

# TREATISE ON INVERTEBRATE PALEONTOLOGY

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Part C

PROTISTA 2

SARCODINA

CHIEFLY "THECAMOEBIANS" AND FORAMINIFERIDA

By ALFRED R. LOEBLICH, JR., and HELEN TAPPAN

with some systematic descriptions of Foraminiferida by R. WRIGHT BARKER, W. STORRS  
COLE, R. C. DOUGLASS, MANFRED REICHEL, and M. L. THOMPSON

VOLUME 1

THE GEOLOGICAL SOCIETY OF AMERICA  
and  
THE UNIVERSITY OF KANSAS PRESS

1964

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By ALFRED R. LOEBLICH, JR.,<sup>1</sup> and HELEN TAPPAN<sup>2</sup>

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COLE, R. C. DOUGLASS, MANFRED REICHEL, and M. L. THOMPSON as recorded

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VOLUME 1

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aperture terminal, rounded. [Known only from sediments where secondary silicification has occurred, but there associated with secondarily silicified species belonging to the Parathuramminacea and Endothyraea.] *L.Carb.(Visean-Namur.)*, Brit. I.—FIG. 231.11-13. \**L. concinna* (BRADY); 11, 12, side view and sectioned specimen,  $\times 45$  (\*400); 13, side view of holotype,  $\times 50$  (\*193).

**Paratikhinella** REYTLINGER, 1954, \*1561, p. 71 [\**Tikhinella cannula* E. V. BYKOVA, 1952, \*257, p. 32; OD] [= *Earlandinella* CUMMINGS, 1955, \*400, p. 229 (type, *Nodosinella cylindrica* BRADY, 1876, \*193, p. 104)]. Test free, cylindrical, spherical proloculus followed by tapering tubular portion, partially subdivided by incomplete septa produced by inward thickenings of test wall, which is calcareous, finely granular; aperture terminal, rounded. *U.Dev.(Frasn.)*, USSR (Russian Platform); *L.Carb.(Avon.)*, Brit.I.—FIG. 231.4. \**P. cannula* (E. V. BYKOVA), *U.Dev.*; USSR; holotype,  $\times 100$  (\*257).—FIG. 231.5-7. *P. cylindrica* (BRADY), *L.Carb.*, Eng.; 5, lectotype,  $\times 30$  (\*193); 6,7, side view and sectioned specimen,  $\times 30$  (\*400).

**Pseudoglomospira** E. V. BYKOVA in E. V. BYKOVA & POLENOVA, 1955, \*261, p. 30 [\**P. devonica*; OD (M)]. Test consisting of globular proloculus and tubular undivided 2nd chamber which is streptospirally enrolled; wall calcareous, homogeneous, dark, and finely granular; aperture at open end of tube. *Dev.-Carb.*, USSR.—FIG. 231.14. \**P. devonica*, *Dev.*, Sartov Province; section of holotype,  $\times 100$  (\*261).

**Saccaminopsis** SOLLAS, 1921, \*1811, p. 193, 211 [\**Saccamina carteri* BRADY, 1871, \*188, p. 177 (= *Nodosaria fusulinaformis* M'COY, 1849, \*1196, p. 131); OD (M)] [= *Carteria* BRADY in C. MOORE, 1870, \*1306, p. 372 (type not designated) (non *Carteria* DIESING, 1866, non GRAY, 1867; nec SIGNORET, 1874)]. Test free, uniserial, with globular to ovate chambers, and strongly constricted sutures, chambers commonly broken apart in preservation; wall thin, calcareous; aperture terminal, rounded. [Originally regarded as agglutinated, the type-species was restudied by SOLLAS, and shown to be originally calcareous, a secondary silicification and infilling having caused the labyrinthine appearance.] *Ord.-Carb.*, Brit.I.—FIG. 232.1,2. \**S. fusulinaformis* (M'COY); 1, exterior of various specimens,  $\times 2$  (\*193); 2, sectioned specimen,  $\times 16$  (\*1811).

#### Subfamily MORAVAMMININAE Pokorný, 1951

[Moravamininae POKORNÝ, 1951, p. 7]

Test attached, tubular. *M.Dev.-M.Carb.*

**Moravamina** POKORNÝ, 1951, \*1472, p. 7 [\**M. segmentata*; OD] [= *Litya* E. V. BYKOVA in E. V. BYKOVA & POLENOVA, 1955, \*261, p. 27 (type, *L. sizaranensis*)]. Test tubular, attached by proloculus, may be enrolled about attachment, later uncoiled and erect; chambers separated by equally

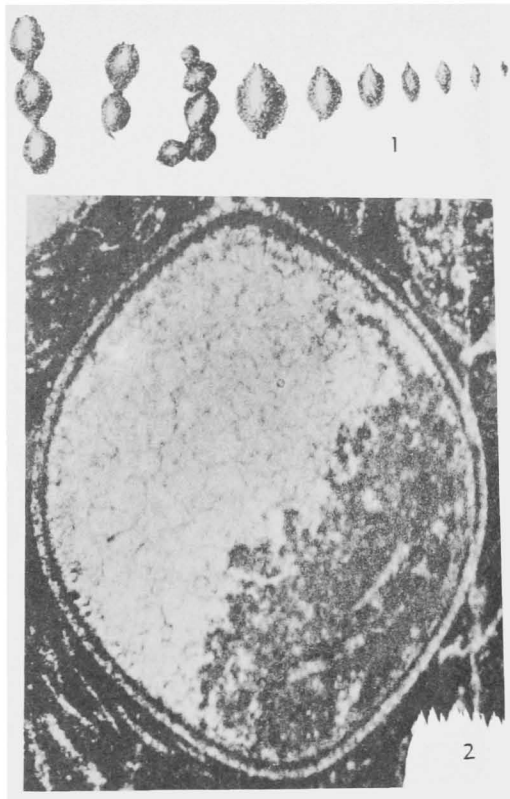


FIG. 232. Moravaminidae (Earlandiinae; 1,2, *Saccaminopsis*) (p. C319).

spaced thin septa; wall calcareous, finely granular; aperture rounded, terminal. [*Litya* was regarded as differing from *Moravamina* in its slight tendency to coil in trochoid manner. Since both are coiled about an attachment, the spires vary considerably and they are here regarded as congeneric.] *M.Dev.(Givet.)*, Czech.; *U.Dev.(Frasn.)*, USSR.—FIG. 233.1. \**M. segmentata*, *M.Dev.*, Czech.; topotype,  $\times 59$  (\*2117).—FIG. 233.2-4. *M. sizaranensis* (E. V. BYKOVA), *U.Dev.*, USSR; 2, holotype; 3a,b, side, edge views of paratype; 4, sec. showing septation; all  $\times 66$  (\*261).

**Kettneramina** POKORNÝ, 1951, \*1472, p. 3 [\**K. givetiana*; OD] [= *Saccorhina* E. V. BYKOVA in E. V. BYKOVA & POLENOVA, 1955, \*261, p. 33 (type, *S. trivirgulina*)]. Test similar to *Moravamina* but with globular proloculus followed by nonseptate tubular 2nd chamber with tendency to bifurcate. *M.Dev.(Givet.) - U.Dev.(Frasn.)*, Czech.-USSR (Russian Platform).—FIG. 233.7. \**K. givetiana*, *M.Dev.(Givet.)*, Czech.; topotype,  $\times 28$  (\*2117).—FIG. 233.8,9. *K. trivirgulina* (E. V. BYKOVA), *U.Dev.(Frasn.)*, USSR; 8, holotype; 9, paratype,  $\times 66$  (\*261).

**Turrispiroides** REYTLINGER in RAUZER-CHERNOUSOVA & FURSENKO, 1959, \*1509, p. 181 [*pro Turrispira*

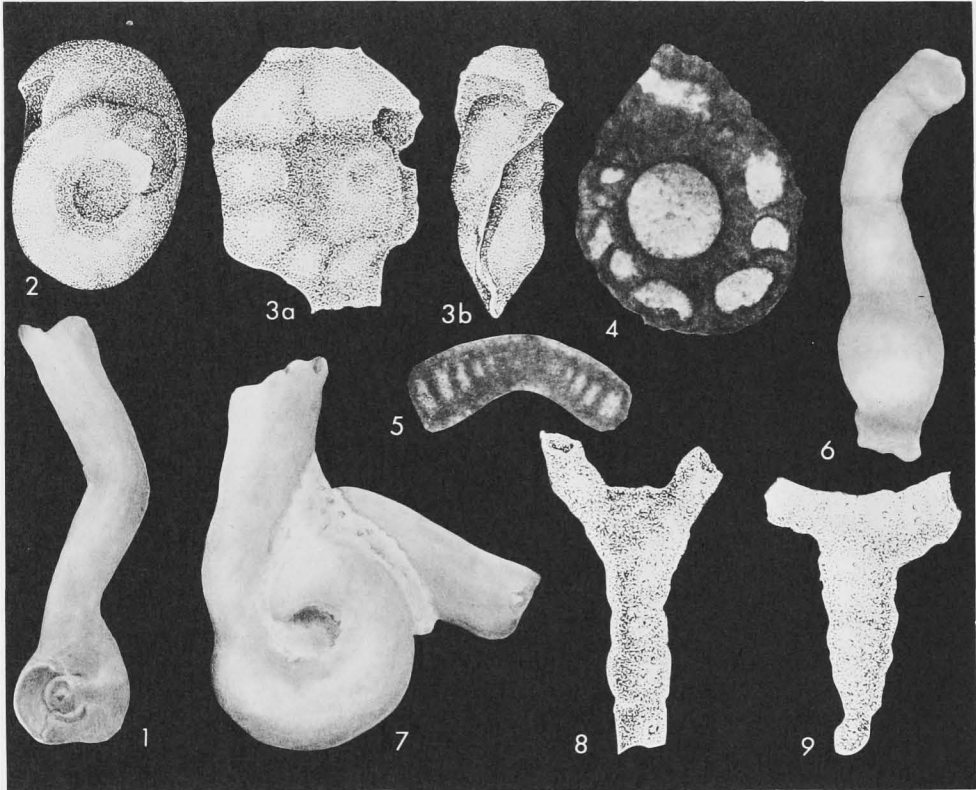


FIG. 233. Moravamminidae (Moravammininae; 1-4, *Moravammina*; 5, *Turrispiroides*; 6, *Vasicekia*; 7-9, *Kettnerammina*) (p. C319-C320).

REYTLINGER, 1950, \*1560, p. 18 (*non* CONRAD, 1866; *nec* PETHO, 1906)] [*\*Turrispira mira* REYTLINGER, 1950, \*1560, p. 19; OD]. Text with proloculus followed by nonseptate tubular 2nd chamber, trochospirally coiled; wall calcareous, finely granular. *M.Carb.*(*L.Moscov.*), USSR (Russian Platform).—FIG. 233.5. *\*T. mira* (REYTLINGER); holotype, sec. showing low spire,  $\times 66$  (\*1509).

*Vasicekia* POKORNÝ, 1951, \*1472, p. 11 [*\*V. moravica*; OD]. Test consisting of elongate tubular segments with bulbous inflated portion near one end, regarded as fragments of originally multilocular test; aperture at open end of tubular portion. [This genus was originally placed in the Reophacidae, but is nonagglutinated and composed of granular calcite, hence here transferred to the Moravammininae. *Vasicekia* is superficially similar to *Moravammina* but has very elongate chambers with swollen area near one extremity.] *M.Dev.*(*Givet.*), Czech.—FIG. 233.6. *\*V. moravica*; topotype,  $\times 86$  (\*2117).

### Superfamily ENDOTHYRACEA Brady, 1884

[*nom. correct.* LOEBLICH & TAPPAN, 1961, p. 284 (*pro* superfamily Endothyridae GLAESSNER, 1945, p. 107)]—[In syn-

onymic citations superscript numbers indicate taxonomic rank assigned by authors (<sup>1</sup>superfamily, <sup>2</sup>family group); dagger(†) indicates *partim*]—[=<sup>1</sup>Orthoklinostegia† EIMER & FICKERT, 1899, p. 685; =Basistomat SCHUBERT, 1921, p. 148; =<sup>2</sup>Archi-Monothalamidia† RHUMBLER in KÜENTHAL & KRUMBACH, 1923, p. 85; =<sup>2</sup>Nodosalidia† RHUMBLER in KÜENTHAL & KRUMBACH, 1923, p. 86; =<sup>2</sup>Rotaliariidia† RHUMBLER in KÜENTHAL & KRUMBACH, 1923, p. 88; =<sup>2</sup>Textulinidia† RHUMBLER in KÜENTHAL & KRUMBACH, 1923, p. 88; =<sup>1</sup>Tournayellidea DAIN in RAUZER-CHERNOUSOVA & FURSENKO, 1959, p. 183]

Tubular or with early trochospiral or irregular coil, biserial or uniserial; interior may be divided into chamberlets, but not labyrinthic; wall calcareous, fibrous or granular, with some arenaceous material included in primitive forms, commonly with 2 layers, finely perforate; aperture simple to multiple, basal or terminal. *L.Sil.-Trias.*

### Family NODOSINELLIDAE Rhumbler, 1895

[Nodosinellidae RHUMBLER, 1895, p. 85]—[All names are of family rank; dagger(†) indicates *partim*]—[=<sup>1</sup>Nodosamminidia† RHUMBLER, 1913, p. 339 (*nom. nud.*); =Nodosinellida COPELAND, 1956, p. 186 (*nom. van.*); =Tuberitiniidae MIKLUKHO-MAKLAY, 1958, p. 134]

Test tubular or uniserial; wall structure compound, of microgranular calcite with inner fibrous layer. *L.Sil.-Perm.*

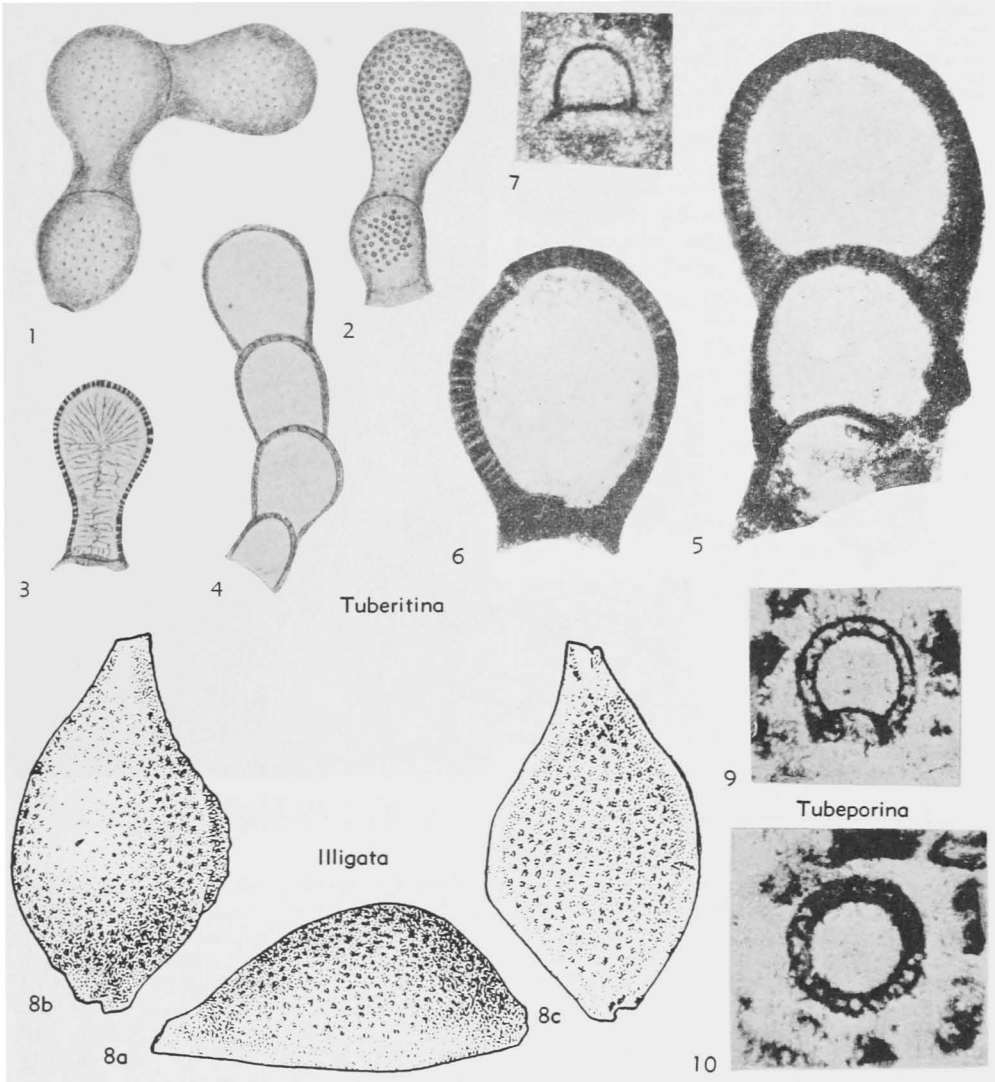


FIG. 234. Nodosinellidae (Tuberitinae; 1-7, *Tuberitina*; 8, *Illigata*; 9,10, *Tubeporina*) (p. C321-C322).

**Subfamily TUBERITININAE**  
Miklukho-Maklay, 1958

[*nom. transl.* LOEBLICH & TAPPAN, 1961, p. 284 (ex family Tuberitinae MIKLUKHO-MAKLAY, 1958)]

Test attached, consisting of one or more subhemispherical chambers, no distinct aperture. *L.Sil.-U.Carb.*

**Tuberitina** GALLOWAY & HARLTON, 1928, \*763, p. 346 [\**T. bulbacea*: OD] [= *Capidulina* MASLOV, 1935, \*1231, p. 11 (type, *C. hemispherica*); *Paratuberitina* A. D. MIKLUKHO-MAKLAY, 1957, \*1267, p. 95 (type, *Tuberitina collosa* REYTLINGER, 1950, \*1560, p. 89); *Neotuberitina* POYARKOV, 1957, \*1480, p. 33, 36 (*nom. nud.*); *Neotuberitina* A. D.

MIKLUKHO-MAKLAY, 1958, \*1269, p. 134 (type, *Tuberitina maljavkini* MIKHAYLOV, 1939, \*1260, p. 48); *Eotuberitina* POYARKOV, 1957, \*1480, p. 33, 35 (*nom. nud.*); *Eotuberitina* A. D. MIKLUKHO-MAKLAY, 1958, \*1269, p. 134 (type, *Tuberitina maljavkini* REYTLINGER, 1950, \*1560, p. 88, *non Tuberitina maljavkini* MIKHAYLOV, 1939, = *Eotuberitina reitlingerae* A. D. MIKLUKHO-MAKLAY, 1958)]. Test attached, to 1.2 mm. in length; proloculus in form of basal disc, later bulbous chambers in rectilinear or curved series, increasing gradually in size as added; wall thick, calcareous, granular and finely perforate, surface commonly punctate; no aperture or intercameral connection except for wall perforations. *U.Dev.*,

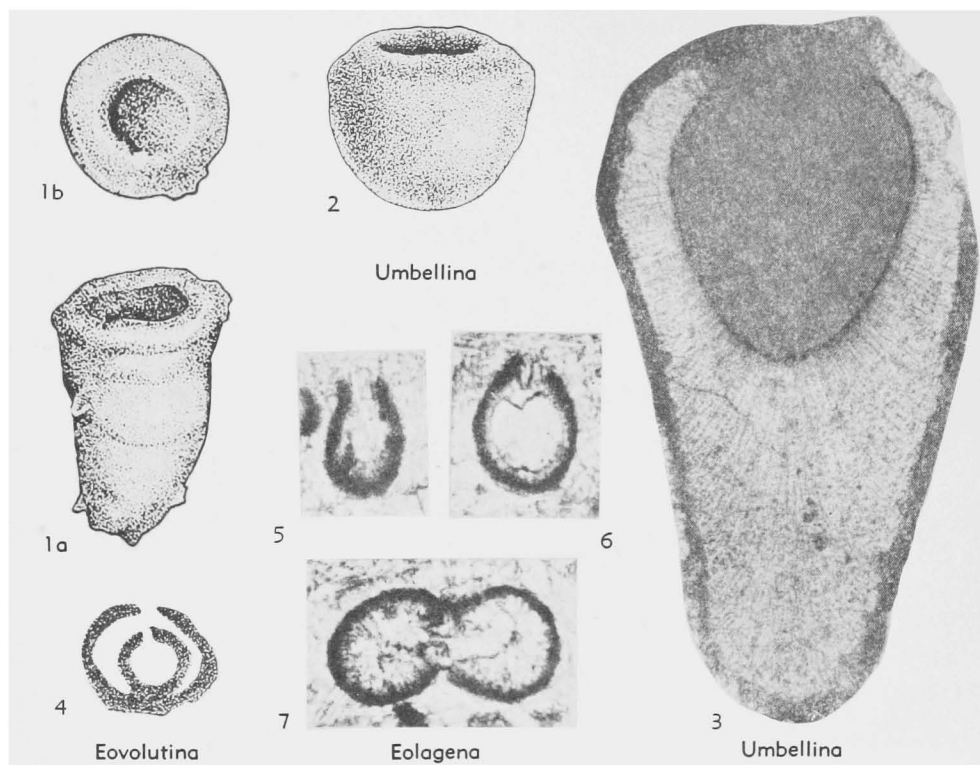


FIG. 235. Nodosinellidae (Umbellinae; 1-3, *Umbellina*; 4, *Eovolutina*; 5-7, *Eolagena*) (p. C322-C323).

USSR; *U.Carb.(Penn.)*, N.Am.; *L.Perm.*, USSR.  
 —FIG. 234,1-4. \**T. bulbacea*, Penn., USA (Okla.); 1, holotype; 2, specimen showing distinctly punctate surface; 3,4, thin secs. showing perforate wall; all  $\times 35$  (\*763).—FIG. 234,5,6. *T. collosa* REYTLINGER, M.Carb.(U.Moscov.), USSR; holotype and paratype,  $\times 90$  (\*700).—FIG. 234,7. *T. veitlingerae* (A. D. MIKLUKHO-MAKLAY), M.Carb., USSR; holotype,  $\times 90$  (\*1560).

***Illigata*** E. V. BYKOVA, 1956, \*258, p. 21 [*I. annae*; OD]. Test unilocular, ovate, attached by one side, shape and convexity of test influenced by substratum; wall calcareous, perforate, smooth; aperture rounded, somewhat produced, at one end of elongate test. *L.Sil.*, Baltic.—FIG. 234,8. \**I. annae*, Lith.; 8a-c, side, top, basal views,  $\times 100$  (\*258).

[This genus was originally placed in the Lagenidae by BYKOVA, and transferred to the Umbellinae by FURSENKO (1959, \*1509, p. 249). Because of its attached nature and perforate wall, it is here placed with the Tubertitinae. BYKOVA (\*258, p. 22) stated that *Thurammia echinata* DUNN from the Silurian of North America appeared similar to *Illigata*. However, as *T. echinata* was obtained from insoluble residues of limestones, its arenaceous nature seems undoubted. *Illigata* is known only from Europe.]

***Tubeporina*** PRONINA, 1960, \*1486, p. 51 [\**T. gloriosa*; OD]. Test attached, single hemispherical to

subglobular chamber, with basal attachment disc; wall thick, calcareous, with 3 layers; aperture consisting of coarse perforations through wall. [*Tubeporina* differs from *Tubertina* in having a 3-layered wall.] *M.Dev.(Givet.)*, USSR (Ural Mts.).—FIG. 234,9-10. \**T. gloriosa*; 9, vert. sec. of holotype showing thick 3-layered chamber wall and attachment disc; 10, horiz. sec., showing coarse perforations,  $\times 150$  (\*1486).

#### Subfamily UMBELLININAE Loeblich & Tappan, 1961

[Umbellininae LOEBLICH & TAPPAN, 1961, p. 284 (nom. subst. pro subfamily Umbellinae FURSENKO in RAUZER-CHERNOUSOVA & FURSENKO, 1959, p. 248)]

Test free, globular or flask-shaped. *Sil.-Dev.*

***Umbellina*** LOEBLICH & TAPPAN, 1961, \*1177, p. 284 [*pro Umbella* MASLOV, 1955 in E. V. BYKOVA & POLENOVA, 1955, \*261, p. 40 (non d'ORBIGNY, 1841; nec SCUDDER, 1882)] [\**Umbella bella* MASLOV in E. V. BYKOVA & POLENOVA, 1955, \*261, p. 37; OD]. Test free, single globular to subconical chamber; wall calcareous, thick, with 2 layers, inner dark finely granular layer and outer radially perforated layer; aperture simple, rounded, may be slightly produced. *Dev.*, USSR (Russian

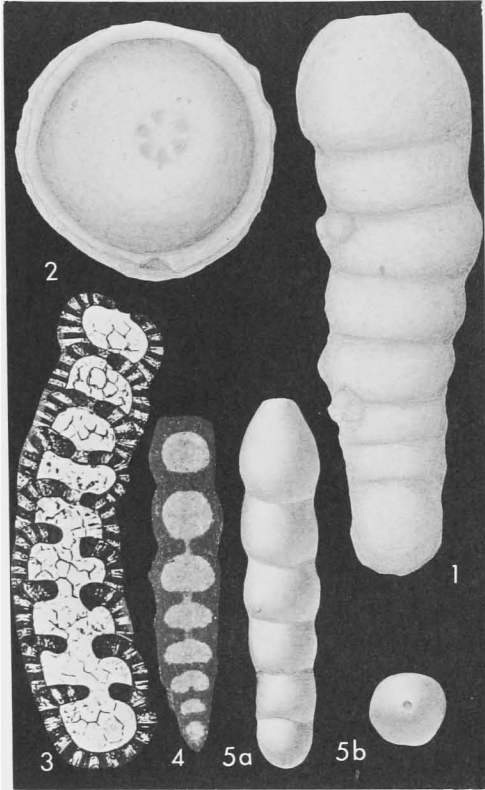


FIG. 236. Nodosinellidae (Nodosinellinae; 1-5, *Nodosinella*) (p. C323-C324).

Platform-W.Urals-Kazakh.).—FIG. 235,1-3. \**U. bella* (MASLOV); 1a,b, side, top views of elongate specimen,  $\times 85$ ; 2, side view of subglobular form,  $\times 100$ ; 3, long. sec. of large specimen showing thick radially perforate wall,  $\times 100$  ( $\times 261$ ).

**Eolagena** LIPINA, 1959, \*1144, p. 825 [\**E. minuta*; OD]. Test ovoid, pyriform, or flask-shaped; wall calcareous, with 2 layers, internal radial layer and outer finely granular layer, aperture simple rounded opening. [*Eolagena* is similar to *Umbellina* in general appearance but much smaller, and the wall structure is different. *Eolagena* is thinner walled, with thin radial internal layer, and thicker external granular layer, whereas *Umbellina* has an extremely thick wall, with thick outer radial layer and thin inner granular layer.] *U.Sil.* (*Ludlov.*), USSR (Sib.).—FIG. 235,5-7. \**E. minuta*; 5, long. sec. of holotype; 6,7, sectioned paratypes; all  $\times 140$  (\*1144).

**Eovolutina** ANTROPOV, 1950, \*25, p. 29 [\**E. elementa*; OD]. Test globular, with 2 chambers, later (outer) chamber completely overlapping proloculus; wall calcareous; aperture simple, at one end of chamber. *M. Dev.* (*Givet.*) - *U. Dev.* (*Frasn.-Famenn.*), USSR.—FIG. 235,4. \**E. elementa*, Frasn.; sectioned specimen,  $\times 140$  (\*1509).

[Originally placed questionably in the Lagenidae, *Eovolutina* was later transferred to the Parathuramminidae. As the aperture is only at one end of the test, rather than absent or with multiple irregularly scattered openings, the genus is here placed tentatively in the Umbellininae. The characteristic fibrous wall of this group has not been noted for *Eovolutina*; the wall has been described as "obscure."]

#### Subfamily NODOSINELLINAE Rhumbler, 1895

[*nom. transl.* LOEBLICH & TAPPAN, 1961, p. 285 (ex family Nodosinellidae RHUMBLER, 1895)]

Test free, uniserial; wall compound, of microgranular calcite with inner fibrous layer. *U.Dev.-Perm.*

**Nodosinella** BRADY, 1876, \*193, p. 102 [\**N. digitata*; SD MILLER, 1889, \*1283, p. 161] [= *Monogenerina* SPANDEL, 1901, \*1822, p. 179 (type, *M. atava*); *Arnodosinum* RHUMBLER, 1913, \*1572b, p. 442 (type, *Nodosinella digitata* BRADY, 1876, \*193, p. 103), SD LOEBLICH & TAPPAN, herein (obj.); *Nodosaroum* RHUMBLER, 1913, \*1572b, p. 443 (type, *Nodosaria index* EHRENBERG, 1854, \*680, p. xxxvii, xi); *Arnodosaroum* RHUMBLER, 1913, \*1572b, p. 443 (type, *A. indictoum*, *nom. van. pro Nodosaria index* EHRENBERG, 1854); *Spandelina* (*Spandelinoides*) CUSHMAN & WATERS, 1928, \*539, p. 367 (type, *S. (S.) nodosarifformis*); *Eonodosaria* LIPINA, 1950, \*1142, p. 126 (type, *E. evlanensis*); *Tikhinella* E. V. BYKOVA, 1952, \*257, p. 29 (type, *T. measpis*); *Protonodosaria* GERKE, 1959, \*779, p. 42 (type, *Nodosaria proceriformis* GERKE, 1952)]. Test free, uniserial, straight or arcuate; septa straight or slightly domed; wall calcareous, outer layer microgranular, inner layer radially striate or fibrous and finely perforate; aperture rounded, at open end of tube. *U.Dev.-Perm.*, Eu.-N.Am.—FIG. 236, 1,2; 237,1. \**N. digitata*, Perm., Eng.; 236,1, lectotype (BMNH-P41657) redrawn,  $\times 48$ ; 236,2, top view of broken paratype (BMNH-P41658) showing apparently multiple aperture in septum, not terminal face,  $\times 48$  (\*2117); 237,1a, diagram.

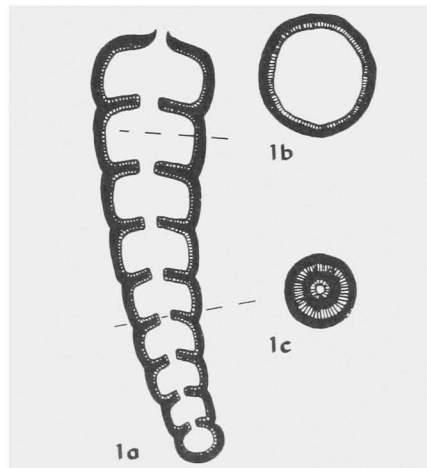


FIG. 237. Nodosinellidae (Nodosinellinae; 1, *Nodosinella*) (p. C323-C324).

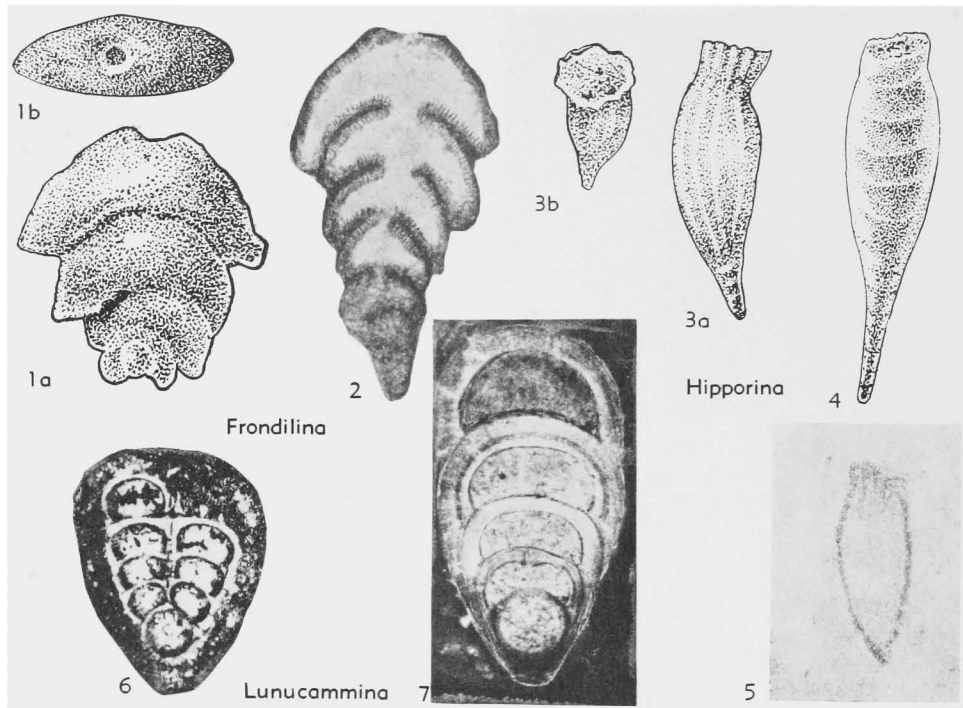


FIG. 238. Nodosinellidae (Nodosinellinae; 1,2, *Fronidilina*; 3-5, *Hipporina*; 6,7, *Lunucammina*) (p. C324-C326).

long. sec.,  $\times 25$ ; 237,1*b,c*, transv. secs. through chamber and septum,  $\times 25$  (\*400).—FIG. 236, 3. *N. index* (EHRENBERG), L. Carb.(Kohlenkalk), USSR, sec. showing radially fibrous wall, approx.  $\times 28$  (\*1572*b*).—FIG. 236,4. *N. measpis* (BYKOVA), U.Dev., USSR; long. sec. of holotype,  $\times 80$  (\*257).—FIG. 236,5. *N. nodosariiformis* (CUSHMAN & WATERS), Perm., USA (Tex.); 5*a,b*, side, top views of paratype,  $\times 47$  (\*2117).

[When restudying the original types of *N. digitata* in the British Museum (Natural History), we noted an apparent multiple aperture on the domed surface of one of the paratypes, a broken specimen, here redrawn. The true apertures of the terminal face appear only to be simple, however, and the apparent multiple aperture may be that of an abnormal specimen. CUMMINGS (\*400, p. 225) noted that the outer microgranular layer of the wall might be altered to recrystallized calcite of irregular grain size, a feature which has led to statements that the test was agglutinated. *Nodosaroum* was defined by RUMBLER for the calcareous *Nodosaria index*, as he believed *Nodosinella* to be an arenaceous genus. As redefined by CUMMINGS (\*400) on the basis of the type-species, the wall of *Nodosinella* is calcareous and distinctly fibrous in appearance. *Spandelinoidea* was originally described as a subgenus of *Spandelina*, but because of the rounded section is here regarded as synonymous with *Nodosinella*. *Spandelina* is a synonym of *Lunucammina*. *Tikhinella* was regarded by POKORSY (1958, \*1478, p. 174) as similar to *Earlandinita*. The radial structure mentioned as occurring in a number of species of *Tikhinella* suggests the fibrous structure of *Nodosinella*, hence *Tikhinella* is here regarded as synonymous with *Nodosinella*.]

**Fronidilina** E. V. BYKOVA, 1952, \*257, p. 24 [*\*F. devexis*; OD]. Test similar to *Lunucammina*, with more strongly overlapping chambers, wall with dark, finely granular homogeneous outer layer

and thicker, radially striate, light inner layer; septa with 3 layers, of which 2 are light and 1 dark. [The wall structure is the reverse of that found in *Lunucammina*, as the granular layer is the outer one in *Fronidilina*, whereas the inner layer is granular in *Lunucammina*. Permian specimens referred to *Fronidularia* (\*1264) belong to *Fronidilina*.] U.Dev.(Frasn.)-Perm., USSR (Urals).—FIG. 238,1,2. *\*F. devexis*; 1*a,b*, side, top views of holotype,  $\times 100$ ; 2, long. sec. of paratype,  $\times 115$  (\*257).

**Hipporina** E. V. BYKOVA in E. V. BYKOVA & POLENOVA, 1955, \*261, p. 36 [*\*H. hastila*; OD] [= *Hypporina* E. V. BYKOVA in E. V. BYKOVA & POLENOVA, 1955, \*261, p. 36, 37 (*nom. null.*)]. Test free, elongate, fusiform, with uniserial arrangement of rapidly enlarging chambers, final chamber constricted toward aperture; wall calcareous, surface may be longitudinally ribbed; aperture cribrate on terminal surface. [Originally placed in the Lagenidae (=Nodosariidae), *Hipporina* is here tentatively placed with the Nodosinellidae, although details of the wall structure are unknown.] U.Dev.(Frasn.), USSR (Russian Platform-Urals).—FIG. 238,3-5. *\*H. hastila*; 3*a,b*, side and oblique top views of holotype; 4, paratype; 5, sectioned specimen; all  $\times 100$  (\*261). **Lunucammina** SPANDEL, 1898, \*1821, p. 8 [*\*Geinitzella (Lunucammina) permiana*; OD] [= *Geinitz-*



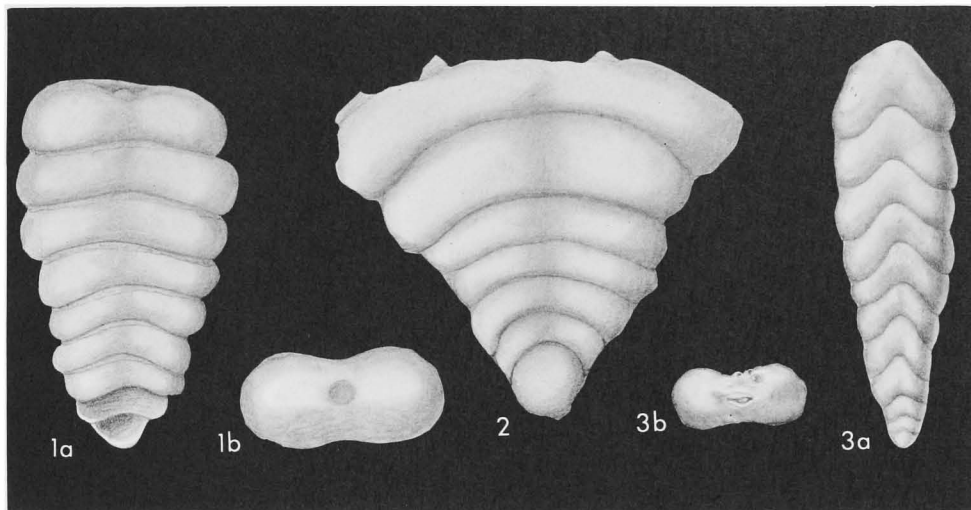


FIG. 239. Nodosinellidae (Nodosinellinae; 1-3, *Lunucammmina*) (p. C324-C326).

*zella* (*Lunucammmina*) SPANDEL, 1898, \*1821, p. 8 (obj.); *Geinitzella* SPANDEL, 1898, \*1821, p. 7 (type, *Textularia cuneiformis* JONES in KING, 1850, \*1039A, p. 18 (non *Textularia cuneiformis* D'ORBIGNY, 1826), = *Textularia jonesi* BRADY, 1876, \*193, p. 133) (non *Geinitzella* WAAGEN & WENTZEL, 1866); *Padangia* LANGE, 1925, \*1091, p. 228 (type, *P. perforata*) (non *Padangia* BABOR, 1900; nec WERNER, 1924); *Geinitzina* SPANDEL, 1901, \*1822, p. 189 (nom. subst. pro *Geinitzella* SPANDEL, 1898); *Spandelina* CUSHMAN & WATERS, 1928, \*539, p. 363 (type, *S. excavata*); *Eogeinitzina* LIPINA, 1950, \*1142, p. 124 (type, *E. devonica*); *Neogeinitzina* K. V. MIKLUKHO-MAKLAY, 1954, \*1277, p. 34 (type, *N. orientalis*). Test free, elongate, uniserial, compressed, commonly with median longitudinal depression which in slightly tangential sections gives pseudobiserial appearance; chambers broad, low, arched as in *Lingulina* or *Fronidularia*; wall calcareous, with microgranular inner layer and radially striate outer layer; aperture terminal, rounded to ovate. U.Dev.-Perm., N.Am.-Eu.-Malay Arch.-Australia. —FIG. 239.1. \**L. permiana* SPANDEL, Perm. (Zech.), Ger.(Thuringia); 1a,b, side, top views of topotype (BMNH-P41666, labeled *Geinitzina jonesi*) partially embedded in limestone slab,  $\times 105$  (\*2117). —FIG. 239.2. *L. jonesi* (BRADY), Perm., Eng.; side view (BMNH-P35421),  $\times 105$  (\*2117). —FIG. 239.3. *L. excavata* (CUSHMAN & WATERS), Perm., USA(Tex.); side, top views of holotype,  $\times 86$  (\*2117). —FIG. 238.6. *L. orientalis* (K. V. MIKLUKHO-MAKLAY), U.Perm., C.Caucasus; slightly tang. long. sec. of holotype, with median long. depression of test resulting in false suggestion of median septum or internal tube,  $\times 65$  (\*1277). —FIG. 238.7. *L. perforata* (LANGE), M.Perm., Indonesia; lat. long., but not axial sec.,  $\times 30$  (\*1091).

