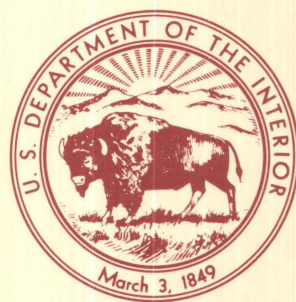


Oligocene Marine Diatoms Recovered
in Dredge Samples from the
Navarin Basin Province, Bering Sea

U.S. GEOLOGICAL SURVEY BULLETIN 1765



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. Baldauf¹ 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 μ m), and rare if a species was encountered 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).

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 *Actinopteryx senarius*, *Asteromphalus symmetricus*, *Cestodiscus* sp. aff. *C. muhinae*, *C. pulchellus*, *Coscinodiscus oculus-iridis*, *Hemiaulus polycistinorum*, *Melosira sulcata*, *Pseudostictodiscus picus*, *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*,

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

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.

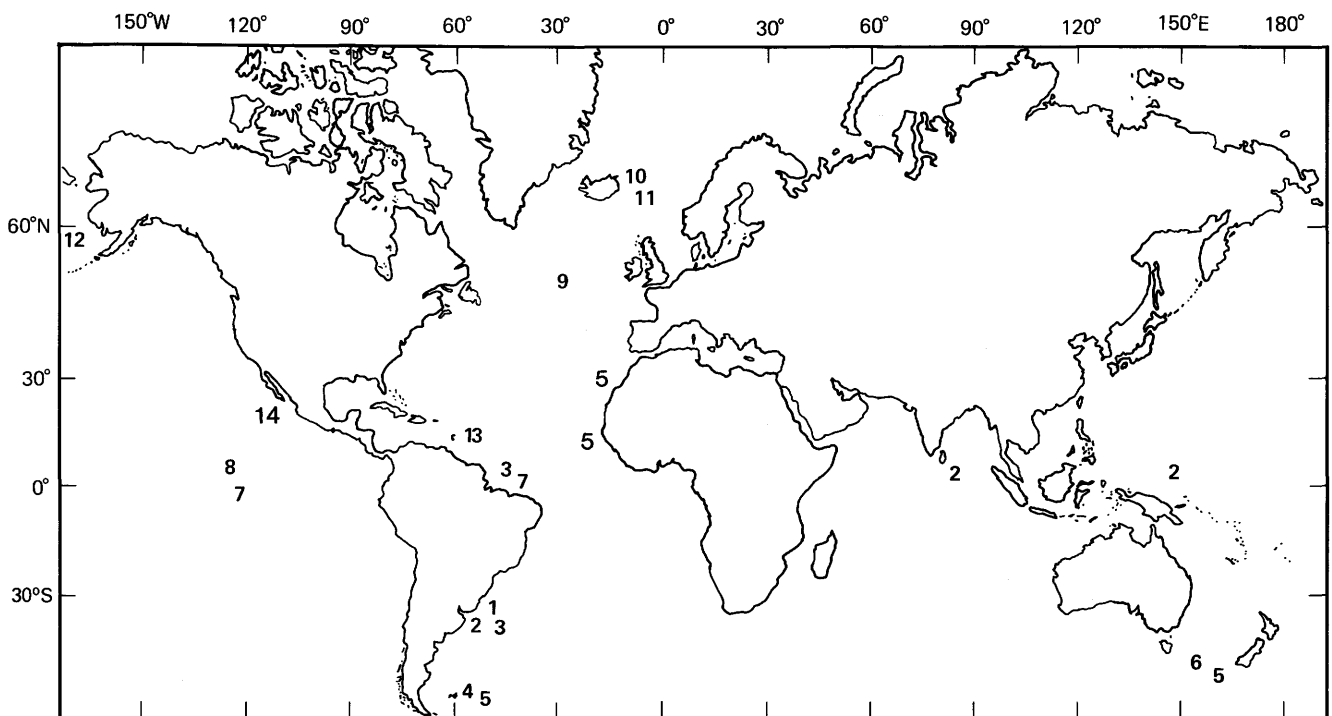


Figure 1. Geographic locations where Oligocene diatoms have been recorded. 1, Gombos (1983); 2, Fenner (1984a); 3, Fenner (1978); 4, Gombos and Ciesielski (1983); 5, Fenner (1984b); 6, Hajós (1976); 7, Jousé (1977); 8, Barron (1983); 9, Baldauf (1985); 10, Dzinoridze and others (1979); 11, Schrader and 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 commun., 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	Species/samples	2-1	2-4	2-9	2-11	5-1
<u>Actinocyclus ehrenbergii</u>	-	R	R	-	R	<u>Melosira</u> sp. 1	R	-	-	-	R
<u>Actinocyclus</u> sp. 1	R	R	-	R	R	<u>Melosira</u> sp. 2	-	-	-	R	R
<u>Actinoptychus senarius</u>	C	F	F	F	F	<u>Muelleriopsis</u> sp. cf. <u>M. limbata</u>	-	R	-	-	-
<u>Actinoptychus splendens</u>	-	R	R	-	F	<u>Odontella aurita</u>	-	R	R	R	C
<u>Actinoptychus vulgaris</u>	-	R	-	-	-	<u>Odontella fimbriata</u>	-	R	-	-	-
<u>Arachnoidiscus decorus</u>	-	-	R	R	-	<u>Odontella tuomeyi</u>	-	R	-	-	-
<u>Asterolampra praeacutiloba</u>	R	R	-	-	R	<u>Odontella</u> sp. 1	-	-	R	-	F
<u>Asteromphalus</u> sp. cf. <u>A. darwinii</u>	-	-	R	-	-	<u>Pleurosigma planktonica</u>	-	R	R	-	-
<u>Asteromphalus oligocenicus</u>	-	R	-	-	R	<u>Ploiaria petasiformis</u>	R	R	R	-	-
<u>Asteromphalus</u> sp. cf. <u>A. robustus</u>	R	R	R	-	R	<u>Ploiaria</u> sp. 1	-	R	R	-	-
<u>Asteromphalus symmetricus</u>	-	-	R	-	-	<u>Ploiaria</u> sp. 2	-	-	R	-	-
<u>Aulacodiscus amoenus</u>	R	-	-	-	-	<u>Podosira</u> sp. 1	-	R	R	-	-
<u>Aulacodiscus crux</u>	-	R	-	-	-	<u>Pseudodimerogramma elegans</u>	-	F	R	-	R
<u>Cestodiscus</u> sp. aff. <u>C. muhinae</u>	R	R	R	R	R	<u>Pseudopyxilla americana</u>	-	R	R	-	-
<u>Cestodiscus pulchellus</u>	R	R	R	R	R	<u>Pseudostictodiscus picus</u>	-	C	R	-	-
<u>Cestodiscus robustus</u>	R	-	R	-	-	<u>Pseudotriceratium chenevieri</u>	R	R	R	R	R
<u>Cestodiscus</u> sp. 1	-	R	-	-	R	<u>Pseudotriceratium motabile</u>	-	-	R	-	-
<u>Cestodiscus</u> sp. 2	-	R	-	-	R	<u>Pterotheca kittoniana</u>	-	-	-	-	-
<u>Cestodiscus</u> sp. 3	-	-	-	R	-	var. <u>kamtschatica</u>	F	-	-	-	-
<u>Cestodiscus</u> sp. 4	-	R	-	-	R	<u>Pterotheca subulata</u>	F	R	R	F	-
<u>Cestodiscus</u> sp. 5	-	-	-	-	R	<u>Pterotheca tetraccladia</u>	F	R	R	-	-
<u>Chaetoceros</u> sp.	-	R	R	R	-	<u>Rhabdonema japonicum</u>	-	R	-	-	-
<u>Cladogramma dubium</u>	-	-	-	-	R	<u>Rhaponeis angulata</u>	-	R	R	R	R
<u>Clavicula polymorpha</u>	-	R	-	-	-	<u>Rhizosolenia hebatata</u>	-	-	-	-	-
<u>Clavicula</u> sp. 1	-	R	-	-	-	var. <u>subacuta</u>	R	F	R	-	R
<u>Cocconeis antiqua</u> var. <u>antiqua</u>	R	-	R	R	-	<u>Rhizosolenia</u> sp. 1	F	R	R	F	R
<u>Cocconeis dirupta</u>	-	-	-	R	-	<u>Rhizosolenia</u> sp. 2	-	-	-	R	-
<u>Cocconeis scutellum</u>	R	-	-	R	-	<u>Rocella gelida</u>	-	-	-	-	C
<u>Cocconeis vitrea</u>	R	-	-	R	-	<u>Rutilaria epsilon</u>	-	-	-	-	-
<u>Coscinodiscus</u> sp. cf. <u>C. decrescens</u>	-	R	-	-	-	var. <u>longicornis</u>	-	R	-	-	-
<u>Coscinodiscus marginatus</u>	R	R	R	R	F	<u>Rutilaria kernerii</u>	-	R	-	-	-
<u>Coscinodiscus nitidus</u>	-	R	R	R	-	<u>Sceptroneis</u> sp. 1	R	R	R	-	F
<u>Coscinodiscus oculus-iridis</u>	R	F	R	-	F	<u>Sceptroneis</u> sp. 2	R	R	R	-	R
<u>Coscinodiscus oligocenicus</u>	-	R	-	-	-	<u>Skeletonema utriculosum</u>	-	-	R	-	-
<u>Coscinodiscus</u> sp. aff. <u>C. radiatus</u>	R	R	-	-	-	<u>Stellarima</u> group	F	C	F	F	R
<u>Coscinodiscus vetustissimus</u>	-	R	R	-	R	<u>Stephanogonia</u> sp. cf.	-	-	-	-	-
<u>Coscinodiscus</u> sp. 1	-	-	R	-	-	<u>S. polycantha</u>	-	R	-	R	-
<u>Cosmidiscus?</u> sp. 1	-	R	R	-	-	<u>Stephanopyxis eocenicus</u>	-	-	-	-	R
<u>Craspedodiscus</u> sp. aff.	-	-	-	-	-	<u>Stephanopyxis grunowii</u>	-	-	-	-	R
<u>C. coscinodiscus</u>	-	R	R	-	-	<u>Stephanopyxis spinoissima</u>	-	-	-	-	R
<u>Cymatosira compacta</u>	-	R	-	-	R	<u>Stephanopyxis turris</u>	R	F	R	R	R
<u>Diploneis</u> sp.	R	R	R	-	R	<u>Stictodiscus grovei</u>	R	-	F	-	R
<u>Eucampia balaustium</u>	R	R	R	R	-	<u>Stictodiscus kittonianus</u>	-	F	-	-	R
<u>Goniothecium decoratum</u>	-	R	R	R	F	<u>Stictodiscus</u> sp. 1	R	F	F	R	R
<u>Goniothecium odontella</u>	-	R	R	-	F	<u>Synedra miocenica</u>	R	R	R	R	R
<u>Goniothecium tenue</u>	R	R	R	R	R	<u>Thalassiosira</u> sp. aff.	-	-	-	-	-
<u>Goniothecium</u> sp. 1	-	-	-	-	R	<u>T. eccentrica</u>	-	R	R	-	-
<u>Goniothecium</u> sp. 2	-	-	-	-	R	<u>Thalassiosira</u> sp. aff.	-	-	-	-	-
<u>Hemiaulus kittonii</u>	-	-	F	-	-	<u>T. manifesta</u>	-	-	-	-	R
<u>Hemiaulus polycystinorum</u>	-	-	R	-	R	<u>Thalassiosira</u> sp. aff.	-	-	-	-	-
<u>Hemiaulus pungens</u>	-	-	R	-	R	<u>T. mediaconvexa</u>	-	-	-	-	R
<u>Hemiaulus</u> sp. 1	-	-	-	-	R	<u>Thalassiosira spinosa</u>	-	-	-	-	R
<u>Hyalodiscus denutatus</u>	R	R	F	R	-	<u>Thalassiosira</u> sp. 1	-	-	R	-	-
<u>Hyalodiscus elegans</u>	-	-	-	-	R	<u>Thalassiosira</u> sp. 2	-	-	R	-	-
<u>Hyalodiscus radiatus</u>	-	R	-	-	R	<u>Thalassiosira</u> sp. 3	-	-	R	-	-
<u>Hyalodiscus</u> sp. 1	-	R	-	-	-	<u>Triceratium arcticum</u>	-	R	-	-	-
<u>Kisseleviella carina</u>	A	A	F	A	F	<u>Triceratium radiosoreticulatum</u>	R	R	-	-	R
<u>Liradiscus</u> sp. aff. <u>L. ovalis</u>	R	-	-	-	-	<u>Trochosira spinosa</u>	R	R	-	-	R
<u>Liradiscus</u> sp.	F	R	R	R	R	<u>Xanthiopyxis panduraeformis</u>	R	R	R	-	R
<u>Melosira clavigera</u>	F	R	F	R	F	<u>Xanthiopyxis</u> sp. 1	R	-	R	-	R
<u>Melosira sulcata</u>	F	R	F	F	F						

