Oligocene Marine Diatoms Recovered in Dredge Samples from the Navarin Basin Province, Bering Sea

By JACK G. BALDAUF and JOHN A. BARRON

The late Oligocene diatom assemblage recovered from dredge samples is the first recorded occurrence of diatoms of this age from the Bering Sea

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Oligocene Marine Diatoms Recovered in Dredge Samples from the Navarin Basin Province, Bering Sea

By Jack G. Baldauf[1] *and* John A. Barron

Abstract

One hundred and thirteen diatom taxa were observed in five dredge samples recovered from the Navarin Basin, Bering Sea. These species are characteristic of the late Oligocene and are the first recorded diatom occurrence of this age from the Bering Sea. Because of this unique occurrence, the diatom flora is documented in detail. The flora shows affinities to diatom floras described from the Norwegian Sea and suggests deposition in a shelf environment.

INTRODUCTION

Oligocene marine diatoms have been described by workers in sediments from the southwest Pacific (Hajós, 1976), the South Atlantic (Gombos, 1983; Gombos and Ciesielski, 1983; Fenner, 1978, 1984a), the Antarctic (McCollum, 1975; Schrader, 1976; Harwood, 1984), the equatorial regions (Jousé, 1973; Fenner, 1978, 1984a, 1984b; Barron, 1983), the North Atlantic (Baldauf, 1985), the Norwegian–Greenland Sea region (Schrader and Fenner, 1976; Dzinoridze and others, 1978), and Baja California in Mexico (Kim and Barron, 1986). Most of these studies were part of the Deep Sea Drilling Project (DSDP) and have reported Oligocene diatoms from the low latitudes or from the Southern Hemisphere (fig. 1). Only the studies of Schrader and Fenner (1976) and Dzinoridze and others (1978) examined in detail the Oligocene diatoms from the high latitudes of the Northern Hemisphere.

Five dredge samples collected during cruise L5-78-BS of the U.S. Geological Survey research vessel S. P. Lee, along the continental slope of the Navarin Basin Province in the western Bering Sea (fig. 2, table 1), contain a common, moderately well to well-preserved diatom assemblage. Although these isolated samples have limited stratigraphic value, taxonomic studies concerning the description and documentation of the diatom flora are valuable because this is the first recorded occurrence of Oligocene diatoms in Bering Sea sediments. Diatoms are generally absent below the Neogene sediment cover in boreholes in the Bering Sea because destruction of diatom frustules is the normal result of the conversion of opal-A to cristobalite at a burial depth of about 600 m (Hein and others, 1978).

Documentation of the diatom flora present in these samples will aid future studies in understanding the geographic distribution of Oligocene diatoms on a global scale and the climatic conditions which prevailed.

Acknowledgments

Special thanks is extended to Juliane Fenner (University of Kiel), Andrew M. Gombos, Jr. (Exxon Production Research), and Nora Radionova (Geological Institute, Academy of Sciences, USSR) for their helpful comments concerning species identification. We also thank Mike Marlow (U.S. Geological Survey—U.S.G.S.) who provided the samples. The manuscript was reviewed by George Andrews (U.S. Geological Survey), Andrew M. Gombos, Jr. (Exxon Production Research), Amanda Palmer (Ocean Drilling Program), and Elliott Taylor (Ocean Drilling Program). This manuscript is Ocean Drilling Program Contribution No. P-861085.

METHODS

Samples were collected during U.S. Geological Survey cruise L5-78-BS of the R/V S. P. Lee. Diatom samples were processed in hydrogen peroxide and hydrochloric acid following the preparation procedures of Barron (1975). Two strewn slides were prepared for each sample and examined in their entirety at 500X. Species identifications were confirmed at 1250X. A species was considered to be abundant if two specimens were observed in each field of view, common if one specimen was observed in every other field of view, few if specimens were observed once in

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each horizontal traverse (length 40 µm), and rare if a species was encounter less frequently.

Numerous specimens of unidentified taxa are recorded here for the first time. Formal name assignment of these taxa is postponed until detailed taxonomic studies can be completed on comparative material. Wide morphological variation is observed in species referred to as Stellarima spp. (=Coscinodiscus symbolophorus). All varieties of this species are recorded as Stellarima group, following the practice of Schrader (1976).

Table 1. Location and water depth of samples examined during this study

Sample no.	Latitude	Longitude	Water depth
2-1	56° 12.3' N.	171° 42.2' W.	2500-2700m
2-4	56° 12.3' N.	171° 42.2' W.	2500-2700m
2-9	56° 12.3' N.	171° 42.2' W.	2500-2700m
2-11	56° 12.3' N.	171° 42.2' W.	2500-2700m
5-1	56° 51.1' N.	173° 32.7' W.	1500-1700m

RESULTS

Table 2 shows the relative abundance of the diatom species observed from the Navarin Basin samples. The samples were divided into two groups on the basis of the diatom and silicoflagellate species content. Samples 2-1, 2-4, 2-9, and 2-11 compose Group 1 and sample 5-1 composes Group 2.

Group 1 is characterized by Actinoptychus senarius, Asteromphalus symmetricus, Cestodiscus sp. aff. C. muhinae, C. pulchellus, Coscinodiscus oculus-iridis, Hemiaulus polycistinorum, Melosira sulcata, Pseudostictodiscus plcus, Pseudotriceratium chenevieri, Pterotheca subulata, Stellarima group, Stictodiscus kittonianus and Synedra miocenica. Although age-diagnostic species are extremely rare, the occurrence of Asteromphalus oligocenicus, Cestodiscus sp. aff. C. muhinae, C. pulchellus, Coscinodiscus oligocenicus, Pseudostictodiscus picus, Triceratium radiosoreticulatum, and Trochosira spinosa suggests that Group 1 is characteristic of the upper Oligocene.

Species of Group 1 like Cladogramma dubium, Coscinodiscus nitidus, C. vetustissimus, Eucampia balaustium, and Goniothecium tenue, suggest a Miocene age. These taxa, however, do not have stratigraphic ranges that are well documented and may actually range down into the Oligocene.

It is also possible that the species indicative of the upper Oligocene are reworked into lower Miocene sediments. There is little support for this possibility because diatom species such as Rocella gelida, which is characteristic of the latest Oligocene and earliest Miocene, are not found within these samples.

The silicoflagellate species observed in Group 1 samples include Dictyocha deflandrei var. completa, Distephanus crux subsp. darwinii, D. speculum subsp.

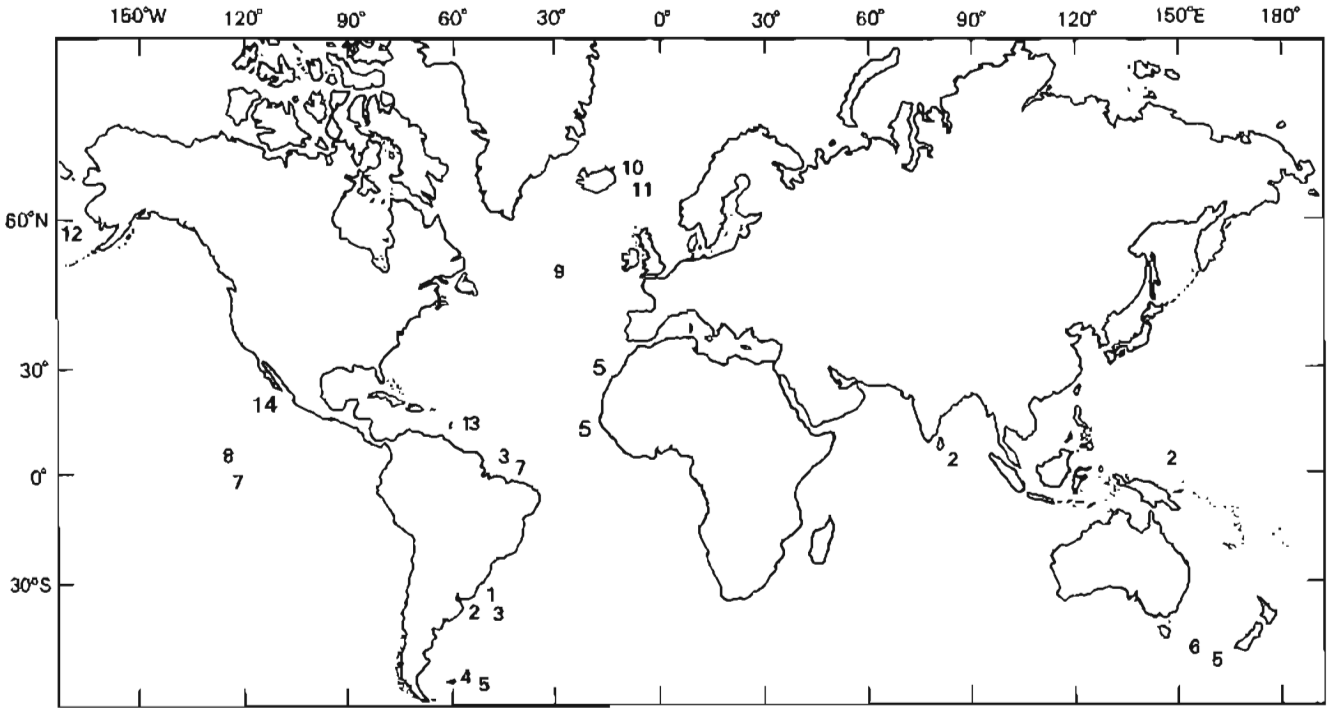

Figure 1. Geographic locations where Oligocene diatoms have been recorded. 1, Gombos (1983); 2, Fenner (1984a); 3, Fenner (1978); 4, Gombos and Ciesielski (1983); 5, Fenner (1984b); 6, Hajós (1976); 7, Jousé (1977); 8, Barron (1983); 9, Baldauf (1985); 10, Dzinoridze and others (1979); 11, Schrader and Fenner (1976); 12, Baldauf and Barron (this study); 13, Barbados deposits, Schmidt and others (1874-1959); 14, Kim and Barron (1986).

triommata, Mesocena apiculata subsp. curvata, and Naviculopsis biapiculata. David Bukry (written commun., 1979) placed samples 2-1 and 2-4 into the upper part of the Naviculopsis biapiculata silicoflagellate Zone. Bukry (written comm., 1979) further indicated that the relatively common occurrence of Dictyocha deflandrei var. completa and Distephanus speculum subsp. triommata suggests placement of these samples into the lower part of the upper part of the N. biapiculata Zone. Mesocena apiculata subsp. curvata is also observed in these samples. Although this subspecies is more typical of the lower Miocene, Bukry (oral commun., 1985) notes sporadic occurrences in the upper Oligocene. A late Oligocene age is favored for samples composing Group 1.

Table 2. Relative abundance of diatom species, Navarin Basin

[A, abundant; C, common; F, few; R, rare; -, absent]

Species/samples	2-1	2-4	2-9	2-11	5-1
Actinocyclus ehrenbergii	-	R	R	-	R
Actinocyclus sp. 1	R	R	-	R	R
Actinoptychus senarius	C	F	F	F	F
Actinoptychus splendens	-	R	R	-	F
Actinoptychus vulgaris	-	R	-	-	-
Arachnoidiscus decorus	-	-	R	R	-
Asterolampra praeacutiloba	R	R	-	-	R
Asteromphalus sp. cf. A. darwinii	-	-	R	-	-
Asteromphalus oligocenicus	-	R	-	-	R
Asteromphalus sp. cf. A. robustus	R	R	R	-	R
Asteromphalus symmetricus	-	-	R	-	-
Aulacodiscus amoenus	R	-	-	-	-
Aulacodiscus crux	-	R	-	-	-
Cestodiscus sp. aff. C. muhinae	R	R	R	R	R
Cestodiscus pulchellus	R	R	R	R	R
Cestodiscus robustus	R	-	R	-	-
Cestodiscus sp. 1	-	R	-	-	R
Cestodiscus sp. 2	-	R	-	-	R
Cestodiscus sp. 3	-	-	-	R	-
Cestodiscus sp. 4	-	R	-	-	R
Cestodiscus sp. 5	-	-	-	-	R
Chaetoceros sp.	-	R	R	R	-
Cladogramma dubium	-	-	-	-	R
Clavicula polymorpha	-	R	-	-	-
Clavicula sp. 1	-	R	-	-	-
Cocconeis antiqua var. antiqua	R	-	R	R	-
Cocconeis dirupta	-	-	-	R	-
Cocconeis scutellum	R	-	-	R	-
Cocconeis vitrea	R	-	-	R	-
Coscinodiscus sp. cf. C.decrescens	-	R	-	-	
Coscinodiscus marginatus	R	R	R	R	F
Coscinodiscus nitidus	-	R	R	R	-
Coscinodiscus oculus-iridis	R	F	R	-	F
Coscinodiscus oligocenicus	-	R	-	-	-
Coscinodiscus sp. aff. C. radiatus	R	R	-	-	-
Coscinodiscus vetustissimus	-	R	R	-	R
Coscinodiscus sp. 1	-	-	R	-	-
Cosmiodiscus? sp. 1	-	R	R	-	-
Craspedodiscus sp. aff. C. coscinodiscus	-	R	R	-	-
Cymatosira compacta	-	R	-	-	R
Diploneis sp.	R	R	R	-	R
Eucampia balaustium	R	R	R	R	-
Goniothecium decoratum	-	R	R	R	F
Goniothecium odontella	-	R	R	-	F
Goniothecium tenue	R	R	R	R	R
Goniothecium sp. 1	-	-	-	-	R
Goniothecium sp. 2	-	-	-	-	R
Hemiaulus kittonii	-	-	F	-	-
Hemiaulus polycistinorum	-	-	R	-	R
Hemiaulus pungens	-	-	R	-	R
Hemiaulus sp. 1	-	-	-	-	R
Hyalodiscus denutatus	R	R	F	R	-
Hyalodiscus elegans	-	-	-	-	R
Hyalodiscus radiatus	-	R	-	-	R
Hyalodiscus sp. 1	-	R	-	-	-
Kisseleviella carina	A	A	F	A	F
Liradiscus sp. aff. L. ovalis	R	-	-	-	-
Liradiscus sp.	F	R	R	R	R
Melosira clavigera	F	R	F	R	F
Melosira sulcata	F	R	F	F	F

