24. RADIOLARIA, LEG 4, DEEP SEA DRILLING PROJECT

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CONTENTS

1. INTRODUCTION

As is indicated in the general description of the cores (Chapters 2-10 of this volume), radiolarians occur in Cretaceous deposits at Sites 24 and 28, in Eocene deposits at Sites 27, 28 and 29, possibly in Oligocene deposits at Site 27, and in Miocene deposits at Sites 30 and 31. Most of these occurrences are in short, isolated core sections, but the Eocene section at Site 29 provides a long sequence of highly radiolarian sediment which permits a fundamental advance in our understanding of the biostratigraphy of this microfossil group.

Stratigraphic correlation by means of radiolarians is not yet as routine a matter as it is with foraminifera and calcareous nannoplankton and, therefore, it has not been possible to provide simple lists of well-known species in other sections of this volume to substantiate the age-assignments indicated. Instead, all information on the occurrences of species is given in this present chapter, together with information necessary to justify the correlations.

In order to describe the stratigraphic positions of the radiolarian sediments obtained on Leg 4, it is necessary to provide an outline of a Cenozoic radiolarian zonation, the details of which are being prepared for publication elsewhere. In the outline of radiolarian zonation presented below, the approximate relation of calcareous microfossil zones to radiolarian zones is indicated wherever possible. It has been necessary to describe a number of new taxa in order to facilitate discussion of the zonation and evolutionary series, and generic assignments of some previously known species are changed to bring them into conformity with a system of classification believed to be more natural than Haeckel's (Riedel, 1967 and in press, a).

Much of the research leading to the development of the Cenozoic radiolarian zonation applied in this report has been supported by the Office of Naval Research Contract Nonr 2216(23) and National Science Foundation Grants GA-11489 and GA-658. The latter grant also made possible some progress toward the intercorrelation of foraminiferal, nannofossil and radiolarian zonations.

The authors are indebted to many colleagues throughout the world for providing samples from land-based sections which have been used in the development of the radiolarian taxonomy and stratigraphy.

2. CRETACEOUS OCCURRENCES

Sediments containing Cretaceous radiolarians were cored at Sites 24 and 28. At Site 24 (Cores 1 to 4 of Hole 24A) they occur from about 500 to about 560 meters (1640 to 1836 feet) below the sea floor, becoming progressively sparser and less well preserved downward, and at Site 28 they occur in only one sample at about 400 meters (1312 feet) below the sea floor.

Hole 24A (6° 16.58'S, 30° 53.46'W; water depth 5148 meters)

Sample 24A-1-1:

The assemblage here is diverse and well preserved, and therefore most of the specimens illustrated from this hole are from this sample. The radiolarian preparations contain a large amount of fish skeletal debris (placoid scales?). The age, to judge from previous records of some of the species, is Upper Cretaceous, probably Campanian.

Below we list some of the commoner and more striking members of the assemblage. At this site there were no representatives of the families: *Collosphaeridae* Müller, *Phacodiscidae* Haeckel, *Coccodiscidae* Haeckel, *Acanthodesmiidae* Haeckel, *Carpocaniidae* Haeckel emend. Riedel, *Pterocoryidae* Haeckel emend. Riedel, or *Cannobotryidae* Haeckel emend. Riedel, probably because these families had not yet evolved.

Family ACTINOMMIDAE Haeckel 1862, emend. Riedel 1967b:

A spherical form with medullary shell and two (rarely more) strong, bladed spines, and cortical shell with tuberose surface and small pores is illustrated (Plate 1, Figure 1).

Subfamily SATURNALINAE Deflandre 1953:

In addition to common fragments of saturnalin rings with many spines (Plate 1, Figure 3), there rarely occurs a form with two half-rings joined directly to the shell (c.f. *Saturnalis minimus* Squinabol, 1914, p. 287, Plate 22, Figure 1; Plate 23, Figure 6; originally described from the Jurassic and Middle Cretaceous of Italy); Plate 1, Figure 2.

Family SPONGODISCIDAE Haeckel 1862, emend. Riedel 1967b:

A number of forms occur, which are evidently related to species that have commonly been assigned to *Amphibrachium* Haeckel. The form illustrated in Plate 1, Figures 4 and 5 is comparable with *A. ornatum* Lipman (1960, p. 126, Plate 28, Figures 10 through 13), and that illustrated in Plate 1, Figures 6 and 7 resembles *Amphibrachium concentricum* Lipman (1960, p. 125, Plate 28, Figures 6 and 7); these species have been recorded from the Santonian-Campanian and Turonian of Western Siberia. There is also a simple, elongated form with two bladed spines in the main axis (Plate 1, Figure 8).

A form with a concentrically chambered circular disc and three strong marginal spines (Plate 1, Figure 9) occurs rather commonly.

There is also a form (Plate 2, Figure 1) resembling *Septinastrum dogeli* Gorbovets (in Kozlova and Gorbovets, 1966, p. 86, Plate 4, Figures 4 and 5), recorded from the upper Campanian of Western Siberia, and one (Plate 2, Figure 2) apparently identical with *Spongopyle insolita* Kozlova (in Kozlova and Gorbovets, 1966, p. 91, Plate 4, Figures 11a and b), recorded from the Campanian of the eastern slope of the Urals.

A three-rayed form (Plate 2, Figure 3) may be identical with *Euchitonia triradiata* Lipman (1960, p. 129, Plate 29, Figures 1 through 3), recorded from the Santonian-Campanian of Western Siberia, but for a four-rayed form with a pronounced radial structure (Plate 2, Figure 4) it is impossible at present to make a satisfactory generic assignment.

Family PSEUDOAULOPHACIDAE Riedel 1967a: There are rare examples of a triangular pseudoaulophacid (Plate 2, Figure 5) resembling *"Theodiscus" superbus* Squinabol (1914, p. 271, Plate 20, Figure 4; recorded from the "Middle Cretaceous" of Italy) or *Pseudoaulophacus gallowayi* (White) (Pessagno, 1963, p. 202, Plate 2, Figures 1, 3 and 6; Plate 4, Figures 2, 5 and 7; Plate 7, Figures 2 and 4; recorded from the Campanian of Puerto Rico and Mexico), and common three-and four-rayed forms (Plate 2, Figures 6 and 7) in which the central portion tends to have a pseudoaulophacid structure and the arms a hagiastrin structure (Riedel, in press, a).

Family THEOPERIDAE Haeckel 1881, emend. Riedel 1967b: There are rather few specimens (Plate 3, Figure 1) of a *Theocapsomma* (in the sense of Foreman, 1968, p. 29) resembling *Tricolocapsa granti* Campbell and Clark (1944b, p. 35, Plate 7, Figures 37 and 38; recorded from the early Maestrichtian or perhaps late Campanian of California) or *Theocapsa salva* Rüst (1888, p. 210, Plate 28, Figure 5; 1892, p. 107, Plate 15, Figure 3).

A common form (Plate 3, Figure 2) with enclosed cephalis and very constricted mouth resembles *Dicolocapsa verbeeki* Tan Sin Hok (1927, p. 44, Plate 8, Figures 40 and 41; *Gongylothorax verbeeki* in Foreman, 1968, Plate 2, Figure 8; recorded from the Turonian or early Senonian of Indonesia and from the Santonian-Campanian to Maestrichtian of Cuba and California), but appears not to have a differentiated pore or tube in the thoracic wall near its junction with the cephalis.

There are a number of other theoperids which are illustrated but which cannot readily be compared with described species – a form probably assignable to Cornutella (Plate 3, Figure 3); a three-segmented form with rather large cephalis, inflated thorax and narrower abdomen (Plate 3, Figure 4); a rare form with strong, bladed feet and horn, and lamellar, sparsely perforate thorax (Plate 3, Figure 5); forms evidently related to *Sciadiocapsa* (Plate 3, Figures 6 and 7); and, common representatives of *Dictyomitra* with and without longitudinal ribs (Plate 3, Figures 8 through 10).

Family AMPHIPYNDACIDAE Riedel, 1967a: This family is represented by a form (Plate 3, Figure 11) with generally two or three transverse rows of pores on each segment, bearing some resemblance to *Dictyomitra uralica* Gorbovets (in Kozlova and Gorbovets, 1966, p. 116, Plate 6, Figures 6 and 7; recorded from the Campanian of Western Siberia) and *Amphipyndax stocki* (Campbell and Clark)–(Foreman, 1968, p. 78, Plate 8, Figures 12 a-c; recorded from Santonian to Paleocene of the Caribbean region and California).

Family ARTOSTROBIIDAE Riedel, 1967a: There are two common species in this assemblage, one (Plate 3, Figure 12) resembling *Theocampe mongolfieri* (see section on Cenozoic radiolarians) but with abdominal pores less numerous and not in such pronounced longitudinal and transverse rows, and the other (Plate 3, Figure 13) with a rough abdominal surface and flared peristome. This latter form occurs in the Santonian-Campanian of Cuba (Sample B191 of P. J. Bermudez; for locality see Foreman, 1966, p. 358) and is not known elsewhere.

Samples 24A-3-1, 78-80 cm; 24A-3-1, 87-89 cm; 24A-3-1, 136-138 cm; 24A-3-1, 138-140 cm; 24A-4-1; 24A-4-2, 10-12 cm; 24A-4-2, 20-22 cm; 24A-4-2, 30-32 cm; and, 24A-4-2, 136-138 cm:

The radiolarian assemblages in these samples are sparser than those in Sample 24A-1-1, but appear not to differ markedly from it in species content.

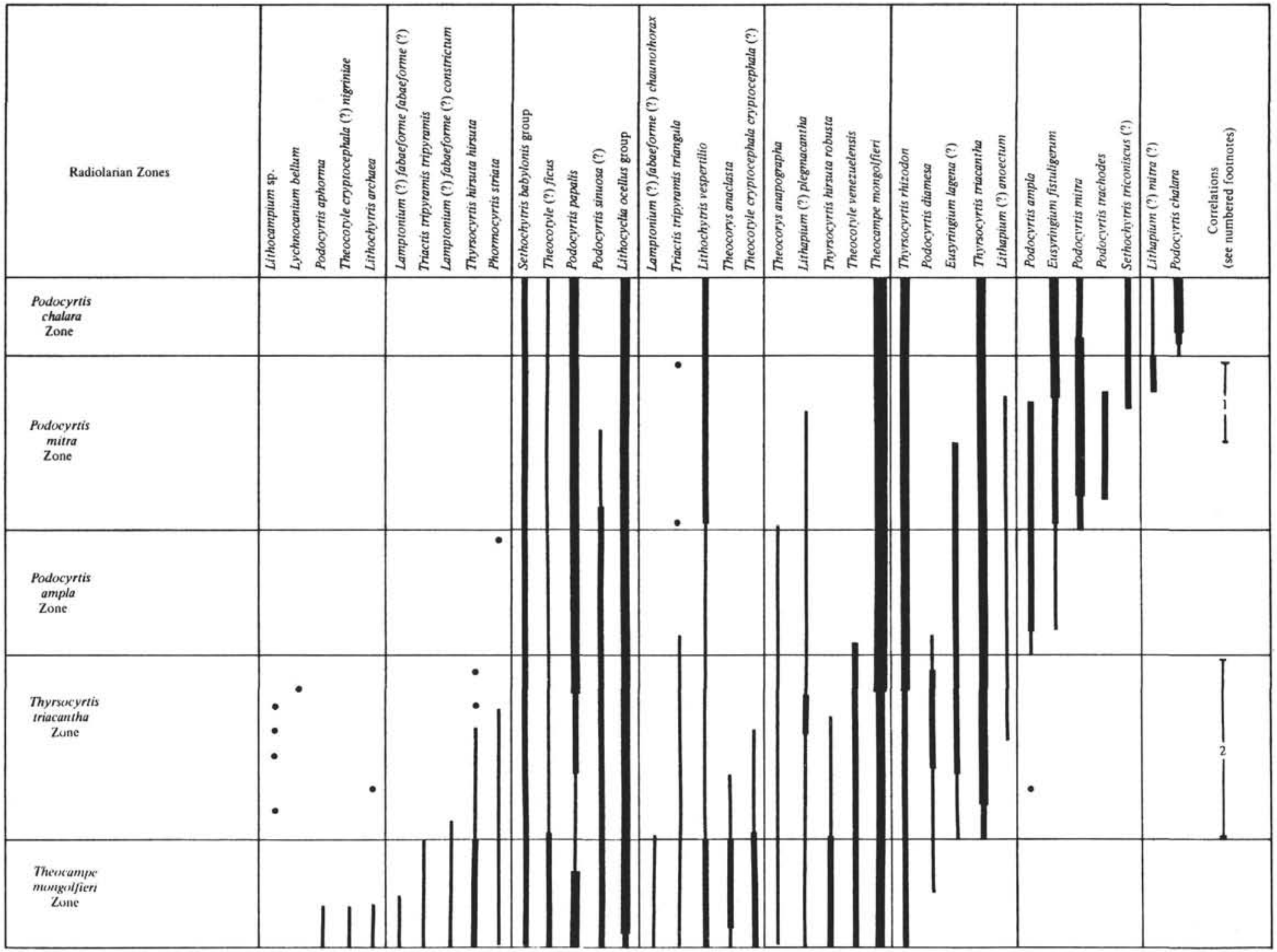
Site 28 (20° 35.19′N, 65° 37.33′W; water depth 5521 meters)

Sample 28-9-Core Catcher:

Rather few, moderately well preserved radiolarians. Small, nondescript spongodiscids constitute the major part of the assemblage, and there are a few pseudoaulophacids, small artostrobiids somewhat resembling *Theocampe mongolfieri* in general form, *Dictyomitra* spp. (some multicostate), and rare specimens of the genus *Holocryptocapsa* Tan Sin Hok. The assemblage is probably Upper Cretaceous in age.

3. CENOZOIC ZONATION

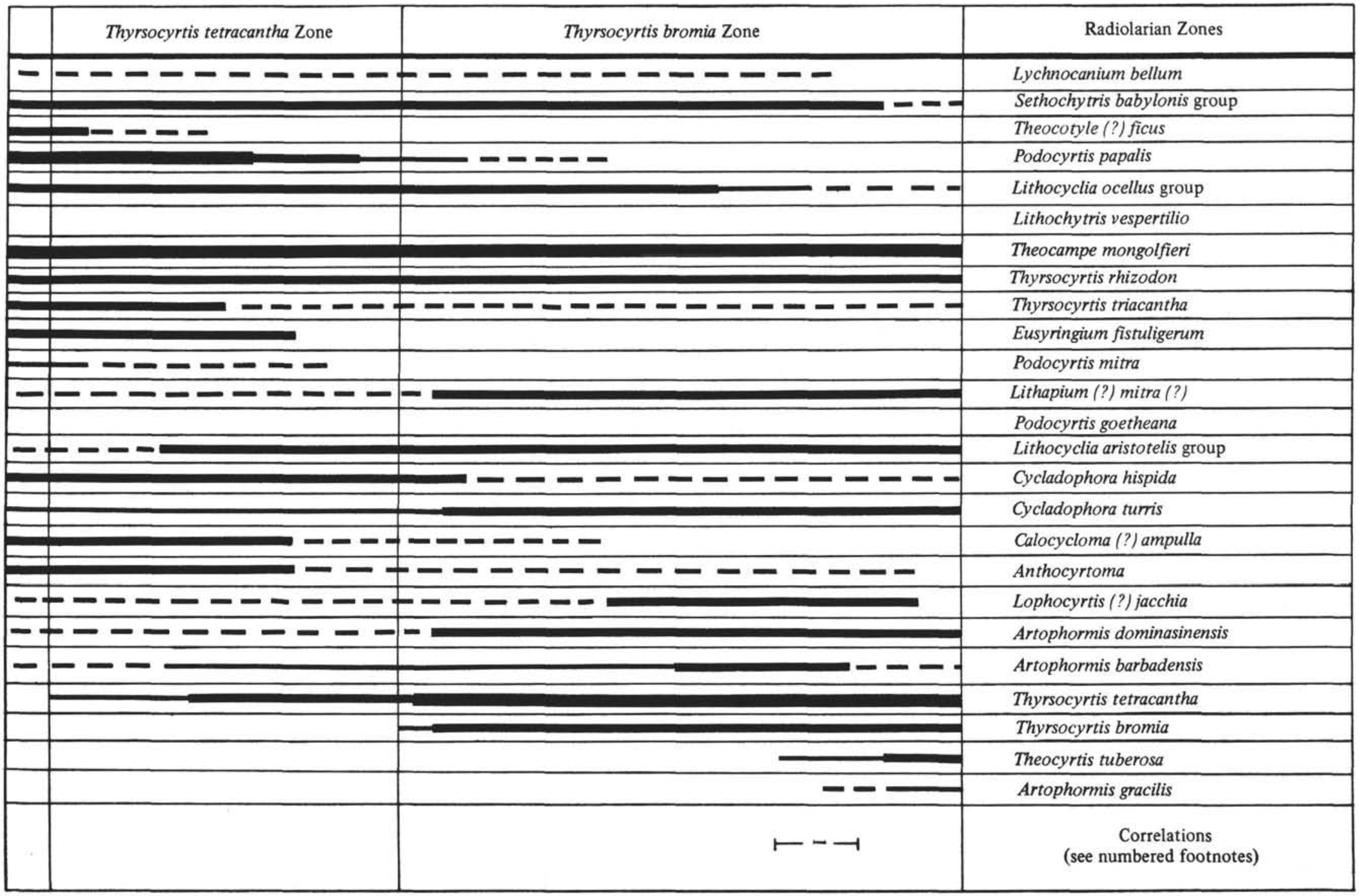
The three summary tables (Figures 1, 2 and 3) present a zonation of Cenozoic radiolarians, as a framework for the stratigraphic interpretation of the assemblages sampled on Leg 4. The middle Eocene zonation is based on the results from Site 29, the late Eocene zonation



[1]DODO 123D. Early or middle Middle Eocene (B.M.F., M.N.B.).

[2]DW BG 23B. Possibly *Hantkenina aragonensis* Zone or bottom of *Globigerapsis kugleri* Zone (Riedel and Funnell, 1964, p. 327).

Figure 1. *Zonation of middle Eocene radiolarians.*



[1] JS 1077, Oceanic Formation, Bath, Barbados, *Isthmolithus recurvus* zone (Hay *et al*, 1967, fig. 8).

Figure 2. *Zonation of late Eocene radiolarians*

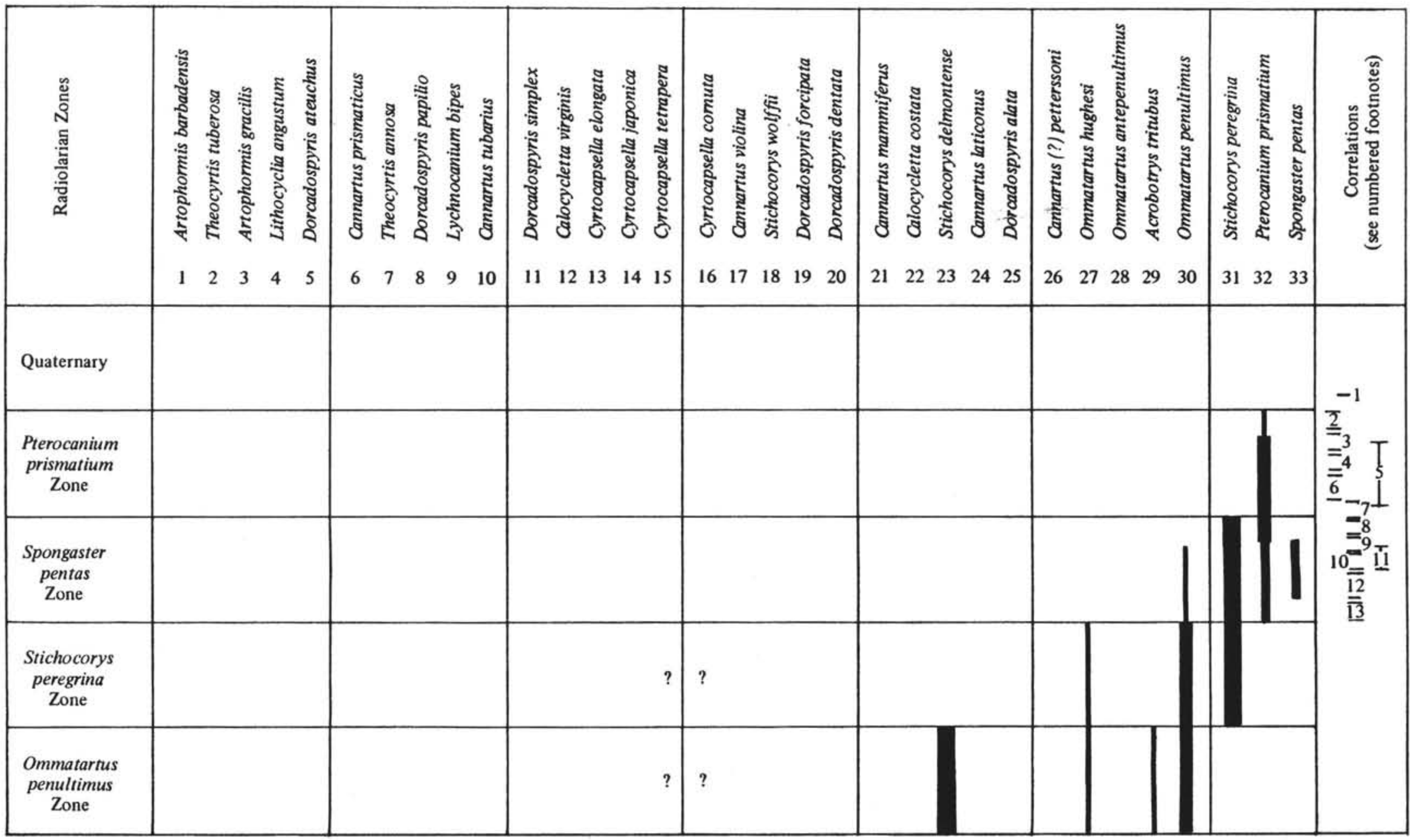


Figure 3. *Zonation of Oligocene and Neogene radiolarians.*

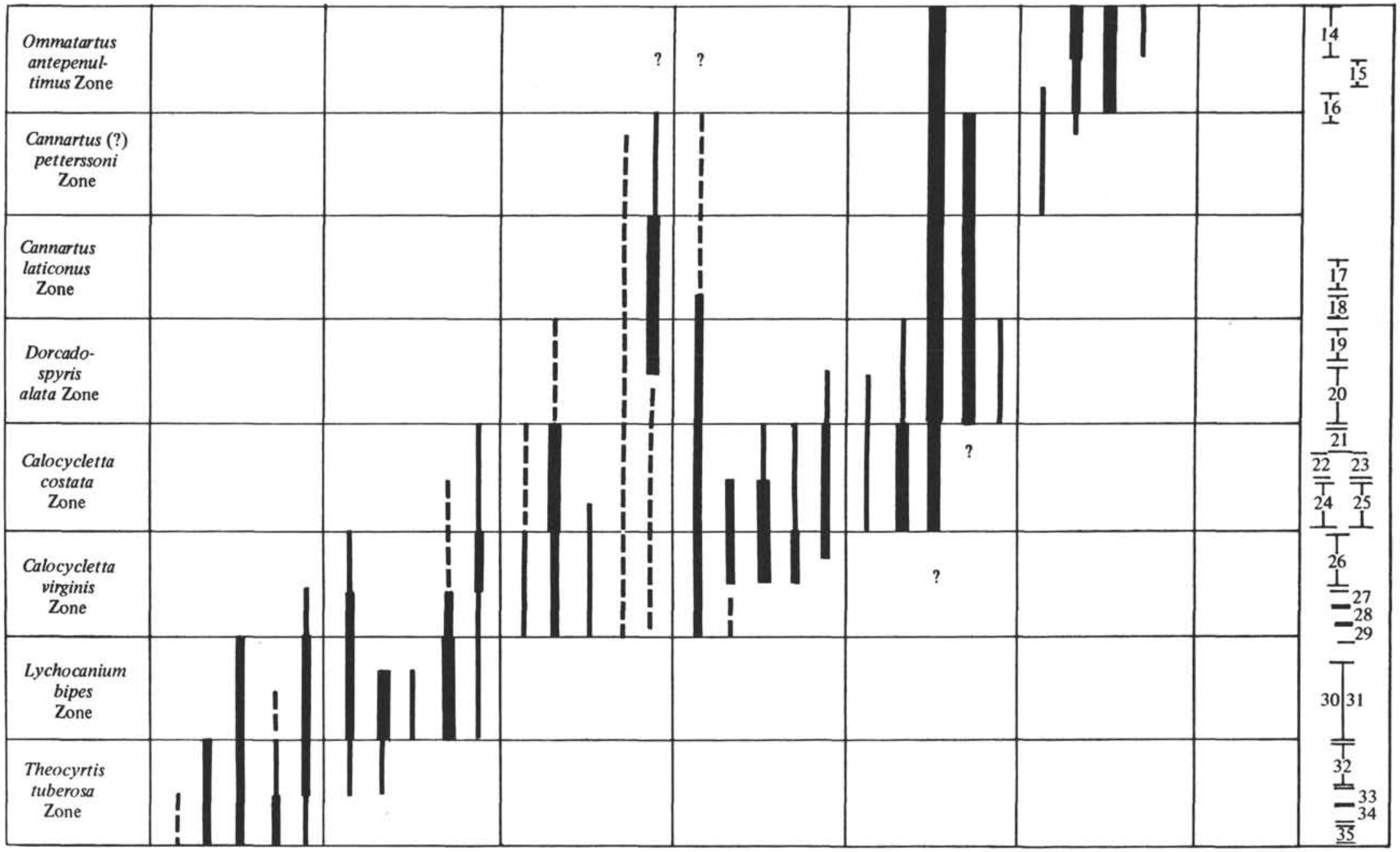


Figure 3. *(Continued).*

[1] CAP 38BP, 415 centimeters. Earliest occurrence of *Globorotalia truncatulinoides* (F.L.P.).

[2] SDSE 62, 1197-1210 centimeters. High in Zone N.21 (F.L.P.).

[3] SDSE 58, 900-902 centimeters. Near middle of Zone N.21 (F.L.P.).

[4] MSN 126G, 65 centimeters. Upper part of Zone N.21 (F.L.P.). Upper limit of common *Discoaster brouweri.*

[5] SDSE 58, 984-986 centimeters. Zone N.21 (Blow, 1969, p. 306).

[6] CAP 38BP, approx. 500 centimeters. Lower part of Zone N.21; latest occurrence of *Globigerinoides obliquus* (F.L.P.).

[7] AMPH 37P, 250 centimeters. Lower part of Zone N.21 (F.L.P.). Upper limit of common *Discoaster pentaradiatus.*

[8] SDSE 62, 1450 centimeters. Zone N.20 (F.L.P.).

[9] AMPH 37P, 350 centimeters. Approx. Zone N.19; latest occurrence of *Globigerina nepenthes* (F.L.P.).

[10] AMPH 37P, 450 centimeters. Lower part of Zone N.19 (F.L.P.). Latest occurrence of *Ceratolithus tricorniculatus.*

[11] LSDH 78P, 98-100 centimeters. Zone N.19 (Blow, 1969, p. 309). Lower part of Zone N.19 (F.L.P.).

[12] LSDH 78P, 513-522 centimeters. Zone N.18 (F.L.P.). Earliest occurrence of *Ceratolithus rugosus.*

[13] LSDA 101G, 38 centimeters. Zone N.17 or 18 (Parker, 1967, p. 131).

[14] RIS 12G, 13-19 centimeters. Zone N.18 (Blow, 1969, p. 306).

[15] PROA 88P, 275 centimeters. Zone N.16 (Parker, 1967, p. 134).

[16] EM 8-11, 70-72 centimeters. Zone N.15 (W.H.B.).

