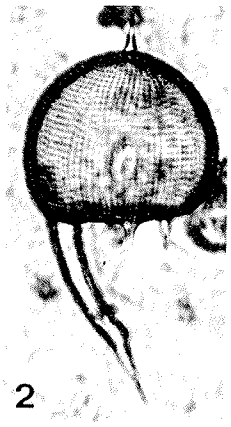
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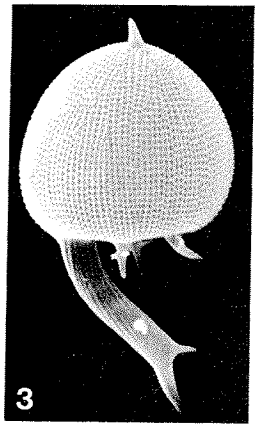
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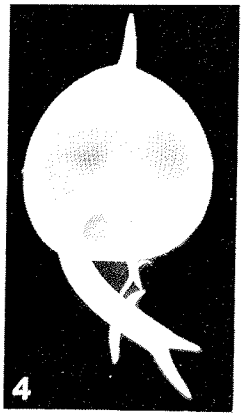
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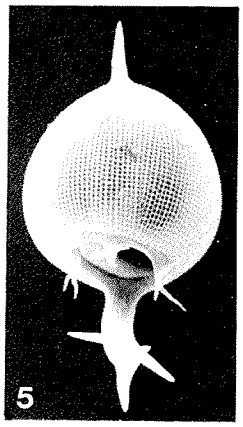
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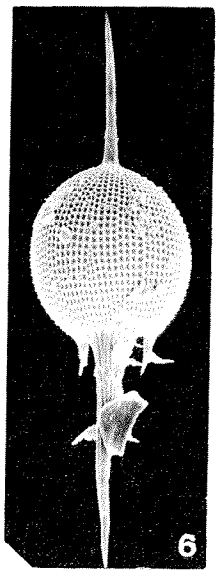
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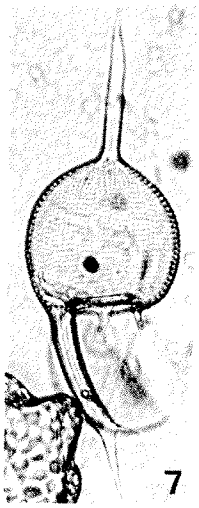
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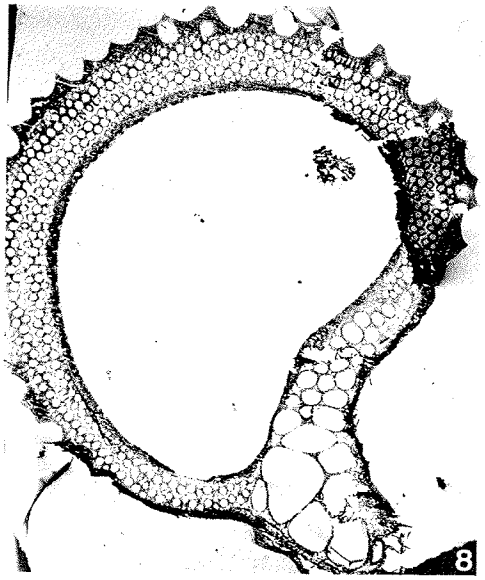
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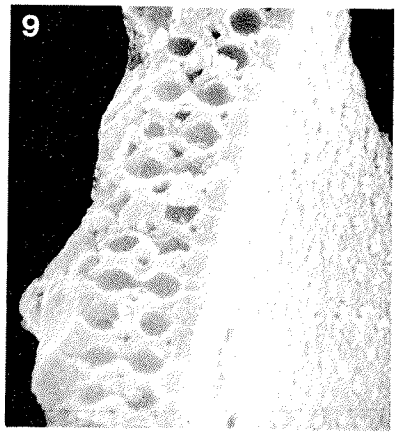
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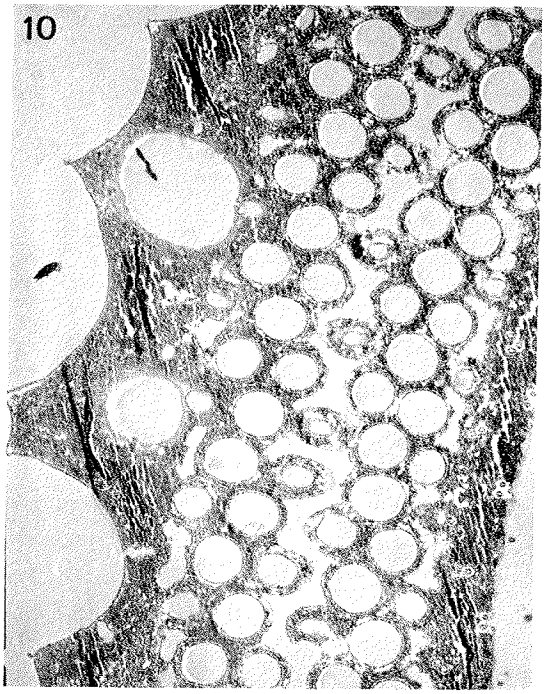
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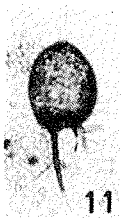
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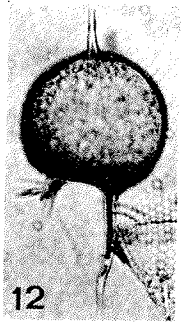
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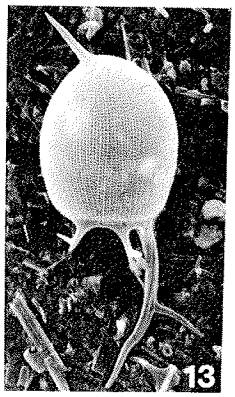
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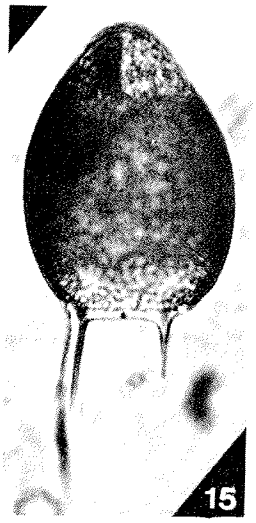
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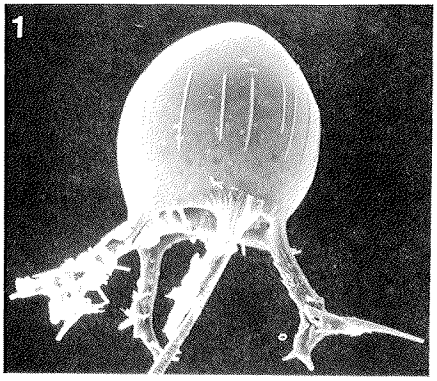
PLATE 54

