V. CENOZOIC SILICOFLAGELLATE AND COCCOLITH STRATIGRAPHY, SOUTH ATLANTIC OCEAN, DEEP SEA DRILLING PROJECT LEG 36

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INTRODUCTION

Leg 36 of the Deep Sea Drilling Project, March to May 1974, which began at Ushuaia, Argentina, and ended at Rio de Janeiro, Brazil (Figure 1), recovered 102 cores at six drilling sites, Sites 326-331. Light-microscope techniques were used to study the silicoflagellates and coccoliths of 115 samples of Cenozoic age. Most of my study time for Leg 36 sites was devoted to the very diverse silicoflagellate assemblages of the upper Paleocene at Site 327 and the upper Oligocene at Site 328.


SILICOFLAGELLATE COUNTING AND PROCESSING

Counts of silicoflagellate assemblages were done by mechanical-stage traverses of one to four slides for each sample using smear slides prepared from unprocessed sediment and strewn slides of acid residues. To help prevent size fractionation of the original fossil assemblage, no sieving or settling techniques were employed. Identifications were made primarily at magnification 500 ×.

ZONATION

Zonation of Cenozoic strata from DSDP Leg 36 is facilitated by especially diverse silicoflagellate assemblages that can be assigned to zones previously described from the Pacific and Southern oceans (Bukry and Foster, 1973; Bukry, 1975d). Coccolith diversity is generally so low that only broad age estimates, based on a few cosmopolitan species, are possible. Only in the Paleogene are coccoliths sufficiently diverse to permit recognition of low-latitude zones (see Site Summaries).

Although the abundance and ranges of several silicoflagellates tabulated for Leg 36 might provide a basis for new biostratigraphic units, none are proposed because of present taxonomic instability and because stratigraphic ranges are only partially determined. The silicoflagellate zones used for Leg 36 cores (Figure 2) are discussed below, from oldest to youngest.

Corbisema hastata Zone (Bukry and Foster, 1974)

The base of the Corbisema hastata Zone, marked by the first appearance of Corbisema hastata, was determined to be near the base of the lower Paleocene by deep-sea drilling in the Pacific (DSDP Site 208); the upper part of the zone was not recovered there. At Hole 327A in the South Atlantic, the first common occurrence of Naviculopsis constricta, which defines the upper limit of the zone, is recorded in Core 5A. Associated coccoliths are of late Paleocene age. Therefore, the C. hastata Zone seems to be restricted to the Paleocene.

Naviculopsis constricta Zone (Bukry and Foster, 1974)

The lower limit of the Naviculopsis constricta Zone, based on the lowest common occurrence of Naviculopsis constricta, occurs in Core 5A in Hole 327A. Marked increases in abundance of Corbisema disymmetrica angulata and C. hastata cunicula relative to older Cores 6A to 8A are noted in Core 5A. Association of the coccolith guide species Helio lithus riedeli with N. constricta in Core 5A helps date the base of the zone as late Paleocene.

Dictyocha deflandrei Zone, Naviculopsis trispinosa Subzone (Bukry, 1975d)

The single silicoflagellate sample from Core 5 in Hole 328B is dominated by Naviculopsis constricta and contains N. biapiculata, N. trispinosa, Dictyo cha aspera martini, D. deflandrei, and D. hexacantha (reworked?). The numerical dominance of N. constricta over N. biapiculata and D. aspera martini and D. deflandrei over D. hexacantha are characteristic of the N. trispinosa Subzone in Hole 328B and Site 283 in the Southern Ocean. Although the sediment at 328B is noncalcareous, a late Eocene age is assigned because coccoliths of the late Eocene Chiasmolithus oamaruensis Subzone are associated with the N. trispinosa Subzone at Site 283.

Naviculopsis biapiculata Zone (Bukry, 1974)

A rather complete section of the Naviculopsis biapiculata Zone, as suggested by the distributions of Dictyo cha deflandrei, Mesocena pappii, Naviculopsis biapiculata, and N. trispinosa, occurs in Cores 3B to 4B in Hole 328B. Although no coccoliths occur in this section, the late Oligocene diatom Stictodiscus gelidus ('syn. Rocella gemma; compare Plate 9, Figures 4-9 to Hanna, 1929, 1930), formerly considered a silicoflagellate, has its characteristic acme in Core 3B (Table 1).

A marked change in silicoflagellate assemblage composition in the lower part of Core 3B makes the upper N. biapiculata Zone distinctive in Hole 328B: Distephanus crux darwinii first appears in abundance; Distephanus speculum varieties with divided apical rings first appear; and Distephanus crux crux and Naviculopsis trispinosa decrease sharply. D. crux darwinii is associated with the late Oligocene coccoliths Cyclicargo-
lithus abisectus and Dictyococcus bisectus in the North Atlantic at Site 338. The acme of Distephanus raupii (syn. Distephanus speculum pentagonus with small apical openings) recorded above the range of N. biapiculata at Site 278 (Bukry, 1975d), appears within the range of N. biapiculata in Hole 328B; this points up the need for more control points to help establish the most consistent criteria for silicoflagellate biostratigraphy and paleoecology.

**Distephanus speculum speculum Zone, Mesocena cyclus Subzone (Bukry, 1975d)**

The silicoflagellate assemblages of a thick upper Miocene section at Site 329 (Cores 1 to 14) are largely dominated by Mesocena cyclus and the Distephanus speculum group. The top of the subzone was not sampled at Site 329, but the base of the subzone is indicated by the first abundant occurrence of M. cyclus in Core 14. Mesocena diodon occurs through most of the range of M. cyclus at Site 329. Several late Miocene samples from Site 328 are tentatively assigned to this subzone, but M. cyclus is not especially abundant. Dictyococcus aspera clinata, a late Miocene species in the North Pacific, occurs at Site 328, providing an auxiliary indicator for this assignment.

**Distephanus boliviensis boliviensis Zone**

(Bukry and Foster, 1973)

An abundant occurrence of the large species Distephanus boliviensis boliviensis above the last common Dictyococcus aspera clinata and Mesocena cyclus in Core 1B in Hole 328B is used to help identify this zone. First described from low latitude at Site 157 at the northern limit of the cool Peru Current, the Distephanus boliviensis boliviensis Zone is probably more applicable to high-latitude assemblages because its key species, D.
sphaera prolata, and common sp. cf. R.
samodurovii
The occurrence of rare ple 327A-2-1, 126-127 cm (14 m) contains a cool-water
Coccoliths are abundant in only a few samples, diversity
section are dominated by silicoflagellates and diatoms.

acoustic-reflector horizons in Cretaceous and lower Ter-
was drilled to determine the age and composition of
the North Pacific Ocean from latitude 0° to 60°N
in D. speculum speculum
equatorial areas. The geographic range of
was missing in strictly tropical assemblages of Pliocene age
such as that of Sample 329-4-5, 50-51 cm (34 m), con-
No samples available; see reports of shipboard scien-
Site 326
(lat 56°35.00'S, long 65°18.20'W, depth 3812 m)
No samples available; see reports of shipboard scien-
Site 327
(lat 50°52.28'S, long 46°47.02'W, depth 2401 m)
Site 327, on the eastern end of the Falkland Plateau,
was drilled to determine the age and composition of acoustic-reflector horizons in Cretaceous and lower Tertiary strata.
Phytoplankton assemblages of the 80-meter Cenozoic
section are dominated by silicoflagellates and diatoms. Coccoliths are abundant in only a few samples, diversity is low, and moderate to intense solution is evident. Sample 327A-2-1, 126-127 cm (14 m) contains a cool-water assemblage dominated by rims of Chiasmolithus spp. The occurrence of rare Discoaster barbadiensis, Thoraco-
sphaera prolata, and common Reticulofenestra sp. cf. R.
samodurovii suggests middle Eocene. The only other abundant age-diagnostic assemblages are from Core 5A (42 to 52 m). The cool-water upper Paleocene assemblages are dominated by Chiasmolithus bidens, Fascicu-

Table 1
Acme of Late Oligocene Diatom
Stictodiscus gelidus Mann (Synonym: Rocella gemma Hanna) Illustrated by Number Intersected During Counts of 300 Silicoflagellates per Sample in Hole 328B

<table>
<thead>
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<th>Sample (Interval in cm)</th>
<th>Depth (m)</th>
<th>Total Stictodiscus gelidus</th>
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boliviensis boliviensis, is more abundant there and is missing in strictly tropical assemblages of Pliocene age such as at Site 77 (Bukry, 1976). D. boliviensis boliviensis has been recorded in Pliocene strata at several sites in the Southern Ocean (Ciesielski and Weaver, 1973).

Dictyocha aculeata Zone (Bukry and Foster, 1973)
The first occurrence and range of cosmopolitan Dictyocha aculeata (D. epipolitan of other reports) defines an upper Quaternary zone in subpolar as well as in equatorial areas. The geographic range of D. aculeata in the North Pacific Ocean from latitude 0° to 60°N (Poelchau, 1974) complements its occurrence at DSDP Sites 328 and 331 in the South Atlantic Ocean at latitudes 50°S and 38°S. The zonal assemblages from Leg 36 have low diversity with D. speculum speculum dominant.