[17] EM 7-1, 14-16 centimeters. Zone N.12 (W.H.B.).

[18] AMPH 6P, 15-17 centimeters. Zone N.11 (Blow, 1969, p. 308).

[19] AMPH 6P, 58-60 centimeters. Zone N.10 (Blow, 1969, p. 308).

[20] WR TR 11 Low (Bo. 202). Type locality of *Globorotalia fohsi barisanensis* Zone (Bolli, 1957, p. 101). *Sphenolithus heteromorphus* Zone (Bramlette and Wilcoxon, 1967, Table 1 and 2).

[21] SDSE 91, 319-320 centimeters. Zone N.9 (Blow, 1969, p. 311).

[22] WR TR 23 (K. 9391). Radiolarian-rich facies of the *Globigerinatella insueta* Zone near the Retrench trig. station, Golconda Estate, Trinidad (Bolli, 1957, p. 101).

[23] SDSE 91, 409-410 centimeters. Zone N.8 (Blow, 1969, p. 311).

[24] TTOC 178888. *Helicosphaera ampliaperta* Zone (Bramlette and Wilcoxon, 1967, Table 1 and 2).

[25] SDSE 91, 820-821 centimeters. Zone N.7 (Blow, 1969, p. 311).

[26] SDSE 91, 1209-1210 centimeters. Zone N.6 (Blow, 1969, p. 311).

[27] CHUB 15, 78-82 centimeters. Approximate *Catapsydrax stainforthi* Zone (F. L. Parker in Riedel, 1959, p. 285).

[28] WAH 7P, 257-259 centimeters. Zone N.5 (Blow, 1969, p. 311).

[29] WAH 7P, 519-521 centimeters. Zone N.4 (Blow, 1969, p. 311).

[30] CHUB 17, 11-15 centimeters. Approximate *Globorotalia kugleri* Zone (F. L. Parker in Riedel, 1959, p. 285). Zone N.4 (Blow, 1969, p. 308).

[31] DW BG 10, 13-15 centimeters. Probably *Globorotalia kugleri* Zone (Riedel and Funnell, 1964, p. 326). Zone N.4 (Blow, 1969, p. 308).

[32] RIS 111P, 280-282 centimeters. Zone N.4 (W.H.B.).

[33] JOIDES (Blake Plateau) 3358 feet (1023 meters). *Sphenolithus predistentus* Zone (Bramlette and Wilcoxon, 1967, Table 2).

[34] MP 5-1, 26-27 centimeters. Zone P.18 (Blow, 1969, p. 291).

[35] WR TR 39F (JS 1068). Just above top of *Isthmolithus recurvus* Zone (Hay *et al.*, 1967, Figure 8).

is based on the exposure of the Oceanic Formation at Bath Cliff, Barbados, and the Oligocene and Neogene zonation is a synthesis of results from many deep-sea cores and outcrops on land. The information forming the basis for Figure 1 will be found in Table 1 of this paper, while that forming the basis for Figures 2 and 3 will be presented in separate papers (in preparation). Because the Eocene zonation is based on two single sections and the later zonation is a patchwork, it is likely that the sequence will require modification when additional information becomes available; but, nevertheless, it seems possible to apply this draft at the present stage. Thicknesses of the middle and late Eocene zones are shown in approximately the same proportions in Figures 1 and 2 as they are in the lithologically rather uniform sequences at Site 29 and Bath Cliff, respectively. There is at present, however, no sufficient basis for estimating the relative durations of the zones shown in Figure 3.

In the figures, the relative abundances of species (abundant, common, few, rare) are indicated by the thicknesses of the vertical bars; intermittent rare occurrences are indicated by dashed lines, and isolated occurrences of individual specimens by dots. The tabulated species are arranged approximately in the order of their first appearances, with the earlier forms on the left and the later ones on the right. If species are not carried from one tabulation to the next (from Figure 1 to Figure 2, and from Figure 2 to Figure 3), this is because they do not occur in the younger assemblages. *Cycladophora hispida, Calocycloma* (?) *ampulla* and *Anthocyrtoma* are not included in Figure 1 or Table 1, although they occur through the entire middle Eocene section at Site 29.

The footnotes to Figures 1 through 3 present interpretations resulting from the examination of calcareous microfossils in some of the radiolarian samples, mainly by M. N. Bramlette, F. L. Parker, B. M. Funnell, W. H. Blow and H. M. Bolli. Initials of these workers in the footnotes to Figures 1, 2 and 3 indicate personal communications from them. Where no such initials (or bibliographic references) are given the correlations are based on investigations by the present authors. Ranges of uncertainty in the correlations are indicated. Many of the samples used to interrelate the radiolarian zonation with those of the calcareous microfossils are from deep-sea sediment cores, and their locations may be found either in the published papers referred to or in Riedel (in press, b).

4. DEFINITION OF CENOZOIC RADIOLARIAN ZONES

As far as possible, the division into zones is here made in accordance with the following principles:

a) The base of each zone is defined by the first occurrence of a taxon that is easily recognizable, of known ancestry, of wide geographic distribution, and represented by numerous specimens in the assemblages in which it occurs.
b) Each zone should include the first or last occurrences of several taxa - i.e., should be a concurrent range zone. Because of this, and because some taxa undergo considerable morphologic evolution within zones, it may be possible in some cases to correlate remote samples with the upper, middle or lower part of some of the zones defined here.

Theocampe mongolfieri **Zone**:

Base is defined by the earliest evolutionary appearance of *Theocampe mongolfieri.* The zone includes the latest occurrences of *Podocyrtis aphorma, Theocotyle cryptocephala* (?) *nigriniae, Lithochytris archaea* and *Lamptonium* (?) *fabaeforme fabaeforme* (?), and the earliest evolutionary appearance of *Podocyrtis diamesa.* The top of the zone is coincident with the base of the *Thyrsocyrtis triacantha* Zone.

Thyrsocyrtis triacantha **Zone**:

Base is defined by the earliest appearance of *Thyrsocyrtis triacantha,* which is approximately synchronous with the earliest appearance of *Eusyringium lagena* (?) and the latest occurrences of *Triactis tripyramis tripyramis* and *Lamptonium* (?) *fabaeforme* (?) *chaunothorax.* The zone includes the latest occurrences of *Lamptonium* (?) *fabaeforme* (?) *constrictum, Thyrsocyrtis hirsuta hirsuta, Theocorys anaclasta, Theocotyle cryptocephala cryptocephala* (?) and *Thyrsocyrtis hirsuta robusta,* and the earliest appearance of *Lithapium* (?) *anoectum.* The top of the zone is coincident with the base of the *Podocyrtis ampla* Zone.

Podocyrtis ampla **Zone**:

The base is defined by the earliest evolutionary appearance of *Podocyrtis ampla.* The zone includes the latest occurrences of *Theocotyle venezuelensis* and *Podocyrtis diamesa,* and the earliest evolutionary appearance of *Eusyringium fistuligerum.* The top of the zone is coincident with the base of the *Podocyrtis mitra* Zone.

Podocyrtis mitra **Zone**:

The base is defined by the earliest evolutionary appearance of *Podocyrtis mitra,* which is approximately coincident with the latest occurrence of *Theocorys anapographa.* The zone includes the latest occurrences of *Podocyrtis sinuosa* (?), *Lithapium* (?) *plegmacantha, Eusyringium lagena* (?), *Lithapium* (?) *anoectum* and *Podocyrtis ampla,* the total range of *Podocyrtis trachodes,* and the earliest evolutionary appearances of *Sethochytris triconiscus* (?) and *Lithapium* (?) *mitra* (?). The top of the zone is coincident with the base of the *Podocyrtis chalara* Zone.

Podocyrtis chalara **Zone**:

Base is defined by the earliest evolutionary appearance of *Podocyrtis chalara.* The top of the zone is not yet defined, but it may prove that the earliest evolutionary appearance of *Podocyrtis goetheana* will provide a suitable datum.

Regarding the unzoned interval, between the top of the radiolarian section represented at Site 29 and the base of *Thyrsocyrtis tetracantha* Zone, this interval is probably represented at the bottom of the Oceanic Formation on Barbados, where the radiolarians are poorly preserved in all samples available to us.

Thyrsocyrtis tetracantha **Zone**:

Base is defined by the earliest evolutionary appearance of *Thyrsocyrtis tetracantha.* The zone includes the last occurrences of *Podocyrtis mitra, Theocotyle* (?) *ficus* and *Eusyringium fistuligerum,* and perhaps the last occurrence of *Podocyrtis goetheana.* The top of the zone is coincident with the base of the *Thyrsocyrtis bromia* Zone.

Thyrsocyrtis bromia **Zone**:

Base is defined by the earliest appearance of *Thyrsocyrtis bromia.* The zone includes the last occurrences of *Lychnocanium bellum, Podocyrtis papalis, Calocycloma* (?) *ampulla* and the genus *Anthocyrtoma,* and the earliest evolutionary appearance of *Artophormis gracilis.* The top of the zone is coincident with the base of the *Theocyrtis tuberosa* Zone.

Theocyrtis tuberosa **Zone**:

Base is defined by the earliest appearance of *Lithocyclia angustum.* The zone includes the earliest occurrences of *Cannartus prismaticus* and *Theocyrtis annosa.* The top of the zone is coincident with the base of the *Lychnocanium bipes* Zone.

Lychnocanium bipes **Zone**:

The base is defined by the earliest appearance of *Lychnocanium bipes,* which is approximately synchronous with the earliest appearances of *Dorcadospyris papilio* and *Cannartus tubarius.* The zone includes the latest occurrences of *Lithocyclia angustum, Theocyrtis annosa* and *Dorcadospyris papilio.* The top of the zone is coincident with the base of the *Calocycletta virginis* Zone.

Calocycletta virginis **Zone**:

The base is defined by the earliest appearance of *Calocycletta virginis,* which is approximately synchronous with the latest occurrence of *Artophormis gracilis* and the earliest appearance of *Dorcadospyris simplex, Cyrtocapsella elongata, C. japonica, C. tetrapera, C. cornuta* and *Cannartus violina.* The zone includes the latest occurrence of *Dorcadospyris ateuchus* and the earliest appearance of *Stichocorys wolffii, Dorcadospyris forcipata* and *D. dentata.* The top of the zone is coincident with the base of the *Calocycletta costata* Zone.

Calocycletta costata **Zone**:

Base is defined by the earliest evolutionary appearance of *Calocycletta costata,* which is approximately synchronous with the latest occurrence of *Cannartus prismaticus* and the earliest appearances of *Cannartus mammiferus* and *Stichocorys delmontensis.* The zone includes the latest occurrences of *Lychnocanium bipes* and *Cyrtocapsella elongata.* The top of the zone is coincident with the base of the *Dorcadospyris alata* Zone.

Dorcadospyris alata **Zone**:

Base is defined by the earliest evolutionary appearance of *Dorcadospyris alata,* which is approximately synchronous with the latest occurrences of *Cannartus tubarius, Dorcadospyris simplex, Stichocorys wolffii* and *Dorcadospyris forcipata.* The zone includes the latest occurrences of *Dorcadospyris dentata* and *Cannartus mammiferus.* The top of the zone is coincident with the base of the *Cannartus laticonus* Zone.

Cannartus laticonus **Zone**:

The base is defined by the latest occurrence of *Dorcadospyris alata,* which is approximately synchronous with the latest occurrences of *Calocycletta virginis* and *C. costata.* The top of the zone is coincident with the base of the *Cannartus* (?) *petterssoni* Zone.

Cannartus (?) *petterssoni* **Zone**:

Base is defined by the earliest evolutionary appearance of *Cannartus* (?) *petterssoni.* The zone includes the earliest appearance of *Ommatartus hughesi.* The top of the zone is coincident with the base of the *Ommatartus antepenultimus* Zone.

Ommatartus antepenultimus **Zone**:

Base is defined by the earliest evolutionary appearance of *Ommatartus antepenultimus,* which is approximately synchronous with the latest occurrences of *Cyrtocapsella japonica* and *Cannartus laticonus.* The zone includes the latest occurrence of *Cannartus* (?) *petterssoni* and the earliest appearance of *Acrobotrys tritubus.* The top of the zone is coincident with the base of the *Ommatartus penultimus* Zone.

Ommatartus penultimus **Zone**:

The base is defined by the earliest evolutionary appearance of *Ommatartus penultimus,* which is approximately synchronous with the latest occurrence of *Ommatartus antepenultimus.* The top of the zone is coincident with the base of the *Stichocorys peregrina* Zone.

Stichocorys peregrina **Zone**:

Base is defined by the earliest appearance of *Stichocorys peregrina,* which is approximately synchronous with the latest occurrences of *Acrobotrys tritubus* and *Stichocorys delmontensis.* The top of the zone is coincident with the base of the *Spongaster pentas* Zone.

Spongaster pentas **Zone**:

The base is defined by the earliest appearance of *Pterocanium prismatium,* which is approximately synchronous with the latest occurrence of *Ommatartus hughesi.* The zone includes a little more than the total range of *Spongaster pentas,* and the latest occurrence of *Ommatartus penultimus.* The top of the zone is coincident with the base of the *Pterocanium prismatium* Zone.

Pterocanium prismatium **Zone**:

Base is defined by the latest occurrence of *Stichocorys peregrina.* The top of the zone is defined by the latest occurrence of *Pterocanium prismatium.*

5. CORRELATION OF MICROFOSSIL ZONATIONS

In order that age assignments based on radiolarians can be compared with assignments based on other microfossil groups, it is necessary to attempt an interrelation of the radiolarian zonation with those for the foraminifera and calcareous nannoplankton. The result of such an attempt is given in Figure 4.

The most reliable basis for correlation of the various zonations would be the investigation of the three types of microfossils found together in samples from long, continuous sequences. An opportunity for this may be provided as the Deep-Sea Drilling Program continues, but at present the attempt must be based on less satisfactory information. The footnotes to Figures 1, 2 and 3 provide direct linkages between the radiolarian zonation and foraminiferal and/or calcareous nannoplankton zonations. These linkages are indicated by the absences of parentheses in Figure 4. Parentheses are used in Figure 4 to distinguish correlations based, not on observation of more than one microfossil group in the same sample, but on published correlations such as those by Bolli (1966, Table 3), Bramlette and Wilcoxon (1967, Table 2) and Blow (1969, Figures 15 and 16). Except for the Eocene, where information is too sparse, hachured areas are used to indicate, approximately, the degree of uncertainty in the correlation of the limits of calcareous microfossil zones with the limits of the radiolarian zones. These are broad because the presentation here is a conservative interpretation of the information given in Figures 1, 2 and 3 and the footnotes thereto.

6. CENOZOIC RADIOLARIA IN THE DRILL-CORES

Tables 1 through 4 show the occurrences of radiolarians in Cenozoic samples from Leg 4. The letters A, C, F and R indicate that a species is abundant, common, few or rare in relation to the total radiolarian assemblage in a sample, and (+) is used to indicate isolated occurrences of one or two specimens. Time has not permitted an exhaustive search for all species in all samples; and, therefore, a (-) sign is used to indicate the absence of a species from a sample in which it was searched for.

Site 29 (14° 47.15′N, 69° 19.38′W; water depth 4247 meters)

Well preserved radiolarians occur in all samples from about 125 meters to about 230 meters below the sea floor. This material forms the basis for proposing the following sequence of radiolarian zones, from the top downward, which apparently span approximately all of the Middle Eocene - *Podocyrtis chalara* Zone, *Podocyrtis mitra* Zone, *Podocyrtis ampla* Zone, *Thyrsocyrtis triacantha* Zone and *Theocampe mongolfieri* Zone. Species occurring at this site are shown in Table 1. As is the case with all assemblages described in this paper, the tabulation includes only a fraction of the total number of species in the material.

Sites 27 (15° 51.39′N, 56° 52.76′W; water depth 5251 meters) and 28 (20° 35.19′N, 65° 37.33′W; water depth 5521 meters)

Poorly preserved radiolarians occur from about 455 meters to about 475 meters below the sea floor at Site 27, and ones in a rather better state of preservation occur from about 170 meters to about 280 meters below the sea floor at Site 28. Species occurring at these sites are shown in Table 2. The assemblages in Core 6 of Site 27 appear to be of an age very near the Eocene-Oligocene boundary, while Core 7 of Site 27 and the upper samples from Site 28 are in the *Podocyrtis mitra* Zone (and probably the upper part of this zone).

Site 31 (14° 56.60′N, 72° 01.63′W; water depth 3369 meters)

At this site, rather well preserved radiolarians occur from about 215 meters to about 280 meters below the sea floor. The forms occurring in this interval are shown in Table 3. The samples from Core 9 and the top of Core 10 appear to belong in the *Calocycletta virginis* Zone, while those from the remainder of Core 10 apparently belong in the *Lychnocanium bipes* Zone. The only serious inconsistency in this interpretation is the presence (in the lower samples from Core 10) of *Dorcadospyris forcipata,* which is not known to occur below the *Calocycletta virginis* Zone in the Pacific. It may be that the form here identified as *D. forcipata* is not really the same as the Pacific

TABLE 1
Radiolarians at Site 29

Samples / Species	*Lithocampium* sp.	*Lychnocanium bellum*	*Podocyrtis aphorma*	*Theocotyle cryptocephala* (?) *nigriniae*	*Lithochytris archaea*	*Lamptonium* (?) *fabaeforme fabaeforme* (?)	*Triactis tripyramis tripyramis*	*Lamptonium* (?) *fabaeforme* (?) *constrictum*	*Thyrsocyrtis hirsuta hirsuta*	*Phormocyrtis striata*	*Sethochytris babylonis* group	*Theocotyle* (?) *ficus*	*Podocyrtis papalis*	*Podocyrtis sinuosa* (?)	*Lithocyclia ocellus* group	*Lamptonium* (?) *fabaeforme* (?) *chaunothorax*	*Triactis tripyramis triangula*	*Lithochytris vespertilio*	*Theocorys anaclasta*	*Theocotyle cryptocephala cryptocephala* (?)	*Theocorys anapographa*	*Lithapium* (?) *plegmacantha*	*Thyrsocyrtis hirsuta robusta*	*Theocotyle venezuelensis*	*Theocampe mongolfieri*	*Thyrsocyrtis rhizodon*	*Podocyrtis diamesa*	*Eusyringium lagena* (?)	*Thyrsocyrtis triacantha*	*Lithapium* (?) *anoectum*	*Podocyrtis ampla*	*Eusyringium fistuligerum*	*Podocyrtis mitra*	*Podocyrtis trachodes*	*Sethochytris triconiscus* (?)	*Lithapium* (?) *mitra* (?)	*Podocyrtis chalara*
29B-8-1, 5-7 cm	–		–	–						–	F	R	C	–	C			F	–	–	–	–		–	A				C	–		C	F		F	–	C
29B-8-2, 121-123 cm																						–								–			F			–	C
29B-8-3, 93-95 cm																						–								–			F			–	C
29B-8-4, 111-113 cm																			–		–	–			A				C	–			F		F	–	C
29B-8-5, 11-13 cm																						–								–			C			–	C
29B-8-6, 83-85 cm				–	–	–		–			F	R				–		F	–	–	–	–		–					C	–	–	C	C		F	R	F
29-9-2, 132-134 cm	–		–	–	–	–	–	–	–	–	F	R	C	–	C	–	–	F	–		–	–		–	A	C		–	C	–		C	C	–	F	R	R
29-9-3, 100-102 cm																																	C			F	–
29-9-4, 110-112 cm																																	C	–		F	–
29-9-5, 112-114 cm			–	–	–	–	–	–	–			R	C	–		–	R	R	–		–	–		–	A	C		-	C	–	–	C	F	–	F	F	–
29-9-6, 103-105 cm														–								–								–	–		C	R	F	F	
29-10-1, 91-92 cm														–								R								R	F		C	F	F	–	
29-10-2, 99-101 cm			–	–		–	–	–	–		F	R		–	C	–	–					–		–	C	C		–	C	R	F	F	C	F	R	–	–
29-10-3, 99-101 cm														–								R								R	F		C	F	-		
29-10-4, 100-102 cm				–	–		–		–		F	R	C	–			–	F	–		–	R		–	C	C		–	C	R	F	F	C	C	–	–	
29-10-5, 120-122 cm														R																			C	R			
29-11-Bottom	R		–	–		–	–	–	–		C	R	C	–		–	–		–	–	–	R		–	A	C	–	F	C	R	R	F	C	F	–	–	–
29-12-2, 34-37 cm							–							R	C		–				–												C	R			
29-12-3, 100-102 cm														F							F												F	–			
29-12-4, 77-79 cm														F			R				F												F	–			

TABLE 1 – *Continued*

Samples \ Species	*Lithocampium* sp.	*Lychnocanium bellum*	*Podocyrtis aphorma*	*Theocotyle cryptocephala (?) nigriniae*	*Lithochytris archaea*	*Lamptonium (?) fabaeforme fabaeforme (?)*	*Triactis tripyramis tripyramis*	*Lamptonium (?) fabaeforme (?) constrictum*	*Thyrsocyrtis hirsuta hirsuta*	*Phormocyrtis striata*	*Sethochytris babylonis* group	*Theocotyle (?) ficus*	*Podocyrtis papalis*	*Podocyrtis sinuosa (?)*	*Lithocyclia ocellus* group	*Lamptonium (?) fabaeforme (?) chaunothorax*	*Triactis tripyramis triangula*	*Lithochytris vespertilio*	*Theocorys anaclasta*	*Theocotyle cryptocephala cryptocephala (?)*	*Theocorys anapographa*	*Lithapium (?) plegmacantha*	*Thyrsocyrtis hirsuta robusta*	*Theocotyle venezuelensis*	*Theocampe mongolfieri*	*Thyrsocyrtis rhizodon*	*Podocyrtis diamesa*	*Eusyringium lagena (?)*	*Thyrsocyrtis triacantha*	*Lithapium (?) anoectum*	*Podocyrtis ampla*	*Eusyringium fistuligerum*	*Podocyrtis mitra*	*Podocyrtis trachodes*	*Sethochytris triconiscus (?)*	*Lithapium (?) mitra (?)*	*Podocyrtis chalara*
29-12-5, 108-110 cm			–	–	–		–		–		C	R	C	F			–	R	–	–	R	F		–	A	C	–	F	C	R	F	R	F	–	–	–	–
29-12-6, 103-105 cm														F																		R	F	–			
29-13-Bottom	–		–	–	–		–		–	R	C	R	C	C			–		–	–	F	F		–	A	C	–	F	C	R	F	R	–	–	–	–	–
29-14-1, 50-52 cm														F																		R	–				
29-14-2, 117-119 cm														F																		R	–				
29-14-3, 118-120 cm																																R					
29-14-4, 102-104 cm	–		–	–					–	–	C	R	C	F	C		R		–	–	F	R		–	A	C	–	C	C	R	R	R	–		–	–	–
29-14-5, 113-114 cm																								–			–				R	–					
29-14-6, 135-137 cm																	R							–			R				R	–					
29-15-1, 11-13 cm	–		–	–	–	–	–	–	–	–	F	R	C	F		–	R	R	–	–	R	R	–	F	A	C	R	F	C	R	R	–	–		–	–	–
29-15-2, 12-14 cm									R								R						–				R		C		–	–					
29-15-3, 13-15 cm									–								R					R	–				R		C	R	–	–					
29-15-4, 86-87 cm									–								R						–				F		C								
29-15-5, 90-92 cm	–		–	–					–	–	F	R	F	F			–	R	–	–	F	F	–	F	C	F	R	F	C	R	–	–	–		–	–	–
29-15-6, 83-85 cm				–					R														–						C								
29-16-1, 116-118 cm		R							–														–						C								
29-16-2, 90-92 cm	R		–	–		–	–	–	–	R	F	R	F	F	C	–	R		–	–	F	F	R	F	C	F	F	R	C	R	–	–	–		–	–	–
29-16-3, 86-88 cm									–											–		F	R						C	R						–	
29-16-4, 80-82 cm									R											–		F	R						C	–						–	
29-16-5, 84-86 cm	R		–	–	–	–	–	–	R	R	F	R	F	F		–	–	R	–	R	R	R	–	F	C	C	F	F	C	R	–	–	–		–		–

TABLE 1 – *Continued*

Samples \ Species	*Lithocampium* sp.	*Lychnocanium bellum*	*Podocyrtis aphorma*	*Theocotyle cryptocephala (?) nigriniae*	*Lithochytris archaea*	*Lamptonium (?) fabaeforme fabaeforme (?)*	*Triactis tripyramis tripyramis*	*Lamptonium (?) fabaeforme (?) constrictum*	*Thyrsocyrtis hirsuta hirsuta*	*Phormocyrtis striata*	*Sethochytris babylonis* group	*Theocotyle (?) ficus*	*Podocyrtis papalis*	*Podocyrtis sinuosa (?)*	*Lithocyclia ocellus* group	*Lamptonium (?) fabaeforme (?) chaunothorax*	*Triactis tripyramis triangula*	*Lithochytris vespertilio*	*Theocorys anaclasta*	*Theocotyle cryptocephala cryptocephala (?)*	*Theocorys anapographa*	*Lithapium (?) plegmacantha*	*Thyrsocyrtis hirsuta robusta*	*Theocotyle venezuelensis*	*Theocampe mongolfieri*	*Thyrsocyrtis rhizodon*	*Podocyrtis diamesa*	*Eusyringium lagena (?)*	*Thyrsocyrtis triacantha*	*Lithapium (?) anoectum*	*Podocyrtis ampla*	*Eusyringium fistuligerum*	*Podocyrtis mitra*	*Podocyrtis trachodes*	*Sethochytris triconiscus (?)*	*Lithapium (?) mitra (?)*	*Podocyrtis chalara*
29-17-1, 22-23 cm									R										–		R	R	R						F	–						–	
29-17-2, 85-87 cm	R		–	–	–	–	–	–	R	R	C	R	C	F		–	R	R	–	R	R	R	–	F	C	F	R	R	C	–	–	–	–		–		–
29-17-3, 84-86 cm						–		–	R							–			–		R		–						C								
29-17-4, 86-88 cm						–	–	–	R							–	R		R		–		–						C								
29-17-5, 80-82 cm	–		–	–		–	–	–	R	R	C	R	F	F		–	R		R	R	R	F	R	F	C	F	R	R	C	–	–	–	–		–	–	–
29-17-6, 86-88 cm	–					–		–	R	R						–			–		R		–						C								
29-18-2, 82-84 cm	R		–	–			–	R	R	R	F	R	R	F	F	–	R	R	R	R	–		–	F	C	C	R	R	F		–	–	–		–		–
29-19-Middle	–		–	–			–	R	R	R	C	F	R	C		R	R		R	F	–	R	F	F	C	C	R	R	F	–	–	–	–		–		–
29B-9-1, 55-57 cm	–			–	–	–	R	R	F	R	F	F		R	C	F	R	F	F	F			R	F		F	R	–	–								
29B-9-3, 90-92 cm									F				C									R	F				–	–	–	–							
29B-9-4, 87-89 cm				–			R		F			F		F	C		R		F	F			F	F		F	–		–								
29B-9-5, 83-85 cm						–		F	R							F						R	F				R		–	–							
29B-9-6, 83-85 cm	–		–	–	–		R		F	R	C	F		F			R	F	F	F		R	F	F		C	–			–						–	
29B-10-1, 143-145 cm	–		–	–	–	–	R	F	R	R		F		F	C	R	R	F	F	F	R	R	F	F		F	–			–						–	
29B-10-2, 100-102 cm			–		–	R		F						F		R		F				R					–			–							
29B-10-3, 100-102 cm	–		R	R	R	R	R	R	F	R		F		F	C	R	R	F	F	F		R	R	F		F				–							
29B-10-4, 100-102 cm			R		–	R		R						F		R		F				R								–							
29B-10-5, 88-90 cm	–		R	R	R	–	–	R	F	R	F	F		F	F	R	R	F	R	F			F	F	C	C											

TABLE 2
Radiolarians at Sites 27 and 28

Samples \ Species	*Lychnocanium bellum*	*Sethochytris babylonis* group	*Theocotyle (?) ficus*	*Podocyrtis papalis*	*Lithocyclia ocellus* group	*Lithochytris vespertilio*	*Theocampe mongolfieri*	*Thyrsocyrtis rhizodon*	*Thyrsocyrtis triacantha*	*Eusyringium fistuligerum*	*Podocyrtis mitra*	*Sethochytris triconiscus* (?)	*Cycladophora hispida*	*Cycladophora turris*	*Calocycloma (?) ampulla*	*Anthocyrtoma*	*Theocyrtis tuberosa*	*Artophormis gracilis*	*Lithocyclia angustum*
27-6-2, 77-78 cm							F	C									C	+	F
27-6-3, 75-77 cm							F	C						R			C	+	R
27-7-1-Top					C	C		C	C	C	A	F	F			+			
28-3-1, 44-45 cm	F	F	R	F	R	F	F	C	C	C	A		C		+	F			
28-3-1, 97-98 cm	F	C	R	C	R	F	F	C		C	A		C			F			
28-5-Catcher	R						F						F						
28-7-Catcher															C	R			

TABLE 3
Radiolarians at Site 31

Samples \ Species	*Artophormis barbadensis*	*Theocyrtis tuberosa*	*Artophormis gracilis*	*Lithocyclia angustum*	*Dorcadospyris ateuchus*	*Cannartus prismaticus*	*Theocyrtis annosa*	*Dorcadospyris papilio*	*Lychnocanium bipes*	*Cannartus tubarius*	*Dorcadospyris simplex*	*Calocycletta virginis*	*Cyrtocapsella elongata*	*Cyrtocapsella japonica*	*Cyrtocapsella tetrapera*	*Cyrtocapsella cornuta*	*Cannartus violina*	*Stichocorys wolffii*	*Dorcadospyris forcipata*	*Dorcadospyris dentata*
31-9-3, 0-4 cm	–	–	–	–	F	R	–	–		–	C	–	–	–	–	–	–	–	–	–
31-9-Catcher	–	–	–	–	R	F	–	–	F	–	F	–	–	–	+	–	–	–	–	–
31-10-1, 0-4 cm	–	–	–	–	R	R	–	R	R	–	R	–	–	–	–	–	–	–	–	?
31-10-2, 0-6 cm	–	–	F	–	R	R	F	R	R	–	–	–	–	–	–	–	–	–	F	–
31-10-3, 0-3 cm	–	–	F	–	+	+	R	R	+	+	–	–	–	–	–	–	–	–	F	–
31-10-4, 0-3 cm	–	–	F	–	F	+	F	F	+	–	–	–	–	–	–	–	–	–	F	–
31-10-5, 0-3 cm	–	–	C	–	F	R	C	F	–	–	–	–	–	–	–	–	–	–	F	–
31-10-Catcher	–	–	C	–	F	+	F	+	–	–	+	–	–	–	–	–	–	–	R	–

form, but instead shows only a superficial similarity. Although typical *Calocycletta virginis* is not present in this section, the upper samples contain a common form (Plate 14, Figure 11) which is similar except for the feet being wide and shovel-shaped rather than narrowly lamellar. This form occurs also in a Pacific assemblage from the lower part of the *Calocycletta virginis* Zone (CHUB 15, 78 to 82 centimeters).