Suborder: Phaeodaria
Families: Medusettidae, Lirellidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Medusetta ansata* Borgert	E: 389	SEM	×450
2	*Medusetta ansata* Borgert	PB: 3769	LM	×210
3	*Medusetta ansata* Borgert	E: 389	LM	×210
4	*Medusetta ansata* Borgert	E: 389	LM	×210
5	*Medusetta ansata* Borgert Cross section of the shell showing rectangular pores.	E: 389	SEM	×6,400
6	*Medusetta ansata* Borgert	PB: 2869	SEM	×280
7	*Medusetta ansata* Borgert	P_1: 2778	LM	×210
8	*Medusetta* sp.	E: 389	LM	×210
9	*Medusetta* sp.	E: 389	LM	×210
10	*Euphysetta lucani* Borgert	P_1: 978	SEM	×170
11	*Euphysetta lucani* Borgert View from oral side showing sub-triangular perimeter.	E: 3755	SEM	×230
12	*Euphysetta lucani* Borgert	E: 3755	LM	×210
13	*Borgertella caudata* (Wallich)	P_1: 4280	SEM	×450
14	*Borgertella caudata* (Wallich) Note that the hollow ring is attached to outside of the shell near the peristome.	PB: 3769	SEM	×830
15	*Borgertella caudata* (Wallich)	PB: 3769	SEM	×830
16	*Borgertella caudata* (Wallich)	E: 389	LM	×850
17	*Borgertella caudata* (Wallich)	P_1: 4280	SEM	×470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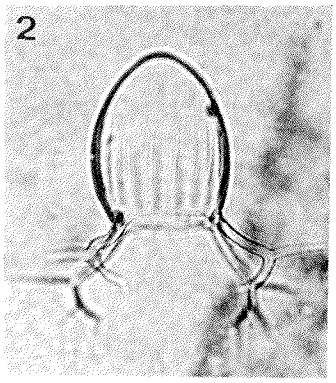
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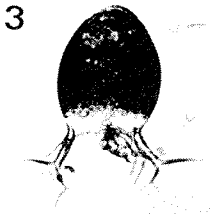
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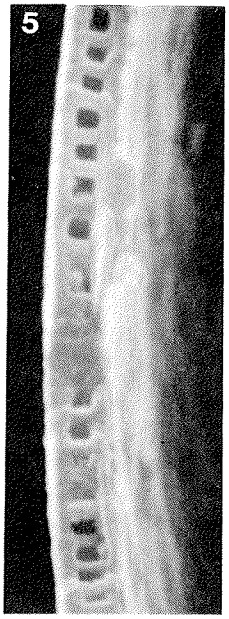
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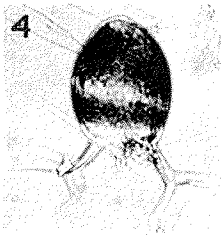
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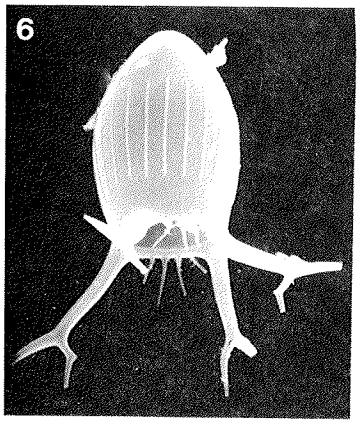
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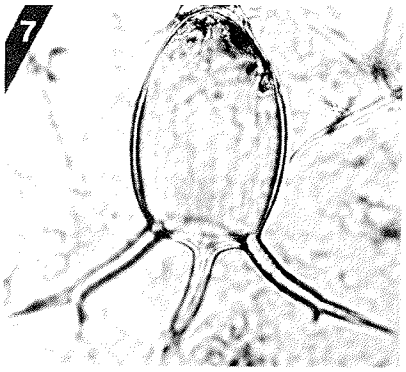
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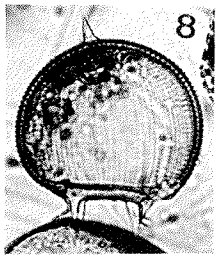
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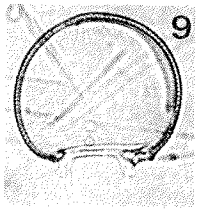
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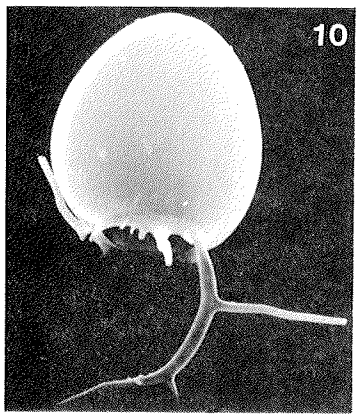
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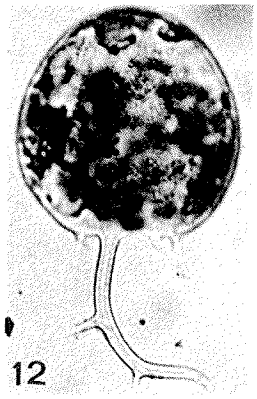
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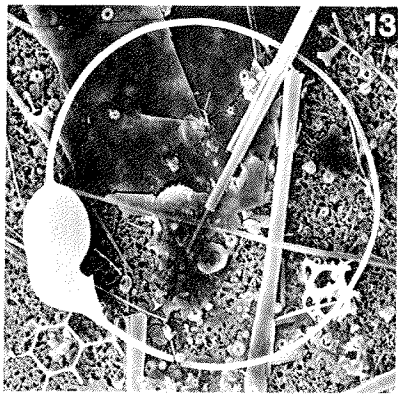
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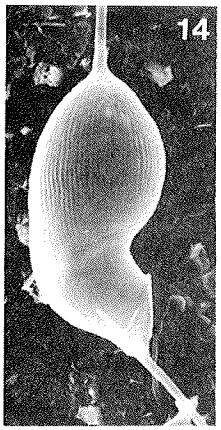
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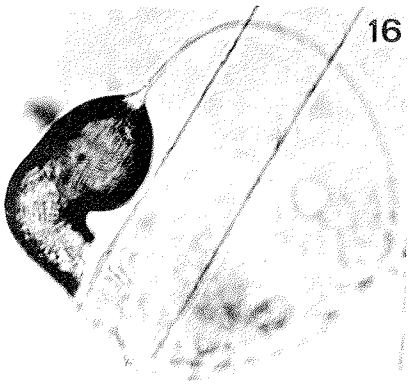
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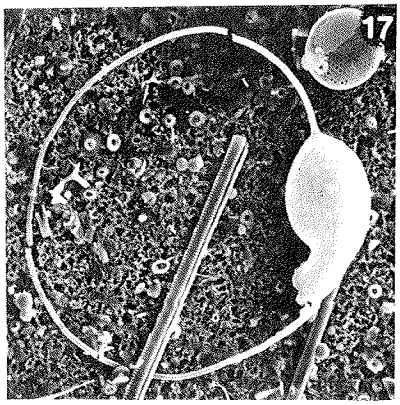
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PLATE 55

Suborder: Phaeodaria
Family: Lirellidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Borgertella caudata* (Wallich) The hollow ring.	PB: 3769	SEM	×4,410
2	*Borgertella caudata* (Wallich)	PB: 3769	SEM	×990
3	*Borgertella caudata* (Wallich) Specimen slightly dissolved.	PB: 3769	SEM	×1,100
4	*Borgertella caudata* (Wallich) Specimen extensively dissolved; integrity of wavy crests and striae lost.	PB: 3769	SEM	×660
5	*Borgertella caudata* (Wallich) Same specimen; pores showing hexagonal meshwork.	PB: 3769	SEM	×2,480
6	*Borgertella caudata* (Wallich) View of internal structure of skeleton. Note hexagonal meshwork structure.	PB: 3769	SEM	×2,260
7	*Lirella baileyi* Ehrenberg	PB: 3769	SEM	×830
8	*Lirella bullata* (Stadum and Ling) Ventral view.	PB: 3769	SEM	×880
9	*Lirella bullata* (Stadum and Ling) Oblique ventral view.	PB: 3769	SEM	×740
10	*Lirella bullata* (Stadum and Ling) Oblique apical view.	E: 3755	SEM	×1,290
11	*Lirella bullata* (Stadum and Ling) Lateral view.	PB: 1268	LM	×850
12	*Lirella melo* (Cleve)	PB: 1268	SEM	×470
13	*Lirella melo* (Cleve) Same specimen	PB: 1268	SEM	×600
14	*Lirella melo* (Cleve)	E: 3755	SEM	×370
15	*Lirella melo* (Cleve)	PB: 3769	SEM	×550
16	*Lirella melo* (Cleve)	PB: 3769	SEM	×410
17	*Lirella melo* (Cleve)	PB: 2869	LM	×210
18	*Lirella melo* (Cleve)	PB: 2869	LM	×210
19	*Lirella tortuosa* Takahashi, n. sp. Paratype; right coiled.	PB: 2869	LM	×210
20	*Lirella tortuosa* Takahashi, n. sp. Paratype; left coiled.	PB: 1268	LM ×210	