Species/samples	2-1	2-4	2-9	2-11	5-1
Melosira sp. 1	R	-	-	-	R
Melosira sp. 2	-	-	-	R	R
Muelleriopsis sp. cf. M. limbata	-	R	-	-	-
Odontella aurita	-	R	R	R	C
Odontella fimbriata	-	R	-	-	-
Odontella tuomeyi	-	R	-	-	-
Odontella sp. 1	-	-	R	-	F
Pleurosigma planktonica	-	R	R	-	-
Ploiaria petasiformis	R	R	R	-	-
Ploiaria sp. 1	-	R	R	-	-
Ploiaria sp. 2	-	-	R	-	-
Podosira sp. 1	-	R	R	-	-
Pseudodimerogramma elegans	-	F	R	-	R
Pseudopyxilla americana	-	R	R	-	-
Pseudostictodiscus picus	-	C	R	-	-
Pseudotriceratium chenevieri	R	R	R	R	R
Pseudotriceratium motabile	-	-	R	-	-
Pterotheca kittoniana var. kamtschatica	F	-	-	-	-
Pterotheca subulata	F	R	R	F	-
Pterotheca tetracladia	F	R	R	-	-
Rhabdonema japonicum	-	R	-	-	-
Rhaponeis angulata	-	R	R	R	R
Rhizosolenia hebatata var. subacuta	R	F	R	-	R
Rhizosolenia sp. 1	F	R	R	F	R
Rhizosolenia sp. 2	-	-	-	R	-
Rocella gelida	-	-	-	-	C
Rutilaria epsilon var. longicornis	-	R	-	-	-
Rutilaria kerneri	-	R	-	-	-
Sceptroneis sp. 1	R	R	R	-	F
Sceptroneis sp. 2	R	R	R	-	R
Skeletonema utriculosum	-	-	R	-	-
Stellarima group	F	C	F	F	R
Stephanogonia sp. cf. S. polycantha	-	R	-	R	-
Stephanopyxis eocenicus	-	-	-	-	R
Stephanopyxis grunowii	-	-	-	-	R
Stephanopyxis spinoissima	-	-	-	-	R
Stephanopyxis turris	R	F	R	R	R
Stictodiscus grovei	R	-	F	-	R
Stictodiscus kittonianus	-	F	-	-	R
Stictodiscus sp. 1	R	F	F	R	R
Synedra miocenica	R	R	R	R	R
Thalassiosira sp. aff. T. eccentrica	-	R	R	-	-
Thalassiosira sp. aff. T. manifesta	-	-	-	-	R
Thalassiosira sp. aff. T. mediaconvexa	-	-	-	-	R
Thalassiosira spinosa	-	-	-	-	R
Thalassiosira sp. 1	-	-	R	-	-
Thalassiosira sp. 2	-	-	R	-	-
Thalassiosira sp. 3	-	-	R	-	-
Triceratium arcticum	-	R	-	-	-
Triceratium radiosoreticulatum	R	R	-	-	R
Trochosira spinosa	R	R	-	-	R
Xanthiopyxis panduraeformis	R	R	R	-	R
Xanthiopyxis sp. 1	R	-	R	-	R

Group 2 is characterized by Actinoptychus senarius, Asteromphalus oligocenicus, Cestodiscus sp. aff. C. muhinae, Coscinodiscus marginatus, C. oculus-iridis, Goniothecium decoratum, G. odontella, Melosira sulcata, Odontella aurita, Odontella sp. 1, Rocella gelida, Stellarima group, and Trochosira spinosa.

The occurrence of R. gelida in this sample suggests a latest Oligocene to earliest Miocene age. Weaver and Gombos (1981) and Gombos and Ciesielski (1983) place the acme of R. gelida in the latest Oligocene. Gombos and Ciesielski (1983) defined the Rocella gelida Zone on the basis of the range of R. gelida stratigraphically below the first occurrence of Rossiella symmetrica. Barron (1983) noted that the range of R. gelida in the equatorial Pacific bracketed the Oligocene-Miocene boundary as recognized by Berggren and others (1985). If we assume R. gelida has a range in the Bering Sea similar to that at the high latitudes of the Southern Hemisphere and in the equatorial Pacific, then sample 5-1 is latest Oligocene to earliest Miocene in age.

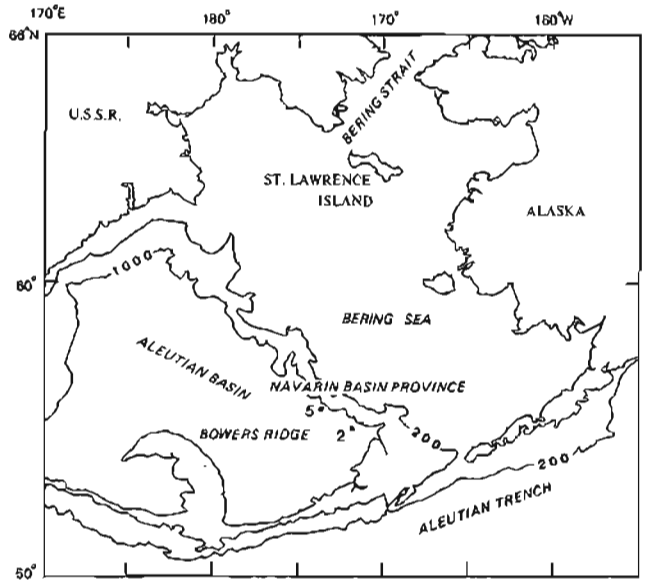

Figure 2. Geographic locations of dredge samples (numbered dots) collected from the Navarin Basin Province, western Bering Sea. Contour interval is in meters.

PALEOECOLOGY

Table 3 shows the modern and inferred distribution of diatom genera. This inferred distribution follows that of Barron (1975). Of the 113 species, varieties, and resting spores observed in the five samples examined, 67 are planktonic, 25 benthic, and 21 resting spores. Sample 2-4 has the greatest diversity, containing 69 different forms, and sample 2-11 is the least diverse, containing only 28 different forms. The low number of forms observed in samples 2-1 and 2-11 may be a result of the moderate preservation observed in these samples compared with good preservation in the remaining samples.

The samples having good preservation (samples 2-4, 2-9, and 5-1) have an average of 30 planktonic species, 18 benthic species, and 11 resting spores. Thirty surface samples of Holocene age examined by Baldauf (1981) from the shelf and slope in the Navarin Basin Province contained a total of 39 species, varieties, and spores (28 planktonic, 10 benthic, 1 spore). As expected, the number of benthic forms and resting spores increased and the number of planktonic forms decreased in samples proceeding from the basin to the slope and onto the shelf. The high number of

Table 3. Modern and inferred distribution (in parentheses) of diatom genera, Navarin Basin

[Updated from Barron, 1975. P, plantonic (oceanic and neritic); B, benthic; S, resting spore of neritic planktonic diatom]

Genus		Genus		Genus	
Actinocyclus	(P)	Actinoptychus	(B)	Arachnoidiscus	(B)
Asterolampra	(P)	Asteromphalus	(P)	Aulacodiscus	(B)
Cestodiscus	(P)	Chaetoceros	(P)	Cladogramma	(S)
Clavicula	(P?)	Cocconeis	(B)	Coscinodiscus	(P)
Cosmiodiscus	(P)	Craspedodiscus	(P)	Cymatosira	(P)
Diploneis	(B)	Eucampia	(P)	Goniothecium	(S)
Hemiaulus	(P)	Hyalodiscus	(P)	Kisseleviella	(P)
Liradiscus	(S)	Melosira	(B)	Muelleriopsis	(S)
Odontella	(P)	Pleurosigma	(B)	Ploiaria	(S)
Podosira	(S)	Pseudodimerogramma	(P?)	Pseudopyxilla	(S)
Pseudostictodiscus	(P?)	Pseudotriceratium	(P)	Pterotheca	(S)
Rhabdonema	(B)	Rhaphoneis	(B)	Rhizosolenia	(P)
Rocella	(P)	Rutilaria	(B)	Sceptroneis	(B)
Skeletonema	(P)	Stellarima	(P)	Stephanogonia	(S)
Stephanopyxis	(P)	Stictodiscus	(B)	Synedra	(P)
Thalassiosira	(P)	Triceratium	(P)	Trochosira	(S)
Xanthiopyxis	(S)				

benthic forms observed in the Oligocene dredge samples suggests shallow water, possibly shelf conditions.

FLORAL LIST

Actinocyclus ehrenbergii Ralfs in Pritchard, 1861, p. 834; Hustedt, 1929, p. 525, fig. 298. Synonym: Actinocyclus octonarius Ehrenberg, 1838, p. 173, pl. 21, fig. 7.

Actinocyclus sp. 1; this paper pl. 2, fig. 1. Remarks: This is a new species from northwest Pacific DSDP Site 438B and will be described by N. Radionova (written commun., 1980).

Actinoptychus senarius Ehrenberg, 1843, pl. 1; fig. 27; this paper pl. 2, figs. 6, 11. Synonym: Actinoptychus undulatus (Bailey) Ralfs in Pritchard, 1861, p. 839, pl. 5, fig. 88; Karsten, 1928, p. 219, fig. 236; Actinocyclus undulatus Bailey, 1842, pl. 2, fig. 11.

Actinoptychus splendens (Shadbolt) Ralfs in Pritchard, 1861, p. 840; Wolle, 1890, pl. 92, fig. 9; Karsten, 1928, p. 219, fig. 236c; Hendey, 1964, p. 95, pl. 22, fig. 1; this paper pl. 2, fig. 3. Synonym: Actinosphaenia splendens Shadbolt, 1854, p. 16.

Actinoptychus vulgaris Schumann, 1867, p. 64; Peragallo and Peragallo, 1897-1908, p. 410, pl. 111, figs. 2 and 3; Hustedt, 1929, p. 482; this paper pl. 14, fig. 4.

Arachnoidiscus decorus Brown, 1933, pl. 71, pl. 6, fig. 3. Synonyms: Arachnoidiscus ehrenbergii var. oamarunesis Schmidt, 1890 in Schmidt and others 1874-1959, pl. 147, fig. 1; Arachnoidiscus grevileanus Hardman in Schmidt and others, 1874-1959, pl. 73, fig. 3; Arachnoidiscus evanescens (Grunow, 1881) Brown sensu Wornardt, 1967, p. 40, fig. 61. Remarks: Recorded from middle Eocene sediments at DSDP Site 356 (Fenner, 1978) and from the middle Miocene part of the Monterey Formation by Schmidt and others (1874-1959), and Wornardt (1967).

Asterolampra praeacutiloba Fenner in Schrader and Fenner, 1976, p. 965, pl. 28, figs. 9-11; this paper pl. 1, figs. 1, 9, 12. Remarks: Schrader and Fenner (1976) recorded this species in upper Eocene to middle Oligocene sediments of the Norwegian Sea.

Asteromphalus sp. cf. A. darwinii Ehrenberg, 1844a, p. 200, pl. (JUNE), fig. 1; Schmidt and others, 1874-1959, pl. 38, fig. 16; this paper pl. 1, fig. 5.

Asteromphalus oligocenicus Schrader & Fenner, 1976, p. 965, pl. 21, figs. 8, 13, 14; pl. 28, fig. 1; this paper pl. 1, fig. 11. Remarks: Recorded from upper Oligocene sediments in the Norwegian Sea (Schrader and Fenner, 1976), lower Oligocene sediments of equatorial and South Atlantic (Fenner, 1978), and lower Oligocene of DSDP Sites 511 and 513A (Gombos and Ciesielski, 1983).

Asteromphalus sp. cf. A. robustus Castracane, 1875, p. 393, pl. 6, fig. 5; Hustedt, 1929, p. 496, fig. 278; this paper pl. 1, figs. 6, 8.

Asteromphalus symmetricus Schrader and Fenner, 1976, p. 966, pl. 21, figs. 7, 10-12; this paper pl. 1, fig. 10. Remarks: Recorded in upper Oligocene sediments from the Norwegian Sea (Schrader and Fenner, 1976).

Aulacodiscus amoenus Greville, 1864, p. 10, pl. 1, fig. 3; Rattray, 1888, p. 357; this paper pl. 2, fig. 9. Remarks: Observed specimen similar to Aulacodiscus amoenus Greville var.? as illustrated in Schmidt, 1876 in Schmidt and others, 1874-1959, pl. 134, fig. 7.

Aulacodiscus crux Ehrenberg, 1844a, p. 76; Ehrenberg, 1854 p. 8, pl. 18, fig. 47; Wolle, 1880, pl. 88, fig. 1.

Cestodiscus sp. aff. C. muhinae Jousé, 1973, p. 344-345, pl. 1, figs. 1-5; Schrader and Fenner, 1976, p. 966, pl. 27, figs. 11 and 12; pl. 29, fig. 4; this paper pl. 9, fig. 4. Remarks: This species is recorded in upper Oligocene sediments from the Norwegian Sea (Schrader and Fenner, 1976).

Cestodiscus pulchellus Greville, 1866 p. 123, pl. 11, fig. 5.

Cestodiscus robustus Jousé, 1973, p. 345, pl. 1, figs. 14, 15; Schrader, 1976, p. 630, pl. 10, fig. 2; this paper pl. 7, fig. 1.

Cestodiscus sp. 1; this paper pl. 2, fig. 7; pl. 12, fig. 6.

Cestodiscus sp. 2; this paper pl. 6, fig. 2.

Cestodiscus sp. 3; this paper pl. 6, figs. 1, 11, 12.

Cestodiscus sp. 4; this paper pl. 12, fig. 8. Remarks: Specimens are similar to Cestodiscus sp. 3 of Schrader, 1976, p. 630, pl. 12, fig. 15.