Silicoflagellates are most abundant in the upper Paleocene samples from Cores 5A to 8A (Table 2). Among shallower samples, only the mixed late Miocene and Pliocene assemblage of 327-1-3, 69-70 cm (4 m) is abundant enough for an accurate count of ratios. The taxa Dictyocha aspera clinata and Dictyochus boliviensis frugalis, recently described from the late Miocene of the North Pacific (Bukry, 1975c), occur with Dictyochus boliviensis boliviensis, Corbisema triacantha, and a large array of variants of other species, suggesting mixing as a result of reworking.

The Paleocene silicoflagellate assemblages are characterized by the dominance of Corbisema hastata and its subspecies. Preservation is excellent, and the transition from the Corbisema hastata Zone to the Naviculopsis constricta Zone is recorded for the first time at this site (see Zonation).

Site 328
(lat 49°48.67'S, long 36°39.53'W, depth 5013 m)
Site 328 is east of the Falkland Plateau in the area where Antarctic bottom water flows from the Weddell Sea into the Argentine Basin. Coring was intended to provide a deep-water reference section for comparison to the Falkland Plateau and to record the initiation of the Antarctic circumpolar current.

Although coccoliths are absent in the Cenozoic section (Cores 1 to 5B, 0 to 51 m), silicoflagellates are abundant at many levels, providing evidence for the presence of Quaternary, Pliocene, upper Miocene, upper Oligocene, and upper Eocene strata (Tables 3 and 4). The cool-water genus Distephanus predominates, but cosmopolitan or cool-water members of Dictyocha such as D. aculeata, D. aspera clinata, and D. speculum speculum also aid in biostratigraphic determinations (see Zonation). Reworking of older taxa is more sporadic and less common than at Site 329 on the Falkland Plateau.

Site 329
(lat 50°39.31'S, long 46°05.73'W, depth 1519 m)
Site 329, on the eastern end of the Falkland Plateau, upslope from Site 327, was cored to determine the age and composition of the Neogene strata on the plateau for comparison with Site 328 and to investigate paleocirculation in the South Atlantic Ocean.

Coccoliths are present throughout the cored interval, upper Paleocene to upper Miocene, but coccolith diversity is so low in the diatom- and silicoflagellate-rich Neogene (Cores 1 to 27, 0 to 370 m) that no existing coccolith zonation can be recognized. The biostratigraphic utility of the basically tropical group of calcareous nanofossils is reduced in the Neogene in cold-water areas (Bukry, 1975a) because of low diversity and long ranges. The reduction in resolution is compounded at Site 329 by pervasive reworking. A typical Neogene assemblage, such as that of Sample 329-4-5, 50-51 cm (34 m), con-
tains a great abundance of specimens but only a few species: Chiasmolithus sp. cf. C. altus (rims), Coccolithus pelagicus, Cyclicargolithus sp. cf. C. floridanus, Reticulofenestra pseudoumbilica (closed and open centers), Reticulofenestra spp. (small). The Chiasmolithus and Cyclicargolithus specimens are probably reworked from Oligocene strata, for age-equivalent Oligocene diatoms and silicoflagellates such as Stictodiscus gelidus and Naviculopsis biapiculata are also present.

A few specimens of Coccolithus miopelagicus and Sphenolithus sp. cf. S. abies in a Reticulofenestra ooze of Sample 329-26-2, 50-51 cm (333 m), suggest a possible
middle Miocene age because Cyclicargolithus floridanus is absent. Reworking introduced Chiasmolithus ribs and late Paleocene C. bidens and Zygrhablithus sp. cf. Z. bijugatus that are abundant in deeper strata at Site 329. Specimens of Cyclicargolithus abissectus, C. sp. cf. C. floridanus, and Discostaer divercatus in Sample 329-27-1, 60-61 cm (361 m) suggest an early Miocene age. The highest Chiasmolithus albus ooze in Sample 329-30-2, 117-118 cm (410 m), considered Oligocene in age, contains abundant Coccolithus pelagicus s. ampl., a few Dictyococccites bissectus and D. scrippsae, but lacks warm-water taxa of the genera Discostaer, Helicopontosphaera, and Sphenolithus, which would further aid in correlating. The two deepest Cenozoic samples available are probably from the upper Paleocene Discostaer multiradiatus Zone. Sample 329-32-4, 33-35 cm (447 m), contains abundant Zygrhablithus sp. cf. Z. bijugatus (Syn. Semicololithus kerabyi), Chiasmolithus bidens, and common to sparse Coccolithus sp. cf. C. magnicrassus, Discostaer multiradiatus, D. nobilis, and Thoracosphaera sp. A more typical Paleocene assemblage occurs in 329-33-4, 77-78 cm (459 m): Chiasmolithus bidens, Discostaer multiradiatus, Fasciculithus typaniformis, Neochiastozygus distentus, N. junctus, Thoracosphaera sp., and Towetess eminens. The cold-water aspect of the assemblage is emphasized by a low Discostaer/Chiasmolithus ratio of 3/97.

Miocene silicoflagellate distribution is summarized in Table 5.

Site 330
(lat 50°55.19'S, long 46°53.00'W, depth 2626 m)

No Cenozoic samples were obtained at this site on the eastern Falkland Plateau. Coring was begun at 129 meters subbottom to sample Mesozoic strata.

Site 331
(lat 37°53.00'S, long 38°06.92'W, depth 5067 m)

Site 331 in the Argentine Basin was aborted by bad mechanical and meterologic conditions. The two samples examined from near-surface sediment at the site are barren of coccoliths. A sparse silicoflagellate assemblage in Sample 331-1-4, 101-102 cm (5 m) contains Dictyocha aculeata, a Pleistocene guide species (Table 4).

**SILICOFLAGELLATE TAXONOMY**

Silicoflagellates present many taxonomic challenges for the biostratigrapher. Study of a single assemblage usually reveals considerable intraspecific variation. But lineages observed in stratigraphic sections commonly can be developed to help establish which forms are phenotypes and which are distinctive evolutionary entities. Although a natural classification that permits reproducible correlation is the ultimate goal of stratigraphic taxonomy, much of the present generic and some species usage follows an artificial form-classification. According to present usage, the two major Cenozoic genera Dictyocha and Distephanus both seem to give rise to each other several times. For example, Dictyocha deflandrei gives rise to Distephanus crux darwinii in the Oligocene of Site 328. Distephanus boliensis boliensis produces Dictyocha pentagona in the Pliocene of Hole 328B, and Dictyocha pseudofibula of various workers arises from Distephanus speculum (see Schulz, 1928) or Distephanus speculum varians (this report). Therefore, better understanding of lineages at the species and subspecies level is needed. Establishing consistent usage and priority between names and the illustrated forms can be difficult, because original materials are commonly poorly dated and illustrated by single simple drawings that

**Table 4**

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Note: The acmes of Mesocena circulus and M. dion in between 3 and 125 meters indicate the late Miocene Mesocena circulus Subzone of the Distephanus speculum speculum Zone (Bukry, 1975d). Deeper assemblages are not diagnostic of presently described zones. X = Taxa present in assemblage too sparse to validly count.

can be ambiguously interpreted and related to several similar forms.

Within major geometric form groups recognized at the species level (for example, D. speculum), stratigraphically or geographically restricted variations have been classified at the subspecies level (for example, D. speculum varians). Below the subspecies level, vernacular descriptive terms seem more appropriate than run-on linnean sequences, because a single subspecies name can be used to stand for a major set of morphologic parameters. Subspecies that are eventually found to be stratigraphically or ecologically limited and generally recognizable can later be elevated. See, for example, Corbisema flexuosa (Stradner) as reported in DSDP Volume 29 (Perch-Nielsen, 1975; Bukry, 1975d).

Species tabulated in the broad sense (s. ampl.) include forms not clearly assignable to an existing subspecies, commonly because specimens are tilted or broken.

**SYSTEMATIC PALEONTOLOGY**

*Genus CANNOPILUS* Haeckel, 1887

*Cannopilus depressus* (Ehrenberg)

*Halicytrira depressa* Ehrenberg, 1854, pl. 18, fig. 111.


*Cannopilus sphaericus* Gemeinhardt, Ling, 1972, p. 149, pi. 23, fig. 10.

*Cannopilus depressus* (Ehrenberg) Locker, 1974, p. 639, pl. 4, fig. 3.

Remarks: The structure of the type species of Cannopilus, C. hemisphaericus, leads me to believe that it is a member of Distephanus.
Therefore, the name Cannoplius is retained for helmet-shaped silicoflagellates only as a convenience in this report. Because of the priority of the name Diastephus, revision of nomenclature should be considered.

Genus CORBISEMA Hanna, 1928

Corbisema apiculata (Lemmermann)

Dickyoxya triacantha var. apiculata Lemmermann, 1901, p. 259, pl. 10, fig. 19, 20.

Corbisema apiculata (Lemmermann), Frenguelli, 1940 (in part), fig. 12h.

Corbisema triacanthia (Ehrenberg), Frenguelli, 1940 (in part), fig. 12g.

Corbisema apiculata (Lemmermann), Ling, 1972, p. 151, pl. 23, fig. 13-17.

Corbisema archangelskiana (Schulz)

Dickyoxya triacanthia archangelskiana Schulz, 1928, p. 250, fig. 33a-c, 77 (not fig. 78).

Corbisema archangelskiana (Schulz), Perch-Nielsen, 1975, p. 685, pl. 3, fig. 17, 22.

Remarks: Specimens with elongate portals, no spines at the apices, and no apical plate are included. Figure 78 of Schulz (1928) has short spines and a broader apical structure.