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.

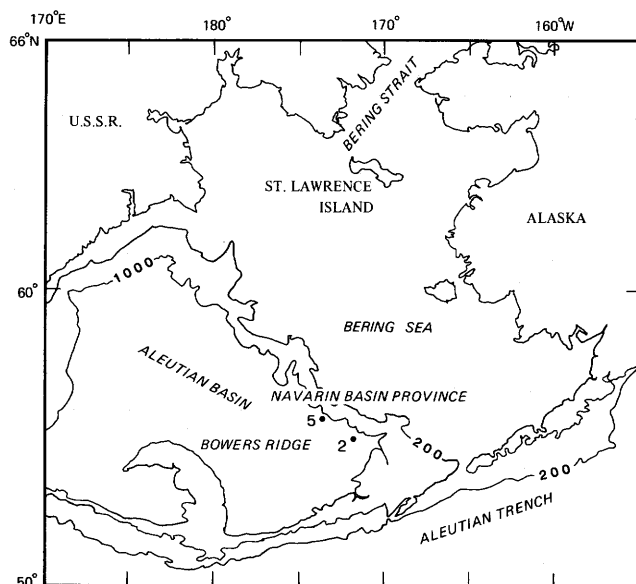


Figure 2. Geographic locations of dredge samples (numbered dots) collected from the Navarin Basin Province, western Bering Sea. Contour interval is in meters.

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, planktonic (oceanic and neritic); B, benthic; S, resting spore of neritic planktonic diatom]

Genus		Genus		Genus	
<u>Actinocyclus</u>	(P)	<u>Actinoptychus</u>	(B)	<u>Arachnoidiscus</u>	(B)
<u>Asterolampra</u>	(P)	<u>Asteromphalus</u>	(P)	<u>Aulacodiscus</u>	(B)
<u>Cestodiscus</u>	(P)	<u>Chaetoceros</u>	(P)	<u>Cladogramma</u>	(S)
<u>Clavicula</u>	(P?)	<u>Cocconeis</u>	(B)	<u>Coscinodiscus</u>	(P)
<u>Cosmiodiscus</u>	(P)	<u>Craspedodiscus</u>	(P)	<u>Cymatosira</u>	(P)
<u>Diploneis</u>	(B)	<u>Eucampia</u>	(P)	<u>Goniothecium</u>	(S)
<u>Hemiaulus</u>	(P)	<u>Hyalodiscus</u>	(P)	<u>Kisseleviella</u>	(P)
<u>Liradiscus</u>	(S)	<u>Melosira</u>	(B)	<u>Muelleriopsis</u>	(S)
<u>Odontella</u>	(P)	<u>Pleurosigma</u>	(B)	<u>Ploiaria</u>	(S)
<u>Podosira</u>	(S)	<u>Pseudodimerogramma</u>	(P?)	<u>Pseudopyxilla</u>	(S)
<u>Pseudostictodiscus</u>	(P?)	<u>Pseudotriceratium</u>	(P)	<u>Pterotheca</u>	(S)
<u>Rhabdonema</u>	(B)	<u>Rhaphoneis</u>	(B)	<u>Rhizosolenia</u>	(P)
<u>Rocella</u>	(P)	<u>Rutilaria</u>	(B)	<u>Sceptroneis</u>	(B)
<u>Skeletonema</u>	(P)	<u>Stellarima</u>	(P)	<u>Stephanogonia</u>	(S)
<u>Stephanopyxis</u>	(P)	<u>Stictodiscus</u>	(B)	<u>Synedra</u>	(P)
<u>Thalassiosira</u>	(P)	<u>Triceratium</u>	(P)	<u>Trochosira</u>	(S)
<u>Xanthiopyxis</u>	(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 grevilleanus 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.
- Cosmioidiscus? 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. 6.
- 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 μ m.
- 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 Korotkevich, 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 (Korotkevich) Gleser, 1974, pl. 54, fig. 4; this paper pl. 10, fig. 11. Synonym: Triceratium motabile Korotkevich, 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 kernerii* 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; Wölle, 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. Synonym: *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 Coosawatchie 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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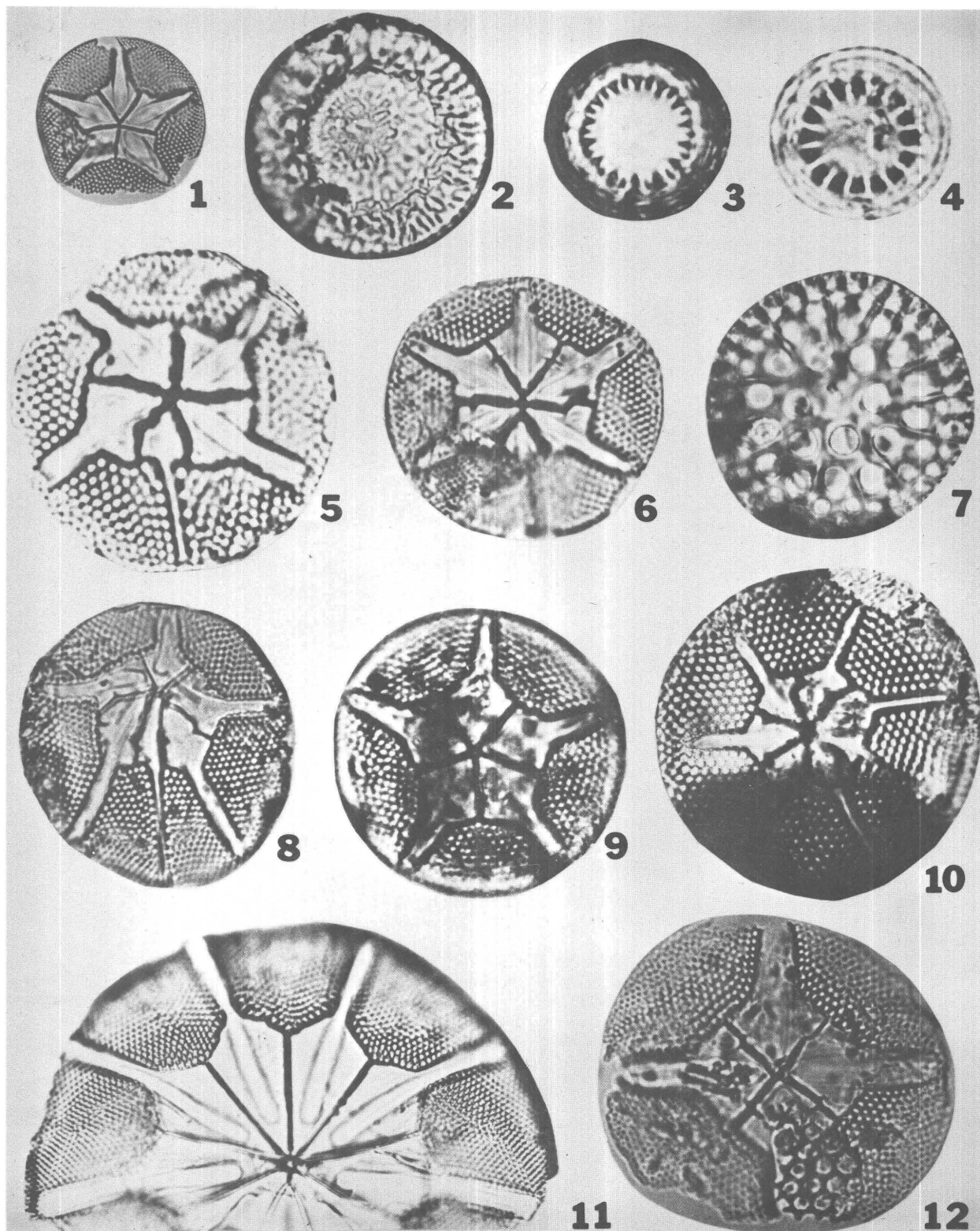
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PLATES 1-14