Cestodiscus sp. 5; this paper pl. 12, fig. 3.

Chaetoceros sp.; this paper pl. 10, fig. 8.

Cladogramma dubium Lohman, 1948, p. 168, pl. 9, fig. 5; Sheshukova-Poretzkaya, 1967, fig. 192; Schrader, 1973, p. 702, pl. 13, figs. 17, 18, 21; this paper pl. 3, fig. 8. Remarks: Schrader and Fenner (1976) recognized this species in Miocene sediments of the Norwegian Sea.

Clavicula polymorpha Grunow & Pantocsek in Pantocsek, 1886, p. 37; this paper pl. 11, figs. 1, 5.

Clavicula sp. 1; this paper pl. 11, fig. 2.

Cocconeis antiqua var. antiqua Tempère & Brun in Brun and Tempère, 1889, p. 32, pl. 8, fig. 5; Boyer, 1926-27, p. 249; this paper pl. 4, fig. 14.

Cocconeis dirupta Gregory, 1857, p. 491, pl. 1, fig. 25; Wolle, 1890, pl. 33, figs. 15, 16; Hustedt, 1933, p. 354, figs. 809a-c; this paper pl. 4, fig. 13.

Cocconeis scutellum Ehrenberg, 1838, p. 194, pl. 14, fig. 8; this paper pl. 4, fig. 16.

Cocconeis vitrea Brun, 1891, p. 19, pl. 18, fig. 2; Cleve, 1895, p. 177; this paper pl. 4, fig. 15.

Coscinodiscus sp. cf. C. decrescens Grunow, 1878 in Schmidt and others, 1874-1959, pl. 61, figs. 7-9; Grunow, 1884, pl. 80; Hustedt, 1928, p. 430, fig. 233; this paper pl. 6, fig. 3; pl. 12, fig. 7. Synonym: Coscinodiscus decrescens var. repleta Grunow, 1884, p. 80, pl. 3, fig. 18; Rattray, 1890, p. 526, fig. 78. Remarks: Recorded in middle Eocene through lower Oligocene sediments from the South Atlantic (Fenner, 1978) and Franz-Josef Land (Grunow, 1884), in upper Eocene sediments of Siberia, the tropical Pacific, the east Urals (Jousé, 1973), and Barbados (Tempère and Peragallo, 1889-1895), and in the middle Miocene Coosawhatchie Clay Member of the Hawthorn Formation, South Carolina and Georgia (Abbott and Andrews, 1979).

Coscinodiscus marginatus Ehrenberg, 1839, p. 142; Ehrenberg, 1854, pl. 18, fig. 44; Boyer, 1916, p. 22, pl. 3, fig. 9; Hustedt, 1928, p. 416, fig. 223; this paper pl. 7, figs. 2, 5. Remarks: Specimens have a wide range of valve size, flat valve vs. domed valve surfaces. Recorded in Upper Cretaceous through Holocene sediments of the Pacific (Wornardt, 1967; Kanaya, 1957), the lower Oligocene sediments of the southwest Pacific (Hajós, 1976), and Eocene and lower Oligocene sediments of the Norwegian Sea (Schrader and Fenner, 1976).

Coscinodiscus nitidus Gregory, 1857, p. 499, pl. 2, fig. 45; Hustedt, 1928, p. 414, fig. 221; Hendey, 1964, p. 76, pl. 23, fig. 12.

Coscinodiscus oculus-iridis Ehrenberg, 1839, p. 147; Ehrenberg 1854, pl. 18, fig. 42; pl. 19, fig. 2; Hustedt, 1928, p. 454, fig. 252; this paper pl. 7, figs. 3, 6. Remarks: Occurs in upper Eocene through Holocene sediments of the eastern Pacific (Wornardt, 1967) and middle Eocene and lower Oligocene of the southern Atlantic (Fenner, 1978).

Coscinodiscus oligocenicus Jousé, 1973, p. 348, pl. 1, figs. 6-8, 16; Schrader and Fenner, 1976, p. 972, pl. 29, figs. 1, 2; Fenner, 1978, p. 515, pl. 4, figs. 5-10; this paper pl. 6, fig. 7(?) pl. 14, fig. 6. Synonym: Coscinodiscus griseus sensu Gleser & Jousé, 1974, p. 56, pl. 1, fig. 10. Remarks: Recorded from the Eocene (Gleser and Jousé, 1974), Oligocene (Jousé, 1973; Schrader and Fenner, 1976), and Eocene and Oligocene (Fenner, 1978) in the equatorial and South Atlantic. Barron (1983) reports this species ranging into the lower Miocene sediments in the equatorial Pacific Ocean.

Coscinodiscus sp. aff. C. radiatus Ehrenberg, 1839, p. 148, pl. 3, figs. 1, 9; Hustedt, 1928, p. 420, fig. 225; this paper pl. 7, fig. 4.

Coscinodiscus vetustissimus Pantocsek, 1886, p. 71, pl. 20, fig. 186. Remarks: Recorded from the middle Eocene (Fenner, 1978) and upper Eocene to Holocene (Gleser and Jousé, 1974) of the equatorial Atlantic and from the middle Miocene to Pliocene (Abbott and Andrews, 1979) of eastern North America.

Coscinodiscus sp. 1; this paper pl. 9, fig. 2.

Cosmiodiscus? sp. 1; this paper pl. 2, fig. 8.

Craspedodiscus sp. aff. C. coscinodiscus Ehrenberg, 1844b, p. 266; Ehrenberg, 1854, pl. 18, fig. 108; pl. 33, fig. 8; Kanaya, 1971, p. 555, pl. 40.4, figs. 1-3; this paper pl. 9, fig. 8.

Cymatosira compacta Schrader & Fenner, 1976, p. 976, pl. 8, figs. 22, 25; pl. 25, figs. 30-32; this paper pl. 10, fig. 3. Remarks: Reported from the upper Oligocene of the Norwegian Sea (Schrader and Fenner, 1976).

Diploneis group; a typical specimen on pl. 4, fig. 11. Remarks: All observed specimens of this genus were recorded as Diploneis sp.

Eucampia balaustium Castracane, 1886, p. 97, pl. 18, fig. 5; Karsten, 1905, p. 126, pl. 11, fig. 7; Hustedt, 1958, p. 136-137, pl. 5, figs. 40-43; Schrader and Fenner, 1976, p. 981, pl. 10, figs. 17, 18; this paper pl. 3, figs. 1, 4. Remarks: Recorded from the middle Miocene to Holocene of the southwest Pacific (Schrader, 1976; McCollum, 1975) and the Pleistocene of the southwest Atlantic (Donahue, 1970; Fenner, 1978).

Goniothecium decoratum Brun, 1891, p. 28, pl. 12, fig. 6; Schrader and Fenner, 1976, p. 982, pl. 6, figs. 3, 5; pl. 37, figs. 1-5, 11-14; this paper pl. 5, figs. 4, 5, 7, 9. Remarks: Recorded from Eocene through Oligocene sediments of the Norwegian Sea (Schrader and Fenner, 1976).

Goniothecium odontella Ehrenberg, 1844a, p. 82; Ehrenberg, 1854, pl. 18, fig. 94; pl. 33, fig. 15; Brightwell, 1856, p. 106, pl. 7, figs. 4, 7; this paper pl. 5, figs. 2, 3, 6, 8. Remarks: Recorded in Cretaceous sediments of the southwestern Pacific Ocean (Hajós and Stradner, 1975), middle Eocene sediments of the South Atlantic (Fenner, 1978), upper Oligocene of the southeastern Pacific (Schrader, 1976), upper Eocene through Oligocene sediments of the Norwegian Sea (Schrader and Fenner, 1976), upper Eocene of the South Atlantic (Gombos, 1983), and upper Eocene and lower Oligocene sediments of the southwest Pacific (Hajós, 1976).

Goniothecium tenue Brun, 1894, p. 77, pl. 6, figs. 5, 6; Schrader and Fenner, 1976b, p. 983, pl. 1, figs. 6-10; pl. 37, figs. 6-10; this paper pl. 5, fig. 1; pl. 10, fig. 7. Remarks: This species was previously considered to be restricted to Miocene sediments (Koizumi, 1973; Schrader and Fenner, 1976; J. Fenner, written commun., 1980).

Goniothecium sp. 1; this paper pl. 4, figs. 8, 9. Remarks: Valves are oval in shape and heavily silicified. Spines are scattered over the valve surface in a square pattern. Valve dimension ranges from 12-30 µm.

Goniothecium sp. 2; this paper pl. 4, fig. 10. Remarks: This form differs from Goniothecium sp. 1 by having spines that are radially arranged to form a centric rather than a square pattern.

Hemiaulus kittonii Grunow, 1884 in van Heurck, 1883, pl. 106, figs. 6-9; Strelnikova, 1974, p. 96, pl. 42, figs. 12-24; Schrader and Fenner, 1976, p. 984, pl. 10, fig. 19; this paper pl. 3, fig. 2. Remarks: Recorded from the middle Eocene of DSDP Site 356 (Fenner, 1978), lower Oligocene of DSDP Site 354 (Fenner, 1978), Upper Cretaceous of western Siberia (Strelnikova, 1974), and lower Eocene of Mors Jutland (Grunow, 1884; Schmidt and others, 1874-1959).

Hemiaulus polycistinorum Ehrenberg, 1854, p. 36, figs. a, b; Ralfs in Pritchard, 1861, p. 851; this paper pl. 3, figs. 3, 10.

Hemiaulus pungens Grunow, 1884, p. 63, pl. 5, figs. 5, 6; Cleve-Euler, 1951, p. 125, figs. 27A; this paper pl. 3, fig. 5.

Hemiaulus sp. 1; this paper pl. 3, fig. 6.

Hyalodiscus denutatus Korotkevicz, 1964, p. 104, pl. 1, figs. 1-4; this paper pl. 2, fig. 2; pl. 6, fig. 5.

Hyalodiscus elegans Strelnikova, 1974, p. 51, pl. 2, figs. 1, 2; this paper pl. 1, fig. 2. Remarks: Recorded in Cretaceous sediments by Strelnikova (1974) and lower Oligocene sediments by Fenner (1978).

Hyalodiscus radiatus (O'Meara) Grunow in Cleve and Grunow, 1879, p. 117; Grunow, 1884, p. 93; Hustedt, 1928, p. 285, fig. 135; this paper pl. 8, fig. 2. Synonym: Pyxidicula radiata O'Meara,

1877, p. 58, pl. 1, fig. 9.

Hyalodiscus sp. 1; this paper pl. 8, fig. 4.

Kisseleviella carina Sheshukova-Poretzkaya in Sheshukova-Poretzkaya and Gleser, 1962, p. 207, figs. 1a, b, 2; Sheshukova-Poretzkaya, 1967, p. 237. pl. 11, fig. 5; this paper pl. 10, figs. 4-6. Remarks: Recorded from the lower Oligocene of the southwest Pacific (Hajós, 1976), middle Eocene of the South Atlantic (Fenner, 1978), and lower and middle Miocene of the North Pacific (Barron, 1980).

Liradiscus sp. aff. L. ovalis Greville, 1865, p. 5, pl. 1, figs. 15, 16; this paper pl. 4, fig. 2. Remarks: This resting spore is reported from upper Eocene through lower Oligocene sediments from the southwest Pacific (Hajós, 1976). Specimens are similar to Liradiscus sp. of Hajós (1976) which has convex-ellipsoidal valves that are well reticulated, irregular in shape, and contain short spines.

Melosira clavigera Grunow, 1882 in Schmidt and others., 1874-1959, pl. 175, figs. 21-24; pl. 202, figs. 8-9; this paper pl. 6, fig. 10.

Melosira sulcata (Ehrenberg) Kützing, 1844, p. 55, pl. 2, fig. 7; Wolle, 1980, pl. 58, figs. 12-15; Hanna, 1927, p. 115, pl. 20, fig. 1; this paper pl. 1, figs. 3, 4; pl. 6, fig. 9. Synonym: Gaillonella sulcata Ehrenberg, 1838, p. 170, pl. 21, fig. 5.

Melosira sp. 1; this paper pl. 10, fig. 1.

Melosira sp. 2; this paper pl. 10, fig. 16.

Muelleriopsis sp. cf. M. limbata Hendey, 1972, p. 87, pl. 1, fig. 2.

Odontella aurita Agardh, 1832, p. 56; this paper pl. 3, figs. 7, 11. Synonyms: Biddulphia aurita (Lyngbye) Brébisson & Godey, 1838, p. 12; Wolle, 1890, pl. 96, figs. 9-11; Hendey, 1964, p. 103, pl. 24, fig. 6; Diatoma auritum Lyngbye, 1819, p. 182, pl. 62, fig. D.

Odontella fimbriata (Greville) Schrader in Schrader and Fenner, 1976, p. 992, pl. 20, fig. 6; this paper pl. 10, fig. 15. Synonym: Biddulphia fimbriata Greville, 1865, p. 6, pl. 1, fig. 4. Remarks: Found in Oligocene sediments of the Norwegian Sea (Schrader and Fenner, 1976) and lower Oligocene sediments of the southwestern Pacific (Hajós, 1976).

Odontella tuomeyi (Bailey) Glezer, 1975; this paper pl. 3, figs. 12, 14. Synonyms: Biddulphia tuomeyi (Bailey) Roper, 1859, p. 8, pl. 1, figs. 1, 2; Hanna, 1927, p. 110, pl. 17, fig. 6; pl. 19, figs. 1, 2; Zygoceros tuomeyi Bailey, 1844, p. 138, pl. 3, fig. 13.

Odontella sp. 1; this paper pl. 3, fig. 13.

Pleurosigma planktonica Schrader in Schrader and Fenner, 1976, p. 993, pl. 5, fig. 25; this paper pl. 11, fig. 15.