[*Lunucammmina* was originally described as a subgenus of *Geinitzella*, differing in being slightly depressed only on one face, the other being slightly convex; it was regarded as a distinct genus by LANGE (1925, \*1091) and others. This minor difference is not considered to be generic, or even subgeneric, in importance. *Lunucammmina* dates from 1898, and thus has priority over *Geinitzina*, described in 1901 as a replacement for the homonym *Geinitzella*; genera and subgenera are of equivalent status for purposes of priority. In the original description and in later publications by SPANDEL, this genus was described as uniserial. BRADY, however, had thought *Textularia jonesi*, the type-species of *Geinitzella*, to be biserial, partially on the basis of very diagrammatic drawings of German specimens sent to him by RICHTER (\*193, pl. 10, figs. 21-22). BRADY stated (\*193, p. 133), however, that "The singular feature of all, whether English or German, consists in the arrangement of the chambers, the two series being almost exactly opposite, instead of alternating with each other. This is so uniform a character that a doubt has more than once occurred to me whether the specimens were actually *Textulariae*—whether they might not belong to some unknown broad variety of one of the uniserial types, the depressed median line being in reality a fracture, the result of pressure on a very thin shell-wall." The type-specimen of *Textularia cuneiformis* JONES, 1850, is apparently not preserved. The German specimens of *Textularia jonesi* BRADY, sent by RICHTER, now in the Brady collection of the British Museum (Natural History), do not show any biseriality. All are in limestone, but one (BMNH-P41666) (\*193, pl. 10, fig. 20), here redrawn, was on the edge of a slab of limestone from the Permian Zechstein of Thuringia. Thus the end could be cleaned, and from the top a single chamber can be seen, slightly depressed on each side, the furrow giving the impression of a median septum in specimens broken open and seen from the interior, or in slightly tangential sections. The single English specimen in the Brady collection (BMNH-P35421) (\*193, pl. 10, fig. 20) was embedded in limestone and could not be sectioned, but it also appears to be calcareous. It comes from the Lower Magnesian Limestone (Permian), Summerhouse, Durham, and is here redrawn. CUSHMAN & WATERS (1928, \*539, p. 363) apparently followed BRADY in considering *Geinitzina* biserial and described *Spandelina* for the uniserial species. It thus is synonymous with *Lunucammmina*. *Neogeinitzina* was differentiated on the basis of an "internal tube," but was described from thin sections. The original figures of the holotype appear to be of a somewhat tangential longitudinal section, the median external groove of the test giving the erroneous appearance of a median septum, or "apertural tube." Similar sections had led BRADY to regard *Textularia jonesi* as "biserial." Illustrations of other new species (*Geinitzina tcherdynzevi*) sectioned by K. V. MIKLUKHO-MAKLAY show merely a depressed central portion of the septa, reflecting the longitudinal depression in nearly central longitudinal sections. *Neogeinitzina* is thus regarded as a synonym of *Lunucammmina*. Species re-

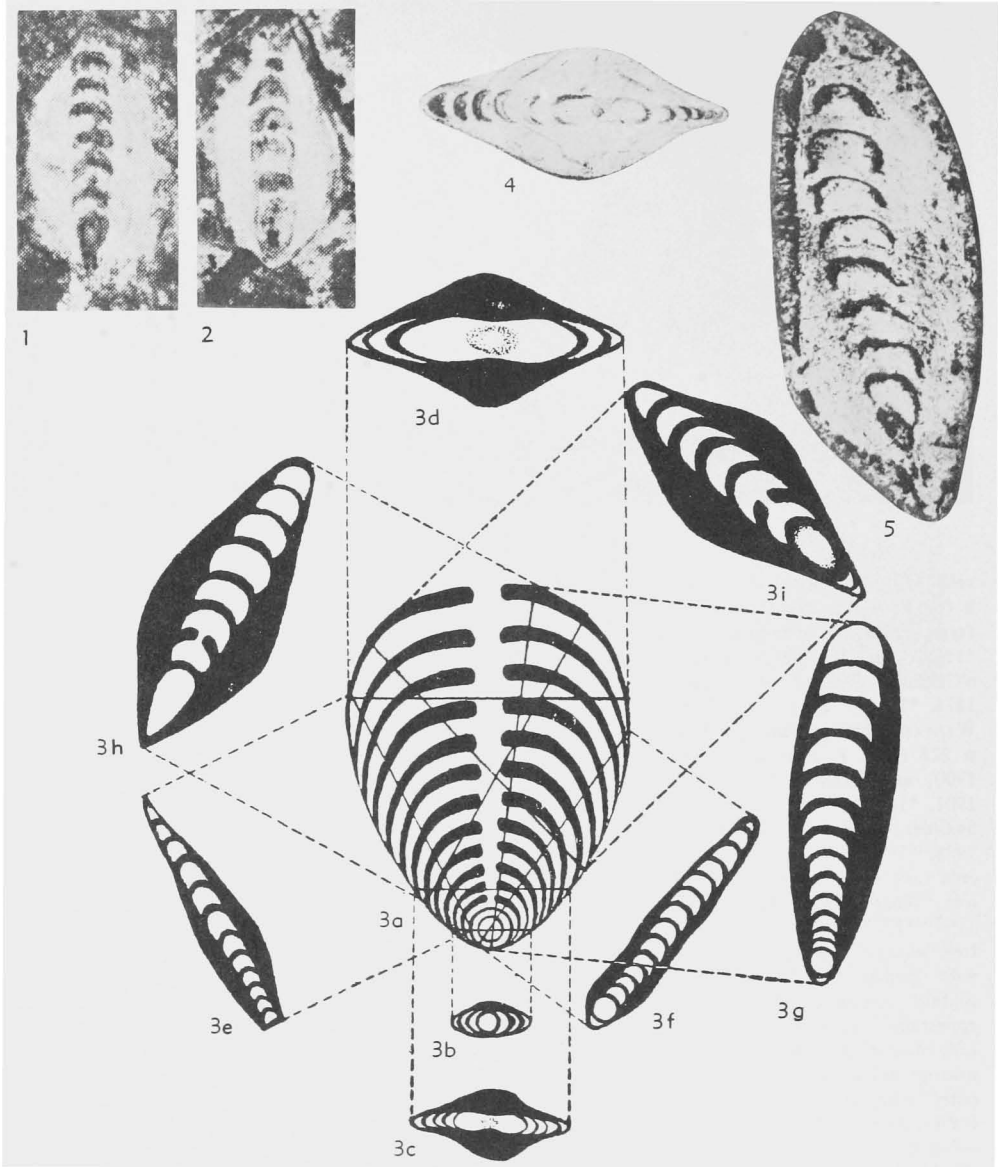


FIG. 240. Nodosinellidae (Nodosinellinae; 1-5, *Pachyphloia*) (p. C326-C328).

ferred to "*Pseudoglandulina*" from the Permian (\*1277) also belong here.]

**Pachyphloia** LANGE, 1925, \*1091, p. 230 [*P. ovata*: SD GALLOWAY, 1933, \*762, p. 172] [= *Parapermodiscus* A. D. MIKLUKHO-MAKLAY, 1953, \*1262, p. 129 (type, *P. gefoensis*); *Parageinitzina* K. V. MIKLUKHO-MAKLAY, 1954, \*1277, p. 61 (type, *P. depressa*); *Parapachyphloia* K. V. MIKLUKHO-MAKLAY, 1954, \*1277, p. 57 (type, *P. asymmetrica*); *Pseudogeinitzina* K. V. MIKLUKHO-MAKLAY, 1954, \*1277, p. 35 (type, *P. magna*)]. Test elongate, compressed, ovate in outline, regu-

larly fusiform to sinuate in horizontal section, consisting of rectilinear series of very broad, low, strongly overlapping chambers; wall calcareous, with radial or fibrous structure, thickened and lamellar, especially at lateral margins, which may be slightly curved, resulting in sinuate section, separate lamellae added with formation of successive chambers; aperture terminal, rounded and with appearance of radial grooves. ?L.Perm., U. Perm., Malay Arch.-USSR.—FIG. 240.1,2. \**P. ovata*, M.Perm., Sumatra; original nonoriented



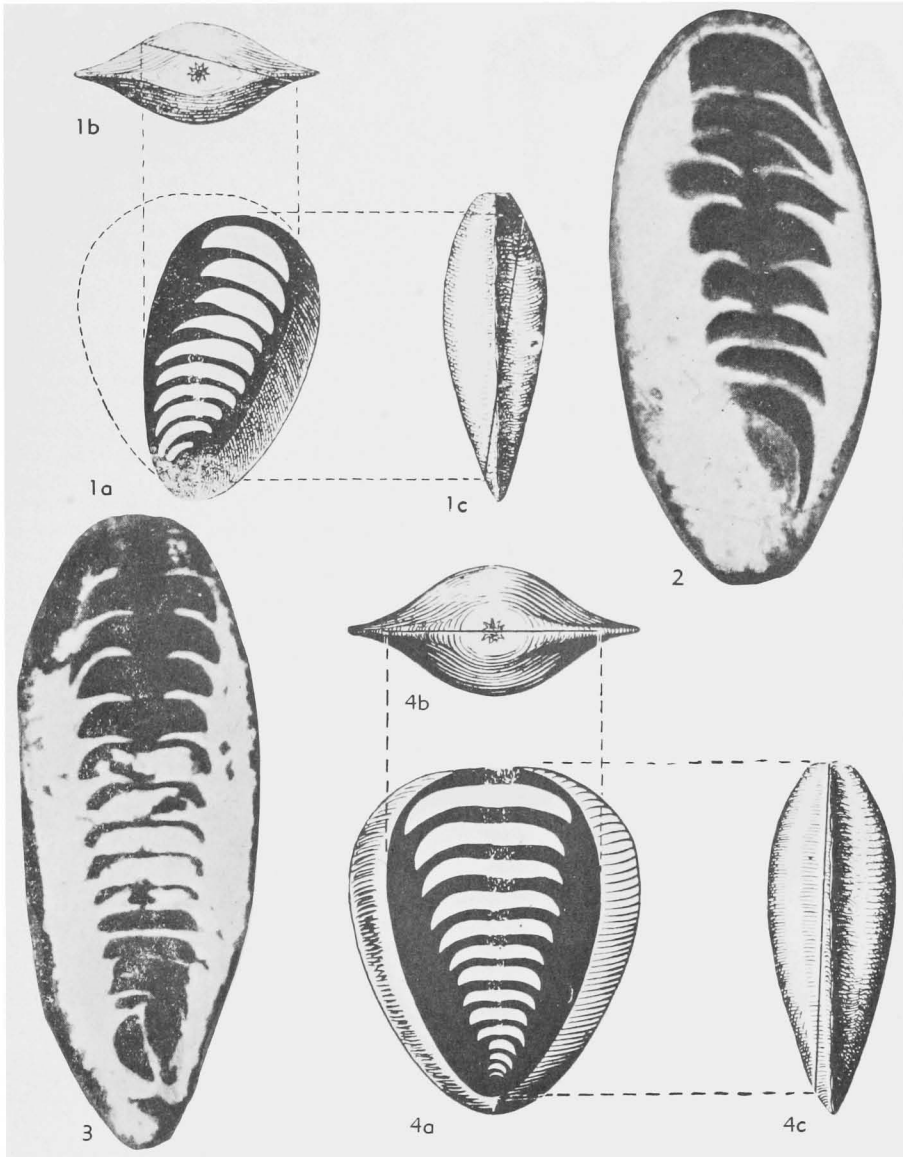


FIG. 241. Nodosinellidae (Nodosinellinae; 1-4, *Pachyphloia*) (p. C326-C328).

lat. secs.,  $\times 90$  (\*1091).—FIG. 240,3. *P.* sp., diagram., showing different appearance of variously oriented sections; 3a, long. sec.; 3b-d, transv. secs. such as were made basis for *Parapermodiscus* and *Pararobuloides*; 3e-g, lat. secs., described as species of *Nodosaria* and *Pachyphloia*; 3h,i, lat. secs. through lamellar thickened area of test, such as original secs. of *Pachyphloia ovata* and those on which *Parapachyphloia* was based (\*1818).—FIG. 240,4. *P. gefoensis* (A. D. MIKLUKHO-MAKLAY), U.Perm., C.Caucasus; transv. sec. (as in 3c) but originally thought to repre-

sent axial sec. of a discoidal genus,  $\times 47$  (\*1262).—FIG. 240,5. *P. asymmetrica* (K. V. MIKLUKHO-MAKLAY), U.Perm., C.Caucasus; holotype, slightly oblique lat. sec. (as in 3g,h),  $\times 47$  (\*1277).—FIG. 241,1. *P.* sp.; 1a-c, diagram showing position of oblique long. secs. such as were made basis for *Parageinitzina* (\*1818).—FIG. 241,2. *P. depressa* (K. V. MIKLUKHO-MAKLAY), U.Perm., C.Caucasus; holotype in oblique long. sec. (as in 1a),  $\times 47$  (\*1277).—FIG. 241,3. *P. magna* (K. V. MIKLUKHO-MAKLAY), U.Perm., C.Caucasus, tang. sec. of holotype (as in 4a),  $\times 65$  (\*1277).—FIG.

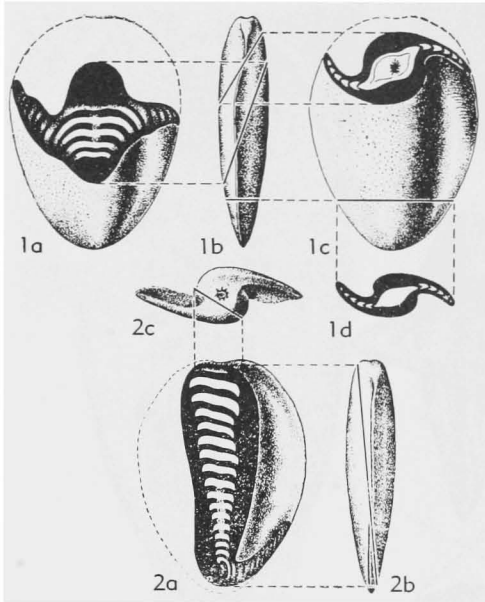


FIG. 242. Nodosinellidae (Nodosinellinae; 1, 2, *Pachyphloia*) (p. C326-C328).

241, 4. *P.* sp.; 4a-c, diagram showing position of slightly tang. long. secs. on which *Pseudogeinitzina* was based (\*1818).—FIG. 242, 1, 2. *P.* sp.; 1a-d, 2a-c, diagrammatic figure of somewhat sinuate specimens showing asymmetry to be expected in nonoriented secs. (\*1818).

[*Pachyphloia* differs from *Lunucammina* in its extremely thickened lamellar walls, and broad low, arcuate chambers. A detailed study of serial sections of *Pachyphloia* by SOSNINA (\*1818, \*1817) showed that nonoriented sections of this form have been referred to 8 different genera, *Nodosaria*, *Pararobuloides*, *Pachyphloia*, *Parapachyphloia*, *Pseudogeinitzina*, *Parageinitzina* and *Parapermodiscus*, of which the last 4 are synonyms of *Pachyphloia*.]

### Family COLANIPELLIDAE Fursenko, 1959

[*nom. transl.* LOEBLICH & TAPPAN, 1961, p. 285 (ex subfamily Colaniellinae FURSENKO in RAUZER-CHERNOUSOVA & FURSENKO, 1959, p. 251)]

Test uniserial, chambers strongly overlapping, internally subdivided by vertical radial partitions; wall of 2 layers, inner layer finely granular, outer layer vitreous; aperture rounded to radiate. *U.Dev.-U. Perm.*

*Colaniella* LIKHAREV, 1939, \*1138, p. 31 [*pro Pyramis* COLANI, 1924, \*354, p. 181 (*non* BOULTEN, 1798; *nec* SCHUMACHER, 1817; *nec* OTTO, 1821; *nec* BROWN, 1827; *nec* PUTZEYS, 1846; *nec* HAECKEL, 1887)] [\**Pyramis parva* COLANI, 1924, \*354, p. 181; OD] [= *Wanganella* SOSNINA in KIPARISOVA, *et al.*, 1956, \*1040, p. 15 (type, *W. ussuriensis*)]. Test elongate, subfusiform to sub-cylindrical, uniserial and rectilinear, with broad,

low and strongly domed chambers which are strongly overlapping for as much as half length of test; interior with radiating secondary interseptal partitions extending nearly to center of test; wall calcareous, finely perforate, and of radial or fibrous appearance; aperture terminal, radiate. *U. Perm.*, IndoChina-Greece-USSR (Caucasus-Pamir).—FIG. 243, 1-3. \**C. parva* (COLANI); 1, reconstr. showing ext. and partial long. and horiz. secs.,  $\times 50$ ; 2, axial sec.,  $\times 100$ ; 3, transv. sec. near middle of test, strongly overlapping chambers resulting in appearance of small chamberlets,  $\times 100$  (\*1517).—FIG. 243, 4, 5. *C. ussuriensis* (SOSNINA), USSR; 4, long. sec. of holotype, slightly oblique at base, nearly tang. toward central part, and lat. oblique toward top of figure; 5, slightly oblique transv. sec.,  $\times 50$  (\*1040).

**Multiseptida** E. V. BYKOVA, 1952, \*257, p. 27 [\**M. corallina*; OD]. Test elongate, uniserial; globular proloculus followed by broad, low, strongly overlapping chambers, as in *Glandulina*; interior of chambers with longitudinal radial partial partitions extending inward from outer wall, which is calcareous, outer wall 2-layered, outer one light colored, semitransparent, with radial striations, inner layer dark, finely granular, homogeneous, vertical partitions and internal thickening around aperture consisting of darker granular material; aperture terminal, rounded. [*Multiseptida* differs from *Colaniella* in its less strongly overlapping chambers, in narrower vertical partitions restricted to the inside wall of chambers, and in a rounded aperture, whereas in *Colaniella* the vertical partitions extend from top to bottom of chambers and the aperture is radiate.] *U.Dev. (Frasn.)*, USSR (Russian Platform).—FIG. 244, 1-3. \**M. corallina*; 1, holotype, long. sec.,  $\times 133$ ; 2, paratype, horiz. sec. showing 2 layers of wall and vertical partial partitions,  $\times 133$ ; 3, diagram. long. sec. showing light outer radial layer of wall, inner dark granular layer, thickened inner layer in ring at aperture, aperture, and radial partial long. partitions, approx.  $\times 123$  (\*257).

### Family PTYCHOCLADIIDAE Elias, 1950

[Ptychocladiidae ELIAS, 1950, p. 288]

Test attached, uniserial and branching or spreading; wall granular, calcareous, banded, with transverse tubuli; no distinct aperture. *Dev.-Perm.*

#### Subfamily PTYCHOCLADIINAE Elias, 1950

[*nom. transl.* LOEBLICH & TAPPAN, 1961, p. 285 (ex family Ptychocladiidae ELIAS, 1950)]

Test uniserial and dichotomously branching, or with branches laterally fused to become discoidal. *U. Penn.*

*Ptychocladia* ULRICH & BASSLER, 1904, \*1966, p. 289 [\**P. agellus*; OD]. Test attached, consisting

of numerous radiating uniserial "branches" of uniserial chambers, extending from common center and bifurcating at irregular intervals; chambers broad and low, with domed septa, broader

chambers may be subdivided internally by interseptal radial partitions; wall calcareous, finely granular, perforated, and with laminar "banding" of thin dark inner layer and thicker light-colored

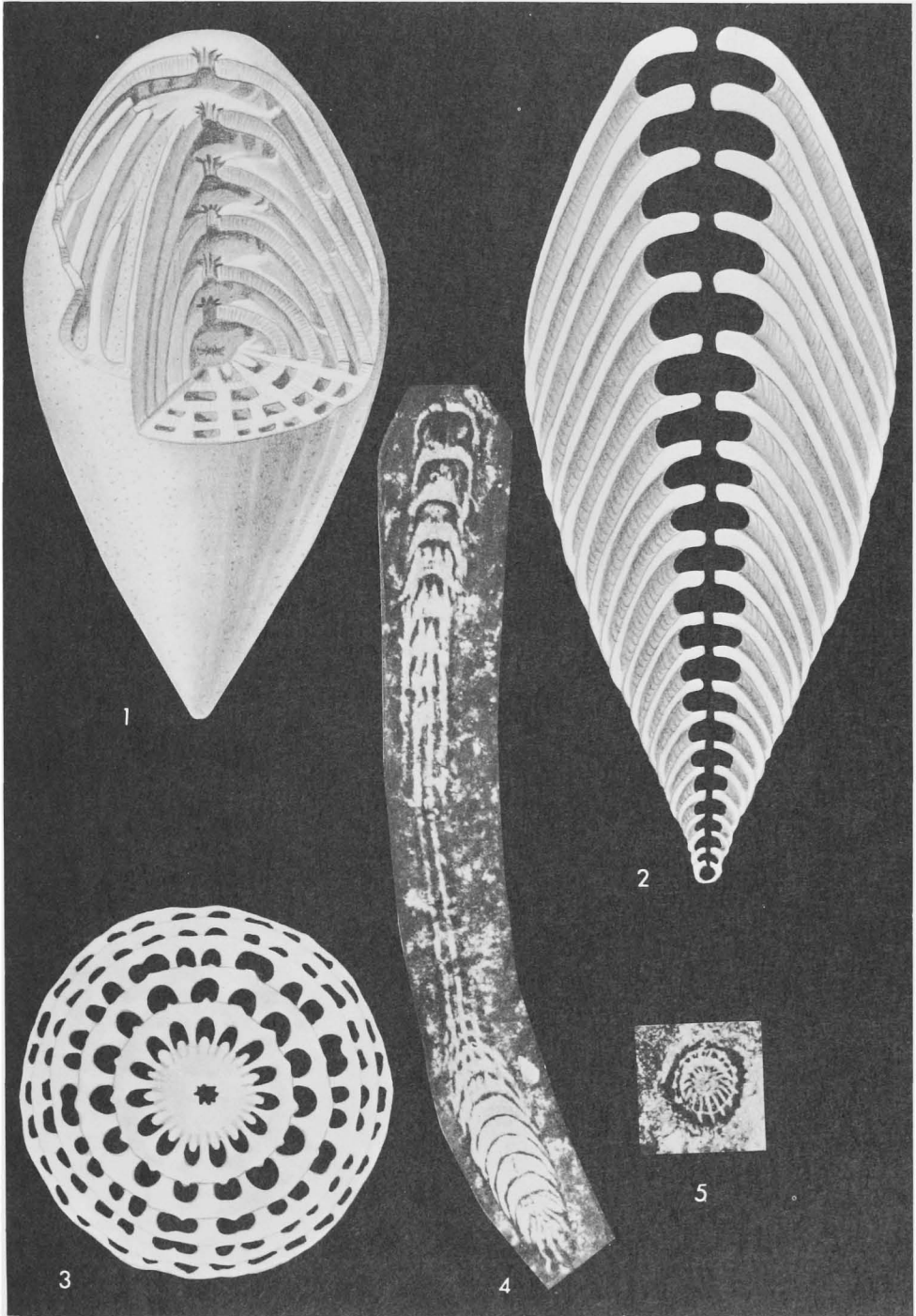


FIG. 243. Colaniellidae; 1-5, *Colaniella* (p. C328).

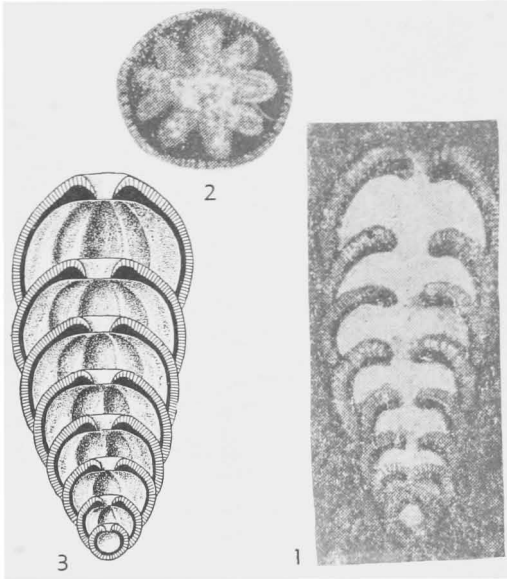


FIG. 244. Colaniellidae; 1-3, *Multiseptida* (p. C328).

layer; no visible aperture. [Originally described as problematical, possibly bryozoan, alga, or foraminifera, *Ptychocladia* was transferred to the Foraminifera by ELIAS, 1950 (\*696)]. *U.Penn.*, N.Am.—FIG. 245, 1-3. \**P. agellus*, USA (Ill.) (1,2), USA (Neb.) (3); 1,2, holotype, paratype,  $\times 9$  (\*1966); 3, specimen,  $\times 20$  (\*696).

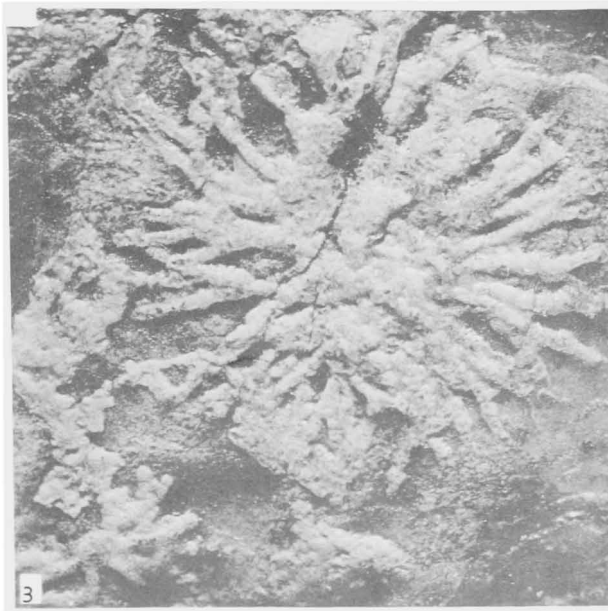


FIG. 245. Ptychocladiidae (Ptychocladiinae; 1-3, *Ptychocladia*) (p. C328-C330).

#### Subfamily STACHEIINAE

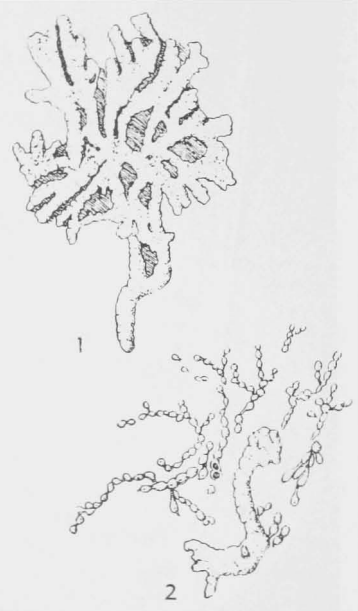
Loeblich & Tappan, 1961

[Stacheiinae LOEBLICH & TAPPAN, 1961, p. 285]

Test attached, spreading, with chambers in sheetlike layers. *Dev.-Perm.*

*Stacheia* BRADY, 1876, \*193, p. 107 [\**S. marginulinoides*; SD CUSHMAN, 1927, \*433, p. 189] [= *Stacheya* DELAGE & HÉROUARD, 1896, \*580, p. 134 (*nom. van.*) (obj.); *Arstachecoum* RHUMBLER, 1913, \*1572b, p. 446 (obj.) (*nom. van.*)]. Test attached during at least part of its development, with central support indicated in some species; early portion spiraling, later uniserial, with low, somewhat embracing chambers that subdivide irregularly into chamberlets with secondary partitions perpendicular to transverse septa, partitions may branch and be so numerous that chamberlets mask basic uniserial structure; sutures of primary chambers show externally as transverse depressions; wall calcareous, granular; surface smooth to quite irregular; aperture simple and rounded, terminal. *L.Carb.*, Eu.-N.Am.—FIG. 246, 1,2. \**S. marginulinoides*, Yoredale, Eng. (Hurst) (1), Eng.(?loc.)(2); 1a,b, side, top views of lectotype (BMNH-P41653 ex P35455, =\*193, pl. 7, fig. 17), redrawn,  $\times 64$  (\*2117); 2, sectioned paratype (BMNH-P35507, =\*193, pl. 7, fig. 21), redrawn,  $\times 64$  (\*2117).

*Aoujgalia* G. TERMIER & H. TERMIER, 1950, \*1882, p. 40 [\**A. variabilis*; OD] [= *Aoujgalia* G. TERMIER & H. TERMIER, 1947, \*1881, p. 146, 271, pl. 5, fig. 46 (*nom. nud.*)]. Test attached, subconical and flattened against attachment, with irregular



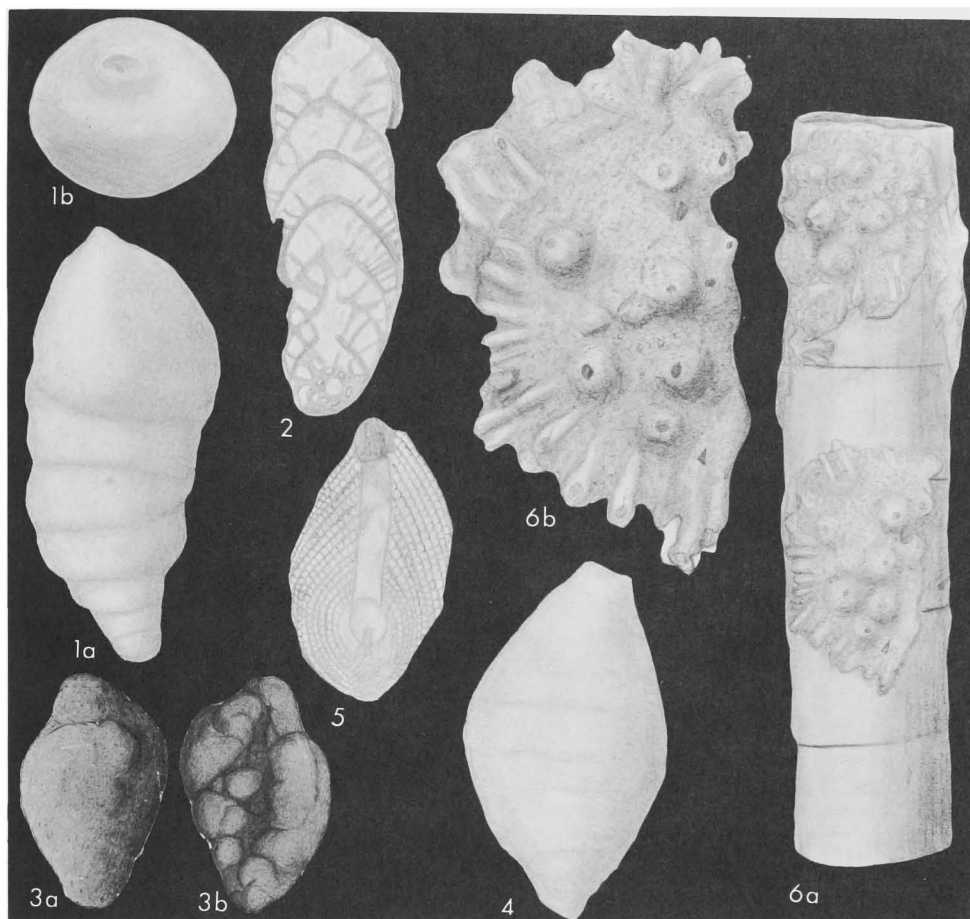


FIG. 246. Ptychoclaidiidae (Stacheiinae; 1,2, *Stacheia*; 3-5, *Fourstonella*; 6, *Stacheoides*) (p. C330-C332).

layers of small chamberlets as in *Stacheoides*, early portion ?planispiral; wall calcareous, fibrous, aperture unknown. *L.Carb.*(*U.Visean*), C.Morocco. —FIG. 247,1,2. \**A. variabilis*, nonoriented secs.,  $\times 40$  (\*1882).

[This genus is poorly known, very little information being available as to details of the wall structure or aperture. It was originally placed in the *Spirillinidae*, but none of that family show such attached, multichambered tests, nor are they composed of fibrous calcite. *Aonigalia* seems closely related to *Stacheia*, *Stacheoides*, and *Fourstonella*. *Stacheia* has a similar irregular or acervuline growth habit, and both primary and secondary septal walls are of equal thickness to that of the chamber roofs and floors. *Stacheia* thus seems closest to *Aonigalia* as far as its characters are known and would preoccupy it if they are found by additional study to be truly congeneric. *Fourstonella* has a distinctive fusiform shape, and regularly arranged chamberlets, the horizontal walls being of greater thickness than the vertical ones. *Stacheoides* has a low encrusting or sheetlike growth form, with mammillate protuberances and vertical chamberlet partitions of different thickness from floor and roofs. All occur in the Carboniferous.]

**Fourstonella** CUMMINGS, 1955, \*398, p. 6 [\**Stacheia fusiformis* BRADY, 1876, \*193, p. 114; OD]. Test attached, commonly to crinoid stems or other

thin columnar foreign objects, possibly encrusting algae, fusiform in outline; composed of many thin layers of small chambers, each layer nearly completely overlapping preceding one and subdivided into minute rectangular chamberlets, no external sutures visible; wall calcareous, finely granular, horizontal walls thicker than vertical secondary partitions, surface granular in appearance, with faint and irregular transverse grooves, possibly reflecting termination of layer of chambers; aperture not evident. [*Fourstonella* differs from *Stacheia* in its low, numerous layers of chambers and distinct chamberlets, with vertical walls thinner than those of horizontal layers. No early spire is present in *Fourstonella*.] *L.Carb.*(*Avon*), Eu.(Eng.). —FIG. 246,3-5. \**F. fusiformis* (BRADY), Northumberland; 3a,b, opposite sides of paratype (Glasgow Univ. Geology Coll. P1001), showing position of former attachment,  $\times 44$  (\*398); 4, lectotype (BMNH-P41654, ex

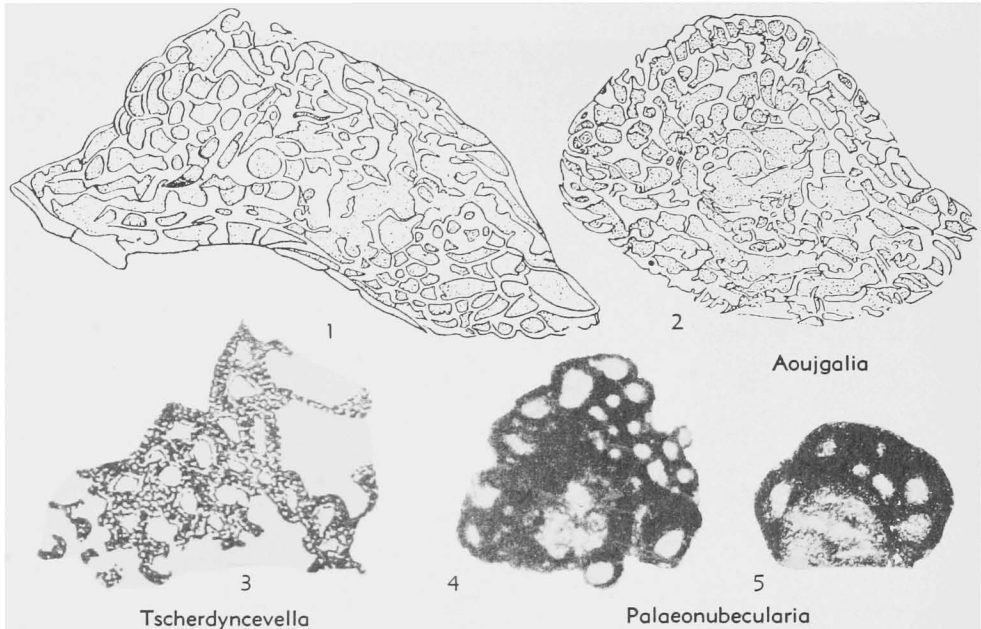


FIG. 247. Ptychocladiiidae (Stacheiinae; 1,2, *Aoujgalia*; 3, *Tscherdyncevella*; 4,5, *Palaeonubecularia*) (p. C330-C332).

P35458), redrawn; 5, sectioned paratype (BMNH-P35509), redrawn; both  $\times 65$  (\*2117).

**Palaeonubecularia** REYTLINGER, 1950, \*1560, p. 91 [*P. fluxa*; OD]. Test attached, consisting of single chamber or of irregular aggregates of chambers; wall calcareous, microgranular, dark, compact. *M.Carb.(Moscov.)-Perm.*, USSR-USA (Kans.).—FIG. 247,4,5. *\*P. fluxa*, *M.Carb.*, USSR (Moscov.); 4, sec. of holotype, 5, paratype,  $\times 46$  (\*1560).

[Possibly *Palaeonubecularia* may be congeneric with *Aoujgalia*, but this is difficult to determine from published descriptions. Both genera were described in 1950, and the actual date (month and day) of publication has not been ascertained, to determine which has priority in the event they are found to be synonymous.]

**Stacheoides** CUMMINGS, 1955, \*399, p. 343 [*Stacheia polytrematoides* BRADY, 1876, \*193, p. 118; OD]. Test attached, encrusting mass irregular in outline, composed of numerous very tiny chamberlets with thickened partitions, small chamberlets clustered around random radiating tubules and forming mammillate protuberances; wall calcareous, finely granular, may have few quartz grains

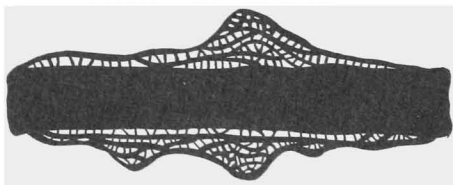


FIG. 248. Ptychocladiiidae (Stacheiinae; *Stacheoides*) (p. C332).

embedded in calcareous material, chamberlet partitions smaller in thickness than roofs and floors; apertures at ends of radiating tubules which form surface protuberances. *L.Carb.*, Eu.(Scot.).—FIG. 246,6; 248. *\*S. polytrematoides* (BRADY), Hosie Ls.; 246,6a,b, lectotype (here refigured, BMNH-P35405, =\*193, pl. 9, figs. 10, 12), attached to crinoid stem,  $\times 10$ ,  $\times 22$  (\*2117); 248, diagram. sec. of chamberlets on an attachment,  $\times 18$  (\*399).

[*Stacheoides* was described as related to *Nubecularia* of the Ophthalmidiidae. It differs from *Stacheia* in including adventitious material in the wall, in having chamberlet walls of different thickness than the roofs and floors, and in having numerous small apertures, instead of a single terminal aperture.]

**Tscherdyncevella** ANTROPOV, 1950, \*25, p. 29 [*\*T. acervulinoides*; OD]. Test free or attached, irregular in form, consisting of one or many acervuline-arranged, successively added chambers; wall calcareous, structure obscure; apertures at base of chambers. *Dev.(Frasn.)*, USSR (Russian Platform).—FIG. 247,3. *\*T. acervulinoides*, Tatar., USSR; sectioned specimen,  $\times 120$  (\*1509).

### Family PALAEOTEXTULARIIDAE Galloway, 1933

[*nom. transl.* WEDEKIND, 1937, p. 79 (ex subfamily Palaeotextulariinae GALLOWAY, 1933, p. 221)]—[dagger(†) indicates *partim*]—[=Dischistidae EIMER & FICKERT, 1899, p. 678 (*nom. nud.*); =Opistho-Dischistidae EIMER & FICKERT, 1899, p. 677 (*nom. nud.*); =Cribrostomatidae WEDEKIND, 1937, p. 79]

Test biserial or may become uniserial; wall granular calcareous, with inner layer



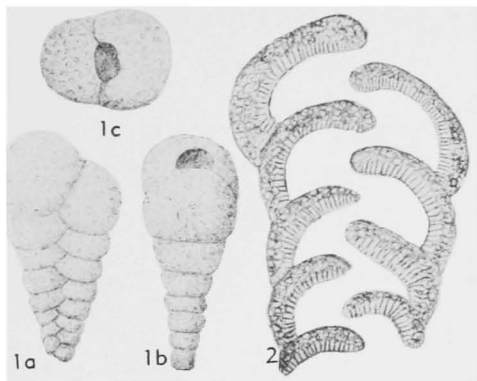


FIG. 249. Palaeotextulariidae; 1,2, *Palaeotextularia* (p. C333).

and thin adventitious coating; aperture simple or multiple. *Carb.-Perm.*

**Palaeotextularia** SCHUBERT, 1921, \*1694, p. 183, 185 [*P. schellwieni* GALLOWAY & RYNICKER, 1930, \*765, p. 20, = *Textularia textulariformis* (MÖLLER) SCHELLWIEN, 1898, \*1644, p. 268 (non *Criboostomum textulariforme* MÖLLER, 1879); SD GALLOWAY & RYNICKER, 1930, \*765, p. 20]. Test free, biserial, as in *Textularia*, but with double-layered calcareous wall, outer finely granular layer and inner radial fibrous layer, and may have small amounts of embedded adventitious material in outer layer; aperture an interiomarginal arch. *Carb.-Perm.*, EU.-N.Am.—FIG. 249,1,2. *P. grahamensis* (CUSHMAN & WATERS), Penn., USA (Okla.); 1a-c, side, edge, and top views,  $\times 35$ ; 2, portion of long. axial sec. showing 2 layers of wall,  $\times 110$  (\*765).

**Climacammina** BRADY in ETHERIDGE, 1873, \*711, p. 94 [*\*Textularia antiqua* BRADY in YOUNG & ARMSTRONG, 1871, \*2097, p. 13; OD (M)] [= *Criboostomum* MÖLLER, 1879, \*1296, p. 39 (type, *C. textulariforme*); *Climacammina* SCUDDER, 1882, \*1709a, p. 77 (nom. van.); *Moellerina* EIMER & FICKERT, 1899, \*692, p. 677 (type, *Criboostomum gracile* MÖLLER, 1879, \*1296, p. 59, non *Moellerina* ULRICH, 1886; nec SCHELLWIEN, 1898); *Deckerella* CUSHMAN & WATERS, 1928, \*538, p. 128 (type, *D. clavata*)]. Test free, large, early portion biserial, later with more or less well-developed uniserial portion; chambers increasing gradually in size, commonly broad, low, sutures depressed; wall calcareous, with 2 layers, inner layer radially fibrous, outer layer granular, and may have agglutinated particles; apertural face of chambers in late biserial and uniserial stages supported by irregular pillars between terminal wall and preceding septum, forming labyrinthic interior; aperture in earliest biserial chambers interiomarginal slit; in later chambers slit supplemented by one or more openings in septal face, gradually becoming nearly termi-

nal in position, and in uniserial stage with 2 or more terminally placed openings, commonly very numerous and covering major portion of terminal face. *L.Carb.(U.Tournais.)-Perm.(Thuring.)*, EU.-N.Am.-Malay Arch.(Sumatra).—FIG. 250,1; 251,1. \**C. antiqua* (BRADY), L.Carb., Scot.; 250, 1a,b, side, top views of hypotype,  $\times 26$  (\*2117); 251,1, diagram. long. axial sec. showing chamber arrangement, 2-layered wall and multiple aperture (\*401).—FIG. 250,2; 251,2. *C. clavata* (CUSHMAN & WATERS), Penn., USA(Tex.); 250,2, side, top views of holotype,  $\times 30$  (\*2117); 251,2, long. axial sec., diagram. (\*401).—FIG. 251,3,4. *C. textulariforme* (MÖLLER), L.Carb.(Visean), USSR, side and long. axial sec.,  $\times 22$  (\*1509).

[Four generic names have been based on species which we consider to belong to *Climacammina*. MÖLLER (1879) described *Criboostomum* with 8 species, of which *C. textulariforme* MÖLLER was later selected as type. CUSHMAN separated *Criboostomum* from *Climacammina* as being completely biserial, but later stated (\*461, p. 111) "These may be only a stage in the development of *Climacammina*." PLUMMER (1945, \*1468, p. 244) stated that the "species" *Criboostomum textulariforme* "is without doubt the immature form of one of the five bifurmed species in the group of eight 'species' recorded in the same paper with the description of *Criboostomum*. *C. commune* MÖLLER is recorded from the same localities as *C. textulariforme* and can well be the mature form of the species." PLUMMER considered *Criboostomum* to differ from *Climacammina* in having irregular, more numerous, and irregularly spaced openings, whereas *Climacammina* had fewer, symmetrically shaped openings. As the original illustrations of *Criboostomum* show only a few regularly spaced rounded pores which closely resemble those of the type-species of *Climacammina*, this distinction apparently fails to separate the two and we here consider *Criboostomum* to be a synonym of *Climacammina*. *Moellerina* was defined by EIMER & FICKERT, the type-species being later designated by CUSHMAN (1928, \*439, p. 120) as *Criboostomum gracile* MÖLLER. This species was originally placed in *Criboostomum* and is typical of that genus. Furthermore, the

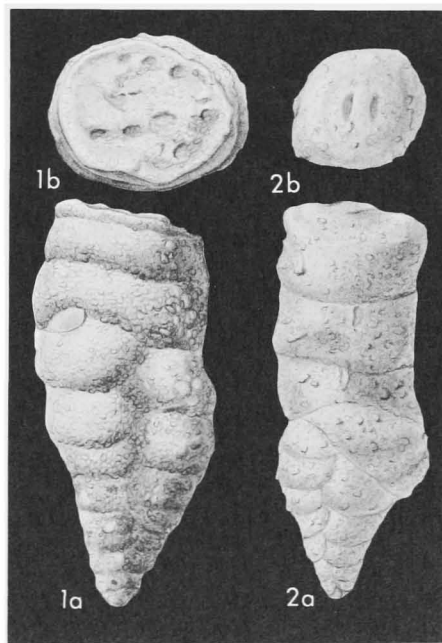


FIG. 250. Palaeotextulariidae; 1,2, *Climacammina* (p. C333-C334).