Corbisema disymmetrica angulata n. subsp.

(Plate 1, Figures 1-4)


Corbisema apiculata (Lemm.) forma naviculoida, Frenguelli, 1940, p. 62, fig. 121. (Invalid by ICBN Art. 32, par. 1, see Loeblich, 1968).

Corbisema inermis ssp. disymmetrica Dumitrică, 1973 (in part), p. 846, pl. 12, fig. 3.

Dickyoxya navicula Ehrenberg, Muhina, 1974, p. 854, pl. 2, fig. 13.

Description: Corbisema disymmetrica angulata is constructed as a large, bilaterally symmetric, boat-shaped basal ring with a slightly arched apical bar across the minor axis of the basal bar. The ends of the basal bar form a rounded or straight angle of 90° or less that is symmetric about the major axis. Well-preserved specimens may have a delicate septum at the apex of the angle. The sides of the basal bar may be parallel near the apical bar juncture, but are typically slightly indented toward the juncture. The apical bar is slightly narrower than the ring. The ratio of the major to minor axis ranges from 1.7 to 2.2.

Remarks: Corbisema disymmetrica angulata is distinguished from Corbisema disymmetrica communis by having angular instead of rounded apices on the basal bar. It is distinguished from C. disymmetrica symmetrica by its more elongate form and lack of crenulate surface texture. The Falkland Plateau specimens of C. disymmetrica angulata are generally less elongate than the forms in synonymy (major/minor axis = 1.7 to 2.4).

Occurrence: Corbisema disymmetrica angulata appears higher in the upper Paleocene section at DSDP Hole 327A than the other subspecies of C. disymmetrica. The specimens in synonymy are from the Paleocene of the Indian Ocean, Tasman Sea, and Denmark. The known range is upper Paleocene.

Size: Major axis 80-120 µm; holotype 100 µm.

Holotype: USNM 221574 (Plate 1, Figure 4).

Paratypes: USNM 221575 to 221577.

Type locality: Falkland Plateau, South Atlantic Ocean, Sample 327A-6-6, 130-132 cm (61 m).

Corbisema disymmetrica symmetrica (Dumitrică) n. comb.

(Plate 1, Figures 10-12)

not Dickyoxya navicula Ehrenberg, 1839, p. 129.

not Dickyoxya navicula Ehrenberg, Schulz, 1928, p. 243, fig. 16a, b.

?Dickyoxya apiculata (Lemm.) var. inermis (Lemm.), Deflandre, 1941 (in part), p. 102, fig. 20, 21.

Corbisema inermis ssp. symmetrica Dumitrică, 1973 (in part), p. 846, pl. 12, fig. 1, 2, 4-6; pl. 13, fig. 1-8.

Corbisema inermis symmetrica Dumitrică, Perch-Nielsen, 1975, p. 685, pl. 8, fig. 1, 2.

Remarks: Corbisema disymmetrica symmetrica ranges in shape from subcircular to oblong to rounded square. The robust and crenulate nature of the basal ring, apical bar, and accessory projections easily distinguish it from other subspecies of C. disymmetrica. And, its major and minor axis are more nearly equal.

Corbisema disymmetrica symmetrica occurs rarely throughout the upper Paleocene section in Hole 327A. The specimens are well preserved and reveal that the regular crenulations are created by regularly spaced cycles of nodes. Because C. inermis crenulata is not present in Hole 327A, the bipolar form is considered to represent an evolutionary development that warrants status at the species level. The individual figured in plate 13, figure 5, of Dumitrică (1973) is herein designated the lectotype specimen of Corbisema disymmetrica symmetrica.

Corbisema falklandensis n. sp.

(Plate 2, Figures 1-15)

Description: Corbisema falklandensis is pear-shaped in plan view. The apical structure has a triangular apical plate supported by arched struts that are ribbon-like or lamelliform. Similar arched lamelliform projections occupy the positions of basal pikes. These flare and terminate irregularly. A short radial spine or pike occurs at the apex of the basal ring, which has a septum at that point. There are no radial spines at the other rounded apices.

Remarks: Corbisema falklandensis is distinguished from other species of Corbisema by having only a single apical spine and by its isocose outline and lamelliform basal pikes. It is distinguished from the isocoses C. hastata group by the nearly T-shaped form of its apical structure, the lack of spines, and the presence of an apical plate.

Occurrence: Corbisema falklandensis occurs rarely through the upper Paleocene in Hole 327A.

Size: Major axis 45-70 µm; holotype 49 µm.

Holotype: USNM 221583 (Plate 2, Figures 8, 9).

Paratypes: USNM 221584 to 221592.

Type locality: Falkland Plateau, South Atlantic Ocean, Sample 327A-6-1, 9-10 cm (52 m).

Corbisema flexuosa (Stradner)

Corbisema triacantha flexuosa Stradner, 1961, p. 89, pl. 1, fig. 1-8.

Corbisema flexuosa (Stradner) Perch-Nielsen, 1975, p. 685, pl. 3, fig. 10.

Corbisema geometrica Hanna

Corbisema geometrica Hanna, 1928, p. 261, pl. 41, fig. 1, 2.

Corbisema geometrica Hanna, Perch-Nielsen, 1975, p. 685, pl. 2, figs. 1-6, 8.
Corbisema geometrica geometrica Hoffman, Bukry, 1975d (in part), p. 853, pl. 1, fig. 7.

**Remarks:** This large, rounded to lobed species has a central plate and lacks spines; it is most abundant in the Upper Cretaceous. Similar large forms that lack a central plate and that persist after the disappearance of *Corbisema geometrica* are assigned to *C. inermis inermis*.

*Corbisema glezerae* n. sp.

(Plate 3, Figures 1-7)


**Description:** *Corbisema glezerae* is a large, robust, symmetric species having an isosceles or nearly triangular-shaped basal ring that is straight sided or slightly convex. The radial spines are medium to long and are separated. The struts are symmetric and have the same diameter as the sides of the basal ring. Large basal pikes extend downward, perpendicular to the plane of the basal ring. The basal ring is convex and the short side is indented and the long sides are scalloped. As the relative proportion of structural components is highly variable, a group of forms is illustrated here. *C. hastata hastata* is abundant in Paleocene assemblages.

*Corbisema hastata* n. comb.

(Plate 4, Figures 9-16)

*Dictyocha triacantha* hastata Lemmermann, 1901, p. 259, pl. 10, fig. 16, 17.

**Remarks:** The basal ring of *Corbisema hastata hastata* is isosceles in plan. On most specimens the short side is indented and the long sides scalloped. As the relative proportion of structural components is highly variable, a group of forms is illustrated here. *C. hastata hastata* is abundant in Paleocene assemblages.

*Corbisema hastata minor* (Schulz)

*Dictyocha triacantha* apiculata minor Schulz, 1928, p. 249, fig. 29b.

*Corbisema hastata* n. comb. (Schulz), Bukry, 1975d, p. 854, pl. 1, fig. 10.

*Corbisema inermis inermis* (Lemmermann)

(Plate 5, Figures 1-3)

*Dictyocha triacantha* inermis Lemmermann, 1901, p. 259, pl. 10, fig. 21.

**Remarks:** *Corbisema inermis inermis* Lemmermann, Schulz, 1928, p. 248, fig. 30a, b.


**Remarks:** This large, rounded to triangular species lacks an apical plate and spines. Whereas its size and proportions are similar to *Corbisema geometrica*, it is distinguished by the absence of an apical plate. It occurs consistently in the Paleocene in Hole 327A, above the range of the basally Upper Cretaceous species *C. geometrica*. Several specimens of an isosceles variant of *C. inermis inermis* in Hole 327A have one rounded and two angular apices. Drawings of specimens of this subspecies portraying smooth (Lemmermann, 1901) or slightly irregular surfaces (Glezer, 1966) are believed to represent reticulate texture, not the more pronounced crenulate texture (Bukry, 1976).

*Corbisema inermis crenulata* n. subsp.

*Corbisema inermis* (Lemmermann) Dumitrica, 1973, p. 845, pl. 12, fig. 7-9.

**Description:** *Corbisema inermis crenulata* has a rounded triangular basal ring. Three apical spurs are symmetrically arrayed and meet simply with no apical plate. Basal pikes may be present at or near the ring-strut junctures. The struts are narrower than the basal ring and lack its distinctive crenulate texture, formed by regular cycles of surface nodes.

**Remarks:** *Corbisema inermis crenulata* is distinguished from *C. inermis inermis* by its proportionately thicker basal ring and crenulate surface texture. Whereas the crenulate body ring shows a genetic relation between *C. inermis crenulata* and *C. disymmetrica disymmetrica* (Dumitrica, 1973), *C. disymmetrica disymmetrica* has an apical bar of comparable size and crenulation to the basal ring, which *C. inermis crenulata* lacks. This structural distinction and the occurrence of only *C. disymmetrica disymmetrica* in the upper Paleocene in Hole 327A indicates that these two crenulate silicoflagellates can be considered as separate taxa.

**Occurrence:** *Corbisema inermis crenulata* is known from the Paleocene of the southwestern Pacific Ocean at DSDP 208.

*Size:* External diameter 93 to 109 µm; holotype 109 µm.

*Holotype:* Plate 12, Figure 9 of Dumitrica, 1973.