Ploiaria petasiformis Pantocsek, 1889, p. 83, pl. 28, figs. 403, 405; van Heurck, 1896, p. 457, fig. 186; Fenner, 1978, p. 526, pl. 26, fig. 9; this paper pl. 5, fig. 11. Synonym: Hemiaulus petasiformis Pantocsek, 1889, p. 50, pl. 29, fig. 295. Remarks: Fenner (1978) reported this species from middle Eocene sediments of DSDP Site 356. Pantocsek (1889) and Hendey (1972) recorded it from the Miocene of Hungary.

Ploiaria sp. 1; this paper pl. 5, fig. 10.

Ploiaria sp. 2; this paper pl. 5, fig. 12.

Podosira sp. 1; this paper pl. 13, fig. 3.

Pseudodimerogramma elegans Schrader in Schrader and Fenner, 1976, p. 993, pl. 3, fig. 13; this paper pl. 11, figs. 6, 7(?) Remarks: Recorded in lower and middle Miocene of the Norwegian Sea (Schrader and Fenner, 1976).

Pseudopyxilla americana (Ehrenberg) Forti, 1909, p. 28, 30, pl. 1, figs. 6, 7; Proshkina-Lavrenko, 1949, p. 200, pl. 98, fig. 4; this paper pl. 11, fig. 12. Synonym: Rhizosolenia americana Ehrenberg, 1841, p. 422; Ehrenberg, 1854, pl. 33, figs. 3, 14.

Pseudostictodiscus picus Hanna, 1927, p. 28, pl. 3, figs. 1-4; Proshkina-Lavrenko, 1949, pl. 16, fig. 11; Schrader and Fenner, 1976, p. 994, pl. 35, figs. 25, 26, 28; Fenner, 1978, p. 527, pl. 1, fig. 10; this paper pl. 12, fig. 4; pl. 14, fig. 7. Remarks: Recorded from upper Eocene through middle Oligocene sediments of the Norwegian Sea (Schrader and Fenner, 1976), middle Eocene of the South Atlantic (Fenner, 1978), and Barbados (Schmidt and others, 1874-1959).

Pseudotriceratium chenevieri (Meister) Gleser, 1975, pl. 2, fig. 4; Strelnikova, 1960, pl. 9, fig. 3; Gleser and others., 1974, pl. 28, fig. 12; Schrader and Fenner, 1976, p. 994, pl. 11, figs. 7-9; pl. 26, fig. 5; this paper pl. 14, figs. 1, 3, 9. Synonym: Triceratium chenevieri Meister, 1937, p. 261, pl. 5, fig. 2. Remarks: Found in Eocene to lower Miocene sediments of the Norwegian Sea (Schrader and Fenner, 1976).

Pseudotriceratium motabile (Korotkevicz) Gleser, 1974, pl. 54, fig. 4; this paper pl. 10, fig. 11. Synonym: Triceratium motabile Korotkevicz, 1964, p. 110, pl. 4, fig. 4.

Pterotheca kittoniana var. kamtschatica Gaponov, 1927, p. 15, pl. 1, fig. 11; Proshkina-Lavrenko, 1949, p. 202, pl. 75, fig. 5; Fenner, 1978, p. 527, pl. 9, figs. 2-5; this paper pl. 10, fig. 14.

Pterotheca subulata Grunow in van Heurck, 1882, pl. 83, fig. 6; Forti, 1909, p. 13; this paper pl. 10, fig. 9. Synonym: Pyxilla subulata (Grunow) Wolle, 1890, pl. 65, fig. 19.

Pterotheca tetracladia (Ehrenberg) Thum, 1899, p. 14; this paper pl. 4, figs. 4, 5. Synonym: Periptera tetracladia Ehrenberg, 1844b, p. 270.

Rhabdonema japonicum Tempère & Brun in Brun and Tempère, 1899, p. 53, pl. 1 fig. 6; Pantocsek, 1892, pl. 30, fig. 440; this paper pl. 10, fig. 10.

Rhaphoneis angulata Fenner in Schrader and Fenner, 1976, pl. 7, fig. 7; pl. 23, figs. 28-30; Fenner, 1978, p. 528; this paper pl. 10, fig. 2. Remarks: Recorded from the middle and upper Oligocene of the Norwegian Sea (Schrader and Fenner, 1976).

Rhizosolenia hebetata var. subacuta Grunow, 1884, p. 96, pl. 5, figs. 49-50; Fenner, 1978, p. 529, pl. 20, figs. 10, 11; this paper pl. 11, figs. 10, 11. Remarks: Fenner (1978) recorded this variety ranging from lower Oligocene to Pliocene sediments of DSDP Site 356 in the southwest Atlantic.

Rhizosolenia sp. 1; this paper pl. 11, fig. 9.

Rhizosolenia sp. 2; this paper pl. 11, fig. 13.

Rocella gelida (Mann) Bukry, 1978, p. 788, pl. 5, figs. 1-13; Barron, 1985, p. 768, fig. 4.16; this paper pl. 1, fig. 7. Synonyms: Stictodiscus gelidus Mann, 1907, p. 268, pl. 50, fig. 5; Rocella gemma Hanna,

1930, p. 415, 416, pl. 40A, figs. 8-18. Remarks: This species occurs in upper Oligocene and lower Miocene sediments in the southwest Atlantic (Gombos and Ciesielski, 1983), the equatorial Pacific (Barron, 1983, 1985), the North Atlantic (Baldauf, 1985), and the Bering Sea (as Stictodiscus gelidus) (Hanna, 1929).

Rutilaria epsilon var. longicornis Tempère & Brun in Brun and Tempère, 1889, p. 54, pl. 1, fig. 1; Schmidt, 1893, in Schmidt and others, 1874-1959, pl. 183, figs. 13-16; this paper pl. 10, fig. 12.

Rutilaria kerneri Pantocsek, 1892, pl. 33, fig. 474; Pantocsek, 1905, p. 94; this paper pl. 10, fig. 13.

Sceptroneis sp. 1; this paper pl. 11, fig. 3.

Sceptroneis sp. 2; this paper pl. 11, fig. 4.

Skeletonema utriculosum Brun, 1891, p. 44, pl. 11, figs. 1a, 1b; Schmidt, 1892, in Schmidt and others, 1874-1959, pl. 180, figs. 27-30; this paper pl. 4, fig. 12.

Stellarima group, Hasle and Simms, 1986, p. 111, figs. 18-27; this paper pl. 8, figs. 1, 3, 5, 7; pl. 9, fig. 1; pl. 12, fig. 5. Synonym: Coscinodiscus symbolophorus group of Schrader (1976), p. 631, pl. 7, figs. 1-3; pl. 10, figs. 1, 4, 5. Remarks: Taxonomic revision is required. All specimens characterized by having a hyaline margin and distinct labiate processes within the central region have been placed in this group following the example of Schrader and Fenner (1976).

Stephanogonia sp. cf. S. polycantha Forti, 1913; Hanna, 1932, p. 218, pl. 16, fig. 8; Hajós, 1976, pl. 17, fig. 13.

Stephanopyxis eocenicus Hajós, 1976, p. 824, pl. 4, figs. 3, 4; this paper pl. 13, fig. 4.

Stephanopyxis grunowii Grove & Sturt, 1888 in Schmidt and others, 1874-1959, pl. 130, figs. 1-4; this paper pl. 13, fig. 5.

Stephanopyxis spinosissima Grunow, 1884, p. 90-91; Schrader and Fenner, 1976, pl. 31, fig. 5; this paper pl. 13, fig. 6.

Stephanopyxis turris (Greville & Arnott) Ralfs in Pritchard, 1861, p. 826, pl. 5, fig. 74; Karsten, 1905, p. 73, pl. 2, fig. 1; this paper pl. 3, fig. 9; pl. 4, fig. 1; pl. 13; fig. 1. Synonym: Cresswellia turgida Greville & Arnott in Gregory, 1857, p. 538, fig. 64, pl. 14, figs. 1, 5.

Stictodiscus grovei Schmidt, 1890 in Schmidt and others., 1874-1959, pl. 147, figs. 5-7; Hajós, 1976, p. 826, pl. 10, figs. 4-6; this paper pl. 12, fig. 2.

Stictodiscus kittonianus Greville, 1861, p. 77, pl. 10, figs. 2, 3; Wolle, 1890, pl. 75, fig. 9; Hanna, 1932, p. 219, pl. 16, fig. 12; this paper pl. 12, fig. 1. Remarks: Recorded in Oligocene sediments of the Norwegian Sea (Schrader and Fenner, 1976).

Stictodiscus sp. 1; this paper pl. 6, fig. 4.

Synedra miocenica Schrader, 1976, p. 636, pl. 1, fig. 1.

Thalassiosira sp. aff. T. eccentrica (Ehrenberg) Cleve, 1904, p. 216; Fryxell and Hasle, 1972, p. 297-317; Abbott and Andrews, 1979, p. 259, pl. 6, fig. 12; this paper pl. 8, fig. 6; pl. 13, fig. 2. Synoynm: Coscinodiscus eccentricus Ehrenberg, 1839, p. 146; Ehrenberg, 1841, p. 371, pl. 3, fig. 5.

Thalassiosira sp. aff. T. manifesta Sheshukova-Poretzkaya in Sheshukova-Poretzkaya and Gleser, 1964, p. 72, pl. 1, fig. 7; this paper pl. 12, fig. 9.

Thalassiosira sp. aff. T. mediaconvexa Schrader in Schrader and Fenner, 1976, p. 1002, pl. 36, fig. 1; this paper pl. 2, figs. 4, 10; pl. 9, fig. 3.

Thalassiosira spinosa Schrader, 1976, p. 636, pl. 6, figs. 5-7.

Thalassiosira sp. 1; this paper pl. 2, fig. 5.

Thalassiosira sp. 2; this paper pl. 6, fig. 8.

Thalassiosira sp. 3; this paper pl. 6, fig. 6; pl. 8, fig. 8.

Triceratium arcticum Brightwell, 1853, p. 250, pl. 4, fig. 11; Hustedt, 1930, p. 816, fig. 479; this paper pl. 9, fig. 5; pl. 14, fig. 8.

Triceratium radiosoreticulatum Grunow, 1883 in van Heurck, 1883, pl. 112, fig. 5; de Toni, 1894, p. 926; this paper pl. 14, fig. 5.

Trochosira spinosa Kitton, 1871, p. 170, pl. 14, figs. 6, 7; Schmidt and others, 1874-1959, pl. 180, fig. 49; this paper pl. 14, fig. 2. Remarks: This species is recorded from the middle Eocene through Oligocene of the Atlantic (Fenner, 1978), the lower Eocene deposits of Mors, Denmark (Kitton, 1871), and the middle Miocene Coosawhatchie Clay Member of the Hawthorn Formation of South Carolina and Georgia (Andrews and Abbott, 1985).

Xanthiopyxis panduraeformis Forti, 1908, p. 133; Forti in Tempère and Peragallo, 1910, p. 197, nos. 367-369.

Xanthiopyxis sp. 1; this paper pl. 4, fig. 6.

Genus and species indet.; this paper pl. 4, fig. 3.

Genus and species indet.; this paper pl. 11, fig. 8.

Genus and species indet.; this paper pl. 11, fig. 14.

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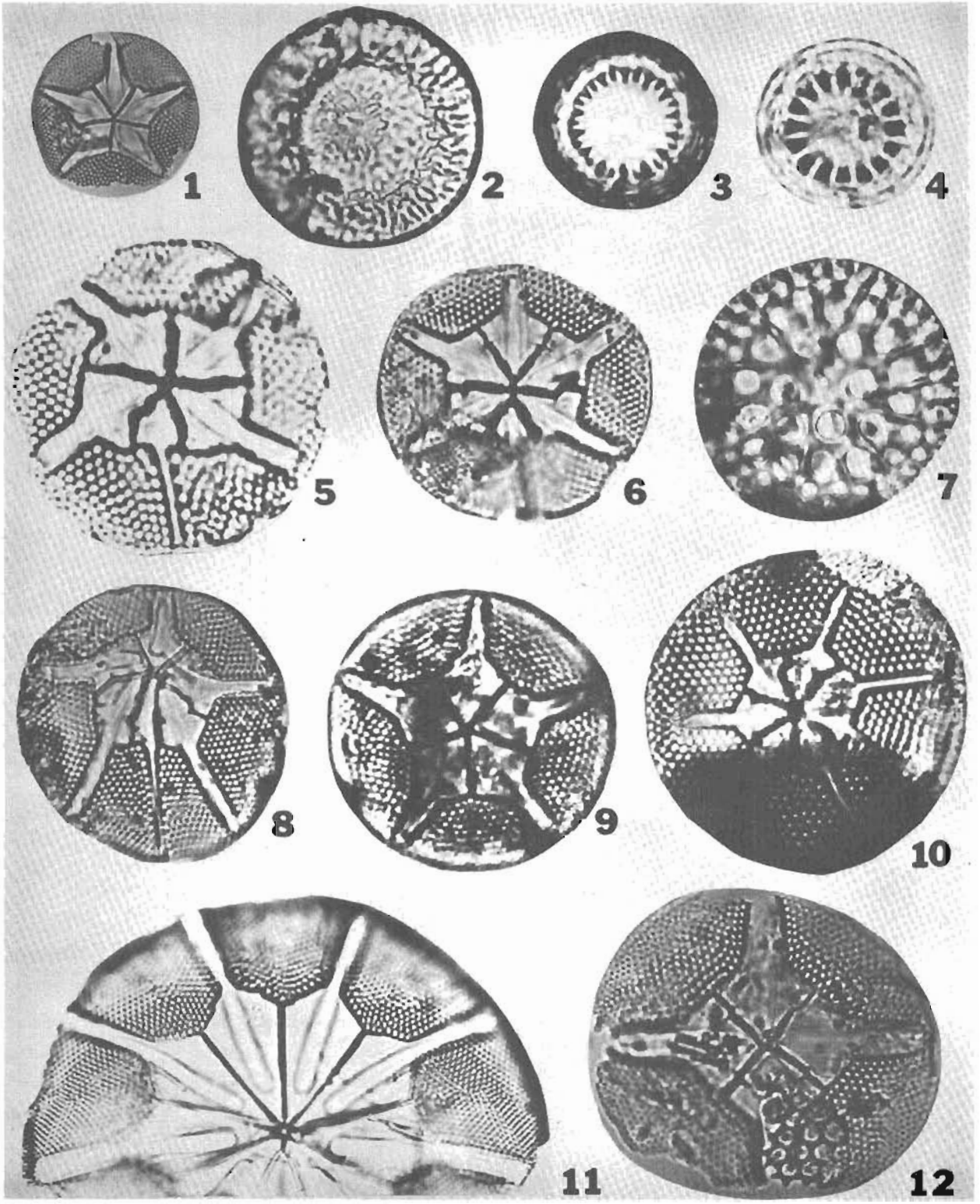
PLATES 1-14