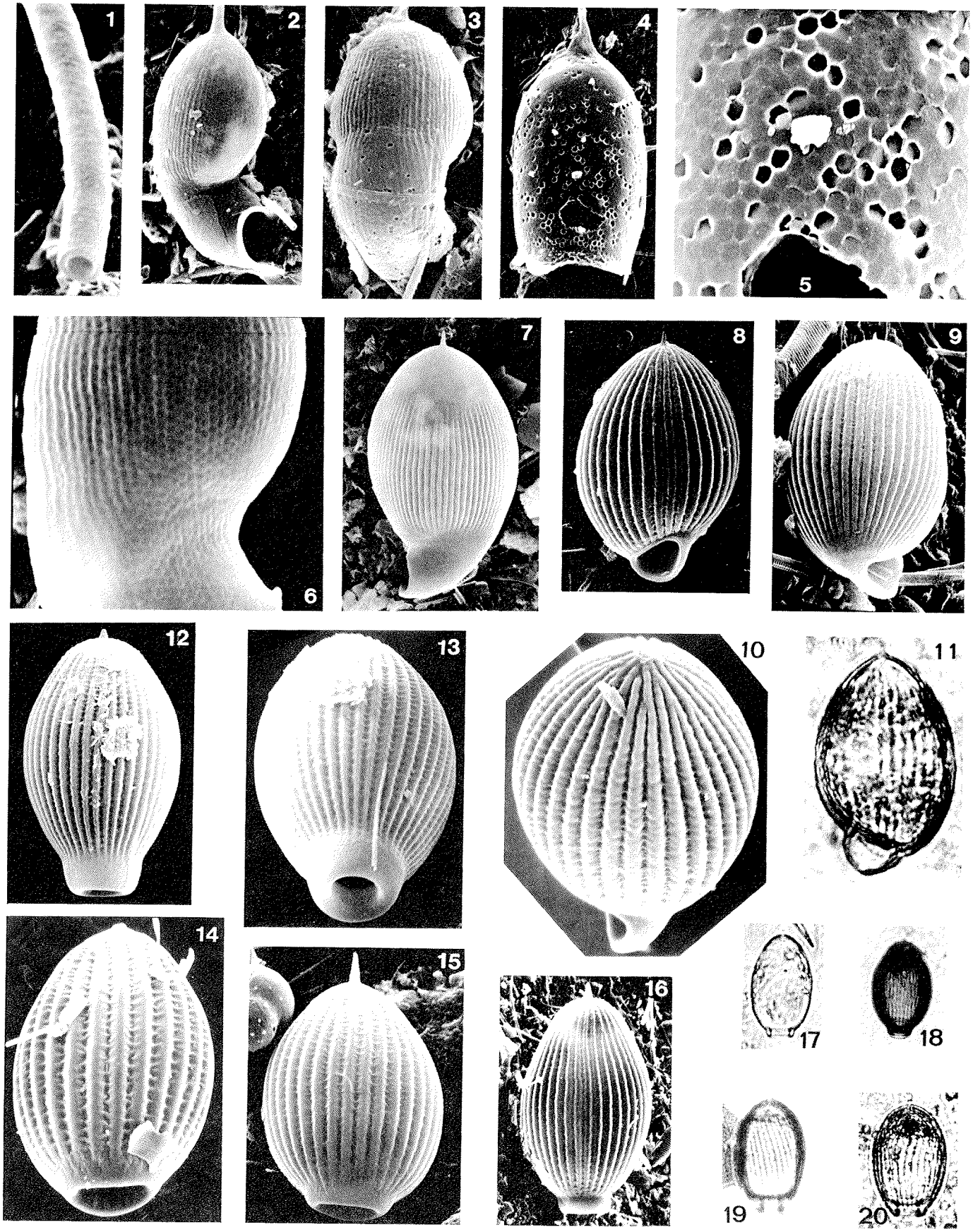
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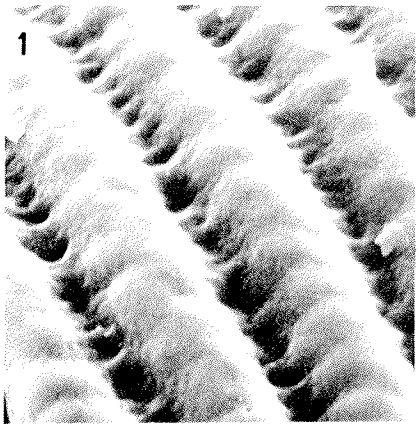
PLATE 56

Suborder: Phaeodaria
Family: Lirellidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Lirella bullata* (Stadum and Ling) Same specimen as Plate 55, figure 10. Detail of wavy crests and striae.	E: 3755	SEM	×6,400
2	*Lirella melo* (Cleve) Cross section of a part of peristome showing several layers of different porosity.	PB: 1268	SEM	×3,000
3	*Lirella melo* (Cleve) Cross section corresponding to figure 2, showing polygonal meshwork in central part and two other layers of different porocity. Specimen ashed at 500°C for one hour.	PB: 2869	TEM	×8,300
4	*Lirella melo* (Cleve) Same specimen.	PB: 2869	TEM	×2,000
5	*Lirella melo* ? (Cleve) Extensively dissolved specimen; shell integrity diminished.	PB: 3769	SEM	×1,600
6	*Lirella melo* (Cleve) Cross section showing polygonal meshwork and the pores.	PB: 1268	SEM	×5,000
7	*Lirella melo* (Cleve) Same specimens as figure 3; cross section showing polygonal meshwork and porous outer layers. Note that the polygons are made of tubes.	P_1: 978	TEM	×7,600
8	*Lirella melo* (Cleve) Cross section showing irregular pores bounded by tubular structure which is different from figures 3, 7.	P_1: 4280	TEM	×6,100
9	*Lirella tortuosa* Takahashi, n. sp. Paratype; right coiled.	PB: 1268	SEM	×500
10	*Lirella tortuosa* Takahashi, n. sp. Holotype; left coiled.	P_1: 4280	SEM	×450
11	*Lirella tortuosa* Takahashi, n. sp. Right coiled.	P_1: 4280	SEM	×470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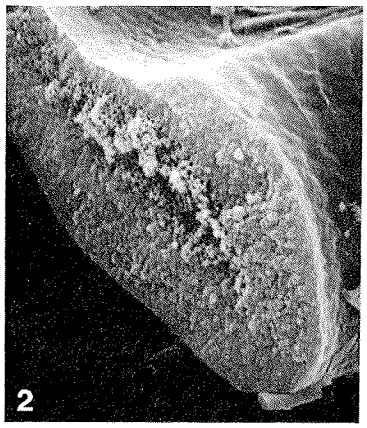
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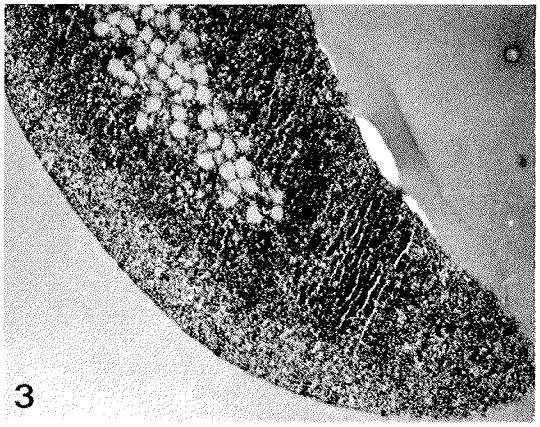
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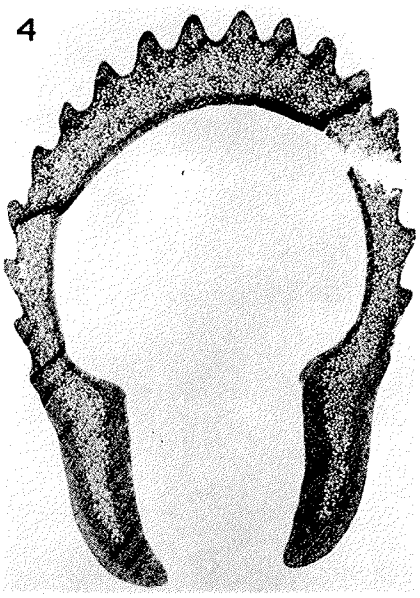
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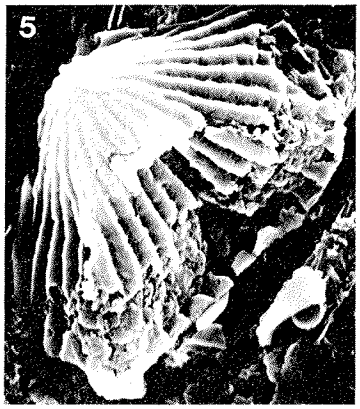
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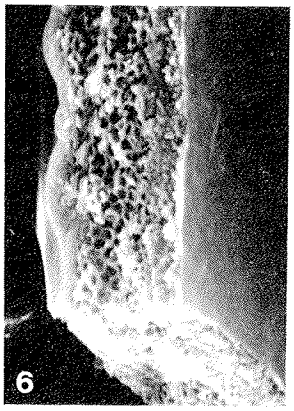
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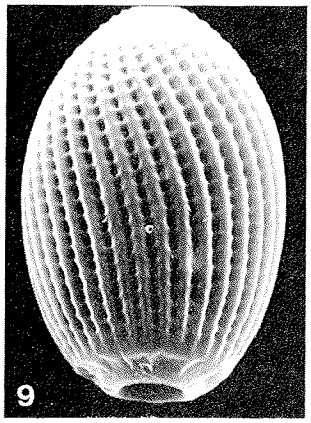
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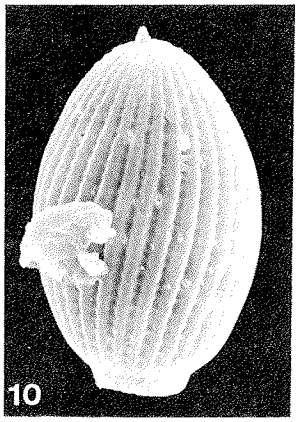
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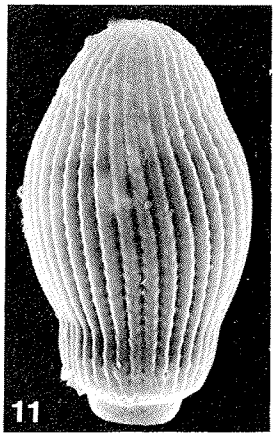
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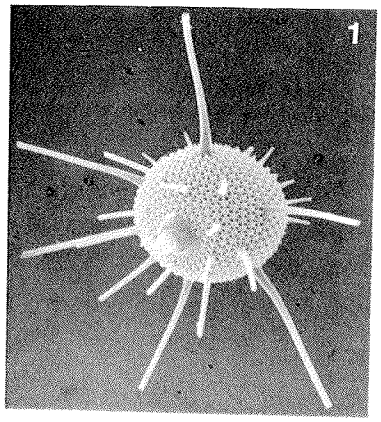
PLATE 57