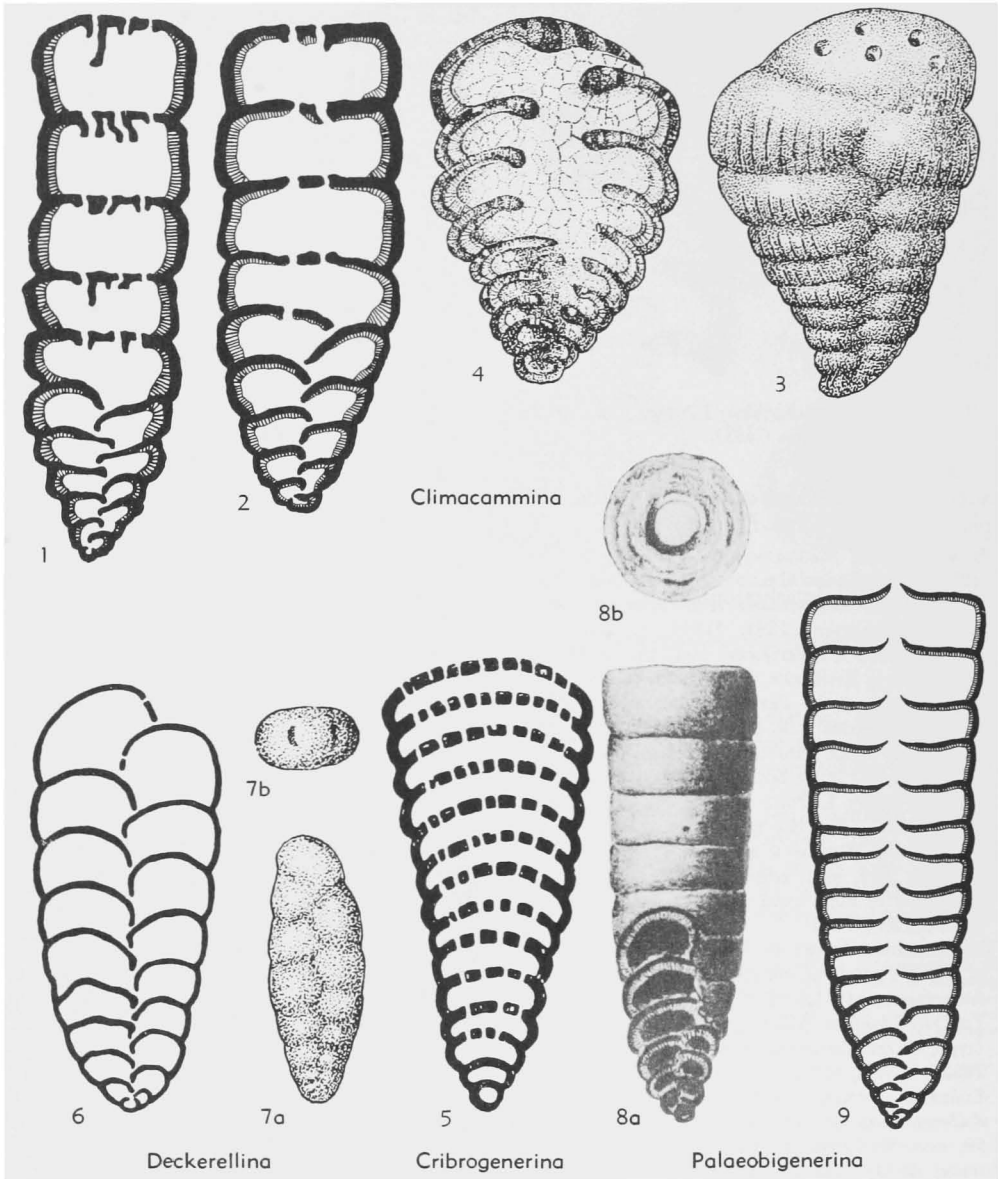


FIG. 251. Palaeotextulariidae; 1-4, *Climacammina*; 5, *Cribrogenerina*; 6, 7, *Deckerellina*; 8, 9, *Palaeobigenerina* (p. C333-C335).

generic name *Moellerina* is a double homonym. *Deckerella* CUSHMAN & WATERS was defined as having only a paired aperture and not a truly multiple one. However, the type-species may have up to 4 openings and other species of *Climacammina* also may show relatively few openings; hence *Deckerella* is here regarded as a synonym of *Climacammina*.]

**Cribrogenerina** SCHUBERT, 1908, \*1687, p. 245 [*\*Bigenerina sumatrana* VOLZ, 1904, \*2024, p. 96 (= *B. sumatrensis*, \*2024, p. 107, 108, 110); OD (M)]. Test free, elongate, uniserial and rectilinear, early portion biserial in microspheric generation,

with 1 or 2 pairs of biserial chambers; chambers broad and low; wall calcareous, with outer granular layer and inner fibrous one; aperture terminal, cribrate, over most of terminal face. ?*U. Carb.*, Perm., Asia (Sumatra-China).—FIG. 251.5. \**C. sumatrana* (VOLZ), Perm., Sumatra,  $\times 8$  (\*700).

[The validity of this genus is questionable. The species regarded by CUMMINGS (1956, \*401) as belonging definitely to *Cribrogenerina* include 3 species described as *Bigenerina* by VOLZ (*B. sumatrana*, *B. leonhardi*, *B. wysogorskyi*). The last named shows a small biserial stage. The 2-layered



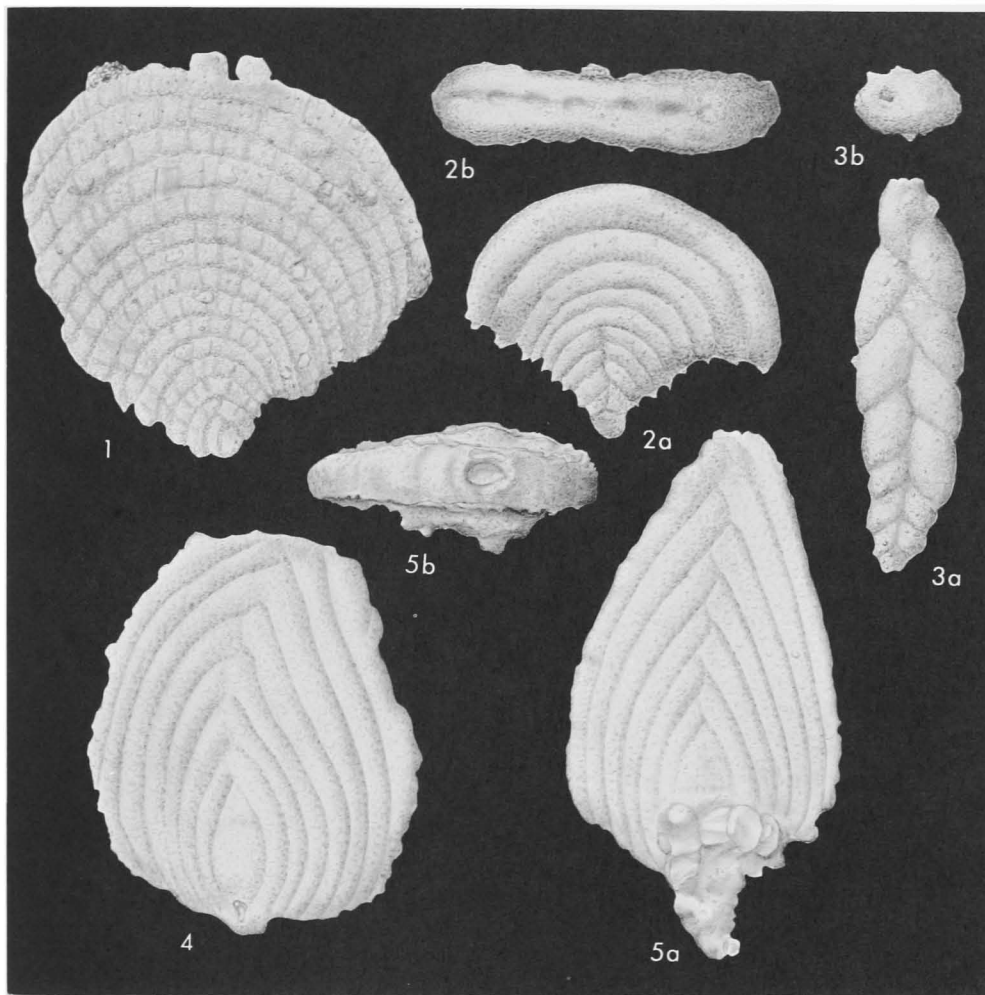


FIG. 252. Semitextulariidae; 1,2, *Semitextularia*; 3, *Paratextularia*; 4,5, *Pseudopalmula* (p. C335-C337).

wall structure, as given by later workers, was not in the original definition of the species, and the only illustrations available are diagrammatic. *Cribrogenerina krizi* CUSHMAN, which has interseptal pillars and a well-developed biserial stage, should be referred to *Climacamina*. Other species distinguished from thin sections (and some on nonoriented sections) were regarded by CUMMINGS as needing further study.]

**Deckerellina** REYTLINGER, 1950, \*1560, p. 57 [*\*D. istiensis*; OD]. Test biserial, as in *Palaeotextularia*, wall calcareous, finely granular, with radial layer poorly developed; aperture in earliest chambers interiomarginal, in later chambers with single supplementary lunate areal opening in addition. *L.Carb.*(Visean), Brit.I.; *M.Carb.*(Moscov.), USSR. —FIG. 251,6,7. *\*D. istiensis*, *M.Carb.*(Moscov.), USSR; 7a,b, side, top views,  $\times 40$  (\*1560); 6, diagram. long. sec. (\*401).

**Palaeobigenerina** GALLOWAY, 1933, \*762, p. 223 [*\*Bigenerina geyeri* SCHELLWIEN, 1898, \*1644, p. 271; OD]. Test biserial in early stage, later uniserial, as in *Bigenerina* with relatively broad,

low chambers; wall with 2 layers, as in *Palaeotextularia*; aperture terminal, rounded. *L.Carb.*(Visean)-*U.Perm.*(Thuring.), Eu.-N.Am.—FIG. 251,8,9. *\*P. geyeri* (SCHELLWIEN), *U.Carb.*, Carnic Alps; 8a,b, side, top views,  $\times 25$  (\*700); 9, diagram. long. axial sec. (\*401).

#### Family SEMITEXTULARIIDAE Pokorný, 1956

[Semitextulariidae POKORNÝ, 1956, p. 284; Pseudopalmulidae E. V. BYKOVA in RAUZER-CHERNOTSOVA & FURSENKO, 1959, p. 264]

Test biserial or may become uniserial, compressed, chambers simple or with vertical pillars; aperture multiple. *Dev.*

**Semitextularia** A. K. MILLER & CARMER, 1933, \*1281, p. 428 [*\*S. thomasi*; OD]. Test free, flattened, palmate, short early biserial portion with 2 to 4 pairs of broad, low alternating chambers, followed by more numerous, very broad, low,

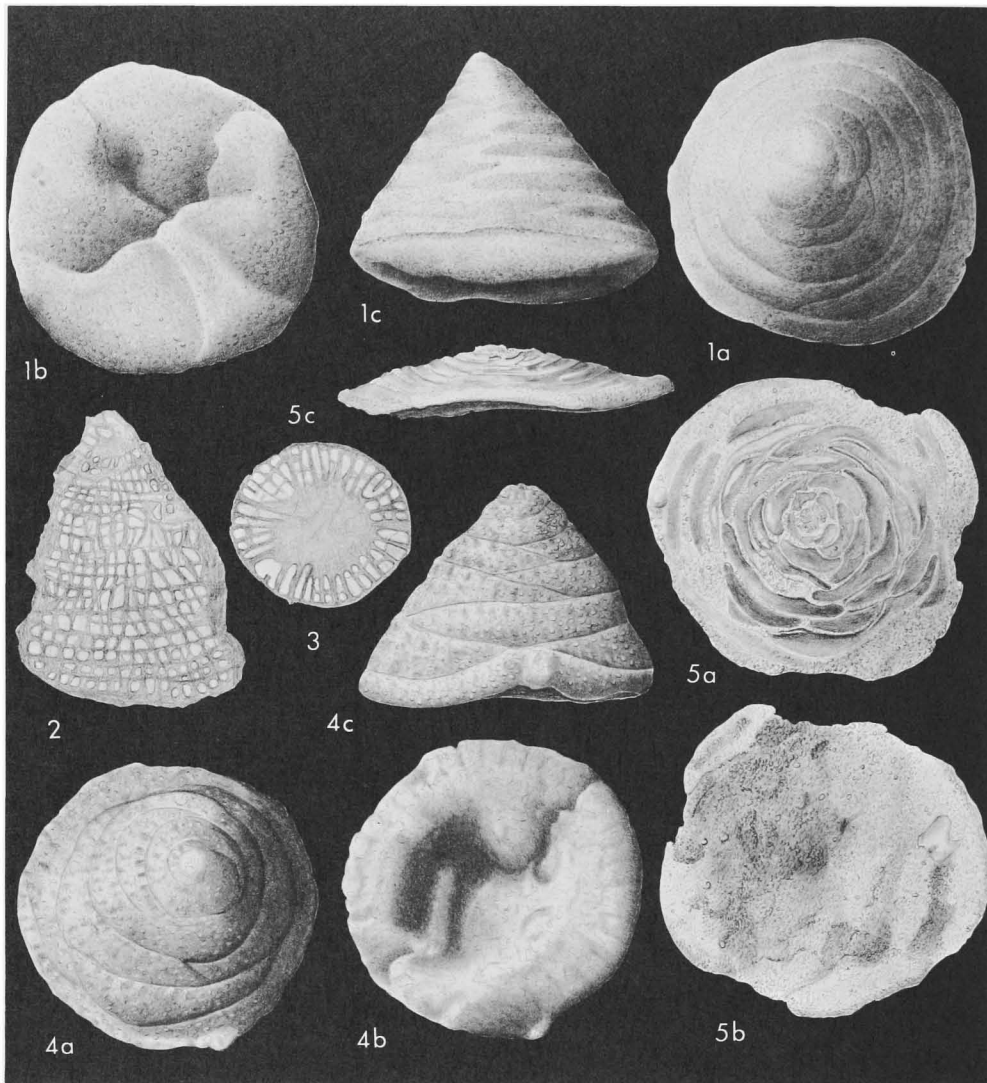


FIG. 253. Tetrataxidae; 1, *Tetrataxis*; 2-4, *Valvulinella*; 5, *Polytaxis* (p. C337).

arched, uniserially arranged chambers somewhat overlapping and inflated laterally, may have lateral spinelike protuberances; interior of chambers with irregular vertical interseptal pillars, those of successive chambers not aligned; wall calcareous, finely granular; aperture consisting of single series of pores on outer margin of final chamber. *M. Dev.-U.Dev.*, N.Am.-Eu.—FIG. 252,1,2. \**S. thomasi*, USA (Iowa); 1, large specimen as seen when dampened to show interseptal pillars; 2a,b, side, top views; all  $\times 86$  (\*2117).

[The original description stated that the early portion was coiled, also that (p. 429) "the planispiral arrangement of these early chambers has been observed only in one of the better preserved specimens with the aid of transmitted light." Later workers have shown only biserial early development. We have examined a large number of specimens and have also found no trace of an early coil.

Perhaps the poor preservation may have given an erroneous suggestion of this feature in the single specimen.]

*Paratextularia* POKORNÝ, 1951, \*1472, p. 20 [*\*Textularia*(?) *proboscidea* CUSHMAN & STAINBROOK, 1943, \*524, p. 78; OD] [= *Cremisia* E. V. BYKOVA, 1952, \*257, p. 50 (obj.)]. Test free, elongate; chambers biserially arranged throughout, final chamber typically somewhat produced; wall calcareous, finely granular; aperture terminal, rounded, on prolongation of final chamber. *Dev.*, N.Am.-Eu.—FIG. 252,3. \**P. proboscidea* (CUSHMAN & STAINBROOK), USA (Iowa); 3a,b, side, top views,  $\times 109$  (\*2117).

[*Paratextularia* and *Cremisia* were defined with the same type-species. *Paratextularia* differs from *Palaeotextularia* SCHUBERT, as described, in having a terminal aperture rather than an interiomarginal one. They may prove synonymous after a restudy of the original specimens or

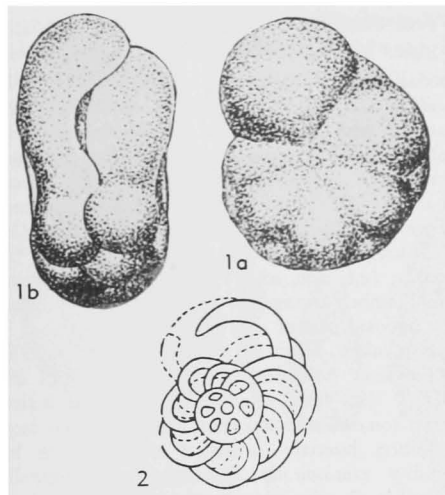


FIG. 254. Biseriamminidae; 1, 2, *Biseriammina* (p. C338).

topotypes of the type-species, *Palaeotextularia schellwieni* GALLOWAY & RYNIKER, 1930. Other species later referred to *Palaeotextularia* include both those with terminal aperture and others with a typical textularian aperture. If the type-species is found to have a terminal aperture and to be otherwise similar, SCHUBERT's name would have priority over *Paratextularia*. However, the original figures appear to be of an internal cast, and the apertural position is not well defined, so that both are here tentatively recognized.]

**Pseudopalmula** CUSHMAN & STAINBROOK, 1943, \*524, p. 78 [*\*P. palmuloides*; OD]. Test free, small, palmate, flattened; chambers biserially arranged throughout, low, very broad, extending far back toward proloculus on each side; wall calcareous, finely granular; aperture ovate on apertural face of final chamber, nearly terminal. [*Pseudopalmula* differs from *Paratextularia* in its palmate test and ovate aperture which is not produced on a neck.] *Dev.*, N.Am.-Eu.—FIG. 252, 4, 5. *\*P. palmuloides*, USA(Iowa); 4, holotype; 5a, b, side, top views of paratype,  $\times 127$  (\*2117).

### Family TETRATAXIDAE Galloway, 1933

[*nom. transl.* POKORNÝ, 1958, p. 199 (ex subfamily Tetrataxinae GALLOWAY, 1933, p. 161); Tetrataxiinae REYTLINGER, 1950, p. 71]

Test free, trochospiral, few chambers in whorl, conical; wall granular calcareous, in 2 layers. *Miss.-Trias.*

**Tetrataxis** EHRENBERG, 1854, \*680, p. 24 [*\*T. conica*; OD (M)] [= *Tetrataxis* EHRENBERG, 1843, \*671, p. 106 (*nom. nud.*); *Ruditaxis* SCHUBERT, 1921; \*1694, p. 180 (type, *Valvulina rudis* BRADY, 1876, \*193, p. 90); *Artetraxoum* RHUMBLER, 1913, \*1572b, p. 391 (*nom. van.*); *Pseudotetrataxis* MARIE in DELEAU & MARIE, 1961, \*580A, p. 91 (type, *Tetrataxis planolocula* LEE & CHEN, 1930, \*1121, p. 94); *Falsotetrataxis* MARIE in DELEAU & MARIE, 1961, \*580A, p. 95 (type, *Tetrataxis*

*scutella* CUSHMAN & WATERS, 1928, \*536, p. 65)]. Test free, trochospirally coiled, with all of numerous broad, low chambers visible on spiral side, and only rather few (commonly 4) of final whorl visible on umbilical side, umbilical cavity broad; wall calcareous, with 2 distinct layers, outer one microgranular and inner fibrous; aperture umbilical. [*Ruditaxis* is based on the type-species *Valvulina rudis* BRADY. His original specimens of this species in the British Museum (Natural History) are crushed internal casts, probably of *Tetrataxis*. The genera are here regarded as synonymous.] *Carb.-Trias.*, N.Am.-Eu.-Japan.—FIG. 253, 1. *\*T. conica*, *Carb.*, Brit.I.; 1a-c, spiral, umbilical, and edge views,  $\times 51$  (\*2117).

**Polytaxis** CUSHMAN & WATERS, 1928, \*535, p. 51 [*\*P. laheei*; OD]. Test low conical, similar to *Tetrataxis* in early stage, later spreading, with numerous small chambers to whorl; aperture on umbilical side, several. [The aperture is not clearly distinguishable on the type-specimen, although the genus was described as having several elongate ventral openings. *Polytaxis* sp. of PAYARD (\*1432), from the Jurassic belongs to the agglutinated genus *Tritaxis* in the Trochamminidae.] *U.Carb.*, N.Am.-Eu.(Carnic Alps).—FIG. 253, 5. *\*P. laheei*, Penn., USA(Tex.); 5a-c, spiral, umbilical, and edge views of holotype,  $\times 19$  (\*2117).

**Valvulinella** SCHUBERT, 1907 (separate of 1908, \*1687, p. 248, dated 1907) [*\*Valvulina youngi* BRADY, 1876, \*193, p. 86; SD SCHUBERT, 1908, \*1686, p. 379] [= *Valvulinella* SCHUBERT, 1907, \*1684, p. 211 (*nom. nud.*); *Palaeovalvulina* SCHU-

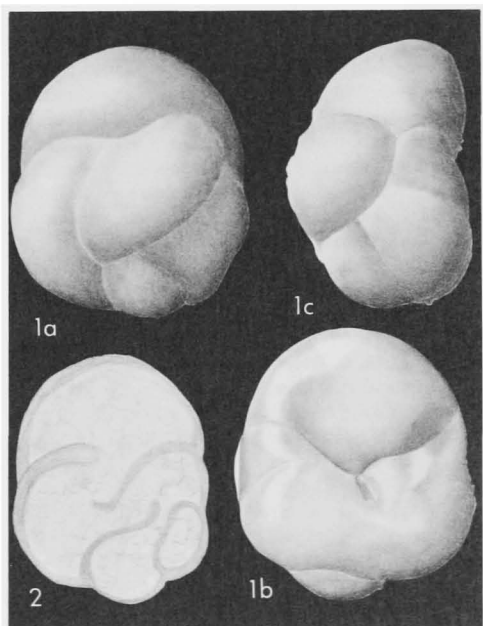


FIG. 255. Biseriamminidae; 1, 2, *Globivalvulina* (p. C338).

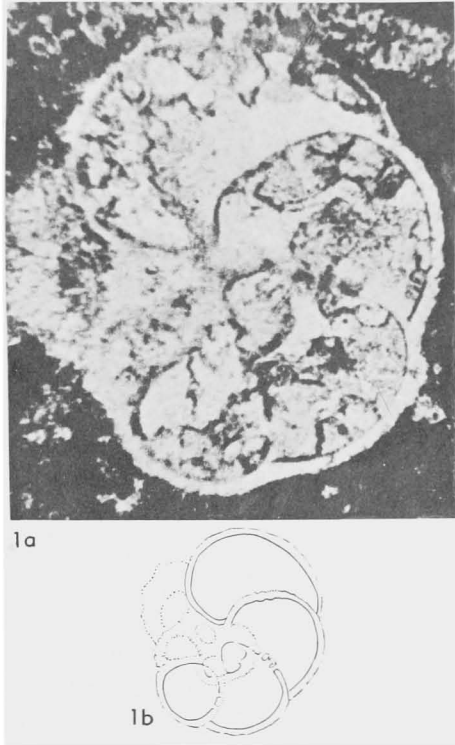


FIG. 256. Biseriamminidae; 1, *Olympina* (p. C338).

BERT, 1921, \*1694, p. 179 (type, *Valvulina youngi* BRADY, 1876, \*193, p. 86, SD LOEBLICH & TAPPAN, herein) (obj.); *Palaeovalvuloria* NEAVE, 1940, \*1348c, p. 534 (*nom. null.*)]. Test conical, chambers trochospirally arranged with only 2 or 3 chambers to whorl; interior subdivided by horizontal and vertical partitions, chamberlets slightly visible through outer wall; wall calcareous, microgranular; aperture interiomarginal, on umbilical side. [Differs from *Tetrataxis* in having secondary partitions which form numerous tiny chamberlets. The Jurassic species previously assigned to *Valvulinella* are here placed in *Kurnubia*. The lectotype (BMNH-P41656) and paratypes (BMNH-P35519, P35520, P41655) are from the Carboniferous, Brockley, Lanarkshire, England.] *L.Carb.* (*Miss.*)-*U.Carb.* (*Penn.*), Eu.-N.Am.—FIG. 253, 2-4. \**V. youngi* (BRADY), *L.Carb.*, Eng.; 2, long. sec. (\*193, pl. 4, fig. 8),  $\times 47$  (\*2117); 3, transv. sec. (\*193, pl. 4, fig. 9),  $\times 47$  (\*2117); 4a-c, spiral, umbilical, and edge views,  $\times 65$  (\*2117).

#### Family BISERIAMMINIDAE Chernysheva, 1941

[Biseriamminidae CHERNYSHEVA, 1941, p. 70] [=Globivalvulininae REYTLINGER, 1950, p. 75; =Globivalvulininae POKORNÝ, 1958, p. 200]

Test enrolled, biserial, involute; aperture at inner border of septal face. *L.Carb.-Perm.* **Biseriammina** CHERNYSHEVA, 1941, \*335, p. 69 [\**B. uralica*; OD]. Test free, chambers biserially arranged, with axis of biseriality planispirally enrolled; wall calcareous, microgranular; aperture comprising narrow interiomarginal slit where chambers of opposed pair touch at short distance above contact with earlier whorl. *L.Carb.* (*M. Tournais.*), USSR (S.Urals).—FIG. 254, 1, 2. \**B. uralica*; 1a, b, side, edge views; 2, cross sec. showing chamber arrangement, dotted lines representing opposed pair of chambers,  $\times 53$  (\*335).

**Globivalvulina** SCHUBERT, 1921, \*1694, p. 153 [\**Valvulina bulloides* BRADY, 1876, \*193, p. 89; OD]. Test free, subglobular to hemispherical when somewhat flattened on broad apertural face; chambers biserially arranged with axis of biseriality planispirally to slightly trochospirally coiled; wall calcareous, microgranular, may have inner fibrous or porous layer particularly well developed along septa; aperture interiomarginal against opposite, penultimate chamber, partially covered by valvular projection extending toward opposite chamber near center of apertural face, commonly overlapping aperture of penultimate chamber. [*Globivalvulina* differs from *Biseriammina* in being more advanced, with an apertural valvular projection.] *U.Penn.-Perm.*, N.Am.-Eu.-C.Asia.—FIG. 255, 1, 2. \**G. bulloides* (BRADY), *U.Penn.*, USA (Iowa); 1a-c, opposite sides and edge of syntype,  $\times 93$ ; 2, sec. of syntype, redrawn (BMNH-P35518, \*193, pl. 4, fig. 14),  $\times 79$  (\*2117).

**Olympina** REICHEL, 1945, \*1517, p. 540 [\**O. insolita*; OD]. Test enrolled, chambers inflated, few to whorl; wall calcareous, perforate; aperture in septal face. *Perm.*, *Medit.* (Cyprus). — FIG. 256, 1. \**O. insolita*; 1a, holotype, photograph of sec.,  $\times 55$ ; 1b, sketch from photograph showing chambers and septal aperture,  $\times 33$  (\*1517).

[This genus, described from 2 sections in an algal limestone, is unknown as to mode of coiling, although it was suggested that the umbilical region seemed to show the possibility of a trochospiral arrangement. From comparison of the figures, it seems probable that *Olympina* could also be a biserially enrolled form and it is here transferred to the Biseriamminidae. The strong similarity to sections of *Biseriammina* suggests that further study may even show *Olympina* to be a junior synonym of *Biseriammina*.]

#### Family TOURNAYELLIDAE Dain, 1953

[Tournayellidae DAIN in DAIN & GROZDILOVA, 1953, p. 16] — [In synonymic citations superscript numbers indicate taxonomic rank assigned by authors (family, <sup>2</sup>subfamily)] — [=<sup>1</sup>Glomospirellinae REYTLINGER, 1950, p. 26 (*nom. nud.*); =<sup>2</sup>Tournayellinae DAIN in DAIN & GROZDILOVA, 1953, p. 20; =<sup>2</sup>Tournayellinae DAIN in DAIN & GROZDILOVA, 1953, p. 21 (*nom. null.*); =<sup>2</sup>Forschiinae DAIN in DAIN & GROZDILOVA, 1953, p. 20, 38; =<sup>2</sup>Forschiidae GROZDILOVA & LEBEDEV, 1954, p. 36; =<sup>2</sup>Forshiinae REYTLINGER, 1953, p. 60 (*nom. null.*); =<sup>1</sup>Teurnayellidae REYTLINGER, 1958, p. 60 (*nom. null.*)]

Test free, proloculus followed by planispirally enrolled tubular second chamber, subseptate, with slight protuberances or in-

cipient septa forming pseudochambers; wall calcareous, granular, and may have agglutinated inclusions; aperture simple or cribrate. *U.Dev.-U.Perm.*

**Tournayella** DAIN in DAIN & GROZDILOVA, 1953, \*550, p. 30 [*T. discoidea*; OD] [= *Carbonella* DAIN in DAIN & GROZDILOVA, 1953, \*550, p. 36 (type, *C. spectabilis*); *Septatournayella* LIPINA,

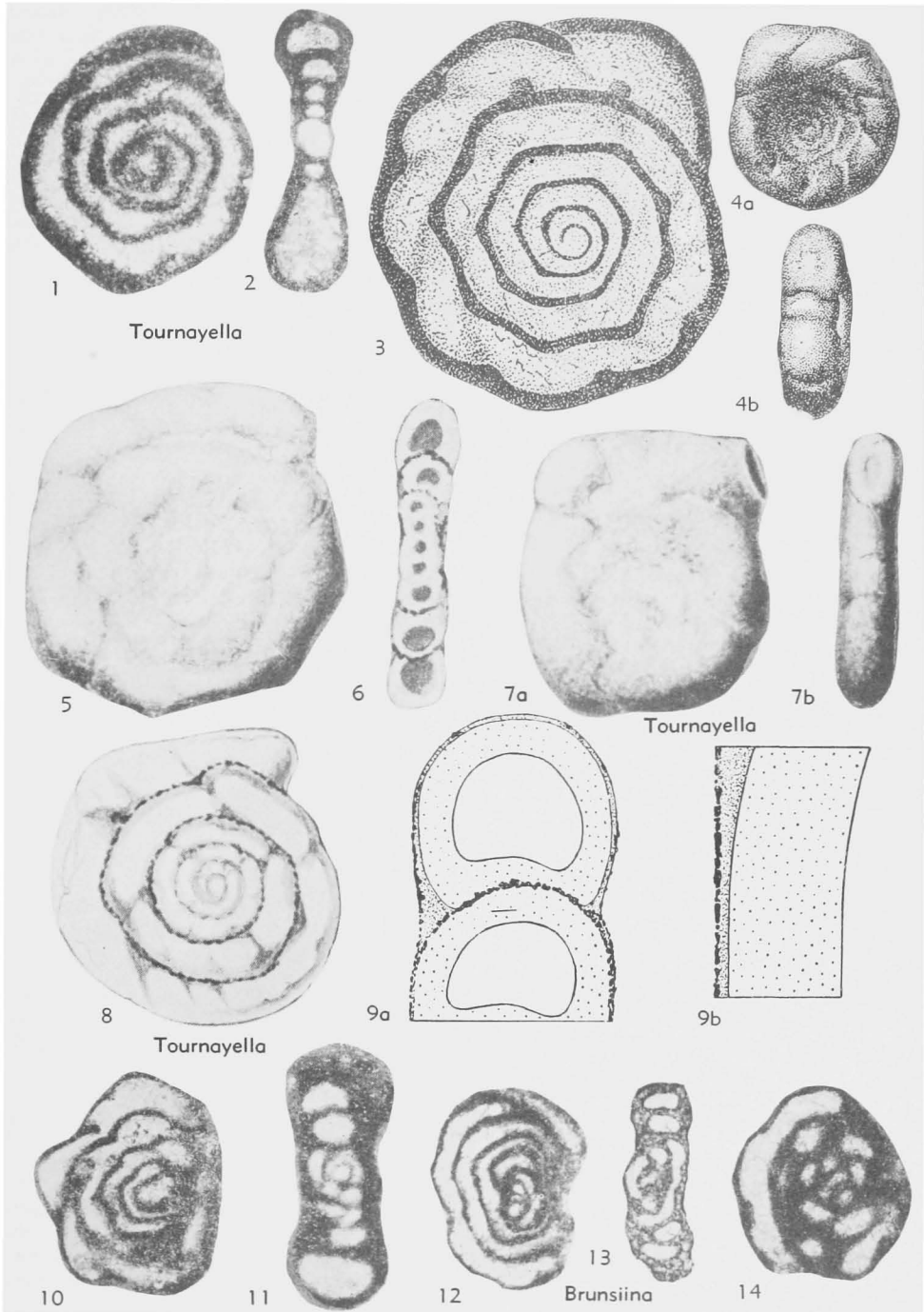


FIG. 257. Tournayellidae; 1-11, *Tournayella*; 12-14, *Brunsiina* (p. C339-C340).

1955, \*1143, p. 36 (type, *Tournayella segmentata* DAIN in DAIN & GROZDILOVA, 1953, \*550, p. 34); *Cepekia* VAŠIČEK & RUŽIČKA, 1957, \*1985, p. 342 (type, *C. cepeki*). Test discoidal, with spherical proloculus and planispirally coiled pseudoseptate later portion, slight apertural constrictions of tubular chamber being preserved as poorly developed septa or slight infoldings of wall; wall thick, calcareous, inner thick translucent layer of microgranular calcite with thin dark opaque layer developed where final whorl overlaps previous coils, and secondary calcareous translucent thickening in sutural depressions; aperture simple rounded or elliptical opening formed by moderate constriction of terminal portion of tubular chambers. *U. Dev.* - *L. Carb.* (*Tournais-Visean*) - *U. Carb.* (*Namur.*), USSR-Czech.—FIG. 257,1,2. \**T. discoidea*, Tournais., USSR (Donets Basin); 1, equat. sec. of holotype; 2, axial sec. of paratype; both  $\times 100$  (\*550).—FIG. 257,3,4. *T. spectabilis* (DAIN), Tournais., USSR (Donets Basin); 3, equat. sec.,  $\times 60$  (\*550); 4a,b, side, edge views of holotype,  $\times 43$  (\*550).—FIG. 257,5-9. *T. cepeki* (VAŠIČEK & RUŽIČKA), Namur., Czech.; 5,7a,b, side, edge views of paratypes; 6,8, axial and equat. secs. of paratypes,  $\times 81$ ; 9a,b, diagrams of wall structure showing part of axial sec. and enlargement of one side of wall with inner granular layer regarded as equivalent to epitheca of fusulinids, dark thin opaque layer resembling fusulinid tectum, and secondary thickening at septal depressions (=protheca) (\*1985).—FIG. 257, 10, 11. *T. segmentata* DAIN, Tournais., USSR; 10, equat. sec.,  $\times 70$  (\*1143); 11, axial sec.,  $\times 81$  (\*831).

[*Carbonella* was regarded originally as slightly more advanced than *Tournayella*, with better developed "septation," but the slight differences in the holotypes of the 2 type-species suggest that only specific distinction should be made. *Septatournayella*, as based on the type-species, has chambers of more irregular width, slightly inflated, and fewer chambers in each whorl, but these also are here regarded as of specific distinction only. *Cepekia cepeki*, type-species of *Cepekia*, is very similar to *Carbonella spectabilis* DAIN, and most probably specifically identical, as well as congeneric.]

**Brunsiina** LIPINA in DAIN & GROZDILOVA, 1953, \*550, p. 27 [\**B. uralica*; OD] [= *Glomospiranella* LIPINA in DAIN & GROZDILOVA, 1953, \*550, p. 21 (type, *G. asiatica*)]. Early portion in streptospiral coil, later planispiral and similar to *Tournayella* in poorly developed septation; aperture simple, at slightly constricted open end of tubular chamber. [Differences between *Brunsiina* and *Glomospiranella* largely consist of a shorter period of streptospiral coiling in *Brunsiina*. This is here regarded as of specific importance only.] *U.Dev.-L.Carb.* (*Tournais.*), USSR.—FIG. 257, 12,13. \**B. uralica*, Tournais.; 12, equat. sec. of holotype; 13, axial sec. of paratype; both  $\times 100$  (\*550).—FIG. 257,14. *B. asiatica* (LIPINA), Tournais., Sib.; equat. sec. of holotype,  $\times 76$  (\*1143).

**Forschia** MIKHAYLOV, 1939, \*1260, p. 50, 59

[\**Spirillina subangulata* VON MÖLLER, 1879, \*1296, p. 27, 130 (= *S. angulata* VON MÖLLER, 1879, \*1296, p. 27) (*nom. null.*); OD]. [= *Forschia* MIKHAYLOV, 1935, \*1259, p. 41 (*nom. nud.*)]. Test free, proloculus followed by planispiral evolutely coiled tubular chamber, without distinct septation; aperture terminal, cribrate where tube flares terminally. *L.Carb.* (*Visean*), USSR.—FIG. 258,1-3. \**F. subangulata* (VON MÖLLER); 1, equat. sec.,  $\times 60$  (\*1509); 2, axial sec.,  $\times 20$  (\*1509); 3, axial sec.,  $\times 75$  (\*1296).

**Forschiella** MIKHAYLOV, 1935, \*1259, p. 41 [\**F. prisca*; OD]. Early stage similar to *Forschia*, later uncoiling and septate; aperture cribrate. *L.Carb.* (*Visean*), USSR.—FIG. 258,7. \**F. prisca*; paratype showing axial sec. through early coiled stage,  $\times 59$  (\*769).

**Glomospiroides** REYTLINGER, 1950, \*1560, p. 28 [\**G. fursenki* (*nom. imperf.*, = *G. fursenki*, *nom. correct.* VOLOSHINOVA, DAIN & REYTLINGER in RAUZER-CHERNOUSOVA & FURSENKO, 1959, \*1509, p. 184); OD] [= *Glomospirella* REYTLINGER, 1950, \*1560, p. 27 (type, *G. borealis*) (*non Glomospirella* PLUMMER, 1945)]. Test with early glomospirine coil, later uncoiling, septate throughout, but septa thin and irregular; wall calcareous, finely granular; aperture terminal, simple. *M.Carb.* (*Moscow.*), USSR.—FIG. 258, 4,5. \**G. fursenki*; 4, long. sec. of holotype; 5, targ. sec.,  $\times 76$  (\*1560).—FIG. 258,6. *G. borealis* (REYTLINGER), holotype,  $\times 76$  (\*1560).

[Originally *Glomospirella* REYTLINGER, 1950 (*non PLUMMER*, 1945) included species with early glomospirine coil and later irregular development, whereas *Glomospiroides* became distinctly rectilinear in the later stage. VOLOSHINOVA, DAIN & REYTLINGER in RAUZER-CHERNOUSOVA & FURSENKO (1959, \*1509, p. 184) regarded *Glomospirella* REYTLINGER as a synonym of *Glomospiroides*.]

**Gourisina** REICHEL, 1945, \*1517, p. 539 [\**G. broennimanni*; OD]. Status of genus doubtful; known only from a single section, it was described as having a calcareous wall, radially striate, with thin dark granular inner layer, and formed from 2 series of chambers in spire around proloculus. [It could equally well consist of a nonseptate plectogyrally coiled tube, so-called chambers consisting of sections through the tube as it spiraled. Because of the similarity to *Glomospiranella* in sections, it is here placed with the Tournayellidae.] *U.Perm.*, Greece (Attica).—FIG. 258,10. \**G. broennimanni*; 10a,b, holotype, photograph of thin sec. and outline of same showing chamber development,  $\times 80$  (\*1517).

**Lituotubella** RAUZER-CHERNOUSOVA, 1948, \*1502, p. 161 [\**L. glomospiroides*; OD]. Test with long tubular chamber, early stage in unsegmented glomospirine coil, later uncoiling, with regular constrictions of wall indicating chambers; no complete septa; wall granular, calcareous; aperture at open end of tube. *L.Carb.* (*Visean*), USSR.—FIG. 258,8,9. \**L. glomospiroides*; 8, median sec. of early coil; 9, long. sec. of holotype,  $\times 50$  (\*1502).



*Septabrunsiina* LIPINA, 1955, \*1143, p. 42 [*Endothyra? krainica* LIPINA, 1948, \*1141, p. 254; OD] [= *Septaglomospiranella* LIPINA, 1955, \*1143, p.