Contact photographs of the plates in this report are available, at cost, from the U.S. Geological Survey, Federal Center, Denver, Colorado, 80225

PLATE 1

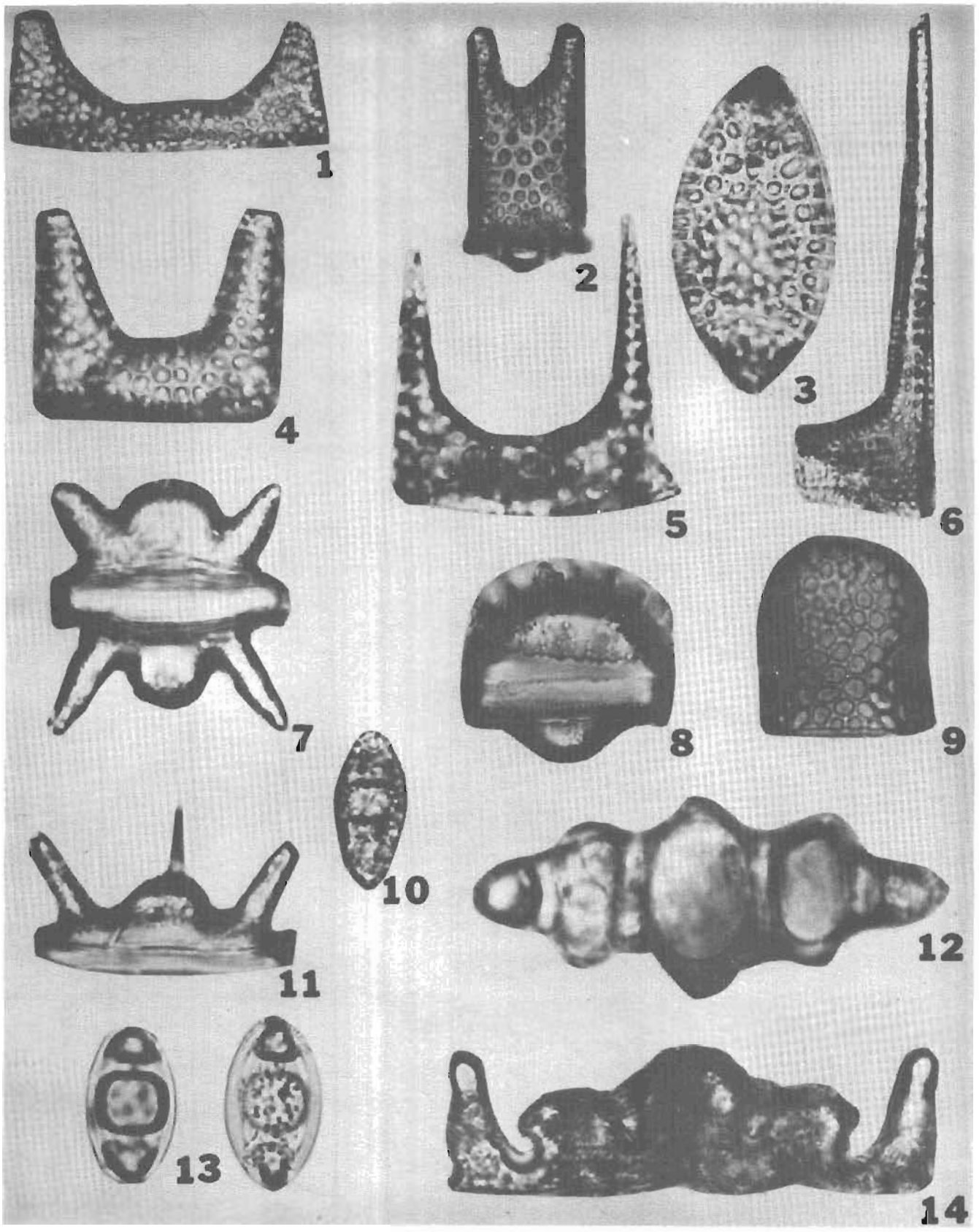
FIGURE 1. *Asterolampra praeacutiloba* Fenner, sample 2-4; 16 µm in diameter.
2. *Hyalodiscus elegans* Strelnikova, sample 5-1; 18 µm in diameter.
3. *Melosira sulcata* (Ehrenberg) Kützing, sample 2-9; 11 µm in diameter.
4. *Melosira sulcata* (Ehrenberg) Kützing, sample 2-9; 14 µm in diameter.
5. *Asteromphalus* sp. cf. *A. darwinii* Ehrenberg, sample 2-9; 34 µm in diameter.
6. *Asteromphalus* sp. cf. *A. robustus* Castracane, sample 5-1; 30 µm in diameter.
7. *Rocella gelida* (Mann) Bukry, sample 5-1; 30 µm in diameter.
8. *Asteromphalus* sp. cf. *A. robustus* Castracane, sample 2-4; 33 µm in diameter.
9. *Asterolampra praeacutiloba* Fenner, sample 2-4; 37 µm in diameter.
10. *Asteromphalus symmetricus* Schrader & Fenner, sample 2-9; 51 µm in diameter.
11. *Asteromphalus oligocenicus* Schrader & Fenner, sample 2-4; 99 µm in diameter.
12. *Asterolampra praeacutiloba* Fenner, sample 2-4; 38 µm in diameter.



ASTEROLAMPRA, HYALODISCUS, MELOSIRA, ASTEROMPHALUS, ROCELLA

PLATE 2

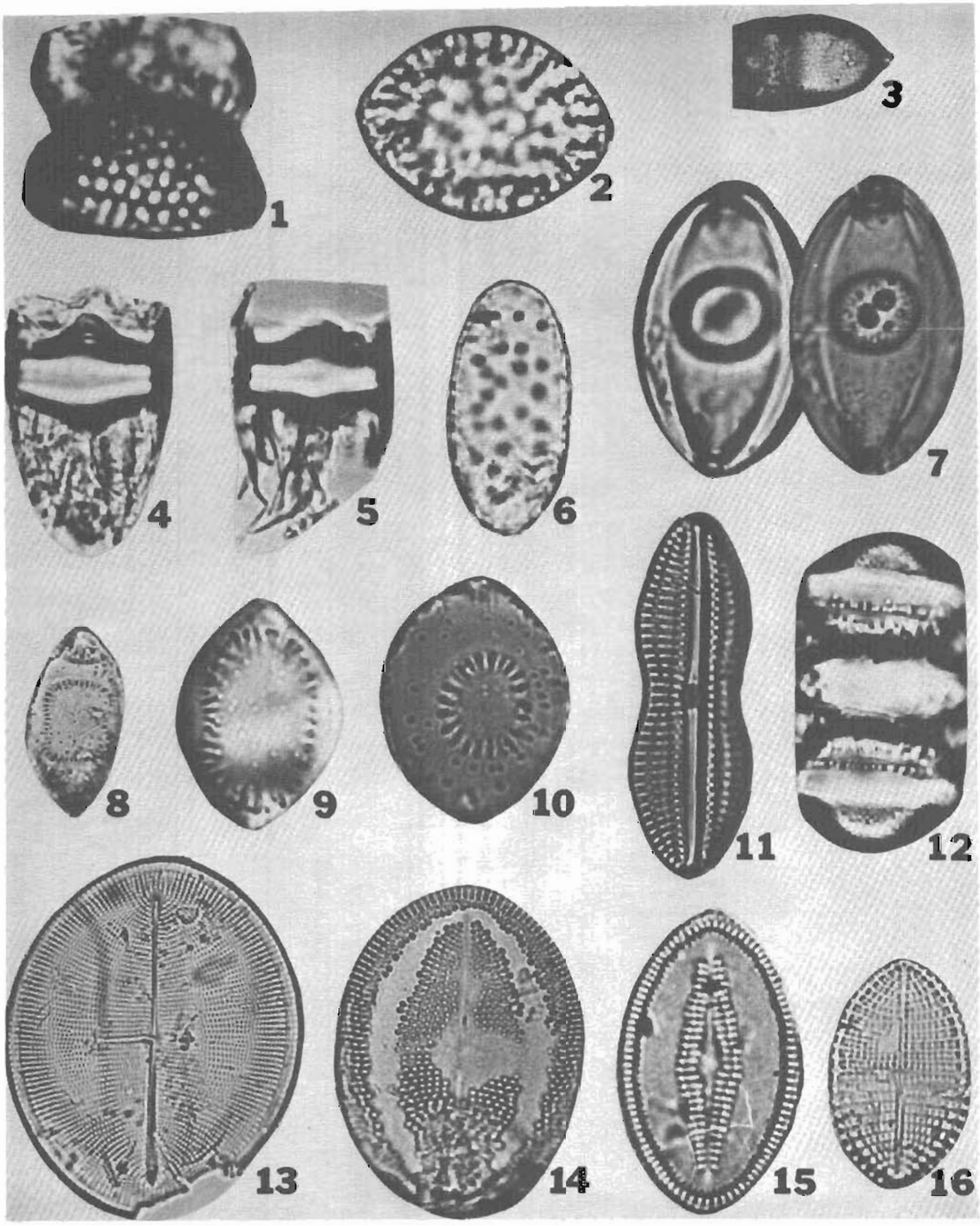
FIGURE 1. *Actinocyclus* sp. 1 (to be described by N. Radionova, written commun., 1985), sample 2-11; 20 µm in diameter.
2. *Hyalodiscus denutatus* Korotkevicz, sample 2-9; 18 µm in diameter.
3. *Actinoptychus splendens* (Shadbolt) Ralfs, sample 5-1; 64 µm in diameter.
4. *Thalassiosira* sp. aff. *T. mediaconvexa* Schrader, sample 5-1; 40 µm in diameter.
5. *Thalassiosira* sp. 1, sample 2-9; 37 µm in diameter.
6. *Actinoptychus senarius* Ehrenberg, sample 5-1; 56 µm in diameter.
7. *Cestodiscus* sp. 1, sample 2-4; 51 µm in diameter.
8. *Cosmiodiscus*? sp. 1, sample 5-1; 31 µm in diameter.
9. *Aulacodiscus amoenus* Greville, sample 2-1; 85 µm in diameter.
10. *Thalassiosira* sp. aff. *T. mediaconvexa* Schrader, sample 5-1; 38 µm in diameter.
11. *Actinoptychus senarius* Ehrenberg, sample 5-1; 42 µm in diameter.