Suborder: Phaeodaria
Families: Porospathididae, Castanellidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Porospathis holostoma* (Cleve) Oblique ventral view.	P_1: 978	SEM	×130
2	*Porospathis holostoma* (Cleve) Lateral view.	P_1: 4280	SEM	×165
3	*Porospathis holostoma* (Cleve) Lateral view.	PB: 3791	LM	×210
4	*Porospathis holostoma* (Cleve) Ventral view.	P_1: 2778	LM	×380
5	*Porospathis holostoma* (Cleve) Lateral view.	PB: 3769	SEM	×360
6	*Porospathis holostoma* (Cleve) Detail of figure 1 showing surface morphology near the projected tube-like mouth.	P_1: 978	SEM	×1,300
7	*Porospathis holostoma* (Cleve) Detail of figure 5 showing surface morphology detail.	PB: 3769	SEM	×5,500
8	*Porospathis holostoma* (Cleve) Detail of figure 2 showing cross section near a spine.	P_1: 4280	SEM	×2,200
9	*Castanidium longispinum* Haecker	PB: 667	SEM	×70
10	*Castanidium longispinum* Haecker	PB: 1268	LM	×106
11	*Castanidium longispinum* Haecker	GO:plt[a]	SEM	×55
12	*Castanidium longispinum* Haecker	PB: 2778	SEM	×130
13	*Castanidium longispinum* Haecker	PB: 3791	LM	×65

[a]Gulf of Oman: surface plankton tow.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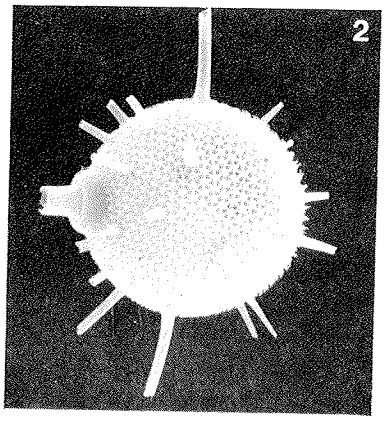
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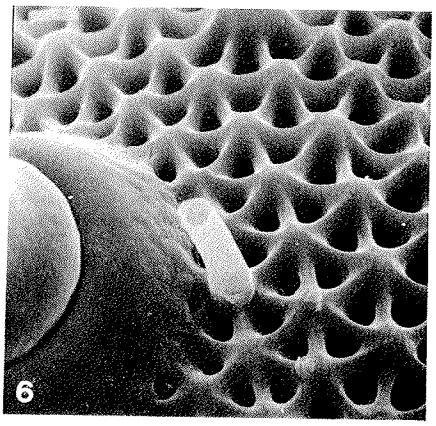
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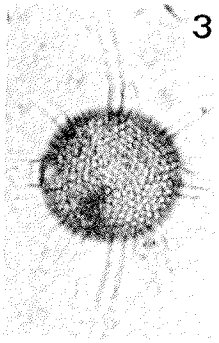
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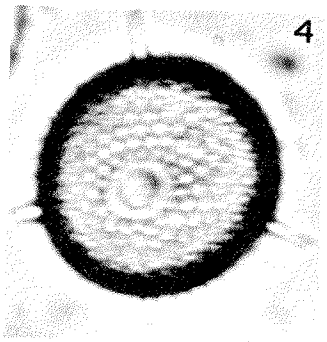
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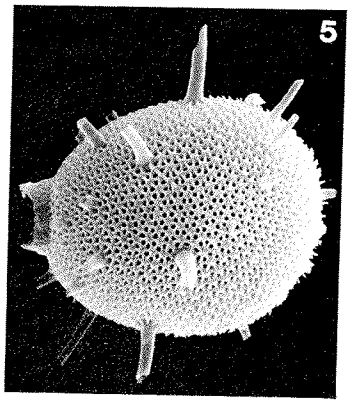
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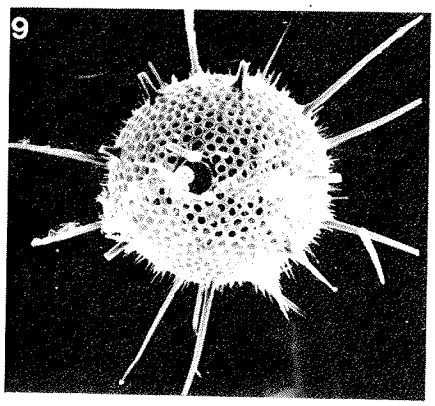
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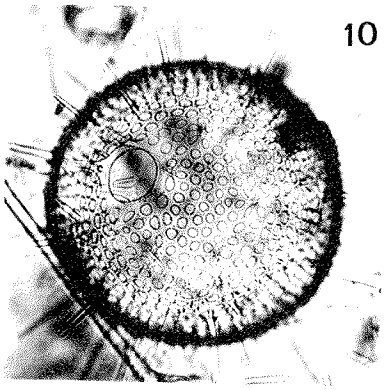
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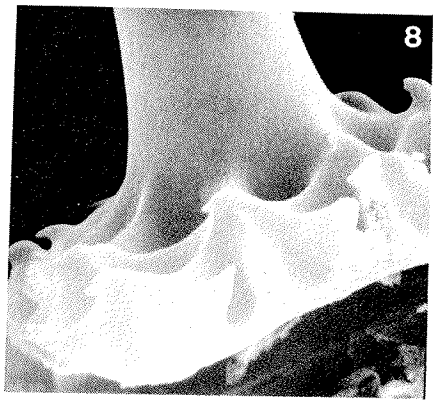
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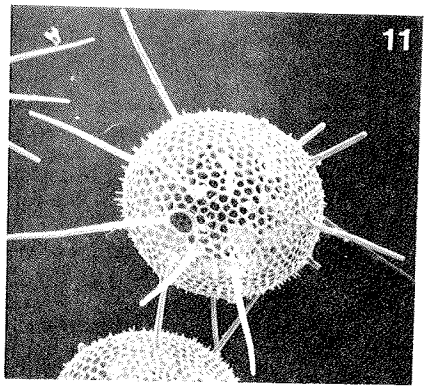
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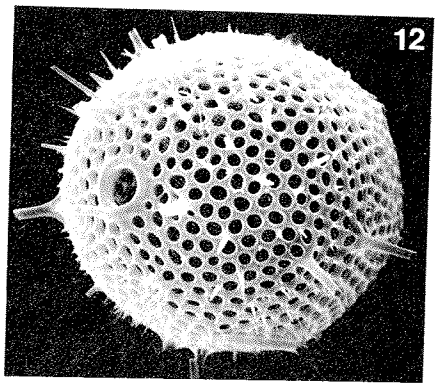
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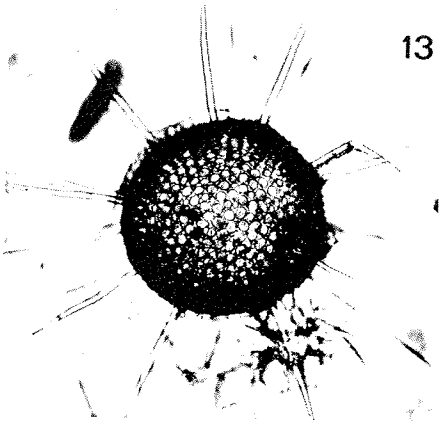
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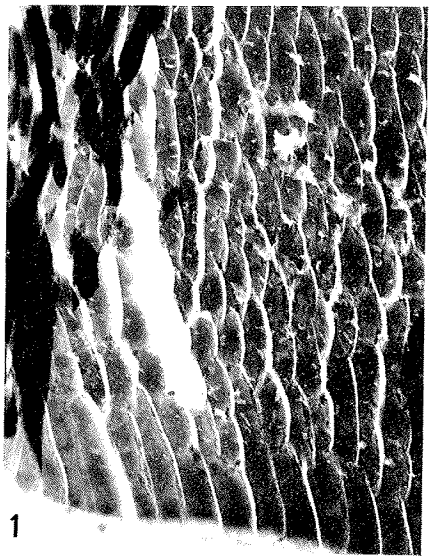
PLATE 58