Site 30 (12° 52.92′N, 63° 23.00′W; water depth 1218 meters)

Radiolarians occur at various levels between about 380 meters and about 405 meters below the sea floor, varying in abundance and state of preservation from sample to sample. Table 4 shows occurrences in the well preserved assemblages. The samples from 30-10-3 to 30-12-2 are assignable approximately to the *Cannartus petterssoni* Zone; the specimens of *Ommatartus antepenultimus* are early forms with scarcely developed polar caps. The samples from 30-12-4 to 30-13-2 may belong to the *Cannartus laticonus* Zone (if the few specimens of *Calocycletta virginis* and *Dorcadospyris alata* are reworked, which seems not improbable) or to the *Dorcadospyris alata* Zone.

7. SYSTEMATIC SECTION (CENOZOIC FORMS)

In this section, an attempt is made to classify the species here into natural genera which will be conformable with the revised family-level classification recently proposed (Riedel, 1967b and in press, a). With the abandonment of the geometrical classification of Haeckel, the earlier definitions of genera are no longer applicable, and emphasis is therefore placed on the relationships of species with the type species of established genera. The result is a genus-level classification which is in many places uncertain, and not yet nearly as comprehensive as Haeckel's, but which offers the possibility of being improved and expanded to reflect the true relationships of all Cenozoic polycystine radiolarians.

Type and figured specimens will be deposited in the U. S. National Museum, Washington, D. C.

TABLE 4
Radiolarians at Site 30

Samples \ Species	*Dorcadospyris simplex*	*Calocycletta virginis*	*Cyrtocapsella elongata*	*Cyrtocapsella japonica*	*Cyrtocapsella tetrapera*	*Cyrtocapsella cornuta*	*Cannartus violina*	*Stichocorys wolffii*	*Dorcadospyris forcipata*	*Dorcadospyris dentata*	*Cannartus mammiferus*	*Calocycletta costata*	*Stichocorys delmontensia*	*Cannartus laticonus*	*Dorcadospyris alata*	*Cannartus (?) petterssoni*	*Ommatartus hughesi*	*Ommatartus antepenultimus*	*Acrobotrys tritubus*	*Ommatartus penultimus*
30-10-3, 74-76 cm																C				
30-11-2, 7-9 cm	–	–	–	F	–	R	–	–	–	–	–	–	C	–	–	–	–	F	–	–
30-12-2, 10-13 cm	–	–	–	–	F	–	–	–	–	–	–	–	F	–	+	–	–	F		
30-12-4, 0-3 cm	–	+	–	–	R	R	–	–	–	–	–	+	F	F	+	?	–	–		
30-12-5, 5-8 cm	–	+	–	–	R	–	–	–	–	–	–	–	C	C	–	–	–	–		
30-13-2, 110-115 cm	–	–	–	–	F	R	–	–	–	–	?	–	F	R	–	–	–	–		

Dimensions of the skeletons are based on at least 25 specimens, from throughout the range of the species, unless otherwise indicated.

Two distinctive Eocene species occurring at Site 29, which are illustrated (Plate 4, Figure 1; Plate 10, Figure 6) but which time did not permit us to treat systematically, are *Spongatractus pachystylus* (Ehrenberg, 1873, p. 256; 1875, Plate 26, Figure 3; Haeckel, 1887, p. 350) and *Dictyophimus craticula* (Ehrenberg, 1873, p. 223; 1875, Plate 5, Figures 4 and 5).

In view of the fact that the presence of a long axial rod has in the past been used as a distinguishing character for some genera, it is interesting to note that a long axial rod, branched distally, is present in some specimens of many of the larger cyrtoids in the assemblages from Site 29. Such an axial rod extends to the central or the distal part of the thorax in at least some specimens of *Thyrsocyrtis hirsuta robusta, Podocyrtis papalis, P. aphorma* and *P. sinuosa*, and into the abdominal cavity in at least some specimens of *Theocotyle cryptocephala cryptocephala* (?), *Theocotyle venezuelensis, Theocotyle* (?) *ficus, Thyrsocyrtis rhizodon* and *Theocorys anaclasta.* Thus, it occurs in several different lineages, and it does not appear to have taxonomic significance at the generic level.

Order POLYCYSTINA Ehrenberg

Polycystina Ehrenberg, 1838, emend. Riedel, 1967b, p. 291.

Suborder SPUMELLARIA Ehrenberg, 1875

Family ACTINOMMIDAE Haeckel

Actinommidae Haeckel, 1862, emend. Riedel, 1967b, p. 294.

Genus **Lithapium** Haeckel

Lithapium Haeckel, 1887, p. 303. Type species (designated by Campbell, 1954, p. 69) *Lithapium pyriforme* Haeckel (1887, p. 303, Plate 14, Figure 9).

In the absence of any clear indication of the evolutionary development of the following two spherical to ellipsoidal forms, these species could be assigned on the basis of their general morphology to the genera *Lithapium* Haeckel 1887, *Dorysphaera* Hinde 1890 or *Monostylus* Cayeux 1897. Their doubtful assignment here to *Lithapium* is arbitrary, and does not imply any close relationship to the type species of that genus.

Lithapium (?) plegmacantha, new species (Plate 4, Figures 2 and 3):
Eucyrtidium ampullus [Ehrenberg] (?), Bury, 1862, Plate 12, Figure 1. *[non] Eucyrtidium ampulla* Ehrenberg, 1854, Plate 36, Figure 15.

Shell approximately spherical, but in one place drawn out as an acute, latticed cone which is surrounded by a bladed or conical spine. Pores subcircular to circular, and shell surface rough or thorny. Some specimens have several long three-bladed spines distributed over the surface with no regular arrangement. Length (excluding spine) 140 to 220μ, breadth 115 to 180μ.
Remarks: The relationships of this species are not known, but there is at least a superficial similarity to the much smaller pyriform medullary shells of some stylosphaerids.

Lithapium (?) anoectum, new species (Plate 4, Figures 4 and 5):
Similar to *Lithapium (?) plegmacantha,* but generally smaller, tending to be ellipsoidal, with rougher surface, no long auxiliary spines, and commonly with a short open tube with irregular termination at the end opposite the conical protuberance. Length (without spine) 125 to 180μ, breadth 85 to 125μ.

Lithapium (?) mitra (Ehrenberg) (?) (Plate 4, Figures 6 and 7):
[?] *Cornutella mitra* Ehrenberg, 1873, p. 221; 1875, Plate 2, Figure 8. [?] *Cornutella circularis* Ehrenberg, 1873, p. 221; 1875, Plate 2, Figure 4. [?] *Podocyrtis* (?) [sp.] Bury, 1862, Plate 9, Figure 4.

An acute cone with subcircular to polygonal pores increasing in size from the apex, with short apical horn and thorny surface. In most complete specimens, the shell is somewhat contracted distally, and terminates in an irregular number of spines of variable length. Total length 155 to 430μ, maximum breadth 115 to 235μ.
Remarks: Although this species differs in its general form from *Lithapium* (?) *anoectum,* it seems clearly related to it because of the similar structure of wall and apex, and because it immediately succeeds it in the core. The transition takes place very rapidly, between 67 centimeters and 54 centimeters in 29-10-1 (an interval in which there is no evidence of an hiatus). It differs from the superficially similar sethophormids associated with it in that they have a less acute apex and, of course, collar pores.

The species assignment of this form is uncertain because of the inadequacy of Ehrenberg's illustrations and descriptions of *Cornutella mitra* and *C. circularis.*

In the latest occurrences of the species (e.g. in the Oceanic Formation of Barbados) the skeletons tend to become less thorny, more acutely conical, and with smaller pores–some of them to such an extent that it may be appropriate to separate them as a distinct species.

Genus **Cannartus** Haeckel

Cannartus Haeckel, 1881, p. 462. Type species (indicated by Campbell, 1954, p. 74) *Cannartus violina* Haeckel (1887, p. 358, Plate 39, Figure 10).
Cannartus Haeckel, emend.; Riedel, *in press*, a.

Cannartus prismaticus (Haeckel) (Plate 15, Figure 1):
Pipettella prismatica Haeckel, 1887, p. 305, Plate 39, Figure 6; Riedel, 1959, p. 287, Plate 1, Figure 1.

Cannartus tubarius (Haeckel) (Plate 15, Figure 2):
Pipettaria tubaria Haeckel, 1887, p. 339, Plate 39, Figure 15; Riedel, 1959, p. 289, Plate 1, Figure 2.

Cannartus violina Haeckel:
Cannartus violina Haeckel, 1887, p. 358, Plate 39, Figure 10; Riedel, 1959, p. 290, Plate 1, Figure 3.

Cannartus mammiferus (Haeckel) (Plate 14, Figure 1):
Cannartidium mammiferum Haeckel, 1887, p. 375, Plate 39, Figure 16. *Cannartus mammiferus* (Haeckel), Riedel, 1959, p. 291, Plate 1, Figure 4.

Cannartus laticonus Riedel (Plate 14, Figure 2):
Cannartus laticonus Riedel, 1959, p. 291, Plate 1, Figure 5.

Cannartus (?) petterssoni, new species (Plate 14, Figure 3):
Cannartus petterssoni, manuscript name proposed conditionally in Riedel and Funnell, 1964, p. 310.
Cortical shell rather thick-walled, approximately cylindrical (sometimes bulged at the equator), with pronounced protuberances surrounding each end of the cortical shell. Pores of the cortical shell circular or subcircular, smaller near the equator. Two medullary shells, of which the outer is commonly spherical, sometimes lenticular. Very broad spongy columns (in some specimens divided into narrow parallel zones) are

separated from the cortical shell by a narrow clearer zone: the distal margin of this clearer zone is commonly at the end of the protuberances.

Length of spongy columns 25 to 100μ (commonly about 50μ); their median breadth 50 to 85μ. Length of cortical shell 80 to 100μ; its maximum breadth (including protuberances) 75 to 95μ. Breadth of outer medullary shell is 25 to 40μ. (Measurements based on specimens from PROA 96P, 227 to 230 centimeters and SDSE 87, 799 to 800 centimeters.)

Remarks: Although the spongy columns of some specimens show parallel zones, these are not distinct caps as in *Ommatartus hughesi*.

Genus **Ommatartus** Haeckel

Ommatartus Haeckel, 1881, p. 463. Type species (indicated by Campbell, 1954, p. 76) *Ommatartus amphicanna* Haeckel (1887, p. 396). *Ommatartus* Haeckel, emend.; Riedel, in press, a.

This species is named in honor of the late Prof. Hans Pettersson, who helped make possible the first stratigraphic application of Cenozoic radiolarians, in cores collected by the Swedish Deep-Sea Expedition.

Ommatartus antepenultimus, new species (Plate 14, Figure 4):
Panarium antepenultimum, manuscript name proposed conditionally in Riedel and Funnell, 1964, p. 311.

Cortical and medullary shells similar to those of *Cannartus laticonus* and *Ommatartus penultimus. C. laticonus* has no polar caps (the distal boundary of the narrow clearer zone between the cortical twin-shell and spongy column is parallel to the distal wall of the cortical shell, as in Plate 14, Figure 2), while *O. penultimus* s.s. has caps at least as well developed as its holotype (Riedel, 1957a, Plate 1, Figure 1). *O. antepenultimus* includes all forms in which the development of the caps (and spongy columns) is intermediate between these two.

Length of spongy columns 20 to 90μ; their median breadth 20 to 55μ. Height of polar caps 15 to 35μ. Length of cortal shell 90 to 115μ; its maximum breadth (including protuberances) 75 to 115μ. Breadth of outer medullary shell 25 to 40μ. (Measurements based on specimens from AMPH 6P, 15 to 17 centimeters; SDSE 87, 399-400 centimeters; and PROA 102P, 490 to 492 centimeters.

Ommatartus hughesi (Campbell and Clark):
Ommatocampe hughesi Campbell and Clark, 1944a, p. 23, Plate 3, Figure 12.

Ommatartus penultimus (Riedel), sensu stricto:
Panarium penultimum Riedel, 1957a, p. 76, Plate 1, Figure 1; Riedel and Funnell, 1964, p. 311.

Family PHACODISCIDAE Haeckel, 1881

Genus **Triactis** Haeckel

Triactis Haeckel, 1881, p. 457.
Triactiscus Haeckel, 1887, p. 432. Type species (designated by Strelkov and Lipman, 1959, p. 433) *Triactiscus tripyramis* Haeckel (1887, p. 432, Plate 33, Figure 6).

Phacotriactis Sutton, 1896a, p. 61. Type species (by monotypy) *Phacotriactis triangula* Sutton (1896a, p. 61, Figure 3).

Triactiscus appears to be a junior objective synonym of *Triactis* under the provisions of Article 33 of the International Code of Zoological Nomenclature (and was so treated by Campbell, 1954, p. 81). *Triactoma* Rüst, however, is not such a synonym–it was evidently erected by Rüst to include forms with a spherical lattice-shell. The type species of *Triactiscus* may be *T. tripyramis* as indicated above, but a case might also be made for its being (by absolute tautonymy) *Haliomma triactis* Ehrenberg (1873, p. 236; 1875, Plate 28, Figure 4) which Haeckel (1887, p. 432) renamed *Triactiscus tripodiscus.* Whichever of the two possibilities is upheld does not affect the generic assignment of the species described below, because both candidates for type species of *Triactiscus* are evidently very closely related.

Triactis tripyramis tripyramis Haeckel (Plate 4, Figure 8):
Triactiscus tripyramis Haeckel, 1887, p. 432, Plate 33, Figure 6.

Similar in structure and dimensions to *Triactis tripyramis triangula,* but phacoid cortical shell circular or more circular than triangular. Although the evidence is inconclusive because of the rarity of the species, it appears that this subspecies may have evolved into *Triactis tripyramis triangula.*

This species was originally described from a sediment sample (Challenger Station 272) in which most of the radiolarians are Quaternary but which contains rare admixed Eocene forms including *Theocotyle cryptocephala* (?) *nigriniae, Thyrsocyrtis hirsuta hirsuta* and *Podocyrtis papalis.*

Triactis tripyramis triangula (Sutton) (Plate 4, Figures 9 and 10):
Phacotriactis triangula Sutton, 1896a, p. 61.
Phacoid cortical shell equilaterally triangular, usually thick-walled, with very small circular pores. From each corner of the shell projects a stout three-bladed spine, of about the same length as the radius of the

shell. Medullary shell apparently double, the outer one with a diameter approximately one-third of the diameter of the cortical shell.

Length from one point of the cortical shell (excluding the spine) to the middle of the opposite side 115 to 150μ.

Remarks: The sides of the triangular cortical shell are straight, concave or convex, and specimens are assigned to this subspecies rather than to the other if the shell is judged to be more triangular than circular.

Family COCCODISCIDAE Haeckel, 1862

Genus **Lithocyclia** Ehrenberg

Lithocyclia Ehrenberg, 1847a, chart to p. 385. Type species (by monotypy) *Lithocyclia ocellus* Ehrenberg (1854, Plate 36, Figure 30; 1873, p. 240; 1875, Plate 29, Figure 3).

Although it is not yet possible to define satisfactorily the limits of this genus, it seems advisable to include in it a wide variety of forms with and without radial spines, and with and without radiating spongy arms. Thus, it may perhaps be desirable to synonymize the following genus-group taxa with *Lithocyclia:*

Astractinium Haeckel, 1887, p. 476. Type species (designated by Campbell, 1954, p. 83) *Astromma aristotelis* Ehrenberg (1847b, p. 55, Figure 10; 1854, Plate 36, Figure 32; 1873, p. 217; 1875, Plate 30, Figures 3 and 4).

Astractura Haeckel, 1881, p. 459. Type species (indicated by Campbell, 1954, p. 82) *Astractura ordinata* Haeckel (1887, p. 476; Bury, 1862, Plate 14, Figure 3).

Astrococcura Sutton, 1896b, p. 138. Type species (by monotypy) *Astrococcura concinna* Sutton (1896b, p. 138).

Astrocyclia Haeckel, 1881, p. 458. Type species (indicated by Campbell, 1954, p. 82) *Astrocyclia solaster* Haeckel (1887, p. 466, Plate 36, Figure 7).

Hymenactinium Haeckel, 1887, p. 475. Type species (designated by Campbell, 1954, p. 83) *Hymenactura copernici* Haeckel (1887, p. 475, Plate 38, Figure 9).

Hymenactura Haeckel, 1881, p. 459. Type species (indicated by Campbell, 1954, p. 83) *Hymenactura archimedis* Haeckel (1887, p. 473, Plate 38, Figure 8).

Hymeniastrum Ehrenberg, 1847a, chart to p. 385. Type species (by monotypy) *Hymeniastrum pythagorae* Ehrenberg (1854, Plate 36, Figure 31; 1873, p. 237; 1875, Plate 30, Figure 5).

Pentactura Haeckel, 1881, p. 459. Type species (indicated by Campbell, 1954, p. 83) *Astromma pentactis* Ehrenberg (1873, p. 217; 1875, Plate 30, Figure 1).

Lithocyclia ocellus group (Plate 5, Figures 1 and 2): Medullary shell double. Phacoid cortical shell with circular to subcircular pores, 12 to 18μ on a diameter, covered in some specimens by a thin spongy layer. Cortical shell surrounded by a continuous spongy zone which, in late specimens especially, is usually concentrically zoned, the innermost zone commonly being the widest and most distinct. Spines of variable number (sometimes none), bladed, acute, originate within the spongy zone, or at the periphery of the cortical shell, or occasionally at the outer medullary shell.

Diameter of outer medullary shell 35 to 50μ, of cortical shell 85 to 140μ, of outer spongy zone 165 to 325μ.

Remarks: The species-group name is here applied to a variety of forms that seem not to be satisfactorily differentiated, including, for example, *Lithocyclia ocellus* Ehrenberg (1854, Plate 36, Figure 30; 1873, p. 240), *L. stella* Ehrenberg (1873, p. 240; 1875, Plate 29, Figure 2), and a number of species described in the genera *Coccocyclia* Haeckel and *Astrocyclia* Haeckel.

Lithocyclia aristotelis group:
This species-group name is used for a number of forms with skeletons similar to those of the *L. ocellus* group, but with separated spongy arms rather than a continuous spongy zone around the phacoid shell. In this group are included forms with three or four (or more?) arms, with or without terminal spines, and with or without a patagium:

Astromma pythagorae Ehrenberg, 1872a, p. 301; 1873, p. 217; 1875, Plate 30, Figure 2.

Astromma aristotelis Ehrenberg, 1847b, p. 55, Figure 10; 1854, Plate 36, Figure 32; 1873, p. 217; 1875, Plate 30, Figures 3 and 4.

Hymeniastrum pythagorae Ehrenberg, 1854, Plate 36, Figure 31; 1873, p. 237; 1875, Plate 30, Figure 5.

[?] *Astromma pentactis* Ehrenberg, 1873, p. 217; 1875, Plate 30, Figure 1.

Lithocyclia angustum (Riedel) (Plate 13, Figures 1 and 2):
Trigonactura angusta Riedel, 1959, p. 292, Plate 1, Figure 6.

Family SPONGODISCIDAE Haeckel

Spongodiscidae Haeckel, 1862, emend. Riedel, 1967b, p. 295.

Genus **Spongaster** Ehrenberg

Spongaster Ehrenberg, 1860, p. 833. Type species (by monotypy) *Spongaster tetras* Ehrenberg (1860, p. 833; 1861, p. 301; 1872b, Plate 6[3], Figure 8).

Spongaster pentas, new species (Plate 15, Figure 3):

Spongy disc usually pentagonal, occasionally hexagonal. Rays from center to marginal angles generally not markedly denser (but usually slightly thicker) than the spongy structure between them. Central area (one-half to one-third of disc diameter) more dense, or thicker, with concentric structure. Diameter 170 to 290μ. (Measurements based on specimens from MSN 143P, 796 to 798 centimeters and LSDH 78P, 63 to 522 centimeters.)

This species is distinguished from *S. tetras,* to which it is apparently very closely related, by its pentagonal or hexagonal outline.

Suborder NASSELLARIA Ehrenberg, 1875

Family ACANTHODESMIIDAE Haeckel, 1862

Acanthodesmiidae Haeckel; Riedel, 1967b, p. 296.
A series of forms which seem to illustrate the development of *Giraffospyris didiceros* (Ehrenberg) (Goll, 1969, p. 332, text-figure 2, Plate 60, Figures 5, 6, 7 and 9) are illustrated from Site 29 (Plate 5, Figures 3, 4 and 5), but not treated systematically.

Genus **Dorcadospyris** Haeckel

Dorcadospyris Haeckel, 1881, p. 441. Type species (indicated by Campbell, 1954, p. 112) *Dorcadospyris dentata* Haeckel (1887, p. 1040, Plate 85, Figure 6).

Dorcadospyris Haeckel, emend.; Goll, 1969, p. 335.
If the evolutionary sequence proposed by Riedel (1959, p. 293, text-figure 3) and the relationships indicated by Goll (1969, text-figure 2) are correct, it would seem appropriate to assign the following species to this genus.

Dorcadospyris ateuchus (Ehrenberg) (Plate 15, Figure 4):

Ceratospyris ateuchus Ehrenberg, 1873, p. 218.

Cantharospyris ateuchus (Ehrenberg); Riedel, 1959, p. 294, Plate 22, Figures 3 and 4.

Dorcadospyris papilio (Riedel) (Plate 15, Figure 5):

Hexaspyris papilio Riedel, 1959, p. 294, Plate 2, Figures 1 and 2.

Dorcadospyris simplex (Riedel) (Plate 15, Figure 6):

Brachiospyris simplex Riedel, 1959, p. 293, Plate 1, Figure 10.

Dorcadospyris forcipata (Haeckel) (Plate 15, Figure 7):

Dipospyris forcipata Haeckel, 1887, p. 1037, Plate 85, Figure 1.
Dipodospyris forcipata Haeckel; Riedel, 1957a, p. 79, Plate 1, Figure 3.

Dorcadospyris dentata Haeckel:

Dorcadospyris dentata Haeckel, 1887, p. 1040, Plate 85, Figure 6; Riedel 1957a, p. 79, Plate 1, Figure 4.

Dorcadospyris alata (Riedel) (Plate 14, Figure 5):

Brachiospyris alata Riedel, 1959, p. 293, Plate 1, Figures 11 and 12.

Family THEOPERIDAE Haeckel

Theoperidae Haeckel, 1881, emend. Riedel, 1967b, p. 296.

Genus **Lamptonium** Haeckel

Lamptonium Haeckel, 1887, p. 1378. Type species (designated by Campbell, 1954, p. 132) *Cycladophora enneapleura* Haeckel (1887, p. 1378).

Lamptonium (?) fabaeforme fabaeforme (Krasheninnikov) (?) (Plate 5, Figure 6):

[?] *Cyrtolcalpis fabaeformis* Krasheninnikov, 1960, p. 296, Plate 3, Figure 11.
Cephalis spherical, surrounded by the thick wall continuing upward from the thorax, bearing a conical or bladed horn of variable length. Thorax inflated-pyriform, with rough or thorny surface, and with circular or subcircular pores which are largest in the mid-region. Abdomen short, narrow, subcylindrical or tapering, with irregularly scattered pores and no differentiated termination.

Length of cephalis plus the thorax 140 to 225μ, maximum breadth 115 to 155μ. Earlier forms tend to be narrower.

Remarks: The relationship, if any, to some other forms with inflated thorax that occur in this sequence (Plate 6, Figures 1 through 4) has not been determined. Also, its specific identification and generic relationship are very uncertain. In general form it resembles the Middle Eocene *Cyrtocalpis fabaeformis* Krasheninnikov, but it (and probably also Krasheninnikov's species) is certainly not related to the type species of *Cyrtocalpis*, which is a carpocaniid. The only genus-group taxon with a type species which might possibly be related to the species here described seems to be *Lamptonium*, and this is the uncertain basis for the generic assignment made here.

Lamptonium (?) fabaeforme (?) constrictum, new subspecies (Plate 5, Figure 7):

Generally similar to the nominate subspecies, but differing in that at the base of the narrow part of the thorax is a constriction which is, however, not accompanied by an internal septal ring. The horn is often long, and in some specimens, twisted spirally.

Length of cephalis plus thorax 165 to 235μ, maximum breadth 125 to 190μ.

Lamptonium (?) *fabaeforme* (?) *chaunothorax*, new subspecies (Plate 5, Figures 8 and 9):

Similar to the nominate subspecies, but with larger thoracic pores.

Length of cephalis plus thorax 165 to 235μ, maximum breadth 135 to 170μ.