*Paratypes:* Plate 12, Figures 7, 8 of Dumitrica, 1973.

*Type locality:* Southwestern Pacific Ocean, Sample 208-31, CC (561 m).

*Corbisema inermis minor* (Glezer) n. comb.

(Plate 5, Figures 4-7)

*Dictyocha triacantha* var. *inermis f. minor* Glezer, 1966, p. 247, pl. 8, fig. 3-5; pl. 31, fig. 7.

**Remarks:** This consistently small, rounded subspecies has an elevated apical structure. The specimens from Hole 327A match those described from the USSR (Glezer, 1966).

*Corbisema lateradiata* (Schulz)

*Dictyocha triacantha* apiculata lateradiata Schulz, 1928, p. 281, fig. 73.

*Corbisema geometrica* Hanna, Ling 1972 (in part), p. 154, pl. 24, fig. 2.

*Corbisema lateradiata* (Schulz) Perch-Nielsen, 1975, p. 686, pl. 2, figs. 7, 10, 11, 17, 18.
Corbisema geometrica lateradita (Schulz) Bukry, 1975d, p. 853, pl. 1, fig. 8.
Corbisema geometrica Hanna var. apiculata Jousé, Hajós, 1975, p. 938, pl. 15, fig. 2, 3, 5.

Corbisema neoparallela n. sp.
(Plate 5, Figures 8-13)

Description: Corbisema neoparallela has a rounded, polygonal basal ring with 12 sides. The apical structure is a symmetric trio of struts with no apical plate. The three portals are six-sided. The three radial spines are very short.

Remarks: Corbisema neoparallela is distinguished from Corbisema parallela by its larger size, apical plate, and lack of spines. The structural relation between C. parallela and C. neoparallela illustrates the general evolutionary trends in Corbisema: the loss of the apical plate, decrease in size, and increased dominance of spined forms between the Cretaceous and Miocene.

Corbisema ovalis Perch-Nielsen

?Dictyocha triacantha var. archangelskiana Schulz, 1928 (in part), p. 250, fig. 78.
Corbisema ovalis Perch-Nielsen, in press, pl. 1, fig. 12, 13.

Corbisema parallela Hajas

Corbisema parallela Hajas, 1975, p. 938, pl. 15, fig. 4, 6, 7.

Remarks: This species differs from Corbisema parallela by its larger size, apical plate, and lack of spines. The structural relation between C. parallela and C. neoparallela illustrates the general evolutionary trends in Corbisema: the loss of the apical plate, decrease in size, and increased dominance of spined forms between the Cretaceous and Miocene.

Corbisema triacantha (Ehrenberg)

Dictyocha triacantha Ehrenberg 1844a, p. 80.

Corbisema triacantha (Ehrenberg) Perch-Nielsen, 1975, p. 686, pl. 3, fig. 11, 15, 16.

Remarks: Some workers include a range of forms in this species. General usage for this report is to include small to moderate-sized long-spined specimens that have a basal ring in the form of an equilateral triangle. Basal pikes are missing or indistinct.

DICTYOCHA Ehrenberg, 1837

Dictyocha aculeata (Lemmermann)

Dictyocha ibula var. aculeata Lemmermann, 1901, p. 261, pl. 11, fig. 1, 2.
Dictyocha epilod (Ehrenberg) Bukry and Foster, 1973, p. 826, pl. 2, fig. 7, 8.
Dictyocha aculeata (Lemmermann), Perch-Nielsen, 1975, p. 686, pl. 5, fig. 3, 4.

Dictyocha aspera aspera (Lemmermann)

Dictyocha ibula aspera Lemmermann, 1901, p. 260, pl. 10, fig. 27, 28.
Dictyocha aspera (Lemmermann), Perch-Nielsen, 1975, p. 686, pl. 4, fig. 9, 10, 15.

Dictyocha aspera clinitata Bukry

Dictyocha sp. A. Ling, 1975, p. 772, pl. 1, fig. 20, 21.
Dictyocha aspera clinitata Bukry, 1975c, p. 695, pl. 1, fig. 1-5.

Dictyocha aspera martini Bukry

Dictyocha frenguellii Deflandre, Perch-Nielsen, 1975, p. 686, pl. 4, fig. 14, 17; pl. 5, fig. 1.

Dictyocha aspera martini Bukry, 1975d, p. 854, pl. 2, fig. 5-8.

Remarks: Dictyocha frenguellii of Perch-Nielsen from DSDP Leg 29 have an apical bar transverse to a distinctly elongate basal ring and the adjoining pair of radial spines. Deflandre (1950) shows Dictyocha frenguellii to have equal to slightly subequal dimensions for the basal ring and spines; the apical structure is not a bar. A robust specimen of D. frenguellii illustrated from the Eocene of USSR (Glezer, 1966) shows the modified nature of the apical structure that distinguishes it from Dictyocha aspera martini. Structurally, Deflandre’s drawings are more similar to the photographs of Oligocene Dictyocha fischeri (see Bukry, 1975d, pl. 3, fig. 9, 10, 11) from Leg 29, but D. frenguellii has basal pikes.

Dictyocha brevispinosa (Lemmermann)

Dictyocha ibula var. brevispinosa Lemmermann, 1901, p. 260.

Dictyocha ibula var. aspera f. rhombica Schulz, 1928, fig. 37.

Dictyocha carentis (Glezer)

Dictyocha frenguellii var. carentis f. carentis Glezer, 1964, p. 52, pl. 1, fig. 12-14.
Dictyocha frenguellii var. carentis f. carentis Glezer, 1966, p. 258, pl. 9, fig. 8, 10-13; pl. 33, fig. 1, 2.

Dictyocha sp. cf. D. elongata Glezer

Dictyocha elongata Glezer, 1960, p. 131, pl. 2, fig. 16-20.
Dictyocha elongata Glezer, Perch-Nielsen, in press, pl. 1, fig. 2.

Dictyocha deflandrei Frenguellii ex Glezer

Dictyocha deflandrei Frenguellii, 1940 (in part), p. 65, fig. 14a, c, d, e, f, (not b and g).
Dictyocha deflandrei Frenguellii ex Glezer, 1966, p. 244.
Dictyocha deflandrei Frenguellii ex Glezer, 1975 (in part), p. 686, pl. 4, fig. 5; pl. 15, fig. 5-7.
Dictyocha deflandrei Frenguellii ex Glezer, 1975 (in part), p. 686, pl. 4, fig. 5; pl. 15, fig. 4.

Dictyocha ibula Ehrenberg

Dictyocha ibula Ehrenberg 1839, fide Loeblich et al., 1968, p. 90, pl. 9, fig. 7-12.

Dictyocha ibula augusta n. subsp.
(Plate 6, Figures 1-5)

?Dictyocha ibula Ehrenberg, Ling, 1973, p. 751, pl. 1, fig. 9, 10.

Description: Dictyocha ibula augusta is a large subspecies having an angular basal ring, usually in the form of an elongate rhomb. Basal pikes are small, rounded, and distinctly offset from the strut-ring junctions. The apical bar is parallel or slightly subparallel to the major axis, and the strut attachment to the basal ring is slightly asymmetric. The spines are long, the major-axis spines being only slightly shorter than the maximum internal diameter of the basal ring. The solid walls of the tubular elements are thicker with respect to the tubular canal than other Neogene species of Dictyocha.

Remarks: Dictyocha ibula augusta is distinguished from the Dictyocha perlavus group by its rhombid basal ring and asymmetric strut placement. It is distinguished from Dictyocha epilod of Locker (1974) by its more regular form, absence of peripherally directed pikes, and the essentially uncanted alignment of the apical bar that is distinctly longer relative to the major axis of the basal ring (30% to 46% compared with only 22% and 23%). It is distinguished from other members of the Dictyocha ibula group by its large size, long spines, and narrow canals in the tubular elements. Ehrenberg’s first figured specimen of Dictyocha ibula, from seawater at Christiania, Norway (Loeblich et al., 1968, pl. 9, fig. 7), closely resembles D. ibula augusta. The stratigraphic dichotomy in occurrence between late Miocene and modern plankton is the only clearcut distinction. However, both of these forms are atypical of the series of specimens illustrated by Ehrenberg (1854) as Dictyocha ibula. That series of specimens with rounded outline and moderate to short spines is believed to define Ehrenberg’s central species concept for Dictyocha ibula (see
D. BUKRY

Ehrenberg, 1854; pl. 28, fig. 54a, c, 55; pl. 19, fig. 43; pl. 20, fig. 45; pl. 22, A, center left; pl. 33, 16 fig. 10). Locker's (1974) subsequent designation of an ambiguous type specimen for D. fibula, which is seemingly antithetic to Ehrenberg's concept, is not followed in this report.

Size: Major axis, basal ring 30-45 µm, holotype 38 µm.

Holotype: USNM 221620 (Plate 6, Figures I-3).

Paratype: USNM 221621.

Type locality: Falkland Plateau, South Atlantic Ocean, Sample 329-18-2, 50-51 cm (163 m).

Dictyocha fischeri n. sp.

Dictyocha frenguellii Deflandre, Ciesielski, 1975, p. 658, pl. 6, fig. 3-9.

Dictyocha frenguellii Deflandre, Bukry, 1975b, pl. 1, fig. 11, 12.


Dictyocha frenguellii Deflandre, Bukry, 1975d, p. 855, pl. 3, fig. 10, 11.