Suborder: Phaeodaria
Family: Castanellidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Castanidium longispinum* Haecker Primary feature of relatively solid unit having ca. 150–800 angstrom pores in the central part of skeleton; conchoidal fractures are artifact with the sectioning.	PB: 0–100 plankton tow	TEM	×17,000
2	*Castanidium longispinum* Haecker Cross section of relatively undissolved specimen showing brittle texture of the broken surface.	PB: 389	SEM	×1,920
3	*Castanidium longispinum* Haecker Secondary feature due to dissolution, having pores bounded by tubular skeleton.	E: 1268	TEM	×5,600
4	*Castanidium longispinum* Haecker Morphology corresponding to figure 3. Note presence of slit-like space; occasionally observed in many specimens.	PB: 667	SEM	×2,260
5	*Castanidium abundiplanatum* Takahashi, n. sp. Elongated specimen; an early stage of binary fission?	PB: 3769	SEM	×60
6	*Castanidium abundiplanatum* Takahashi, n. sp. Two specimens splitting apart.	PB: 3769	SEM	×55
7	*Castanidium abundiplanatum* Takahashi, n. sp. Holotype	PB: 1268	LM	×105
8	*Castanidium abundiplanatum* Takahashi, n. sp. Paratype	PB: 3769	SEM	×90
9	*Castanissa circumvallata* Schmidt Bi-spines broken off.	E: 389	SEM	×130
10	*Castanidium* sp.	PB: 3769	SEM	×66
11	*Castanella aculeata* Schmidt	P_1: 4280	SEM	×90
12	*Castanella macropora* (Borgert)	P_1: 4280	SEM	×200
13	*Castanella aculeata* Schmidt	P_1: 978	SEM	×80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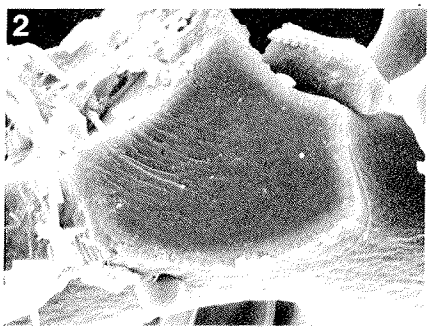
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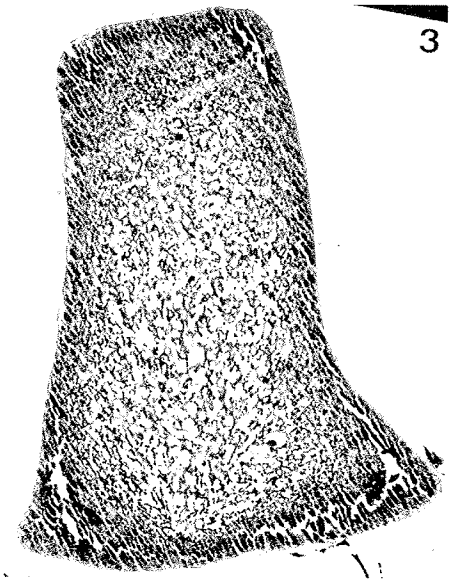
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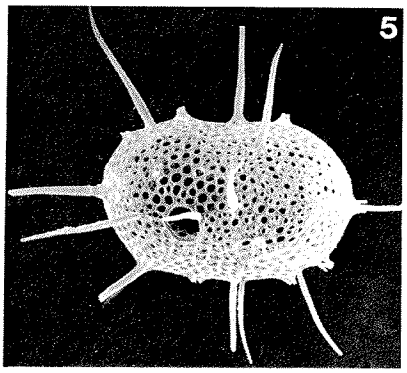
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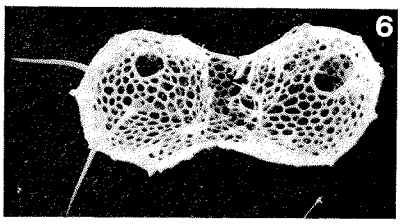
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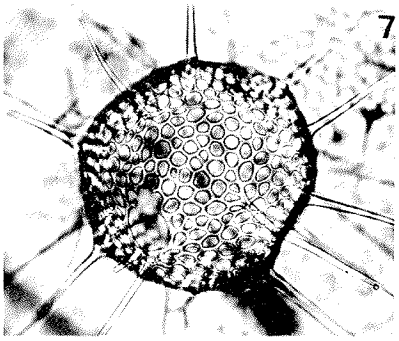
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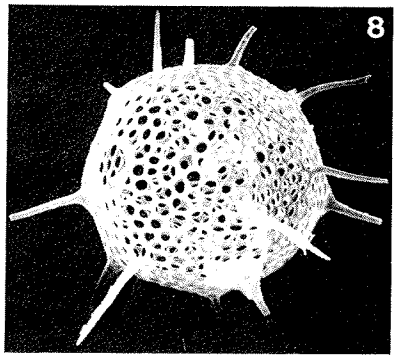
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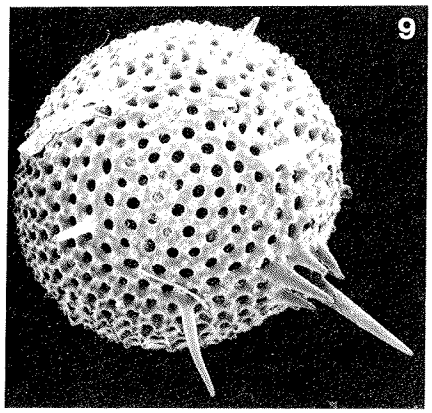
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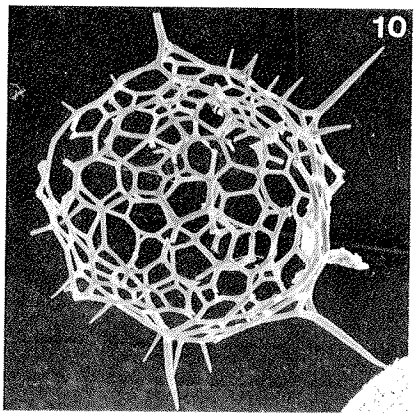
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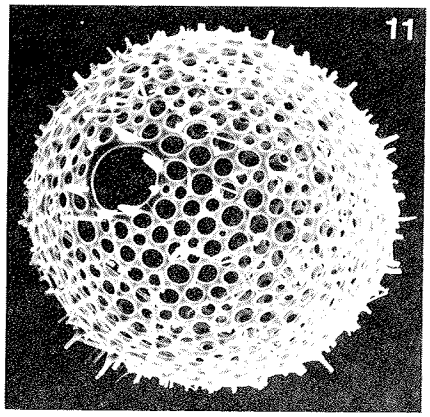
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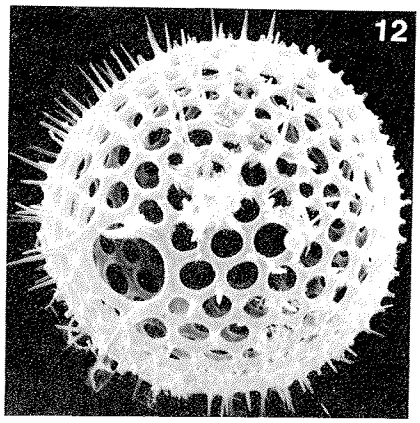
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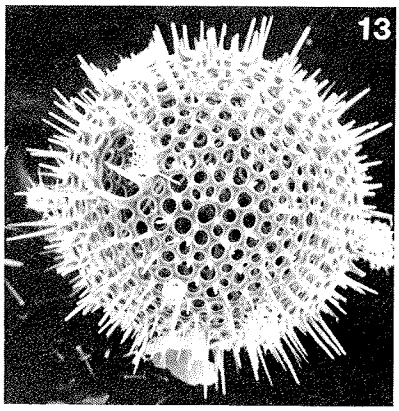
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PLATE 59