Genus **Anthocyrtoma** Haeckel

Anthocyrtoma Haeckel, 1887, p. 1268. Type species (designated by Frizzell and Middour, 1951, p. 29) *Anthocyrtis serrulata* Ehrenberg (1873, p. 217; 1875, Plate 6, Figure 7).

In the middle Eocene sediments at Site 29, and in the Eocene part of the Oceanic Formation of Barbados, occur two or more species of dicyrtids with inflated thorax and rather constricted mouth (Plate 6, Figures 2 through 4), which seem to be closely related to the type species of this genus. They may also be related to the species questionably assigned to *Lamptonium*, but because of the uncertainty of the relationship the two groups of species are assigned to different genera for the time being (though the apparently close relationship of the type species of *Lamptonium* and *Anthocyrtoma* suggest that these two genera might appropriately be synonymized).

The limits of the species comprising this group have not yet been determined, and therefore all are tabulated together as *Anthocyrtoma* spp. There seems to be some tendency for the larger form to have its mouth more constricted higher in the section, and for the smaller form to become more hispid upward.

Dimensions of the larger form: length (cephalis plus thorax) 205 to 265μ, maximum breadth (excluding spines) 165 to 220μ, and the dimensions of the smaller form: length 150 to 230μ, maximum breadth 115 to 185μ.

Genus **Calocycloma** Haeckel

Calocycloma Haeckel, 1887, p. 1384. Type species (designated by Campbell, 1954, p. 132) *Calocyclas casta* Haeckel (1887, p. 1384, Plate 73, Figure 10).

It is not yet possible to be confident in the assignment of species to this and related genera, because there appears to be some confusion in the literature regarding the number of segments. In forms resembling the type species, the proximal part of the inflated segment has much smaller pores than the distal part, and there is commonly a change in contour between the two parts. In the specimens that have been observed from the Oceanic Formation on Barbados and from Site 29 the authors have not found a segmental division separating these two parts of the inflated segment, and, therefore, it is doubtful whether it is appropriate to assign them to this genus.

Calocycloma (?) ampulla (Ehrenberg) (Plate 6, Figure 1):

Eucyrtidium ampulla Ehrenberg, 1854, Plate 36, Figure 15; 1873, p. 225; 1875, Plate 10, Figures 11 and 12.

Cephalis hemispherical to subspherical, with a few small pores or pits, bearing a small conical horn. Collar stricture not strongly expressed externally. Thorax conical proximally and inflated distally, with constricted mouth surrounded by a distinct peristome. Pores of the conical part small, subcircular, in approximate longitudinal rows separated by ribs; those of the inflated part much larger, with thick intervening bars from the points of junction of which arise surface thorns or spines.

Total length (excluding horn) 140 to 185μ, maximum breadth (excluding spines) 125 to 175μ.

Remarks: In the lowest samples dealt with, some specimens of this species tend to have smaller pores and a shorter conical proximal part of the thorax than do later specimens. The relation between this species and that reported by Nigrini from Leg 2 as *Calocyclas casta* Haeckel has not yet been determined.

Genus **Theocotyle,** new genus

Type species: *Theocotyle venezuelensis*, new species.

This genus is erected to include the members of the lineage leading from *Theocotyle cryptocephala* (?) *nigriniae* to *T. venezuelensis*, inclusive, and perhaps to *T.* (?) *ficus*. Shells are three-segmented, terminated in a distinctly differentiated peristomial collar. The cephalis is hemispherical to subspherical (bearing an apical horn), the thorax campanulate, hemispherical or conical, and the abdomen (the largest segment) subcylindrical to inflated.

In the Haeckelian system, the species included in this genus might be included in the genus *Theocorys* or *Theocorythium*. However, *Theocorys* is used later in this paper for two species which seem to be not closely related to those described here, and the type species of *Theocorythium* is apparently a pterocoryid. At least the first three of the four forms described below clearly belong to a distinct lineage, which seems best treated under a new generic name.

The generic name is derived from the Greek "theos" (divine) and "kotyle" (small cup; feminine).

Theocotyle cryptocephala cryptocephala (Ehrenberg) (?) (Plate 6, Figures 7 and 8):

[?] *Eucyrtidium cryptocephalum* Ehrenberg, 1873, p. 227; 1875, Plate 11, Figure 11.

Similar in structure to *Theocotyle cryptocephala* (?) *nigriniae,* but with thicker shell wall, more inflated abdomen, and abdominal pores consistently larger than those of the thorax.

Length (excluding horn) 140 to 170μ, maximum breadth 110 to 135μ.

Theocotyle cryptocephala (?) nigriniae, new subspecies (Plate 6, Figures 5 and 6):

Cephalis hemispherical, with small circular pores, bearing a conical horn of variable length. Thorax campanulate, almost as wide as the abdomen, with circular pores. Lumbar stricture distinct. Abdomen subcylindrical or slightly inflated, usually longer than thorax but commonly shorter in early specimens. Abdominal pores subcircular, as large to about twice as large as those of the thorax, commonly in longitudinal rows. Abdomen terminates in a thickened poreless rim which occasionally bears three or more short, pointed projections.

Length (excluding horn) 110 to 205μ, maximum breadth 70 to 125μ.

Remarks: This species was recorded as *Theocorys* sp. by Nigrini in her report on the radiolarians from Leg 2 of this expedition, and the specimens illustrated by her are considered to be more typical of the subspecies than those illustrated here. Therefore, we designate as holotype the specimen illustrated in her Plate 4, Figure 12.

Theocotyle venezuelensis, new species (Plate 6, Figures 9 and 10; Plate 7, Figures 1 and 2):

Cephalis subspherical, with few small pores, bearing a short conical horn. Collar and lumbar strictures distinct. Thorax hemispherical (tending to become conical in late specimens), with circular pores. Abdomen inflated, much wider than the mouth and the thorax, with large circular pores and terminating in a thickened rim. Surface of thorax and abdomen rough.

Length (excluding horn) 155 to 240μ, maximum breadth 125 to 210μ.

Remarks: This species is distinguished from late specimens of *Theocotyle cryptocephala cryptocephala* by its larger and more inflated abdomen, and from *Theocotyle* (?) *ficus* by its larger abdominal pores, generally thinner wall, and usually hemispherical thorax. However, some late specimens with relatively small, almost conical thorax might be confused with *Theocotyle* (?) *ficus;* later specimens are considerably larger than earlier ones, with the thorax relatively smaller.

Theocotyle (?) ficus (Ehrenberg) (Plate 7, Figures 3, 4 and 5):

Eucyrtidium ficus Ehrenberg, 1873, p. 228; 1875, Plate 11, Figure 19.

Cephalis subspherical, with small circular pores, merging in contour with the thorax, bearing a bladed or conical horn of variable length. Cephalis conical, with small circular pores. Lumbar stricture very slight or not expressed externally. Abdomen large, inflated (sometimes with straight sides), with circular pores arranged quincuncially in apparent longitudinal rows, and with a thickened rim around the somewhat constricted mouth. The entire shell is thick-walled.

Length (excluding horn) 155 to 240μ, maximum breadth 140 to 225μ.

Remarks: The distinction of this species from *Theocotyle venezuelensis* is discussed under that heading.

Genus **Thyrsocyrtis** Ehrenberg

Thyrsocyrtis Ehrenberg, 1847b, chart to p. 54. Type species (indicated by Campbell, 1954, p. 130) *Thyrsocyrtis rhizodon* Ehrenberg (1873, p. 262; 1875, Plate 12, Figure 1).

Podocyrtarium Haeckel, 1887, p. 1337. Type species (designated by Campbell, 1954, p. 130) *Podocyrtis tripodiscus* Haeckel (1887, p. 1338, Plate 72, Figure 4).

The five forms described below are assigned to the same genus as a matter of convenience, rather than from a conviction that they are closely related. *Thyrsocyrtis triacantha* (and subsequently *T. tetracantha*) may be descended from *T. hirsuta,* but it is not yet possible to demonstrate this. *T. rhizodon* may also have developed from *T. hirsuta hirsuta,* but it is equally possible that it developed from *Theocotyle cryptocephala* (?) *nigriniae*—this possibility derives some credence from the fact that occasional specimens of the latter form have three short projections from the poreless abdominal rim. *Thyrsocyrtis bromia* may have developed from *T. rhizodon.* It may eventually prove desirable to establish two subgenera to accommodate these separate lineages.

Thyrsocyrtis rhizodon Ehrenberg (Plate 7, Figures 6 and 7):

Thyrsocyrtis rhizodon Ehrenberg, 1873, p. 262; 1875, Plate 12, Figure 1.

[?] *Podocyrtis rhizodon* Ehrenberg, 1873, p. 253; 1875, Plate 15, Figure 2.

[?] *Thyrsocyrtis rhizopus* Haeckel, 1887, p. 1351.

Cephalis subspherical, with rather few small pores, bearing a conical horn which is usually short but occasionally up to half the length of the shell. Collar stricture, and usually the lumbar stricture, distinct. Thorax campanulate, with small subcircular pores. Abdomen barrel-shaped, wider and usually longer than the thorax, with pores commonly 2 to 3 times as large as those of the thorax. Surface of thorax and abdomen rough. Three short feet arise smoothly from the poreless abdominal rim, and are terminally truncate or bluntly pointed, sometimes with an outwardly direct ridge or indistinct thorn, or occasionally more complicatedly branched.

Length (excluding horn and feet) 125 to 180μ, maximum breadth 85 to 125μ.

Remarks: Later specimens tend to have a more robust wall than earlier ones, and consequently have the collar and lumbar strictures less pronounced or not at all expressed externally. Also, in later specimens, the feet are usually short and not branched terminally.

Thyrsocyrtis bromia Ehrenberg:

Thyrsocyrtis bromia Ehrenberg, 1873, p. 260; 1875, Plate 12, Figure 2.

Although no transitional forms have been found (perhaps because of too wide spacing of available samples), it seems probable that *T. bromia* arose from *T. rhizodon*, the latter persisting to occur together with the former.

Thyroscyrtis hirsuta hirsuta (Krasheninnikov) (Plate 7, Figures 8 and 9):

Podocyrtis hirsutus Krasheninnikov, 1960, p. 300, Plate 3, Figure 16.

Cephalis subspherical, poreless or with a few small pores, bearing a cylindrical or elongate conical horn which is extremely variable in length and thickness. Collar and lumbar strictures distinct. Thorax campanulate, somewhat inflated, with subcircular pores. Abdomen subcylindrical or slightly inflated, of approximately the same length and breadth as the thorax, with subcircular pores generally slightly larger than those of the thorax. Shell wall not very robust, of about the same thickness in thorax and abdomen, with rough surface. Three feet arise smoothly from poreless rim of abdomen, and are subcylindrical and tapered (often widest medially), slightly divergent, generally curved with convexity inward, often as long as the abdomen.

Length (excluding horn and feet) 120 to 195μ, maximum breadth 80 to 140μ.

Remarks: This form differs from *Thyrsocyrtis rhizodon* in having simply pointed feet. Earlier forms, considered more typical of this subspecies, have a more conical thorax and smoother shell surface.

Thyrsocyrtis hirsuta robusta, new subspecies (Plate 8, Figure 1):

Similar to *Thyrsocyrtis hirsuta hirsuta* but with usually more inflated thorax, larger pores, shell wall more robust and very rough or slightly thorny, and feet which are sometimes straight or curved with convexity outward, and sometimes ragged terminally.

Length (excluding horn and feet) 195 to 230μ, maximum breadth 115 to 155μ.

Remarks: This form differs from *Thyrsocyrtis triacantha* in having a larger thorax, and an abdominal wall structure not so pronouncedly different from that of the thorax.

Thyrsocyrtis triacantha (Ehrenberg) (Plate 8, Figures 2 and 3):

[?] *Podocyrtis cothurnata* Ehrenberg, 1854, Plate 36, Figure 21; 1873, p. 250; 1875, Plate 14, Figure 1.

[?] *Podocyrtis schomburgkii* Ehrenberg, 1847b, Figure 1; 1854, Plate 36, Figure 22; 1873, p. 253; 1875, Plate 14, Figure 7.

Podocyrtis princeps Ehrenberg, 1873, p. 252; 1875, Plate 13, Figure 1.

Podocyrtis radicata Ehrenberg, 1873, p. 253; 1875, Plate 13, Figure 5.

Podocyrtis triacantha Ehrenberg, 1873, p. 254; 1875, Plate 13, Figure 4.

Cephalis subspherical, poreless or with a few small pores, bearing a cylindrical or elongate-conical horn of variable length and thickness. Collar stricture distinct. Thorax considerably shorter than abdomen, broadly conical or slightly inflated, with small subcircular pores. Lumbar stricture slight. Abdomen is the broadest segment with thick wall, large subcircular pores, and poreless distal rim, occasionally with thorny surface. Three feet cylindrical, of variable length (often longer than abdomen), curved with convexity generally outward, with terminations simple or ragged, rarely forked.

Length (excluding horn and feet) 145 to 220μ, breadth of abdomen 120 to 180μ.

Remarks: This form is defined more broadly than earlier authors defined it and related species, but at present we find it difficult to separate species or subspecies within it. We have, however, excluded a larger form (Plate 8, Figure 4) with less robust, broader abdomen, relatively small abdominal pores, and generally three-bladed feet.

Thyrsocyrtis tetracantha (Ehrenberg):

Podocyrtis tetracantha Ehrenberg, 1873, p. 254; 1875, Plate 13, Figure 2.

Podocyrtis aculeata Ehrenberg, 1873, p. 248; 1875, Plate 13, Figure 3.

Podocyrtis pentacantha Ehrenberg, 1873, p. 252; 1875, Plate 17, Figure 1.

The earliest specimens of *T. tetracantha* have a less robust abdomen with no thickened termination, and commonly no well-developed feet. It seems likely that these early forms developed from *T. triacantha* by loss of the differentiated peristomial rim and the feet.

Genus **Eusyringium** Haeckel

Eusyringium Haeckel (1881, p. 437). Type species (designated by Frizzell and Middour, 1951, p. 35) *Eusyringium conosiphon* Haeckel (1887, p. 1496, Plate 78, Figure 10).

[?] *Sethocapsa* Haeckel (1881, p. 433). Type species (indicated by Strelkov and Lipman, 1959, p. 456) *Sethocapsa pyriformis* Haeckel (1887, p. 1310, Plate 57, Figure 2).

Eusyringium lagena (Ehrenberg) (?) (Plate 8, Figures 5, 6 and 7):

[?] *Lithopera lagena* Ehrenberg, 1873, p. 241; 1875, Plate 3, Figure 4.

[?] *Sethocapsa lagena* (Ehrenberg), Haeckel, 1887, p. 1310.

[?] *Sethocapsa pyriformis* Haeckel, 1887, p. 1310, Plate 57, Figure 2.

Cephalis subspherical, with few small pores, bearing a stout conical horn. Thorax pyriform with no appendages, thick wall, subcircular pores, and very constricted mouth. Some late specimens have an abdomen in the form of a narrow tube with very thin wall and irregular pores (commonly elongated longitudinally).

Length to base of thorax 110 to 170μ, maximum breadth 70 to 115μ.

Remarks: The ancestry of this species is uncertain, but it may have arisen from a form such as *Dictyophimus babylonis* by loss of the feet.

Eusyringium fistuligerum (Ehrenberg) (Plate 8, Figures 8 and 9):

[?] *Eucyrtidium tubulus* Ehrenberg, 1854, Plate 36, Figure 19; 1873, p. 233; 1875, Plate 9, Figure 6.

[?] *Theosyringium tubulus* (Ehrenberg), Haeckel, 1887, p. 1410.

Eucyrtidium fistuligerum Ehrenberg, 1873, p. 229; 1875, Plate 9, Figure 3.

Eusyringium fistuligerum (Ehrenberg), Haeckel, 1887, p. 1498.

Eucyrtidium sipho Ehrenberg, 1873, p. 233; 1875, Plate 9, Figure 2.

Eusyringium sipho (Ehrenberg), Haeckel, 1887, p. 1497.

Cephalis thick-walled, subspherical, with very few small pores, bearing a thick conical spine with rough surface, approximately as broad at the base as the cephalis itself. Collar stricture indistinct. Thorax thick-walled, pyriform in early specimens to almost fusiform in some late specimens, with circular pores which are larger distally than proximally. Occasionally, the thorax bears three inconspicuous wings proximally. In some specimens, a stricture separates off the narrower proximal part of the thorax. Abdomen narrow, tubular, of variable length, with irregular subcircular pores and a wall which is thinner than that of the thorax in early specimens and similar to that of the thorax in late specimens. In late specimens the junction between thorax and abdomen is obscured, the one merging imperceptibly into the other.

Length to base of thorax 135 to 225μ, maximum breadth 60 to 150μ.

Remarks: Only specimens with a moderately robust abdominal wall are here assigned to *Eusyringium fistuligerum,* those with a very tenuous abdomen being assigned to *Eusyringium lagena* (?). The presence of a stricture in some specimens between the narrower proximal and broader distal parts of the thorax seems to be of little importance, being developed strongly in some individuals, weakly in others, and not at all in still others.

Genus **Sethochytris** Haeckel

Sethochytris Haeckel (1881, p. 433). Type species (indicated by Campbell, 1954, p. 124) *Sethochytris triconiscus* Haeckel (1887, p. 1239, Plate 57, Figure 13). Although we have not been able to find *S. triconiscus* at its type locality: the sediment sample from Challenger Station 268, that sample does contain a little Eocene admixture indicated by rare specimens of the *Lithocyclia ocellus* group, *Theocampe mongolfieri* and *Lithochytris vespertilio.*

It might appear more convenient (for stability of nomenclature) to use *Dictyophimus* Ehrenberg as the generic name of the two species described below, but the correct type species of that genus seems not to be closely related to them. Campbell (1954, p. 122) designated *Lychnocanium lucerna* Ehrenberg as the type species of *Dictyophimus,* but the facts that the first species described in this genus are *D. crisiae* Ehrenberg and *D.* (?) *tethyis* Ehrenberg, and that the latter was questionably assigned, lead to the conclusion that the type species should be *D. crisiae* Ehrenberg (1854, p. 241) as indicated by Nigrini (1967, p. 66).

Sethochytris babylonis (Clark and Campbell) group (Plate 9, Figures 1, 2 and 3):

Dictyophimus babylonis Clark and Campbell, 1942, p. 67, Plate 9, Figures 32 and 36.

Lychnocanium lucerna Ehrenberg, 1847b, Figure 5; 1854, Plate 36, Figure 6; 1873, p. 244.

Included in this group of at least superficially similar species are a wide variety of forms with small spherical cephalis, pyriform to tetrahedral thorax with very restricted mouth, and robust cylindrical or conical feet and horn. This group is widespread and long-ranging, and its component species have not yet been satisfactorily differentiated. Excluded from the group are very large forms with inflated pyriform thorax (Plate 8, Figure 10) and forms with three-bladed feet. The length of the shell (excluding feet and horn) in the *Sethochytris babylonis* group is 95 to 155μ, and its breadth 80 to 150μ.

Sethochytris triconiscus Haeckel (?) (Plate 9, Figure 6):

Rhopalocanium ? Bury, 1862, Plate 5, Figure 4.

[?] *Lithochytris barbadensis* Ehrenberg, 1875, p. 160, Plate 5, Figure 2.

[?] *Sethochytris triconiscus* Haeckel, 1887, p. 1239, Plate 57, Figure 13.

Cephalis poreless, spherical, bearing a stout conical horn. Thorax pyriform with circular pores, drawn out in its distal part into three divergent cylindrical porous tubes, which are open terminally. In some specimens, a rib terminating in a short free spine can be distinguished in the outer wall of the distal portion of these tubes.

Total length of skeleton 150 to 210μ, its total breadth 100 to 170μ.

Remarks: Although this species superficially resembles some species of *Lithochytris,* it is clearly developed from a member of the *Sethochytris babylonis* group, as is indicated by the transitional forms illustrated on Plate 9, Figures 4 and 5. *Lithochytris barbadensis* may be one such transitional form.

Genus **Lithochytris** Ehrenberg

Lithochytris Ehrenberg, 1847a, chart to p. 385. Type species (indicated by Campbell, 1954, p. 132) *Lithochytris vespertilio* Ehrenberg (1873, p. 239; 1875, Plate 4, Figure 10).

Lithochytris archaea is evidently the earliest species of this genus, and indicates its origin from a probably open podocyrtid (possibly resembling that illustrated on Plate 10, Figure 1).

Lithochytris archaea, new species (Plate 9, Figure 7):

Cephalis spherical, with a few small pores and bearing a stout conical horn of about the same length to three times the length. Collar stricture distinct in some specimens, not in others. Thorax inflated-hemispherical, with thick wall and circular pores. Lumbar stricture distinct. Abdomen joined to the divergent feet through most of their length, with circular pores and truncate distally. The three feet are strong and prominent; throughout the length of the abdomen they are evident as prominent ridges beyond the surface of the abdominal wall, and their free distal portions are robust and cylindro-conical.

Total length 180 to 270μ, maximum breadth 125 to 195μ.

Remarks: The distinction from *Lithochytris vespertilio* is given under that heading. Many of the specimens in older assemblages have the feet less integrated into the abdominal wall, and the abdomen longer and less triangular, than in the holotype.

Lithochytris vespertilio Ehrenberg (Plate 9, Figures 8 and 9):

Lithochytris vespertilio Ehrenberg, 1873, p. 239; 1875, Plate 4, Figure 10.

Lithochytris lucerna Haeckel, 1887, p. 1364, Plate 67, Figure 14.

Lithochytris cheopsis Clark and Campbell, 1942, p. 81, Plate 9, Figure 37.

Cephalis subspherical, with few small pores, bearing a short, stout conical horn. Thorax small, inflated-hemispherical, with circular pores. Some early specimens have a slight collar stricture, but in late specimens the horn, cephalis and thorax together tend to have a smooth contour, set off from the abdomen by a change in contour. Abdomen almost tetrahedral (truncated proximally and closed distally) in form, the three distal corners prolonged into structures resembling stubby, proximally latticed, distally robust and conical feet. The homologues of the proximal parts of the feet of *Lithochytris archaea* are reduced to ribs within the abdominal wall at the edges of the tetrahedron. Abdominal pores are subcircular, and the entire shell is thick-walled.

Total length 200 to 260μ, maximum breadth 135 to 250μ.

Remarks: This form differs from *Lithochytris archaea* in having shorter free distal feet, and in having the part of the feet from the collar stricture to the end of the abdomen reduced to ribs within the abdominal wall. It is interesting to note that, while early specimens are invariably longer than they are wide, a considerable number of the late specimens closely approach the proportions of a regular tetrahedron.

Genus **Lychnocanium** Ehrenberg

Lychnocanium Ehrenberg, 1847a, chart to p. 385. Type species (desginated by Campbell, 1954, p. 124) *Lychnocanium falciferum* Ehrenberg (1854, Plate 36, Figure 7; 1875, p. 160, Plate 8, Figure 4).

It is not yet possible to specify appropriate limits for the genus *Lychnocanium,* and the following two species are assigned here more as a matter of temporary convenience than from any conviction that they are closely related to each other and to the type species. It may eventually prove desirable to synonymize some or all of the following genus-group taxa with *Lychnocanium:*

Acerahedrina Vinassa, 1900, p. 581. Type species (by monotypy). *Acerahedrina hirta* Vinassa (1900, p. 581. Plate 2, Figure 32).

Acerocanium Vinassa, 1900, p. 580. Type species (by monotypy) *Acerocanium globosum* Vinassa (1900, p. 581, Plate 2, Figure 28).

Lithornithium Ehrenberg, 1847b, chart to p. 54. Type species (indicated by Campbell, 1954, p. 132) *Lithocampe hirundo* Ehrenberg (1840, p. 200; 1854, Plate 19, Figure 53).

Lychnocanoma Haeckel, 1887, p. 1229. Type species (designated by Campbell, 1954, p. 124) *Lychnocanium clavigerum* Haeckel (1887, p. 1230, Plate 61, Figure 4).

Lychnocanium bellum Clark and Campbell (Plate 10, Figure 5):

Lychnocanium bellum Clark and Campbell, 1942, p. 72, Plate 9, Figures 35 and 39.

Lychnocanium sp., Riedel, 1957b, p. 259, Plate 63, Figure 5.

Lychnocanium bipes Riedel (Plate 15, Figure 8):

Lychnocanium bipes Riedel, 1959, p. 294, Plate 2, Figures 5 and 6.

Genus **Pterocanium** Ehrenberg

Pterocanium Ehrenberg, 1847a, chart to p. 385. Type species (indicated by Campbell, 1954, p. 130) *Pterocanium proserpinae* Ehrenberg (1858, p. 39; 1872b Plate 11, Figure 22).

[?] *Lamprodiscus* Ehrenberg, 1860, p. 831. Type species (designated by Campbell, 1954, p. 122) *Lamprodiscus monoceros* Ehrenberg (1872a, p. 314; 1872b, Plate 7, Figure 2).

Pleuropodium Haeckel, 1881, p. 436. Type species (indicated by Campbell, 1954, p. 130) *Podocyrtis charybdea* Müller (1855, p. 673; 1858, Plate 6, Figures 7 through 10).

Pterocanidium Haeckel, 1887, p. 1332. Type species (designated by Campbell, 1954, p. 130) *Pterocanium eucolpum* Haeckel (1887, p. 1332, Plate 73, Figure 4).

It is not yet possible to define satisfactorily the limits of this genus, but it seems clear that the following species is closely related to its type species.

Pterocanium prismatium Riedel:

Pterocanium prismatium Riedel, 1957a, p. 87, Plate 3, Figures 4 and 5.

The original description of this species admitted specimens without thorns on the three thoracic ribs, but such forms are now excluded.

Genus **Cycladophora** Ehrenberg

Cycladophora Ehrenberg, 1847a, chart to p. 385. Type species (indicated by Campbell, 1954, p. 132) *Cycladophora stiligera* Ehrenberg (1873, p. 223; 1875, Plate 18, Figure 3).

Calocyclas Ehrenberg, 1847b, chart to p. 54. Type species (indicated by Campbell, 1954, p. 132) *Calocyclas turris* Ehrenberg (1873, p. 218; 1875, Plate 18, Figure 7).

Cycladophora hispida (Ehrenberg) (Plate 10, Figure 9):

Anthocyrtis hispida Ehrenberg, 1873, p. 216; 1875, Plate 8, Figure 2.

Cycladophora turris (Ehrenberg), (Plate 13, Figures 3 and 4):

Calocyclas turris Ehrenberg, 1873, p. 218; 1875, Plate 18, Figure 7.

Cycladophora stiligera Ehrenberg, 1873, p. 223; 1875, Plate 18, Figure 3.

Cycladophora turris evidently developed from *C. hispida* by the feet becoming joined to form an abdomen.

Genus **Lophocyrtis** Haeckel

Lophocyrtis Haeckel, 1887, p. 1410. Type species (designated by Campbell, 1954, p. 134) *Eucyrtidium stephanophorum* Ehrenberg (1873, p. 233; 1875, Plate 8, Figure 14).

Lophocyrtis (?) jacchia (Ehrenberg):

Thyrsocyrtis jacchia Ehrenberg, 1873, p. 261; 1875, Plate 12, Figure 7.

Thyrsocyrtis dionysia Ehrenberg, 1873, p. 260; 1875, Plate 12, Figure 5.

[?] *Eucyrtidium stephanophorum* Ehrenberg, 1873, p. 233; 1875, Plate 8, Figure 14.

[?] *Podocyrtis amphiacantha* Ehrenberg, 1873, p. 248; 1875, Plate 17, Figure 2.

It is not yet possible to demonstrate a close relationship between *Lophocyrtis* (?) *jacchia* and the type species of this genus, and therefore the generic assignment is only tentative. Early forms of *L.* (?) *jacchia* appear possibly to be related to *Dictyopodium eurylophos* (1873, p. 223; 1875, Plate 19, Figure 4), which was indicated as the type species of *Dictyopodium* Ehrenberg (1847b, chart to p. 54) by Campbell (1954, p. 130).