46 (type, *Endothyra? primaeva* RAUZER-CHERNOUSOVA, 1948, \*1505, p. 5); *Tournayellina* LIPINA, 1955, \*1143, p. 52 (type, *T. vulgaris*). Early

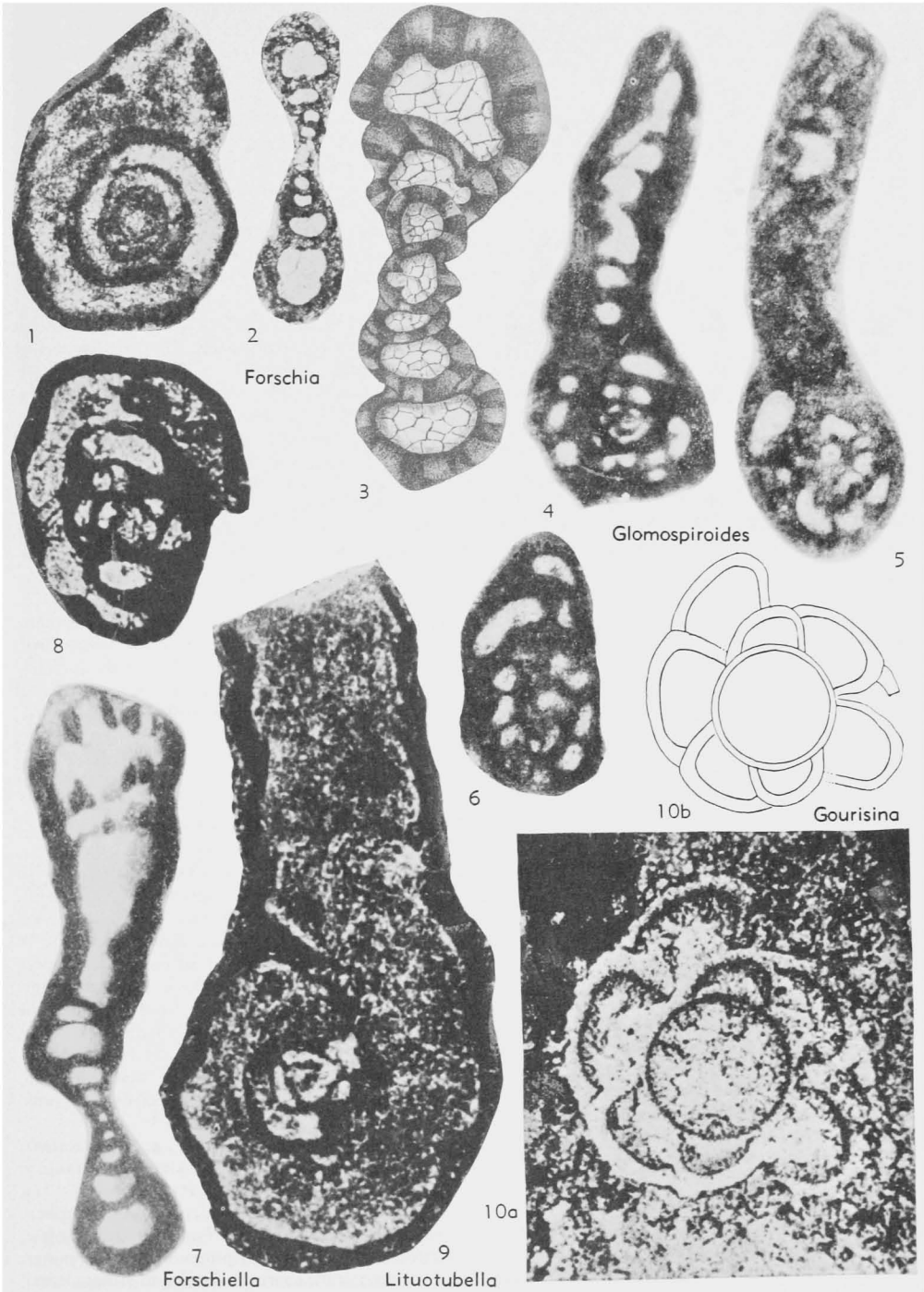


FIG. 258. Tournayellidae; 1-3, *Forschia*; 4-6, *Glomspiroides*; 7, *Forschiella*; 8,9, *Lituotubella*; 10, *Gourisina* (p. C340).

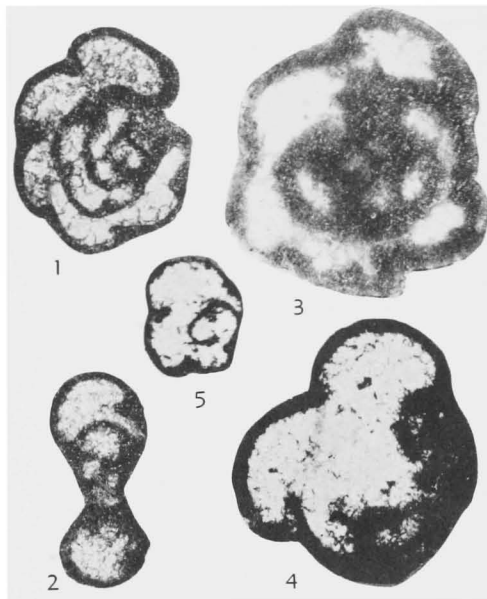


FIG. 259. Tournayellidae; 1-5, *Septabrunciina* (p. C341-C342).

stage streptospiral and poorly or nonseptate, later planispiral as in *Brunsiina*, but with few inflated chambers to whorl, resulting in appearance of better-developed septation in later portion; wall calcareous, microgranular; aperture simple, at open end of tube. *U.Dev.-L.Carb. (Tournais.)*, USSR.—FIG. 259,1,2. \**S. kranica* (LIPINA), Tournais.; 1, equat. sec.; 2, axial sec.; both  $\times 70$  (\*1143).—FIG. 259,3. *S. primaeva* (RAUZER-CHERNOUSOVA), Tournais.;  $\times 100$  (\*550).—FIG. 259,4,5. *S. vulgaris* (LIPINA), L.Carb.; 4, sub-equat. sec. of paratype (early coil poorly seen); 5, equat. sec. of smaller paratype showing early spire,  $\times 70$  (\*1143).

#### Family ENDOTHYRIDAE Brady, 1884

[*nom. correct.* RHUMBLER, 1895, p. 92 (*pro* family Endothyridina LANKESTER, 1885, p. 847)]—[All names referred to are of family rank]—[=Endothyridinae DELAGE & HÉROUARD, 1896, p. 133; =Cribrospiridae WEDEKIND, 1937, p. 79; =Plectogyridae REYTLINGER MS in POYARKOV, 1957, p. 29; =Bradyiniidae REYTLINGER, 1958, p. 57]

Test enrolled, planispiral or plectogyral; aperture simple or multiple. *Dev.-Perm.*

#### Subfamily LOEBLICHINAE Cummings, 1955

[*nom. correct.* LOEBLICH & TAPPAN, 1961, p. 286 (*pro* subfamily Loeblichinae CUMMINGS, 1955, p. 3)] [=Nanicellinae FURSENKO in RAUZER-CHERNOUSOVA & FURSENKO, 1959, p. 252]

Test planispiral, compressed, involute or evolute; chambers numerous; aperture basal. *Dev.-Perm.*

*Loeblichia* CUMMINGS, 1955, \*398, p. 3 [*\*Endothyra ammonoides* BRADY, 1873, \*190, p. 63, 95; OD]. Test free, discoidal, planispiral and evolute,

with numerous whorls; chambers small, numerous, appearing rectangular in horizontal section; sutures distinct, radial; wall calcareous, finely granular; aperture low equatorial, interiomarginal arch. [*Loeblichia* differs from *Endothyra* PHILLIPS in being evolute rather than involute and planispiral rather than with changing axis of coiling. It also has a much shorter axis of coiling, resulting in a discoid or complanate test, and far more numerous whorls and chambers in each whorl. It differs from *Nanicella* in being completely evolute, and with more numerous chambers.] *L.Carb. (Visean)*, Brit.I.-USSR.—FIG. 260,1,2; 261,1. \**L. ammonoides* (BRADY), Eng.; 260,1a,b, side, edge views of lectotype (BMNH-P41650, \*193, pl. 5, fig. 5), redrawn; 260,2, sec. of paratype (BMNH-P35500, \*193, pl. 5, fig. 6), redrawn,  $\times 64$  (\*2117); 261,1a, axial sec. (where septa are cut area appears darker),  $\times 75$ ; 261,1b, diagram of wall structure, enlarged (\*398).

*Eocristellaria* K. V. MIKLUKHO-MAKLAY, 1954, \*1277, p. 67 [*\*E. permica*; OD]. Test ovate in outline, with gradually arranging chambers arranged as in *Astacolus*; wall calcareous, with outer hyaline layer and granular calcareous inner layer; aperture peripheral, ?radiate. *U.Perm.*, USSR (Caucasus).—FIG. 261,4. \**E. permica*, holotype,  $\times 47$  (\*1277).

*Nanicella* HENBEST, 1935, \*895, p. 34 [*\*Endothyra gallowayi* THOMAS, 1931, \*1907, p. 40; OD]. Test planispirally coiled and partially evolute; chambers numerous, low; wall calcareous with thin dark outer layer and thicker inner finely granular layer; aperture interiomarginal equatorial slit. *Dev.*, N.Am.-USSR.—FIG. 260,3,4; 261,2,3. \**N. gallowayi* (THOMAS), USA (Iowa); 260,3a,b,4, side, edge views of topotypes,  $\times 99$  (\*2117); 261,2,3a, axial and equat. secs. of paratypes; 3b, portion of 3a enlarged (\*1907).

*Rhenothyra* H. BECKMANN, 1950, \*103, p. 184, 187 [*\*R. refrathensis*; OD]. Test planispiral, evolute, similar to *Loeblichia*, but with few chambers to whorl; wall with 3 layers; aperture large, rounded, at the base of apertural face. [*Loeblichia* may prove to be a synonym of *Rhenothyra*, but in view of the fewer chambers in each whorl, fewer whorls, different wall structures described, large, round aperture instead of a basal slit, and the different geologic ages, both are tentatively recognized.] *M.Dev.*, Eu.—FIG. 261,8-10. \**R. refrathensis*, Ger.; 8,9, equat. and axial secs.; 10, somewhat abraded exterior of holotype; approx.  $\times 60$  (\*103).

*Robuloides* REICHEL, 1945, \*1517, p. 531 [*\*R. lens*; OD] [= *Pararobuloides* K. V. MIKLUKHO-MAKLAY, 1954, \*1277, p. 65 (type, *P. orientalis*)]. Test lenticular, nearly planispiral, involute, periphery acute; wall calcareous perforate, radially striate, with lamellar thickening pronounced; septa porous as is outer wall; aperture circular to radiate, areal, in lower part of septal face. [*Robuloides* differs from *Lenticulina* in the wall character, in having



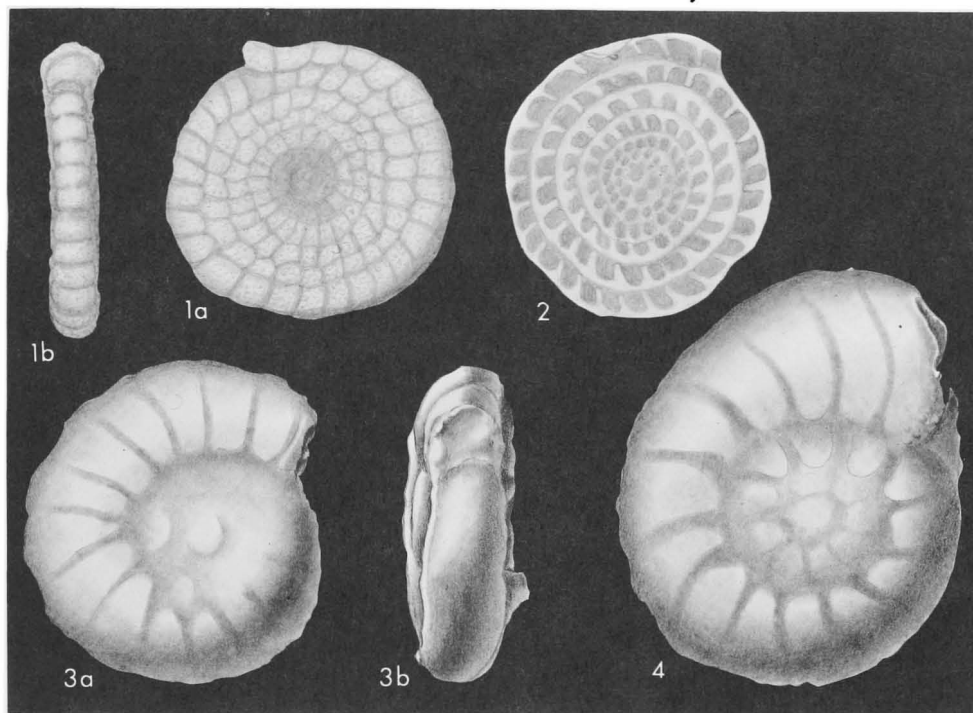


FIG. 260. Endothyridae (Loeblichinae; 1,2, *Loeblichia*; 3,4, *Nanicella*) (p. C342).

perforate septa, and an areal rounded aperture instead of a radial aperture at the dorsal angle.] *U.Perm.*, Eu.(Greece)-USSR(Caucasus). — FIG. 261,5,6. \**R. lens*, Greece(Hydra Is.); 5, holotype nearly equat. sec., tang. to proloculus; 6, paratype, slightly oblique axial sec.; both  $\times 100$  (\*1517). — FIG. 261,7. *R. orientalis* (K. V. MIKLUKHO-MAKLAY), USSR(Caucasus), axial sec. of holotype,  $\times 47$  (\*1277).

#### Subfamily ENDOTHYRINAE Brady, 1884

[Endothyrinae BRADY, 1884, p. 66] [=Plectogyrinae REYTLINGER, 1958, p. 57; =Quasiendothyrinae REYTLINGER, 1961, p. 53]

Test enrolled, planispiral to streptospiral, possibly uncoiling in later stages; may be incompletely septate; wall of granular calcite, nonporous, with 2 or 3 distinct layers in well-preserved specimens, may have agglutinated material in addition; aperture single, simple, basal or areal. *U.Dev.* (*Famenn.*)-*Perm.*

*Endothyra* PHILLIPS, 1846, \*1452B, p. 277 (*nom. conserv.* ICZN (S.) 768, pending) (*non Endothyra* GÜDE, 1899) [\**E. bowmani* (= *Involutina lobata* BRADY, 1870, \*187A, p. 382); = *Endothyra bradyi* MIKHAYLOV, 1939, \*1260, p. 51 (*nom. conserv.* ICZN (S.) 768, pending); OD (M)] [*Endothyra* PHILLIPS in BROWN, 1843, \*245, p. 17 (*nom. reject.* ICZN (S.) 768, pending)] [= *Plectogyra* ZELLER, 1950, \*2103, p. 3 (type,

*P. plectogyra*); *Plectogyrina* REYTLINGER in RAUZER-CHERNOUSOVA & FURSENKO, 1959, \*1509, p. 196 (type, *Endothyra*(?) *fomichaensis* LEBEDEVA, 1954, \*1100, p. 256); *Endostaffella* ROZOVSKAYA, 1961, \*1593, p. 20 (type, *Endothyra parva* MÖLLER, 1879, \*1296, p. 18)]. Test enrolled, partially involute, plane of coiling changes during growth, turning through  $30^{\circ}$ - $90^{\circ}$ , may turn gradually as in plectogyral coiling, or abruptly nearly  $90^{\circ}$ , few chambers to whorl, whorls few; wall calcareous, with 2 layers, thin dark outer layer (tectum) and thicker, fibrous alveolar, inner layer (diaphanoteca); partial recrystallization may result in granular appearance, secondary deposits in form of nodes, ridges, or forward-directed hooks secreted on chamber floors; external aperture not always evident, but interiomarginal, equatorial to asymmetrical slit may be present, relatively large intercameral foramina in same position. ?*U.Dev.*, *L.Carb.-Perm.*, Eu.-N. Am.-Afr.-Japan-S.Am. — FIG. 262,1,2. \**E. bowmani*, *L.Carb.*, Eng.; 1a,b, side and apertural views of neotype, here designated, showing "skew"-coiling,  $\times 82$ ; 2, equat. sec. (BRADY's specimen BMNH-P41674 ex P35440) showing coiling,  $\times 64$  (\*2117). — FIG. 262,3. *E. plectogyra* (ZELLER), *U.Miss.*(Meramec.), USA(Mo.); equat. sec. of holotype,  $\times 66$  (\*2103). — FIG. 262,4,5. *E. sp.*, *U.Miss.*(Meramec.), USA(Mo.); 4, axial sec.,  $\times 66$  (\*2103); 5, equat. sec. showing well-developed hook-shaped secondary deposit

in final chamber,  $\times 66$  (\*2103).—FIG. 262,6,7. *E. fomichaensis* LEBEDEVA, L.Carb. (Visean), USSR; 6, equat. sec. of paratype,  $\times 33$  (\*1100); 7, axial

sec.,  $\times 20$  (\*1509).—FIG. 263,8. *E. sp.*, diagram of wall structure (\*398).

[The confusion as to the status of *Endothyra* has been

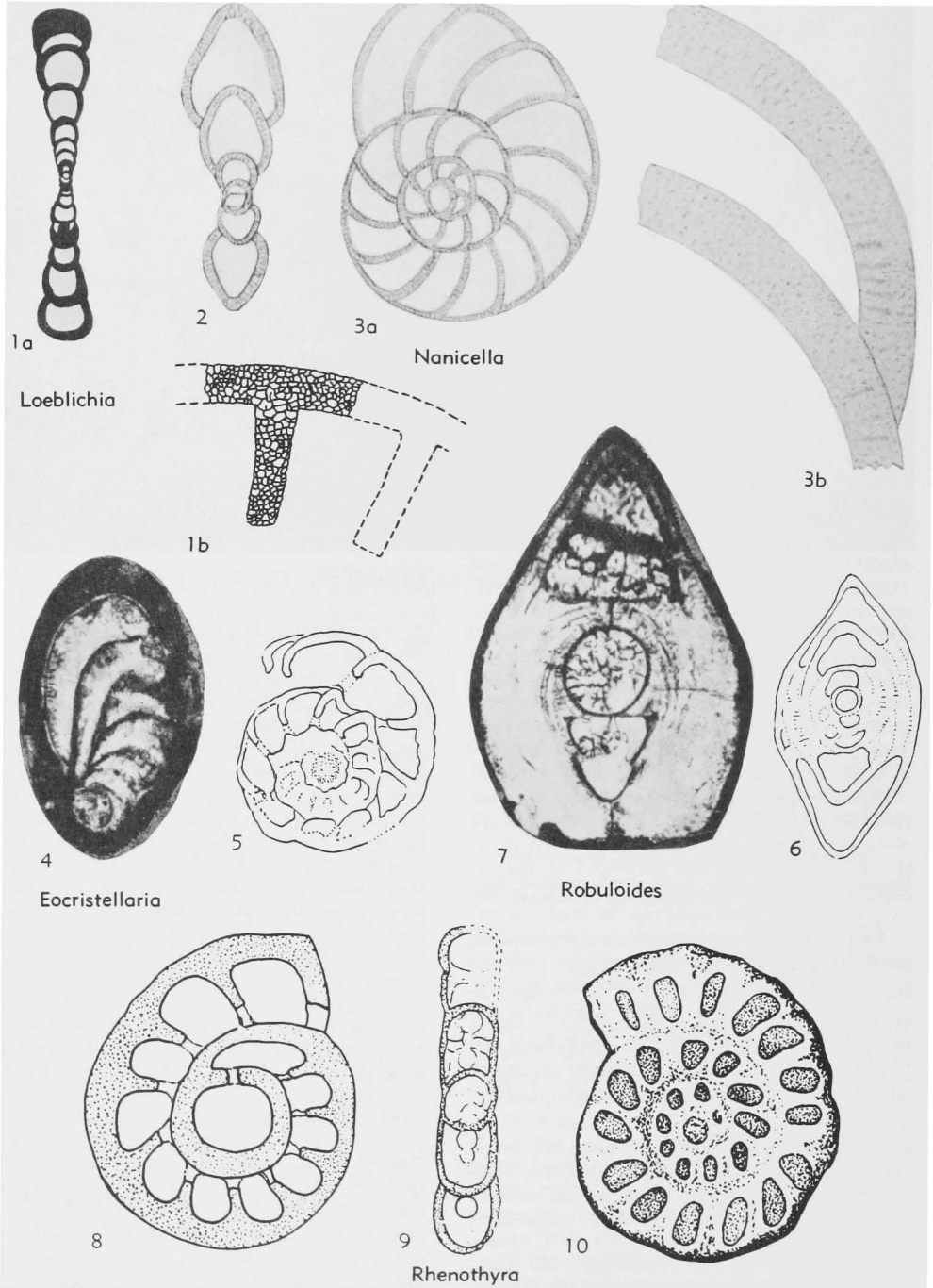


FIG. 261. Endothyridae (Loeblichinae; 1, *Loeblichia*; 2,3, *Nanicella*; 4, *Eocrstellaria*; 5-7, *Robuloides*; 8-10, *Rhenothyra*) (p. C342-C343).

discussed in detail by SCOTT, ZELLER & ZELLER (1947, \*1708), ZELLER (1950, \*2103), HENBEST (1953, \*897), and ST. JEAN (1957, \*1619), some authors regarding the plectogyral and planispiral modes of coiling as representing

only a dimorphism found within most species. Others have regarded it variously as a generic, subfamily, or family character. According to HENBEST (1953, \*897, p. 64), about 1 per cent of shells referred to *Endothyra baileyi*

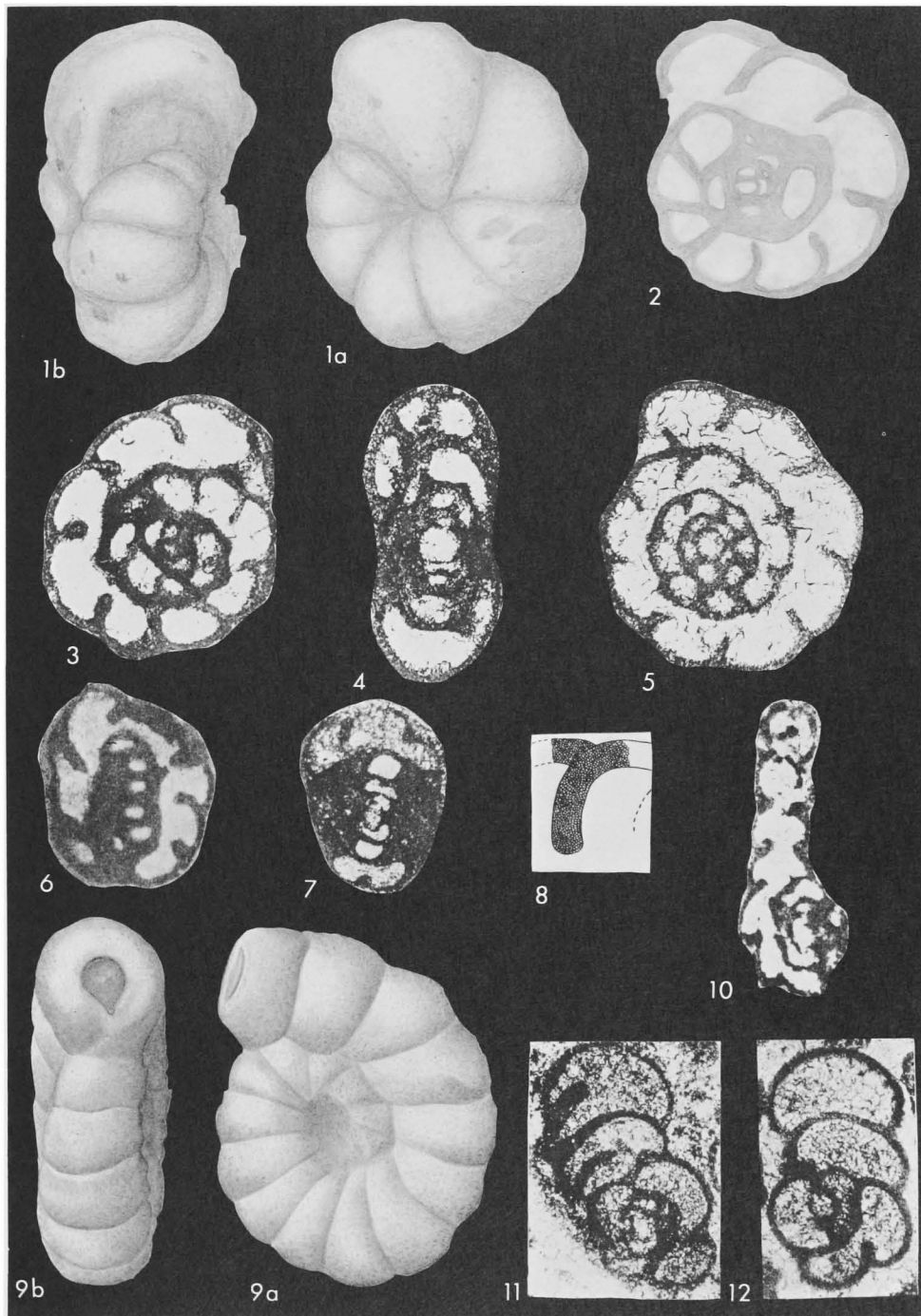


FIG. 262. Endothyridae (Endothyrinae; 1-8, *Endothyra*; 9-12, *Endothyranella*) (p. C343-C346).

(HALL) have an early plectogyral coil and later planispiral growth, the remainder being planispiral throughout. *Endothyra? fomichaensis* has a sharp change of 90° in plane of coiling just before the final whorl is added. Much of the confusion is due to the loss of the type specimens of *Endothyra*. HENBEST (1953, \*897) stated that a petition was to be submitted to the ICZN validating *Endothyra* PHILLIPS, 1846, as emended by BRADY, 1876, and to suppress "*Endothyra* BROWN, 1843." This was again referred to by ST. JEAN (1957, \*1619), but apparently such a petition has never been formally acted upon by the ICZN. In the interests of stability of nomenclature and because of loss of the original types of *Endothyra bowmani* PHILLIPS the specimen of BRADY in the British Museum (Natural History) (BMNH-P41665, ex P35440) here redrawn, is designated as neotype. It is from the Carboniferous, Brankamhall Quarry, Lanarkshire. After the present text had been sent to press, May, 1962, HENBEST published the ICZN petition Z.N. (S.) 768, July, 1962, in which *Endothyra bowmani* PHILLIPS, 1846, is to be conserved, in the sense of BRADY, 1876, and *Endothyra bowmani* PHILLIPS in BROWN, 1843, rejected.]

**Dainella** BRAZHNKOVA, 1962 (see p. C795).

**Endothyranella** GALLOWAY & HARLTON in GALLOWAY & RYNIKER, 1930, \*765, p. 13 [*Ammobaculites powersi* HARLTON, 1927, \*879, p. 21; OD] [= *Chernyshinellina* REYTLINGER in RAUZER-CHERNOUSOVA & FURSENKO, 1959, \*1509, p. 196 (type, *Ammobaculites pygmaeus* MALAKHOVA, 1954, \*1207, p. 58); *Rectochernyshinella* LIPINA, 1960, \*1145, p. 51 (type, *Spiroplectamina mirabilis* LIPINA, 1948, \*1141, p. 257)]. Test free, early portion enrolled and plectogyral, later nearly planispiral, finally uncoiling and becoming rectilinear; wall calcareous, fibrous, or may be recrystallized and granular, aperture high interiomarginal equatorial arch, later areal and terminal in uncoiled portion. *L.Carb.* (U.Miss.)-*U.Penn.*, USA-USSR.—FIG. 262,9. \**E. powersi* (HARLTON), Penn., USA (Okla.); 9*a,b*, side, edge views of holotype, ×76 (\*2117).—FIG. 262,10. *E. pygmaea* (MALAKHOVA), *L.Carb.* (Tournais.), USSR; long. sec., ×66 (\*1509).—FIG. 262, 11,12. *E. mirabilis* (LIPINA), *L.Carb.* (Tournais.), USSR; long. secs. of holotype and paratype, ×50 (\*700).

[*Chernyshinellina* was regarded as differing in characters of the septa, which were a gradual extension of the outer chamber wall and not sharply delineated. The angle of septal insertion is here regarded as of specific value only and *Chernyshinellina* is thought to be a synonym of *Endothyranella*. The briefly diagnosed *Rectochernyshinella* was regarded as similar to *Chernyshinellina*, with a biserial later stage. The type-species (original figures here reproduced) is known only from thin sections and shows some irregularities in chamber development, but is not truly biserial. Later references to the type-species (\*1143, pl. 13, figs. 10, 11) are equally inconclusive. It is regarded as a synonym of *Endothyranella*.]

**Kahlerina** KOCHANSKY-DEVIDÉ & RAMOV, 1955, \*1047A, p. 383, +12 [*\*K. pachythea*; OD] [= *Ussuriella* SOSNINA in KIPARISOVA *et al.*, 1956, \*1040, p. 21 (type, *U. ussurica*) (non *Ussuriella* PARAMONOV, 1929)]. Test enrolled, subspherical, umbilici slightly indented; early coiling somewhat plectogyral, that of microspheric form having 1 or 2 abrupt turns of about 90 degrees similar to *Endothyra*, few (4-8) whorls; microspheric proloculus small and globular, megalospheric proloculus up to 0.14 mm., 8-10 chambers per whorl, increasing fairly rapidly in height; septa straight,

radial, thick-walled; wall thick, of 2 layers (referred to tectum and keriotheca, although keriothecal structure is indistinct), reduced chomata, as in *Quasiendothyra*, and some very small parachomata rarely present, tunnel low, not continuous, observed rarely; foramina and very fine septal pores present. [Originally *Kahlerina* was regarded as a primitive form placed in the Verbeekiniinae \*1047A), but later it was transferred to the Staffellinae (\*1509). It is here considered as simpler than the Fusulinacea and tentatively placed in the Endothyriinae.] *U.Perm.*, Yugoslav.-USSR.—FIG. 262A,1. \**K. pachythea*, *U.Perm.*, Yugoslav.; 1*a*, axial sec. of microspheric form (holotype), ×40; 1*b*, axial sec. of megalospheric form, ×20; 1*c,d*, median secs. of microspheric forms, ×20 (\*1047A).—FIG. 262A,2. *K. ussurica* (SOSNINA), *U.Perm.*, USSR; 2*a,b*, axial and median secs., ×25; 2*c*, portion of wall showing "keriothecal" structure, ×70 (\*1040).

**Novella** GROZDILOVA & LEBEDEVA, 1950, \*830A, p. 20 [*\*N. evoluta*; OD]. Test small, discoidal, planispiral and evolute, symmetrical; early chambers small and globular, later ones numerous, relatively broad and low and forming 2.5 to 7 whorls; septa straight, simple; wall thin, undifferentiated, chomata well developed in later whorls; aperture a single crescentic opening. [Originally placed with the staffellids, close to *Eostaffella* and *Millerella*, it was also considered to be related to *Nanicella*. It is here assigned to the Endothyriinae, because of the undifferentiated wall, single aperture, and presence of chomata.] *U.Carb.* (Namur-Moscow.), USSR.—FIG. 262A,3. \**N. evoluta*, *Moscow.*, Ural Mtns.; 3*a,b*, axial secs. of paratype and holotype, ×100 (\*830A).—FIG. 262A,4. *N. primitiva* RAUZER-CHERNOUSOVA, Vereisk., medial sec., ×80 (\*2074).

**Paraendothyra** CHERNYSHEVA, 1940, \*334, p. 129, 134 [*\*P. nalivkini*; OD]. Test free, enrolled, slightly evolute, biumbilicate, early coiling plectogyral, later nearly planispiral; wall dark, coarsely granular; aperture areal, crescentic slit. [*Paraendothyra* is characterized by its areal aperture.] *L.Carb.* (Tournais.), USSR (Urals).—FIG. 263,1-3. \**P. nalivkini*; 1*a,b*, side, apert. views, ×30; 2, axial sec., ×40; 3, equat. sec., ×40 (\*1509).

**Paraplectogyra** OKIMURA, 1958, \*1386, p. 254 [*\*P. masanae*; OD]. Test similar to *Endothyra*, but wall with 3 distinct layers, corresponding to tectum, diaphanotheca, and lower tectorium of fusulinids. *L.Carb.-Low.U.Carb.*, Japan.—FIG. 263,6,7. \**P. masanae*, *L.Carb.* (M.Miss.); 6, axial sec. of paratype; 7, equat. sec. of holotype, ×125 (\*1386).

**Quasiendothyra** RAUZER-CHERNOUSOVA, 1948, \*1504, p. 228 [*\*Endothyra kobeitusana* RAUZER-CHERNOUSOVA, 1948, \*1505, p. 7; OD] [= *Criboendothyra* LEBEDEVA, 1956, \*1101, p. 46 (type, "C. no. 1 sp. et gen. nov." *nom. nud.*); *Planoendothyra* REYTLINGER, 1958, \*1564, p. 57 (*nom.*

*nud.*); *Planoendothyra* REYTLINGER in RAUZER-CHERNOUSOVA & FURSENKO, 1959, \*1509, p. 194 (type, *Endothyra aljutovica* REYTLINGER, 1950,

\*1560, p. 34); *Eoendothyra* MIKLUKHO-MAKLAY, 1960, \*1273, p. 140 (type, *Endothyra communis* RAUZER-CHERNOUSOVA, 1948, \*1505, p. 6)]. Test

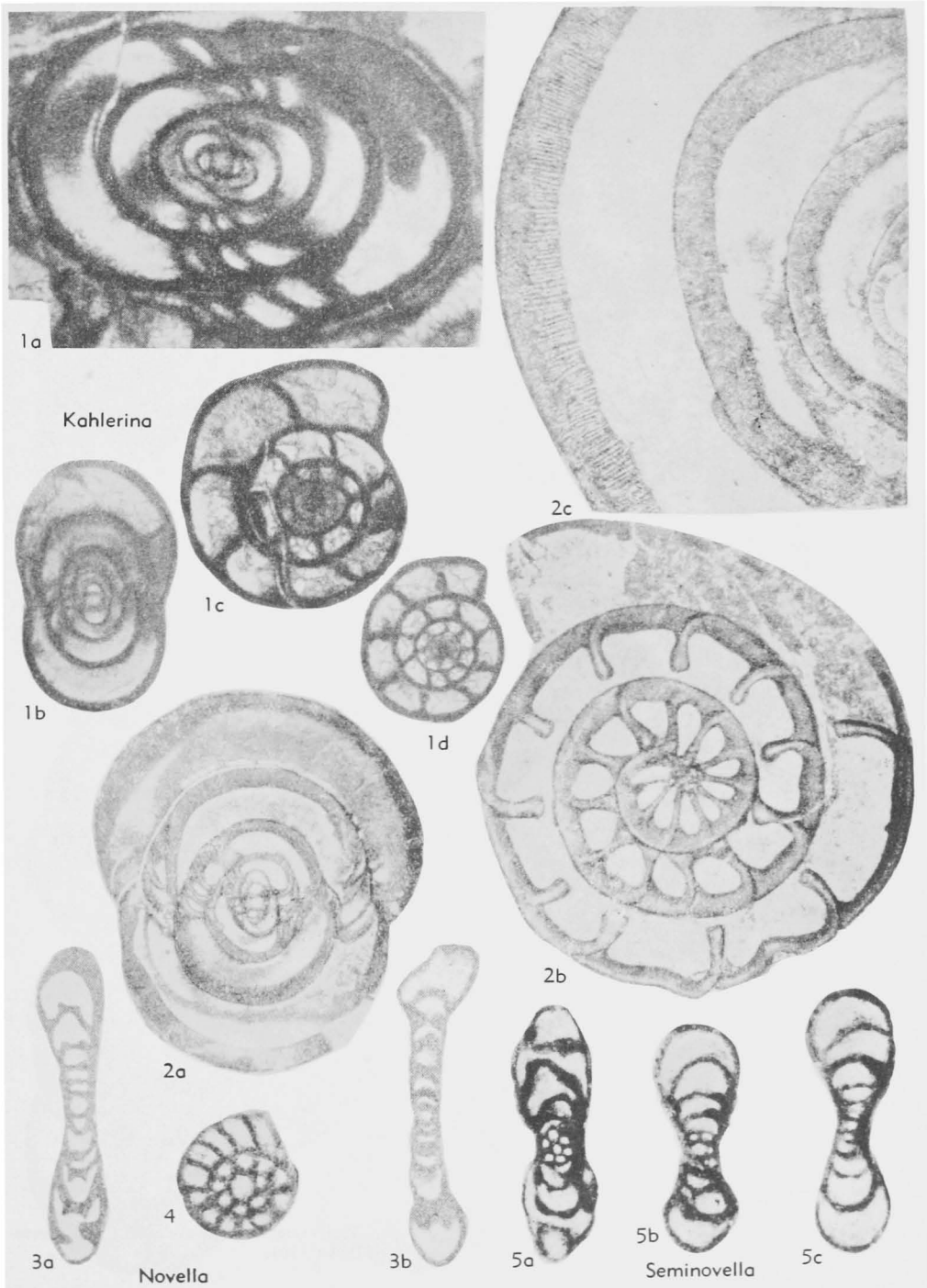


FIG. 262A. Endothyridae (Endothyrinae; 1,2, *Kahlerina*; 3,4, *Novella*; 5, *Seminovella*) (p. C346, C350).

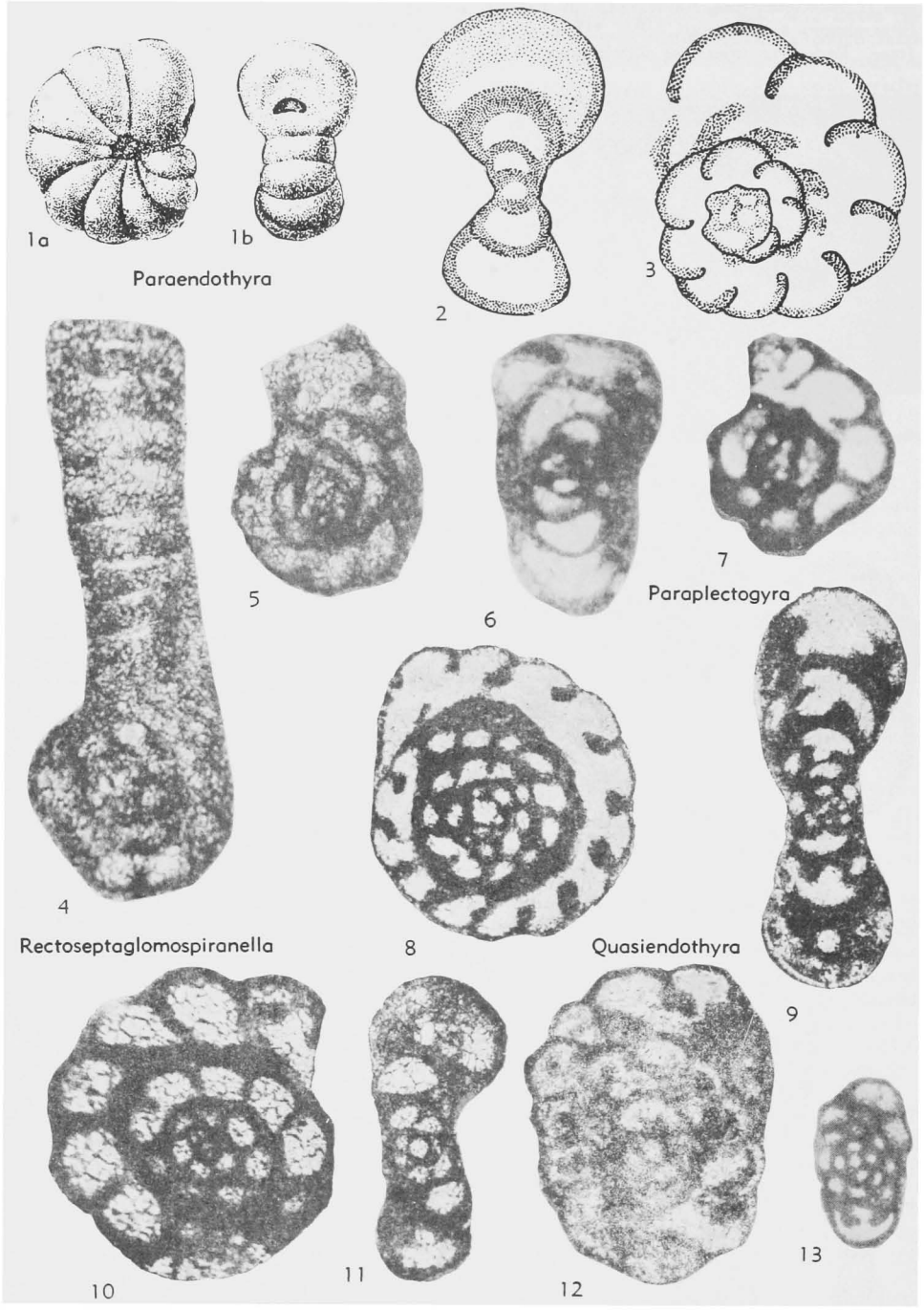


FIG. 263. Endothyridae (Endothyrinae; 1-3, *Paraendothyra*; 4,5, *Rectoseptaglomospiranella*; 6,7, *Paraplectogyra*; 8-13, *Quasiendothyra*) (p. C346-C350).



enrolled, compressed, early stage plectogyral, later planispiral, evolute; wall homogeneous, with secondary deposits at base of chambers at outer margins, giving appearance of chomata of fusulinids, aperture interiomarginal. *Dev.-Carb., USSR.*

—FIG. 263,8,9. \**Q. kobeitusana* (RAUZER-CHERNOUSOVA), *Dev.(Famenn.)*; equat. and axial secs., showing lateral secondary deposits,  $\times 75$  (\*1509).—FIG. 263,10,11. *Q. aljutovica* (REYTLINGER), *U.Carb.(Moscov.)*; equat. and axial secs.,

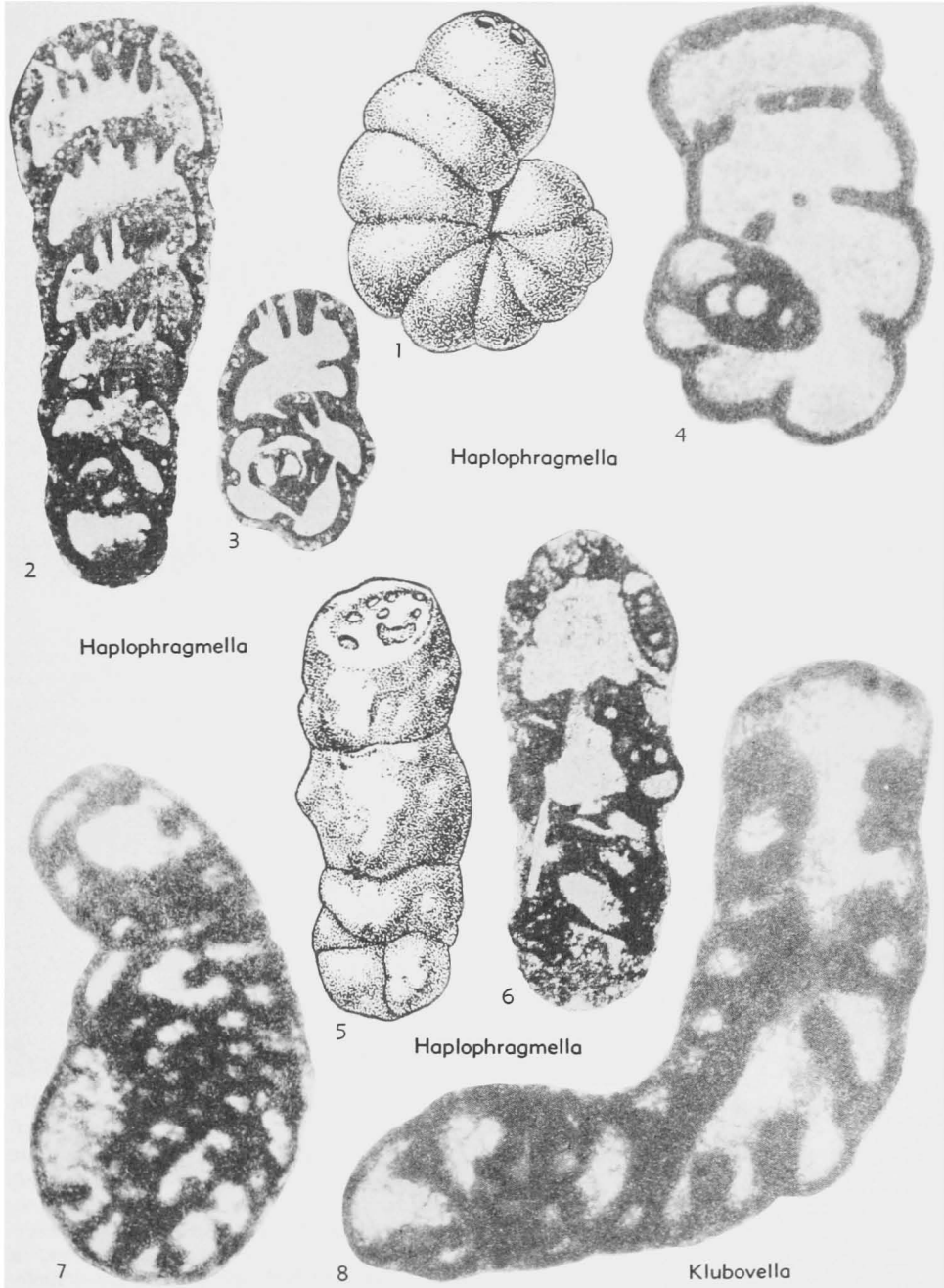


FIG. 264. Endothyridae (Haplophragmellinae; 1-6, *Haplophragmella*; 7,8, *Klubovella*) (p. C350-C352).