Suborder: Phaeodaria
Families: Castanellidae, Circoporidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Castanella aculeata* Schmidt Typical specimen having glassy texture.	P_1: 389	RLM	×54
2	*Castanella sloggetti* Haeckel	P_1: 978	LM	×106
3	*Castanella balfouri* Haeckel	P_1: 2778	LM	×125
4	*Haeckeliana porcellana* Murray	P_1: 978	LM	×100
5	*Haeckeliana porcellana* Murray	P_1: 978	SEM	×77
6	*Haeckeliana porcellana* Murray	E: 988	SEM	×64
7	*Haeckeliana porcellana* Murray A specimen without bi-spines.	E: 988	SEM	×130
8	*Haeckeliana porcellana* Murray A specimen without bi-spines.	E: 988	SEM	×190
9	*Haeckeliana porcellana* Murray Extensively dissolved specimen.	P_1: 4280	SEM	×100
10	*Haeckeliana porcellana* Murray A cross section showing porous inner layer and relatively solid outer layer.	P_1: 978	SEM	×1,490
11	*Haeckeliana porcellana* Murray A cross section showing porous and relatively solid layer.	E: 988	SEM	×2,560
12	*Haeckeliana porcellana* Murray A cross section of ultra-structure showing polygonal pores bounded by tubes.	P_1: 978	TEM	×26,700
13	*Haeckeliana porcellana* Murray Same specimen, showing layers of several different morphology.	P_1: 978	TEM	×7,600

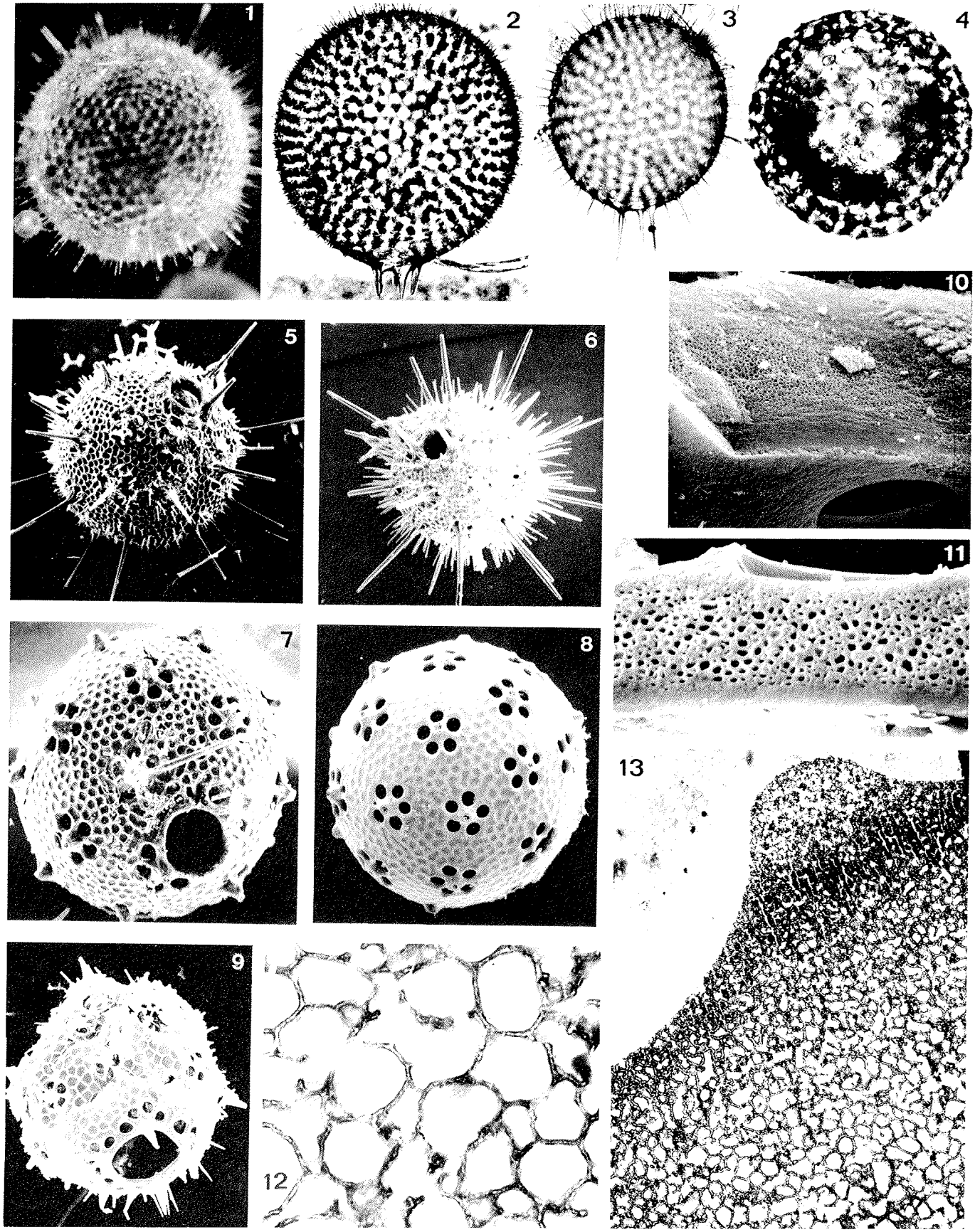
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PLATE 60

Suborder: Phaeodaria
Family: Circoporidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Circoporous sexfuscinus* Haeckel	PB: 2869	LM	×210
2	*Circoporous oxyacanthus* Borgert	PB: 3791	LM	×210
3	*Circoporous sexfuscinus* Haeckel	PB: 667	SEM	×165
4	*Circoporous oxyacanthus* Borgert	E: 389	SEM	×190
5	*Circoporous sexfuscinus* Haeckel Same specimen as figure 3; view from oral side.	PB: 667	SEM	×180
6	*Circoporous oxyacanthus* Borgert Detail near the base of a hollow spine which has fibers inside.	PB: 667	SEM	×1,500
7	*Circoporous oxyacanthus* Borgert Irregular size and shape of internal structure is seen through thin membrane.	PB: 667	SEM	×1,460
8	*Circoporous oxyacanthus* Borgert Circular to polygonal pores varying in size.	PB: 3769	SEM	×2,100
9	*Circogonia* sp.	E: 3755	SEM	×90
10	*Circogonia* sp.	E: 389	SEM	×100
11	*Circoporous oxyacanthus* Borgert Near the base of a spine.	PB: 667	SEM	×1,050
12	*Circoporous oxyacanthus* Borgert Same specimen.	PB: 667	SEM	×3,030
13	*Circoporous oxyacanthus* Borgert A cross section across near the base of a spine; pores are variable in shape and size.	PB: 3769	TEM	×2,700

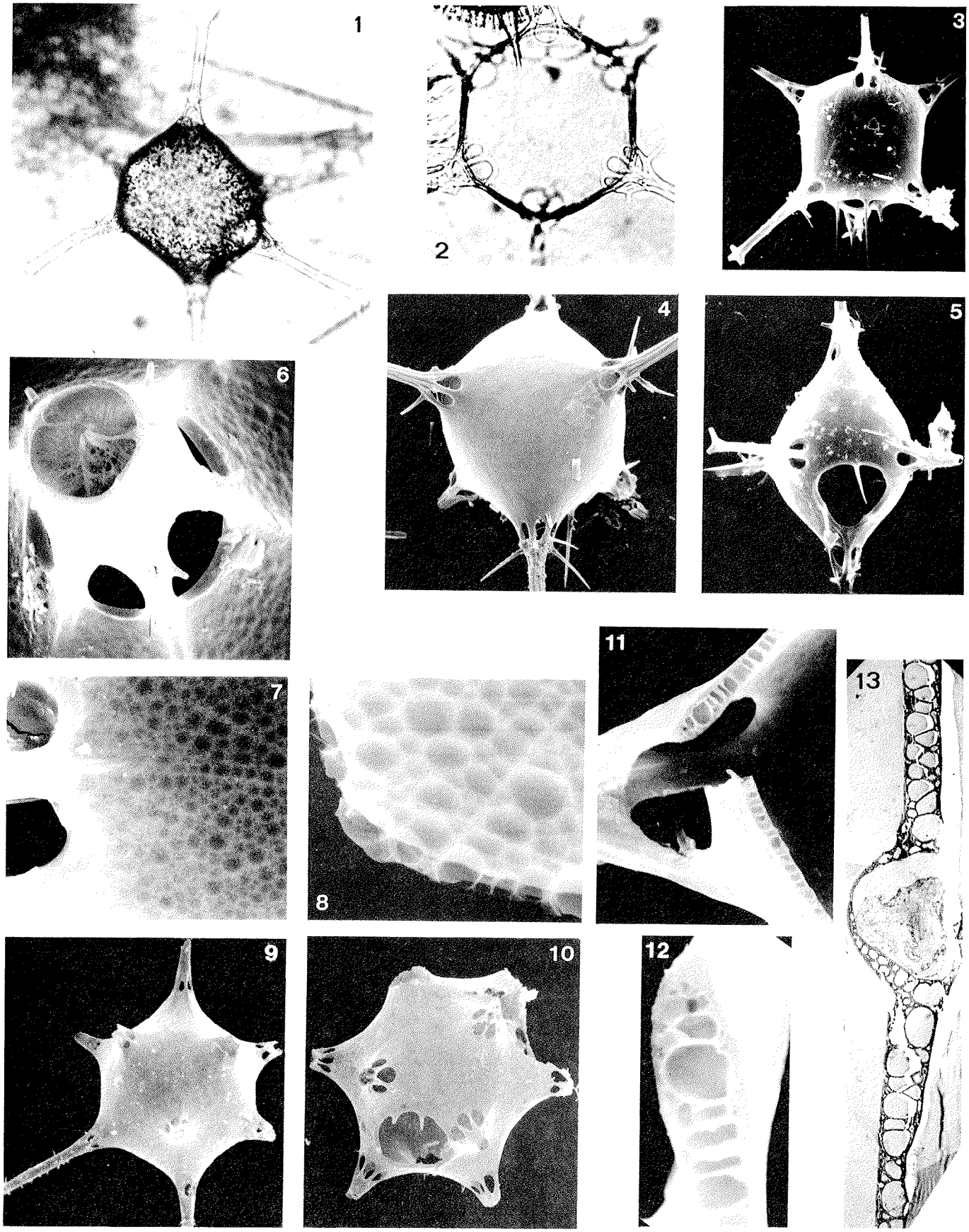
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PLATE 61