Genus **Theocorys** Haeckel

Theocorys Haeckel, 1881, p. 434. Frizzell and Middour (1951, p. 30) designated *Eucyrtidium turgidulum* Ehrenberg (1872a, p. 312; 1872b, Plate 7, Figure 13) as the type species of this genus, and Strelkov and Lipman (1959, p. 457) indicated that the type species is *Theocorys veneris* Haeckel (1887, p. 1415, Plate 69, Figure 5), but Campbell (1954, p. 134) was legally correct in indicating, as the type species, the first species described in the genus (*Theocorys morchellula* Rüst, 1885, p. 308, Plate 37, Figure 6).

Assignment of the following species to *Theocorys* is not based on a belief that they are closely related to any of the above candidates for type species, but is only a temporary expedient pending determination of where their true relationships lie.

Theocorys anaclasta, new species (Plate 10, Figures 2 and 3):

Cephalis spherical, poreless or with few small pores, bearing a stout conical horn of variable length. Collar and lumbar strictures distinct. Thorax conical to hemispherical, with small subcircular pores. Abdomen broader than thorax, with thick wall (less robust in late specimens) and large rounded pores. Abdomen inflated in its main part, then constricting distally and expanded terminally, lacking distinct terminal ring. Proximal part of abdomen often thorny, and thorax less so.

Length (excluding horn) 225 to 390μ, maximum breadth 135 to 235μ. Measurements based on 20 specimens.

Theocorys anapographa, new species (Plate 10, Figure 4):

Cephalis spherical, poreless or with a few small pores, bearing a thin conical horn of about the same length. Collar and lumbar strictures distinct. Thorax conical to campanulate, with pores subcircular or irregular, commonly of various sizes. Abdomen subcylindrical, broader and commonly longer than the thorax, usually increasing in width distally especially in late specimens. Abdominal pores rounded, irregular in size and shape, larger than those of the thorax, increasing in size distally. Thoracic and abdominal wall sometimes thorny.

Length (excluding horn) 140 to 220μ, maximum breadth 110 to 155μ.

Remarks: This species is probably closely related to the form illustrated as *Clathrocyclas* sp. by Nigrini (Plate 4, Figure 2) in her report on Eocene radiolarians from Leg 2 of this Deep-Sea Drilling program.

Genus **Stichocorys** Haeckel

Stichocorys Haeckel, 1881, p. 438. Type species (indicated by Campbell, 1954, p. 140) *Stichocorys wolffii* Haeckel (1887, p. 1479, Plate 80, Figure 10).

Stichocorys wolffii Haeckel:

Stichocorys wolffii Haeckel, 1887, p. 1479, Plate 80, Figure 10; Riedel, 1957a, p. 92, Plate 4, Figures 6 and 7.

Stichocorys delmontensis (Campbell and Clark) (Plate 14, Figure 6):

Eucyrtidium delmontense Campbell and Clark, 1944a, p. 56, Plate 7, Figures 19 and 20; Riedel, 1952, p. 8, Plate 1, Figure 5; Riedel, 1957a, p. 93.

Stichocorys peregrina (Riedel):

Eucyrtidium elongatum peregrinum Riedel, 1953, p. 812, Plate 85, Figure 2; Riedel, 1957a, p. 94.

Genus **Cyrtocapsella** Haeckel

Cyrtocapsella Haeckel, 1887, p. 1512. Type species (designated by Campbell, 1954, p. 143) *Cyrtocapsa tetrapera* Haeckel (1887, p. 1512, Plate 78, Figure 5).

Syringium Principi, 1909, p. 19. Type species (by monotypy) *Syringium vinassai* Principi (1909, p. 19, Plate 1, Figure 60).

[?] *Eusyringoma* Haeckel, 1887, p. 1498. Type species (designated by Frizzell and Middour, 1951, p. 35) *Eucyrtidium lagenoides* Stöhr (1880, p. 104, Plate 20, Figure 8).

Cyrtocapsella tetrapera Haeckel (Plate 14, Figure 7):

Cyrtocapsa tetrapera Haeckel, 1887, p. 1512, Plate 78, Figure 5; (cf.) Nakaseko, 1955, p. 119, Plate 11, Figure 7.

Cyrtocapsa compacta Haeckel, 1887, p. 1512, Plate 77, Figure 8; Nakaseko, 1955, p. 119, Plate 11, Figure 6.

Cyrtocapsa pyrum Haeckel, 1887, p. 1513, Plate 78, Figure 8.

[?] *Eucyrtidium globicephalum* Vinassa, 1890, p. 586, Plate 3, Figure 23.

Theocapsa elongata Vinassa, 1900, p. 584, Plate 3, Figure 8.

Tricolocapsa hexagonata Vinassa, 1900, p. 584, Plate 3, Figure 9.

[?] *Tricolocapsa elliptica* Vinassa, 1900, p. 584, Plate 3, Figure 10.

Eusyringium haeckelianum Vinassa, 1900, p. 587, Plate 3, Figure 25.

[?] *Eusyringium oligoporum* Vinassa, 1900, p. 587, Plate 3, Figure 26.

Eusyringium marianii Vinassa, 1900, p. 587; Plate 3, Figure 27.

Cyrtocapsa rothpletzi Vinassa, 1900, p. 588, Plate 33, Figure 34.

Cyrtocapsa brevicornis Vinassa, 1900, p. 589, Plate 3, Figure 35.

Cyrtocapsa hirta Vinassa, 1900, p. 589, Plate 3, Figure 36.

Cyrtocapsa macropora Vinassa, 1900, p. 589, Plate 3, Figure 37.

Cyrtocapsa strangulata Vinassa, 1900, p. 589, Plate 3, Figure 38.

[?] *Cyrtocapsa bicornis* Vinassa, 1900, p. 589, Plate 3, Figure 39.

Cyrtocapsa miocenica Vinassa, 1900, p. 590, Plate 3, Figure 42; Lucchese, 1927, p. 108, Plate 8, Figure 15.

Cyrtocapsa miocenica laevicauda Vinassa, 1900, p. 590, Plate 3, Figure 43.

Stichocapsa hexagona Vinassa, 1900, p. 590, Plate 3, Figure 44.

[?] *Stichocapsa elongata* Vinassa, 1900, p. 590, Plate 3, Figure 45.

[?] *Stichocapsa laevigata* Vinassa, 1900, p. 590, Plate 3, Figure 46.

Stichocapsa macropora Vinassa, 1900, p. 591, Plate 3, Figure 47; Martin, 1904, p. 451, Plate 130, Figures 6 and 7.

Stichocapsa hirta Vinassa, 1900, p. 591, Plate 3, Figure 48.

Stichocapsa strangulata Vinassa, 1900, p. 591, Plate 3, Figure 49.

Stichocapsa longicauda Vinassa, 1900, p. 591, Plate 3, Figure 50.

Artocapsa dunikowskyi Vinassa, 1900, p. 591, Plate 3, Figure 51.

Eucyrtidium isseli Principi, 1909, p. 18, Plate 1, Figure 56.

Eusyringium curvispina Principi, 1909, p. 18, Plate 1, Figure 59.

Syringium vinassai Principi, 1909, p. 19, Plate 1, Figure 60.

Cyrtocapsa poligonalis Principi, 1909, p. 19, Plate 1, Figure 61.

Cyrtocapsa marinellii Principi, 1909, p. 19, Plate 1, Figure 63.

[?] *Stic[h]ocapsa brevicauda* Principi, 1909, p. 20, Plate 1, Figure 65.

[?] *Theocapsa piriformis* Lucchese, 1927, p. 106, Plate 8, Figure 6.

Eucyrtidium lagenoides Stöhr; Lucchese, 1927, p. 107, Plate 8, Figure 11, [*non E. lagenoides* Stöhr].

Eucyrtidium globicephalum Vinassa; Lucchese, 1927, p. 108, Plate 8, Figure 13.

Cyrtocapsa miocenica imperforaticauda Lucchese, 1927, p. 109, Plate 8, Figure 16.

Eucyrtidium ichikawai Nakaseko, 1955, p. 112, Plate 11, Figures 1, 3 and 5; Nakaseko and Chiji, 1964, p. 91, text-figure 5.

Eusyringium nipponicum Nakaseko, 1955, p. 114, Plate 10, Figure 10; Plate 11, Figure 2.

[?] *Eusyringium yatsuoense* Nakaseko, 1955, p. 115, Plate 11, Figure 4.

Cyrtocapsa subconica Nakaseko, 1955, p. 120, Plate 11, Figure 9.

Podocampe yatsuoensis Nakaseko, 1955, p. 127, Plate 11, Figure 8.

Cyrtocapsa miocenica Vinassa ?; Bachmann, Papp and Stradner, 1963, p. 129, Plate 6, Figure 24.

Cyrtocapsella cornuta Haeckel (Plate 14, Figure 8):

Cyrtocapsa cornuta Haeckel, 1887, p. 1513, Plate 78, Figure 9.

[?] *Eucyrtidium lagenoides* Stöhr, 1880, p. 104, Plate 20, Figure 8.

Eucyrtidium typus Vinassa, 1900, p. 587, Plate 3, Figure 24.

Lithocampe micropyle Vinassa, 1900, p. 587, Plate 3, Figure 28.

Cyrtocapsella elongata (Nakaseko):

Theocapsa elongata Nakaseko, 1963, p. 185, Plate 3, Figures 4 and 5.

Cyrtocapsella japonica (Nakaseko) (Plate 14, Figure 9):

Eusyringium japonicum Nakaseko, 1963, p. 193, text-figures 20 and 21, Plate 4, Figures 1, 2, and 3.

[?] *Dicolocapsa elongata* Vinassa, 1900, p. 582, Plate 2, Figure 36.

[?] *Theocapsa cayeuxi* Vinassa, 1900, p. 584, Plate 3, Figure 7.

Theocapsa himiensis Nakaseko, 1963, p. 184, text-figure 15, Plate 3, Figures 1, 2 and 3.

Eusyringium isozakiense Nakaseko, 1963, p. 194, Plate 4, Figures 5, 6 and 7, 11 and 12.

Genus **Artophormis** Haeckel

Artophormis Haeckel, 1881, p. 438. Type species (indicated by Campbell, 1954, p. 139) *Artophormis horrida* Haeckel (1887, p. 1458, Plate 75, Figure 2).

Although it seems very unlikely that the three following species are closely related to the type species of this genus, the generic name is retained because it seems inappropriate to erect a new genus for them in this paper dealing with samples in which they are not well represented–this will be done in a paper on the radiolarians of Barbados which is in preparation.

Artophormis dominasinensis (Ehrenberg):

Podocyrtis dominasinensis Ehrenberg, 1873, p. 250; 1875, Plate 14, Figure 4.

Podocyrtis brevipes Ehrenberg, 1873, p. 249; 1875, Plate 16, Figure 6.

Eucyrtidium apiculatum Ehrenberg, 1873, p. 225; 1875, Plate 10, Figure 10.

Although Ehrenberg's original figure of this species shows an apparently three-lobed cephalis, our examination of specimens from Barbados leads us to conclude that this species is not a pterocoryid because when its cephalis is bulged this is not in the regular manner characteristic of that family. Our form is apparently not the same as that recorded as *? Clathrocyclas dominasinensis* by Nigrini in her report on the radiolarians from Leg 2 of this expedition.

Artophormis barbadensis (Ehrenberg) (Plate 13, Figure 5):

Calocyclas barbadensis Ehrenberg, 1873, p. 217; 1875, Plate 18, Figure 8.

Cephalis spherical, with thorny surface and a moderate number of small subcircular pores, bearing a loosely spongy (occasionally latticed-bladed) apical horn. Collar stricture pronounced. Thorax inflated-campanulate, with thorny surface and subcircular pores. Lumbar stricture distinct. Abdomen tending to be somewhat longer than thorax and with slightly thinner wall, truncate-conical, with thorny surface and irregular subcircular pores. Fourth segment short, formed of very irregular latticework of which some elements are longitudinal ribs which commonly extend a short distance as free terminal spines. No differentiated termination of fourth segment.

Measurements based on 7 specimens from Site 29 and 37 from the Oceanic Formation at Bath, Barbados. Length of first three segments (excluding horn) 95 to 145μ. Maximum breadth of the abdomen 70 to 120μ. Ratio of abdomen length: thorax length (0.8-1.8): 1.

Remarks: This species is distinguished from *A. gracilis* by the abdomen being longer and truncate-conical rather than inflated, and by the fourth segment being less developed. It is distinguished from *A. dominasinensis* by the generally latticed horn, proportionately shorter abdomen, and the development of a fourth segment.

Artophormis gracilis Riedel (Plate 13, Figures 6 and 7):

Artophormis gracilis Riedel, 1959, p. 300, Plate 2, Figures 12 and 13.

Genus **Phormocyrtis** Haeckel

Phormocyrtis Haeckel, 1887, p. 1368. Type species (designated by Campbell, 1954, p. 134) *Phormocyrtis longicornis* Haeckel (1887, p. 1370, Plate 69, Figure 15).

It seems very unlikely that the following species is closely related to the type species of this genus, but it is retained here until its relationships are understood.

Phormocyrtis striata Brandt (Plate 10, Figure 7):

Phormocyrtis striata Brandt, 1935, *in* Wetzel, 1935, p. 55, Plate 9, Figure 12.

Cephalis hemispherical, with samll pores, and bearing a bladed horn of about the same length or somewhat longer. Collar stricture indistinct. Thorax inflated-hemispherical, with circular pores irregularly arranged. Lumbar stricture distinct. Abdomen (constituting the main part of the shell) fusiform, its greatest breadth usually near the middle, with circular pores in longitudinal rows usually separated by ridges. Termination ragged, toothed, or in rare specimens closed.

Total length 170 to 255μ, maximum breadth 70 to 100μ.

Remarks: In assemblages older than those described here (very early Eocene or Paleocene) the abdomen of this species tends to be triangular in cross section.

Genus **Lithocampium** Haeckel

Lithocampium Haeckel, 1881, p. 437. Type species (indicated by Campbell, 1954, p. 141) *Lithocampium stabile* Rüst (1885, p. 311, Plate 38, Figure 6).

Assignment of the following species to this genus does not result from a belief that it is closely related to the type species, but is only a matter of convenience pending determination of its relationships.

Lithocampium sp. (Plate 10, Figure 8):

Cephalis subspherical, with few small pores, bearing a bladed horn of about the same length. Collar and subsequent strictures not expressed externally. Thorax truncate-conical or slightly inflated, with circular pores irregularly arranged. Third segment the largest, barrel-shaped, with circular pores regularly quincuncially arranged. Fourth segment shorter, thinner-walled, with pores in transverse rows and tapering to the unrimmed mouth.

Total length 115 to 170μ, maximum breadth 65 to 85μ.

Remarks: This species bears a superficial resemblance to *Lithocampe turgida* Krasheninnikov (1960, p. 301, Plate 3, Figure 17), but the latter is much larger and has its greatest breadth near the base of the third segment.

Family PTEROCORYIDAE Haeckel

Pterocoryidae Haeckel, 1881, emend. Riedel, 1967b, p. 296.

Genus **Podocyrtis** Ehrenberg

Podocyrtis Ehrenberg, 1847a, chart to p. 385. Type species (indicated by Campbell, 1954, p. 130) *Podocyrtis papalis* Ehrenberg (1847a, Figure 2; 1854, Plate 36, Figure 23; 1873, p. 251).

Subgenus **Podocyrtis** Ehrenberg

Podocyrtis (Podocyrtidium) Haeckel, 1887, p. 1344.

Podocyrtis (Podocyrtis) in Campbell, 1954, p. 130.

To this nominate subgenus are assigned the members of the lineage leading from *Podocyrtis papalis* to *P. ampla*, inclusive.

Podocyrtis (Podocyrtis) papalis Ehrenberg (Plate 11, Figure 1):

Podocyrtis papalis Ehrenberg, 1847b, Figure 2; 1854, Plate 36, Figure 23; 1873, p. 251.

Podocyrtis fasciata Clark and Campbell, 1942, p. 80, Plate 7, Figures 29 and 33.

Cephalis is subhemispherical, with many small pores, bearing a horn of variable length which is usually three-bladed, sometimes conical. Collar stricture marked by change in contour. Thorax inflated-conical, with circular pores in longitudinal rows separated by ribs. Lumbar stricture not (or only very slightly) expressed externally. Abdomen inverted truncate-conical, with pores and ribs similar to those of thorax. Pored part of abdomen generally shorter than thorax, and this is followed by a poreless part of the abdominal wall from which arise three large, shovel-shaped feet.

Length (excluding horn) 170 (rarely 150) to 280μ, maximum breadth 95 to 140μ.

Remarks: This form is here described very broadly, and later careful study may prove the desirability of separating it into several species or subspecies.

Podocyrtis (Podocyrtis) diamesa, new species (Plate 12, Figures 4, 5 and 6):

Cephalis elongate-hemispherical, with small pores, bearing a horn of variable length which is bladed in early specimens, conical and robust in late specimens. Collar stricture marked by change in contour. Thorax inflated-conical, with pores circular and in longitudinal rows separated by ridges in early specimens, larger and lacking intervening ridges in late specimens. Thorax and abdomen of variable proportions, but often of approximately the same length. Slight lumbar stricture. Abdomen tapering distally, sometimes slightly inflated. Abdominal pores subcircular in longitudinal rows, in early specimens similar in size to distal thoracic pores and separated by longitudinal ridges, in late specimens larger and lacking longitudinal ridges. Three feet shovel-shaped, irregular in some specimens with very restricted aperture.

Length (excluding horn) 220 to 360μ, maximum breadth 140 to 180μ.

Remarks: This form is clearly transitional, early specimens approaching *Podocyrtis papalis* and late ones *Podocyrtis ampla*. It differs from *P. papalis* in its larger size and the presence of a lumbar stricture, and from *P. ampla* in its general form being spindle-shaped rather than conical.

Podocyrtis (Podocyrtis) ampla Ehrenberg (Plate 12, Figures 7 and 8):

Podocyrtis (?) *ampla* Ehrenberg, 1873, p. 248, 1875, Plate 16, Figure 7.

Cephalis subspherical, with few small pores, bearing a stout conical horn of variable length. Collar and lumbar strictures not pronounced. Thorax conical, of approximately the same length as the abdomen, with circular pores in longitudinal rows separated by ridges. Abdomen truncate-conical or subcylindrical, slightly inflated, with pores, larger than those of the thorax, usually arranged in approximate longitudinal rows without intervening ridges. Abdomen terminates in a narrow, thickened rim from which arise (in early specimens only) three small, shovel-shaped or spathulate feet.

Length (excluding horn and feet) 240 to 280μ, maximum breadth 170 to 205μ.

Remarks: This species is distinguished from *Podocyrtis diamesa* by being conical rather than spindle-shaped, in general form. An interesting feature is the narrow, thickened rim terminating the abdomen, which is foreshadowed by some late specimens of *P. diamesa* having the poreless distal part of the abdominal wall narrower than that of earlier specimens.

Subgenus **Lampterium** Haeckel

Lampterium Haeckel, 1881, p. 434. Type species (indicated by Campbell, 1954, p. 132) *Cycladophora goetheana* Haeckel (1887, p. 1376, Plate 65, Figure 5).

Podocyrtonium Haeckel, 1887, p. 1347. Type species (designated by Campbell, 1954, p. 130) *Podocyrtis pedicellaria* Haeckel (1887, p. 1347, Plate 72, Figure 8).

This subgenus comprises those forms (beginning with *Podocyrtis aphorma*) that developed from *Podocyrtis papalis* and evolved into *Podocyrtis chalara.* It appears highly probable that *Cycladophora goetheana* Haeckel and similar forms represent the culmination of this lineage, and that the following genus-group taxa should therefore be synonymized with *Lampterium:*

Lamptidium Haeckel, 1887, p. 1377. Type species (designated by Campbell, 1954, p. 132) *Cycladophora hexapleura* Haeckel (1887, p. 1377; Bury, 1867, Plate 13, Figure 7).

Tetralacorys Haeckel, 1881, p. 436. Type species (indicated by Campbell, 1954, p. 132) *Alacorys lutheri* Haeckel (1887, p. 1370, Plate 65, Figure 4).

Podocyrtis (Lampterium) aphorma, new species (Plate 11, Figure 2):

Cephalis hemispherical, with many small pores, bearing a three-bladed horn of about the same length. Collar stricture marked by change in contour. Thorax inflated campanulate, with subcircular pores in longitudinal rows separated by ribs. Lumbar stricture moderate to indistinct. Abdomen subcylindrical, slightly inflated or simply tapering distally, of approximately the same width as the thorax, with pores subcircular to longitudinally elongate, arranged less regularly than on thorax. Porous part of abdomen shorter than thorax. Three feet broad, shovel-shaped, arising as prolongations of poreless distal part of abdomen.

Total length 155 to 240μ, maximum breadth 95 to 110μ.

Remarks: This species is distinguishable from *P. papalis* only by the less regular abdominal pores and the presence of a slight lumbar stricture. Specimens more typical (with less regular abdominal pores) than the holotype occur in older assemblages.

Podocyrtis (Lampterium) sinuosa Ehrenberg(?) (Plate 11, Figures 3 and 4):

[?] *Podocyrtis sinuosa* Ehrenberg, 1873, p. 253; 1875, Plate 15, Figure 5.

Podocyrtis mitra Ehrenberg, in Ehrenberg, 1875, Plate 15, Figure 4 [*non* Ehrenberg, 1854, Plate 36, Figure B20].

Cephalis hemispherical, with many small pores, and bearing a three-bladed horn of about the same length. Collar stricture marked by a change in contour, obscure in late specimens. Thorax campanulate (conical in some late specimens); and the abdomen subcylindrical, slightly inflated, both segments with subcircular pores in longitudinal rows usually (but not in some late specimens) separated by longitudinal ribs. Pores of the abdomen larger than those of thorax. Lumbar stricture moderate to slight. Three feet are broad, arising from poreless distal rim of abdomen, generally shovel-shaped but spathulate in some late specimens.

Thorax in early specimens 55 to 80μ long and 85 to 110μ wide; in late specimens 45 to 60μ long and 85 to 95μ wide. Length of abdomen plus feet in early specimens 125 to 180μ, in late specimens 145 to 225μ. Maximum breadth of abdomen in early specimens 115 to 140μ, in late specimens 135 to 170μ.

Remarks: This species is distinguished from *Podocyrtis aphorma* by the larger abdomen, and from *P. trachodes* by the smoother surface. With time, the abdomen increases in size while the thorax decreases.

Podocyrtis (Lampterium) mitra Ehrenberg (Plate 11, Figures 5 and 6):

Podocyrtis mitra Ehrenberg, 1854, Plate 36, Figure B20; 1873, p. 251; [*non* Ehrenberg, 1875, Plate 15, Figure 4].

Podocyrtis eulophos Ehrenberg, 1873, p. 251; 1875, Plate 14, Figure 6.

[?] *Podocyrtis pedicellaria* Haeckel, 1887, p. 1347, Plate 72, Figure 8.

Cephalis hemispherical, with few to many small pores, bearing a bladed horn of about the same length. Thorax thick-walled, conical to campanulate, with usually rather large subcircular pores and rough surface. Collar and lumbar strictures distinct. Abdomen thick-walled, expanding distally and contracting abruptly near its end, with large subcircular pores longitudinally aligned and in some specimens with the rows separated by ribs. Abdominal pores in many specimens have delicate spines projecting into them from their periphery. Abdominal surface is usually smooth, sometimes rough. Three feet short and flat, spathulate or triangular, or absent.

Thorax 55 to 80μ long, 80 to 100μ wide. Length of abdomen plus feet 125 to 250μ. Maximum breadth of abdomen 110 to 180μ.

Remarks: This species differs from *P. sinuosa* and *P. trachodes* in having its abdomen widest near the distal end rather than medially.

Podocyrtis (Lampterium) trachodes, new species (Plate 11, Figure 7; Plate 12, Figure 1):

Cephalis hemispherical, with many small pores, bearing a three-bladed horn of about the same length. Thorax campanulate and abdomen moderately inflated, broadest at about its mildde; both segments thick-walled with rough surfaces and with subcircular pores, larger in abdomen than in thorax, in indistinct longitudinal rows. Collar and lumbar strictures moderately distinct. Three feet short and flat, spathulate or triangular. In occasional specimens, feet are absent.

Thorax 45 to 70μ long, 85 to 100μ wide. Abdomen plus feet 135 to 220μ long. Greatest breadth of abdomen 135 to 170μ.

Remarks: This species is distinguished by the rough surface of its thorax and (especially) abdomen.

Podocyrtis (Lampterium) chalara, new species (Plate 12, Figures 2 and 3):

[?] *Podocyrtis* (?) sp. Bury, 1862, Plate 12, Figure 2.

Cephalis irregularly hemispherical, with few to many small pores, and bearing a stubby bladed horn. Thorax thick-walled with rough surface approximately hemispherical, with rather large subcircular pores. Collar and lumbar strictures distinct. Abdomen robust, with smooth surface, of very large subangular meshes usually in approximate longitudinal rows; in outer form it expands slightly, then contracts distally. Abdominal pores commonly have short thorns projecting inward from their periphery. Vestigial triangular teeth are rarely present.

Thorax 40 to 65μ long, 80 to 95μ wide. Abdomen 155 (rarely 85) to 255μ long and 125 (rarely 100) to 165μ wide.

Remarks: This species differs from *Podocyrtis mitra* in having larger abdominal pores, and in generally lacking feet.

Podocyrtis (Lampterium) goetheana (Haeckel):

Cycladophora goetheana Haeckel, 1887, p. 1376, Plate 65, Figure 5.

Genus **Theocyrtis** Haeckel

Theocyrtis Haeckel, 1887, p. 1405. Type species (designated by Campbell, 1954, p. 134) *Eucyrtidium barbadense* Ehrenberg (1873, p. 226; 1875, Plate 9, Figure 7).

Although it is not yet possible to demonstrate satisfactorily any very close relationship between the following species assigned to this genus, it seems likely that this will be possible when more suitable material becomes available.

Theocyrtis tuberosa Riedel (Plate 13, Figures 8, 9 and 10):

Theocyrtis tuberosa Riedel, 1959, p. 298, Plate 2, Figures 10 and 11.

Theocyrtis annosa (Riedel) (Plate 15, Figure 9):

Phormocyrtis annosa Riedel, 1959, p. 295, Plate 2, Figure 7.

Genus **Calocycletta** Haeckel

Calocycletta Haeckel, 1887, p. 1381. Type species (designated by Campbell, 1954, p. 132) *Calocyclas veneris* Haeckel (1887, p. 1381, Plate 74, Figure 5).

It is not yet possible to define satisfactorily the limits of this genus, but there seems little doubt that the following two species are closely related to the type species.

Calocycletta virginis Haeckel (Plate 14, Figure 10):

Calocyclas virginis Haeckel, 1887, p. 1381, Plate 74, Figure 4; Riedel, 1959, p. 295, Plate 2, Figure 8.

Calocycletta costata (Riedel) (Plate 14, Figure 12):

Calocyclas costata Riedel, 1959, p. 296, Plate 2, Figure 9.

Family ARTOSTROBIIDAE Riedel, 1967a

Genus **Theocampe** Haeckel

Theocampe Haeckel, 1887, p. 1422. Type species (designated by Campbell, 1954, p. 134) *Dictyomitra ehrenbergi* Zittel (1876, p. 82, Plate 2, Figure 5).

Although the genera of artostrobiids are not yet satisfactorily worked out, it seems likely that the following species is more closely related to the type species of *Theocampe* than it is to that of *Sethamphora* (a carpocaniid according to Riedel, in press, a).

Theocampe mongolfieri (Ehrenberg) (Plate 12, Figure 9):

Eucyrtidium mongolfieri Ehrenberg, 1854, Plate 36, Figure 18B; 1873, p. 230; 1875, Plate 10, Figure 3.