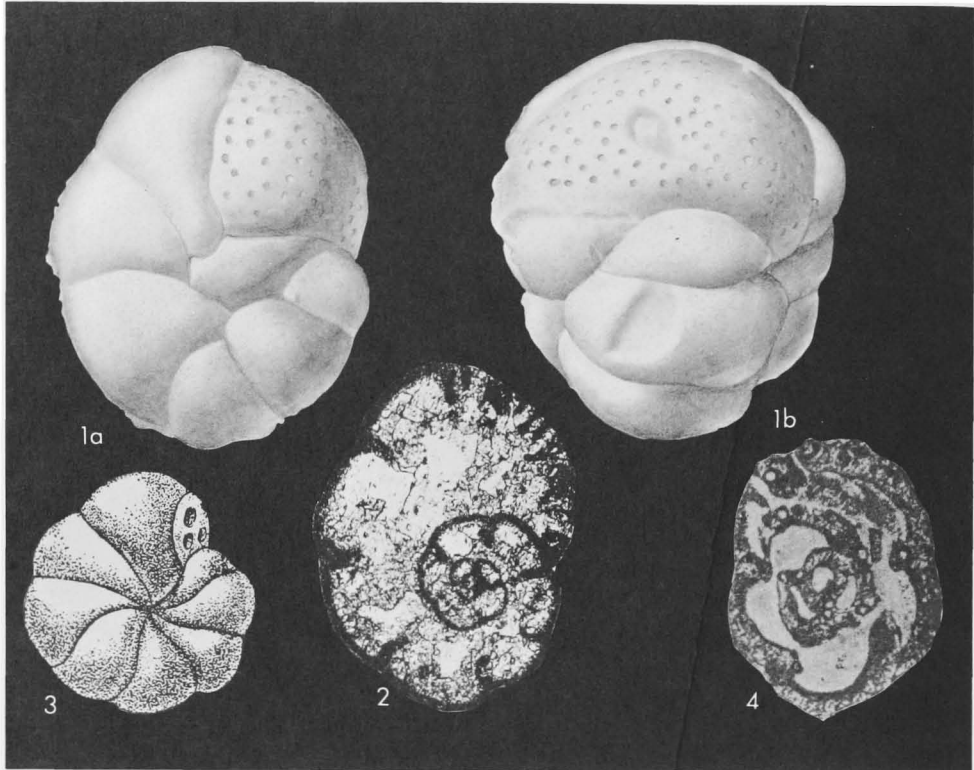


FIG. 265. Endothyridae (Haplophragmellinae; 1-4, *Cribrospira*) (p. C352).

×46 (\*1509).—FIG. 263,12,13. *Q. communis* (RAUZER - CHERNOUSOVA), U.Dev., USSR (C. Kazakh.); 12, horiz. sec., ×46 (\*1505); 13, axial sec., ×61 (\*1101).

**Rectoseptaglomospiranella** REYTLINGER, 1961, \*1566, p. 62 [*Septaglomospiranella* (*Rectoseptaglomospiranella*) *asiatica*; OD] [= *Septaglomospiranella* (*Rectoseptaglomospiranella*) REYTLINGER, 1961, \*1566, p. 62 (obj.)]. Test elongate, early portion streptospirally coiled, later becoming planispiral and then uncoiled and rectilinear; incompletely septate in coiled stage, rectilinear stage with broad, low, closely appressed chambers, completely septate; wall calcareous, coarsely granular, thick; aperture simple, at least in early stages. *U.Dev.* (*Famenn.*), ?*L.Carb.* (*L.Tournais.*), USSR (Kazakh.).—FIG. 263,4,5. \**R. asiatica*, U.Dev. (*Famenn.*); 4, long. equat. sec. of holotype; 5, equat. sec. of juvenile specimen, ×75 (\*1566).

[This genus was originally described as a subgenus of *Septaglomospiranella* (here placed in the synonymy of *Septabrünsina*), which is similar to the early coiled stage of the present form. As *Rectoseptaglomospiranella* differs in the uncoiled later stage, it is here elevated to generic status. It differs from *Haplophragmella* in its low, closely appressed chambers and simple noncribrate aperture of the rectilinear stage.]

**Seminovella** RAUZER-CHERNOUSOVA, 1951, \*2074, p. 64 [*Eostaffella* (*Seminovella*) *elegantula*; OD] [= *Eostaffella* (*Seminovella*) RAUZER-CHERNOUSOVA, 1951, \*2074, p. 64 (obj.)]. Test planispiral,

discoidal to biconcave, slightly asymmetrical, early 1 or 2 whorls involute, later 2 to 4 whorls becoming evolute, with whorls rapidly increasing in thickness, leaving broad, deep umbilicus; septa simple; wall homogeneous in structure, minor supplementary deposits (pseudochomata); single aperture. [*Seminovella* was originally regarded as transitional between *Millerella* and *Novella*, but because of the simple wall structure and single aperture it is here transferred to the Endothyridae and elevated to generic status.] *U.Carb.* (*U. Namur.-Moscov.*), USSR.—FIG. 262A,5. \**S. elegantula*; 5b, axial sec. of holotype, ×74; 5a,c, axial secs. of paratypes, ×74 (\*2074).

#### Subfamily HAPLOPHRAGMELLINAE Reytlinger, 1959

[Haplophragmellinae REYTLINGER in RAUZER-CHERNOUSOVA & FURSENKO, 1959, p. 185]

Test free, early stage enrolled as in the Endothyridae, later may be uncoiled; aperture simple in early stage, areal and cribrate in adult. *L.Carb.* (*Tournais.*) - *M.Carb.* (*Moscov.*).

**Haplophragmella** RAUZER-CHERNOUSOVA & REYTLINGER in RAUZER-CHERNOUSOVA, BELYAEV, & REYTLINGER, 1936, \*1507, p. 215, 228 [*Endothyra panderi* von MÖLLER, 1879, \*1296, p. 17; OD] [= *Endothyra* MIKHAYLOV, 1935, \*1259,



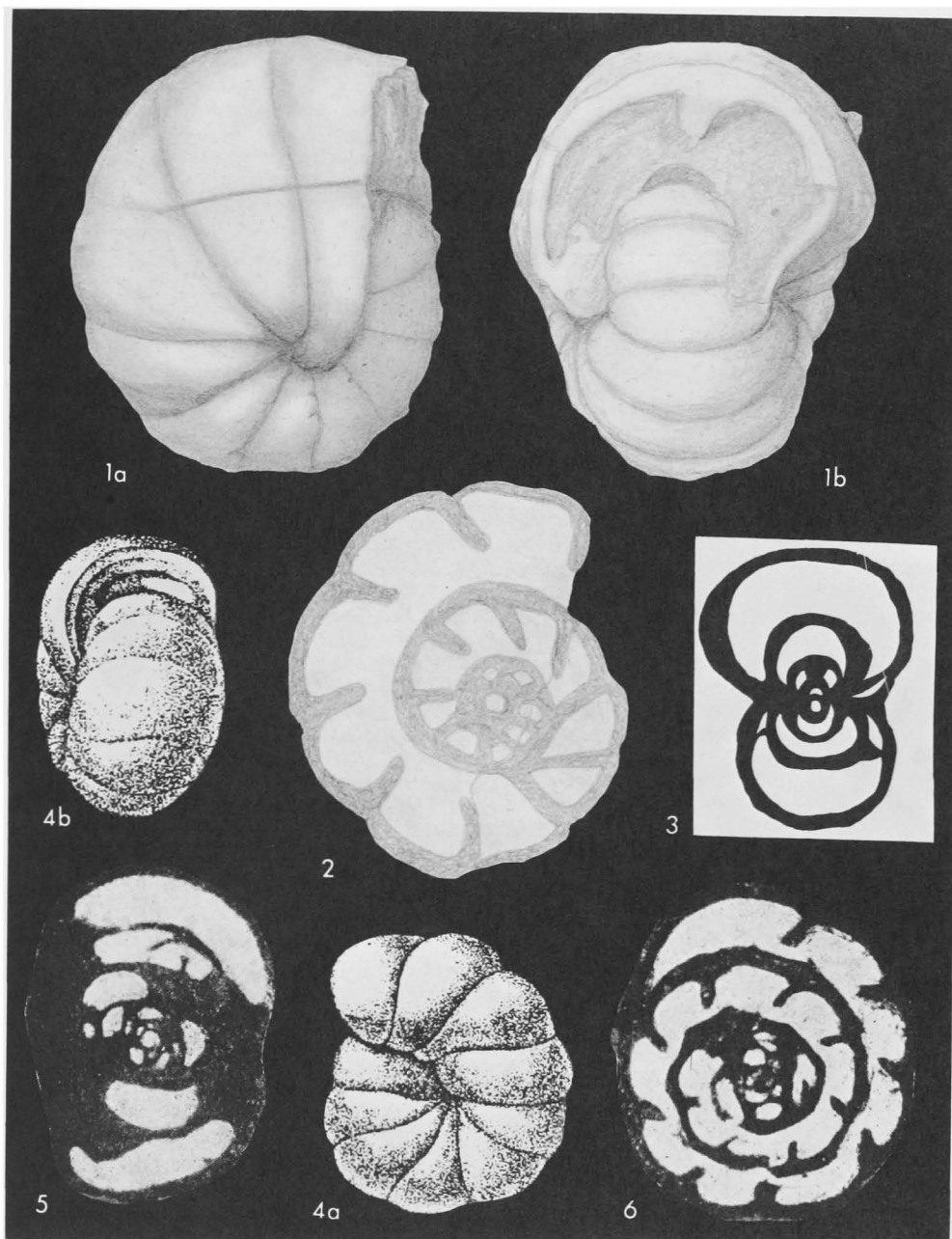


FIG. 266. Endothyridae (Endothyranopsinae; 1-6, *Endothyranopsis*) (p. C352).

p. 40 (type, *E. typica*, nom. nud.); *Haplophragmina* REYTLINGER, 1950, \*1560, p. 28 (type, *H. kashirica*); *Mikhailovella* GANELINA, 1956, \*769, p. 100 (type, *Endothyra*? *gracilis* RAUZER-CHERNOUSOVA, 1948, \*1502, p. 163)]. Test free, early portion enrolled as in *Endothyra*, later uncoiling and rectilinear; wall calcareous but may include some adventitious material; aperture sim-

ple and interiomarginal in early coiled stage, later becoming terminal and cribrate. *L.Carb. (Tournais.) - U. Carb. (Moscov.)*, USSR.—FIG. 264,1. \**E. panderi* (VON MÖLLER), Viséan; side view,  $\times 44$  (\*1509).—FIG. 264,2,3. *E. irregularis* (RAUZER-CHERNOUSOVA), Viséan, long. secs.,  $\times 20$  (\*1509).—FIG. 264,4. *E. gracilis* RAUZER-CHERNOUSOVA, *L.Carb.*; long. sec.,  $\times 72$  (\*769).

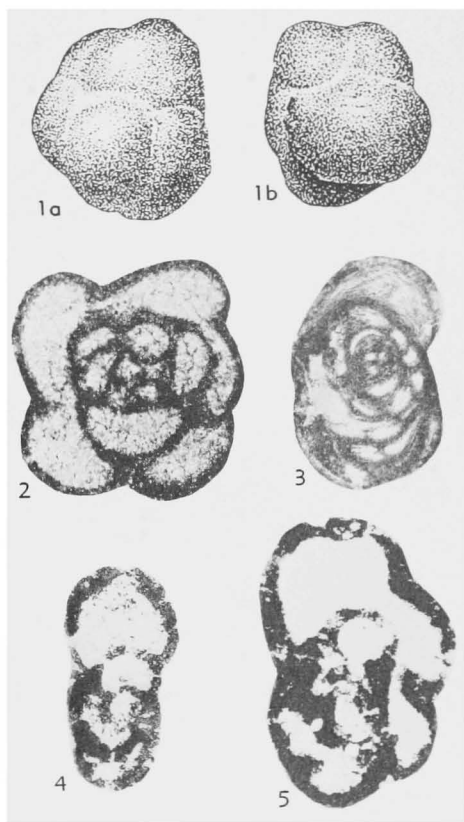


FIG. 267. Endothyridae (Endothyranopsinae; 1-5, *Chernyshinella*) (p. C352-C353).

—FIG. 264,5,6. *E. kashirica* (REYTLINGER), Moscow; 5, side view,  $\times 55$ ; 6, long. sec.,  $\times 46$  (\*1509).

**Criborespira** VON MÖLLER, 1878, \*1295, p. 86 [*\*C. panderi*; OD (M)] [= *Mstinia* MIKHAYLOV, 1939, \*1260, p. 59 (type, *M. bulloides*)]. Test free, enrolled, with somewhat irregular coiling, probably plectogyral, nearly involute, chambers increasing rapidly in size, whorls few; septa short, final septal face probably resorbed as new chambers are added; wall calcareous, granular; aperture cribrate, consisting of large pores on apertural face, intercameral openings large, interiomarginal, possibly by resorption of apertural face. [*Mstinia* was defined as differing from *Criborespira* in having the final septal face equivalent to the septa. These differences seem to be rather a matter of shape and proportions, however.] *L.Carb.* (Visean), USSR.—FIG. 265,1,2. *\*C. panderi*; 1a,b, side, apert. views,  $\times 44$  (\*2117); 2, equat. sec., approx.  $\times 28$  (\*1503).—FIG. 265,3,4. *C. bulloides* (MIKHAYLOV); 3, side view; 4, equat. sec.,  $\times 28$  (\*1509).

**Klubovella** LEBEDEVA, 1956, \*1101, p. 52 [*\*K. konensis*; OD]. Test with early plectogyral enrolled portion, later uncoiled, with "biserially arranged" chambers; wall calcareous, with 2 layers; aperture simple, basal in early stage, later terminal, multiple. *L.Carb.*, USSR (Kazakh).—FIG. 264,7,8. *\*K. konensis*; 7,8, syntypes, long. secs.,  $\times 83$  (\*1101).

[This genus is provisionally recognized on the basis of the original description, but the "biserial" character seems questionable. No other biserial forms are known in this group and the original illustrations (here copied) do not show any clear biseriality. Both of the original figured specimens were labeled "holotype" on the plate description.]

#### Subfamily ENDOTHYRANOPSINAE Reytinger, 1958

[Endothyranopsinae REYTLINGER, 1958, p. 57] [= Chernyshinellinae REYTLINGER, 1958, p. 60]

Test planispiral, involute, not compressed, distinctly septate; wall a single layer of thick granular calcite with some adventitious material, perforate; aperture simple, basal. *L.Carb.*

**Endothyranopsis** CUMMINGS, 1955, \*398, p. 1 [*\*Involutina crassa* BRADY in MOORE, 1870, \*1306, p. 379, 382; OD] [= *Globoendothyra* REYTLINGER, 1958, \*1564, p. 57 (*nom. nud.*); *Globoendothyra* REYTLINGER in RAUZER-CHERNOUSOVA & FURSENKO, 1959, \*1509, p. 196 (type, *G. pseudoglobulus*)]. Test free, subglobular to nautiloid, biumbilicate, planispiral and involute but with slight axial rotation resulting in somewhat asymmetrical test; chambers broad, low; sutures somewhat depressed, radial; wall finely granular, perforate, may have some adventitious material, surface smoothly finished; aperture low, interiomarginal, equatorial arch. *L.Carb.*, Eu.-Asia (USSR, Bashkiri).—FIG. 266,1,2. *\*E. crassa* (BRADY), Wales; 1a,b, side, apert. views of lectotype; 2, equat. sec.,  $\times 41$  (\*2117).—FIG. 266,3. *E. sp.*; axial sec.,  $\times 35$  (\*398).—FIG. 266,4-6. *E. pseudoglobulus* (REYTLINGER), Visean, USSR (Bashkiri); 4a,b, side, apert. views,  $\times 22$  (\*1509); 5,6, axial equat. secs., approx.  $\times 40$  (\*2008).

[Differs from *Bradyina* in its slight axial rotation and in having a simple arched aperture, rather than one or more rows of pores across the apertural face. It differs from *Endothyra* in its included adventitious matter and wall perforations, whereas *Endothyra* has a 2-layered, imperforate wall.]

**Chernyshinella** LIPINA, 1955, \*1143, p. 47 [*\*Endothyra glomiformis* LIPINA, 1948, \*1141, p. 254; OD] [= *Granuliferella* E. J. ZELLER, 1957, \*2104, p. 694 (type, *G. granulosa*)]. Test enrolled, slightly asymmetrical, coiling plectogyral, few volutions, umbilicate; chambers few to whorl and relatively large; septa oblique, continuing chamber curvature and not sharply delineated from outer chamber wall, which is single-layered, relatively thick, and granular; aperture low, narrow, equatorial interiomarginal slit. [Differs from *Endothyra* in having a single-layered wall, and

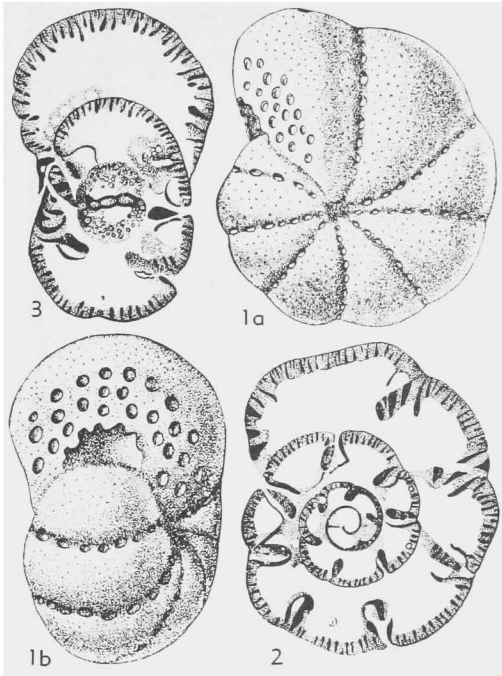


FIG. 268. Endothyridae (Bradyininae; 1-3, *Bradyina*) (p. C353).

from *Endothyranopsis* in its fewer, more inflated chambers in each whorl, and plectogyral coiling.] *L.Carb.(Tournais.)*, USSR-N.Am.-Japan. — FIG. 267, 1-3. \**C. glomiformis* (LIPINA), USSR; 1a,b, ext. views,  $\times 72$  (\*1509); 2, equat. sec.,  $\times 70$

(\*1143); 3, axial sec.,  $\times 35$  (\*649). — FIG. 267, 4, 5. *C. granulosa* (ZELLER), L.Miss., USA (Utah); axial and equat. secs.,  $\times 100$  (\*2104).

#### Subfamily BRADYININAE Reytlinger, 1950

[Bradyininae REYTLINGER, 1950, p. 38]

Test planispiral, involute; wall of granular calcite, complex interior; chambers alternating, with small chamberlets visible externally by row of openings along sutures; aperture multiple, areal, and interiomarginal. *Carb.*

*Bradyina* VON MÖLLER, 1878, \*1295, p. 78 [\**B. nautiliformis* (= *Nonionina rotula* EICHWALD, 1860, \*691, p. 349); SD CUSHMAN, 1927, \*433, p. 189]. Test free, robust, planispiral, involute, few chambers and whorls; chamberlets or canals formed by converging septal lamellae or infolding of outer wall to form septa, chamberlets extending into umbilical region; wall calcareous, microgranular, perforate, with distinct radial lamellae; primary interiomarginal aperture, with additional large areal pores forming cribrate aperture, and supplementary septal pores opening into septal chamberlets. *L.Carb.(Miss.)-U.Carb.(Penn.)*, Eu.-N.Am. — FIG. 268, 1-3. \**B. rotula* (EICHWALD), *L.Carb.(Visean)*, USSR; 1a,b, side, apert. views; 2, 3, equat., axial secs.,  $\times 14$  (\*1509).

*Glyphostomella* CUSHMAN & WATERS, 1928, \*535, p. 53 [\**Ammochilostoma? triloculina* CUSHMAN & WATERS, 1927, \*534, p. 152 (= *Bradyina holdenvillensis* HARLTON, 1927, \*879, p. 18); OD] [= *Pseudobradyna* REYTLINGER, 1950, \*1560, p. 45 (type, *P. pulchra*)]. Test planispiral, involute, few (usually 3) chambers to whorl, in-

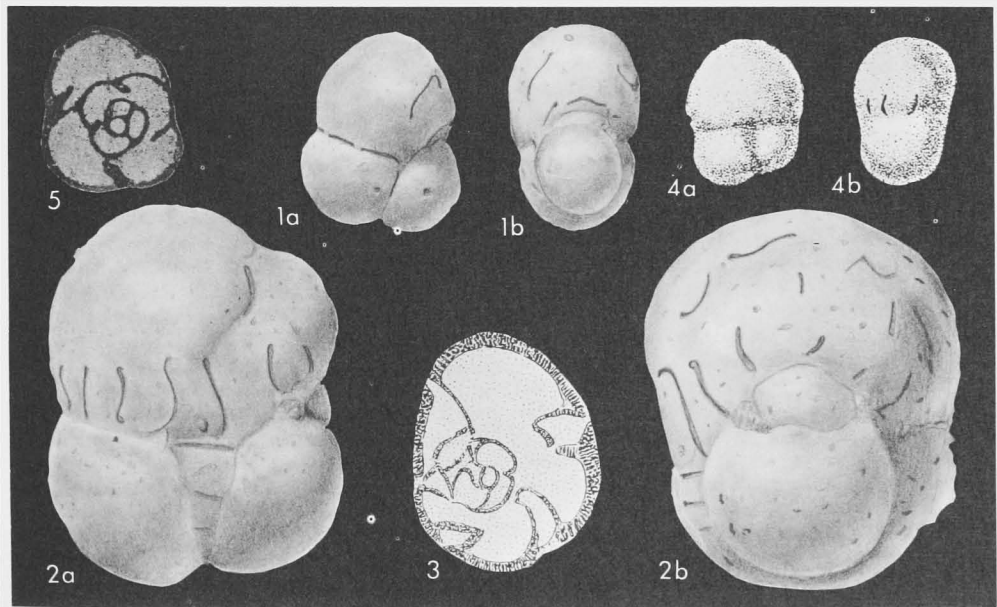


FIG. 269. Endothyridae (Bradyininae; 1-5, *Glyphostomella*) (p. C353-C354).

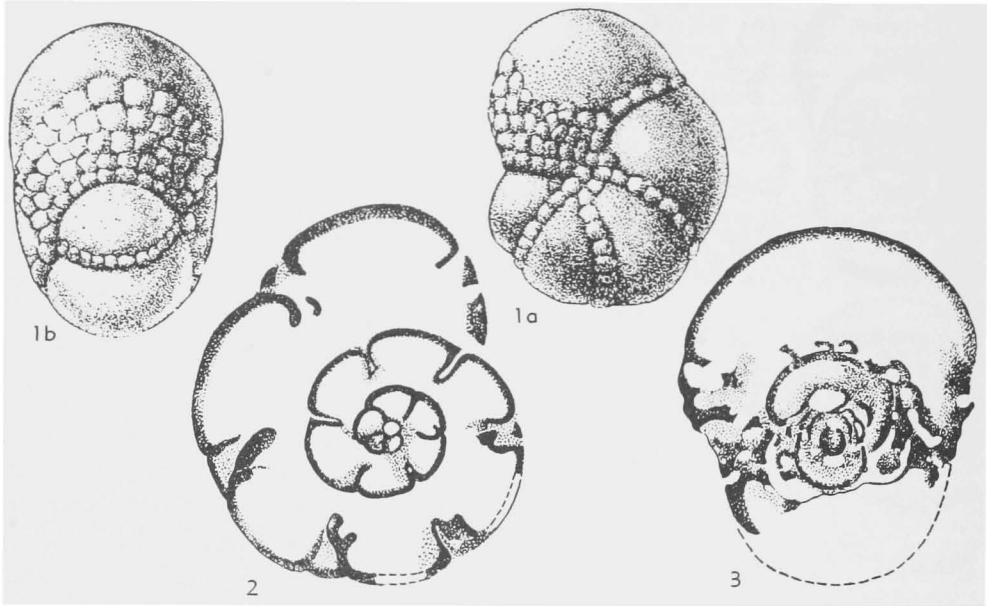


FIG. 270. Endothyridae (Bradyininae; 1-3, *Janischewskina*) (p. C354).

creasing rapidly in size; septal chamberlets similar to those of *Bradyina*; wall calcareous, alveolar, granular, perforate; aperture consists of one to many straight or curved narrow slits at base and in face of final chamber, and supplementary sutural slits opening into septal chamberlets. [The synonymy of *Ammochilostoma? trilocolina* CUSHMAN & WATERS, 1927 (Sept.) with *Bradyina holdenvillensis* HARLTON, 1927 (July) was noted by WARTHIN (1930, \*2040, p. 23).] *U.Carb.(Penn.)*, USA-USSR.—FIG. 269,1,2. \**G. holdenvillensis* (HARLTON), Penn., USA(Tex.); 1*a,b*, side, apert. views of holotype of *Ammochilostoma? trilocolina* CUSHMAN & WATERS,  $\times 50$ ; 2*a,b*, large paratype of *A.? trilocolina*,  $\times 50$  (\*2117).—FIG. 269,3, *G. sp.*, equat. sec.,  $\times 24$  (\*535).—FIG. 269,4,5. *G. pulchra* (REYTLINGER), *U.Carb.*, USSR; 4*a,b*, side, apert. views,  $\times 28$ ; 5, equat. sec.,  $\times 36$  (\*1509).

**Janischewskina** MIKHAYLOV, 1935, \*1259, p. 40 [\*]. *typica*; OD] [= *Janischewskina* MIKHAYLOV, 1939, \*1260, p. 59 (*nom. null.*); *Samarina* RAUZER-CHERNOUSOVA & REYTLINGER in RAUZER-CHERNOUSOVA, BELYAEV & REYTLINGER, 1940, \*1508, p. 53 (type, *S. operculata*)]. Test free, planispiral, involute; septal chamberlets formed by infolding of outer wall as in *Bradyina*; wall calcareous, fibrous, but without radial lamellae of *Bradyina*; aperture cribrate, in apertural "shield" and with secondary sutural openings. [*Janischewskina* differs from *Bradyina* in its less complex wall and cribrate aperture in a "shield," but without a definite interiomarginal opening.] *L.Carb.*

(*Visean*), USSR.—FIG. 270,1-3. \**J. typica*; 1*a,b*, side, apert. views,  $\times 14$ ; 2,3, equat., axial secs.,  $\times 25$  (\*1509).

#### Family ARCHAEDISCIDAE Cushman, 1928

[*nom. transl.* CHERNYSHEVA, 1948, p. 151 (*ex subfamily* Archaediscinae CUSHMAN, 1928, p. 209)] [= *Asteroarchaediscinae* MIKLUKHO-MAKLAY, 1957, p. 37]

Proloculus followed by tubular second chamber, involute in early stage, later streptospirally or planispirally coiled; outer wall layer of radial calcite, inner layer finely granular; aperture at end of spiral chamber. *L.Carb.-Perm.*

**Archaediscus** BRADY, 1873, \*189, p. 286 [\**A. karveri*; OD (M)] [= *Archaediscoum* RHUMBLER, 1913, \*1572b, p. 389 (*obj.*) (*nom. van.*); *Neodiscus* A. D. MIKLUKHO-MAKLAY, 1953, \*1262, p. 129 (type, *N. milliloides*); *Propermodiscus* A. D. MIKLUKHO-MAKLAY, 1953, \*1262, p. 128 (type, *Hemigordius ulmeri* MIKHAYLOV, 1939, \*1260, p. 61); *Paraarchaediscus* ORLOVA, 1955, \*1399, p. 621 (type, *P. dubitabilis*); *Asteroarchaediscus* A. D. MIKLUKHO-MAKLAY in KIPARISOVA, *et al.*, 1956, \*1040, p. 10 (type, *Archaediscus bashkiricus* KRESTOVNIKOV & TEODOROVITCH, 1936, \*1055, p. 87); *Rugosoarchaediscus* A. D. MIKLUKHO-MAKLAY, 1957, \*1266, p. 37 (type, *Archaediscus akhimensis* GROZDILOVA & LEBEDEVVA, 1954, \*831, p. 53)]. Test free, lenticular; proloculus followed by streptospirally coiled, long, undivided tubular second chamber, evolute, tending to become more

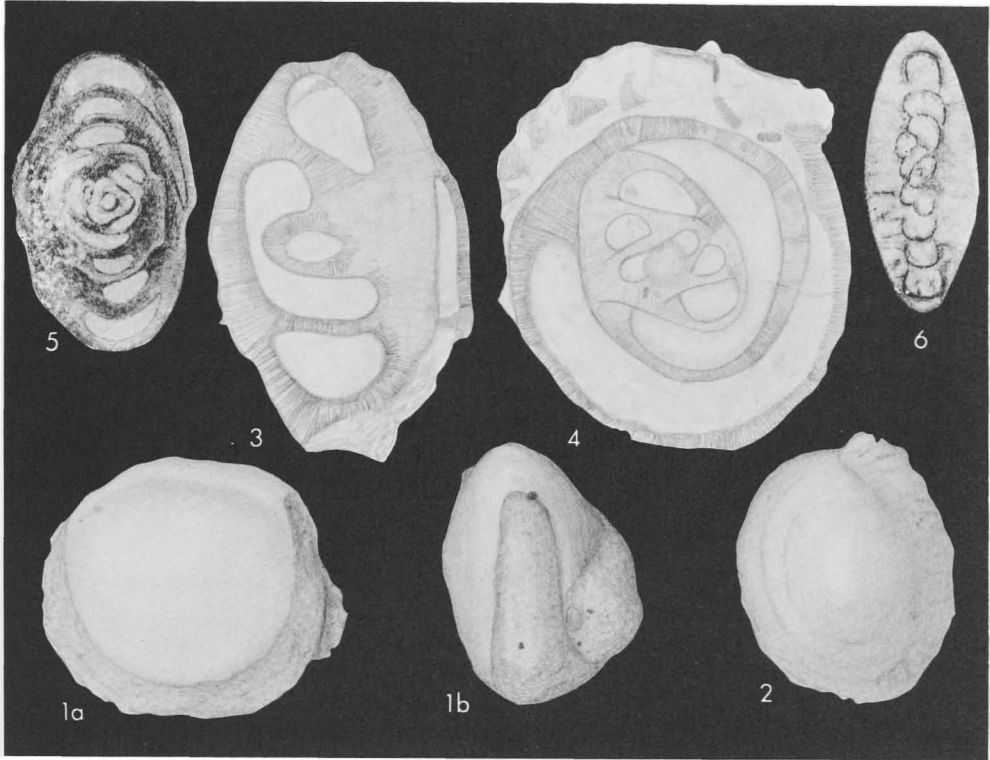


FIG. 271. Archaediscidae; 1-6, *Archaediscus* (p. C354-C355).

nearly planispiral with growth; wall calcareous, finely fibrous, with noticeable thickenings at sides of test, no outer imperforate layer observed; aperture at open end of tube. [Different generic names have been given to forms with varying degrees of symmetry of test thickening and relative amount of planispiral development. These are here regarded as specific distinctions only.] *L.Carb.-Perm., Eu.*—FIG. 271,1-4. \**A. karreri*, *Carb., Eng.*; 1a,b, side, edge views of syntype; 2, syntype in which later planispiral development can be distinguished; 3, axial sec. of syntype; 4, equat. sec. of syntype; all  $\times 64$  (\*2117).—FIG. 271,5. *A. milliloides* (MIKLUKHO-MAKLAY), *U.Perm., Caucasus*; axial sec. of holotype,  $\times 17$  (\*1262).—FIG. 271,6. *A. ulmeri* (MIKHAYLOV), *L.Carb. (Visean), USSR*;  $\times 80$  (\*1262).—FIG. 272,1,2. *A. dubitabilis* (ORLOVA), *U.Tournais, Saratov, I, ext.*,  $\times 40$ ; 2, axial sec. of holotype,  $\times 100$  (\*1399).—FIG. 272,3. *A. baschkiricus* KRESTOVNIKOV & TEODOROVITCH, *M.Carb. (Bashkir.), USSR (Kolva)*; axial sec.,  $\times 100$  (\*1509).—FIG. 272,4. *A. akchimensis* GROZDILOVA & LEBEDEVA, *L.Carb. (L.Bashkir.), USSR*; axial sec.,  $\times 100$  (\*831).

**Brunsia** MIKHAYLOV, 1939, \*1260, p. 58 [*\*Spirillina irregularis* von MÖLLER, 1879, \*1295, p. 41; OD] [= *Neoarchaediscus* A. D. MIKLUKHO-MAKLAY in KIPARISOVA, *et al.*, 1956, \*1040, p. 11 (type,

*Archaediscus incertus* GROZDILOVA & LEBEDEVA, 1954, \*831, p. 60); *Planoarchaediscus* A. D. MIKLUKHO-MAKLAY in KIPARISOVA, MARKOVSKII & RADCHENKO, 1956, \*1040, p. 10 (type, *Archaediscus spirillinoides* RAUZER-CHERNOUSOVA, 1948, \*1505, p. 12); *Hemiarchaediscus* A. D. MIKLUKHO-MAKLAY, 1957, \*1266, p. 36 (type, *H. planus*); *Quasiarchaediscus* A. D. MIKLUKHO-MAKLAY, 1960, \*1274, p. 150 (type *Q. pamirensis*)]. Test discoidal, consisting of proloculus followed by coiled nonseptate tubular chamber, which in early stage is plectogyral as in *Archaediscus* and in later stage is planispiral; wall calcareous, perforate, without lateral thickening; aperture at open end of tubular chamber. *L.Carb. (Visean)-U.Carb. (Namur.), Eu. (USSR)-Asia (USSR)*.—FIG. 272,5. *B. plana* (MIKLUKHO-MAKLAY), Pamir region; axial sec. of holotype,  $\times 100$  (\*1266).—FIG. 272,6. *B. incerta* (GROZDILOVA & LEBEDEVA), Baskir region; holotype,  $\times 100$  (\*1509).—FIG. 272,7,8. *B. pulchra* MIKHAYLOV, Ukraine; equat. and axial secs.,  $\times 100$  (\*1509).—FIG. 272,9. \**B. irregularis* (von MÖLLER), holotype,  $\times 135$  (\*700).—FIG. 272,10,11. *B. spirillinoides* (RAUZER-CHERNOUSOVA), Kazakh.; 10, axial sec. of holotype; 11, equat. sec. of paratype,  $\times 75$  (\*1505).—FIG. 272,12. *B. pamirensis* (A. D. MIKLUKHO-MAKLAY), Visean, Pamir region; holotype, horiz. sec.,  $\times 180$  (\*1274).



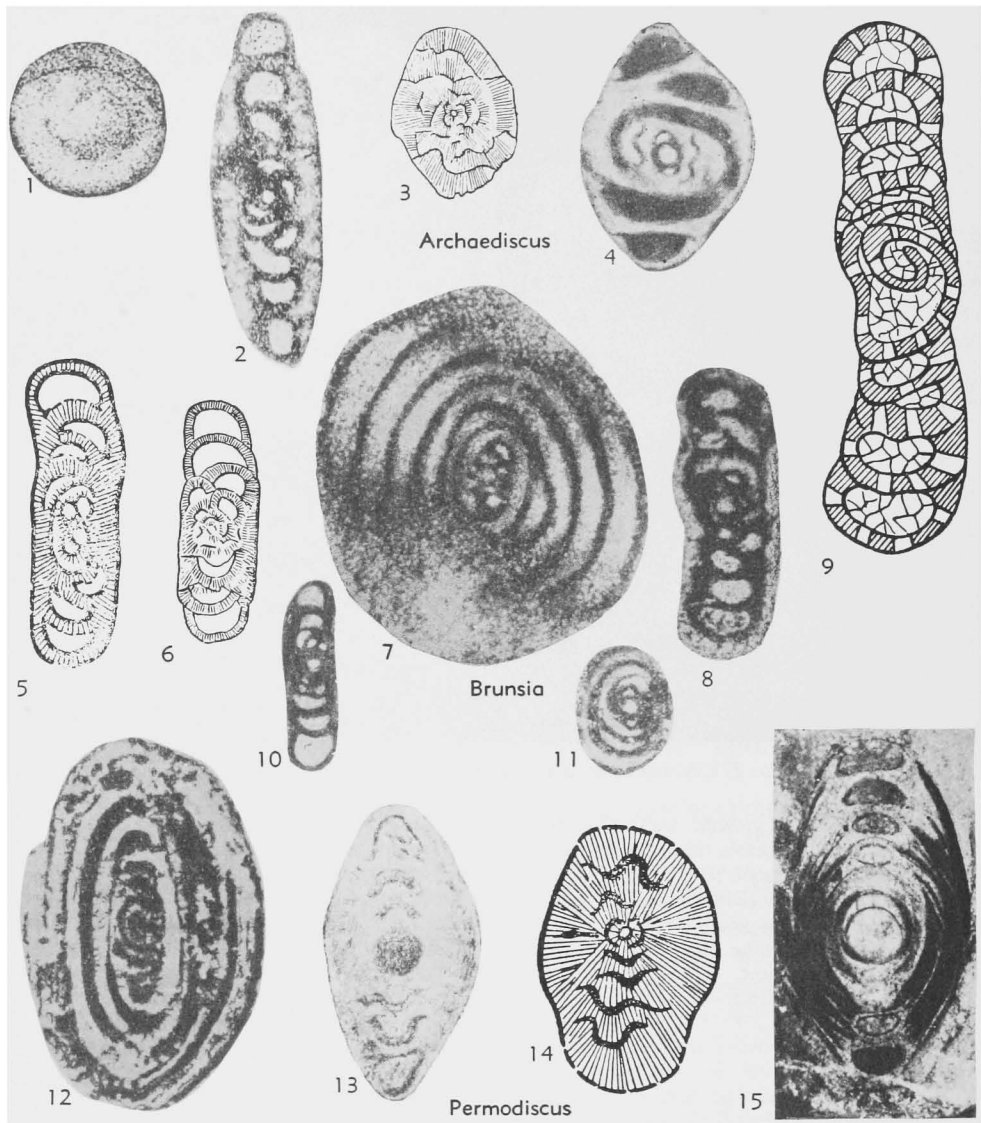


FIG. 272. Archaeodiscidae; 1-4, *Archaeodiscus*; 5-12, *Brunsia*; 13-15, *Permodiscus* (p. C355-C358).

[*Brunsia* differs from *Archaeodiscus* in being plectogyral only in the early stage, and planispiral in the later stage, and in lacking the pronounced lateral thickening of the wall. *Brunsia* was originally described as being agglutinated calcareous, with a cribrate aperture. The type-species is *Spirillina irregularis* von MÖLLER, by original designation. Later MYATLYUK (\*1332, p. 26) stated that *Spirillina? irregularis* was calcareous, with a very thin perforate wall and not agglutinated, hence she did not regard it as belonging to *Brunsia*, as that genus had been described. In a later publication, GROZDILOVA & LEBEDEVVA (1954, \*831, p. 29) cited *Brunsia pulchra* MIKHAYLOV as genotype species. As the type-species can never be changed once it has been fixed, the genus *Brunsia* must include *S. irregularis* von MÜLLER, whose specimens were described from thin sections which show an early irregular coil and later planispiral one, with distinctly fibrous or porous wall (the original figures being similar to those

of *S. subangulata* von MÖLLER, type-species of *Forschia*). Both undoubtedly have the granular calcareous fibrous or radially striate walls of the majority of the Endothyraea which are also characteristic of the Tournayellidae and Archaeodiscidae. True *Spirillina* does not appear in the Carboniferous. The cribrate aperture described by MIKHAYLOV apparently refers to the coarse perforations seen in the walls of *S. irregularis*, and does not represent a true aperture in these nonseptate forms. We regard *B. irregularis* and *B. pulchra* as congeneric. In addition, *Neoarchaeodiscus*, *Planorchaediscus*, and *Hemiarchaediscus* are regarded as synonymous, their differences being regarded as of specific importance only.]