Suborder: Phaeodaria
Family: Conchariidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Conchellium capsula* Borgert Lateral view.	E: 389	LM	×210
2	*Conchellium capsula* Borgert Cross section showing solid parts, porous layer and less porous outer layer.	E: 3775	TEM	×11,900
3	*Conchellium capsula* Borgert Relatively undissolved specimen having only outermost thin layer porous.	P_1: 2778	TEM	×11,900
4	*Conchellium capsula* Borgert Lateral view.	E: 389	SEM	×150
5	*Conchellium capsula* Borgert View from inside valve.	E: 389	LM	×210
6	*Conchellium tridacna* Haeckel Oblique lateral view.	E: 3755	SEM	×120
7	*Conchellium capsula* Borgert Oral view.	E: 389	SEM	×150
8	*Conchellium capsula* Borgert Oblique view from inside valve.	P_1: 2778	SEM	×180
9	*Conchellium tridacna* Haeckel Surface texture having six denticles and less marked triangular facets than those shown by Haeckel (1887).	E: 3755	SEM	×610
10	*Conchellium capsula* Borgert Partially dissolved specimens; thin solid outer layer covering porous inner layer.	E: 3755	SEM	×3,840
11	*Conchellium tridacna* Haeckel Dorsal view.	P_1: 978	LM	×150
12	*Conchophacus diatomeus* Haeckel Dorsal view.	E: 988	LM	×210

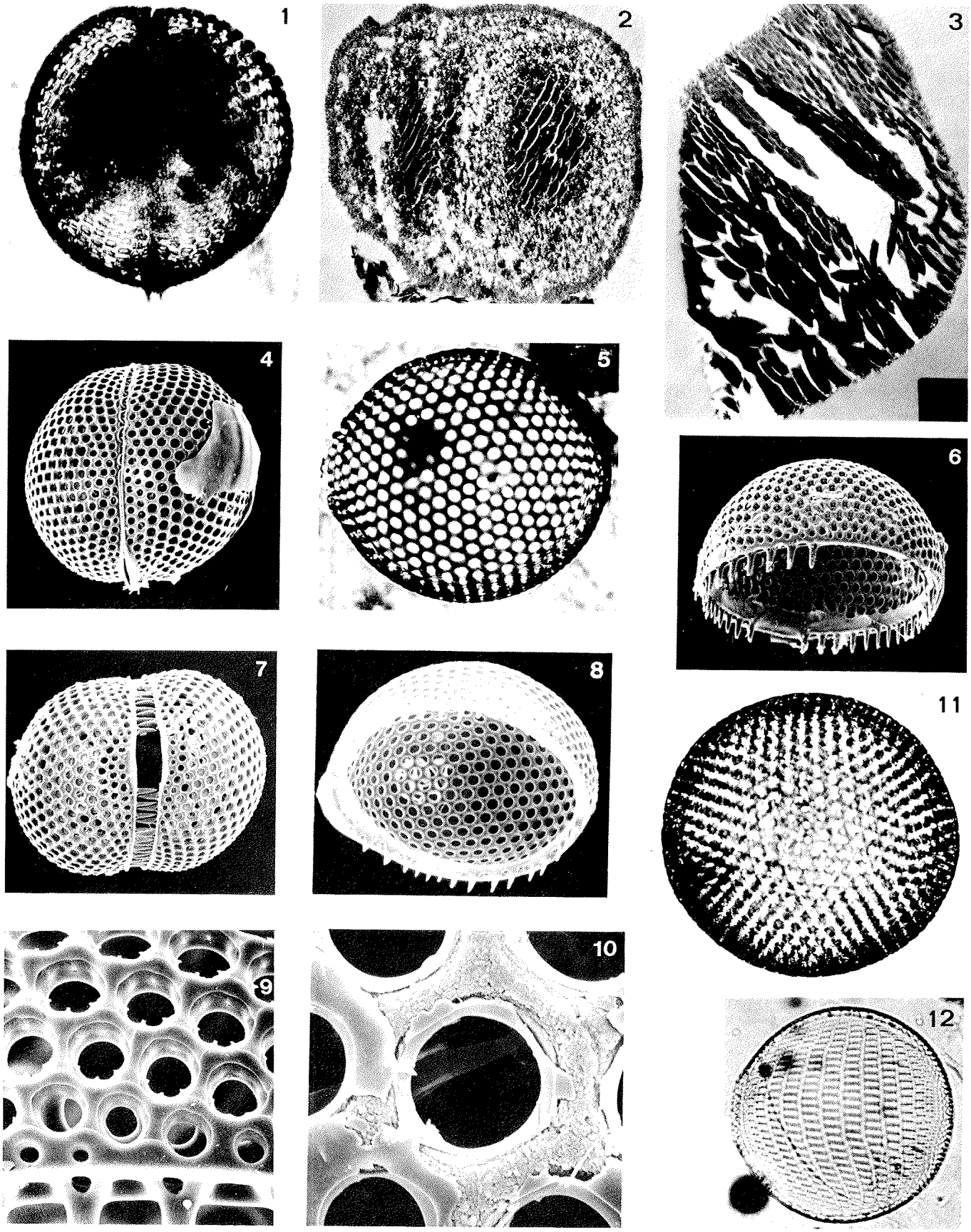
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PLATE 62

Suborder: Phaeodaria
Family: Conchariidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Conchidium argiope* Haeckel Dorsal view.	PB: 1268	LM	×210
2	*Conchidium argiope* Haeckel Lateral view.	P_1: 2778	SEM	×150
3	*Conchidium caudatum* (Haeckel) Lateral view.	E: 389	LM	×210
4	*Conchidium caudatum* (Haeckel) Lateral view.	P_1: 4280	SEM	×150
5	*Conchidium caudatum* (Haeckel) Lateral view of bivalves.	E: 389	SEM	×100
6	*Conchidium caudatum* (Haeckel) Oblique apical view.	E: 389	SEM	×150
7	*Conchidium caudatum* (Haeckel) A cross section showing several layers of different morphology with dissolution underway.	P_1: 2778	TEM	×19,200
8	*Conchidium caudatum* (Haeckel) Skeletal surface morphology showing smooth texture.	E: 389	SEM	×1,920
9	*Conchopsis compressa* Haeckel Lateral view.	E: 988	LM	×95
10	*Conchopsis compressa* Haeckel Lateral view of bivalves.	E: 988	SEM	×64
11	*Conchopsis compressa* Haeckel Skeletal surface morphology showing rough surface.	E: 988	SEM	×3,200
12	*Conchopsis compressa* Haeckel View from inside valve.	P_1: 2778	LM	×95
13	*Conchopsis compressa* Haeckel View from inside valve.	E: 988	SEM	×63
14	*Conchopsis compressa* Haeckel Dorsal view showing a prominant keel.	E: 988	SEM	×63
15	*Conchopsis compressa* Haeckel Lateral view showing teeth.	E: 988	SEM	×66
16	*Conchopsis compressa* Haeckel Oblique view showing teeth and inside.	E: 988	SEM	×61