Sethamphora mongolfieri (Ehrenberg), Haeckel, 1887, p. 1251.

Theocampe mongolfieri (Ehrenberg), Burma, 1959, p. 329.

Cephalis hemispherical, with circular pores, and with an inconspicuous lateral tubule lying against the upper part of the thoracic wall. Collar stricture indistinct. Thorax slightly inflated annular, with circular pores inclined obliquely upward and inward as they traverse the thick wall. Lumbar stricture distinct. Abdomen inflated barrel-shaped, constricted distally to a short cylindrical, hyaline peristome. Abdominal pores strictly in longitudinal and transverse rows, the longitudinal rows separated by ridges.

Total length 115 to 170μ, maximum breadth 70 to 100μ.

Remarks: This species is evidently derived from a form with pores in transverse but not regular longitudinal rows, which precedes and co-occurs with it.

Family CANNOBOTRYIDAE Haeckel

Cannobotryidae Haeckel, 1881, emend. Riedel, 1967b, p. 296.

The sequence obtained at Site 29 contains a form (Plate 12, Figure 10) that may represent the earliest record of this family subsequent to the forms described by Foreman (1968) as *Eribotrys*, but this species is rare and has not been investigated in detail.

Genus **Acrobotrys** Haeckel

Acrobotrys Haeckel, 1881, p. 440. Type species (indicated by Campbell, 1954, p. 144) *Acrobotrys monosolenia* Haeckel (1887, p. 1114).

The limits of this genus have not been worked out satisfactorily, and assignment here of the following species is a matter of temporary convenience only.

Acrobotrys tritubus Riedel:

Acrobotrys tritubus Riedel, 1957a, p. 80, Plate 1, Figure 5.

8. EVOLUTIONARY LINEAGES

One of the most interesting aspects of the middle Eocene radiolarian sequence at Site 29 is the fact that even a preliminary examination has resulted in the recognition of a number of evolutionary lineages (albeit many of them comprising only two species). These lineages are listed below, together with others known from late Eocene and younger sequences. Recognition of such phylogenetic series permits a modification of the Haeckelian generic classification of the species involved, so that the taxonomic system more closely reflects natural relationships. The lineages also provide a more reliable basis for the zonation and correlation of radiolarian sequences than would be provided by cryptogenetic species.

It seems highly probable that further research will reveal additional phylogenetic series in the Site 29 material, and thus these cores and the Oceanic Formation will become increasingly valuable in advancing our understanding of the polycystine radiolarians. Factors contributing to the usefulness of these sedimentary sequences for this type of investigation include: (1) deposition within the tropics, assuring representation of a wide variety of forms; (2) apparent continuity of the sequences, without disturbing hiatuses; and, (3) representation of periods long enough to demonstrate marked evolutionary changes.

Lithapium (?) *anoectum* - *L.* (?) *mitra* (?) Lineage:

This lineage includes only two species. Its origin is unknown, and the series apparently ends with the latter species.

Cannartus prismaticus - *Ommatartus tetrathalamus* Lineage:

The general outline of this lineage has been described previously (Riedel, 1959, p. 292 and text-figure 2), and extends from *Cannartus prismaticus* through *C. tubarius*, *C. violina*, *C. mammiferus*, *C. laticonus*, *Ommatartus antepenultimus* and *O. penultimus* to *O. tetrathalamus*. It appears likely that *Cannartus* (?) *petterssoni* and *Ommatartus hughesi* represent a side-branch from this lineage.

Triactis tripyramis tripyramis - *T. tripyramis triangula* Lineage:

This lineage also includes only two taxa. It probably originated from a phacodiscid with more than three marginal spines, and is not known to have left any descendants.

Lithocyclia ocellus group - *Lithocyclia angustum* Lineage (?):

Although the details are not yet known, it seems possible that *Lithocyclia angustum* developed from a member of the *L. ocellus* group via a member of the *L. aristotelis* group.

Tristylospyris triceros - Dorcadospyris alata Lineage:

Although the evolutionary sequence may be more complicated than suggested earlier (Riedel, 1959, p. 293, and text-figure 3), it appears that *Dorcadospyris alata* developed from *Tristylospyris triceros* through the intermediate forms *Dorcadospyris ateuchus* (and perhaps *D. papilio), D. forcipata, D. dentata* and perhaps *D. simplex.*

Lamptonium (?) *fabaeforme fabaeforme* (?) - *L.* (?) *fabaeforme* (?) *constrictum* Lineage:

This lineage also includes only two taxa, and is of uncertain origin.

Theocotyle cryptocephala (?) *nigriniae - T. venezuelensis* Lineage:

The intermediate form in this lineage is *Theocotyle cryptocephala cryptocephala* (?). *T. venezuelensis* is defined very broadly, and apparently left no descendants.

Thyrsocyrtis rhizodon - T. bromia Lineage:

Two species are included, and the lineage apparently left no descendants.

Thyrsocyrtis triacantha - T. tetracantha Lineage:

It seems clear that the latter species developed from the former, which may in turn have descended from *Thyrsocyrtis hirsuta.*

Eusyringium lagena (?) - *E. fistuligerum* Lineage:

Only two species are included, and the lineage apparently left no descendants.

Sethochytris babylonis group - *S. triconiscus* (?) Lineage:

This lineage includes only two species, with clearly transitional intermediate forms. The series apparently became extinct with the latter species.

Lithochytris archaea - L. vespertilio Lineage:

Although only two species are included, both are defined broadly and may later be split into additional taxa. The lineage apparently terminates with the latter species. The development of *Lithochytris vespertilio* from *L. archaea* may prove to be a useful biostratigraphic datum, since both forms are robust and *L. vespertilio* at least is widespread. In the assemblages which include *L. archaea* there are a number of other forms with some similarities of structure (thick-walled inflated thorax, and cylindro-conical appendages with characteristically rough surface) which may later prove to be related to this lineage; one of them is illustrated on Plate 10, Figure 1.

Cycladophora hispida - C. turris Lineage:

Only two species are included, and no descendants are known.

Stichocorys delmontensis - S. peregrina Lineage (?):

Although no convincing intermediate forms are known, it appears likely that the latter species developed from the former.

Artophormis barbadensis - A. gracilis Lineage:

Only these two species are included.

Podocyrtis papalis - P. ampla Lineage:

Three broadly defined species are included (*P. diamesa* being the intermediate form), and no descendants are known.

Podocyrtis aphorma - P. goetheana Lineage:

This lineage commences with *Podocyrtis (Podocyrtis) papalis,* and proceeds through *Podocyrtis aphorma, P. sinuosa* (?), *P. mitra* and *P. chalara,* to terminate in *P. goetheana.* It thus includes four of the five species (*P. trachodes* being evidently related but apparently not in the direct line) here assigned to the subgenus *Lampterium* to separate them from the nominate subgenus (*P. papalis - P. ampla* lineage). The succession in *Lampterium* is characterized by a decrease in the size of the thorax, an increase in the size of the abdomen and of its pores, and a diminution and ultimately the loss of the feet, with time.

Calocycletta virginis - C. costata Lineage:

Only two species are included, and no descendants are known.

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10. EXPLANATION OF PLATES

On the following plates, all figures are at a magnification of × 225 unless otherwise specified.

The U. S. National Museum catalog numbers (from catalog 35) following each figure identification and its locality indicate the slide on which the illustrated specimen is to be found. These specimen locations following the USNM numbers are given in terms of "England Finder" coordinates (see Riedel and Foreman, 1961). The England Finder is always used with its label at the microscopist's left hand, and the RHS and LHS in the notations indicate whether the label of the specimen slide was on the right-hand side or left-hand side, respectively.

Figures are arranged in approximately systematic order in four groups–Cretaceous, middle Eocene, late Eocene and Oligocene, and Miocene. Illustrations of some members of the two last-mentioned groups are taken from well-preserved assemblages from Caribbean localities and deep-sea cores, since some of the species are not widely familiar and could not be effectively illustrated from the less well preserved material in the drill-cores.

On the plates of middle Eocene forms, groups of illustrations showing intraspecific variation are bracketed together, and arrows are used to show lines of evolutionary development.

PLATE 1

Cretaceous Radiolaria

Figure 1	Actinommid, gen. et sp. indet. 24A-1-1. Dark; USNM 167256; A 30/3; LHS.
Figure 2	Saturnalin aff. *Saturnalis minimus.* 24A-1-1. Dark; USNM 167257; S 25/0; LHS.
Figure 3	Saturnalin, gen. et sp. indet. 24A-1-1. Dark; USNM 167258; Q 45/0; LHS.
Figures 4&5	*Amphibrachium* cf. *A. ornatum.* 24A-1-1. 4: Dark; USNM 167256; S 22/0; LHS. 5: Dark; USNM 167259; C 49/2; RHS.
Figures 6&7	*Amphibrachium* cf. *A. concentricum.* 24A-1-1. 6: Dark; USNM 167259; T 35/0; RHS. 7: Dark; USNM 167258; L 43/3; LHS.
Figures 8&9	Spongodiscids, genn. et spp. indet. 24A-1-1. 8: Dark; USNM 167256; D 40/4; LHS 9: USNM 167260; E 55/0; RHS.

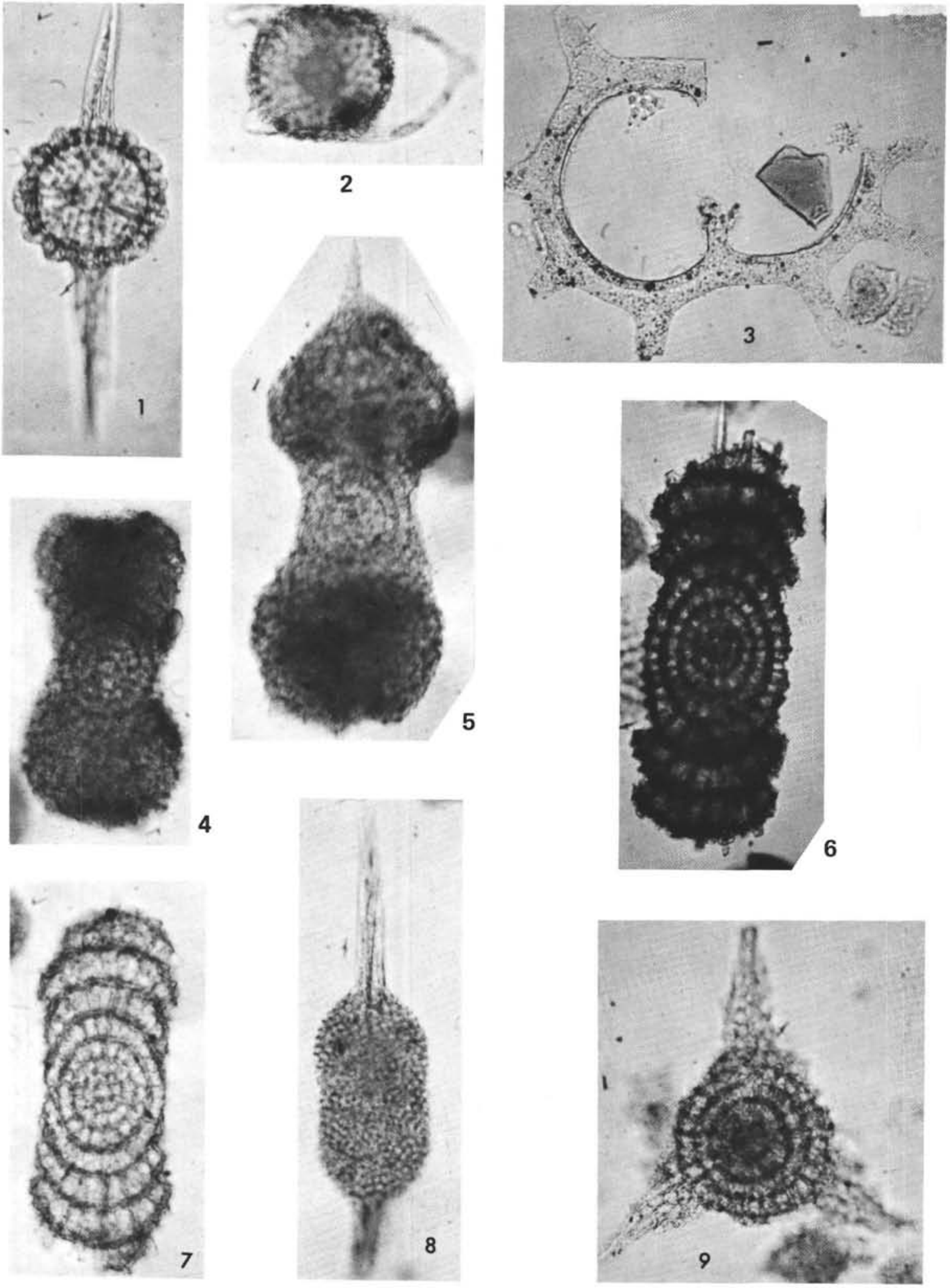

Plate 1.

PLATE 2

Cretaceous Radiolaria

Figure 1	Spongodiscid cf. *Septinastrum dogeli.* 24A-1-1. Dark; USNM 167256; W 18/0; LHS.
Figure 2	*Spongopyle insolita.* 24A-4-2, 20-22 cm. USNM 167261; Z 14/2; LHS.
Figure 3	*Euchitonia triradiata* (?). 24A-4-2, 20-22 cm. USNM 167261; S 29/3; LHS
Figure 4	Spongodiscid, gen. et sp. indet. 24A-4-2, 20-22 cm. USNM 167262; B 57/1; LHS.
Figure 5	*Pseudoaulophacus gallowayi* (?). 24A-1-1. Dark; USNM 167257; T 25/3; LHS.
Figures 6&7	Pseudoaulophacids (?), genn. et spp. indet. 24A-1-1. × 150. 6: USNM 167258; P 27/3; LHS. 7: USNM 167257; A 14/4; LHS.

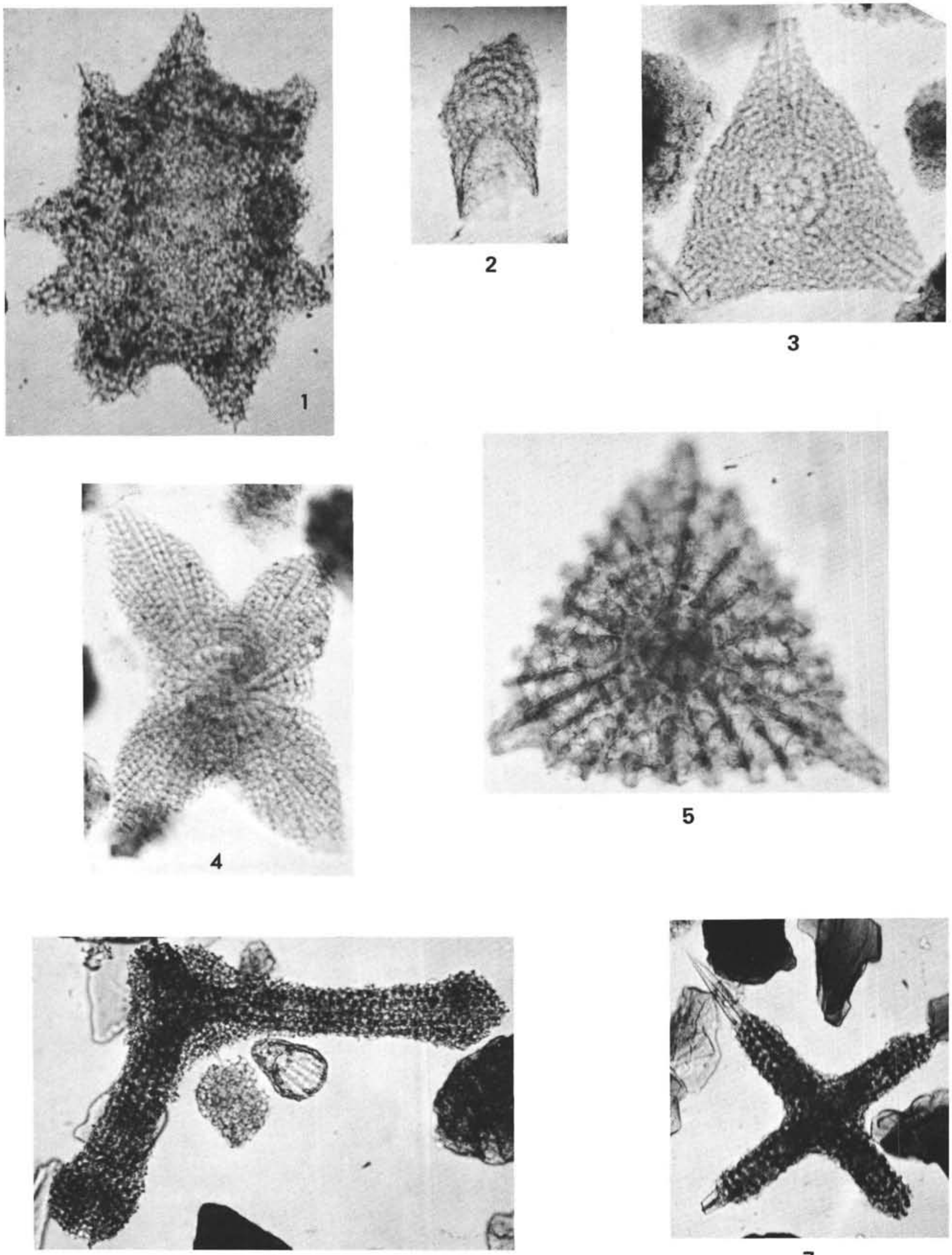

Plate 2.

PLATE 3

Cretaceous Radiolaria

Figure 1	*Theocapsomma* sp. 24A-1-1 Dark; USNM 167257; M 52/0; RHS.
Figure 2	*Dicolocapsa verbeeki* (?) 24A-1-1. Dark; USNM 167259; G 30/1; RHS. The specimen is oblique, the cephalis (in the lower part of the illustration) being on the side of the specimen toward the observer, and the mouth opposite.
Figure 3	*Cornutella* sp. 24A-1-1. Dark; USNM 167263; W 26/1; LHS.
Figures 4&5	Theoperids, genn. et sp. indet. 24A-1-1. 4: Dark; USNM 167259; X 33/0; RHS. 5: Dark; USNM 167256; M 53/0; RHS.
Figures 6&7	Theoperids cf. *Sciadiocapsa.* 24A-1-1. 6: USNM 167256; N 20/3; LHS. 7: USNM 167259; P 31/0; LHS.
Figures 8,9&10	*Dictyomitra* spp. 24A-1-1. 8: USNM 167259; W 34/2; LHS. 9: USNM 167256; D 43/1; LHS. 10: USNM 167259; S 40/0; LHS.
Figure 11	*Amphipyndax* sp. 24A-1-1. Dark; USNM 167256; G 10/0; LHS.
Figure 12	*Theocampe* sp. 24A-1-1. Dark; USNM 167256; G 36/2; RHS.
Figure 13	Artostrobiid, gen. et sp. indet. 24A-4-2, 20-22 cm. USNM 167264; M 44/4; LHS.

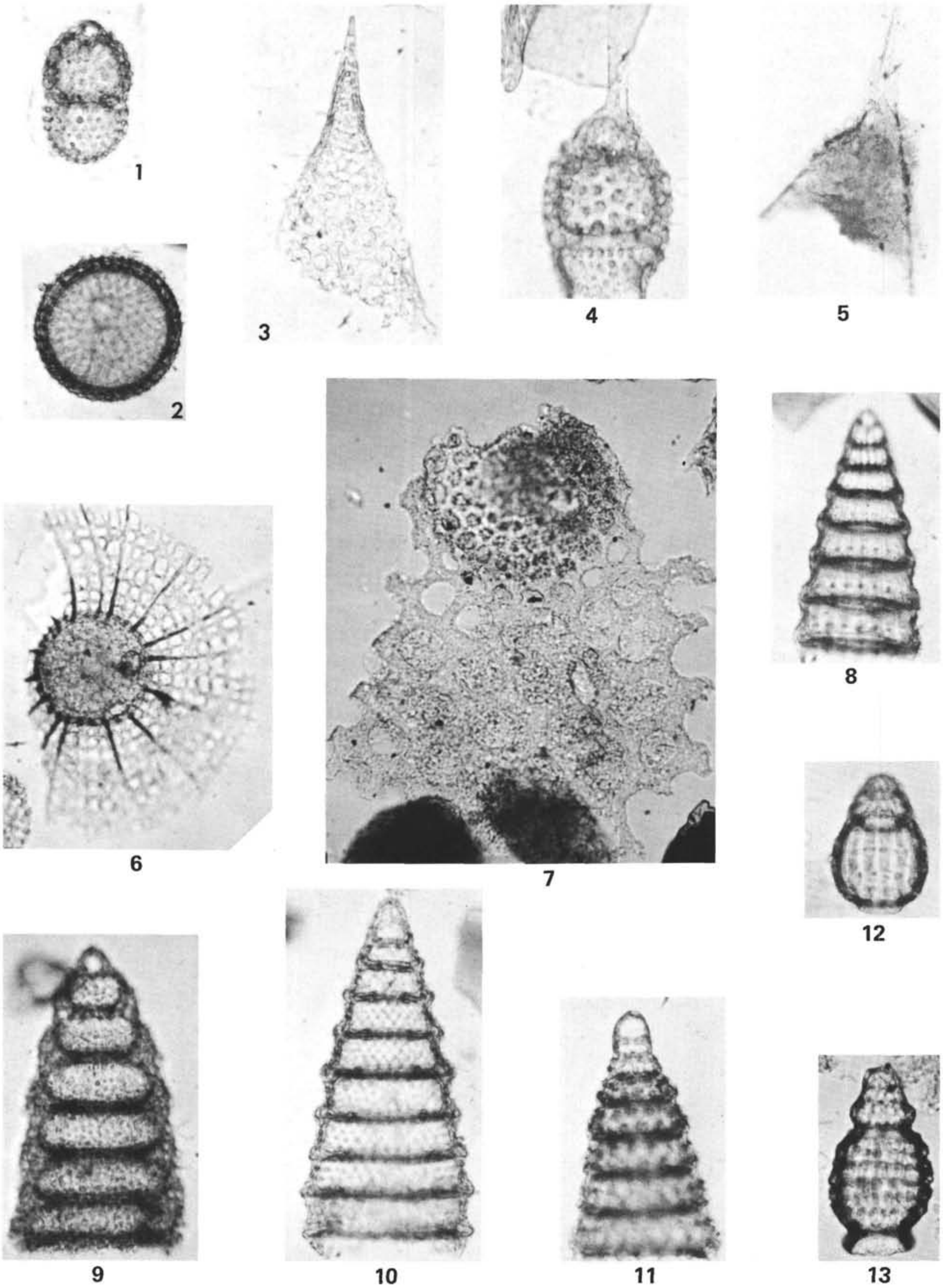

Plate 3.

PLATE 4

Middle Eocene Radiolaria

Figure 1	*Spongatractus pachystylus.* 29-10-1, 78-80 cm. USNM 167265; B 29/0; RHS.
Figure 2	*Lithapium* (?) *plegmacantha.* 29-12-3, 100-102 cm. USNM 167266; R 11/4; RHS. Holotype.
Figure 3	*Lithapium* (?) *plegmacantha.* 29B-10-2, 100-102 cm. USNM 167267; X 26/1; RHS.
Figure 4	*Lithapium* (?) *anoectum.* 29-10-5, 120-122 cm. USNM 167268; H 54/4; LHS.
Figure 5	*Lithapium* (?) *anoectum.* 29-14-4, 102-104 cm. USNM 167269; T 54/1; RHS. Holotype.
Figure 6	*Lithapium* (?) *mitra* (?). 29-9-6, 72-74 cm. X 150. USNM 167270; W 58/0; RHS.
Figure 7	*Lithapium* (?) *mitra* (?). 29-9-5, 112-114 cm. X 150. USNM 167271; U 38/1; LHS.
Figure 8	*Triactis tripyramis tripyramis.* 29B-10-4, 24-26 cm. USNM 167272; L 45/2; RHS.
Figure 9	*Triactis tripyramis triangula.* 29B-9-5, 83-85 cm. USNM 167273; F 15/0; LHS.
Figure 10	*Triactis tripyramis triangula.* 29B-10-2, 100-102 cm. USNM 167267; F 44/1; RHS.

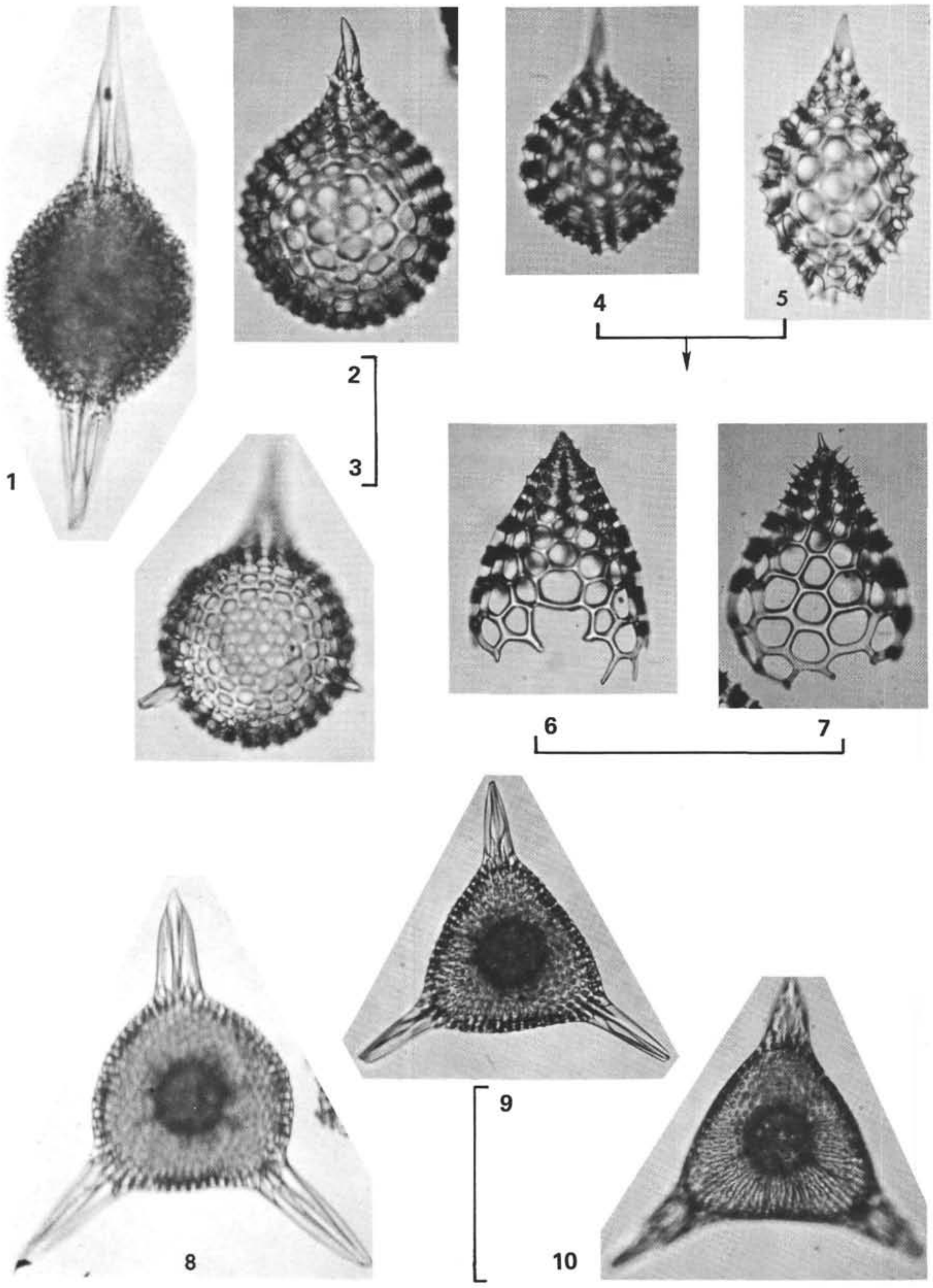

Plate 4.