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

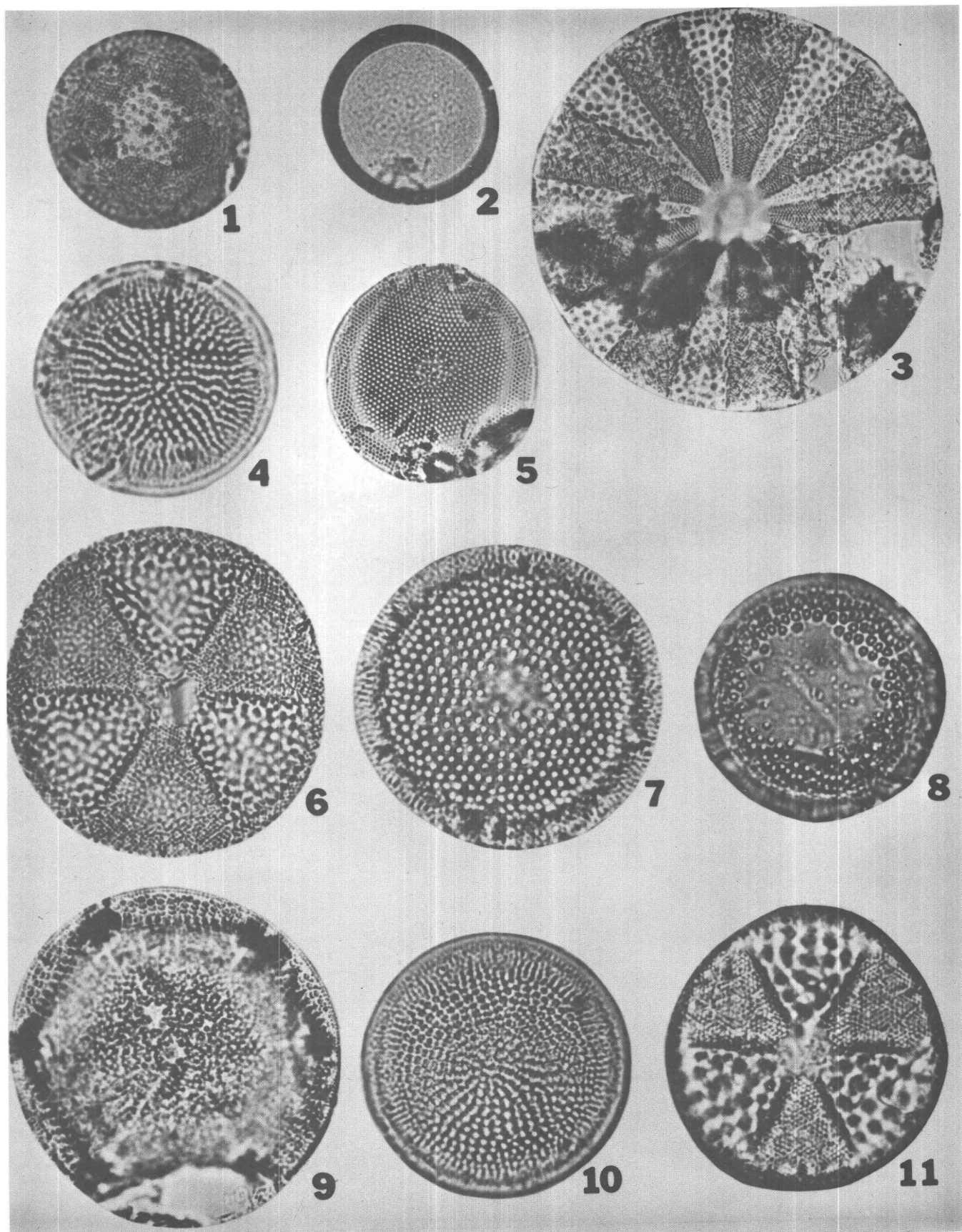
- FIGURE
1. Asterolampra praeacutiloba Fenner, sample 2-4; 16 μm in diameter.
 2. Hyalodiscus elegans Strelnikova, sample 5-1; 18 μm in diameter.
 3. Melosira sulcata (Ehrenberg) Kützing, sample 2-9; 11 μm in diameter.
 4. Melosira sulcata (Ehrenberg) Kützing, sample 2-9; 14 μm in diameter.
 5. Asteromphalus 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

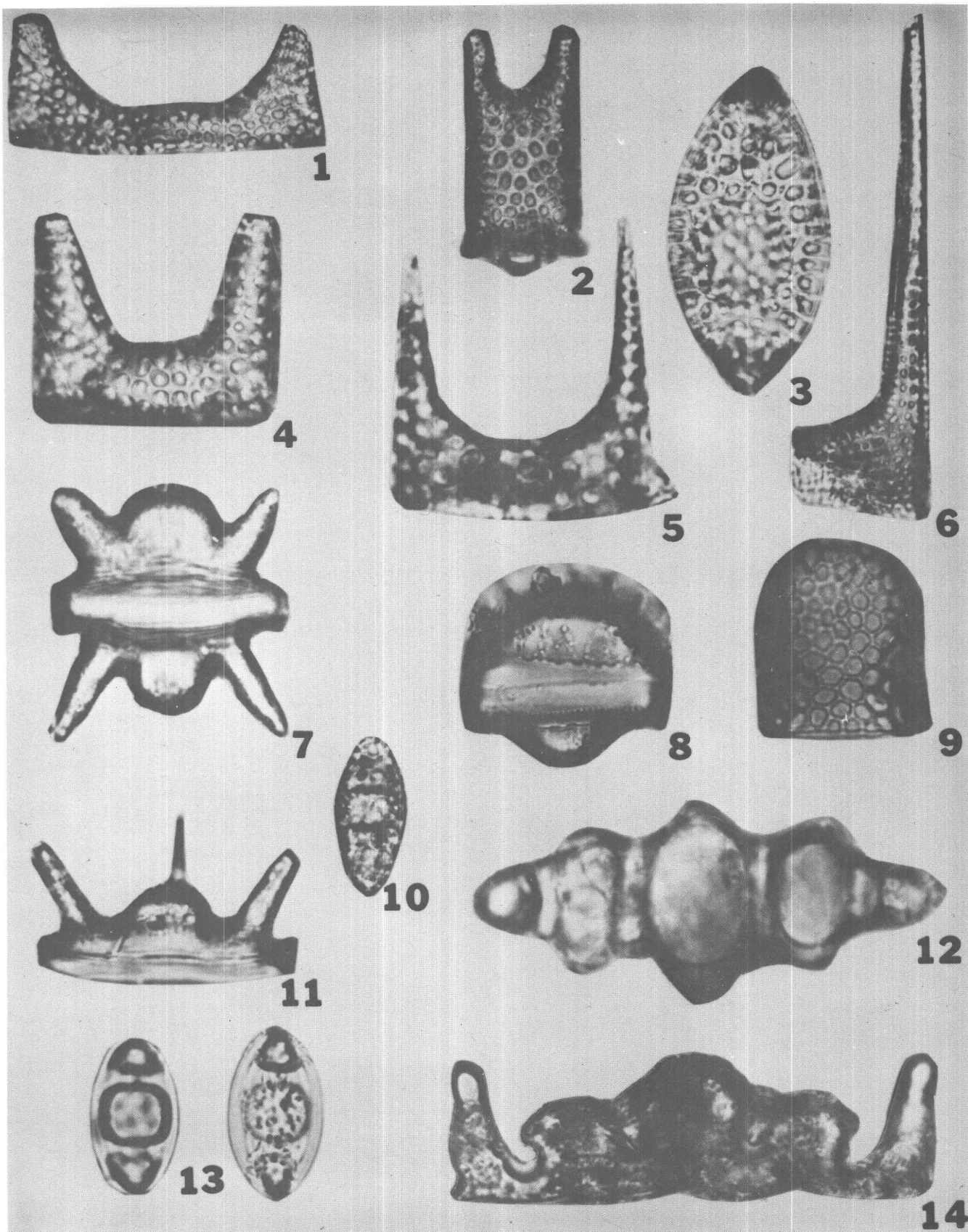
- FIGURE 1. Actinocyclus sp. 1 (to be described by N. Radionova, written commun., 1985), sample 2-11; 20 μ m in diameter.
2. Hyalodiscus denutatus Korotkevich, sample 2-9; 18 μ m in diameter.
3. Actinoptychus splendens (Shadbolt) Ralfs, sample 5-1; 64 μ m in diameter.
4. Thalassiosira sp. aff. T. mediaconvexa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