*Permodiscus* DUTKEVICH in CHERNYSHEVA, 1948, \*336, p. 154 [*P. vetustus*; OD] [= *Permodiscus* MIKHAYLOV, 1939, \*1260, p. 49 (*nom. nud.*); *Multidiscus* A. D. MIKLUKHO-MAKLAY, 1953, \*1262,



p. 130 (type, *Nummulostegina padangensis* LANGE, 1925, \*1091, p. 271); *Lensarchaediscus* PORCHNJA-KOVA in A. D. MIKLUKHO-MAKLAY, 1957, \*1266,

p. 37 (type, *L. ovalis*]. Similar to *Archaediscus*, with massive lateral thickening of wall, but planispiral throughout. *L. Carb.-U. Perm.*, USSR-

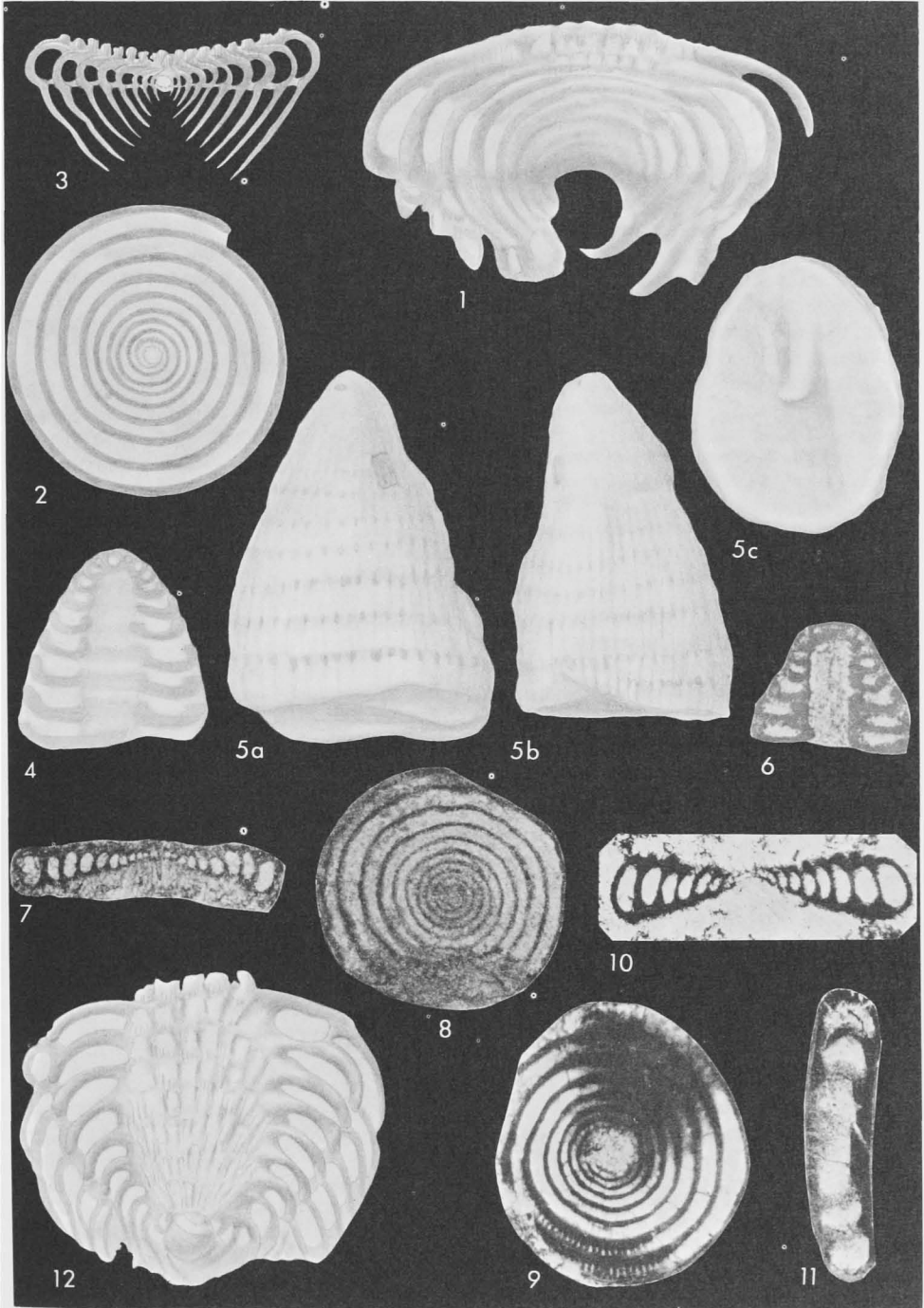


FIG. 273. Lasiiodiscidae; 1-3, *Lasiiodiscus*; 4-6, *Howchinia*; 7-11, *Monotaxinoides*; 12, *Lasiotrochus* (p. C358).

Malay Arch. (Sumatra).—FIG. 272,13. \**P. vetustus*, L.Carb. (Viséan), USSR;  $\times 100$  (\*1262).—FIG. 272,14. *P. ovalis* (PORCHNJAKOVA), U.Carb. (Namur.), USSR (Fergana); axial sec. of holotype,  $\times 100$  (\*1266).—FIG. 272,15. *P. padangensis* (LANGE), M.Perm., Sumatra;  $\times 12$  (\*1091).

### Family LASIODISCIDAE Reytlinger, 1956

[Lasiodiscidae REYTLINGER, 1956, p. 74]

Test planispiral to conical, proloculus followed by unsegmented tubular chamber; wall calcareous, with microgranular layer and radially built vitreous layer, latter concentrated as umbilical fillings perforated by canal-like fissures in advanced forms but consisting only of bridges across spiral suture in simple forms; aperture at open end of tubular chamber, with supplementary sutural openings. *L. Carb.-U. Perm.*

**Lasiodiscus** REICHEL, 1945, \*1517, p. 525 [*\*L. granifer*; OD]. Test free, consisting of proloculus, followed by planispirally enrolled tubular second chamber, one of surfaces ornamented by hyaline tubercles of radially fibrous thickening, and opposite side with tubular chamberlets, opening into main enrolled chamber by apertures along spiral suture; test calcareous, imperforate, finely granular, dark in transmitted light, tubercles vitreous. [Magnification of the illustrations has been computed from the size of the specimens, as a discrepancy is found in the stated magnifications of the photographs and text figures with the stated size in the original publication.] *M. Carb.-U. Perm.*, Eu. (Greece - Cyprus - USSR). — FIG. 273,1-3. \**L. granifer*, U.Perm., Cyprus; 1, holotype, oblique sec. passing near proloculus,  $\times 145$ ; 2,3, reconstr. equat. and axial secs.,  $\times 85$  (\*1517).

**Howchinia** CUSHMAN, 1927, \*431, p. 42 [*\*Patellina bradyana* HOWCHIN, 1888, \*965, p. 544; OD] [= *Monotaxis* VISSARIONOVA, 1948, \*2009, p. 190 (type, *Tetraxis conica* var. *gibba* VON MÖLLER, 1879, \*1296, p. 71) (non *Monotaxis* BENNETT, 1830; nec HULST, 1898; nec HAMPSON, 1900)]. Test free, conical, consisting of nonseptate tube coiled in high spire around slightly depressed umbilical region filled with microcrystalline calcite; spiral suture depressed, bridged by many small extensions of shell matter, leaving spiraling series of small pits between them; wall calcareous, minutely granular; aperture extending from umbilicus to periphery. *L. Carb. (Viséan)*, Eu. (Eng.-USSR).—FIG. 273,4,5. \**H. bradyana* (HOWCHIN), Eng.; 4, sectioned hypotype,  $\times 105$ ; 5a-c, side, edge and apert. views of neotype,  $\times 105$  (\*2117).—FIG. 273,6. *H. gibba* (VON MÖLLER), USSR;  $\times 80$  (\*2009).

[The specimen of *Howchinia bradyana* here figured is that designated by DAVIS (1951, \*564) as lectotype (BMNH-

P40403) from the Carboniferous limestone, Tipalt, D Zone, Old High Shd., Tipalt, Northumberland, England, lat. 54°59'53" N., long. 2°30'46" W. However, as it is not from the original type lot it must be considered as a neotype.]

**Lasiotrochus** REICHEL, 1946, \*1517, p. 531 [*\*L. tatoiensis*; OD]. Test free, small, similar in structure to *Lasiodiscus*, but with conical form due to high trochospiral enrollment of tubular chamber; tubular chamberlets from outer margin recurving toward proloculus, umbilical region filled by hyaline tubercles which have developed into distinct pillars of transparent calcite; wall calcareous, finely granular, umbilical pillars vitreous. [The genus was originally described from a single section of the type-species. Possibly additional material may show this to be a synonym of *Lasiodiscus*.] *L. Perm.-U. Perm.*, Eu. (Greece) - USSR (Azerbaijan).—FIG. 273,12. \**L. tatoiensis*, U.Perm., Greece; long. sec. of holotype,  $\times 140$  (\*1517).

**Monotaxinoides** BRAZHNIKOVA & YARTSEVA, 1956, \*205, p. 65 [*\*M. transitorius*; OD] [= *Eolasiodiscus* REYTLINGER, 1956, \*1562, p. 75 (type, *E. donbassicus*)]. Test discoidal, concave on one side with proloculus followed by planispirally coiled nonseptate tubular second chamber; wall calcareous, with finely granular dark inner layer and clear, radiate vitreous outer layer that becomes thickened on concave side; aperture at open end of tube. [*Eolasiodiscus* was described as having supplementary fissure-like openings along the spiral suture, as seen in the figured equatorial section. It seems probable that this appearance is due to cutting of the radiate layer by the section. *Eolasiodiscus* is here regarded as synonymous with *Monotaxinoides*. It is apparently transitional between *Howchinia* and *Lasiodiscus*.] *L. Carb.-U. Carb.*, Eu. (USSR).—FIG. 273,7,8. \**M. transitorius*, L.Carb., Donets Basin; 7, axial sec. of holotype; 8, equat. sec. of paratype; both  $\times 100$  (\*205).—FIG. 273,9-11. *M. donbassicus* (REYTLINGER), M.Carb., Donets Basin; 9, equat. sec. of holotype; 10, axial sec.; 11, tang. axial sec., all  $\times 174$  (\*1562).

## FUSULINACEA

By M. L. THOMPSON

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## INTRODUCTION

Foraminifers of the superfamily Fusulinacea are mostly robust representatives of the order characterized by distinctive complex internal structure of their spindle-shaped, spheroidal, or discoid calcareous tests (Fig. 274). Extraordinarily profuse in many rock formations, they are an exclusively late Paleozoic group of fossils. In the century

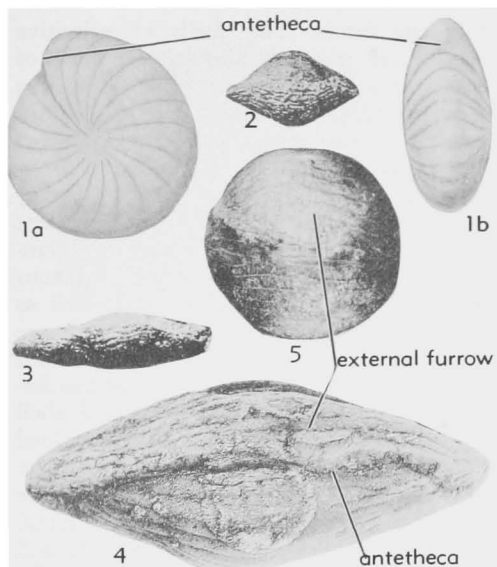


FIG. 274. Exterior views of fusulinaceans showing typical shapes of shells.—1. Discoid; \**Nummulostegina velebitana* SCHUBERT, Perm., Yugo., 1a,b, side and edge views of holotype,  $\times 20$  (\*2120B).—2-4. Fusiform: 2, *Fusulina girtyi* (DUNBAR & CONDRA), M.Penn., USA (Ill.), holotype,  $\times 3.3$  (\*1922); 3, \**Waeringella spiveyi* THOMPSON, U. Penn., USA (Tex.), paratype,  $\times 6.7$  (\*1922); 4, *Triticites ventricosus* (MEEK & HAYDEN), L.Perm., USA (Kans.), holotype,  $\times 6.7$  (\*1926).—5. Spheroidal: \**Verbeekina verbeeki* (GEINITZ), U. Perm., Sumatra, topotype,  $\times 6.7$  (\*1922).

and a half during which they have been under study by paleontologists, several dozen workers have contributed to our knowledge of their shell morphology, taxonomy, stratigraphic distribution, and evolution.

The fusulinaceans had their beginning in late Mississippian time, and the last members did not survive to the close of Permian time. Within this relatively short span of their collective existence, they developed into many biologic branches.

For classification of the whole assemblage, different students have proposed that the fusulinaceans should be ranked as an independent order, treated as a suborder, grouped in three rather disparate superfamilies, divided into seven families and 21 subfamilies, and recognized as containing more than 150 genera and subgenera with many hundreds of species. Many of these taxonomic units are not considered in the *Treatise* to be valid, since numerous

nominal genera of fusulinaceans undoubtedly are synonymous with others. It is evident that these foraminifers became very highly diversified, yet as a whole seem to be classifiable appropriately as a superfamily. Because members of various major fusulinacean groups are found associated in certain deposits of a given age, it is judged that several lines of evolution developed simultaneously within the superfamily.

In terms of well-preserved entire specimens, fusulinaceans far outnumber the representatives of any other single invertebrate group in Pennsylvanian and Permian strata of many areas. In some of these, well-preserved entire fusulinaceans probably exceed in number, and possibly in volume, the combined remains of all other types of invertebrates in this part of the upper Paleozoic.

The fusulinaceans were sensitive to their physical environment and mostly are closely restricted to certain lithologic units of the Pennsylvanian and Permian. Although exceedingly abundant in various stratigraphic units, in some of which fusulinaceans may compose more than half the bulk of the rock, they are found in many places associated with very few other types of fossils. At numerous stratigraphic levels in the Pennsylvanian and Permian, the same general types of invertebrate faunas immediately precede and immediately follow the units in which prolific fusulinaceans are found. This order of faunal arrangement and association is especially noticeable in the central United States.

Fusulinaceans have been recognized in more than 80 distinct stratigraphic units of Pennsylvanian age in New Mexico. Many of the fusulinacean-bearing rock divisions occur over areas hundreds of square miles in extent. About an equal number of fusulinacean-bearing units have been found in the Pennsylvanian of the northern mid-continent region and in Texas. In the mid-continent region, some fusulinacean-rich strata are distributed over even larger geographic areas than those in New Mexico, and some seem to be continuous with New Mexico units that extend outward from the edges of Pennsylvanian land areas in the Rocky Mountain region.

Although fusulinaceans are abundant and occur in many widespread zones in the Per-

mian of the United States, most fusulinacean faunas of this system are more restricted in geographic distribution than are those of the Pennsylvanian, presumably owing largely to the physical nature of the Permian seas.

#### ACKNOWLEDGMENTS

Thanks are extended to the many individuals who contributed to this section of the *Treatise*. A part of the years 1960-61 was spent by me in Fukuoka, Japan, working with RYUZO TORIYAMA and other members of the staff of Kyushu University on fusulinacean genera recently proposed in the Asiatic area. Many other individuals in Japan and in the United States contributed information and material. SUSUMU HONJO, of Hokkaido University, worked briefly with me in Urbana. KENJI KONISHI, of Kanazawa University, went with me on trips to Akasaka with Prof. TORIYAMA and HISAYOSHI IGO, of the Tokyo University of Education. Dr. IGO later spent a year with me in Urbana. YASUO NOGAMI, of Kyoto University, furnished thin sections and information concerning some Japanese fusulinaceans. J. W. SKINNER and G. L. WILDE, of the Humble Oil & Refining Company, Midland, Texas, furnished illustrations and information. Use has been made of all published reports. W. D. FARRIS and BEULAH UNFER of the Illinois State Geological Survey prepared photographs and copies. P. X. SARAPUKA, of the Survey, prepared numerous translations from the Russian. Special thanks are given to FRANCES ALSTERLUND, of the Survey, who contributed greatly to the final organization of the transcript.

Numerous data bearing on fusulinacean systematics and the literature were kindly furnished by A. R. LOEBLICH, JR. and HELEN TAPPAN.

## MORPHOLOGY

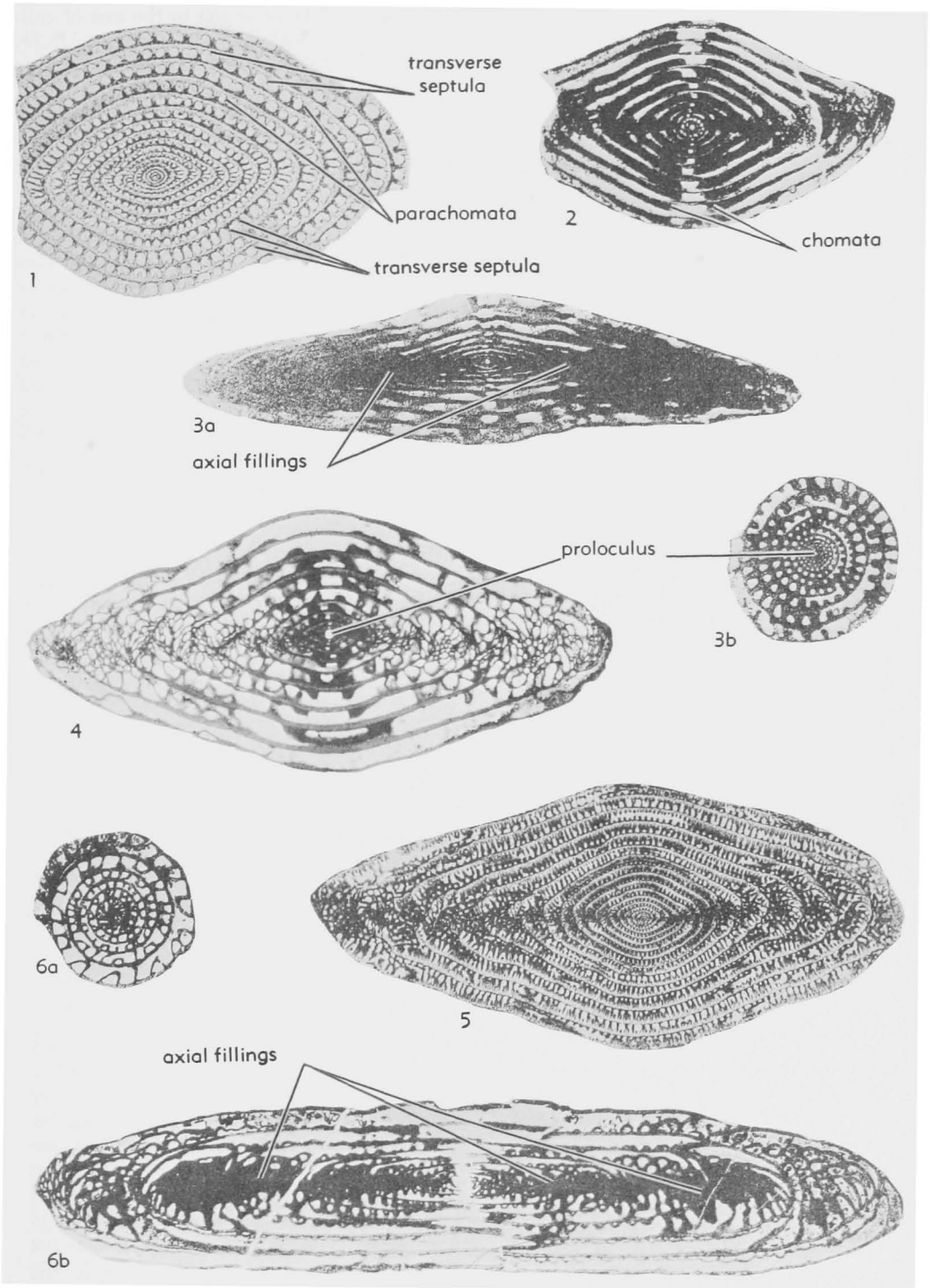
### GENERAL DESCRIPTION OF SHELL

The fusulinaceans are referred to the order Foraminiferida and are therefore assumed to have been one-celled animals. As with many of the foraminifers, the individual shells of fusulinacean species are remarkably similar in almost all respects. Externally, the shells of many species closely resemble each other. Internally, however, structures may be markedly different in

different forms. The shells of primitive species are relatively simple, but those of some more advanced forms are among the most complex of all foraminifers. The fusulinaceans occur geologically only a short time after the earliest foraminifers having unquestionably calcareous shells, and they died out considerably before development of the prolific Mesozoic foraminifer faunas dominated by groups having calcareous shells. Most of the calcareous, as well as arenaceous types of other foraminifers, are classified on the basis of external shell structures, but classification of the fusulinaceans is based largely on internal shell features that generally can be determined only from thin or polished sections. The few other groups of Foraminiferida that are classified largely on the basis of internal shell structures, such as nummulitids and orbitoidids, occur in the upper part of the geologic section, and the terminology applied to their shell structures is mostly not applicable to shell features of the fusulinaceans, and conversely. Although some terms applied to fusulinacean shell structures are also used for other foraminifers, much of the terminology used in describing fusulinacean shells is restricted to this superfamily. The terms are included in the glossary given in the general description of foraminifer morphology (p. C58).

Some of the structural features of fusulinacean shells can be interpreted from external observations, but many are completely internal. Two sections cut through the beginning chamber reveal most internal features of the shell. One of these is cut along the axis of coiling and is called an **axial section** (Fig. 275, 1-3a, 4, 5, 6b). The

FIG. 275. (Facing page.) Axial, sagittal, and parallel sections of fusulinaceans.—1. *Neoschwagerina craticulifera* (SCHWAGER), U. Perm., China; slightly oblique axial sec. of holotype,  $\times 16.3$  (\*1922).—2. *Yangchienia tobleri* THOMPSON, U. Perm., Sicily; axial sec.,  $\times 16.3$  (\*1922).—3. *Wedekindellina euthysepta* (HENBEST), M. Penn., USA (Ill.); 3a, axial sec. of holotype; 3b, sagittal sec. of paratype; both  $\times 20$  (\*1922).—4. *Triticites ventricosus* (MEEK & HAYDEN), L. Perm., USA (Kans.); axial sec., toptype,  $\times 8$  (\*1926).—5. *Lepidolina elongata* (GUBLER), U. Perm., Cambodia; axial sec. of submature specimen,  $\times 8$  (\*838).—6a. *Parafusulina nosonensis* THOMPSON & WHEELER, L. Perm., USA (Calif.); parallel sec. of paratype showing cuniculi,  $\times 8$  (\*1922).—6b. *Parafusulina wanneri* (SCHUBERT), Perm., Timor; axial sec. of holotype,  $\times 8$  (\*1923).



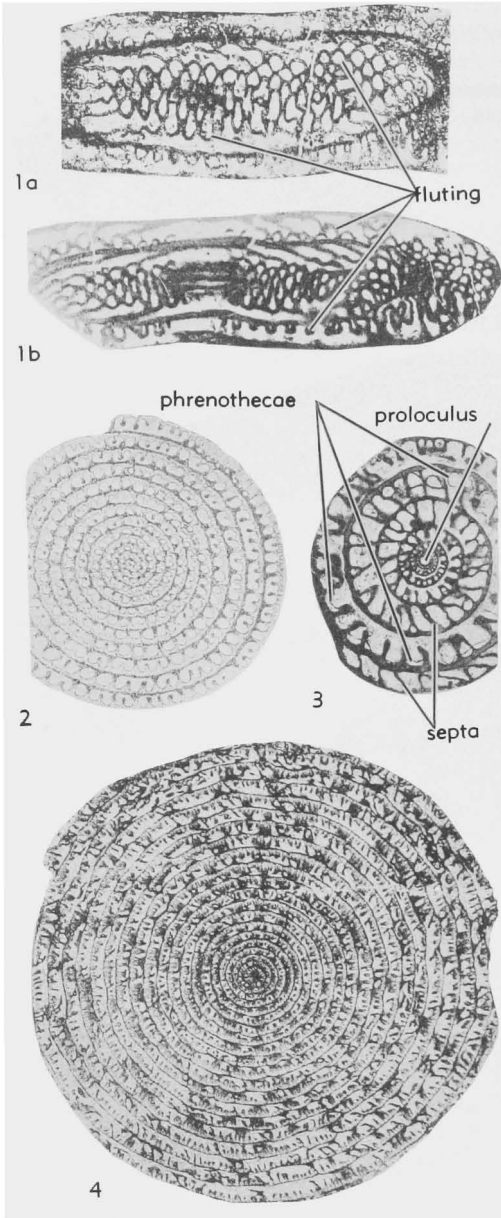


FIG. 276. Sagittal, tangential, and parallel sections of fusulinaceans.—1a. *Parafusulina nosonensis* THOMPSON & WHEELER, L.Perm., USA (Calif.); tang. sec. of paratype showing septal fluting,  $\times 8$  (\*1922); 1b. *Parafusulina gracilis* (MEEK), L.Perm., USA (Calif.); tang. sec. showing septal fluting and cuniculi,  $\times 8$  (\*1934).—2. *Neoschwagerina craticulifera* (SCHWAGER), U.Perm., China; parallel sec. of paratype,  $\times 16$  (\*1922).—3. *Schwagerina fax* THOMPSON & WHEELER, L.Perm., USA (Calif.); sagittal sec. of syntype,  $\times 8$  (\*1922).—4. *Lepidolina elongata* (GUBLER), U.Perm., Cambodia; parallel sec.,  $\times 12$  (\*838).

other, cut at right angles to the axis of coiling, is called a **sagittal section** (Fig. 275,3b, 276,3). The terminology applied to sections cut through areas other than these two depends on directions of their orientation and position. A section cut normal to the axis of coiling but not through the beginning chamber is termed a **parallel section**. One cut parallel to the axis of coiling but not through the beginning chamber is termed a **tangential section** (Fig. 276,1). Sections cut in directions not parallel to the axis of coiling or normal to it are referred to as **oblique sections**. For thorough observation of all structural features of a species, it is necessary to study numerous axial and sagittal sections and numerous parallel, tangential, and oblique sections cut through different parts of the shell and at various angles. It is also desirable to observe the external nature of the shell.

An external view of the fusulinacean shell shows a relatively smooth surface broken by shallow, closely spaced **external furrows** (Fig. 274). These furrows extend from end to end of the shell and mark the tops of the partitions between the chambers, termed **septa** (Fig. 276,3). Adjacent external furrows come together as they reach the axial poles. The surface is interrupted by an abrupt wall, termed the **antetheca** (Fig. 274), which forms the front wall of the last chamber and is punctured by numerous small openings, called **septal pores** (Fig. 277,2,3a). In many fusulinaceans the antetheca is arcuate anteriorly, or is plane. In others it is folded or corrugated into somewhat irregular to uniformly spaced waves, termed **fluting** (Fig. 275,4; 276,1; 278). The fluting is more pronounced in the lower part of the antetheca than in its upper portion.

Thin sections of the fusulinacean shell reveal highly complicated internal structures, all of which are considered in the classification and identification of species. The beginning chamber, termed the **proloculus** (Fig. 275, 276, 282), of most forms is spherical to subspherical in shape, and several coils or volutions of chambers are developed about it. The antetheca does not possess an aperture, and accordingly the cell depended on the septal pores for communication with the exterior of the shell.



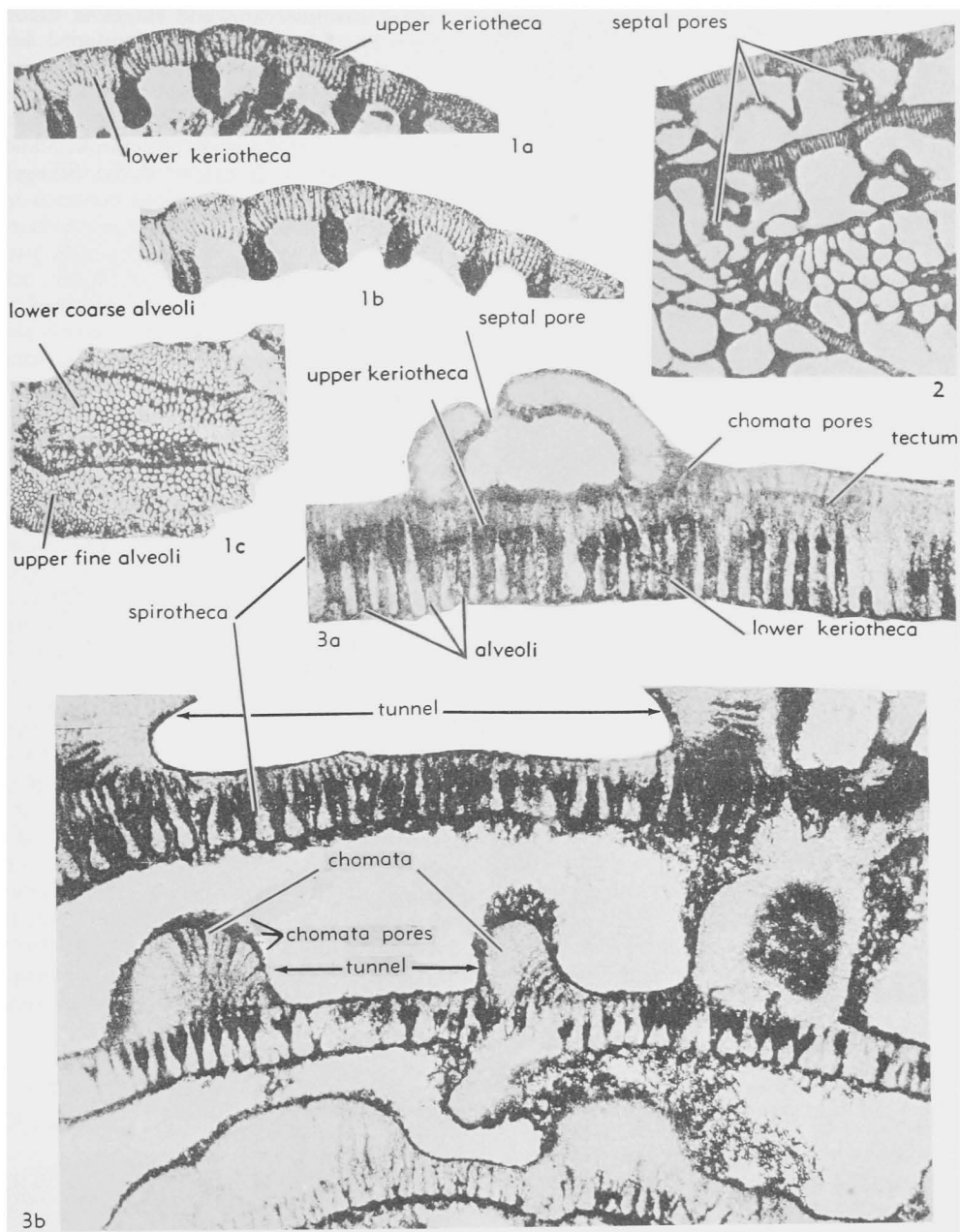


FIG. 277. Spirothecal and septal structures of fusulinaceans.—1. *Schwagerina rutschi* THOMPSON, L. Perm., Sumatra; 1a, part of sagittal sec. showing lower and upper keriotheca of spirotheca; 1b, part of sagittal sec. showing coarse and fine alveoli in lower and upper keriothecal layers of spirotheca; 1c, tang. sec. of spirotheca showing cross sections of coarse and fine alveoli of lower and upper keriothecal layers, respectively; all  $\times 40$  (\*1915).—2. *Triticites ventricosus* (MEEK & HAYDEN), L.Perm., USA (Kans.); part of axial sec. showing numerous closely spaced septal pores in outer volution,  $\times 30$  (\*1922).—3. *Schwagerina campensis* THOMPSON, L.Perm. (Camp Cr. Sh.), USA (Tex.); 3a, part of sagittal sec. of spirotheca showing septal and chomatal pores, alveoli, lower and upper keriotheca, and tectum; 3b, part of axial sec. showing tunnel, chomata, and chomata pores; both  $\times 200$  (\*1924).



FIG. 278. \**Parafusulina wordensis* DUNBAR & SKINNER, L.Perm.(Word F.), USA(Tex.); acid-etched silicified specimens showing prominent septal fluting which produces regularly arranged chamberlets,  $\times 5$  (\*1922).

Communication between adjacent chambers inside the shell was aided by resorption of a **tunnel** (Fig. 277,3b) at the base of septa in the central part of the shell of many fusulinaceans, and by resorption of several tunnels or small circular **foramina** (sing., foramen) at the base of septa throughout the length of the shell in others. Ridges of dense calcite, termed **chomata** (sing., choma) (Fig. 275,2; 277,3b), were built along the margins of the single tunnel

in most fusulinaceans, and ridges of dense calcite (**parachomata**) were developed between adjacent foramina in forms having multiple foramina. Seemingly simultaneous formation of the chomata or parachomata, excavation of the tunnel or foramina, and deposition of dense calcite (**axial fillings**) (Fig. 279) in the axial regions occurred in some fusulinaceans. The internal surfaces of the chamber of many fusulinaceans, particularly in the subfamily Fusulininae, are lined with a layer of dense calcite formed at or near the same time as that in which the tunnel was excavated, and near the time the chomata and axial fillings were deposited. This lining of the chambers comprises layers designated as **tectoria** (sing., tectorium) (Fig. 280).

The wall above the chamber is referred to as the **spirotheca** (Fig. 277) because of its spiral arrangement. In primitive forms it consists of a thin, dense, primary layer (**tectum**) (Fig. 280, 281) that is later covered above and below by layers of tectoria. In more advanced forms, the tectum is supplemented by various other layers, including a transparent layer (**diaphanotheca**) or a thick layer of honeycomb-like structure (**keriotheca**) (Fig. 277, 280, 281). Each chamber has only a front and top wall of its own, for it uses the front wall of the preceding chamber as its posterior wall, and the tops of the chambers in the preceding evolution as its floor. The structure of the spirotheca plays an important part in classification and differentiation of fusulinaceans. Ridges, termed **septula** (sing., septulum) (Fig. 275,1; 276,2, 290), extend

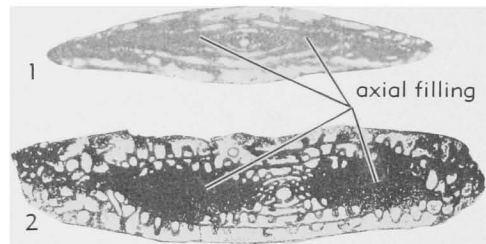


FIG. 279. Axial fillings in fusulinacean shells.—1. \**Pseudowedekindellina prolixa* SHENG, M.Penn. (Penchi Ser.), China; axial sec. showing dense axial filling,  $\times 14$  (\*1729).—2. \**Quasifusulina longissima* (VON MÖLLER), U.Carb.(C<sub>3</sub>), USSR (Tsarev Kurgan); axial sec. showing solid axial filling,  $\times 10.5$  (\*1922).

down from the lower surface of the spirotheca in the subfamily Neoschwagerininae so as partly to subdivide the chambers.

Numerous specimens of *Schwagerina campensis* obtained from the Camp Creek Shale of Texas were gray in color when collected. Of the many specimens sectioned,

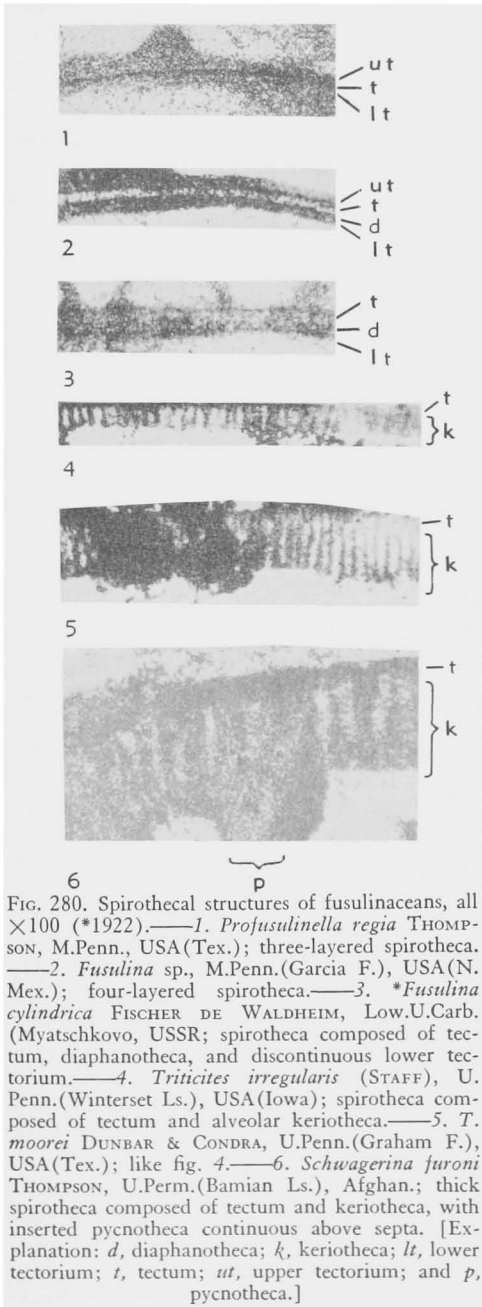


FIG. 280. Spirothecal structures of fusulinaceans, all  $\times 100$  (\*1922).—1. *Projusulinella regia* THOMPSON, M.Penn., USA (Tex.); three-layered spirotheca.—2. *Fusulina* sp., M.Penn. (Garcia F.), USA (N. Mex.); four-layered spirotheca.—3. *Fusulina cylindrica* FISCHER DE WALDHEIM, Low.U. Carb. (Myatschkovo, USSR; spirotheca composed of tectum, diaphanotheca, and discontinuous lower tectorium.—4. *Triticites irregularis* (STAFF), U. Penn. (Winterset Ls.), USA (Iowa); spirotheca composed of tectum and alveolar keriotheca.—5. *T. moorei* DUNBAR & CONDRA, U. Penn. (Graham F.), USA (Tex.); like fig. 4.—6. *Schwagerina furoni* THOMPSON, U. Perm. (Bamian Ls.), Afghan.; thick spirotheca composed of tectum and keriotheca, with inserted pycnotheca continuous above septa. [Explanation: d, diaphanotheca; k, keriotheca; lt, lower tectorium; t, tectum; ut, upper tectorium; and p, pycnotheca.]

all were found to be filled with calcite. On heating to temperatures just short of calcining, the specimens became red to brown. The structural features of the shell became greatly accentuated, and the septa, septal pores, keriotheca, and surface of the spirotheca became well defined. In most of them, the fibrous-like structures of the spirotheca were seen to penetrate the tectum and pass on through the chomata deposits. Both surfaces of the septa and walls of the septal pores are covered by thin layers of reddish oxides. It seems evident that these surfaces were coated by iron-bearing deposits before the chambers were filled with crystalline calcite. Similarly, it can be observed that thin layers of oxidized deposits cover surfaces of the spirotheca and completely line insides of the clear cell-like structures (alveoli) (Fig. 277,3), continuing around the lower surfaces of their bordering walls. Although these films of iron oxide completely line the alveoli, they do not occur over their lower ends, indicating that the alveoli were open spaces when the films were deposited. Furthermore, thin films of oxide line the inside or completely fill the continuations of alveoli as they pass through the tectum and overlying chomata. It might be argued that these films formed on parts of the outer area of secreted calcite crystals. However, if the clear areas were calcite pillars, the oxide films lining the alveoli should also be found over the lower ends of the prisms. Other evidence that the spirotheca was perforate is observed in continuity of the oxide films in the alveoli with those that occur as coatings on the septa, linings of the septal pores, and coatings on top of the chomata, all of which almost certainly were open spaces shortly after death of the animal.

Similar oxidized coatings within the wall of the fusulinacean shell have been observed and photographed by HENBEST (\*896). He did not state whether these specimens were dissolved by weathering and replacement, however, or whether they contained solid calcite fillings. DUNBAR (\*639) has observed that specimens of *Parafusulina alaskensis* contain fillings of iron oxides in alveoli of the spirotheca, but the degree of replacement of associated fossils by oxides was not discussed. SKINNER & WILDE (\*1796) have observed similar features in *Fusulina*

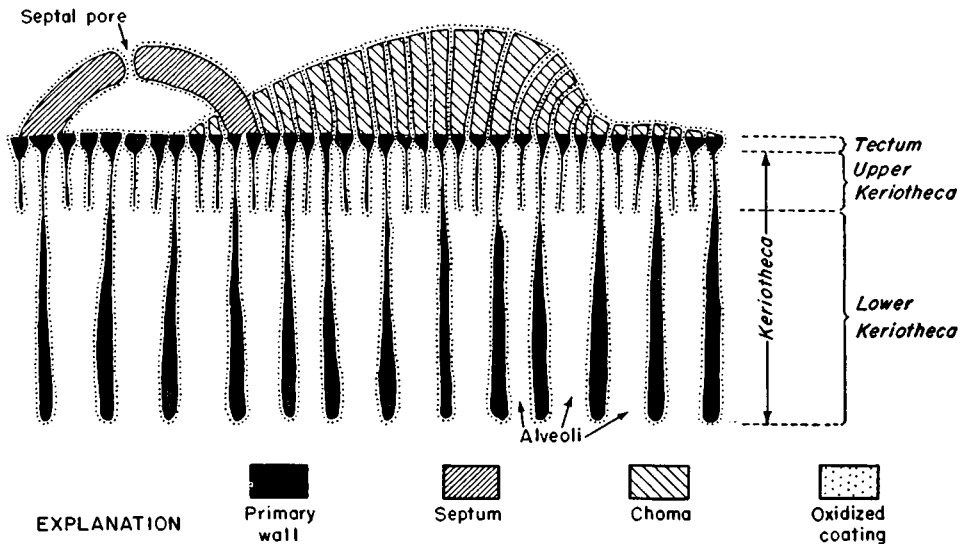


FIG. 281. Diagram of spirotheca showing pendant-like walls of alveoli, choma with chomatal pores, and septal pore, based on exceptionally well-preserved specimens of *Schwagerina campensis* THOMPSON, L.Perm. (Camp Cr. Sh.), USA (Tex.) (\*1924).

from Desmoinesian rocks of Texas. These authors also observed and photographed porosity in the wall of *Millerella*.

The tectum has been interpreted by some to be a rindlike layer of the shell above the keriotheca, and the alveoli have been considered to end at the tectum. Since the alveoli and their bordering walls are almost perfectly displayed in specimens of *Schwagerina campensis* which I have studied, it is possible to demonstrate the cause for the seemingly solid nature of the dense tectum. I have been unable to show by photographs the structures of the tectum because its pores are very minute and partly filled with red oxides. An accompanying diagrammatic sketch is given from a highly magnified tectum, however (Fig. 281). It is evident that even though the tectum is not a solid layer, its density is due to a sharp reduction in size of pores of the keriotheca and a simultaneous and comparable sharp increase in thickness of the pore walls. Perhaps most important for study of thin sections, pores of the tectum are considerably smaller in diameter than thickness of the sections, and therefore observation is nearly always through several of the pore walls.

It has been noted by several students of fusulinaceans that structure of the keriotheca is more evident in the lower area of

the spirotheca than in its upper part. In the lower area, the alveoli walls are thick and widely spaced, whereas in the upper part they are thin and closely spaced. Many specimens show a faint line of demarcation between the lower, coarser part of the keriotheca and its upper, finer part. Oxidized specimens demonstrate that the line of demarcation parallel to the tectum and located slightly below the keriothecal top is a line that marks the lower ends of the tubelike fine alveoli at the point where they open into the larger alveoli below.

The terminology here employed for different parts of the fusulinacean spirotheca is the same, in general, as that commonly used in recent years by most students of the superfamily. Although the tectum (roof) is not a complete covering as it was thought to be when proposed, and the keriotheca (honeycomb wall) lacks a truly honeycomb-like nature, the alveoli being tubes instead of pits or cavities, these terms have become well established in the literature, and most of them are reasonably descriptive of the spirothecal structures.