PLATE 5

Middle Eocene Radiolaria

Figure 1	*Lithocyclia ocellus* group. 29-10-1, 78-80 cm. USNM 167265; R 30/0; RHS.
Figure 2	*Lithocyclia ocellus* group. 29B-8-4, 111-113 cm. USNM 167274; J 37/0; RHS.
Figure 3	*Giraffospyris didiceros* group. 29B-9-2, 17-19 cm. USNM 167275; O 38/0; RHS.
Figure 4	*Giraffospyris didiceros* group. 29-12-3, 100-102 cm. USNM 167276; W 17/0; LHS.
Figure 5	*Giraffospyris didiceros* group. 29-9-6, 8-10 cm. USNM 167277; M 26/1; RHS.
Figure 6	*Lamptonium* (?) *fabaeforme fabaeforme* (?). 29B-10-2, 100-102 cm. USNM 167267; P 51/4; RHS.
Figure 7	*Lamptonium* (?) *fabaeforme* (?) *constrictum.* 29B-9-5, 83-85 cm. USNM 167278; J 39/0; RHS. Holotype.
Figures 8&9	*Lamptonium* (?) *fabaeforme* (?) *chaunothorax.* 29B-10-2, 100-102 cm. 8: USNM 167267; Y 43/0; RHS. 9: USNM 167267; S 18/3; LHS. Holotype.

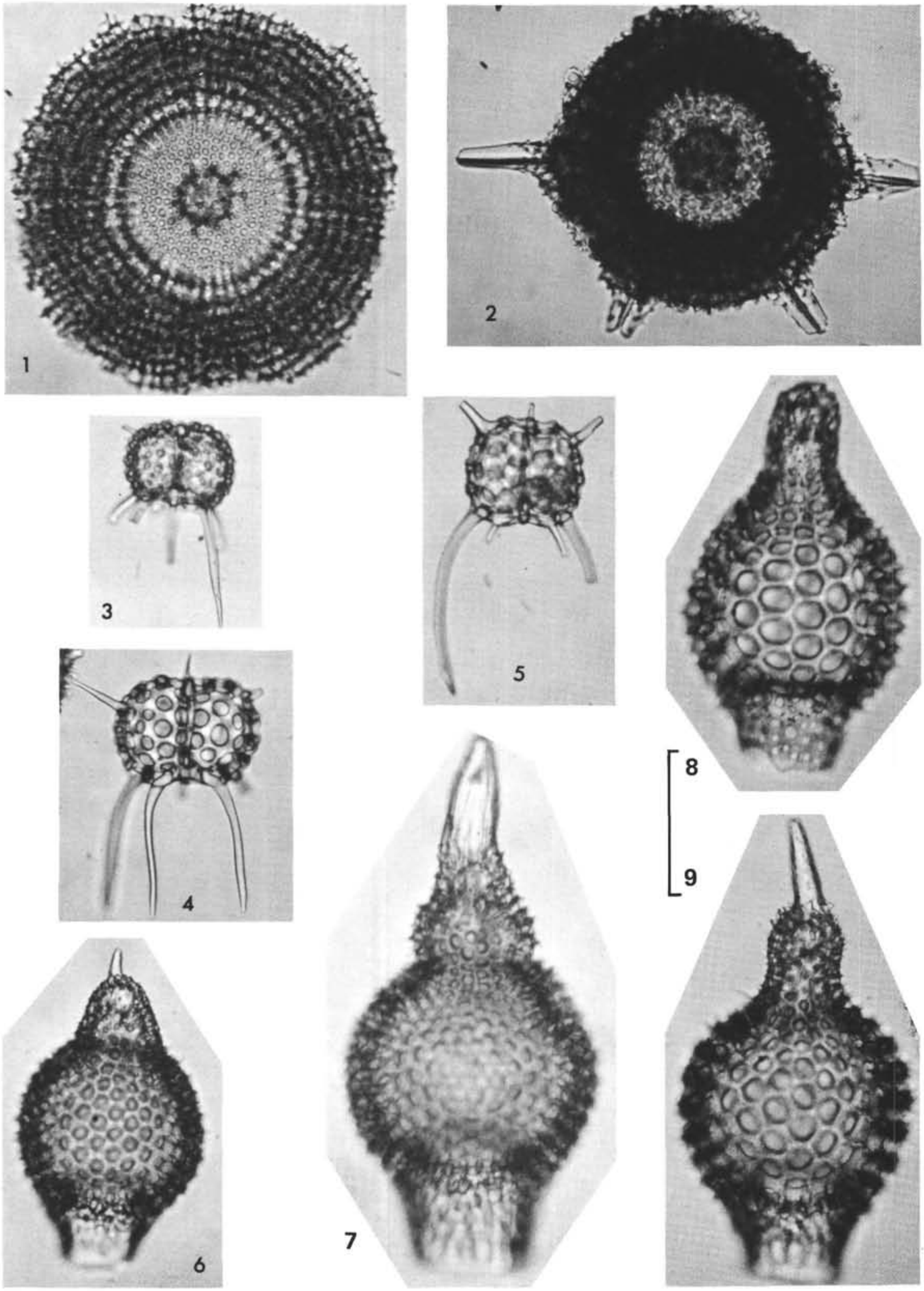

Plate 5.

PLATE 6

Middle Eocene Radiolaria

Figure 1	*Calocycloma* (?) *ampulla.* 29-16-1, 116-118 cm. USNM 167279; W 29/2; RHS.
Figure 2	*Anthocyrtoma* sp. 29B-9-5, 83-85 cm. USNM 167280; M 36/0; LHS.
Figures 3&4	*Anthocyrtoma* sp. 29-9-5, 112-114 cm. 3: USNM 167271; H 42/4; RHS. 4: USNM 167271; L 15/3; LHS.
Figures 5&6	*Theocotyle cryptocephala* (?) *nigriniae.* 29B-10-3, 10-12 cm. 5: USNM 167281; W 47/2; RHS. 6: USNM 167282; S 54/0; RHS.
Figures 7&8	*Theocotyle cryptocephala cryptocephala* (?). 29B-10-2, 100-102 cm. 7: USNM 167283; K 18/4; LHS. 8: USNM 167267; K 54/3; RHS.
Figures 9&10	*Theocotyle venezuelensis.* 29B-10-2, 100-102 cm. 9: USNM 167267; D 55/4; RHS. 10: USNM 167267; D 26/0; RHS. Holotype.

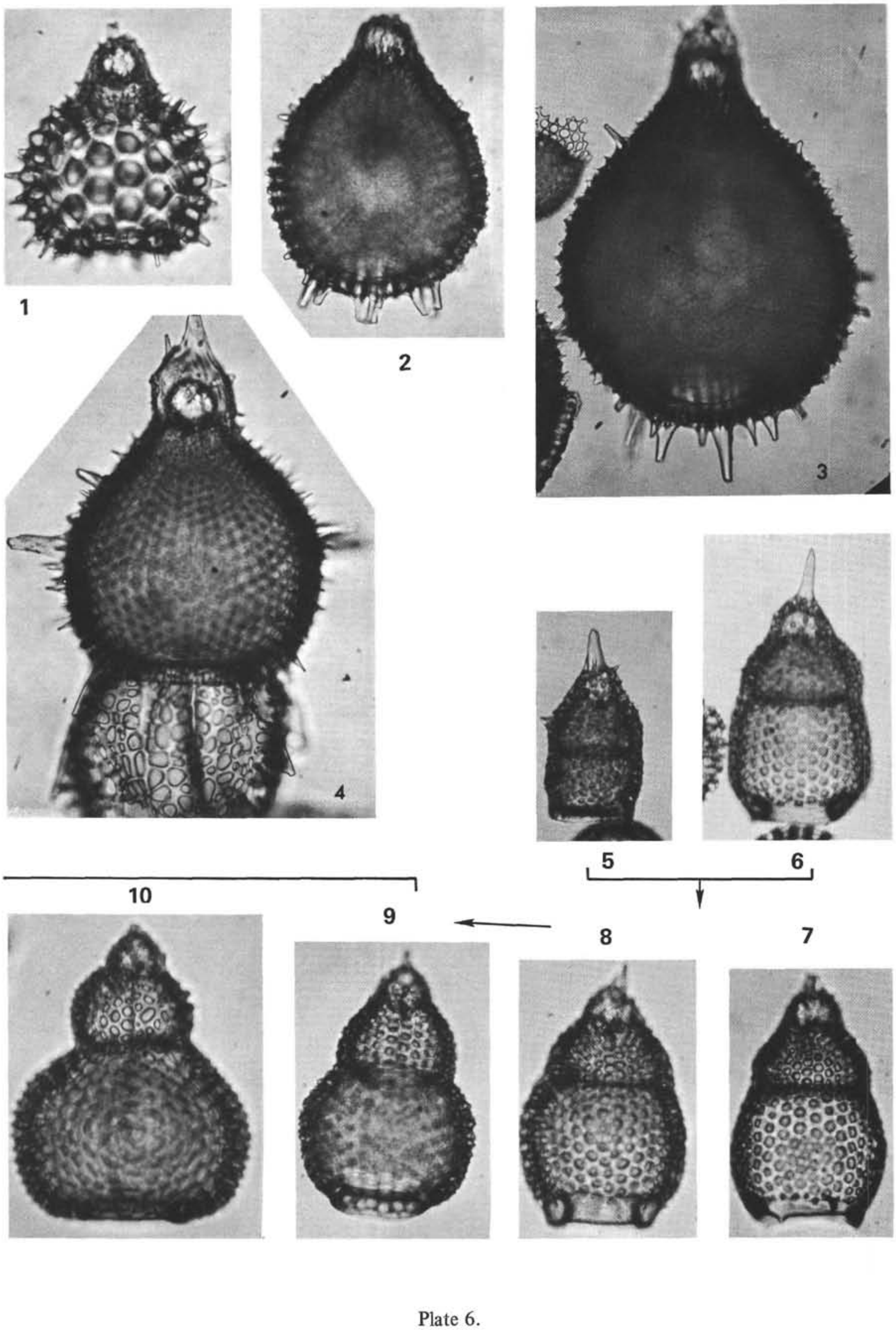

Plate 6.

PLATE 7

Middle Eocene Radiolaria

Figures 1&2	*Theocotyle venezuelensis.* 29-16-1, 116-118 cm. 1: USNM 167284; R 43/1; RHS. 2: USNM 167285; M 35/0; RHS.
Figure 3	*Theocotyle* (?) *ficus.* 29B-10-2, 100-102 cm. USNM 167286; S 30/0; RHS.
Figure 4	*Theocotyle* (?) *ficus.* 29B-9-5, 83-85 cm. USNM 167278; M 43/2; RHS.
Figure 5	*Theocotyle* (?) *ficus.* 29-9-5, 112-114 cm. USNM 167271; W 42/0; RHS.
Figures 6&7	*Thyrsocyrtis rhizodon.* 29-9-6, 72-74 cm. 6: USNM 167287; T 31/1; RHS. 7: USNM 167287; S 50/1; LHS.
Figures 8&9	*Thyrsocyrtis hirsuta hirsuta.* 29B-10-4, 24-26 cm. 8: USNM 167288; T 29/1; RHS. 9: USNM 167289; F 54/0; RHS.

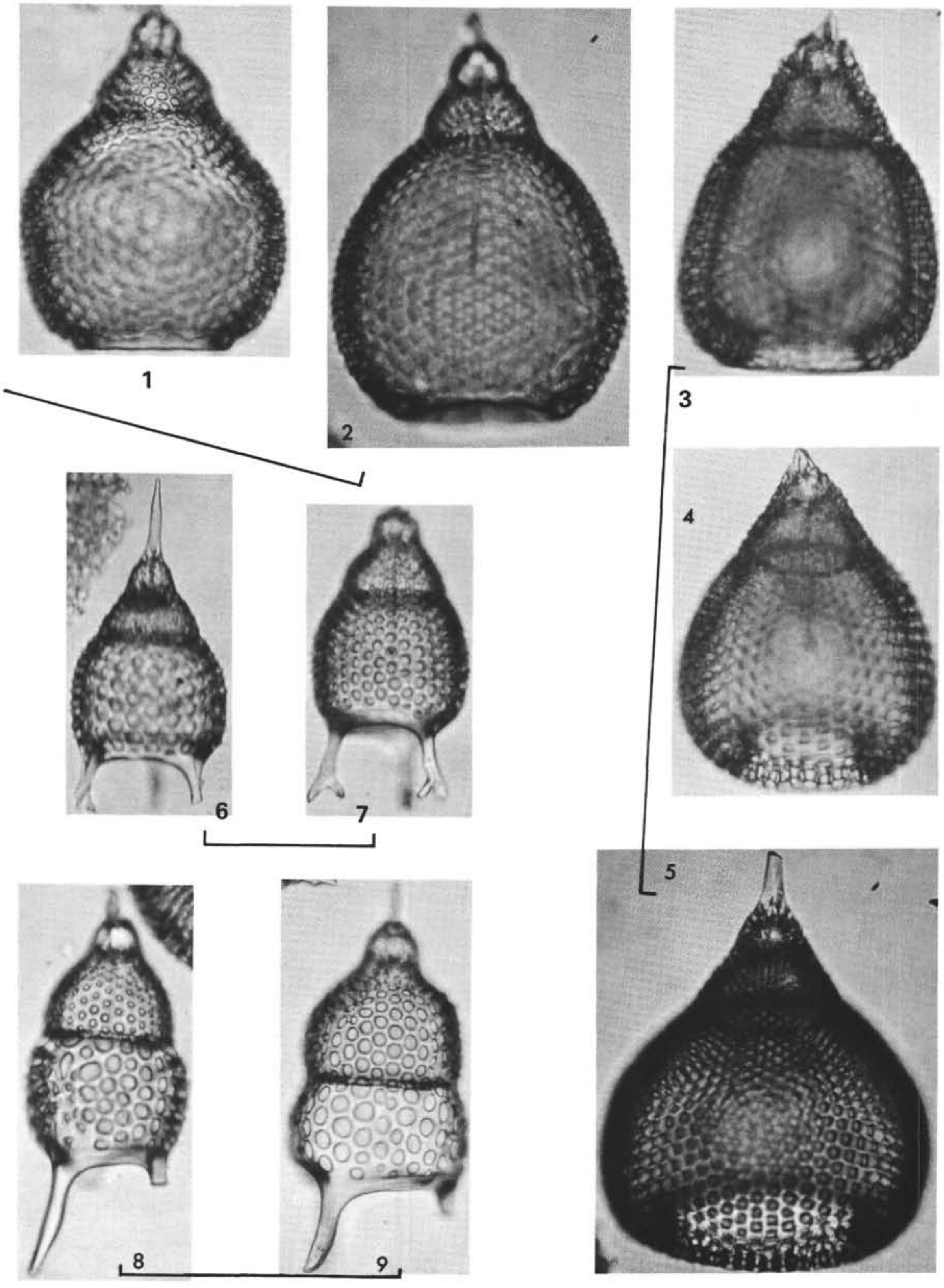

Plate 7.

PLATE 8

Middle Eocene Radiolaria

Figure 1	*Thyrsocyrtis hirsuta robusta.* 29B-9-5, 83-85 cm. USNM 167290; V 56/4; RHS. Holotype.
Figure 2	*Thyrsocyrtis triacantha.* 29-10-1, 78-80 cm. USNM 167265; M 33/0; RHS.
Figure 3	*Thyrsocyrtis triacantha.* 29-9-6, 72-74 cm. USNM 167287; M 26/2; RHS.
Figure 4	Gen. et sp. indet. 29-9-5, 112-114 cm. USNM 167294; P 35/0; RHS.
Figure 5	*Eusyringium lagena* (?). 29-10-5, 120-122 cm. USNM 167291; R 36/1; LHS.
Figure 6	*Eusyringium lagena* (?). 29-16-1, 116-118 cm. USNM 167279; N 25/4; LHS.
Figure 7	*Eusyringium lagena* (?). 29-14-5, 37-39 cm. USNM 167292; H 46/0; RHS.
Figures 8&9	*Eusyringium fistuligerum.* 29-10-5, 120-122 cm. 8: USNM 167293; K 16/2; LHS. 9: USNM 167268; M 50/1; LHS.
Figure 10	Gen. et sp. indet. 29-9-5, 112-114 cm. USNM 167271; B 17/0; LHS.

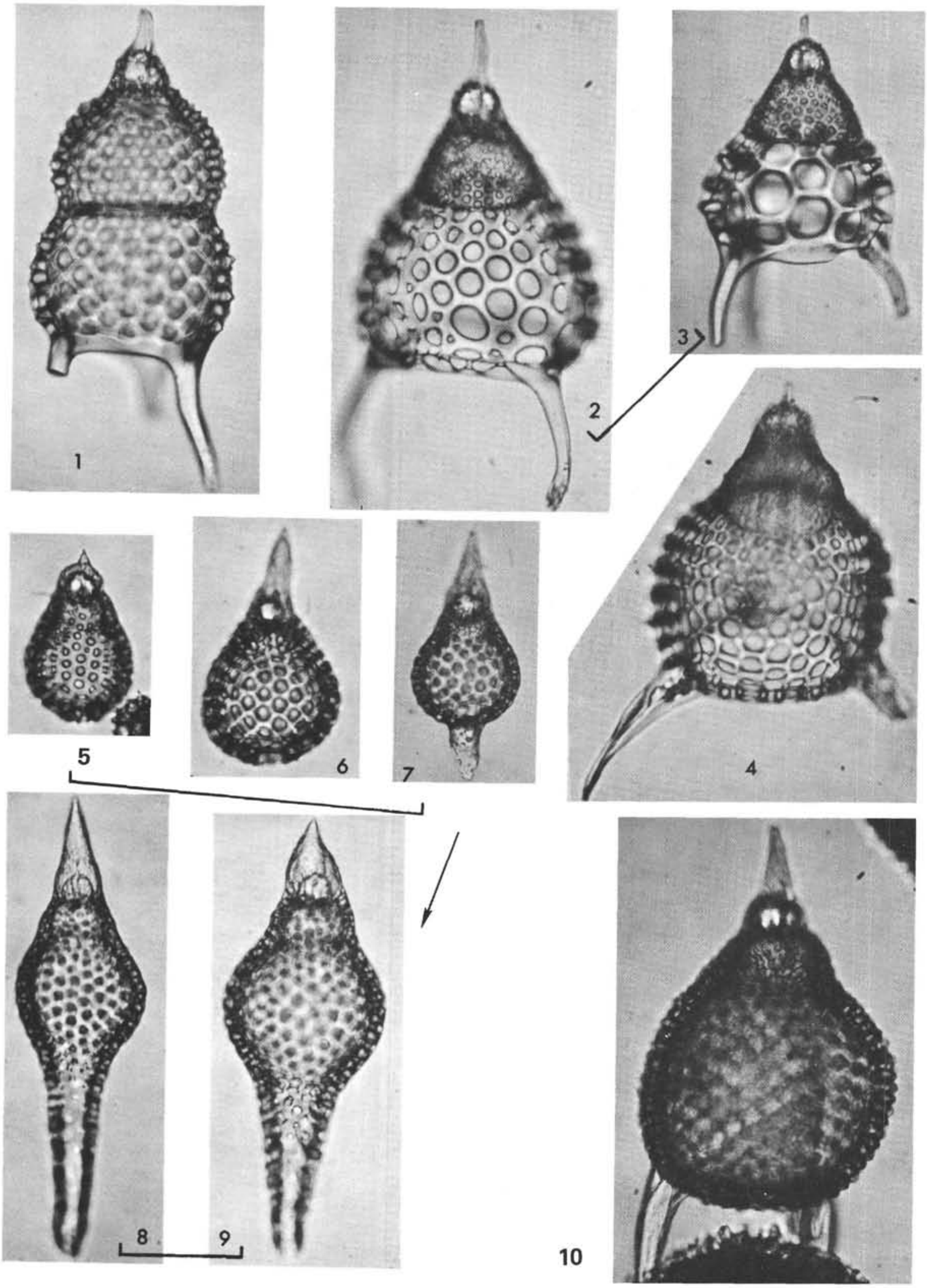

Plate 8.

PLATE 9

Middle Eocene Radiolaria

Figure 1	*Sethochytris babylonis* group. 29-10-5, 120-122 cm. USNM 167293 R 45/2; LHS.
Figure 2	*Sethochytris babylonis* group. 29-9-3, 70-72 cm. USNM 167295; J 46/0; RHS.
Figure 3	*Sethochytris babylonis* group. 29-16-1, 116-118 cm. USNM 167296; G 45/0; LHS.
Figure 4	Gen. et sp. indet. 29-10-2, 99-101 cm. USNM 167297; D 29/0; RHS.
Figure 5	Gen. et sp. indet. 29-9-6, 72-74 cm. USNM 167287; B 32/1; RHS.
Figure 6	*Sethochytris triconiscus* (?). 29-9-6, 8-10 cm. USNM 167277; M 43/4; RHS.
Figure 7	*Lithochytris archaea.* 29B-10-4, 24-26 cm. USNM 167289; B 30/0; RHS. Holotype.
Figure 8	*Lithochytris vespertilio.* 29-16-1, 116-118 cm. USNM 167284; T 46/3; LHS.
Figure 9	*Lithochytris vespertilio.* 29-10-1, 78-80 cm. USNM 167265; E 41/1; RHS.

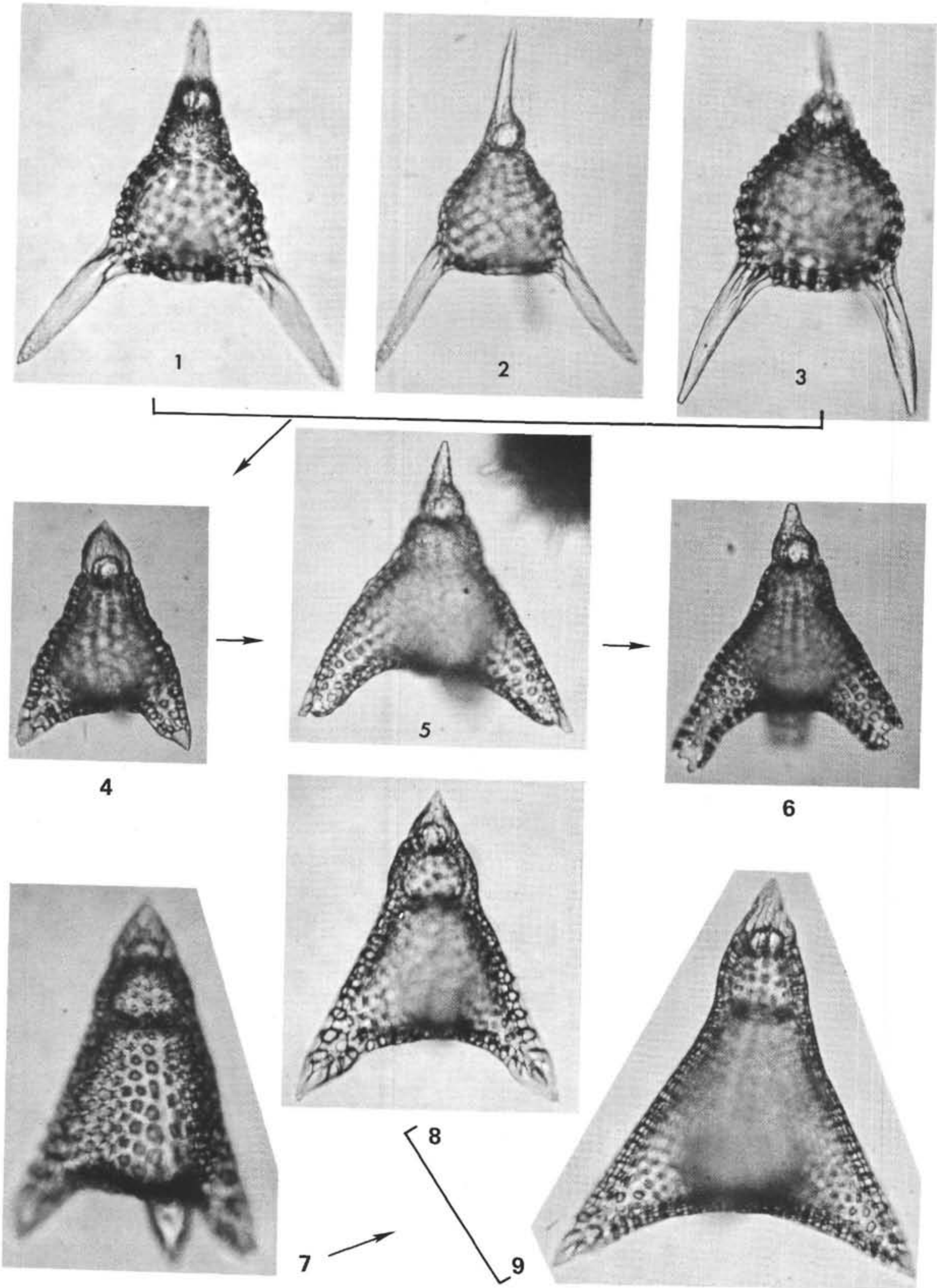

Plate 9.

PLATE 10

Middle Eocene Radiolaria

Figure 1	Gen. et sp. indet. 29B-10-4, 24-26 cm. USNM 167298; Q 15/0; LHS.
Figures 2&3	*Theocorys anaclasta.* 29B-9-5, 83-85 cm. 2: USNM 167299; E 37/4; LHS. Holotype. 3: USNM 167299; H 11/0; LHS.
Figure 4	*Theocorys anapographa.* 29-14-4, 102-104 cm. USNM 167300; J 46/1; RHS. Holotype.
Figure 5	*Lychnocanium bellum.* 29-16-1, 116-118 cm. USNM 167301; H 38/3; RHS.
Figure 6	*Dictyophimus craticula.* 29-10-4, 100-102 cm. × 150. USNM 167302; F 29/2; RHS.
Figure 7	*Phormocyrtis striata.* 29B-10-2, 100-102 cm. USNM 167267; T 40/0; RHS.
Figure 8	*Lithocampium* sp. 29-16-2, 90-92 cm. USNM 167303; O 52/3; RHS.
Figure 9	*Cycladophora hispida.* 29-9-6, 72-74 cm. USNM 167287; S 49/4; LHS.