Description: Dictyocha fischeri has a slightly rounded, square basal ring that lacks basal pikes. The spines are moderately long and are nonseptate. The apical process is a modified apical plate or expanded strut junction that is usually square in outline. The four struts are equant and join the basal ring symmetrically; each strut has a distinct process that extends beyond the basal ring and may be as long as the spines.

Remarks: Dictyocha fischeri is distinguished from D. frenguellii by the absence of basal pikes and by its more equant form. It is distinguished from D. deflandrei, its probable ancestor, by the elevated distal processes of its struts.

Occurrence: Dictyocha fischeri occurs in the lower or upper Oligocene of the Southern Ocean at Sites 274, 278, and 328. It is a guide fossil for the Subzone of the Paleocene without Basal Pikes and by its more equant form. It is distinguished from D. deflandrei, its probable ancestor, by the elevated distal processes of its struts. D. deflandrei is distinguished from D. frenguellii by its septate radial spines and lack of distinct basal pikes. And the type specimen of D. fibula longispina is Holocene, from which no septate Dictyocha are known. The general form of the Holocene specimen is similar to the Paleocene Falkland assemblages that they might be considered identical (Lemmermann listed the Paleocene as an occurrence for D. fibula longispina, according to Loeblich et al., 1968), but the accessory structures—septa and basal pikes—make the distinction possible.

Occurrence: Dictyocha precarentis is especially abundant in the lower part of the Paleocene in Hole 327A.

Size: Internal diameter 15-25 µm.

Holotype: Plate 1, figures 11, 12 of Bukry (1975b).

Type locality: Southern Ocean, Sample 274-21-5, 51 cm (197 m).

Dictyocha frenguellii Deflandre

Dictyocha hexacantha Schulz

Schulz, 1928, p. 255, fig. 43.

Dictyocha hexacantha Schulz, Bukry 1975d, p. 855, pl. 4, fig. 1, 2.

Dictyocha pentagona (Schulz)

Dictyocha fibula vvar. pentagona Schulz, 1928, p. 255, fig. 41a, b.

Remarks: The long Paleocene to Quaternary range reported for this supposed taxon suggests it could be a polyphyletic form category. Certain specimens from Leg 36 support this possibility. A specimen having the form of Dictyocha pentagona, but bearing a spire and having the same size and proportions as associated D. stapedia stapedia, is included in the count for that subspecies at Sample 328A-1-1, 111-112 cm (1 m). The specimens of D. pentagona tabulated for 328B-1-2, 130-131 cm (10 m) are large and robust and match the associated specimens of Distephanus boliensis boliensis in size, surface texture, and proportions. This implies two different sources for silicoflagellate specimens having the D. pentagona geometry at Site 328.

Holocene Dictyocha fibula pentagona Deflandre (of Loeblich et al., 1968) has the D. pentagona geometry, but also has a spire and lacks basal pikes. A peculiar combination for that epoch because other dominant Dictyocha species have basal pikes whether they have a spire or not. Uchio (1974) illustrated a suite of upper Miocene specimens attributed to D. fibula pentagona that lacks spires but has basal pikes. Bukry illustrated his Distephanus pentagona from the Paleocene without pikes (probably derived from D. precarentis) and a second, scalloped specimen with pikes from the Holocene (probably derived from D. perlensis perlensis). Irregular specimens of D. pentagona dominated a plexus of aberrant forms produced by a laboratory clone of Dictyocha fibula s. ampl. (Van Valkenburgh and Norris, 1970). Therefore, the status of Dictyocha pentagona as a form category should be recognized. On a local basis it may be stratigraphically useful, but it would be misleading for transoceanic correlation.

Dictyocha perlensis perlensis Frenguelli

Dictyocha perlensis Frenguelli, 1951, p. 279, fig. 4b, c.

Dictyocha fibula perlensis (Frenguelli) Bukry, 1975d, p. 855, pl. 3, fig. 5.

Dictyocha perlensis perlensis Frenguelli, Bukry, 1976, p. 724, pl. 2, fig. 4, 5.

Dictyocha precarentis n. sp.

(Plate 6, Figures 6-13; Plate 7, Figures 1-3)

not Dictyocha fibula Ehrenberg var. longispina Lemmermann, 1901, p. 260, pl. 10, fig. 26; fide Loeblich et al., 1968, p. 93, pl. 12, fig. 1.


Description: Dictyocha precarentis has a regular basal ring that is straight-sided and nearly square in outline. The four medium to long spines at the corners are equant, and axially aligned. The struts and apical bar are almost square in outline, but the bar may be slightly wider, typically by less than a factor of two. Basal pikes are rarely present and are small and indistinct. The portals are large relative to tube width.

Remarks: Dictyocha precarentis is distinguished from younger D. carentis by a much narrower apical bar; in D. carentis, the bars is broadened almost to a plate. The portals of D. precarentis are more angular and proportionally much larger than in D. carentis. D. precarentis is septate, suggesting evolution from early Corbisema. As Deflandre, Ciesielski, 1975, p. 686, Pl. 6, Fig. 3-9.

Occurrence: Dictyocha precarentis is widely distributed and abundant in the lower part of the Paleocene in Hole 327A.

Size: Internal diameter 15-30 µm; holotype 20 µm.

Holotype: USNM 221622 (Plate 6, Figures 10, 11).

Paratypes: USNM 221623 to 221630.

Type locality: Falkland Plateau, South Atlantic Ocean; Sample 327A-8-3, 43-44 cm (74 m).

Dictyocha pulchella Bukry


Dictyocha pulchella Bukry, 1975c, p. 701, pl. 4, fig. 1-3.

Dictyocha spinosa (Deflandre)

Corbisema spinosa Deflandre, 1950, p. 193, fig. 178-182.

Dictyocha spinosa (Deflandre) Glezer, 1966, p. 238, pl. 10, fig. 76, 7, 8.

Dictyocha stapedia aspinosa Bukry

Dictyocha stapedia aspinosa Bukry, 1976, p. 724, pl. 2, fig. 6-9.

Dictyocha stapedia stapedia Haeckel

Dictyocha stapedia Haeckel, 1887, p. 1561, pl. 101, fig. 10-12.

Dictyocha stapedia stapedia Haeckel, Bukry, 1976, p. 724, pl. 3, fig. 1-7.

Genus DISTEPHANUS Stöhr, 1880

Distephanus boliensis boliensis (Frenguelli) (Plate 8, Figure 5)

Distephanus boliensis Frenguelli, 1940 (in part), p. 44, fig. 4a.

Distephanus boliensis Frenguelli, 1951 (in part), p. 274, fig. 2c, h; fig. 4d, f.

Distephanus boliensis (Frenguelli) Bukry and Foster, 1973, p. 827, pl. 4, fig. 1-3.

Remarks: Although separation of specimens with divided and subdivided apical rings appears to be an unnatural classification (see Bukry and Foster, 1973, pl. 7, fig. 2-4), the possible paleoecologic and stratigraphic use of such forms cannot be assessed for a rarely cited
taxon until they are identified at more sites. *Distephanus speculum* populations are better known, and simple divided forms, such as *D. speculum binonculus*, are usually a low-frequency variation throughout the stratigraphic and geographic range of *D. speculum*. An exceptional series of assemblages from the early Miocene at Site 338 in the North Atlantic have *D. speculum binonculus* and *D. speculum trimorpha* more numerous than *D. speculum speculum*; the multiply divided *D. speculum hemisphaericus* is even more abundant there. The problem of distinguishing binoculoid variants, produced by various species of *Distephanus*, makes their usefulness suspect. The same problem exists for pentagonal variants of several especially hexagonal taxa of *Distephanus*. The name *Distephanus speculum pentagonus* accommodates such forms for the *Distephanus speculum* group. Pentagonal variants of *D. boliviensis boliviensis*, *D. boliviensis frugalis*, or *D. speculum minutus* can be alternatively tabulated as *D. speculum pentagonus* (making it a polyphyletic form category), given a vernacular listing under the parent species, or, as Frenguelli (1951) implied, considered as undistinguished members of the parent species. Frenguelli’s usage for pentagonal variants was followed for *D. boliviensis boliviensis* in this report. See remarks on *Dictyocha pentagona*.

**Distephanus boliviensis frugalis Bukry**

*Distephanus boliviensis frugalis* Bukry, 1975e, p. 697, pl. 2, fig. 2-7.

**Distephanus boliviensis major** (Frenguelli)

*Dictyocha boliviensis* Frenguelli, 1940 (in part), p. 44, fig. 4b-d.

*Dictyocha boliviensis* Frenguelli, 1951 (in part), p. 274, fig. 2d-f, g; fig. 4e.

*Dictyocha boliviensis var. major* Frenguelli, 1951, p. 277, fig. 3a-c.

*Canopilus major* (Frenguelli) Bukry and Foster, 1973, p. 826, pl. 1, fig. 4-7; pl. 7, fig. 2.

**Distephanus crux crux** (Ehrenberg)

*Dictyocha crux* Ehrenberg, 1840, p. 207; Ehrenberg, 1854, pl. 18, fig. 56; pl. 20(1), fig. 46; pl. 33(15), fig. 9; pl. 33(16), fig. 9; pl. 33(17), fig. 5.

*Dictyocha crux* Ehrenberg, Frenguelli, 1951 (in part), p. 277, fig. 4n.