*ACTINOCYCLUS, HYALODISCUS, ACTINOPTYCHUS, THALASSIOSIRA, CESTODISCUS,
COSMIODISCUS, AULACODISCUS*

PLATE 3

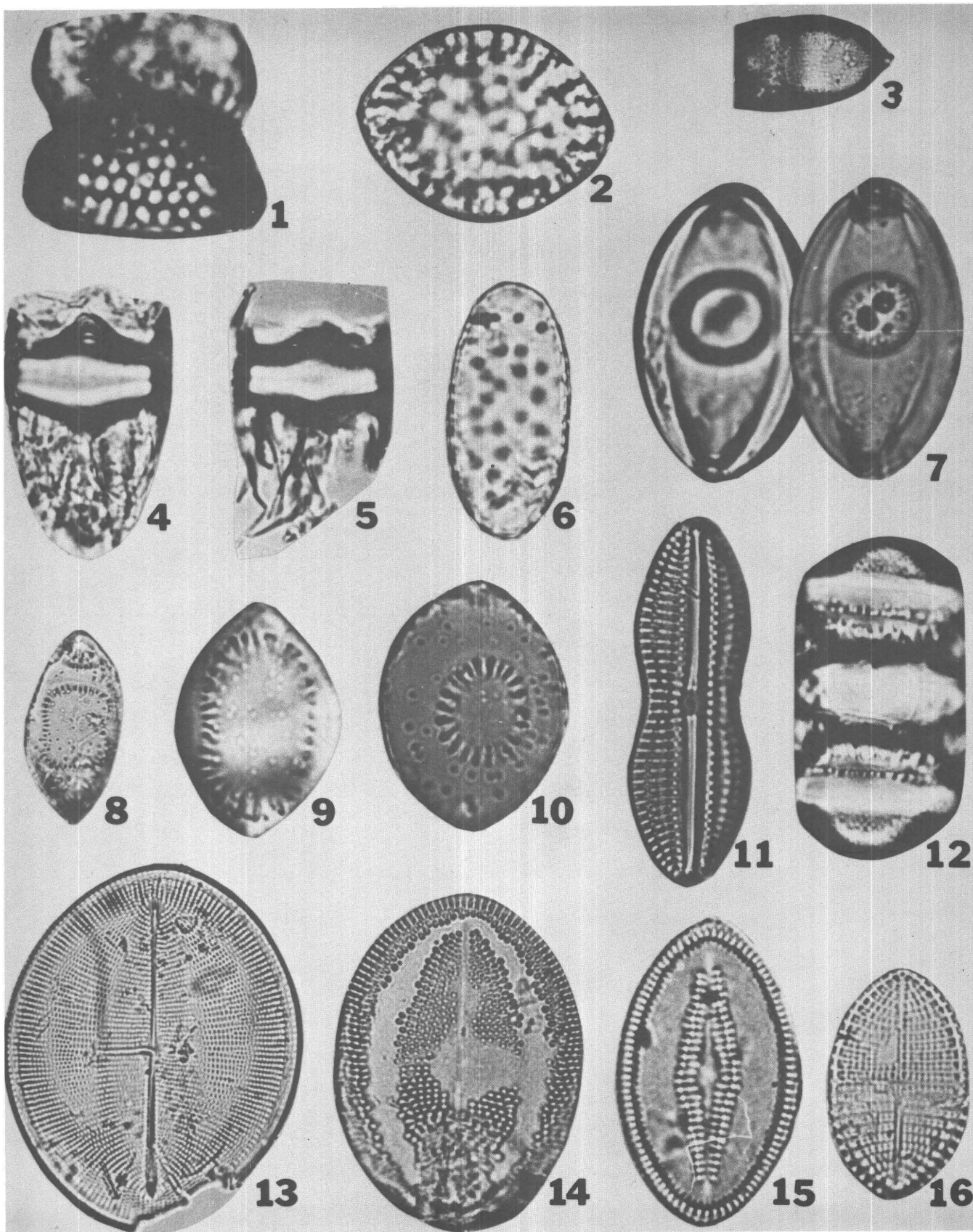
- FIGURE
1. Eucampia balaustium Castracane, sample 2-9; 28 μm in length.
 2. Hemiaulus kittonii Grunow, sample 2-9; 15 μm in length.
 3. Hemiaulus polycistinorum Ehrenberg, sample 5-1, 34 μm in length.
 4. Eucampia balaustium Castracane, sample 2-9; 15 μm in length.
 5. Hemiaulus pungens Grunow, sample 5-1; 21 μm in length.
 6. Hemiaulus sp. 1, sample 5-1; 32 μm in length.
 7. Odontella aurita Agardh, sample 5-1; 28 μm in length.
 8. Cladogramma dubium Lohman, sample 5-1; 18 μm in diameter.
 9. Stephanopyxis turris (Greville & Arnott) Ralfs, sample 2-4; 20 μm in diameter.
 10. Hemiaulus polycistinorum Ehrenberg, sample 2-9; 8 μm in length.
 11. Odontella aurita Agardh, sample 5-1; 34 μm in length.
 12. Odontella tuomeyi (Bailey) Glezer, sample 2-4; 42 μm in length.
 13. Odontella sp. 1, sample 5-1; 12 μm in length.
 14. Odontella tuomeyi (Bailey) Glezer, sample 2-4; 51 μm in length.



EUCAMPIA, HEMIAULUS, ODONTELLA, CLADOGRAMMA, STEPHANOPYXIS

PLATE 4

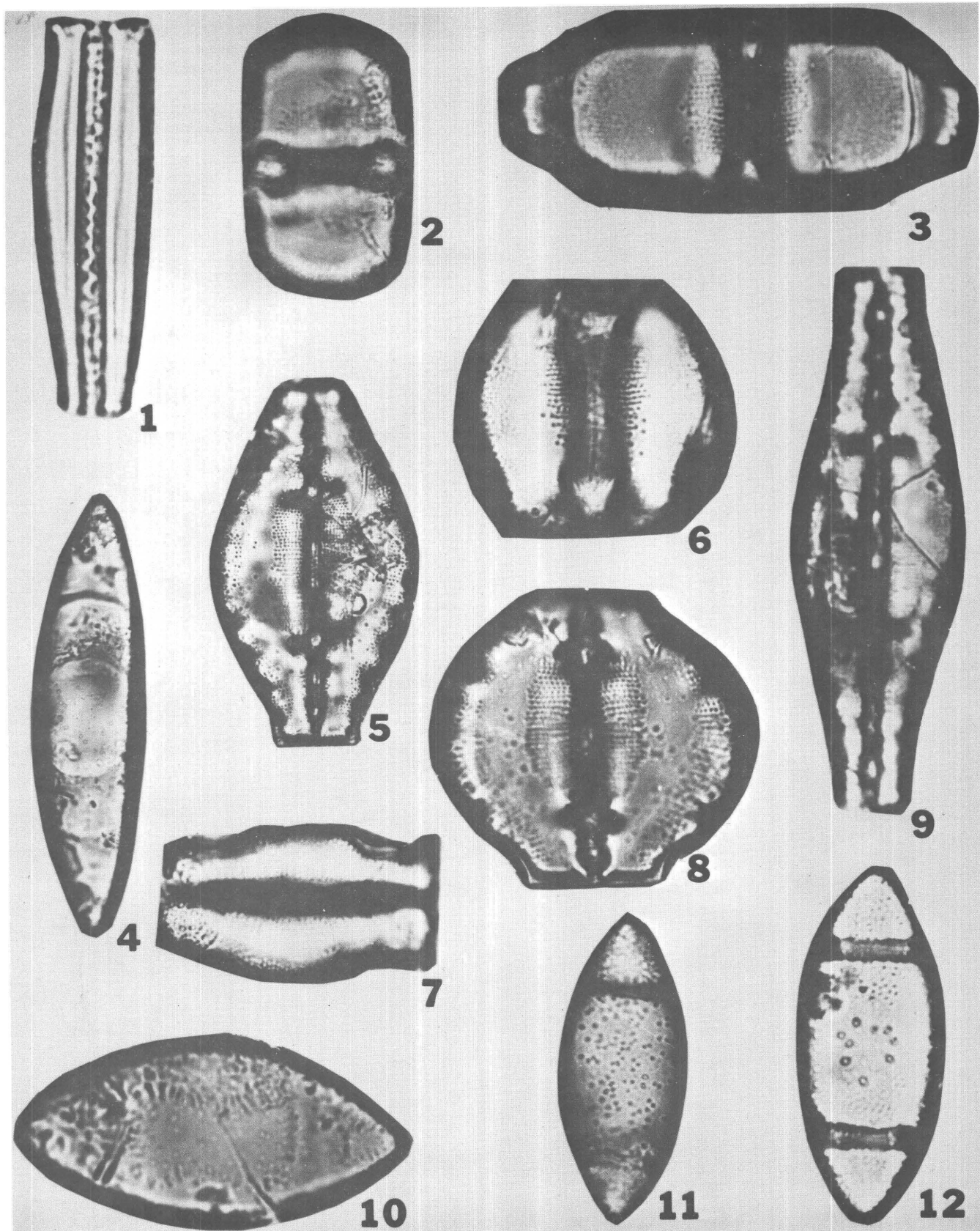
- FIGURE
1. Stephanopyxis turris (Greville & Arnott) Ralfs, sample 2-9; 18 μ m in length.
 2. Liradiscus sp. aff. L. ovalis Greville, sample 2-1; 12 μ m in length.
 3. Genus and species indet., sample 2-9; 8 μ m in length.
 4. Pterotheca tetracladia (Ehrenberg) Thum, sample 2-4; 14 μ m in length.
 5.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