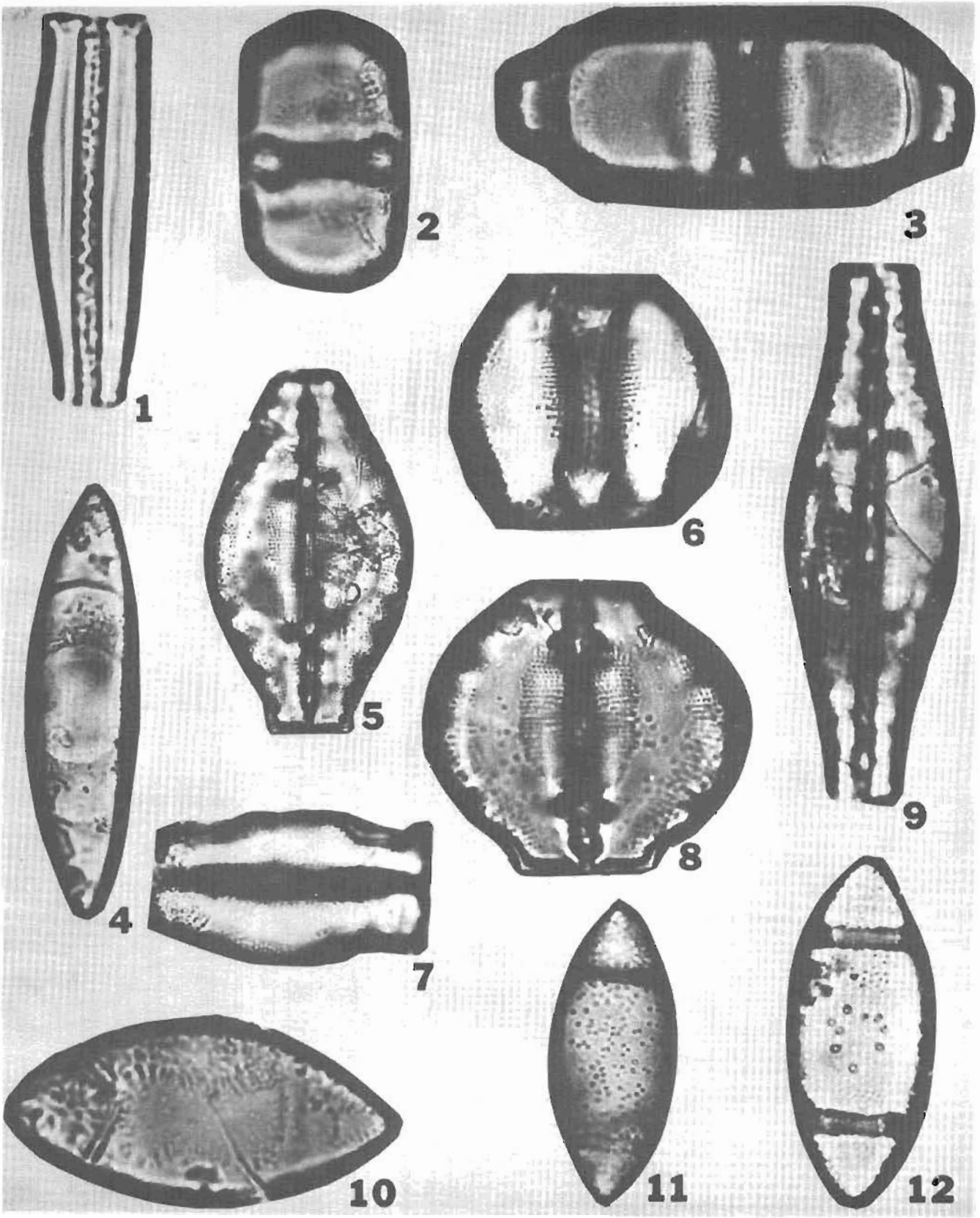
EUCAMPIA, HEMIAULUS, ODONTELLA, CLADOGRAMMA, STEPHANOPYXIS

PLATE 4

FIGURE 1. *Stephanopyxis turris* (Greville & Arnott) Ralfs, sample 2-9; 18 µm in length.
2. *Liradiscus* sp. aff. *L. ovalis* Greville, sample 2-1; 12 µm in length.
3. Genus and species indet., sample 2-9; 8 µm in length.
4. *Pterotheca tetracladia* (Ehrenberg) Thum, sample 2-4; 14 µm in length.
5. *Pterotheca tetracladia* (Ehrenberg) Thum, sample 2-4; 16 µm in length.
6. *Xanthiopyxis* sp. 1, sample 2-9; 21 µm in length.
7. Genus and species indet., sample 5-1; 34 µm in length.
8. *Goniothecium* sp. 1, sample 5-1; 10 µm in length.
9. *Goniothecium* sp. 1., sample 5-1; 13 µm in length.
10. *Goniothecium* sp. 2., sample 5-1; 15 µm in length.
11. *Diploneis* sp., sample 2-4; 70 µm in length.
12. *Skeletonema utriculosum*? Brun, sample 2-9; 28 µm in length.
13. *Cocconeis dirupta* Gregory, sample 2-11; 62 µm in length.
14. *Cocconeis antiqua* var. *antiqua* Tempère & Brun, sample 2-11; 43 µm in length.
15. *Cocconeis vitrea* Brun, sample 2-11; 35 µm in length.
16. *Cocconeis scutellum* Ehrenberg, sample 2-1; 20 µm in length.



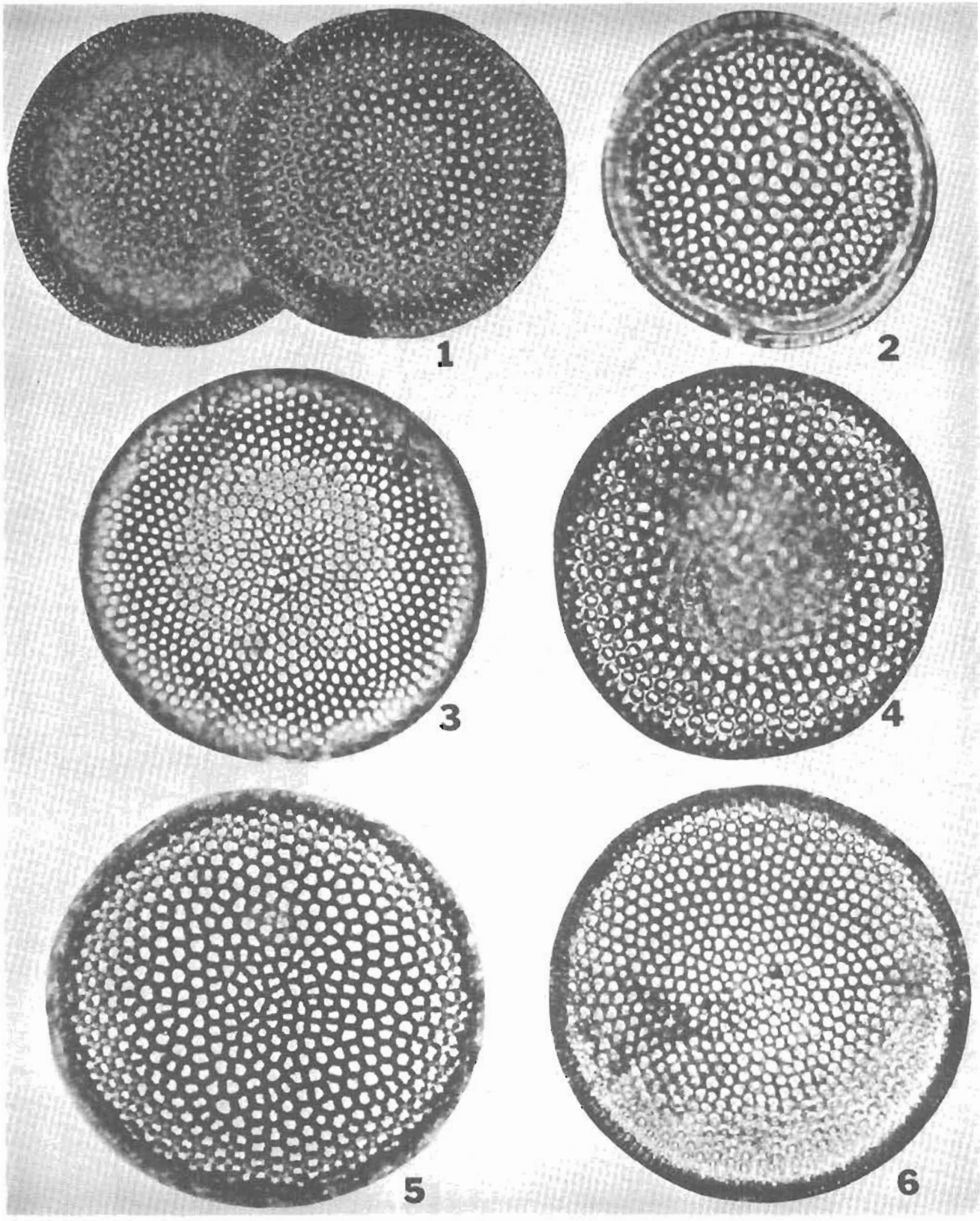
STEPHANOPYXIS, LIRADISCUS, PTEROTHECA, XANTHIOPYXIS, GONIOTHECIUM, DIPLONEIS, SKELETONEMA, COCCONEIS, GENUS INDET.



GONIOTHECIUM, PLOIARIA

PLATE 5

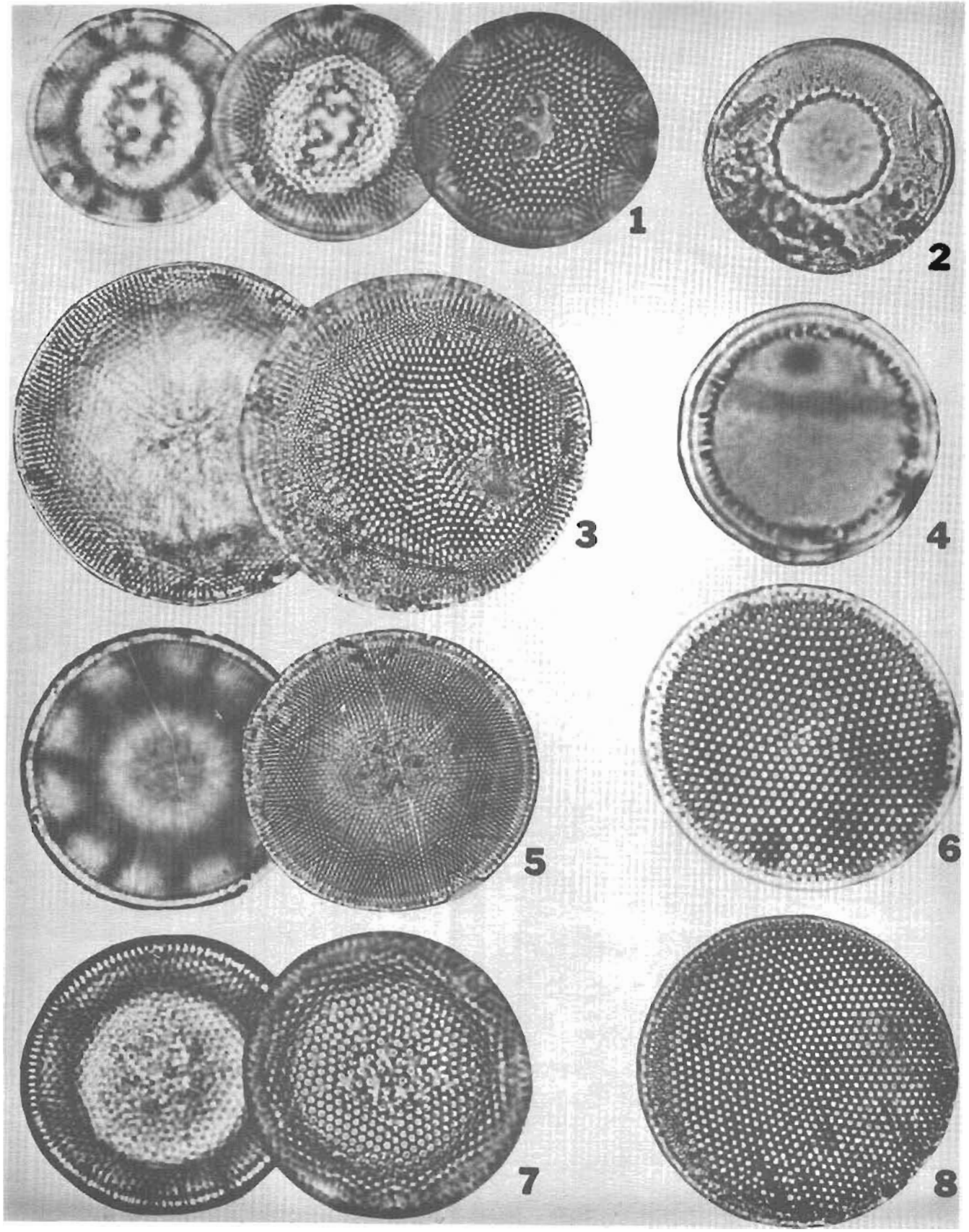
FIGURE 1. *Goniothecium tenue* Brun, sample 2-9; 37 µm in length.
2. *Goniothecium odontella* Ehrenberg, sample 5-1; 36 µm in length.
3. *Goniothecium odontella* Ehrenberg, sample 5-1; 56 µm in length.
4. *Goniothecium decoratum* Brun, sample 5-1; 63 µm in length.
5. *Goniothecium decoratum* Brun, sample 2-9; 89 µm in length.
6. *Goniothecium odontella* Ehrenberg, sample 5-1; 42 µm in length.
7. *Goniothecium decoratum* Brun, sample 2-11; 50 µm in length.
8. *Goniothecium odontella* Ehrenberg, sample 5-1; 51 µm in length.
9. *Goniothecium decoratum* Brun, sample 2-4; 98 µm in length.
10. *Ploiaria* sp. 1, sample 2-9; 38 µm in length.
11. *Ploiaria petasiformis* Pantocsek, sample 2-9; 35 µm in length.
12. *Ploiaria* sp. 2, sample 2-9; 42 µm in length.



CESTODISCUS, COSCINODISCUS

PLATE 8

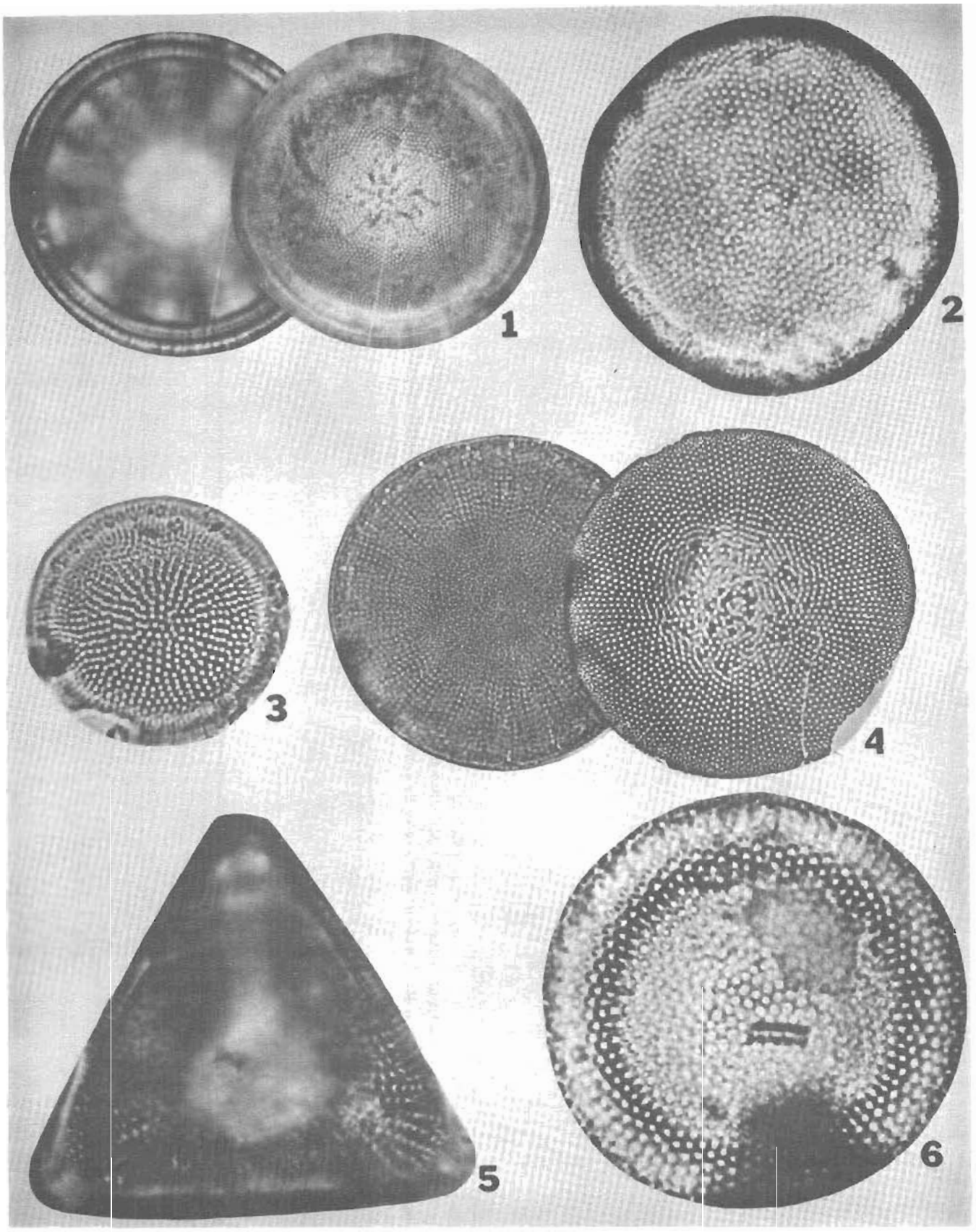
FIGURE 1. *Stellarima* group, sample 5-1; 28 µm in diameter.
2. *Hyalodiscus radiatus* (O'Meara) Grunow (group), sample 5-1; 30 µm in diameter.
3. *Stellarima* group, sample 2-4; 79 µm in diameter.
4. *Hyalodiscus* sp. 1, sample 2-4; 38 µm in diameter.
5. *Stellarima* group, sample 2-4; 42 µm in diameter.
6. *Thalassiosira* sp. cf. *T. eccentrica* (Ehrenberg) Cleve, sample 2-9; 56 µm in diameter.
7. *Stellarima* group, sample 2-4; 39 µm in diameter.
8. *Thalassiosira* sp. 3, sample 2-9; 50 µm in diameter.