*Dictyocha crux* Bachmann and Keck, 1969, p. 205, pl. 2, figures on lower left and lower right.

*Distephanus crux ssp. bispinosus* Dumitrica, 1973, p. 850, pl. 6, fig. 3, 6, 7.

*Distephanus crux* (Ehrenberg), Dumitrica, 1973 (in part), p. 850, pl. 6, fig. 4, 5, 8, (not 11).

*Distephanus mesophthalmus* (Ehrenberg), Dumitrica, 1973, p. 850, pl. 6, fig. 9, 10, 12, 13.

*Distephanus crux* (Ehrenberg), Locker, 1974 (in part), p. 637, pl. 3, fig. 8, (not 10).

**Distephanus crux darwinii** n. subsp.

(Plate 7, Figures 4-13)

*Distephanus crux crux* Glazer, 1966 (in part), p. 279, pl. 18, fig. 9.

Description: *Distephanus crux darwinii* has a small rounded to angular basilar ring. The radial spines at the corners are nonseparate and medium to long. There are no basal pikes. The struts rise from the apical surface of the basal ring and flare slightly toward the center of the apical structure, which resembles an apical plate with a small rounded apical opening. Whereas the diameter of the apical area occupies a large fraction (30% to 50%) of the basal-ring diameter, the small apical opening occupies only about 50% of the apical area.

Remarks: *Distephanus darwinii* is distinguished from other quadrate species of *Distephanus* by the combination of large apical area, small apical opening, and lack of basal pikes. The apical area to basal ring proportions of *Dictyocha crux* Ehrenberg (1854) are in the range 27% to 33%. *Distephanus crux* (Ehrenberg) of Locker (1974), including the types of *Dictyocha staurodon* Ehrenberg and *D. mesophthalmus* Ehrenberg, has distinct basal pikes and apical proportions that do not match *D. crux darwinii*. The *Distephanus schauinslandii* group has small apical openings similar to *D. crux darwinii*, if defined simply by the criterion of an apical ring, is polyphyletic. Future consideration of accessory structures such as basal pikes (Dumitrica, 1979; Poelchau, 1974) sepiate spines (Dumitrica, 1973), and surface textures (Jerkovic, 1969; Mandra and Mandra, 1972; McPherson and Ling, 1973), should help develop a more natural classification for the study of silicoflagellate phylogeny.

Occurrence: *Distephanus crux darwinii* is common to abundant in the upper Oligocene in Hole 325B. It occurs reworked at Site 329.

Size: Internal diameter 14-20 μm; holotype 19 μm.

Holotype: USNM 221631 (Plate 7, Figures 6, 7).

Paratypes: USNM 221632 to 221637.

Type locality: Falkland outer basin, South Atlantic Ocean, Sample 325B-3-1, 109-110 cm (28 m).

**Distephanus crux hannai Bukry**

*Distephanus crux hannai* Bukry, 1975d, p. 855, pl. 4, fig. 4-6.

**Distephanus polyacis (Ehrenberg)**

*Dictyocha polyacis* Ehrenberg, 1839, p. 129.

*Distephanus polyacis* Ehrenberg, Perch-Nielsen, 1975, p. 688, pl. 7, fig. 12; pl. 11, fig. 11.

**Distephanus raupii** n. sp.

(Plate 7, Figures 14, 15)

*Distephanus speculum pentagonus* (Lemmermann), Bukry, 1975d (in part), p. 867, pl. 4, fig. 9, 10 (not 11).

Description: *Distephanus raupii* has a small pentagonal basal ring and short to moderate spines. The corners of the basal ring are rounded or angular; there are no basal pikes on the ring. The apical structure is broad, occupying 30% to 50% of the interfing area, however, the rounded apical opening is generally small. The strut-basal ring junctions are offset from the midpoints of the sides of the basal ring.

Remarks: *Distephanus raupii* is distinguished from *Distephanus speculum pentagonus* by the absence of basal pikes, smaller more rounded apical opening, and generally smaller overall size. Because of its small, compact form, the absence of basal pikes, and its stratigraphic occurrence, *D. raupii* most likely evolved from the *Dictyocha deflandrei* and *Distephanus crux darwinii* lineage.

Occurrence: *Distephanus raupii* occurs in upper Oligocene and lower Miocene silicoflagellate assemblages from the Pacific and Atlantic oceans at Sites 278 and 328.

Size: Basal ring inner diameter 15-25 μm.

Holotype: USNM 221638 (Plate 7, Figures 14, 15).

Type locality: Falkland outer basin, South Atlantic Ocean, Sample 325B-3-5, 100-102 cm (34 m).

**Distephanus schauinslandii stradneri Jerkovici**

*Dictyocha schauinslandii stradneri* Jerkovici, 1965, p. 3, pl. 2, fig. 2.

*Distephanus crux Ehrenberg, Dumitrica, 1973 (in part), p. 850, pl. 6, fig. 11.

*Distephanus schauinslandii stradneri* (Jerkovici), Bukry, 1975, p. 866, pl. 4, fig. 7.

Remarks: Large cruxoid specimens with small apical openings and nearly equant major and minor axis are assigned to this taxon.

**Distephanus speculum hemisphaericus** (Ehrenberg)

*Dictyocha hemisphaerica* Ehrenberg 1844b, p. 258, 266.

*Canopilus hemisphaericus* (Ehrenberg), Locker, 1974, p. 639, pl. 4, fig. 1, 4, 5, 7, 8.

*Distephanus speculum hemisphaericus* (Ehrenberg) Bukry 1975d, p. 855, pl. 4, fig. 8.

**Distephanus speculum minutus** (Bachmann)

(Plate 8, Figures 1-3)

*Dictyocha speculum f. minutus* Bachmann in Ichikawa et al., 1967, p. 161, pl. 7, fig. 12-15.

*Distephanus minutus* (Bachmann) Bukry and Foster, 1973, p. 828, pl. 4, fig. 10, 11.

Remarks: Specimens from Leg 36 have exceptionally wide apical rings, nearly as wide as the basal ring. Although six-spined forms predominate, eight-spined forms having distinct basal pikes are common in Cores 4 to 6 at Site 329.

**Distephanus speculum pentagonus** Lemmermann

*Distephanus speculum var. pentagonus* Lemmermann, 1901, p. 264, pl. 11, fig. 19.
Distephanus quinquangellus Bukry and Foster nomen novum, 1973, p. 838, pl. 5, fig. 4.

Remarks: This taxon is perplexing because of its form, distribution, and potential polyphyletic origins (see Distephanus boliviensis boliviensis). In many assemblages it is obviously related to the more abundant Distephanus speculum pseudofibula by size, proportions, and ornamentation. Such forms cannot be considered as distinct species in a natural scheme of classification. But other assemblages have abundant "D. speculum pentagonus" whose form is not matched by any associated specimens of Distephanus speculum, for example, the small-centered forms at Site 278, Core 28 (Bukry, 1975d). By their size, proportion, and absence of basal pikes the late Oligocene or early Miocene populations of pentagonal specimens of Distephanus (Sites 328B and 278) show closer affinity to the Distephanus crux darwinii group than to the type of D. speculum pentagonus which has distinct basal pikes and a large polygonal apical ring. These pentagonal specimens are distinguished herein as Distephanus raupii.

Distephanus speculum pseudofibula Schulz

Distephanus speculum l. pseudofibula Schulz, 1928, p. 262, fig. 51a, b.
Remarks: The apical bar of Distephanus speculum pseudofibula seems to suggest assignment to the genus Dictyocha, as does its paleotemperature significance at DSDP 173 (Ingle, 1973). The hexagonal base, however, suggests a relation to Distephanus speculum. Curiously, it occurs as part of a double skeleton with D. speculum varians (symmetric) at Site 329 (Plate 8, Figures 8, 9). Therefore, the distinction of D. speculum varians from D. speculum pseudofibula seems artificial. The lack of an apical ring in each of the paired skeletons does not support the relation of these two taxa to D. speculum. The regular hexagonal basal ring, however, is believed to be a character trait better ascribed to Distephanus than to Dictyocha. When more double skeletons are studied, it may be found to be appropriate to elevate D. speculum pseudofibula to species rank within Distephanus.

Distephanus speculum quintus (Bukry and Foster)

Cannoplis quintus Bukry and Foster, 1973, p. 826, pl. 1, fig. 8, 9; pl. 2, fig. 1.
Distephanus speculum quintus (Bukry and Foster) Bukry, 1975d, p. 855.

Distephanus speculum speculum (Ehrenberg)

Dictyocha speculum Ehrenberg, 1839, p. 150; Ehrenberg, 1854, pl. 18, fig. 57; pl. 19, fig. 41; pl. 21, fig. 44; pl. 22, fig. 47.

Remarks: Specimens with many different proportions are included in Distephanus speculum speculum. Radially and bilaterally symmetric forms are not separated for this report, nor are short- and long-spired forms. Several abnormal specimens of D. speculum s. ampl. are illustrated (Plate 8, Figures 4, 6).

Distephanus speculum varians Gran and Braarud

(Plate 8, Figures 7-10)

Distephanus speculum l. varians Gran and Braarud, 1935, p. 390, fig. 68A, B.
Distephanus speculum varians (Gran and Braarud) Bukry, 1975d, p. 868, pl. 5, fig. 3.