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

PLATE 5

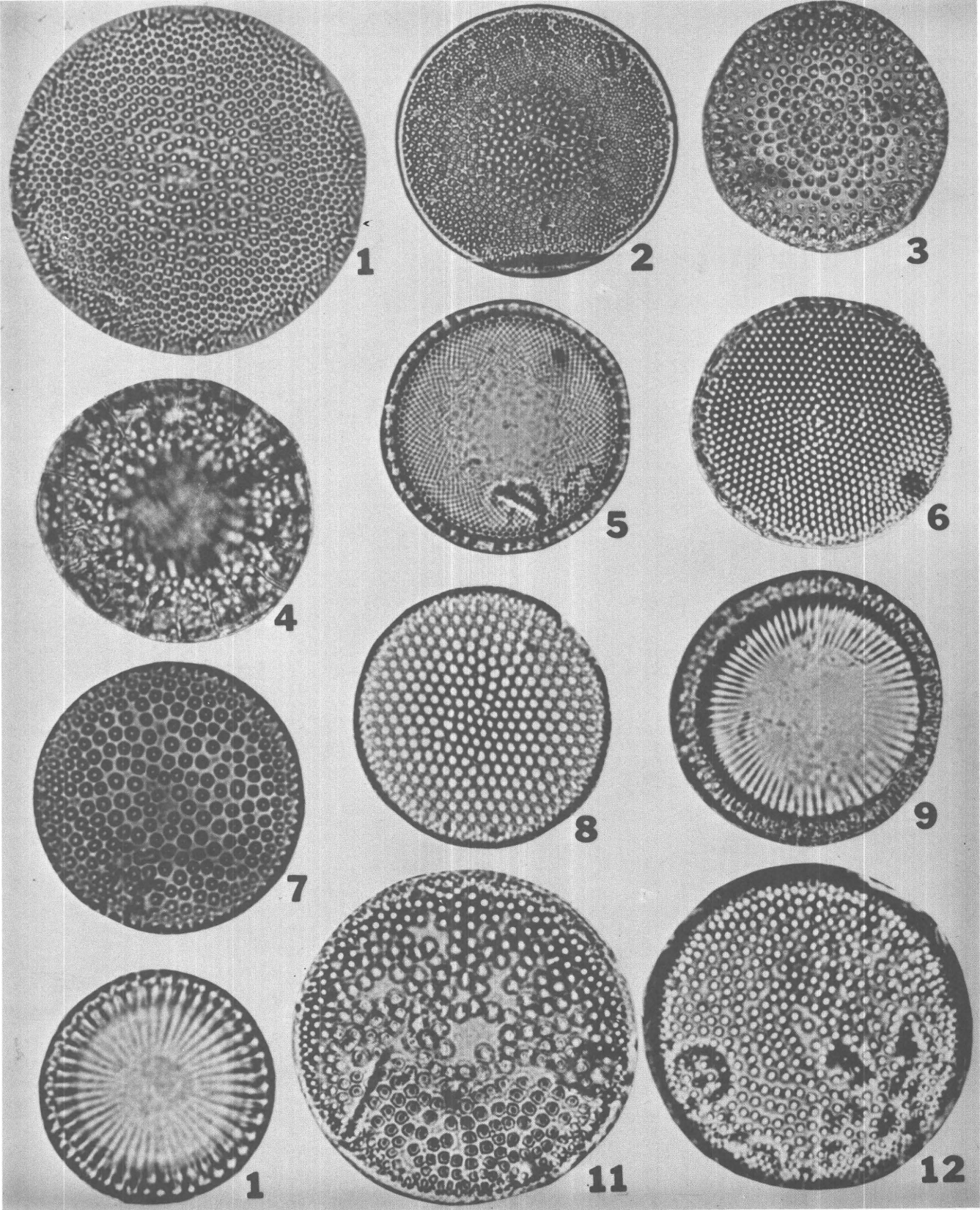
- FIGURE
1. Goniothecium tenue Brun, sample 2-9; 37 μ m in length.
 2. Goniothecium odontella Ehrenberg, sample 5-1; 36 μ m in length.
 3. Goniothecium odontella Ehrenberg, sample 5-1; 56 μ m in length.
 4. Goniothecium decoratum Brun, sample 5-1; 63 μ m in length.
 5. Goniothecium decoratum Brun, sample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



GONIOTHECIUM, PLOIARIA

PLATE 6

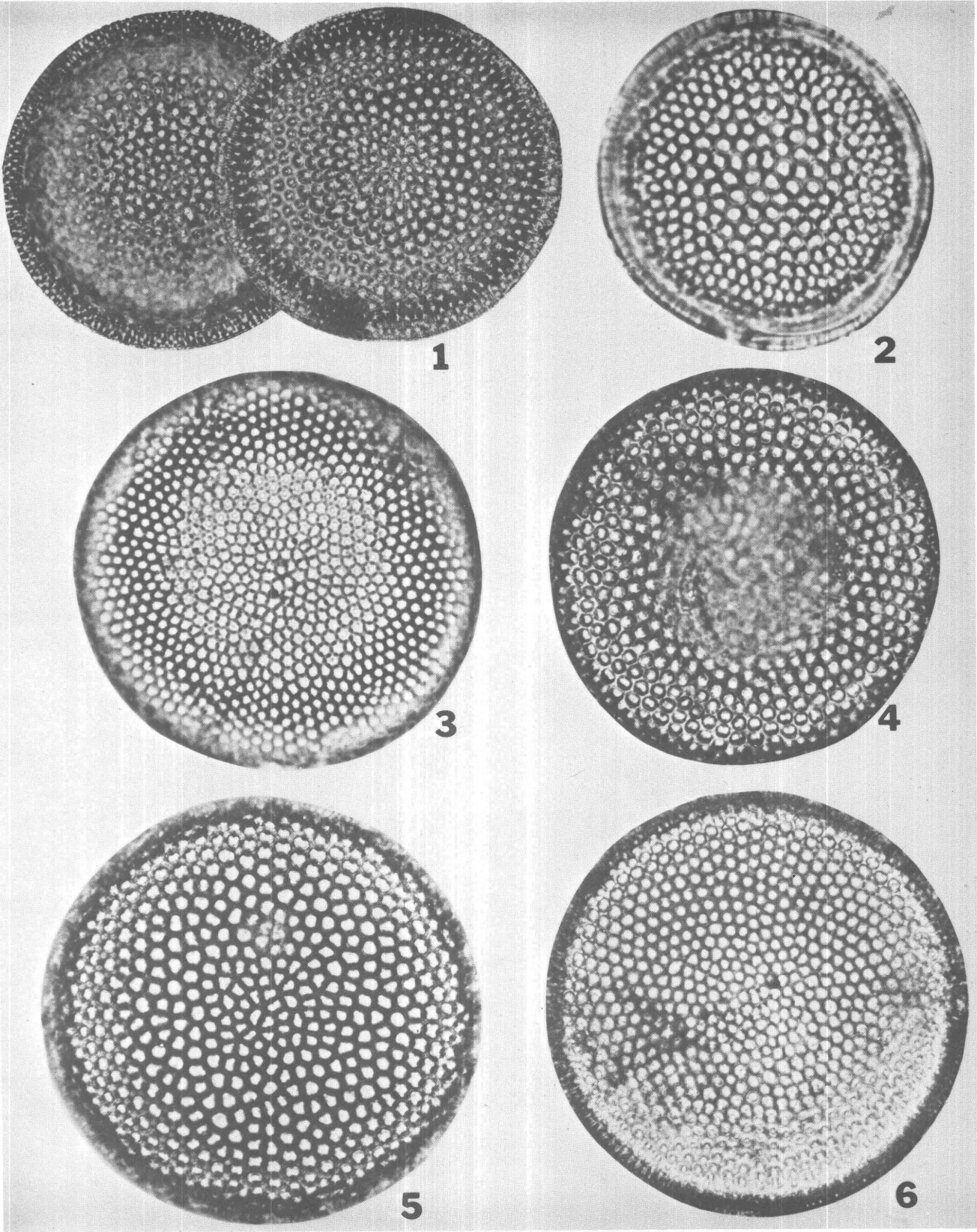
- FIGURE
1. Cestodiscus sp. 3, sample 2-11; 56 μ m in diameter.
 2. Cestodiscus sp. 2, sample 5-1; 42 μ m in diameter.
 3. Coscinodiscus sp. cf. C. decrescens Grunow, sample 2-9, 31 μ m in diameter.
 4. Stictodiscus sp. 1, sample 2-9; 22 μ m in diameter.
 5. Hyalodiscus denutatus Korotkevich, sample 2-4; 26 μ m in diameter.
 6. Thalassiosira sp. 3, sample 2-9; 34 μ m in diameter.
 7. Coscinodiscus sp. aff. C. oligocenicus Jousé, sample 2-4; 37 μ m in diameter.
 8. Thalassiosira sp. 2, sample 2-9; 28 μ m in diameter.
 9. Melosira sulcata (Ehrenberg) Kützing, sample 2-4; 35 μ m in diameter.
 10. Melosira clavigera Grunow, sample 2-4; 26 μ m in diameter.
 11. Cestodiscus sp. 3, sample 2-11; 61 μ m in diameter.
 12. Cestodiscus sp. 3, sample 2-11; 53 μ m in diameter.



CESTODISCUS, COSCINODISCUS, STICTODISCUS, HYALODISCUS, THALASSIOSIRA, MELOSIRA

PLATE 7

- FIGURE 1. Cestodiscus robustus Jousé, sample 2-9; 28 μm in diameter.
2. Coscinodiscus marginatus Ehrenberg, sample 2-4; 39 μm in diameter.
3. Coscinodiscus oculus-iridis Ehrenberg, sample 2-4; 76 μm in diameter.
4. Coscinodiscus sp. aff. C. radiatus Ehrenberg, sample 2-4; 74 μm in diameter.
5. Coscinodiscus marginatus Ehrenberg, sample 2-4; 90 μm in diameter.
6. Coscinodiscus oculus-iridis Ehrenberg, sample 2-4, 83 μm in diameter.