STELLARIMA, HYALODISCUS, THALASSIOSIRA

PLATE 9

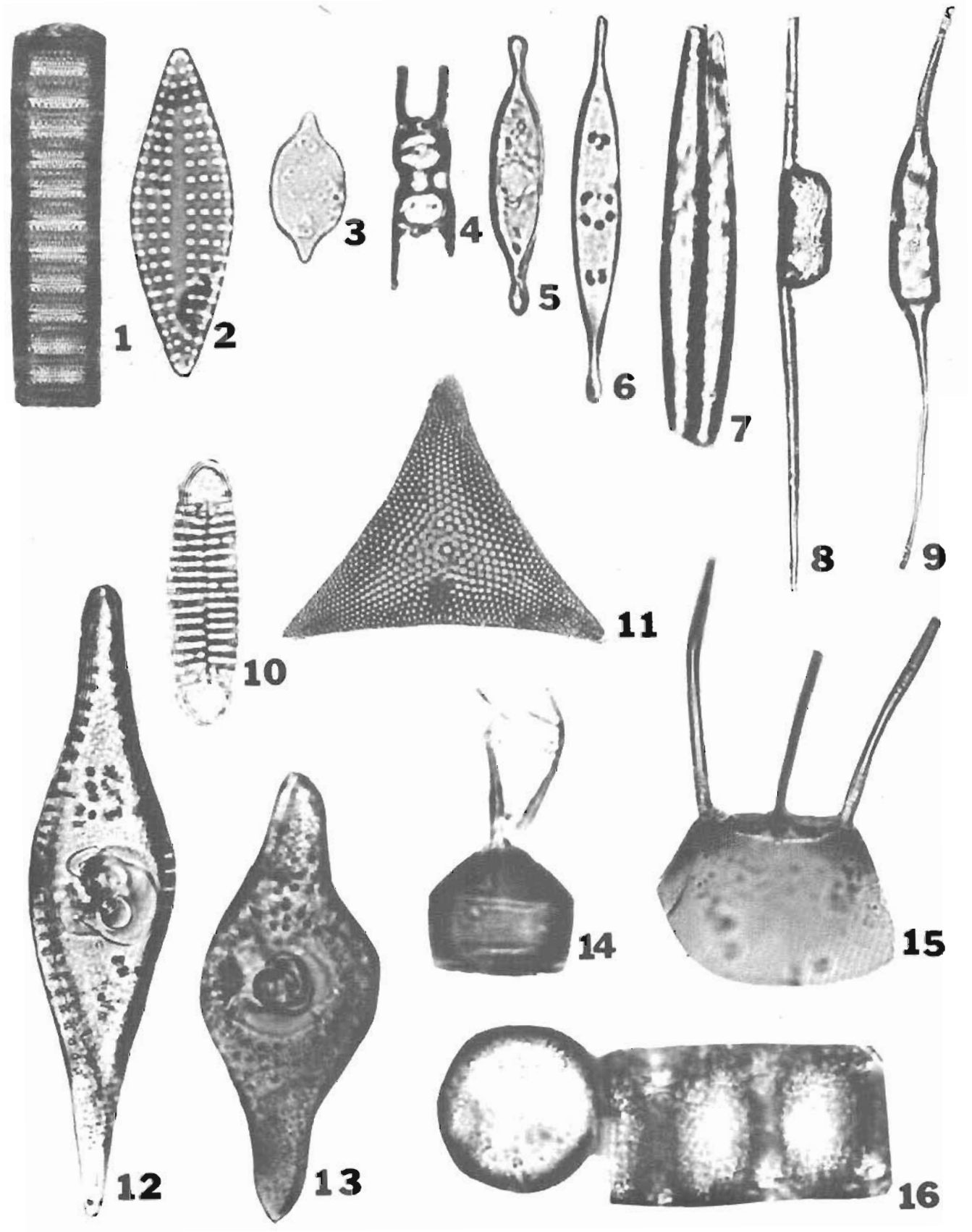
FIGURE 1. *Stellarima* group, sample 2-4; 64 µm in diameter.
2. *Coscinodiscus* sp. 1, sample 2-9; 62 µm in diameter.
3. *Thalassiosira mediaconvexa* Schrader, sample 5-1; 24 µm in diameter.
4. *Cestodiscus* sp. aff. *C. muhinae* Jousé, sample 5-1; 62 µm in diameter.
5. *Triceratium arcticum* Brightwell, sample 2-4, 99 µm in diameter.
6. *Craspedodiscus* sp. cf. *C. coscinodiscus* Ehrenberg, sample 2-9; 87 µm in diameter.



STELLARIMA, COSCINODISCUS, THALASSIOSIRA, CESTODISCUS, TRICERATIUM, CRASPEDODISCUS

PLATE 10

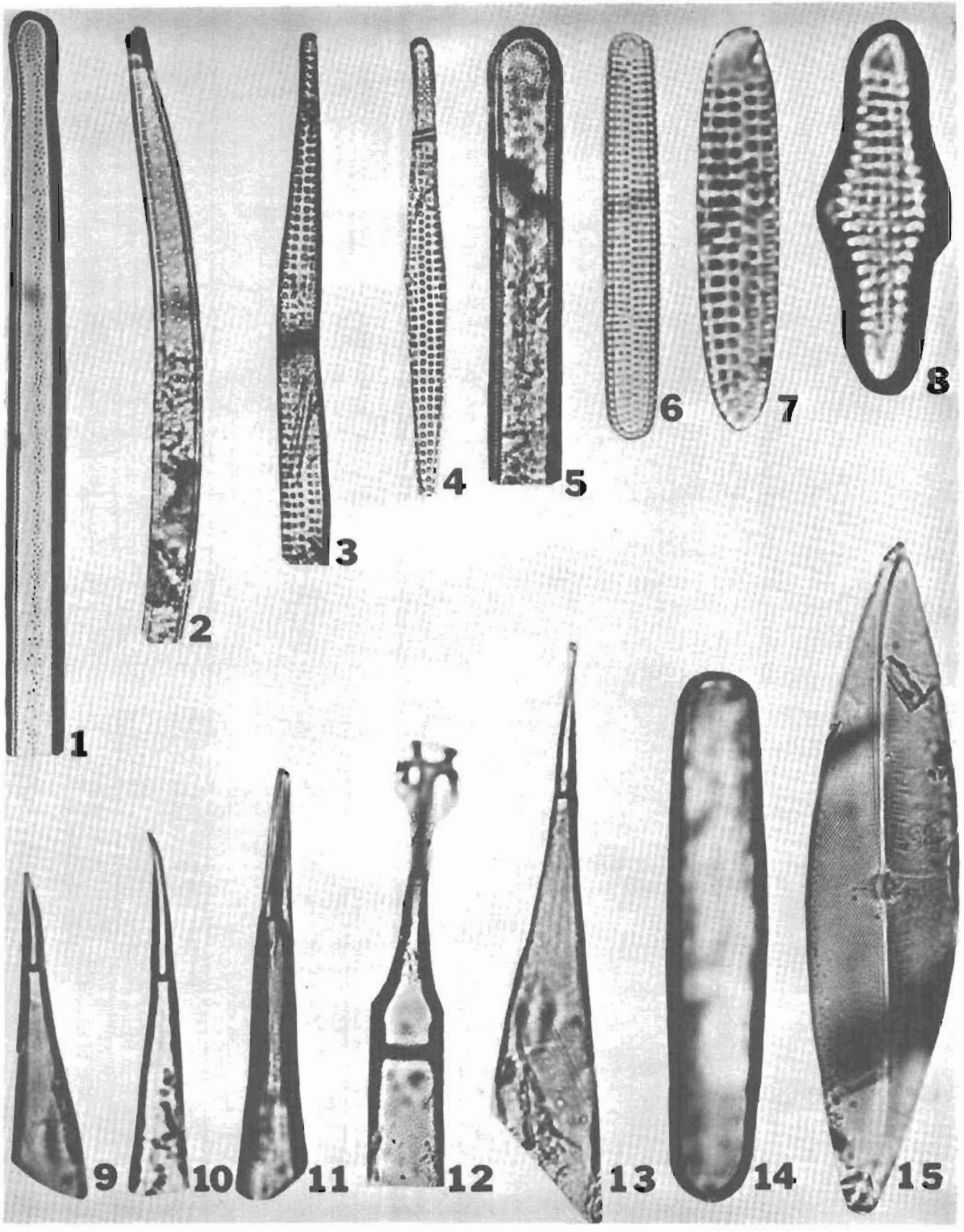
FIGURE 1. Melosira sp. 1, sample 2-1; 113 µm in length.
2. Rhaphoneis angulata Fenner, sample 2-11; 24 µm in length.
3. Cymatosira compacta Schrader & Fenner, sample 5-1; 18 µm in length.
4. Kisseleviella carina Sheshukova-Poretzkaya, sample 2-4; 24 µm in length.
5. Kisseleviella carina Sheshukova-Poretzkaya, sample 2-4; 30 µm in length.
6. Kisseleviella carina Sheshukova-Poretzkaya, sample 5-1; 56 µm in length.
7. Goniothecium tenue Brun, sample 2-4; 40 µm in length.
8. Chaetoceros sp., sample 2-11; 30 µm in length.
9. Pterotheca subulata Grunow, sample 2-4; 63 µm in length.
10. Rhabdonema japonicum Tempère & Brun, sample 2-4; 18 µm in length.
11. Pseudotriceratium motabile (Korotkevich) Gleser, sample 2-9; 43 µm in length.
12. Rutilaria epsilon var. longicornis Tempère & Brun, sample 2-4; 99 µm in length.
13. Rutilaria kerneri Pantocsek, sample 2-4; 57 µm in length.
14. Pterotheca kittoniana var. kamtschatica Gaponov, sample 2-1; 31 µm in length.
15. Odontella fimbriata (Greville) Schrader, sample 2-4; 89 µm in length.
16. Melosira sp. 2, sample 5-1; 67 µm in length.



MELOSIRA, RHAPHONEIS, CYMATOSIRA, KISSELEVIELLA, GONIOTHECIUM, CHAETOCEROS, PTEROTHECA, RHABDONEMA, PSEUDOTRICERATIUM, RUTILARIA, ODONTELLA