The pendant shape of the walls of the alveoli, as displayed in some thin sections, is due to their downward thickening as they approach the lower surface of the spirotheca. Correspondingly, the alveoli become con-

stricted downward as their walls increase in thickness. Some of the abnormal downward thickening of the alveoli walls observed in thin sections is due partly to their oblique intersection with the thin sections. Growth of the fusulinacean wall after its inception does not seem difficult to understand, accepting the general concept that the wall was porous (\*1924) (Fig. 277, *1b*, *3a,b*). The spirotheca of *Schwagerina campensis* is divisible into three parts that are distinguishable largely because of variation in size of the alveoli and thickness of their surrounding walls. The terms applied to them are, from top to bottom, tectum, **upper keriotheca** composed of small alveoli with thin walls, and **lower keriotheca**, composed of large alveoli with thick walls (Fig. 281). It seems probable that the walls of all fusulinaceans have the same three layers. The alveoli of many fusulinaceans are too small for observation, and in others it seems possible that the upper and lower keriotheca appear in thin sections as a single layer because the upper one is too thin to be distinguished from the lower.

The differences between details of structures of the diaphanotheca and those of the keriotheca are not clearly understood. Furthermore, it seems possible that the central single layer of *Profusulinella* may be comparable in structure to the diaphanotheca and tectum of the Fusulininae and to the tectum and keriotheca of the Schwagerininae (Fig. 281).

### PROLOCULUS

All fusulinaceans are multichambered. The chambers can be divided into first chamber (proloculus) and chambers of the coiled part of the shell (Fig. 282). In most fusulinaceans the proloculus is spherical to subspherical in shape, and proloculi of conspecific specimens generally are closely similar in size. Some forms have a proloculus only a few microns in diameter, whereas in others, it is more than 1 mm. in diameter. Although the proloculus of most forms is spherical, or nearly so, in some it is irregularly subspherical or even irregularly rectangular in shape. Almost all forms possessing irregular proloculi are large and have large proloculi. Although the irregular proloculi are much larger than the average size of those for the entire superfamily,

some specimens of a given species characterized by large proloculi may have a spherical proloculus or one that is ellipsoidal, rectangular, or somewhat irregular.

DUNBAR & HENBEST (\*643) and others have discussed the shape of the proloculus of fusulinaceans and have proposed several hypotheses as to the cause for its spherical

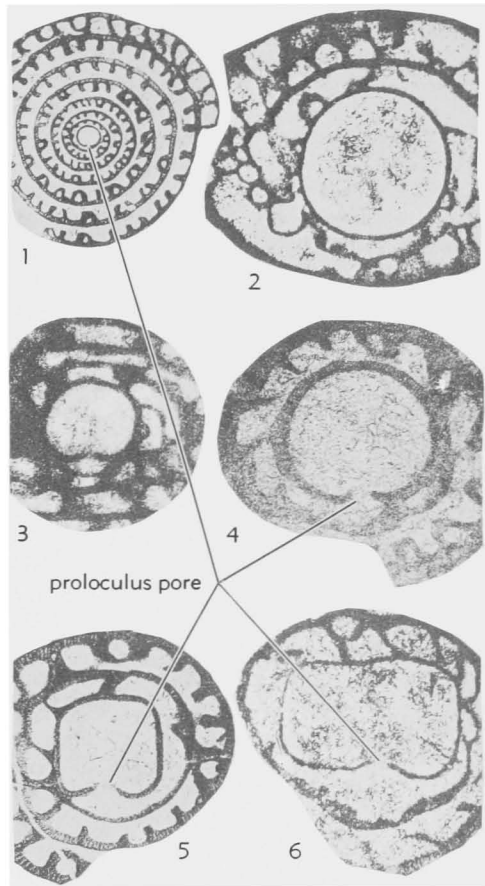


FIG. 282. Initial chambers (proloculi) of fusulinacean shells illustrated by species of *Parafusulina*, Permian, all "Fr. Indochina" except 5, from Japan; proloculus pore, if present in section, directed downward.—1. *P. padangensis* (LANGE); almost spherical proloculus with slightly thickened wall near pore,  $\times 10$ .—2. *P. gigantea* (DEPRAT), axial sec. showing spherical proloculus but not intersecting pore,  $\times 20$ .—3. *P. parumvoluta* (DEPRAT); pore at base of depressed funnel,  $\times 23.5$ .—4. *P. dongvanensis* (COLANI); subspherical proloculus with depressed area around pore,  $\times 27$ .—5. *P. japonica* (GÜMBEL); subquadrate proloculus with depressed area around pore,  $\times 30$ .—6. *P. gigantea* (DEPRAT); rectangular proloculus with cone around pore,  $\times 20$  (\*1922).

to subspherical shape. One of these suggests that the cell around which the proloculus was formed may have had a different surface tension than fluids outside the area of the proloculus, which would tend to give the cell a globular form and produce a spherical proloculus. The smaller the fluid globule, the more nearly spherical should be its shape, and this accords with the more nearly spherical shape of small proloculi as compared with larger ones. It should be pointed out, however, that specimens of several forms having abnormally large proloculi may possess almost perfectly spherical proloculi. It cannot be demonstrated that the proloculus of fusulinaceans enclosed the entire embryonic cell, the nucleus, or an area of multiple nuclei. MYERS (\*1336, \*1337) has observed formation of the proloculus in several living foraminifers. In some, the proloculus surrounded the embryonic cell but in others only the nucleus of the cell, and in still others it surrounded a budlike protrusion on a side of the cell. The beginning chamber or beginning part of the shell of many other animals is spherical to subspherical. The cause of the spherical shape of this initial chamber or beginning stage of the shell in multicellular animals is not known, but it may be similar to that which developed the spherical proloculus of most fusulinaceans.

The wall of the proloculus is dense and uniform throughout its thickness, and in general structure it resembles closely that of the dense wedge-shaped layer of the septa of some forms. Its structure does not resemble that of the walls of immediately following chambers, except in forms having walls composed of a single thin layer, and the proloculus with a wall composed of a single thin layer. The proloculus wall in most fusulinaceans is thicker than that of the beginning chamber of the coiled part of the shell.

The proloculus wall is broken by a single circular opening, called **proloculus pore** (Fig. 282), that opens into the first chamber of the coiled part of the shell. The aperture of the proloculus in some specimens has a simple unmodified margin that is continuous with the surface of the proloculus wall. In some specimens the margin of the aperture is bordered by a short tube-

like structure that extends into the proloculus. In many others the aperture is not bordered by a tubelike structure, but the surface of the wall immediately surrounding the aperture is depressed and the aperture is at the base of a shallow funnel. Various shapes and configurations of proloculi of fusulinaceans are shown on Figure 282.

Scattered specimens of many species of fusulinaceans contain two proloculi, around each of which one or more volutions of normal-appearing chambers are developed, and around both of which a normal set of spirally arranged chambers is seen. Rare specimens contain three proloculi. The full size of these specimens is not noticeably different from that of other conspecific associated specimens having a single proloculus. Specimens provided with double proloculi have been illustrated by many workers since those illustrated by STAFF in 1909 (\*1830). Double or triple proloculi seem not to be confined to any particular group of fusulinaceans, though observed most commonly among Fusulininae and Schwagerininae.

Several hypotheses as to why some shells contain two or three proloculi have been suggested. The most generally accepted idea is that young individuals became joined to continue as a single individual, though the cause for such union is not known. It may have been for mutual benefit under conditions of adverse food supply, or union may have been merely an accident caused by close crowding of embryonic forms, such as may occur during encystation.

Characters of the proloculus have a bearing on the subject of dimorphism in fusulinaceans. Dimorphic reproduction in this group has been postulated by many workers, and attempts often have been made to demonstrate the presence of microspheric forms (representing sexual generation) and megalospheric forms (asexual generation). In many cases cited all gradations in size of proloculi have been found in a single suite of specimens, and the range of volume of the proloculus is no greater than the range in size of other features in specimens having equal-sized proloculi. Some most convincing evidence of dimorphism among fusulinaceans has been presented by DUN-



BAR, SKINNER, & KING (\*647), based on studies of *Parafusulina*. Giant individuals with minute proloculi and highly asymmetrical early volutions occur in association with smaller individuals which bear large proloculi and differing internal shell structures. The giant specimens are rare among relatively abundant smaller specimens. Giant specimens of *Parafusulina* possessing minute proloculi do not show a distinct single tunnel, but associated smaller specimens provided with large proloculi have a well-developed tunnel. DUNBAR & SKINNER (\*646) described giant specimens of several forms of *Polydiexodina* that contain minute proloculi and asymmetrical early volutions, and these are associated with more abundant, smaller specimens with large proloculi and symmetrical volutions. The smaller specimens possess multiple tunnels, whereas the giant specimens lack tunnels. These giant individuals have tunnel-like paths, however, that penetrate the septal walls and provide for internal communication. Rare specimens having minute proloculi and highly asymmetrical early volutions have been found in association with abundant normal-appearing specimens of species of *Fusulina* and of *Triticites*. The outer parts of shells of these two types seem identical in other respects. It is supposed by some that the specimens characterized by minute proloculi represent the microspheric generation and that the more abundant specimens with large proloculi represent the megalospheric generation. The preponderance of specimens considered to represent the asexual generation is noticeable. Only one type of shell has been identified for most species of fusulinaceans. It is not certain that the fusulinaceans display dimorphism.

### CHAMBERS

The proloculus aperture opens into the first chamber of the coiled part of the shell. The first coiled chamber of most specimens is smaller in cross section than the proloculus, but in most specimens it is distinctly elongate in the direction of the axis of coiling of the outer volutions. In some specimens having an unusually large proloculus, the aperture opens into a somewhat irregular chamber that almost completely surrounds the proloculus. This large irregular chamber generally does not contain as large

a volume as that of the proloculus, and its walls conform in structure more closely to the walls of the succeeding chambers (Fig. 283). In some specimens, the first chamber

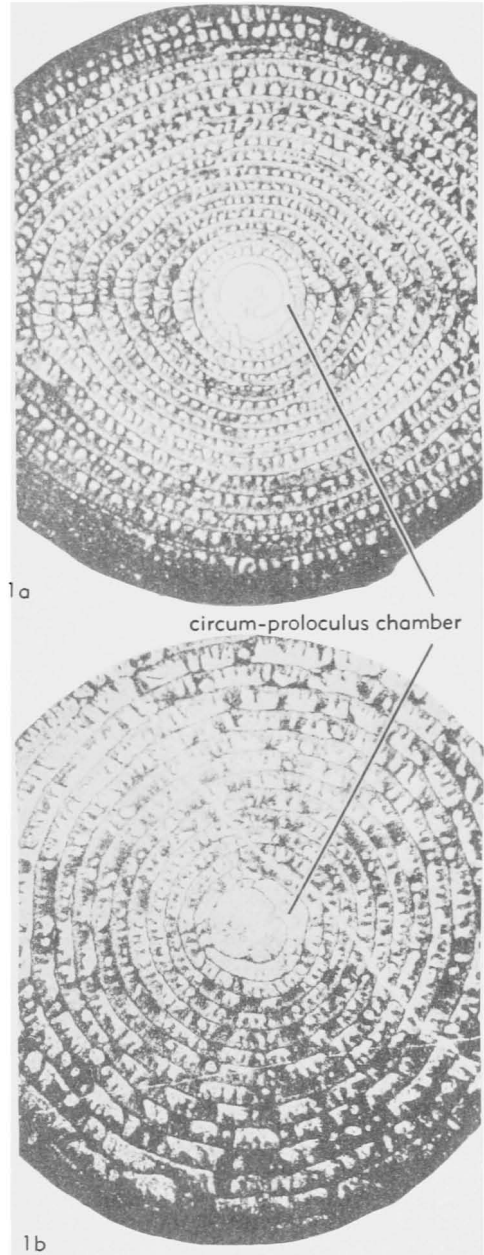


FIG. 283. Irregular circum-proloculus chamber observed in some fusulinaceans.—1. *Lepidolina multiseptata* (DEPRAT), U. Perm., Cambodia; 1a, b, axial sec. of holotype, sagittal sec. of paratype,  $\times 10$  (\*1922).

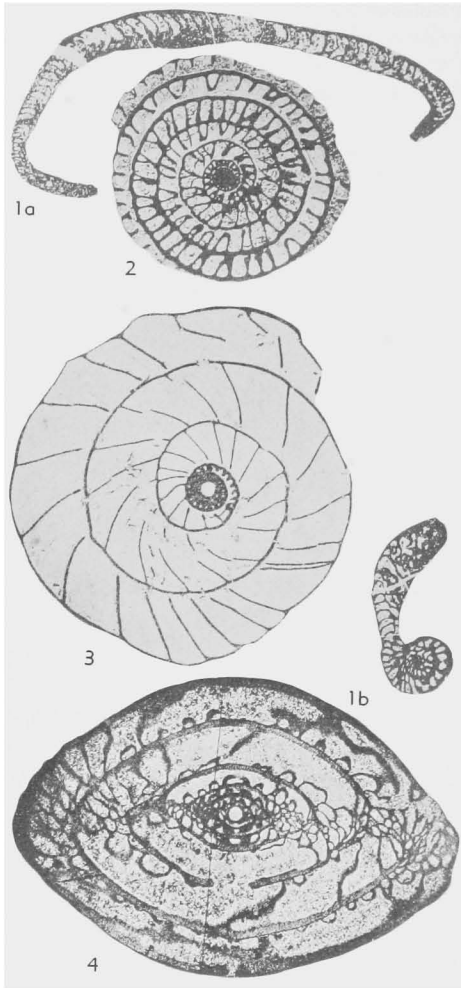


FIG. 284. Variation in chamber height and coiling in ontogeny of fusulinaceans.—1. *Nipponitella* HANZAWA, Perm.(Maiya Gr.), Japan; 1a, *N. auricula* HANZAWA, axial sec. of syntype showing extreme uncoiling,  $\times 6$  (\*1922); 1b, \**N. explicata* HANZAWA, parallel sec. of paratype,  $\times 6$  (\*1922).—2. \**Paraschwagerina gigantea* (WHITE), L. Perm.(Wolfcamp.), USA(Tex.), sagittal sec. of paratype showing contrast between juvenile and mature parts of shell,  $\times 6$  (\*1922).—3. \**Robustoschwagerina tumida* (LITKAREV), Perm.(Darvaz Ser.), USSR(Darvaz); sagittal sec. of paratype showing relatively large proloculus surrounded by two or three volutions with very low height of chambers followed by greatly increased height in mature parts of the shell,  $\times 6$  (\*1276).—4. *Pseudoschwagerina muongthensis* (DEPRAT), L. Perm., N.Vietnam(Tonkin); axial sec. showing abrupt increase in chamber height beginning in fourth whorl,  $\times 9$  (\*587A).

of the coiled part of the shell is much larger than that of the immediately succeeding chamber.

Beyond the proloculus, the fusulinacean shell is composed of numerous chambers coiled about the proloculus in such a fashion that the axis of coiling in most forms coincides with the greatest diameter of the shell, commonly defined as length of the shell. Similarly, the greatest diameter at right angles to the axis of coiling is commonly defined as width of the shell. In some, length of the shell in the axis of coiling is about equal to the width, and in others the axis of coiling is the shortest diameter. Almost all chambers of the coiled part of the shell are much shorter in the direction of coiling than their width measured parallel to the axis of coiling. The chambers are widest in the center of the shell and are reduced to near-zero width at the poles. Starting with the first few chambers of the first volution, the chambers gradually increase in height. This increase is almost uniform throughout most of the shell in many fusulinaceans, but chambers of the last one or two volutions of gerontic individuals in many forms are lower than those of the immediately preceding volutions. In forms of some genera, particularly of *Pseudoschwagerina* and *Paraschwagerina*, the chambers of the first few volutions are low; in the following one or two volutions their heights increase rapidly, and the outer volutions are highly inflated (Fig. 284,2-4). However, the last one or two volutions of gerontic individuals of these genera decrease in height slightly. In a few aberrant genera (e.g., *Codonofusiella*, *Nipponitella*), the inner volutions increase in height gradually, but the outer volutions are uncoiled and highly flared or subrectilinear (Fig. 284,1).

Most specimens of all genera of Schubertellinae have minute proloculi and the first one to three volutions are tightly coiled, their axis of coiling being at large angles to the axis of coiling of the outer volutions. The first part of this asymmetrically coiled part of the shell is slightly evolute, and it does not attain a form ratio of unit value. Early members of the Fusulininae also have highly asymmetrical early volutions, particularly species of *Pseudostaffella* and early

species of *Profusulinella*. The cause of this asymmetrically coiled nature of the juvenile shell is not known. The asymmetrical coiling of the juvenile part of giant specimens associated with *Parafusulina* and *Polydiexodina*, discussed by DUNBAR, SKINNER & KING (\*647), is seemingly similar to that in more primitive forms of *Profusulinella* and some of the Schubertellinae (Fig. 299, 1a-d). However, specimens of Schubertellinae distinguished by asymmetrical coiling are not large, and many such forms are not associated with specimens having symmetrical early volutions and markedly larger proloculi. No evidence is found that these primitive fusulinaceans exhibiting minute proloculi and asymmetrical early volutions represent the microspheric generation of dimorphic forms. The proloculus is unevenly ellipsoidal in some forms (Fig. 285).

#### ANTETHECA AND SEPTA

The anterior wall of the last chamber (antetheca) becomes the septum between the last two chambers when an additional chamber is developed. In primitive forms of *Millerella* the antetheca is curved anteriorly immediately below its top and is curved posteriorly near its base, resulting in septa that are strongly arcuate. In most of the more highly developed forms of the family Ozawainellidae, the antetheca is plane and perpendicular to the outer wall of the chamber. Also, members of the family Verbeekinidae have plane perpendicular antetheca and septa.

Except in *Pseudostaffella* and very primitive forms of *Profusulinella*, the septa of members of the subfamily Fusulininae are corrugated or fluted to some extent. The fluting in primitive forms is confined to broad undulations in the extreme polar regions and to the basal part of the septa. In more highly developed forms, the plication of the septal walls progressively moves from the poles toward the center of the shell and progressively moves up toward the tops of the septa. The salient of the fold in the antetheca corresponds in position to the re-entrant in the fold of the preceding septum. In forms with closely spaced septa or sufficiently strong septal fluting, adjacent septa are brought into contact at these points, resulting in enclosed areas (**chamberlets**) at

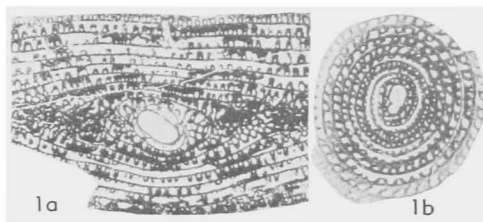


FIG. 285. Axial and sagittal sections of fusulinacean shells.—1. *Polydiexodina* DUNBAR & SKINNER, U. Perm.; 1a, *P. afghanensis* THOMPSON, Bamian Ls., Afghan., axial sec. of holotype showing ellipsoidal proloculus and adjacent volutions,  $\times 6.7$  (\*1922); 1b, \**P. capitanensis* DUNBAR & SKINNER, Capitan Ls., USA (Tex.), sagittal sec. of paratype,  $\times 6.7$  (\*1922).

base of the chambers that open upward (Fig. 278). In primitive forms of Fusulininae the fluting is sufficiently intense to bring adjacent septa into contact only at their lower margins and only in the extreme polar regions where the chambers are shortest. Primitive forms of Schwagerininae (e.g., *Triticites*), also have septal fluting developed only in the extreme polar regions (Fig. 275, 4). Highly developed forms of the Fusulininae and Schwagerininae have closely and highly fluted septa throughout the length of the shell, and the fluting brings the septa into contact at opposing folds even above the tunnel. In some members of the Schwagerininae (e.g., many forms of *Paraschwagerina* and most forms of *Pseudofusulina*) the septa are plicated to the top of the septa. In many species of these genera the fluting forms chamberlets that extend more than half the height of the chambers. In highly developed forms of *Schwagerina* and all species of *Parafusulina* and *Polydiexodina*, the salient fold of the fluting extends forward a great distance and the antetheca or septum of the following chamber bends downward near to or even behind the greatest forward projection of this salient (Fig. 276, 278). Therefore, the re-entrant of the later antetheca or septum is impounded against the salient of the preceding septum, as illustrated in the accompanying diagram (Fig. 286). In the polar regions of many forms of *Parafusulina* the salient extends forward as much as the combined length of the following two chambers.

In species of *Parafusulina* and *Polydiexodina* the extended salients, combined with

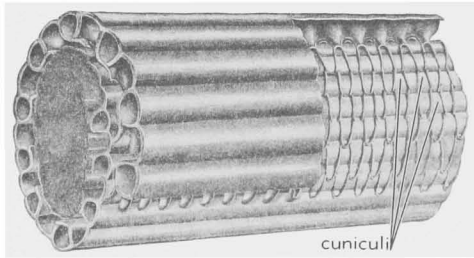


FIG. 286. Diagram illustrating inferred development of cuniculi in *Parafusulina* and *Polydiexodina* (\*1922).

impounded re-entrants of the following septum, produce a tunnel-like structure running transverse to the axis of coiling at each crest and trough of the fluting in the antetheca. Interruptions formed by the downturned edge of septal salients in the earlier volutions are resorbed or excavated so as to form a continuous tunnel-like path throughout the earlier part of the shell; this path has been termed *cuniculus* by DUNBAR & SKINNER (\*646) (Fig. 286). The cuniculi are bordered by edges of opposing salients and re-entrants to give the appearance of septa running transverse to the axis of coiling. The bordering walls of the cuniculi are highly sinuous in primitive forms that have only moderately fluted septa. They are almost straight in forms having intensely fluted septa (Fig. 287).

DUNBAR & SKINNER (\*644) were the first to observe cuniculi in *Parafusulina* and *Polydiexodina*. The structure of the cuniculus has been discussed further by DUNBAR & HENBEST (\*643). It was suggested by these workers, and later by THOMPSON (\*1921), that foramina are developed by the up-turned edges of the salients in the antetheca. Further observations seem to demonstrate that salients in the antetheca do not form foramina but turn downward to the top surface of the preceding volution. The lower margins of the salients are later resorbed to develop the continuous tunnel-like cuniculus. In the earlier parts of the shell of *Parafusulina*, only the margins of the salients remain along the borders of the cuniculi (Fig. 287). It is evident that excavation of the cuniculi developed into the auxiliary tunnels of *Polydiexodina* by coalescence of several cuniculi. The necessity of widening passageways seemingly was

due to the extreme length of the shells of *Polydiexodina*.

The antetheca of the shell contains numerous septal pores (Fig. 277,2).

So far as can be determined, none of the fusulinaceans had an aperture or foramina in the antetheca; they depended largely or entirely on the septal pores and wall pores for external communication. The antetheca of many fusulinaceans is fluted, and it has seemed quite impossible to determine the total number of septal pores in the antetheca. The relative abundance of septal pores is judged to have no connection with the stage of evolution of the individual (Fig. 303, 3a,c). Whether the number of septal pores is constant among individuals of a species is not known, but the more highly fluted types of fusulinaceans seem to have more abundant septal pores than those with less fluting.

Primitive fusulinaceans characterized by a *Profusulinella*-type spirothecal structure have a septal structure almost identical to that of the spirotheca. All evidence indicates that the spirotheca and antetheca were deposited simultaneously, for none of the many thousand fusulinacean sections examined by me reveals an incompletely built last chamber. The antetheca of the last chamber of primitive Ozawainellidae, Schubertellinae, and Fusulininae is composed only of tectum that seemingly is identical in structure to the tectum of the spirotheca except for the presence of septal pores. Both the anterior and posterior surfaces of the septa are later covered by tectoria which appear to be simultaneously developed with

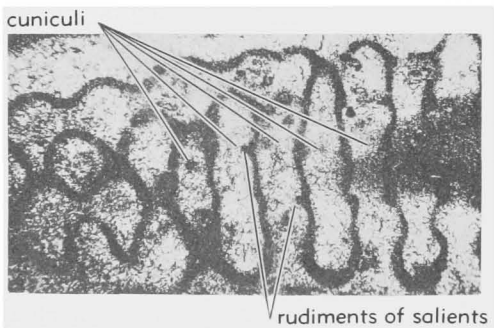


FIG. 287. Rudiments of salients of septa left after excavation of cuniculi in the test of *Parafusulina nosonensis* THOMPSON & WHEELER, L.Perm.(Nosoni F.), USA(Calif.), shown in part of tang. sec. of paratype,  $\times 30$  (\*1922).

the tectorial lining of the chamber, with the chomata, and with the axial fillings if they are present.

In highly developed genera of the Fusulininae (e.g., *Fusulinella*, *Fusulina*, *Wedekindellina*) the tectum and diaphanotheca of the spirotheca are deflected downward to form the septum, but the diaphanotheca decreases in thickness rapidly downward from the top of the septum. Also, the diaphanotheca of the spirotheca of the following chamber extends a short distance down the anterior side of the septum. The development of tectoria on the septa of these genera is similar to that of the more primitive genera discussed above. However, the tectoria of the more highly developed forms of *Fusulina* are thin and discontinuous or they may be entirely absent.

The tectum of the spirotheca of Schwagerininae is deflected downward to the base of the antetheca. The keriotheca of the spirotheca of members of this subfamily extends only a short way down the septa. At the point of downward deflection of the tectum at the top of the antetheca, a dense layer is developed on the posterior side of the tectum in most forms. This layer, designated *pycnotheca* by DUNBAR & HENBEST (\*643), seems to wedge in between the anterior edge of the keriotheca and the tectum (Fig. 280,6). It extends to the base of the antetheca, gradually decreasing in thickness. The structure of the pycnotheca is similar to that of the wall of the proloculus in being dense and uniform. The uniformity of the pycnotheca is broken only by the septal pores. The keriotheca does not resemble the pycnotheca closely and a sharp line of demarcation appears where they come in contact. The pycnotheca is thickest immediately above the tunnel and thins toward the poles. In many forms of Schwagerininae that have thin septa, the pycnotheca is so tenuous that it cannot be distinguished from the thin tectum, or it is absent. In other Schwagerininae, the pycnotheca is distinctly thick just below its upper surface but cannot be distinguished from the tectum in the lower part of the septum. It has been suggested that the pycnotheca developed from the keriotheca, but its structure strongly suggests that it was formed by thickening of the tectum.

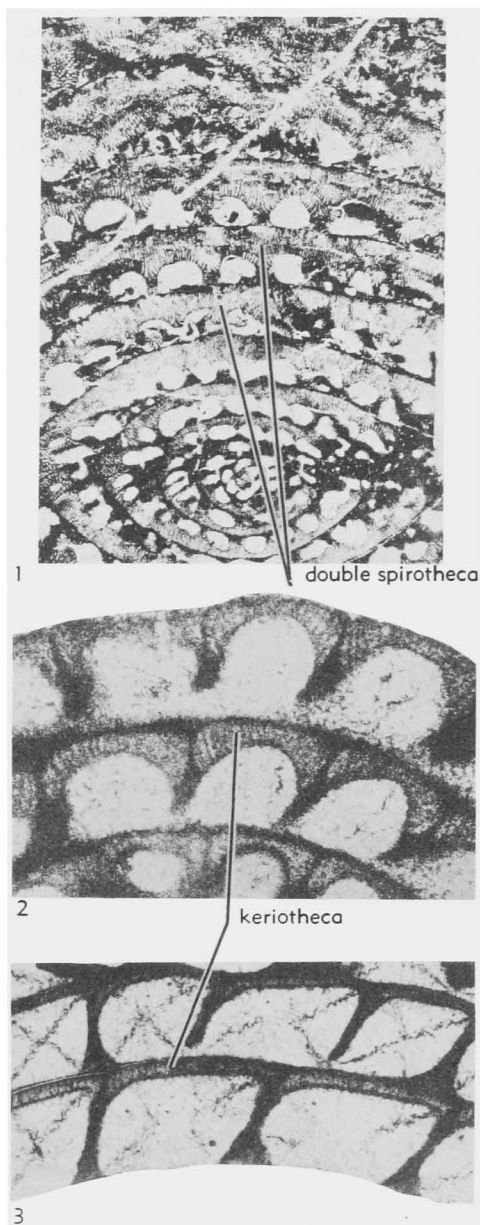


FIG. 288. Structural features of fusulinacean spirotheca and septa illustrated by *Neoschwagerina* YABE, U. Perm., and *Cancellina* HAYDEN, U. Perm., with thick spirotheca, and *Verbeekina* STAFF, U. Perm., with thin spirotheca.—1. *N. oralis* (MINATO & HONJO), Akasaka Ls., Japan (Gifu Pref.); slightly tang. axial sec. showing radially diverging alveoli of keriotheca in basal parts of septa,  $\times 40$  (\*1287).—2. *C. primigena* (HAYDEN), Iran; part of sagittal sec. showing keriothecal layers on both sides of septa,  $\times 100$  (\*1922).—3. *V. verbeeki* (GEINITZ), Sumatra; part of sagittal sec. showing structure of spirotheca,  $\times 40$  (\*1922).

The antetheca of members of the Verbeekinae and Neoschwagerininae is formed by the downward deflection of the tectum of the spirotheca. In forms with thick spirotheca, the keriotheca of the spirotheca extends down both sides of septa almost to their base, and keriothecal structures can be observed almost to the base of the septa (Fig. 288,2). In genera having a thin keriotheca (e.g., *Verbeekina*) this layer extends only a short distance down both sides of a septum (Fig. 288,3).

The lower margins of the septa of many fusulinaceans, as seen above the tunnel or above the foramina in sagittal sections, are distinctly thicker than the upper part of the septa, resulting in a pendant-shaped cross section. Their cross section, however, is not pendant-shaped in the outer few chambers. The thickening of the lower margins of the septa is due largely, if not entirely, to deposits similar to the chomata, parachomata, and tectoria that are laid down during or shortly after excavation of the tunnel or foramina.

### SPIROTHECA

The structure of the spirotheca, which furnishes one of the most reliable criteria for differentiation and classification of many fusulinaceans, is highly complicated, and its evolution has been determined within many branches of the group (Fig. 277, 280). The anterior-posterior profile of the top of the spirotheca of most forms turns downward sharply immediately adjacent to the septa, resulting in distinct external septal furrows. The upper surface across the central part of the chamber of most tests conforms closely with the curvature of the volution.

The spirotheca of the most primitive genus, *Millerella*, is composed of a central thin dense layer, the tectum, and adjoining less dense but thicker structureless layers, the **upper tectorium** above and the **lower tectorium** below. The spirothecal structure of most early Middle Pennsylvanian genera is similar to that of *Millerella*. This type of structure is best developed in *Profusulinella* and is referred to as a *Profusulinella*-type of wall (Fig. 280,1). A transparent layer, the diaphanotheca, is developed below the tectum in forms more highly advanced biologically than *Profusulinella*, resulting in

a four-layered spirotheca. This sort of spirotheca is referred to as a *Fusulinella*-type of wall (Fig. 280,2). The spirotheca in the outer part of the last volution of mature and submature specimens of *Millerella*, *Profusulinella*, and other primitive forms is composed of a single thin layer. It is evident that the tectoria are deposited later, and that the primary spirothecal structure is composed of a single layer, the tectum. In forms of *Fusulinella*, *Fusulina*, and other genera having a *Fusulinella*-type of spirothecal structure, the last few chambers of both mature and immature individuals have a spirotheca composed of tectum and diaphanotheca. Seemingly, the primary structure of the spirotheca of these forms is composed of a tectum and diaphanotheca (Fig. 280,3). The tectoria are of later or secondary origin, developed contemporaneously with the chomata and axial fillings and with excavation of the tunnel.

The spirotheca of the Schwagerininae is composed of a tectum and a lower, thicker layer, the keriotheca. Such spirothecal structure is referred to as a *Triticites*-type of spirotheca (Fig. 280,4-6).

Although it seems that the entire spirotheca of a chamber was deposited simultaneously with deposition of its antetheca, all evidence indicates that the spirotheca continued to grow in thickness after completion of its original form. The keriotheca of the last chamber is thinner in most shells than in immediately preceding chambers. In submature specimens the keriotheca of the last chamber seems to be thinner than that of the same part of the shell in mature specimens. Thus, the keriotheca of any chamber seemingly continued to increase in thickness with later growth of the individual.

Thin sections of the keriotheca show numerous dark lines normal to its surfaces, and these are separated by larger transparent areas. Sections cut tangent to the surface of the spirotheca show that the transparent areas (alveoli) are columnar in cross section, somewhat irregular to circular in outline, and are surrounded by the darker thin areas (Fig. 277,1c). Most students have interpreted the alveoli as cell-like openings in the keriotheca, and the darker thin zones as the enclosing walls of the openings. The



keriotheca of many Schwagerininae is divisible into a lower layer with coarse alveoli (lower keriotheca) and an upper layer of smaller alveoli (upper keriotheca) (Fig. 277,1a,c). Several smaller alveoli of the upper area are replaced by a single large alveolus below, into which they grade.

GUBLER (\*837, \*838) has interpreted the keriotheca as a masonry-like structure, in which the alveoli are coarse crystals of calcite cemented with a more fine-grained calcite impregnated with organic material, the latter less transparent material serving as "mortar." The tectum was interpreted by GUBLER as composed of fine-grained calcite and included organic material.

The spirotheca has been judged by most other workers to be porous. The alveoli decrease in size upward and at least part of them in some forms seem to pass through the tectum. Many thin sections of specimens show fine clear areas that pass through the upper surface of the spirotheca, as indicated in figures published by HAYDEN (\*885), THOMPSON (\*1915, \*1921, \*1924), DUNBAR & SKINNER (\*646), and DUNBAR & HENBEST (\*643). Some illustrations published by DUNBAR & SKINNER (\*646) and DUNBAR & HENBEST (\*643) indicate that fine, rodlike transparent structures penetrate the entire wall and even continue through the chomata.

HENBEST (\*896) has stained numerous types of fusulinaceans and has observed structures of the spirotheca that suggest porosity. Stained specimens of Fusulininae reveal porelike structures that pass through all layers of the spirotheca and the chomata (Fig. 277,3; 281). As the tunnel is well developed immediately adjacent to the chomata, a necessity for such openings is not obvious. Also, the tunnel is developed when the tectoria are deposited.

The diaphanotheca of some highly developed forms of Fusulininae shows a finely striated structure that seems comparable to the alveoli of the Schwagerininae. Most Fusulininae do not show a porous structure, but the pores may be too small to observe. Pores have not been noted in the tectum of fusulinaceans having a *Profusulinella*-type of spirotheca, even in species represented by abnormally large mature shells. It seems important that in large specimens of *Sumatrina* the spirotheca is composed of a single

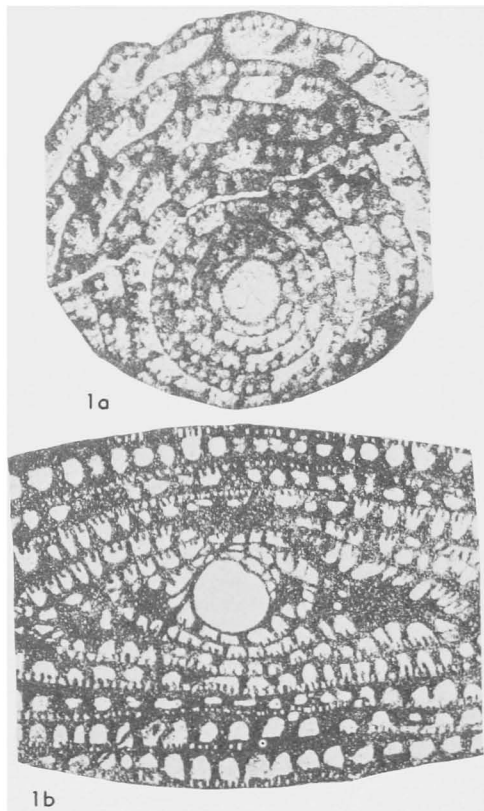


FIG. 289. Thin spirotheca of *Sumatrina* Volz, U. Perm., consisting of a single dense layer.—1a. *S. longissima* (DEPRAT), Cambodia (type-sp. of *Pseudolepidolina*), part of sagittal sec.,  $\times 45$ ; 1b, *S. annae* Volz, Sumatra, part of axial sec. of holotype,  $\times 30$  (\*1922).

thin layer, but pores have not been observed even in the outer part of the shell (Fig. 289).

The porosity of the spirotheca has been especially stressed in recent years by WHITE (\*2056), DUNBAR & SKINNER (\*646), and DUNBAR & HENBEST (\*643). The imperforate nature of the spirotheca was especially stressed by GUBLER (\*837, \*838). DUNBAR & SKINNER presented the following three points to refute GUBLER's postulate that the alveoli represent clear calcite cemented with finer-grained calcite-bearing organic material: (1) The crystallographic orientation of the calcite in several adjacent alveoli of at least some specimens corresponds to the orientation of the calcite immediately on the inside of the chamber, indicating that the alveoli were filled with

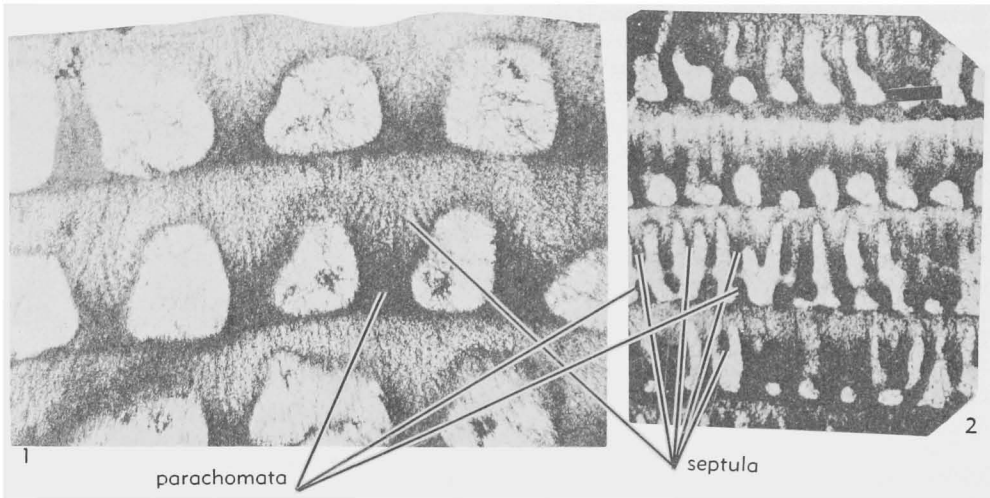


FIG. 290. Alveolar structure of spirotheca and septula in *Neoschwagerina* YABE, U.Perm., and *Yabeina* DEPRAT, U.Perm.—1. *N. haydeni* DUTKEVICH & KHABAKOV, Bamian Ls., Afghan.; part of axial sec. showing divergent alveoli extending through spirotheca into basal part of septula,  $\times 100$  (\*1922).—2. *Y. inouyei* (DEPRAT), Japan (Akasaka Ls.); part of axial sec., enlarged (\*1922).

calcite at the same time as the inside of the chamber was filled during fossilization. Therefore, the alveoli seemingly were open spaces during the life of the animal, and they were filled with calcite coincidentally with filling of the inside of the chamber; (2) the tectum shows dark and light bands, indicating that its structure somewhat resembles keriothecal structure and that the tectum is not a homogeneous layer on which the calcite prisms of the keriotheca were formed, as postulated by GUBLER; (3) DUNBAR & SKINNER observed in deformed specimens from Nevada that at points of compression of the keriotheca, dark lines of the keriotheca are close together and at points of tension the dark lines are much farther apart. This suggests that the alveoli were compressible in the compressed areas, and they were points of weakness in areas of tensional stresses. Therefore, the alveoli seemingly were hollow spaces during this early period of deformation and before complete fossilization.

As pointed out by DUNBAR & SKINNER, the alveoli of all fusulinaceans are smaller in diameter than the thickness of most thin sections, and consequently it is difficult to observe the crystallographic structure of the materials in a single alveolus. Some fusulinacean shells collected from surface samples have hollow chambers, but shells have

not been observed that also have hollow alveoli. Many fusulinacean shells have been studied in which the inside of the chambers are filled with chalcedony, but alveoli in the shells seem to be filled with calcite and lack chalcedony.

The more primitive members of both *Neoschwagerininae* and *Verbeekininae* have a spirotheca in which the lower layer contains alternating dark and less dense areas that resemble closely the structure of the keriotheca of the Schwagerininae. The less dense tubelike features are referred to as alveoli. In the *Verbeekininae*, the alveoli are about normal to the surfaces of the spirotheca but are more easily identified near the lower surface. In primitive members of the *Neoschwagerininae*, the keriotheca is thicker than in the *Verbeekininae*, and the alveoli are slightly broader. Also, in *Neoschwagerininae* the keriothecal structure extends to the base of the septula. In forms of *Neoschwagerina* having a thick keriotheca, the alveoli diverge as the base of the septula is approached. In some forms this divergence seemingly occurs without the introduction of additional alveoli, and both the alveoli and intervening dark areas merely increase in width.

The structure of the septula has been diagrammatically illustrated by many workers, including SCHWAGER (\*1706), STAFF

(\*1831), DEPRAT (\*584, \*586, \*587), LEE (\*1120), and GUBLER (\*838). The addition of alveoli in the lower part of the septula has not been indicated in any of these illustrations. Axial sections of *Yabeina katoi* from Akasaka, Japan, indicate that the transverse septula in some parts of the shell, especially near the poles in outer volutions, contain four or five alveoli in this upper area and may have three or four short alveoli added in their lower areas where the alveoli fan out to the edges of the septula (Fig. 290). This does not prove that alveoli are added in the lower part of the septula, for those extending down from the tectum may intersect the plane on the thin section near their lower ends and merely seem to pinch out between the alveoli that follow the plane of the section down from the tectum.