Remarks: Two morphotypes were originally illustrated for this subspecies. Because the work of Ciesielski and Weaver (1973) suggested some difference in the ranges of the symmetric and asymmetric forms of Distephanus speculum varians, they were tabulated separately at several Leg 36 sites. No significant difference in range was noted. Lindsay (1972) considered the pseudofibula-variants complex to represent a single phenotype suite (see remarks for Distephanus speculum pseudofibula, this chapter). Clearcut differences in skeletal form, proportions, and ornamentation do not necessarily reflect different taxa (see Plate 8, Figures 8, 9).
Some specimens of Dictyocha fibula hexagona Marshall (see Loeblich et al., 1968) mimic the form of Distephanus speculum varians, but their struts are peculiarly widened.

Distephanus speculum trionumata (Ehrenberg) n. comb.

Dictyocha trionumata Ehrenberg, 1845, p. 56, 76.
Dictyocha trionumata Ehrenberg, Locker, 1974, p. 639, 643, pl. 4, fig. 5

Genus LYRAMULA Hanna, 1928

Lyramula furcula Hanna, 1928, p. 262, pl. 41, fig. 4, 5.

Genus MESOCENA Ehrenberg, 1843

Remarks: For this report all silicoflagellates constructed as a single ring are assigned to genus Mesocena.

Mesocena apiculata (Schulz)

Mesocena oamaruensis apiculata Schulz, 1928, p. 240, fig. 11.
Mesocena apiculata (Schulz), Bukry, 1975d, p. 856, pl. 5, fig. 6-9.

Mesocena circulus (Ehrenberg)

Mesocena circulus (Ehrenberg) Ehrenberg, 1844a, p. 65.
Mesocena circulus (Ehrenberg), Ling, 1972, p. 175, pl. 28, fig. 5, 6.
Mesocena circulus (Ehrenberg), Bukry, 1975d, p. 868, pl. 6, fig. 1, 2.

Remarks: The several forms of Mesocena circulus are tabulated together. Polygonal, coarse-spined forms (see Ling, 1972) dominate at Site 329.

Mesocena diodon Ehrenberg

Mesocena diodon Ehrenberg, 1844a, p. 71, 84.
Mesocena diodon Ehrenberg, Bukry, 1973, p. 830, pl. 3, fig. 4, 5.

Mesocena elliptica (Ehrenberg)

Mesocena elliptica (Ehrenberg) Ehrenberg, 1844a, p. 71, 84.
Mesocena elliptica (Ehrenberg) Bukry and Foster, 1973, p. 828, pl. 6, fig. 2-4.

Mesocena oamaruensis quadrangula Schulz

Mesocena oamaruensis quadrangula Schulz, 1928, p. 240, fig. 12, 13.

Mesocena pappii Bachmann


Mesocena pentagona Haeckel

Mesocena pentagona Haeckel, 1887, p. 1556; Lemmermann, 1901, pl. 10, fig. 8.

Mesocena triangula (Ehrenberg)

Mesocena triangula (Ehrenberg) Ehrenberg, 1844a, p. 65, 71.
Mesocena triangula (Ehrenberg), Bukry and Foster, 1973, p. 829, pl. 6, fig. 9, 10.

Mesocena sp.


Genus NAVICULOPSIS Frenguelli, 1940

Remarks: The species concepts for Naviculopsis are the same as those used for DSDP Leg 29 (Bukry, 1975d). Two additional species recognized for DSDP Leg 36 are based on Perch-Nielsen (in press).

Naviculopsis aspera (Schulz)

(Plate 8, Figures 11, 12)
Dictyocha navicula var. aspera Schulz, 1928, p. 246, fig. 20a, b.
Naviculopsis aspera (Schulz) Perch-Nielsen, in press, pl. 1, fig. 8, 9; pl. 3, figs. 7, 10, 11.

Remarks: The narrow apical band appears to be continuous with the body ring and to have a rim along its margins in light microscopy. Because the surface texture is indistinct in light microscopy, the rim along the apical band and body rim is used to distinguish the compared specimens in Hole 327A from Naviculopsis constricta.

Naviculopsis biapiculata (Lemmermann)

Dictyocha navicula biapiculata Lemmermann, 1901, p. 228, pl. 10, fig. 14, 15.

Remarks: The specimens in Hole 328B match those from DSDP Legs 28 and 29 in form and size. The apical bar is distinctly arched. A few compared specimens have a short spine on the apical bar. These
Naviculopsis constricta (Schulz) (Plate 9, Figures 1, 2)

*Dictyocha navicula biplicata constricta* Schulz, 1928, p. 246, fig. 21.
*Dictyocha navicula minor* Schulz, 1928, p. 246, fig. 22.
*Naviculopsis constricta* (Schulz) Frenguelli, 1940, p. 61, fig. 11a, b.

**Remarks:** Specimens having short and elongate basal rings and long and short apical spines occur through the Paleocene to Oligocene range of this species. The elongate form is typically less abundant. Because these two forms are considered conspecific the name *Naviculopsis constricta* has figure priority.

*Naviculopsis danica* Perch-Nielsen (Plate 9, Figure 3)

*Naviculopsis danica* Perch-Nielsen, in press, p. 2, fig. 5, 6; pl. 2, fig. 5.

**Remarks:** The single specimen from the Falkland Plateau shows the same proportions as the type Danish suite (Perch-Nielsen, in press).

*Naviculopsis foliacea* Deflandre

*Naviculopsis foliacea* Deflandre 1950, p. 203, fig. 235-239.

*Naviculopsis navicula* (Ehrenberg)

*Dictyocha navicula* Ehrenberg, 1839, p. 129.
*Naviculopsis navicula* (Ehrenberg), Ling, 1972, p. 186, pl. 31, fig. 1.
*Naviculopsis navicula* (Ehrenberg), Locker, 1974 (in part), p. 635, pl. 2, fig. 1.

**Remarks:** The internal breadth of the two ends of this boat-shaped species is approximately one half the breadth in the region of the apical bar. Characteristically, *Naviculopsis navicula* has no spines, but rare specimens having one or two spines occur. The tubular basal ring is not broadened at the ends.

*Naviculopsis ponticula* (Ehrenberg) n. comb.

*Dictyocha ponticula* Ehrenberg, 1844b, p. 258, 267.
*Naviculopsis navicula* (Ehrenberg), Martini, 1972, p. 120, text-fig. 2.
*Naviculopsis quadrate* (Ehrenberg), Bukry and Foster, 1973, p. 306, fig. 2a.
*Naviculopsis navicula* (Ehrenberg), Locker, 1974 (in part: lectotype illustration of *Dictyocha ponticula* Ehrenberg), p. 635, pl. 2, fig. 2 (not fig. 1).

**Remarks:** According to the illustration of Locker (1974), the lectotype of *Dictyocha ponticula* Ehrenberg shows the ends of the basal ring distinctly broader than the other tubular portions of the ring. This is an easily determined morphologic feature. Specimens showing this feature should be distinguished from *Naviculopsis navicula* sensu stricto (Locker, 1974, pl. 2, fig. 1) until the stratigraphic and ecologic significance of this structural difference is determined.

*Naviculopsis quadrate* (Ehrenberg)

*Dictyocha quadrate* Ehrenberg, 1844b, p. 258, 267; fide Loeblich et al., 1968, p. 105, pl. 19, fig. 12.

*Dictyocha navicula rectangulare* Schulz, 1928, p. 243, fig. 17a, b.

*Naviculopsis trispinosa* (Schulz)

*Dictyocha navicula trispinosa* Schulz, 1928, p. 246, fig. 23a, b.

*Naviculopsis trispinosa* (Schulz), Perch-Nielsen, 1975, p. 689, pl. 12, fig. 1-4; pl. 13, fig. 1-10.

Genus VALLACERTA Hanna, 1928

*Vallacerta tumidula* Glezer

*Vallacerta tumidula* Glezer, 1959, p. 104, 107, fig. 4, 5.

**Remarks:** A single pentagonal specimen was observed in the upper Paleocene of Hole 327A.

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Corbisema disymmetrica angulata n. subsp.
1. USNM 221575, Sample 327A-5-2, 100-102 cm (45 m).
2. USNM 221576, Sample 327A-5-2, 100-102 cm (45 m).
3. USNM 221577, Sample 327A-5-4, 100-102 cm (48 m).
4. Holotype, USNM 221574, Sample 327A-5-4, 100-102 cm (48 m).

Corbisema disymmetrica communis n. subsp.
5. USNM 221579, Sample 327A-8-3, 43-44 cm (74 m).
6. USNM 221580, Sample 327A-8-3, 43-44 cm (74 m).
7. USNM 221581, Sample 327A-8-1, 130-132 cm (72 m).
8. Holotype, USNM 221578, Sample 327A-6-6, 130-132 cm (61 m).
9. USNM 221582, Sample 327A-5-1, 60-62 cm (43 m).

Corbisema disymmetrica disymmetrica (Dumitrica) n. comb.
10. Sample 327A-6-3, 100-102 cm (56 m).
11. Sample 327A-8-1, 130-132 cm (72 m).
12. Sample 327A-5-2, 100-102 cm (45 m), fragment.
PLATE 2
Silicoflagellates from DSDP Leg 36.
Scale bar equals 10 µm for all figures.