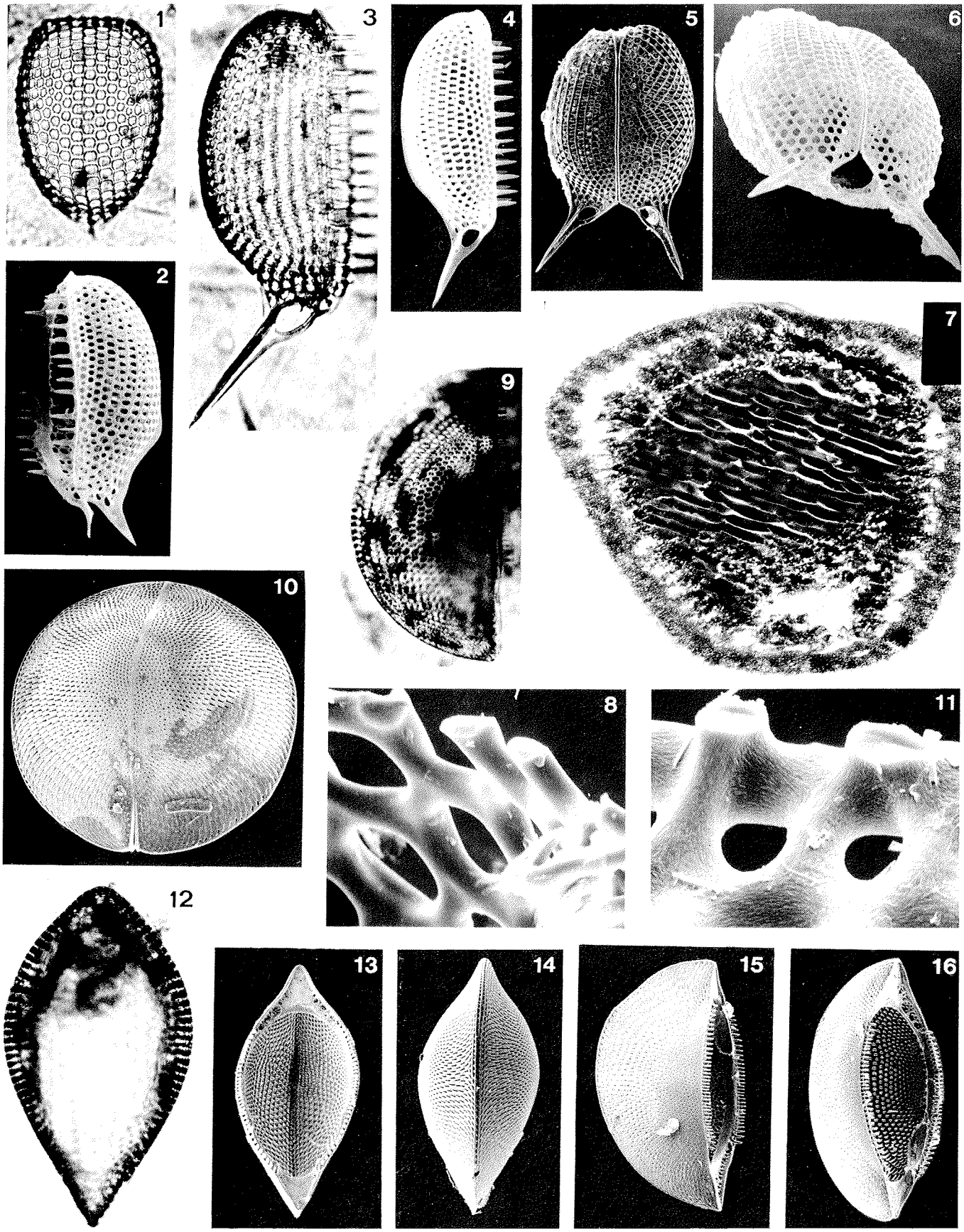
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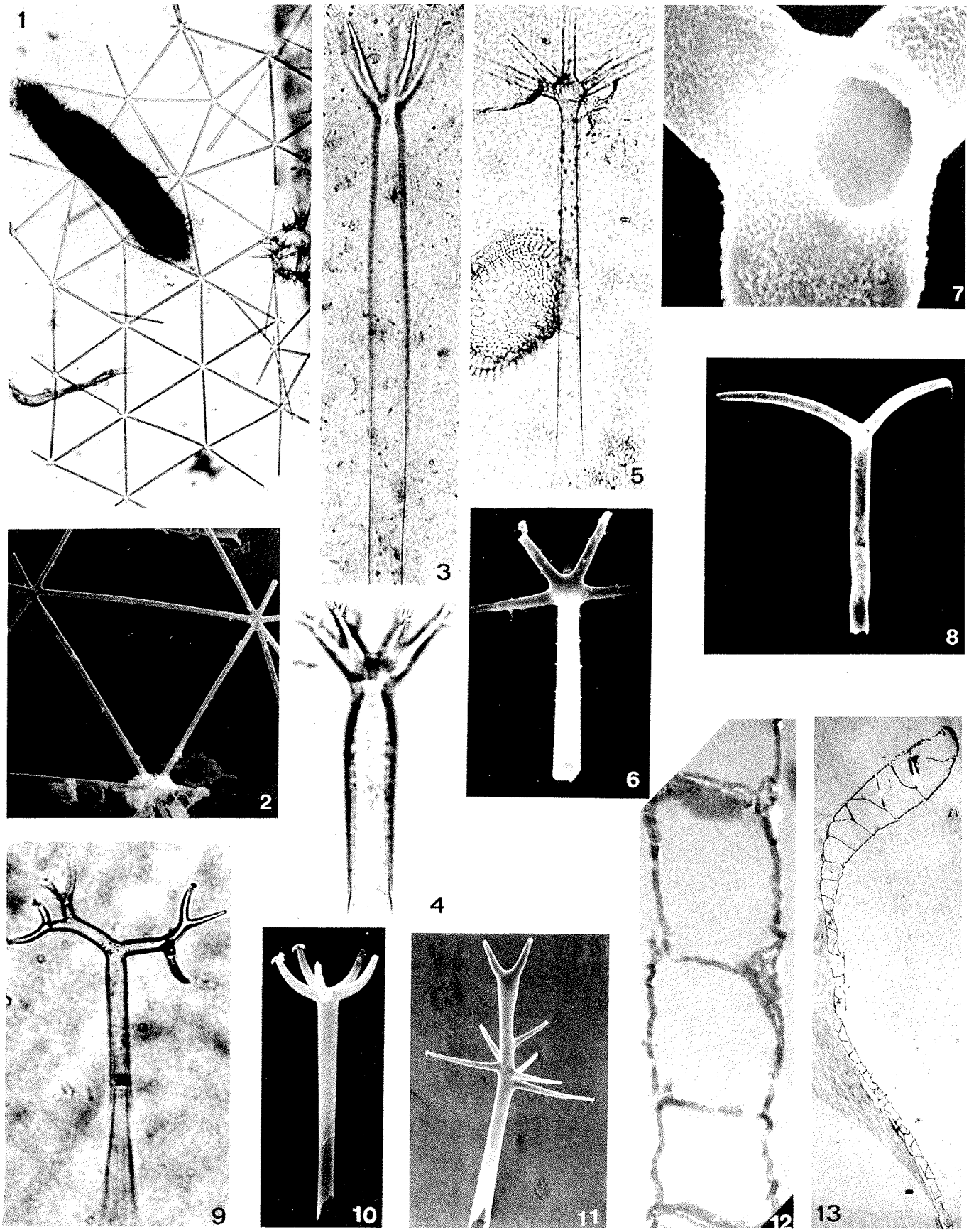
PLATE 63

Suborder: Spumellaria
Families: Aulosphaeridae, Medusettidae

Figure		Station: Depth (m)	Type of Micrograph	Magnification
1	*Aularia ternaria* Haeckel Portion of a shell made of triangular meshwork of tubes.	PM: 3791	LM	×84
2	*Aularia ternaria* Haeckel Portion of triangular meshwork.	E: 3755	SEM	×230
3	*Aulographis stellata* Haeckel	PB: 1268	LM	×210
4	*Auloceras spathillaster* Haeckel	PB: 1268	LM	×210
5	*Aulographonium bicorne* Haecker	PB: 3769	LM	×210
6	*Aulographonium bicorne* Haecker	P_1: 4280	SEM	×100
7	*Aulospathis taumorpha* ? Haeckel	P_1: 4280	SEM	×1,900
8	*Aulospathis taumorpha* ? Haeckel Same specimen.	P_1: 4280	SEM	×94
9	*Auloceras arborescens* Haeckel *birameus* (Immermann)	P_1: 5582	LM	×210
10	*Aulographis tetrancistra* Haeckel	P_1: 5582	SEM	×220
11	*Aulospathis variabilis* Haeckel *bifurca* Haecker	P_1: 5582	SEM	×47
12	*Medusetta* sp. B Skeleton made of a single layer of thin tubes.	PB: 0–100 plankton tow	TEM	×20,000
13	*Medusetta* sp. B Same specimen showing variable shape of pores.	PB: 0–100 plankton tow	TEM	×1,700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