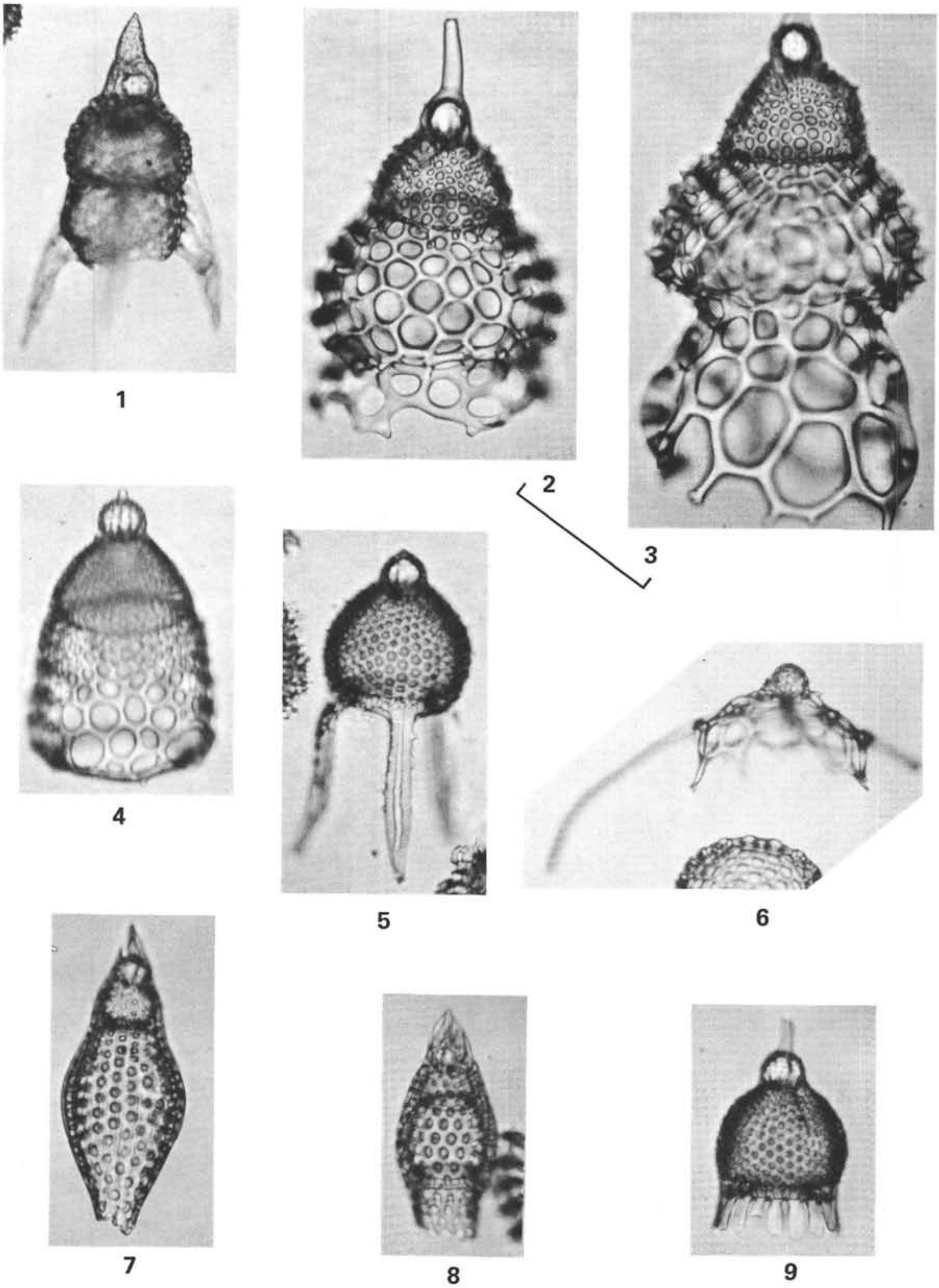

Plate 10.

PLATE 11

Middle Eocene Radiolaria

Figure 1	*Podocyrtis papalis.* 29-9-5, 112-114 cm. USNM 167304; Q 19/0; LHS.
Figure 2	*Podocyrtis aphorma.* 29B-10-4, 24-26 cm. USNM 167272; U 56/0; RHS. Holotype.
Figure 3	*Podocyrtis sinuosa* (?). 29-14-4, 102-104 cm. USNM 167300; U 42/2; RHS.
Figure 4	*Podocyrtis sinuosa* (?). 29-12-3, 100-102 cm. USNM 167276; X 18/4; LHS.
Figure 5	*Podocyrtis mitra.* 29-10-5, 120-122 cm. USNM 167268; E 18/4; LHS.
Figure 6	*Podocyrtis mitra.* 29-10-1, 78-80 cm. USNM 167165; S 41/3; RHS.
Figure 7	*Podocyrtis trachodes.* 29-10-1, 78-80 cm. USNM 167265; T 29/2; RHS. Holotype.

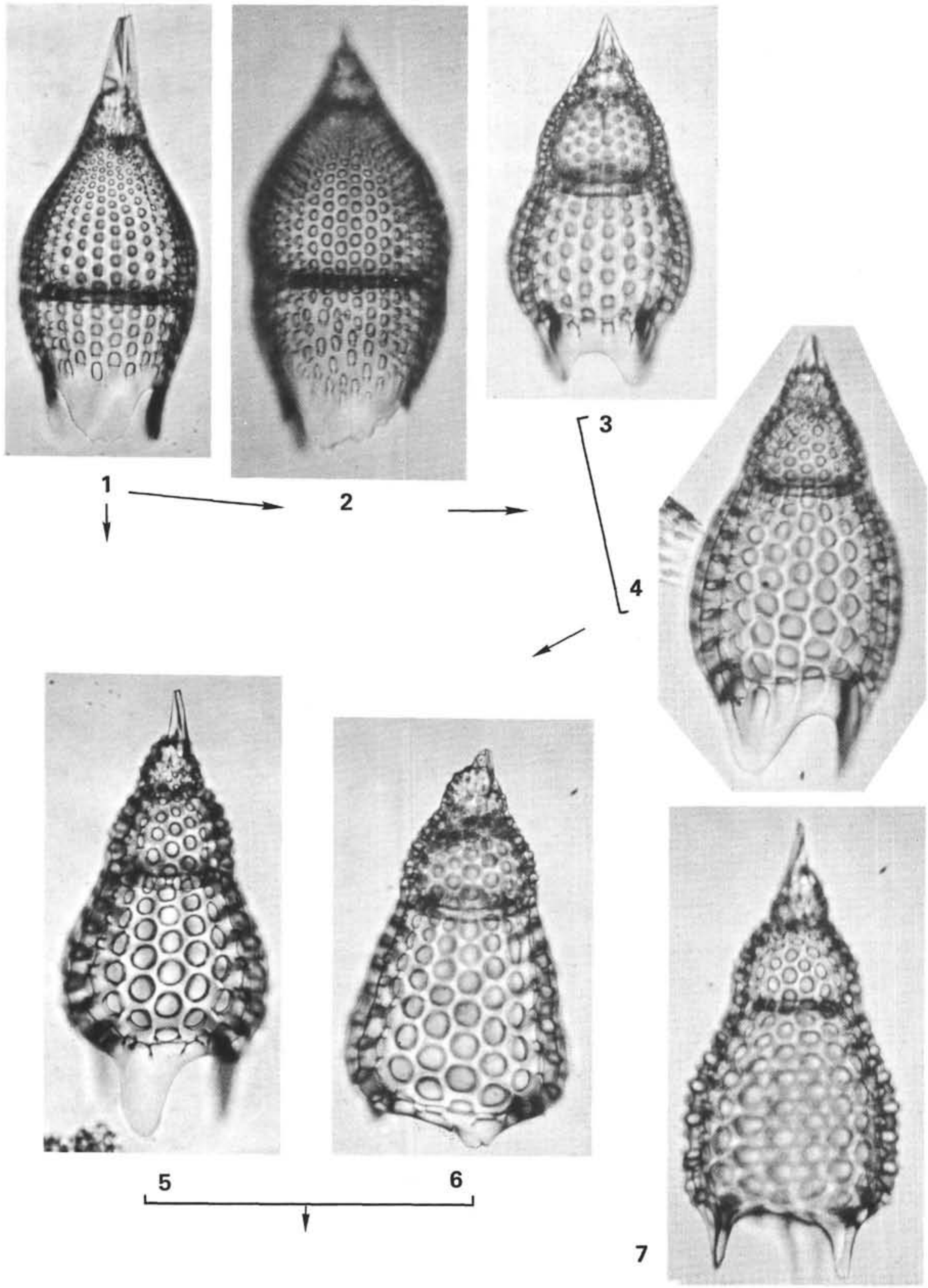

Plate 11.

PLATE 12

Middle Eocene Radiolaria

Figure 1	*Podocyrtis trachodes.* 29-10-4, 100-102 cm. USNM 167302; 0 53/0; RHS.
Figures 2&3	*Podocyrtis chalara.* 29B-8-4, 111-113 cm. 2: USNM 167305; C 36/4; LHS. 3: USNM 167305; K 52/4; RHS.
Figures 4&5	*Podocyrtis diamesa.* 29-16-1, 116-118 cm. × 150. 4: USNM 167285; K 41/0; LHS. 5: USNM 167306; J 15/4; LHS.
Figure 6	*Podocyrtis diamesa.* 29-15-3, 13-15 cm. × 150. USNM 167307; M 53/1; LHS.
Figure 7	*Podocyrtis ampla.* 29-14-4, 102-104 cm. × 150. USNM 167308; X 23/4; LHS.
Figure 8	*Podocyrtis ampla.* 29-10-5, 120-122 cm. × 150. USNM 167309; B 16/3; LHS.
Figure 9	*Theocampe mongolfieri.* 29-12-3, 100-102 cm. USNM 167310; Y 22/1; LHS.
Figure 10	Gen. et sp. indet. 29-16-2, 90-92 cm. USNM 167311; Q 52/2; RHS.

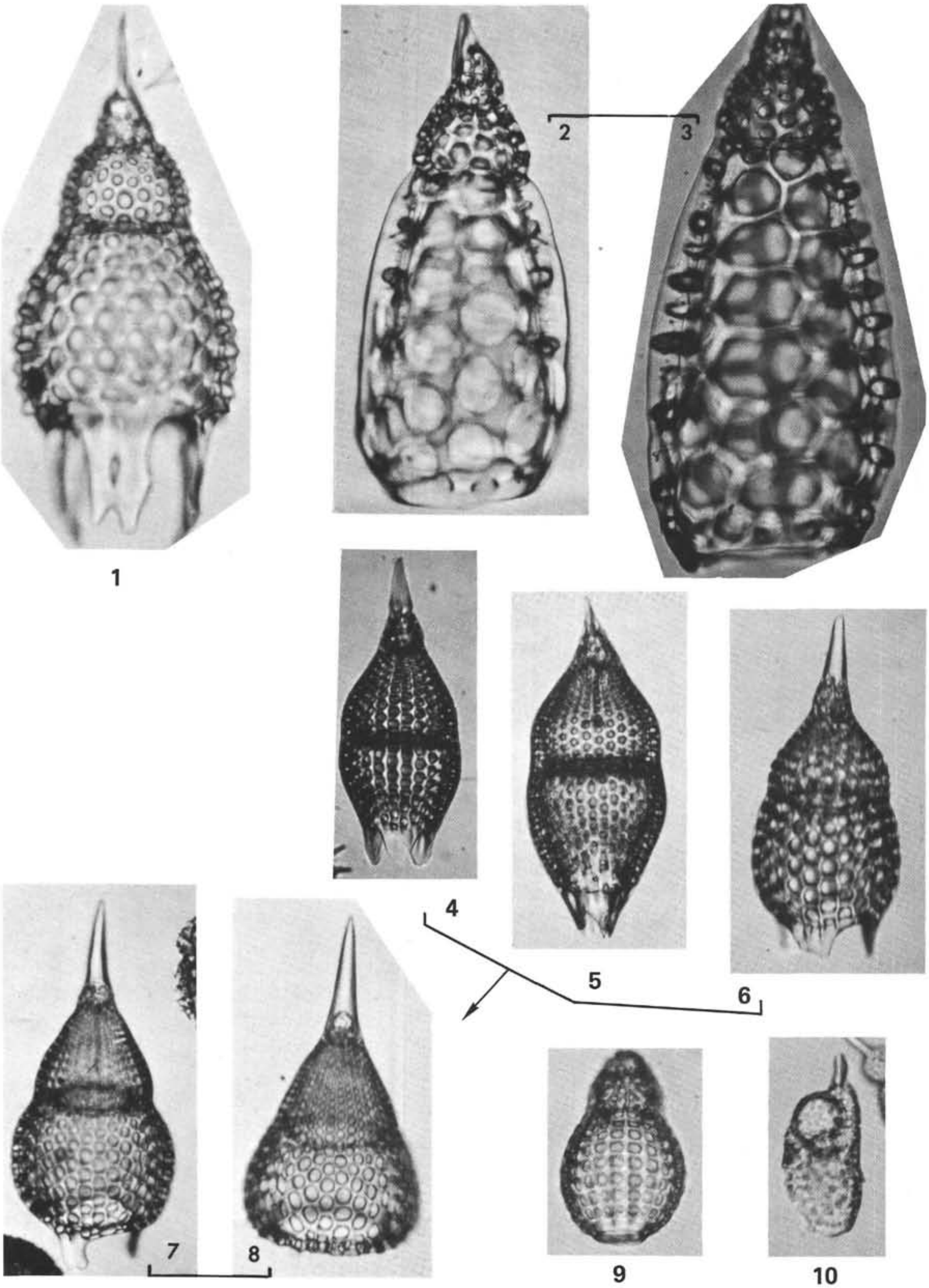

Plate 12.

PLATE 13

Late Eocene and Oligocene Radiolaria

Figures 1&2	*Lithocyclia angustum.* Bath Cliff, Barbados. 1: M-171; USNM 167312; E 34/1; RHS. 2: M-171; USNM 167312; V 34/0; RHS.
Figures 3&4	*Cycladophora turris.* Bath Cliff, Barbados. 3: M-166; USNM 167313; Q 41/0; RHS. 4: M-167; USNM 167314; X 34/1; RHS.
Figure 5	*Artophormis barbadensis.* Bath Cliff, Barbados. M-163; USNM 167315; P 51/3; RHS.
Figures 6&7	*Artophormis gracilis.* Bath Cliff, Barbados. 6: M-171; USNM 167312; L 45/3; RHS. 7: M-171; USNM 167312; N 25/0; RHS.
Figures 8,9&10	*Theocyrtis tuberosa.* Bath Cliff, Barbados. (Figure 10 shows a fragment of the thorax, viewed along the axis of the shell.) 8: M-171; USNM 167312; O 42/2; RHS. 9: M-171; USNM 167312; C 46/0; RHS. 10: M-171; USNM 167312; F 44/3; RHS.

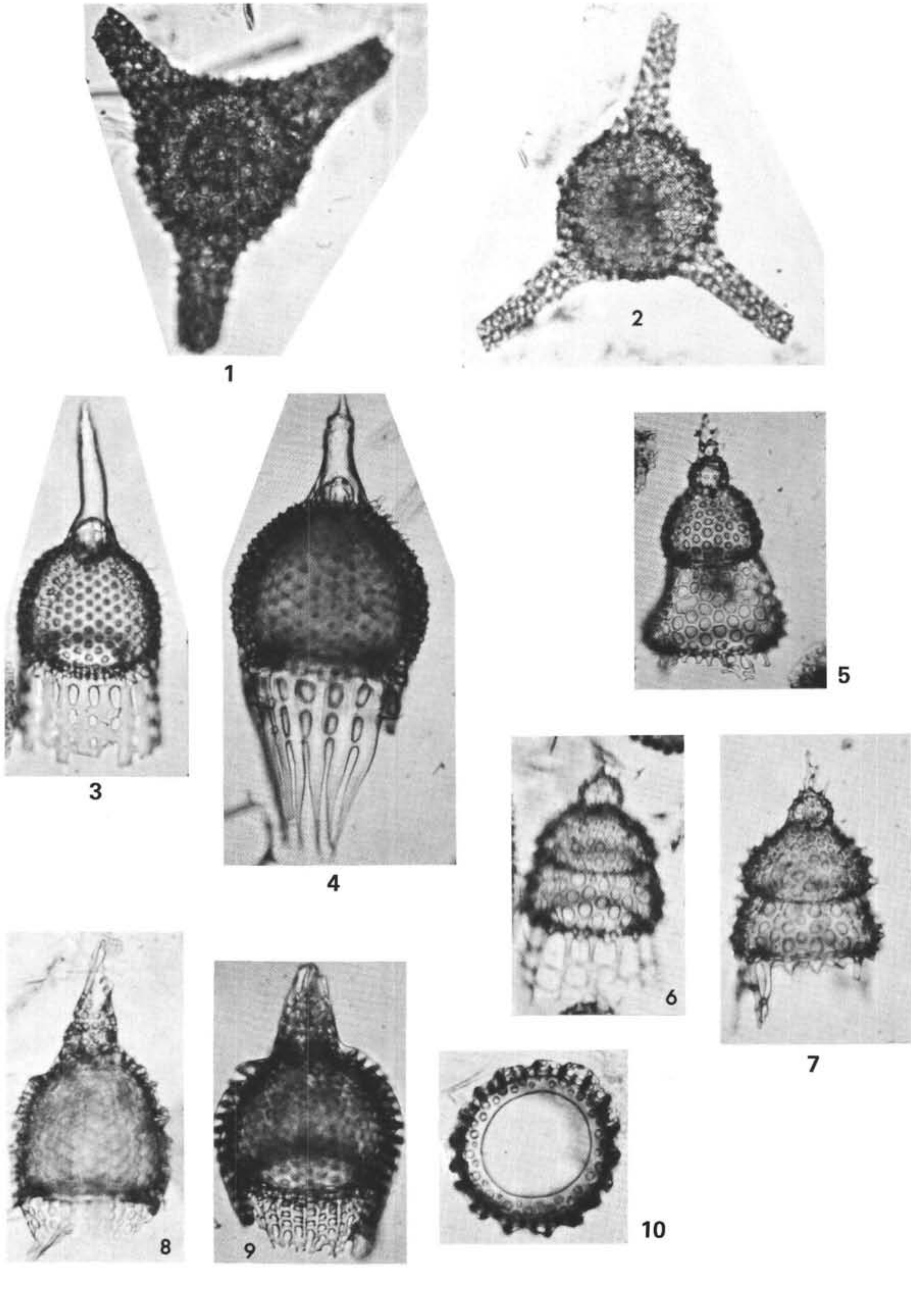

Plate 13.

PLATE 14

Miocene Radiolaria

Figure 1	*Cannartus mammiferus.* Golconda, Trinidad (Rz. 554). USNM 167316; T 36/3; RHS.
Figure 2	*Cannartus laticonus.* AMPH 6P, 60-62 cm. USNM 167317; E 41/3; RHS. Holotype.
Figure 3	*Cannartus (?) petterssoni.* PROA 96P, 227-230 cm. USNM 167318; G 33/2; RHS. Holotype.
Figure 4	*Ommatartus antepenultimus.* AMPH 6P, 15-17 cm. USNM 167319; G 27/3; RHS.
Figure 5	*Dorcadospyris alata.* AMPH 91P, 243-245 cm. × 150. USNM 167320; U 31/2; RHS.
Figure 6	*Stichocorys delmontense.* AMPH 6P, 60-62 cm. USNM 167317; J 39/3; RHS.
Figure 7	*Cyrtocapsella tetrapera.* AMPH 6P, 60-62 cm. USNM 167317; G 34/2; RHS.
Figure 8	*Cyrtocapsella cornuta.* WAH 7P, 257-259 cm. USNM 167321; N 49/0; RHS.
Figure 9	*Cyrtocapsella japonica.* AMPH 6P, 60-62 cm. USNM 167322; W 53/0; RHS.
Figure 10	*Calocycletta virginis.* AMPH 91P, 569-571 cm. USNM 167323; K 40/0; RHS.
Figure 11	*Calocycletta* cf. *virginis.* 31-9-Catcher. USNM 167324; F 41/0; RHS.
Figure 12	*Calocycletta costata.* AMPH 91P, 569-571 cm. USNM 167325; L 38/2; RHS.

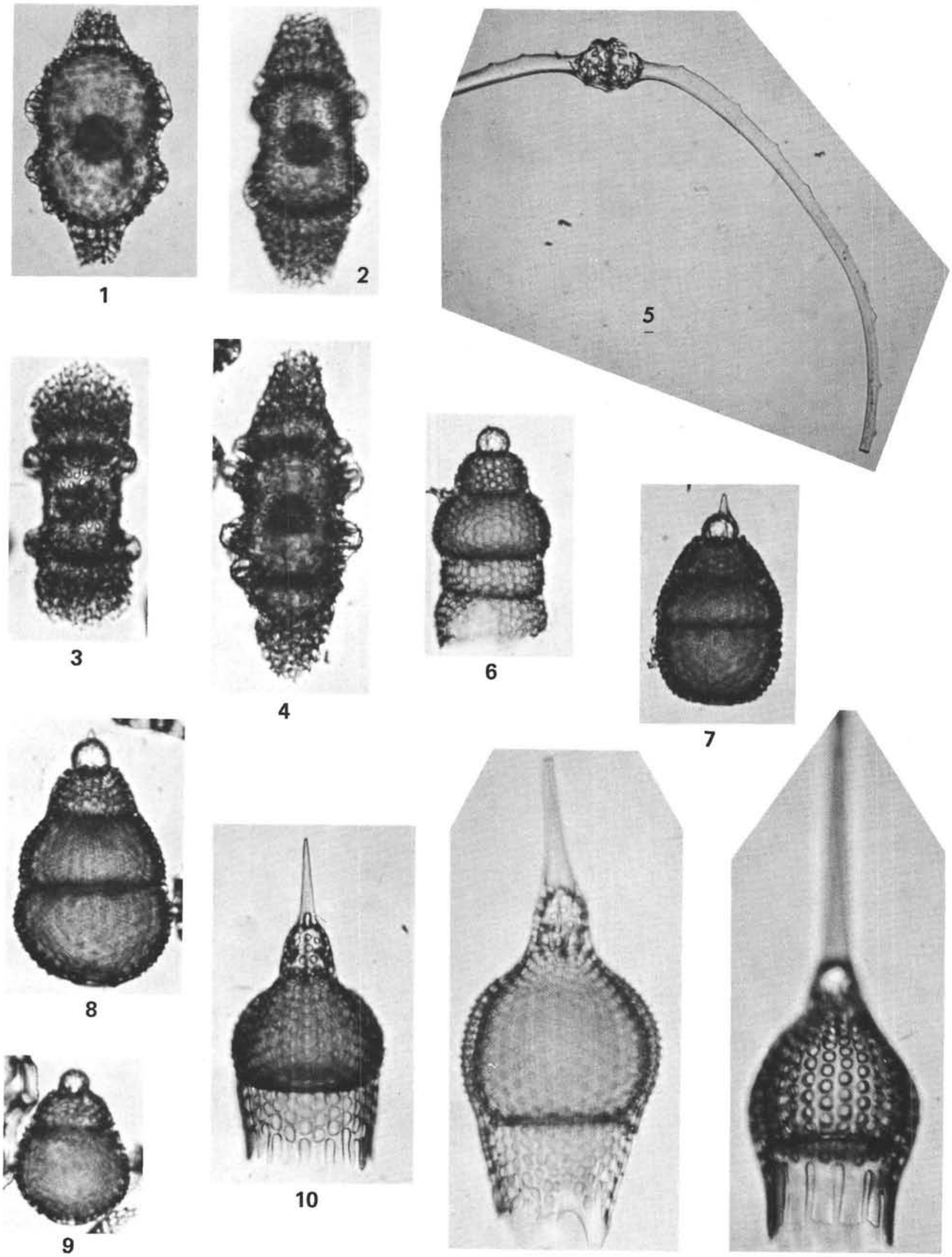

Plate 14.

PLATE 15

Early Miocene and Pliocene Radiolaria

Figure 1	*Cannartus prismaticus.* 31-10-4. 0-3 cm. USNM 167326; T 50/3; RHS.
Figure 2	*Cannartus tubarius.* JYN V 20P. 457-459 cm. USNM 167327; O 58/2; RHS.
Figure 3	*Spongaster pentas.* LSDH 78P. 520-522 cm. USNM 167328; H 43/3; RHS. Holotype.
Figure 4	*Dorcadospyris ateuchus.* 31-10-4. 0-3 cm. × 150, USNM 167326; B 38/0; RHS.
Figure 5	*Dorcadospyris papilio.* 31-10-3. 0-3 cm. × 150, USNM 167329; D 17/2; LHS.
Figure 6	*Dorcadospyris simplex.* 31-9-3. 0-4 cm. × 150, USNM 167330; F 57/4; RHS.
Figure 7	*Dorcadospyris forcipata.* 31-10-4. 0-3 cm. × 150, USNM 167331; R 44/4; RHS.
Figure 8	*Lychnocanium bipes.* 31-9-Catcher. USNM 167324; L 34/3; RHS.
Figure 9	*Theocyrtis annosa.* 31-10-5. 0-3 cm. USNM 167332; X 58/0; RHS.

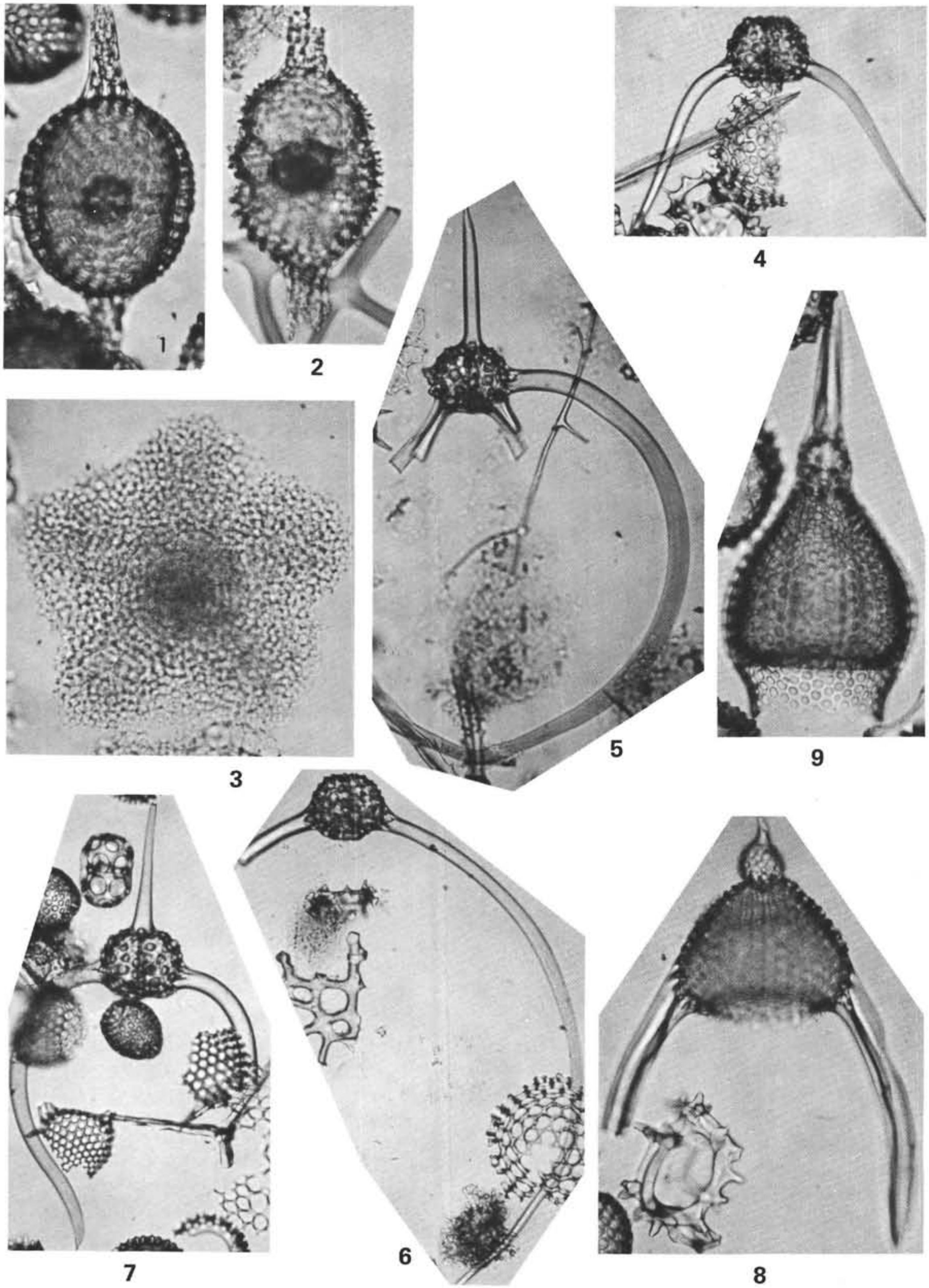

Plate 15.

XI. INDEX OF RADIOLARIAN NAMES

Only genus-group and species-group taxa are indexed. The principal references to thoroughly treated taxa are in italics.