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.

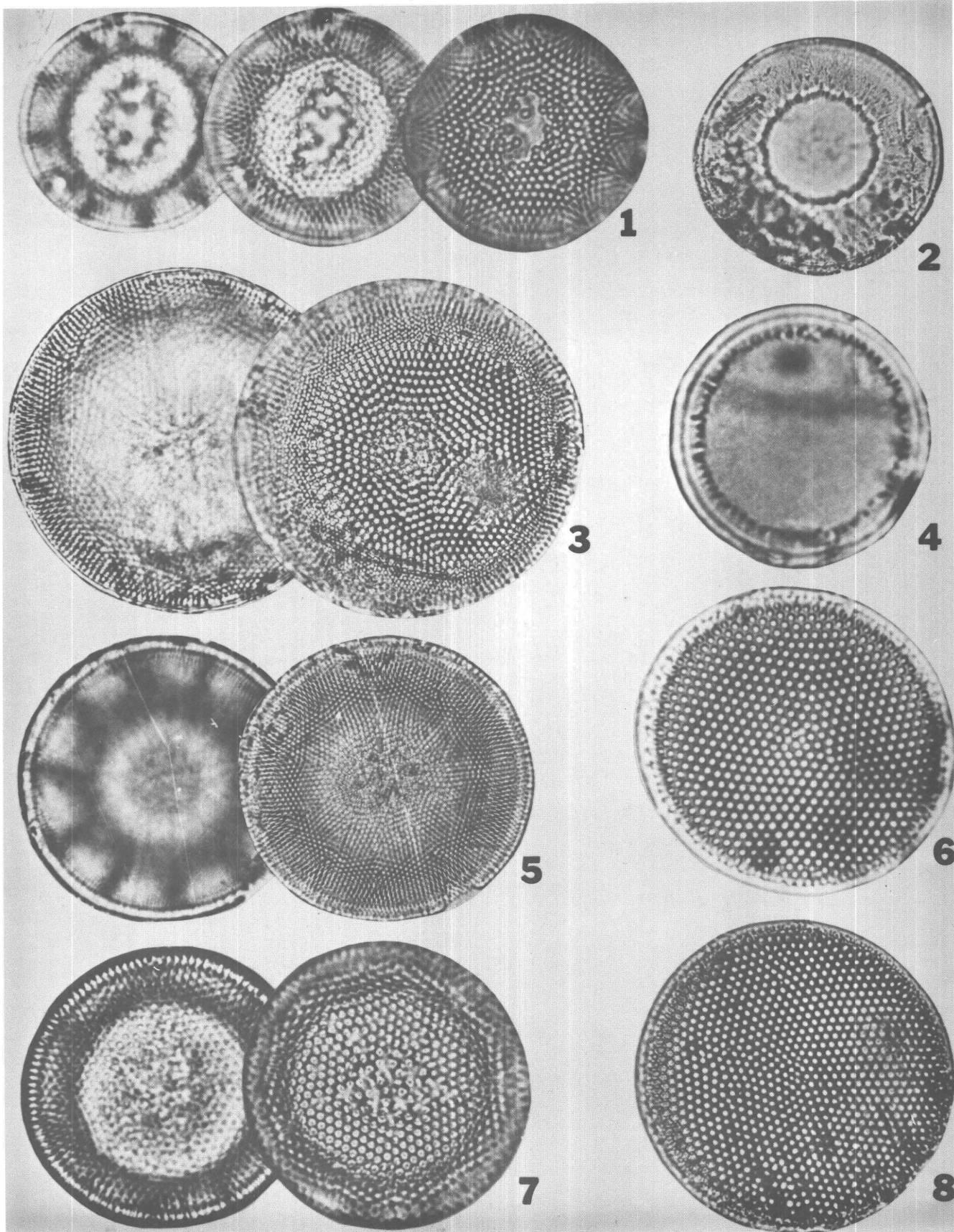
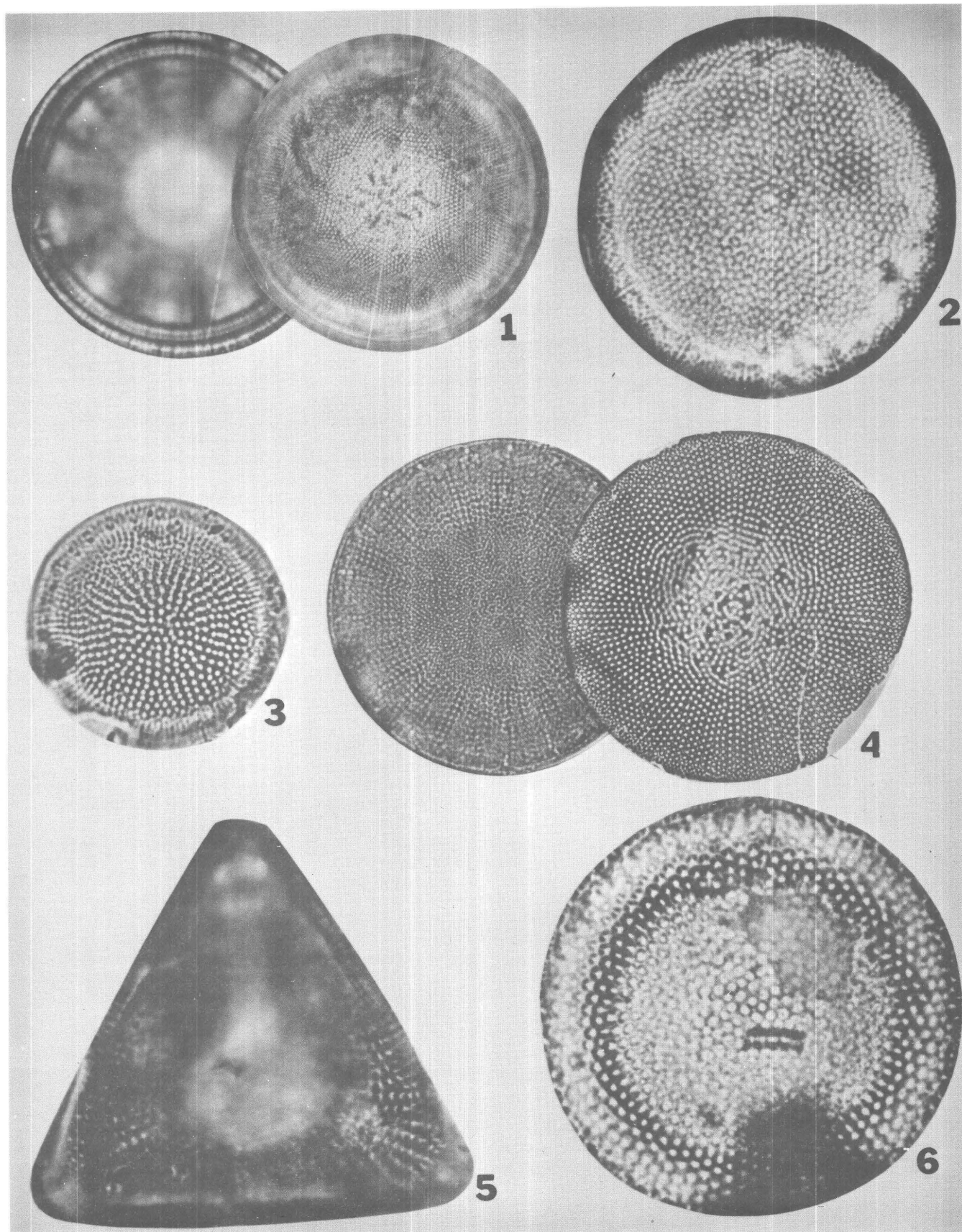


PLATE 9

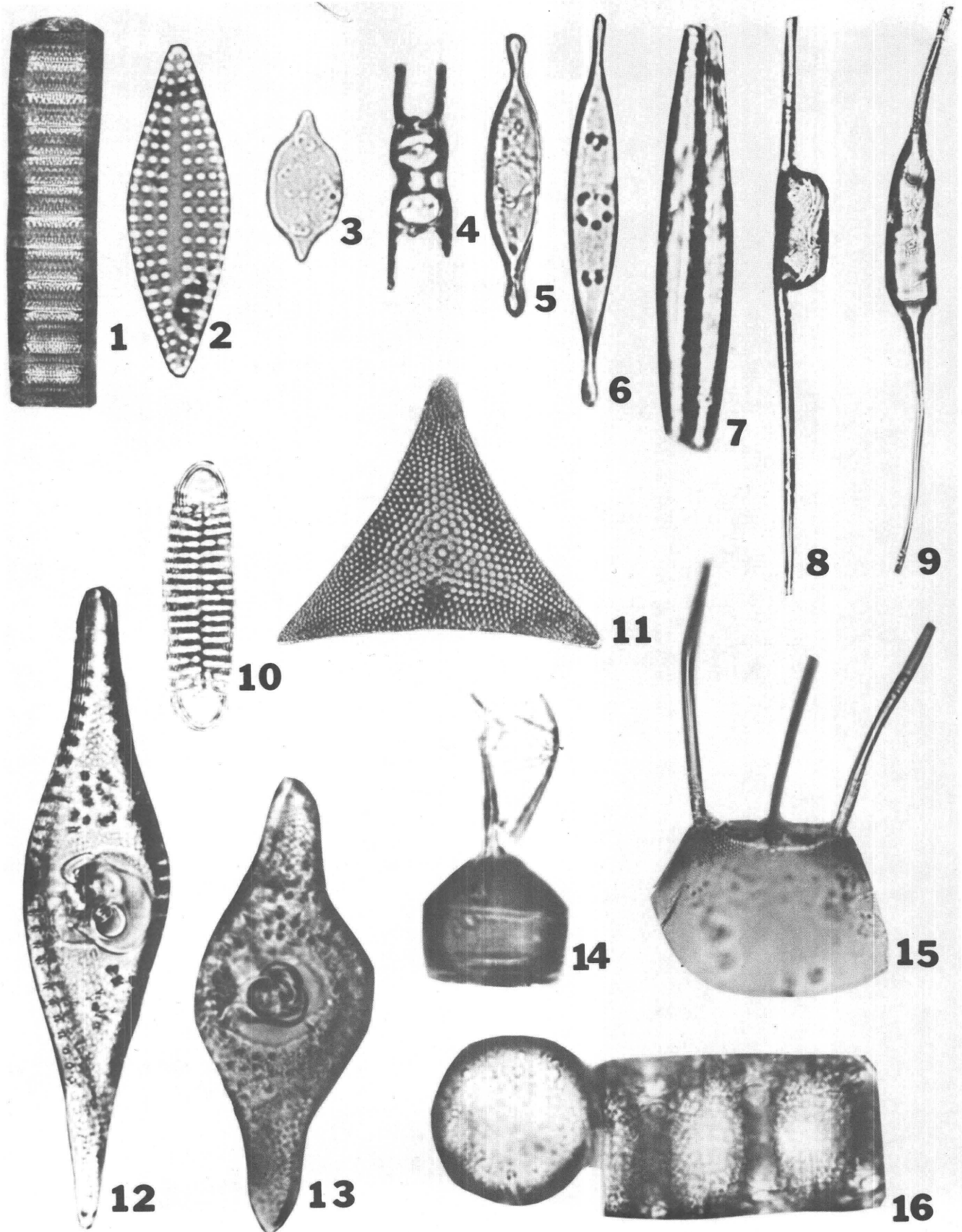
- FIGURE 1. Stellarima group, sample 2-4; 64 μ m in diameter.
2. Coscinodiscus sp. 1, sample 2-9; 62 μ m in diameter.
3. Thalassiosira mediaconvexa Schrader, sample 5-1; 24 μ m in diameter.
4. Cestodiscus sp. aff. C. muhinae Jousé, sample 5-1; 62 μ m in diameter.
5. Triceratium arcticum Brightwell, sample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