PLATE 11

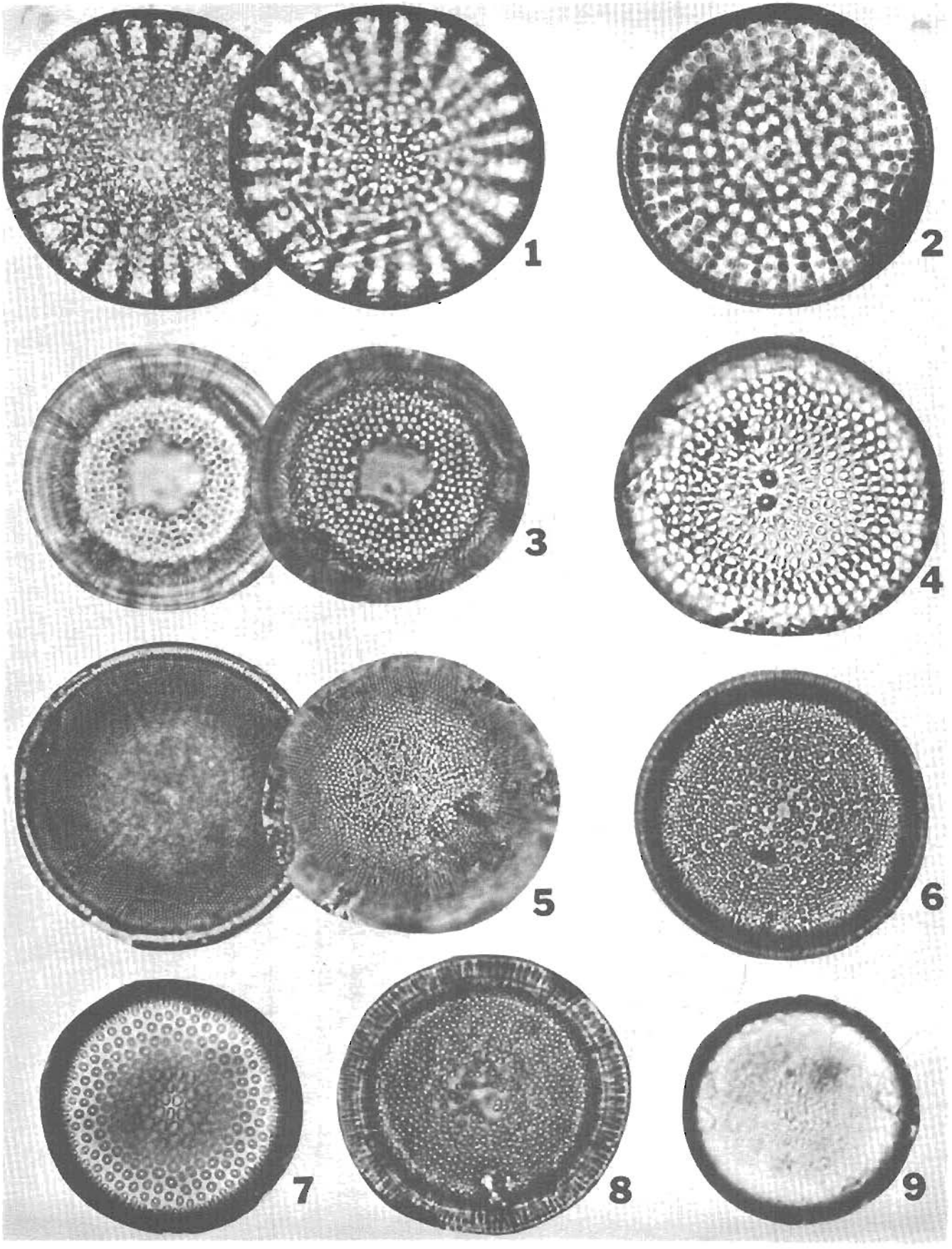
FIGURE 1. *Clavicula polymorpha* Grunow & Pantocsek, sample 2-4; 112 µm in length.
2. *Clavicula* sp. 1, sample 2-4; 80 µm in length.
3. *Sceptroneis* sp. 1, sample 2-4; 74 µm in length.
4. *Sceptroneis* sp. 2, sample 2-4; 63 µm in length.
5. *Clavicula polymorpha* Grunow & Pantocsek, sample 2-4, 65 µm in length.
6. *Pseudodimerogramma elegans* Schrader *in* Schrader and Fenner, sample 5-1; 31 µm in length.
7. *Pseudodimerogramma elegans*? Schrader *in* Schrader and Fenner, sample 5-1; 31 µm in length.
8. Genus and species indet., sample 5-1; 26 µm in length.
9. *Rhizosolenia* sp. 1, sample 2-11; 44 µm in length.
10. *Rhizosolenia hebatata* var. *subacuta* Grunow, sample 2-9; 48 µm in length.
11. *Rhizosolenia hebatata* var. *subacuta* Grunow, sample 2-9; 57 µm in length.
12. *Pseudopyxilla americana* (Ehrenberg) Forti, sample 2-9; 67 µm in length.
13. *Rhizosolenia* sp. 2, sample 2-11; 84 µm in length.
14. Genus and species indet., sample 5-1; 76 µm in length.
15. *Pleurosigma planktonica* Schrader, sample 2-4; 121 µm in length.



CLAVICULA, SCEPTRONEIS, PSEUDODIMEROGRAMMA, RHIZOSOLENIA, PSEUDOPYXILLA, PLEUROSIGMA, GENUS INDET.

PLATE 12

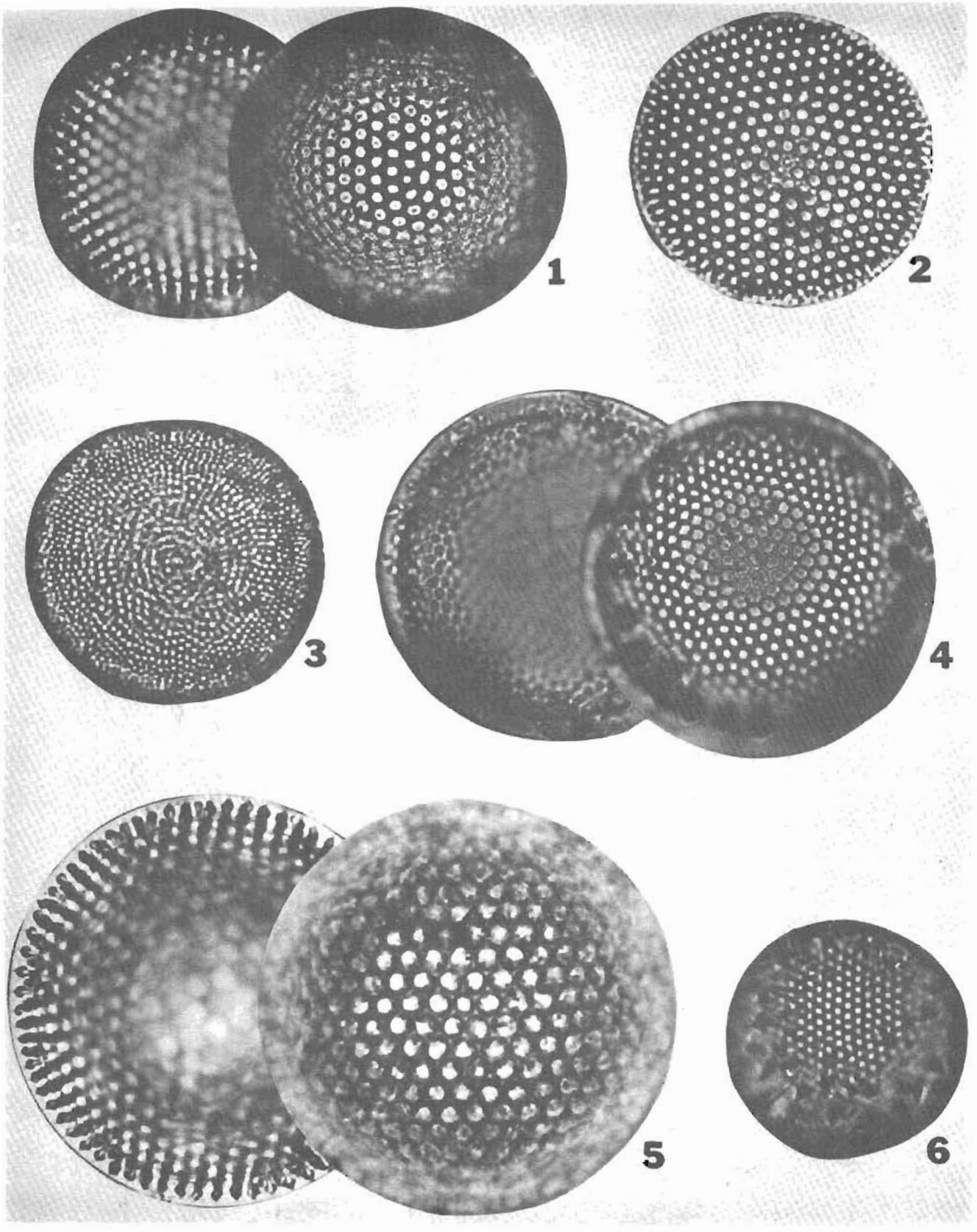
FIGURE 1. Stictodiscus kittonianus Greville, sample 2-4; 43 µm in diameter.
2. Stictodiscus grovei Schmidt, sample 2-9; 41 µm in diameter.
3. Cestodiscus sp. 5, sample 5-1; 31 µm in diameter.
4. Pseudostictodiscus picus Hanna, sample 2-4; 67 µm in diameter.
5. Stellarima group, sample 2-4; 40 µm in diameter.
6. Cestodiscus sp. 1., sample 2-4; 39 µm in diameter.
7. Coscinodiscus sp. cf. C. decrescens Grunow, sample 2-4; 28 µm in diameter.
8. Cestodiscus sp. 4, sample 5-1; 33 µm in diameter.
9. Thalassiosira sp. aff. T. manifesta Sheshukova-Poretzkaya, sample 5-1; 19 µm in diameter.



STICTODISCUS, CESTODISCUS, PSEUDOSTICTODISCUS, STELLARIMA, COSCINODISCUS, THALASSIOSIRA

PLATE 13

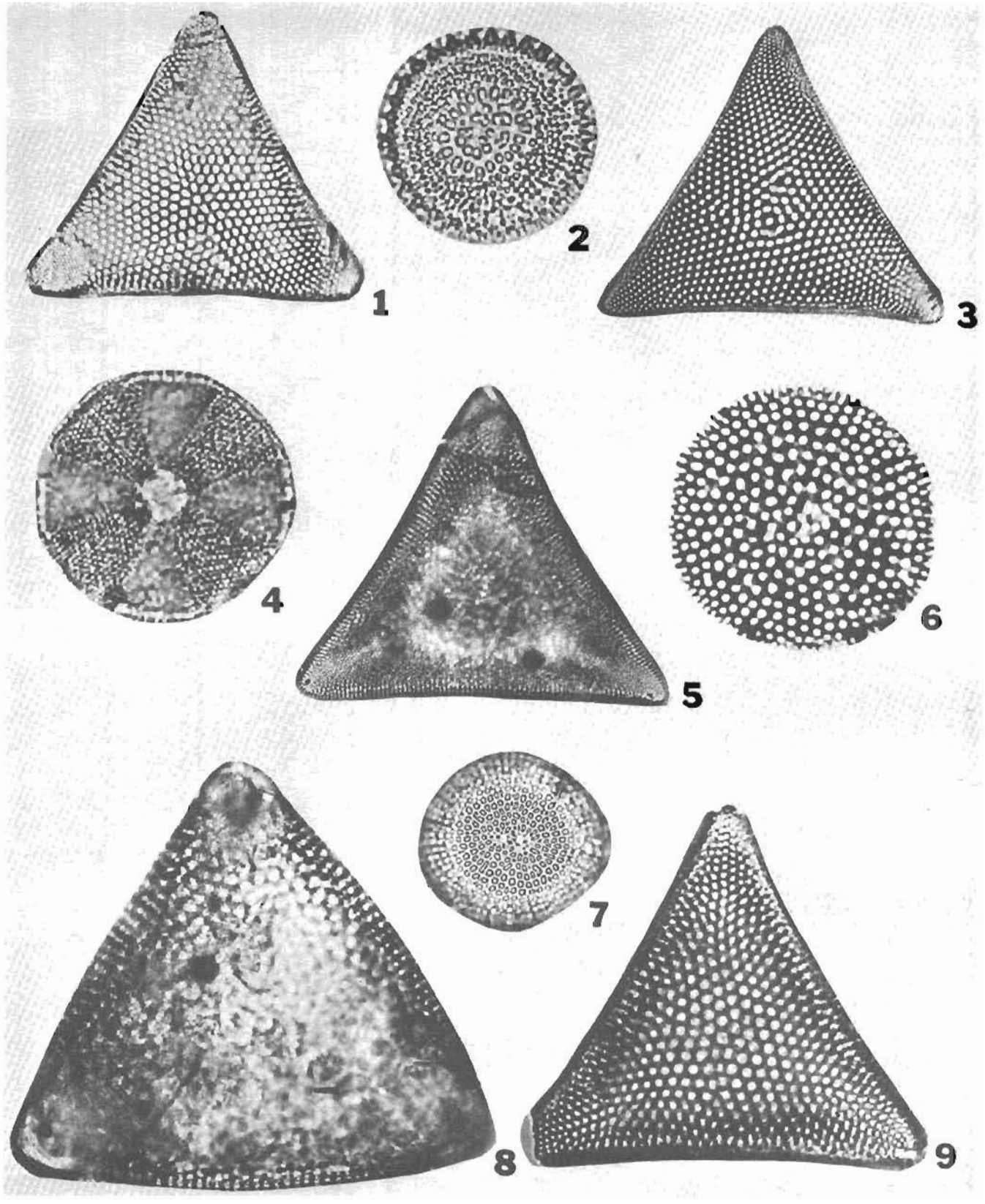
FIGURE 1. *Stephanopyxis turris* (Greville & Arnott) Ralfs, sample 2-4; 46 µm in diameter.
2. *Thalassiosira* sp. cf. *T. eccentrica* (Ehrenberg) Cleve, sample 2-9; 39 µm in diameter.
3. *Podosira* sp. 1, sample 2-9; 35 µm in diameter.
4. *Stephanopyxis eocenicus* Hajós, sample 5-1, 65 µm in diameter.
5. *Stephanopyxis grunowii* Grove & Sturt, sample 5-1, 87 µm in diameter.
6. *Stephanopyxis spinosissima* Grunow, sample 5-1, 27 µm in diameter.



STEPHANOPYXIS, THALASSIOSIRA, PODOSIRA

PLATE 14

FIGURE 1. Pseudotriceratium chenevieri (Meister) Gleser, sample 2-9; 47 µm in diameter.
2. Trochosira spinosa Kitton, sample 5-1; 35 µm in diameter.
3. Pseudotriceratium chenevieri (Meister) Gleser, sample 2-1; 48 µm in diameter.
4. Actinoptychus vulgaris Schumann, sample 2-4; 45 µm in diameter.
5. Triceratium radiosoreticulatum Grunow, sample 2-4; 50 µm in length.
6. Coscinodiscus oligocenicus Jousé, sample 2-4; 52 µm in diameter.
7. Pseudostictodiscus picus Hanna, sample 2-4; 15 µm in diameter.
8. Triceratium arcticum Brightwell, sample 2-4; 98 µm in length.
9. Pseudotriceratium chenevieri (Meister) Gleser, sample 2-4; 56 µm in length.



PSEUDOTRICERATIUM, TROCHOSIRA, ACTINOPTYCHUS, TRICERATIUM, COSCINODISCUS, PSEUDOSTICTODISCUS

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