Figures 1-15  *Corbisema falklandensis* n. sp.
1, 2. USNM 221584, Sample 327A-5-4, 100-102 cm (48 m), apical and basal focuses.
3, 4. USNM 221585, Sample 327A-5-4, 100-102 cm (48 m), apical and basal focuses.
5. (USNM 221586, Sample 327A-5-2, 100-102 cm (45 m), apical focus.
6, 7. USNM 221587, Sample 327A-6-1, 9-10 cm (52 m), apical and basal focuses.
8, 9. Holotype, USNM 221583, Sample 327A-6-1, 9-10 cm (52 m), apical and basal focuses.
10. USNM 221588, Sample 327A-6-3, 100-102 cm (56 m), basal focus.
11. USNM 221589, Sample 327A-7-2, 3-4 cm (62 m), apical focus.
12. USNM 221590, Sample 327A-6-1, 9-10 cm (52 m), side view.
13. USNM 221591, Sample 327A-5-5, 100-102 cm (45 m), side view.
14, 15. USNM 221592, Sample 327A-6-3, 100-102 cm (54 m), apical and basal focuses.
PLATE 3
Silicoflagellates from DSDP Leg 36
Scale bar equals 10 µm for all figures.

Figures 1-7  *Corbisema glezerae* n. sp.
1. USNM 221594, Sample 327A-8-1, 130-132 cm (72 m).
2. USNM 221595, Sample 327A-8-1, 130-132 cm (72 m).
3. Holotype, USNM 221593, Sample 327A-6-3, 100-102 cm (56 m).
4. USNM 221596. Sample 327A-5-5, 100-102 cm (49 m).
5. USNM 221597, Sample 327A-6-6, 130-132 cm (61 m).
6, 7. USNM 221598, Sample 327A-5-2, 100-102 cm (45 m), side view, high and mid focuses.

Figures 8-15  *Corbisema hastata cunicula* n. subsp.
8. USNM 221600, Sample 327A-5-2, 100-102 cm (45 m).
9. USNM 221601, Sample 327A-6-1, 9-10 cm (52 m).
10. USNM 221602, Sample 327A-6-6, 130-132 cm (61 m).
11. USNM 221603. Sample 327A-5-2, 100-102 cm (45 m).
12. USNM 221604, Sample 327A-5-2, 100-102 cm (45 m).
13. USNM 221605, Sample 327A-5-2, 100-102 cm (45 m).
14. USNM 221606, Sample 327A-5-2, 100-102 cm (45 m).
15. Holotype, USNM 221599, Sample 327A-6-6, 130-132 cm (61 m).
PLATE 4
Silicoflagellates from DSDP Leg 36
Scale bar equals 10 µm for all figures.

Figures 1-8  *Corbisema hastata globulata* n. subsp.
1. USNM 221608, Sample 327A-5-4, 100-102 cm (48 m).
2. Holotype, USNM 221607, Sample 327A-5-4, 100-102 cm (48 m).
3. USNM 221609, Sample 327A-5-2, 100-102 cm (45 m).
4. USNM 221610, Sample 327A-6-1, 9-10 cm (52 m).
5. USNM 221611, Sample 327A-6-3, 100-102 cm (56 m).
6. USNM 221612, Sample 327A-7-2, 3-4 cm (62 m).
7. USNM 221613, Sample 327A-5-2, 100-102 cm (45 m).
8. USNM 221614, Sample 327A-5-2, 100-102 cm (45 m).

Figures 9-16  *Corbisema hastata hastata* (Lemmermann)
9. Sample 327A-6-1, 9-10 cm (52 m).
10. Sample 327A-5-6, 130-131 cm (51 m).
11. Sample 327A-6-6, 130-132 cm (61 m).
12. Sample 327A-6-1, 9-10 cm (52 m).
13. Sample 327A-5-2, 100-102 cm (45 m).
14. Sample 327A-6-3, 100-102 cm (56 m).
15. Sample 327A-6-3, 100-102 cm (56 m).
16. Sample 327A-5-5, 100-102 cm (49 m).
PLATE 5
Silicoflagellates from DSDP Leg 36
Scale bar equals 10 µm for all figures.

Figures 1-3  *Corbisema inermis inermis* (Lemmermann)
1. Sample 327A-5-1, 60-62 cm (43 m).
3. Sample 327A-6-6, 130-132 cm (61 m), isosceles specimen.

Figures 4-7  *Corbisema inermis minor* (Glezer) n. comb.
4. Sample 327A-5-4, 100-102 cm (48 m), basal and apical focuses.
6. Sample 327A-7-2, 3-4 cm (62 m), basal and apical focuses.

Figures 8-13  *Corbisema neoparallela* n. sp.
8. USNM 221616, Sample 327A-5-1, 60-62 cm (43 m), fragment.
9. Holotype, USNM 221615, Sample 327A-5-2, 100-102 cm (45 m).
10. USNM 221617, Sample 327A-5-1, 60-62 cm (43 m), tilted.
11. USNM 221618, Sample 327A-5-1, 60-62 cm (43 m).
12, 13. USNM 221619, Sample 327A-5-1, 60-62 cm (43 m), tilted, two focus levels.
PLATE 6
Silicoflagellates from DSDP Leg 36
Scale bar equals 10 µm for all figures.

Figures 1-5
*Dictyocha fibula augusta* n. subsp.
1-3. Holotype, USNM 221620, Sample 329-18-2, 50-51 cm (163 m), basal, mid, and apical focuses.
4, 5. USNM 221621, Sample 329-18-2, 50-51 cm (163 m), basal and apical focuses.

Figures 6-13
*Dictyocha precarentis* n. sp.
6. USNM 221623, Sample 327A-8-1, 130-132 cm (72 m).
7. USNM 221624, Sample 327A-8-3, 43-44 cm (74 m).
8. USNM 221625, Sample 327A-8-1, 130-132 cm (72 m).
9. USNM 221626, Sample 327-8-3, 43-44 cm (74 m), abnormal specimen.
10, 11. Holotype, USNM 221622, Sample 327A-8-3, 43-44 cm (74 m), apical and basal focuses.
12. USNM 221627, Sample 327A-8-3, 43-44 cm (74 m).
13. USNM 221628, Sample 327A-5-6, 130-131 cm (51 m).
Figures 1-3  *Dictyocha precarentis* n. sp.
1. USNM 221629, Sample 327A-8-3, 43-44 cm (74 m).
2, 3. USNM 221630, Sample 327A-8-3, 43-44 cm (74 m), basal and apical focuses.

Figures 4-13 *Distephanus crux darwinii* n. subsp.
4. USNM 221632. Sample 328B-3-3, 95-96 cm (31 m).
5. USNM 221633. Sample 328B-3-1, 109-110 cm (28 m).
6, 7. Holotype, USNM 221631, Sample 328B-3-1, 109-110 cm (28 m), basal and apical focuses.
8. USNM 221634, Sample 328B-3-3, 95-96 cm (31 m).
9. USNM 221635. Sample 328B-3-1, 109-110 cm (28 m).
10,11. USNM 221636, Sample 328B-3-1, 109-110 cm (28 m), basal and apical focuses.
12, 13. USNM 221637, Sample 328B-3-1, 109-110 cm (28 m), frenguelloid variant, basal and apical focuses.

Figures 14, 15 *Distephanus raupii* n. sp.
14, 15. Holotype, USNM 221638, Sample 328B-3-5, 100-102 cm (34 m), basal and apical focuses.
Figures 1-3
*Distephanus speculum minutus* (Bachmann)
1. Sample 329-12-2, 50-51 cm (106 m), pentagonal.
2. Sample 329-15-2, 50-51 cm (134 m).
3. Sample 329-4-3, 50-51 cm (31 m), octagonal.

Figures 4, 6
*Distephanus speculum* (Ehrenberg) s. ampl., abnormal
4. Sample 328-2-4, 2-3 cm (11 m), spineless.
6. Sample 328-2-4, 2-3 cm (11 m), swirled and binoculoid.

Figure 5
*Distephanus* sp. cf. *D. boliviensis boliviensis* (Frenguelli)
5. Sample 328-2-4, 2-3 cm (11 m), swirled.

Figures 7-10
*Distephanus speculum varians* Gran and Braarud
7. Sample 328-2-4, 2-3 cm (11 m), symmetric.
8, 9. Sample 329-1-3, 50-51 cm (3 m), double skeleton; 8, high focus; 9, low focus.
10. Sample 328-2-4, 2-3 cm (11 m), asymmetric.

Figures 11, 12
*Naviculopsis* sp. cf. *N. aspera* (Schulz)
11. Sample 327A-5-2, 100-102 cm (45 m).
12. Sample 327A-5-1, 60-62 cm (43 m), abnormal specimen.
PLATE 9
Silicoflagellates and diatoms from DSDP Leg 36
and Baja California
Figures 1-5, 7-9; scale bar equals 10 µm.
Figure 6; scale bar equals 5 µm.

Figures 1, 2  *Naviculopsis constricta* (Schulz)
1. Sample 327A-5-2, 100-102 cm (45 m).
2. Sample 327A-5-4, 100-102 cm (48 m).

Figure 3  *Naviculopsis danica* Perch-Nielsen
3. Sample 327A-8-1, 130-132 cm (72 m).

Figures 4-9  *Stictodiscus gelidus* Mann
4. Sample 328B-3-5, 100-102 cm (34 m).
5-9. Sample CAS54064, San Gregorio, Baja California; 5-7, plan views; 8 and 9, side views.