STELLARIMA, COSCINODISCUS, THALASSIOSIRA, CESTODISCUS, TRICERATIUM, CRASPEDODISCUS

PLATE 10

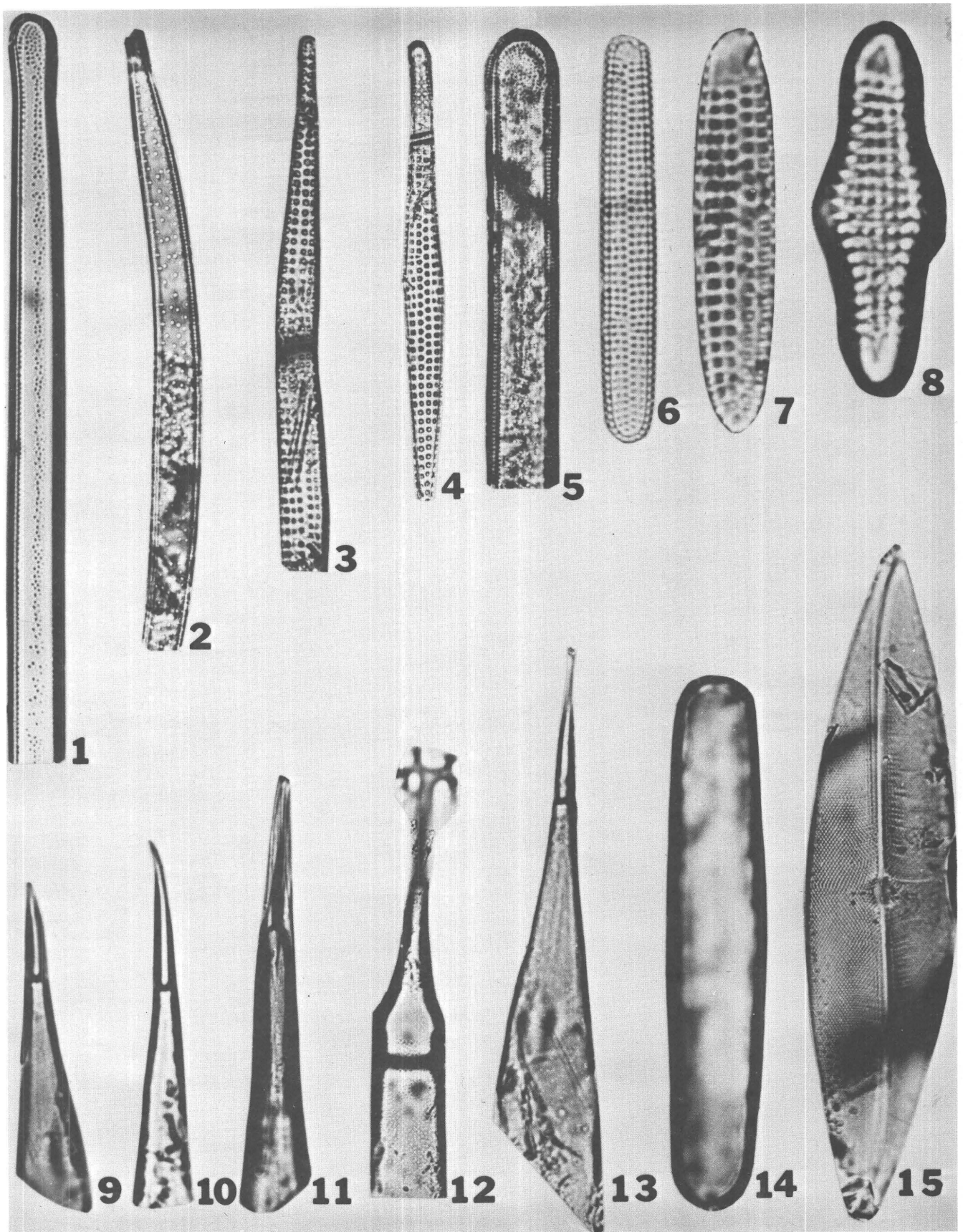
- FIGURE
1. Melosira sp. 1, sample 2-1; 113 μ m in length.
 2. Rhaphoneis angulata Fenner, sample 2-11; 24 μ m in length.
 3. Cymatosira compacta Schrader & Fenner, sample 5-1; 18 μ m in length.
 4. Kisseleviella carina Sheshukova-Poretzkaya, sample 2-4; 24 μ m in length.
 5. Kisseleviella carina Sheshukova-Poretzkaya,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



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

PLATE 11

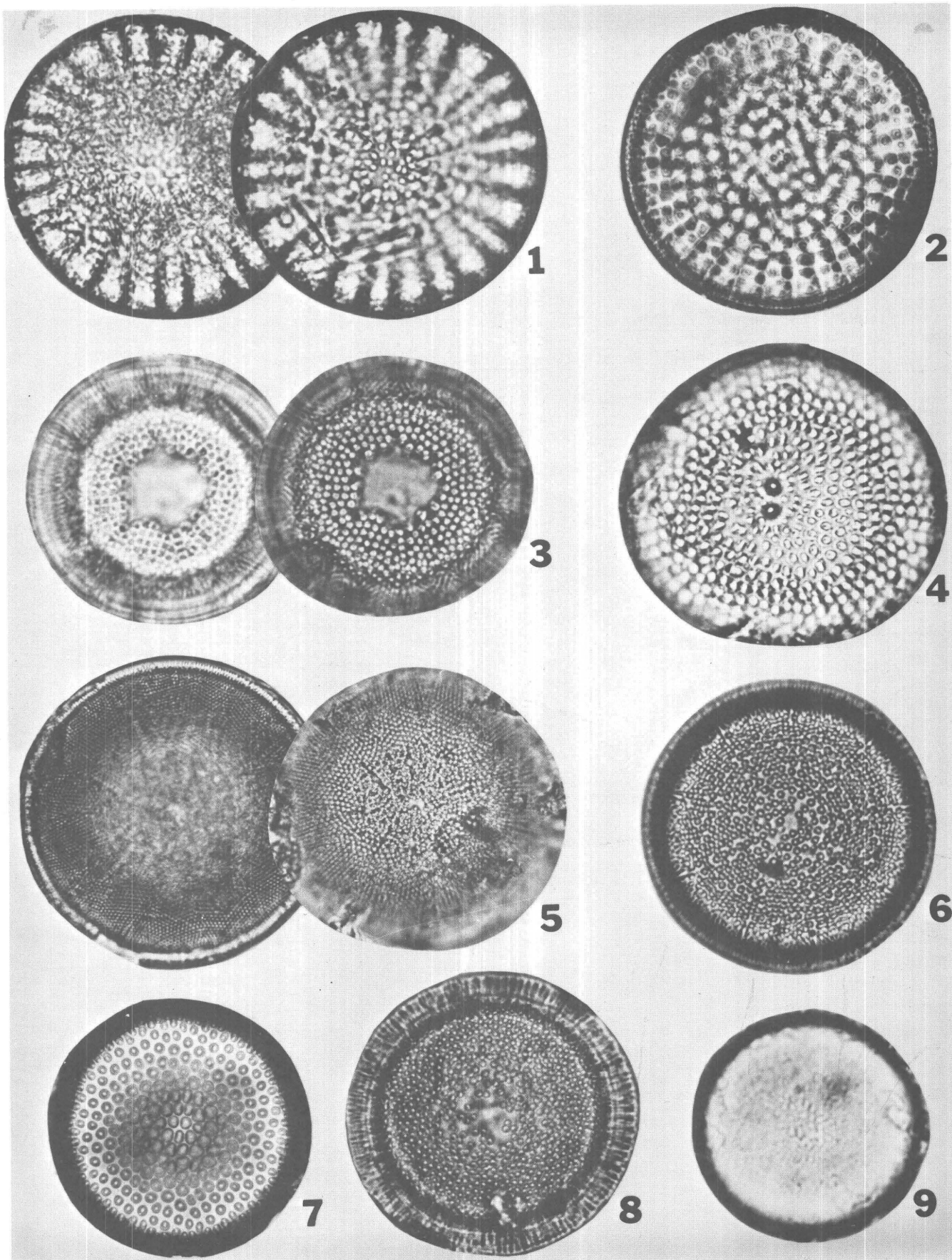
- FIGURE 1. Clavicula polymorpha Grunow & Pantocsek, sample 2-4; 112 μ m in length.
2. Clavicula sp. 1, sample 2-4; 80 μ m in length.
3. Sceptroneis sp. 1, sample 2-4; 74 μ m in length.
4. Sceptroneis sp. 2, sample 2-4; 63 μ m in length.
5. Clavicula polymorpha Grunow & Pantocsek, sample 2-4, 65 μ m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



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

PLATE 12

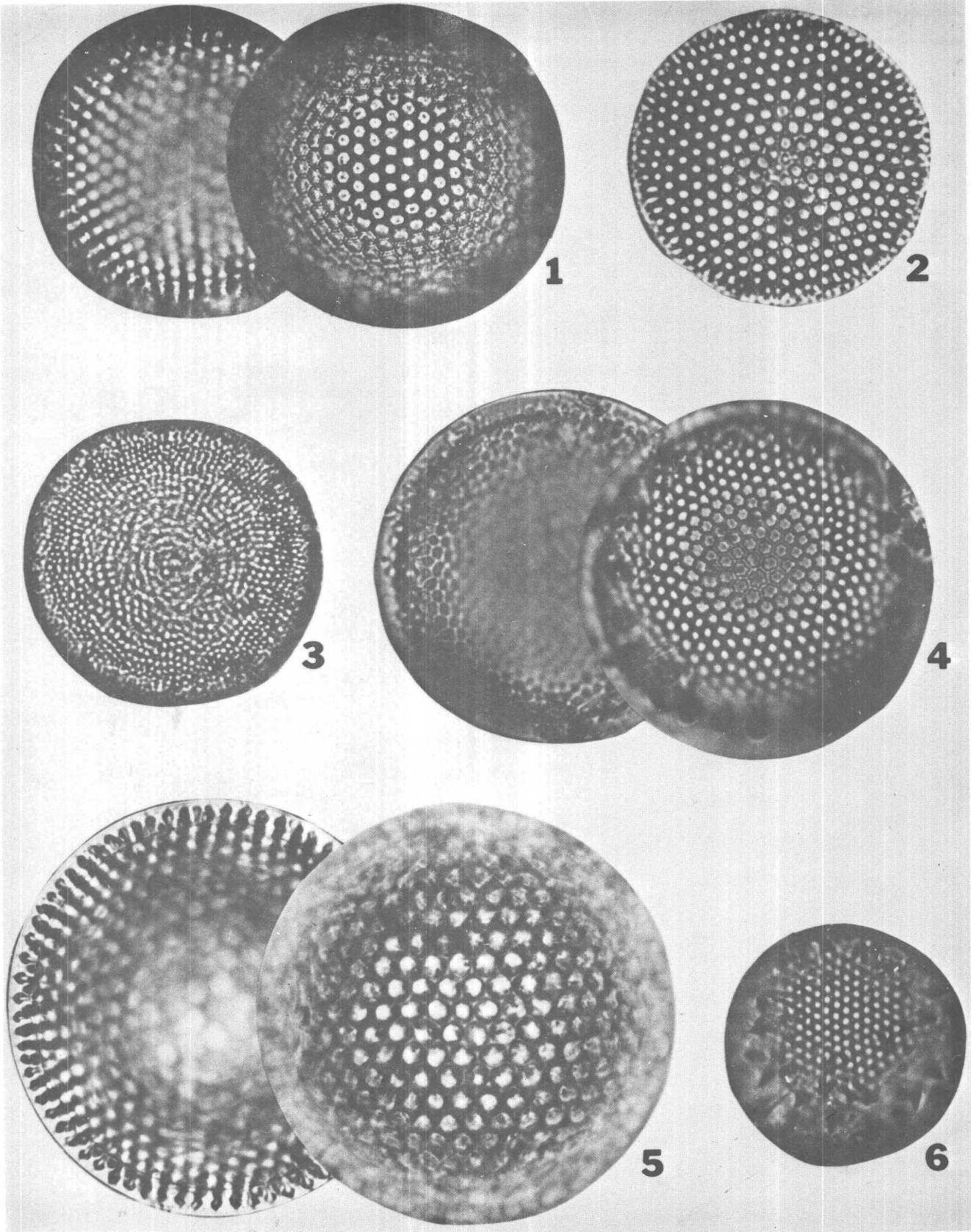
- FIGURE
1. Stictodiscus kittonianus Greville, sample 2-4; 43 μ m in diameter.
 2. Stictodiscus grovei Schmidt, sample 2-9; 41 μ m in diameter.
 3. Cestodiscus sp. 5, sample 5-1; 31 μ m in diameter.
 4. Pseudostictodiscus picus Hanna, sample 2-4; 67 μ m in diameter.
 5. Stellarima group, sample 2-4;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



STICTODISCUS, *CESTODISCUS*, *PSEUDOSTICTODISCUS*, *STELLARIMA*, *COSCINODISCUS*, *THALASSIOSIRA*

PLATE 13

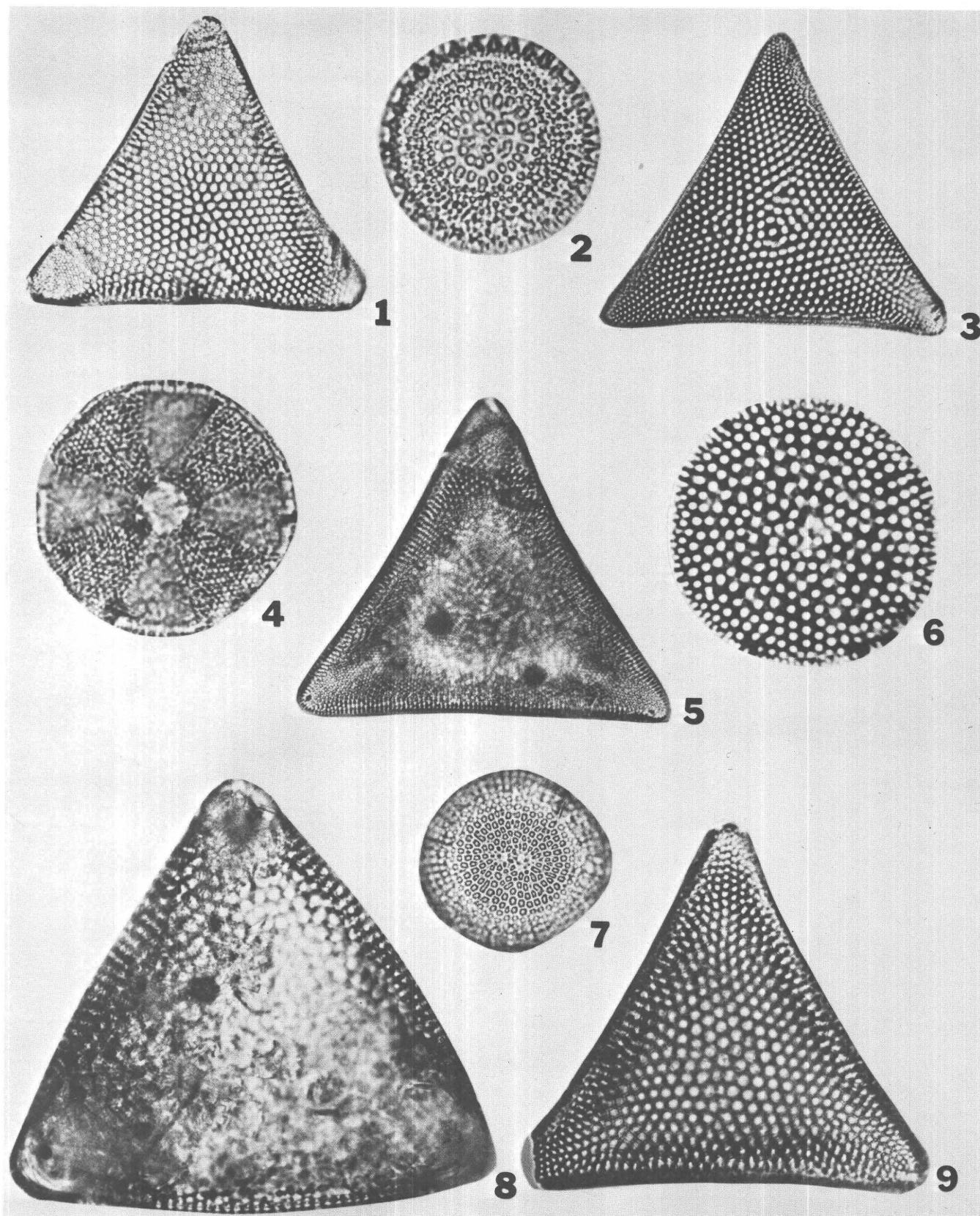
- FIGURE 1. Stephanopyxis turris (Greville & Arnott) Ralfs, sample 2-4; 46 μ m in diameter.
2. Thalassiosira sp. cf. T. eccentrica (Ehrenberg) Cleve, sample 2-9; 39 μ m in diameter.
3. Podosira sp. 1, sample 2-9; 35 μ m in diameter.
4. Stephanopyxis eocenicus Hajós, sample 5-1, 65 μ m in diameter.
5.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



PSEUDOTRICERATUM, TROCHOSIRA, ACTINOPTYCHUS, TRICERATUM,
COSCINODISCUS, PSEUDOSTICTODISCUS