Thin, dense, diaphragm-like partitions that extend across the chambers of *Pseudofusulina* at various angles and in various parts of the chambers are termed **phreno-**

**thecae**. The structure of the phrenothecae resembles that of the tectum and seemingly is broken at irregular intervals by small openings similar to the septal pores. The phrenothecae are concave upward in some parts of the chambers and are concave downward in other parts. Most commonly, their edges are attached to the septa, but they may be attached to the floor or roof of the chamber. In forms such as *Pseudofusulina huecoensis* DUNBAR & SKINNER, having less well-developed phrenothecae, they are confined to the lower part of the chambers and are best developed in the region of the tunnel (Fig. 291). That they are primary parts of the shell structure is indicated by their occurrence in all specimens of some species collected from widely separated localities. Phrenothecae occur in most, if not all, species of *Pseudofusulina*, but are found only rarely in species of *Schwagerina*, as defined in the *Treatise*. At some localities, shells of *Pseudofusulina* contain abundant phrenothecae, but numerous

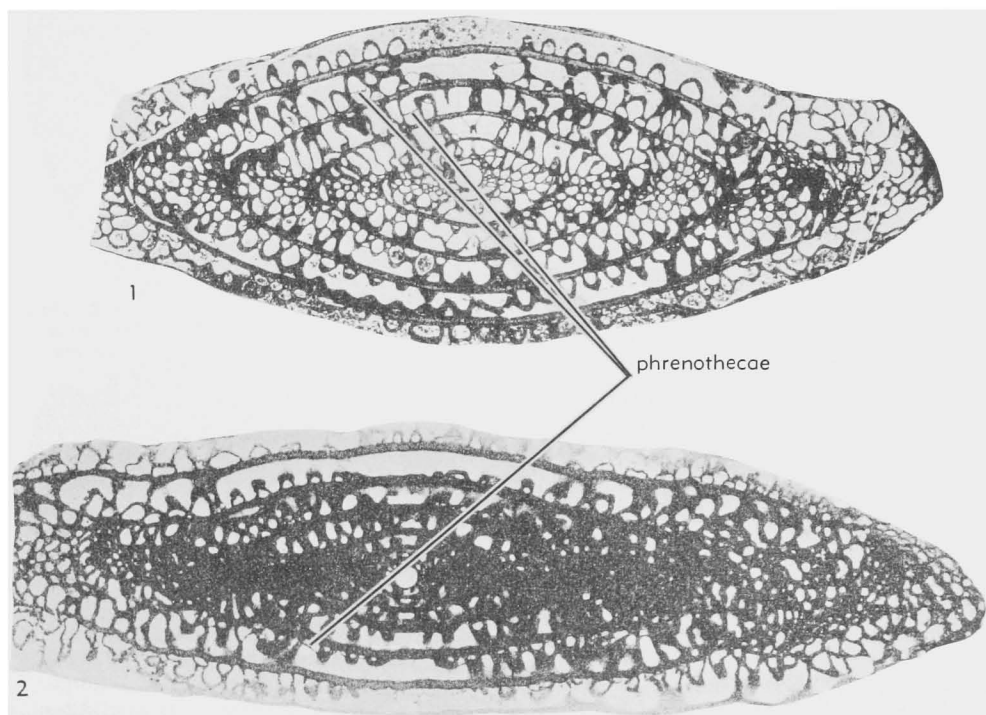


FIG. 291. Phrenothecae of fusulinaceans illustrated by *Pseudofusulina* DUNBAR & SKINNER, L. Perm.—1. *P. nelsoni* (DUNBAR & SKINNER), Hueco Ls., USA (Tex.); axial sec. with phrenothecae chiefly adjacent to tunnel,  $\times 10$  (\*1922).—2. *P. huecoensis* DUNBAR & SKINNER, Hueco Ls., USA (Tex.); axial sec. of holotype,  $\times 10$  (\*1922).

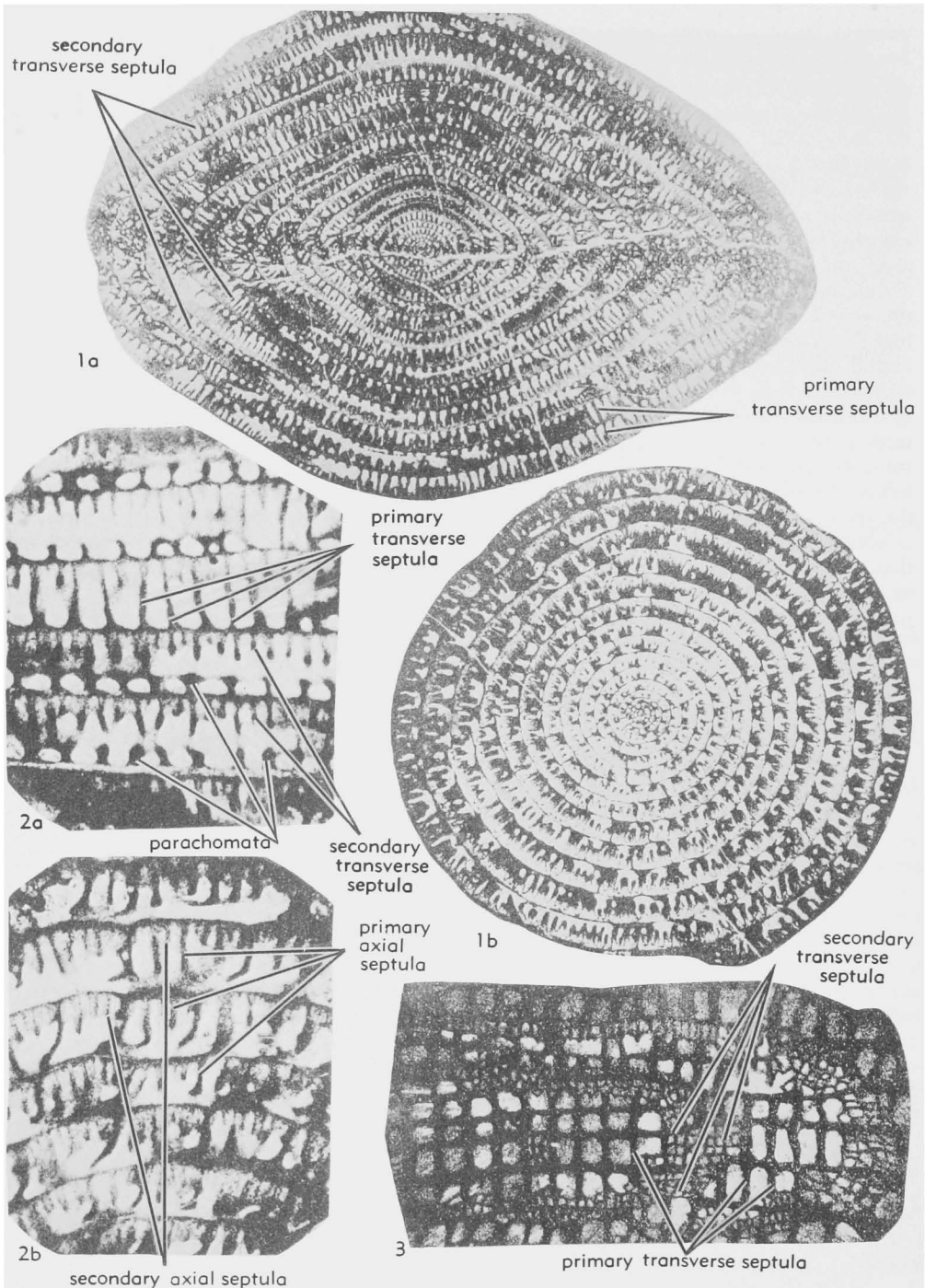


FIG. 292. Septula and parachomata of specialized fusulinaceans illustrated by *Yabeina* DEPRAT, U.Perm., *Lepidolina* LEE, U.Perm., and *Sumatrina* VOLZ, U.Perm.—1. \**Y. inouyei* (DEPRAT), Akasaka Ls., Japan; 1a, axial sec. of holotype showing primary and secondary transverse septula, especially in outer volutions,  $\times 10$ ; 1b, sagittal sec. of paratype showing primary and secondary axial septula,  $\times 10$  (\*1922).—2. \**L. multiseptata* (DEPRAT), Cambodia (2a), Akasaka Ls., Japan (2b); 2a, part of axial sec. showing transverse septula and parachomata,  $\times 45$ ; 2b, part of sagittal sec. showing long primary septula with short secondary ones between them,  $\times 45$  (\*1922).—3. \**S. annae* VOLZ, Sumatra; tang. sec. showing transverse and axial septula,  $\times 30$  (\*1922).

associated shells belonging to other genera (e.g., *Pseudoschwagerina*, *Schwagerina*) lack them. The function and origin of phrenothecae are not known.

### SEPTULA

The lower surface of the spirotheca of members of the Neoschwagerininae contains ridges (septula) that hang down into the chambers. The septula of primitive members are transverse to the axis of coiling, but highly developed members have two sets of septula, one of which is transverse and the other parallel to the axis of coiling. Septula transverse to the axis of coiling are termed **transverse septula**, and those parallel to the axis are termed **axial septula** (Fig. 292).

The septula of *Cancellina* are represented by broad, short, downward protrusions of the keriotheca that correspond in position with the parachomata on the base of the chamber. The alveoli of the keriotheca of this genus extend to the base of the septula without obvious divergence (Fig. 293). The parachomata are in contact with the septula immediately adjacent to the septa, where the parachomata are highest and septula are longest. The septula are very broad and short in the center of the chamber, and the parachomata are low. The transverse septula of other Neoschwagerininae are long enough to reach the tops of the parachomata completely across the chambers, except for a small circular opening in the center of the chamber above the parachomata. The alveoli of the keriotheca continue to the base of the transverse septula in *Neoschwagerina* and *Yabeina*, and the alveoli diverge outward as they approach the base of the septula. In many sections it seems that alveoli may have been added in the lower part of the septula between the diverging alveoli that extend from the tectum of the keriotheca (Fig. 290, I). Short transverse septula, termed **secondary transverse septula**, occur above the foramina in the outer volutions of *Yabeina* and throughout the shell of higher forms. These secondary transverse septula resemble the **primary transverse septula** in all respects except that they are shorter and narrower (Fig. 292). As septula are added, the individual primary septulum, as well as secondary septula, become narrower. The transverse septula of highly de-

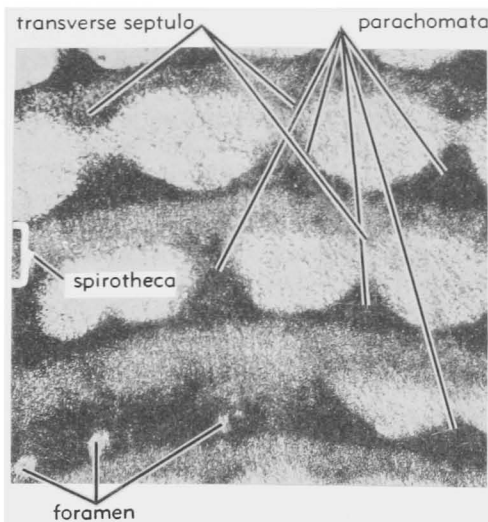


FIG. 293. Spirotheca, rudimentary transverse septula, and parachomata shown in axial sec. of \**Cancellina primigena* (HAYDEN), U. Perm., Iran; septula comprise pendant extensions of keriotheca from roofs of chambers opposite parachomata (dark) on floors of chambers,  $\times 100$  (\*1922)

veloped Neoschwagerininae (e.g., *Lepidolina*, *Sumatrina*) are very thin and do not contain recognizable alveoli.

Axial septula are lacking in *Cancellina*; they first appear in the outer volutions of *Neoschwagerina*. In *Afghanella*, *Sumatrina*, *Yabeina*, and *Lepidolina*, several axial septula are introduced between the septa. The axial septula of *Yabeina* and *Lepidolina* are irregular in length, and their lower margins do not reach the tops of the chambers of the preceding volutions. The axial septula of *Afghanella* and *Sumatrina* are short and uniform in length. The upper part of the chambers is divided by the transverse and axial septula into numerous rectangular cubicles.

The structure of the septula of more primitive forms of the Neoschwagerininae (e.g., *Cancellina*, *Neoschwagerina*) resembles closely that of the keriotheca between the septula (Fig. 293). In *Yabeina*, the width of the septula corresponds closely to the thickness of the keriotheca. The spirotheca of *Lepidolina* consists of a single dense layer, and the septula are composed of a single dense layer without any recognizable alveoli. Also, the spirotheca of *Sumatrina* is composed of a very thin, dense layer and the alveoli are very thin (Fig. 289).



Some paleontologists have suggested that the thin, dense septula of highly developed Neoschwagerininae are formed by isolation of the walls of alveoli, and that the cubicles between opposing pairs of septula are comparable in structure to the alveoli of more primitive forms. The evolutionary trend of the Neoschwagerininae indicates that reduction in thickness of the septula corresponds to reduction in thickness of the spirotheca and that the septula are not the bounding walls of enlarged alveoli.

Both the structure and shape of the septula differ considerably among the Neoschwagerininae. The septula of *Yabeina* and *Lepidolina* are variable in length and are sinuous to irregular in shape, but the sinuosity is not regular or uniform (Fig. 292). Both the transverse and axial septula of *Sumatrina* are uniform in length and they are spaced regularly in both directions. The septula of the inner volutions of *Afghanella*, *Sumatrina*, and *Lepidolina* are thicker in their lower margins than near their upper margins. However, the septula in the outer few chambers of these genera are about the same in thickness throughout their heights, and it seems evident that the thick lower margins of the septula of earlier volutions are developed by secondary deposits.

The biologic cause or purpose of the septula is problematical. It has been suggested that they serve as strengthening supports for the shell. However, the first Neoschwagerininae to develop septula have a ratio of shell material to open chamber space that is far in excess of most other fusulinaceans, as well as of many other shell-bearing animals. Furthermore, the fusulinacean shell seemingly was filled with cell substance of the animal throughout its development, and there is no evident source of stresses on the shell. Also, the spirotheca of *Sumatrina* is exceedingly thin and fragile, but the septula are shorter and do not seem capable of giving as much support for the shell as those found in more primitive forms having much thicker and stronger walls (Fig. 289, 292, 3).

#### TUNNEL AND FORAMINA

So far as has been demonstrated, the only communication between the inside of the

fusulinacean shell and the exterior is by means of the numerous septal pores in the antetheca. After the shell developed a few chambers beyond the antetheca of a given chamber, communication with earlier parts of the shell was facilitated by resorption of the lower surface of the septum so as to form a single opening, the tunnel, several widely spaced openings, **multiple tunnels**, or a series of small, closely spaced elliptical openings, foramina. About the same time as the development of these openings at the base of the septa, the fusulinacean laid down dense deposits of calcite in several parts of the shell. In forms having a single tunnel, ridges of dense calcite, the chomata, were deposited at the sides of the tunnel. Dense deposits similar in structure to the chomata completely lined the inside of the chambers of members of Fusulininae and of primitive members of the Ozawainellidae and Schubertellinae. These linings form the tectoria of the spirotheca and septa in forms having *Profusulinella*- and *Fusulinella*-type of wall structure. Dense deposits (axial fillings) completely fill the chambers in the polar regions of *Wedekindellina*, highly developed forms of *Fusulina*, and all forms of *Quasifusulina* (Fig. 275, 3a; 279).

Primitive members of the Schwagerininae have a single tunnel and massive chomata but no other type of secondary deposits. Highly developed members of this subfamily have small or indistinct chomata and heavy axial fillings. The most highly developed genus of the subfamily, *Polydiexodina*, has multiple tunnels that lack bordering chomata, and axial fillings are well developed (Fig. 275, 3a, 6b).

Foramina occur in all members of the Verbeekininae, and all members have parachomata developed to some extent between adjacent foramina. The parachomata of *Eoverbeekina* are poorly developed and extend only a short distance from the septa in the outermost volutions of mature specimens. The parachomata are discontinuous in the earlier volutions of *Verbeekina* but extend completely across the chambers in outer volutions of mature specimens. All species of more advanced genera have parachomata developed completely across the chambers. Axial fillings occur in some advanced forms of both subfamilies. Also,



secondary deposits cover the septa and some parts of the surfaces of the spirotheca of many forms.

The secondary deposits are best developed in chambers having a tunnel or foramina, which seems to mean that these structures are related in origin. The excavated shell material may have been used to form the secondary deposits. Many specimens have secondary deposits that are too massive to have been obtained entirely from the excavated tunnel or foramina, and, accordingly, part of the deposits must have come from other sources. The upper tectorium of many shells occurs on the floor of the tunnel, and it must have been partly formed after excavation of the tunnel. This theory is supported by the absence of secondary deposits in chambers into which the tunnel does not extend.

With few exceptions, most secondary deposits resemble one another closely in structure. In *Yangchienia*, a clear layer occurs above the tectum of the spirotheca and is overlain by a thick layer of dense calcite similar to the tectoria of other fusulinaceans. Neither of these upper layers occurs on the floor of the last chamber; obviously, they are deposited as secondary layers on the floor of the chambers. The chomata of many fusulinaceans are stratified in structure, indicating that they were laid down in stages.

The tunnel and foramina of fusulinacean shells were developed by resorption of the lower parts of the septa, for they do not occur in the antetheca at any stage of growth of the individual. The only logical explanation of their development is that they furnished means of communication between earlier chambers, which may have been more needed after the septal pores were partly sealed by secondary deposits on the septa. The purpose served by the secondary deposits is not known.

## EVOLUTIONARY TRENDS

### GENERAL CONSIDERATIONS

Fusulinacean shells seem to have changed in structural features more rapidly than has been recognized in most other large groups of fossils. That the shell structures of these foraminifers changed both rapidly

and markedly is made evident by comparing *Millerella* from basal Pennsylvanian beds with complex forms from the Permian, such as *Yabeina* and *Polydiexodina*. At first glance these extreme members of the fusulinaceans bear little resemblance, but most of the changes that took place in the shells of forms intermediate between the simple and complex can be identified in the geologic order of their occurrence. During their relatively short geologic history, several larger divisions and about 72 genera represented by more than 1,000 species developed.

Many evolutionary trends of the fusulinaceans can be distinguished with assurance, but it should be stressed that much is yet unknown concerning details of the development within the group. The fusulinaceans had their beginning near the end of the Mississippian, and only two genera are recognized in oldest Pennsylvanian rocks. Very shortly after the beginning of Pennsylvanian time, however, several major divisions of the fusulinaceans evolved and these are recognizable in both the Eastern and Western Hemispheres. Therefore, the fusulinaceans developed along several lines of evolution rather early in their history.

In many provinces that contain abundant fusulinacean faunas distributed throughout great thicknesses of rocks, the fusulinaceans are so closely spaced in stratigraphic sequence that one may observe almost continuous changes which took place within certain groups. Among many large assemblages, changes in shell structure are not only of identical nature, but are found to appear in the same relative geologic order in widely separated areas throughout both hemispheres. Some branches reached ultimate stages of development along certain lines in early Pennsylvanian time, others reached similar stages in early Permian time, and still others did not reach similar stages until the latter half of the Permian. Therefore, it seems evident that many of these changes were due to evolutionary trends inherent within the division.

Gradual changes in shell structure of fusulinaceans in some areas may have been due largely to introduction of more favorable environmental conditions; other

changes originating in other areas may represent adaptation to gradually developing adverse conditions. Whatever may have been the causes of some changes in shell structures, certain types of progressive alteration took place in almost all groups, regardless of locality or geologic time. Some of these major changes are summarized below.

(1) Shells became larger. The most primitive fusulinaceans are minute, measuring only a fraction of a millimeter in maximum diameter. Almost all highly developed fusulinaceans are relatively large; in-

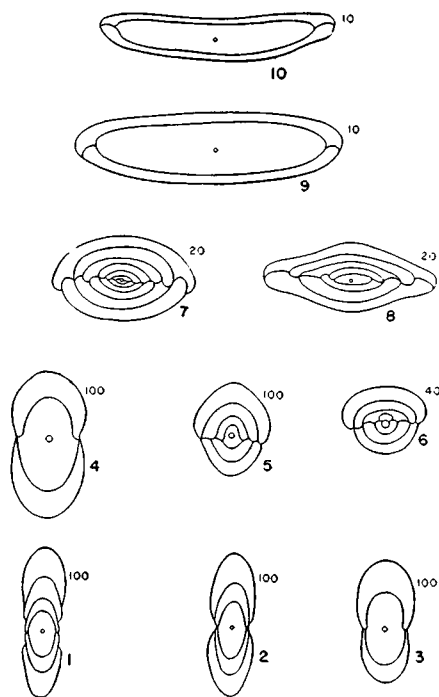


FIG. 294. Development of shell shape and size of fusulinaceans belonging to the Ozawainellidae and Fusulinidae (Fusulininae), numbers at upper right of each figure denoting relative (not actual) magnifications.—1. \**Millerella marblensis*, M.Penn. (Marble Falls Ls.), USA (Tex.).—2. *M. pressa*, L.Penn. (Kearny F.), USA (Kans.).—3. *Paramillerella pinguis*, L.Penn. (Bloyd Sh.), USA (Ark.).—4. *P. circuli*, L.Penn. (Belden F.), USA (Utah).—5. *P. sp.*, L.Penn. (Amsden F.), USA (Wyo.).—6. *Eoschubertella gallowayi*, M.Penn. (Boggy F.), USA (Okla.).—7. *Profusulinella regia*, M.Penn., USA (W.Tex., Powow Canyon).—8. *Fusulinella acuminata*, M.Penn. (Fra Cristobal F.), USA (N.Mex.).—9. *Fusulina mysticensis*, M.Penn. (Worland Ls.), USA (Iowa).—10. *F. eximia*, M.Penn. (Cooper Cr. Ls.), USA (Iowa) (\*1922).

deed, the volume of some advanced forms exceeds that of the most primitive fusulinaceans by several thousand times.

(2) Shells changed in shape from discoidal to spherical, fusiform, or elongate-subcylindrical. The most primitive genus of the fusulinaceans is discoidal; the axis of coiling of its slightly evolute shell is the shortest diameter through the proloculus. Except for a few aberrant genera, most fusulinaceans have involute shells. The length of the axis of coiling of most of them increased more rapidly than other diameters of the shell, and most groups developed the greatest shell dimension along the axis of coiling.

(3) Shell walls became more complex. The most primitive genus has a thin wall of simple structure. Later fusulinaceans have thicker walls of more complex structure (except in several later aberrant genera that contain thin structureless walls).

(4) The antetheca and septa tended to become fluted. Those of primitive fusulinaceans are straight, but many highly developed fusulinaceans have antetheca and septa that progressively become more irregular or highly fluted.

These general trends are common to most fusulinaceans. Many other progressive developments of shell structure were restricted to parts of the group. Some of the more important of these are (1) development of septula in the Neoschwagerininae; (2) reduction of the chomata in the Fusulininae and later in the Schwagerininae; (3) development of parachomata both in the Verbeekininae and Neoschwagerininae; and (4) development of axial fillings in the Fusulininae, later in the Schwagerininae, and still later in the Verbeekininae and Neoschwagerininae. Some of these changes seem to mark definite evolutionary trends; others probably reflect a combination of factors which may not be related to evolutionary trends.

#### SIZE AND SHAPE OF TEST

The primitive members of all subfamilies and nearly all genera are smaller than most of the highly developed members. The size of individuals of most types of animals is partly dependent on local environmental conditions, such as food supply, and the

average size of mature specimens in one locality may be somewhat different from the average size of mature specimens in another. Therefore, a small difference in size alone is not considered a basis for specific differentiation. Pronounced increase in shell size is recognized within most groups of the fusulinaceans. Primitive Schubertellinae were minute (0.4 to 1.3 mm. maximum diameter) and so were later Permian members (1.3 to 3.0 mm. maximum diameter).

Primitive fusulinaceans are minute (with maximum diameter as small as 0.4 to 0.9 mm.), but most late forms are relatively large (up to 16 mm. in maximum diameter). Marked increase in length is especially noticeable among the Schwagerininae, from early *Triticites* (2 to 3 mm.) to very large *Polydiexodina* and *Parafusulina* (as large as 60 mm.); the relative size increase in this group, however, is no greater than that of the fusulinaceans in general. Early Neoschwagerininae (e.g., *Cancellina*) are small (about 3 mm.), but late members (e.g., *Yabeina*) are large (at least 16 mm.). Figure 294 illustrates the ranges in size of some Ozawainellidae and some Fusulinidae (Fusulininae).

Although the general trend of fusulinaceans was toward increase in size of the shell, some forms seemingly developed from slightly larger ancestors.

The classification of fusulinaceans is based partly on shape of the shell, even though external form, taken alone, is not sufficient for recognition of many genera. The most primitive fusulinaceans are discoidal in shape, and the general trend of most later groups is toward a longer axis of coiling. The general shell profile of *Millerella* to advanced members of *Fusulina* exhibits progressive change from discoidal, slightly evolute ozawainellids (e.g., *Millerella*) to spherical or irregular-elongate members of this family (e.g., *Rauserella*) and Staffellidae (e.g., *Sphaerulina*). Schubertellinae evolved from an ellipsoidal shell (e.g., *Eoschubertella*) to very elongate-fusiform or irregular shapes. Fusulininae developed from subspherical tests (e.g., *Pseudostaffella*) to highly elongate-fusiform or irregular forms (e.g., *Fusulina*, *Quasi-fusulina*). Out of fusiform shells of primitive *Triticites*, the Schwagerininae pro-

duced the highly elongate-subcylindrical shells of *Parafusulina* and *Polydiexodina*. Most early Verbeekininae are subspherical in shape, but very advanced forms (e.g., *Pseudodoliolina*) are elongate-ellipsoidal in shape. The genus *Brevaxina* has a subspherical shell and strongly umbilicate axial regions, its development and shape being inharmonious with the general trend among fusulinaceans. The most primitive form of the Neoschwagerininae is inflated-ellipsoidal in shape; advanced forms are elongate-subcylindrical to strongly inflated-fusiform in shape. Some subfamilies, particularly the Verbeekininae and Neoschwagerininae, possibly are biphyletic, and the similarity of internal structures, as well as shape of the shell, may indicate parallel development.

Although a general tendency among fusulinaceans was toward development of an elongate shell, possible reversals can be pointed out. A few forms of Schwagerininae, particularly *Triticites* in the Pennsylvanian and *Pseudoschwagerina* in the Permian, have subspherical mature shells. The inner volutions of *Pseudoschwagerina* have far greater length along the axis of coiling, and it is solely the outermost volutions that control the subspherical shape of the mature shell. The subspherical or inflated forms of *Triticites* occur stratigraphically above elongate forms, but it cannot be demonstrated that the former were derived from the latter.

*Brevaxina* has a short axis of coiling and umbilicate axial regions. Other members of the Verbeekininae are spherical or elongate in the direction of the axis of coiling. Evolutionary trends within this subfamily are obscure; probably the assemblage is biphyletic, *Eoverbeekina* and *Verbeekina* having come from one ancestral form and *Brevaxina*, *Misellina*, and *Pseudodoliolina* having descended from another.

### SPIROTHECA

Rather definite trends in evolutionary development of the spirotheca are seen among fusulinaceans. These trends took slightly different paths and rates of change in different divisions of the superfamily. The spirotheca of the more primitive fusulinaceans, such as *Millerella*, was originally

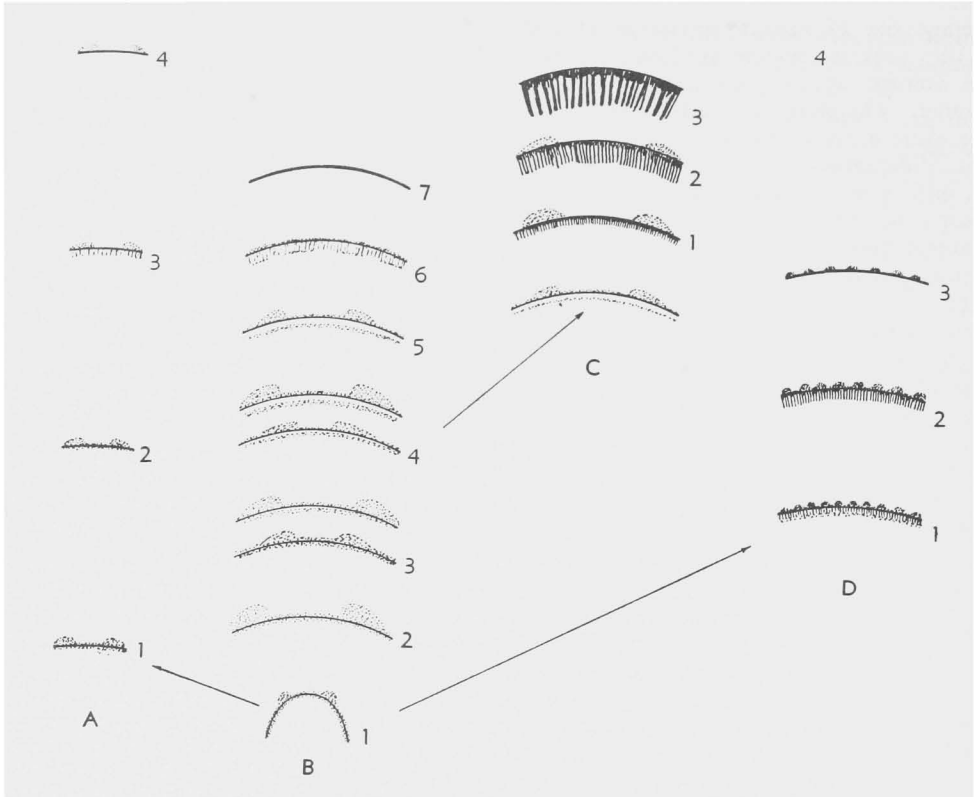


FIG. 295. Evolution of the spirotheca in the Fusulinidae.—A1-4. Schubertellinae; 1, primitive *Eoschubertella*; 2, highly developed *Eoschubertella*; 3, typical *Schubertella*; 4, highly developed *Schubertella*.—B1-7. Fusulininae; 1, *Pseudostaffella*; 2, *Profusulinella regia*; 3, *Fusulinella primaeva*; 4, *Fusulinella juncea*; 5, *Fusulina* n. sp. (intermediate); 6, *Fusulina cylindrica*; 7, *Gallowayinella* (idealized).—C1-3. Schwagerininae; 1, *Triticites irregularis*; 2, *T. moorei*; 3, *Schwagerina furoni*.—D1-3. Verbeekinae; 1, *Verbeekina verbeeki*; 2, *Misellina*; 3, highly developed *Pseudodoliolina* (\*1922).

formed above the last chamber as a single thin dense layer. With growth of additional chambers in an individual, this thin layer was covered above and below by secondary layers of tectoria. The evolutionary trend of most fusulinaceans was to develop a thicker primary wall. Secondary deposits are lacking in many specialized forms.

Among Ozawainellidae, the spirotheca developed from a simple wall structure like that of *Millerella* to a wall composed of a thin indistinct upper primary layer (tectum), a lower, less dense primary layer (diaphanotheca), and secondary layers of upper and lower tectoria. Some advanced forms of the group seem to have a spirotheca composed of a tectum and a less dense structureless lower layer.

Primitive Schubertellinae have a spirotheca like that of *Paramillerella* or *Miller-*

*ella*. Highly developed forms have a spirotheca composed of a tectum and a relatively thick lower clear layer, but late Permian members of the group have a spirotheca throughout the shell that is composed of only a thin dense layer. The evolution of the wall of the Schubertellinae is diagrammatically shown in Figure 295 (A1 to A4).

Evolution of the spirotheca of the Fusulininae seems to be similar to that of the Schubertellinae, but changes took place geologically much more rapidly than in the Schubertellinae. The three-layered spirotheca of *Pseudostaffella* and *Profusulinella* (Fig. 295, B1, 2) developed into the four-layered spirotheca of *Fusulinella* (Fig. 295, B4). This type of spirothecal structure characterizes all forms of *Fusulina*, with gradually increasing thickness of the diaphanotheca and decreasing thickness of the

upper and lower layers. In advanced forms of *Fusulina* (e.g., *F. cylindrica*, Fig. 280,3; 295, B6), the diaphanotheca is thick and has a structure somewhat like that of the keriotheca of higher forms, the upper tectorium being absent or thin and the lower tectorium discontinuous. Later forms of Fusulininae (e.g., *Quasifusulina*, *Gallowayinella*) have a thin spirotheca (Fig. 295, B7). *Gallowayinella* has a spirotheca seemingly composed of a single dense thin layer. The general trend of fusulinaceans characterized by this wall structure (Fig. 280,3; 295, B1-B7) reached a peak of development in Pennsylvanian (Desmoinesian) time, but advanced genera range into the Permian period.

Schwagerininae were introduced in rocks of early Missourian age (Pennsylvanian) in North America by *Triticites*. Although the ancestral form of *Triticites* is not definitely known, seemingly it was closely allied to *Fusulinella*. The spirotheca of *Triticites* is composed of a tectum and thick keriotheca having clearly visible alveoli. The structure of the spirotheca remained the same in later members, but the keriotheca increased in thickness and the alveoli became coarser (Fig. 280,4-6; 295, C1-C3).

The evolution of the spirothecal structure of the Verbeekininae and Neoschwagerininae was somewhat similar to that of the Schwagerininae, except that late genera of both groups possess a spirotheca composed of only a single dense layer (Fig. 295, D1-D3).

It seems evident that evolutionary development of the spirotheca of the fusulinaceans was toward a thickening of the lower primary layer, the diaphanotheca or keriotheca. All major groups followed the same general pattern of evolution of the spirotheca independently and at different times, and this trend seems to have been inherent within the entire superfamily.

#### ANTETHECA AND SEPTA

The antetheca and septa of the most primitive fusulinaceans are unfluted from end to end. They are also unfluted throughout the shell in all members of the Ozawainellidae, Verbeekininae, and Neoschwagerininae. Septal fluting developed

at different rates in the Schubertellinae, Fusulininae, and Schwagerininae.

The septa of primitive Schubertellinae are unfluted. A few highly developed Permian forms of Schubertellinae have septal fluting developed throughout the length of the shell. The septa of Schubertellinae remained unfluted for a long time and never reached a high stage of development, even in the upper Permian.

The septa of the most primitive Fusulininae (*Pseudostaffella*) are unfluted throughout the length of the shell. *Profusulinella* has septa fluted only in the extreme polar regions. Septal fluting developed rather rapidly and uniformly in the Fusulininae, from *Pseudostaffella*, without septal fluting, to upper Desmoinesian *Fusulina*, with highly fluted septa throughout the length of the shell, and still further to *Quasifusulina* with closely fluted septa.

The development of septal fluting in Schwagerininae was rapid. In North America, the Schwagerininae were first developed in early late Pennsylvanian time and are represented by *Triticites*, having septa fluted only in the polar regions. Before middle late Pennsylvanian time the septa of some forms were fluted throughout the length of the shell. *Triticites* is first known in the mid-continent region in the basal part of the Missourian Series, but the forms there probably are not the most primitive of the genus. More primitive forms of *Triticites* are known from the middle Oquirrh Formation of the Wasatch Mountains of Utah and from the lower part of the Upper Carboniferous as designated by RAUZER-CHERNOUSOVA, BELYAEV & REYTLINGER (\*1508) in the Samara Bend area of Russia. Highly evolved Permian members of the group (e.g., *Parafusulina*, *Polydixodina*) have intensely fluted septa throughout the length of the shell.

Evolution of septal fluting closely parallels that of shape of the shell. Septal fluting is not developed in some groups having discoidal or spherical shells, such as the Staffellidae and Verbeekinidae. It first began to form in other groups after the shell assumed a fusiform shape, and reached its highest development in subcylindrical shells. In genera that acquired a fusiform shell only after the shell structures had be-

come very complex, as in *Sumatrina*, septal fluting was never developed.

## OTHER TRENDS

### SEPTULA

The appearance and progressive modification of septula in the Neoschwagerininae comprise one of the most definite evolutionary developments among the fusulinaceans, but septula are restricted to this group (Fig. 292, 293). Their development can be traced from the short, broad, transverse septula of *Cancellina* to the elongate set of broad transverse septula and simple axial septula of *Neoschwagerina*, and still further to the complex sets of transverse and axial septula of *Yabeina* and *Lepidolina*. Complicated sets of transverse and axial septula are found in *Afghanella* and *Sumatrina*, but the position of these genera within the division is not definitely known. The complexity of their septula does not accord with their geologic occurrence associated with primitive forms of the group, such as *Cancellina* and *Neoschwagerina*. Their ancestral forms are unknown.

### CHOMATA

The chomata of fusulinaceans with a single tunnel changed with their progressive development, but it is not certain that the changes took definite trends. The chomata of many primitive forms of Fusulininae are massive and large, and the tectoria are correspondingly thick. As the group became more advanced, the chomata became less massive and the tectoria became thinner. In late members of the group the chomata are feebly developed in the innermost volution and are absent or indistinct in the outer part of the shell. The subfamily Schwagerininae experienced a similar reduction in the chomata. This general reduction in the massiveness of the chomata in late Fusulininae and late Schwagerininae is in reality a reversal of their development in early members of the group, which had small chomata; the chomata gradually became more massive as the early fusulinaceans evolved.

### PARACHOMATA

Structural features that are progressively developed in the Verbeekininae and well

defined in all members of the Neoschwagerininae are the parachomata (Fig. 292, 293). These are feeble in the outer volution of *Eoverbeekina* and occur only adjacent to the septa of inner volution of *Verbeekina* but extend across the chambers of outer volution. Advanced forms of Verbeekininae have distinct parachomata throughout the shell.

### AXIAL FILLINGS

Dense deposits of calcite occur in the axial regions to some extent in all major divisions of the Fusulinacea except the Ozawainellidae (Fig. 279). They are best defined in late members of these divisions. Heavy axial fillings occur in *Wedekindellina* near the middle of the stratigraphic range of the Fusulininae, but it seems probable that *Wedekindellina* is a specialized member of an early branch of the group. The appearance of heavy axial fillings in late forms of Fusulininae and Schwagerininae coincides with reduction of the chomata. Both of these features are of secondary origin, and when one is well developed the other is absent or feeble. Axial fillings are inconspicuous in late forms of the Verbeekininae and Neoschwagerininae.

Some investigators of the fusulinaceans have concluded that development of axial fillings is not constant even among conspecific specimens. Observations do not bear out these statements. It is difficult to cut axial sections exactly along the axis of coiling, and in forms having thin zones of axial fillings many axial sections fail to intersect these fillings. Accordingly, one may not realize the presence of axial fillings in such specimens unless they are seen during the sectioning procedure. Critical observations of many forms indicate that axial fillings are about equally massive in all conspecific specimens.

## PHYLOGENY

The phylogeny of the fusulinaceans is interpreted from a combined view of their stratigraphic occurrence and progressive changes of their shell structures. Many fusulinaceans are so closely spaced stratigraphically that it is possible to observe details of progressive development, and their phylogeny can be interpreted with consid-



erable assurance. Some other groups are most common in relatively isolated localities, and their exact stratigraphic relationships to fusulinaceans of other areas are not yet determined. In such cases it is necessary to rely largely on degree of similarity of shell structures. The genus *Misellina*, for example, which represents the early part of one branch of the subfamily Verbeekinae, lacks a recognized closely similar ancestor and its relationship to other members of the Verbeekinae is doubtful. The ancestry of *Afghanella* and *Sumatrina* is likewise open to question. Both resemble other members of the Neoschwagerininae in many respects, but obviously they have reached a stage of evolution far in advance of associated primitive members of the major group (e.g., *Cancellina*, *Neoschwagerina*).

## ECOLOGY

Considerable evidence is available to indicate that fusulinaceans were uncommonly sensitive to their physical surroundings. They seem to have been restricted to offshore open-water environments, and their shells occur as fossils most commonly in limestones or highly calcareous shales, and less commonly in sandstones. Also, fusulinaceans are not considered to be indigenous in coarse clastics or in close association with evaporites. In the Permian of the Texas-New Mexico area, certain limestones can be traced laterally from areas in which fusulinacean faunas are prolific to areas characterized by brackish-water types of faunas, and likewise to areas where the limestones grade into dolomites and evaporites. The fusulinaceans disappear laterally in the section long before the approach to regions of evaporites. Also, fusulinaceans are not found in direct association with fossil forms of invertebrates of the types that live today in brackish-water or near-shore environments.

Fusulinaceans occur abundantly in sandstones at some localities. Several such occurrences are in upper Desmoinesian sandstones of southern Oklahoma and northern Texas. Fusulinacean shells have been found at a few places in these sandstones concentrated in the troughs of undulating structures interpreted as ripple marks, but

it is not certain that they were indigenous to the ripple-mark surfaces. Also, fusulinacean shells have been observed with their elongated axes arranged in spiral patterns that make them appear to have been affected upon final settling to the bottom by turbulent currents and swirling eddies or whirlpools. At some outcrops thick limestones contain abundant fusulinaceans with highly elongate shells, most of them oriented in the same direction. Such occurrences have been observed in the Permian of Timor (\*1923) and in the Permian of the Island of Letti (\*1693), where oriented shells of fusulinaceans compose more than 50 per cent of great thicknesses of limestones. Similar occurrences of oriented fusulinacean shells are found in some Pennsylvanian and Permian limestones of North America and in the Tethyan Permian reef-like limestones of western United States and western Canada. This orientation of the shells of fusulinaceans suggests the presence of submarine currents in these places at the time when the shells were deposited. In no case has it been possible to determine whether the fusulinaceans were dead or alive when their tests became thus oriented.

The most convincing evidence of the normal offshore, open-water habitat of the fusulinaceans is furnished by studies of the sedimentary cycles in the Pennsylvanian rock column of the northern mid-continent region. MOORE (\*1307, p. 25) divided the complete Pennsylvanian sedimentary cyclothem into ten units, the lower two and uppermost one of which are of continental origin. The intervening seven units are marine, and fusulinaceans occur most abundantly in the middle unit of the marine part of the cyclothem. The fusulinaceans seem to have lived offshore in open seas and they penetrated continental basins farthest when the seas reached their greatest advancement. A fusulinacean-bearing unit at any given place typically is underlain by rocks formed by the advancing sea and overlain by sediments of the retreating sea. The sedimentary cycle in the Lower Permian (Wolfcampian) of Kansas, Oklahoma, and Nebraska differs somewhat from that in the Pennsylvanian (\*1308), but, as in Pennsylvanian cyclothem, the fusulinaceans occur in and near

the central part of the marine phase of the sedimentary cycle.

## OCCURRENCE

### GEOGRAPHIC DISTRIBUTION

Fusulinaceans are almost world-wide in geographic distribution, for they have been found on all continents except Australia and Antarctica. The most northerly known occurrence is on Ward Hunt Island north of Ellesmere Island, Canada (\*1928). They also have been found in northeastern Greenland (\*878, \*1949, \*647A) and at several places on Spitzbergen (Svalbard) (\*1832, \*1918). The most southerly recorded occurrence of fusulinaceans in the Western Hemisphere is in Patagonia of southern Chile (\*306), and the most southerly occurrence in the Eastern Hemisphere is on North Island of New Zealand (\*958). Some of the thicker marine sequences of upper Paleozoic rocks from which fusulinaceans have not been found are the Permian deposits of Australia, Tasmania, and Madagascar.

The accompanying outline map (Fig. 296) shows some of the principal localities from which fusulinacean faunas of Pennsylvanian and Permian ages have been described or reported. This shows that fusulinaceans are more widely known in the Northern than in the Southern Hemisphere. It should be pointed out, however, that other types of upper Paleozoic faunas are about equally more widely known in the Northern Hemisphere than in the Southern Hemisphere. Furthermore, large parts of the land areas of the Southern Hemisphere are covered by permanent ice and snow and are practically unknown geologically.

Fusulinaceans occur in Pennsylvanian and Permian rocks on many of the Arctic islands of Europe and throughout most of the north-south distance across European Russia and Siberia, in the Viséan of Germany, in the Pennsylvanian of Spain, and in the Permian of the Carnic Alps, Velebit Mountains of Yugoslavia, Sicily, Aegean Islands of Greece, and Crimea.

Fusulinaceans have been described from Tunisia in Africa where they occur in Upper Permian rocks.

Fusulinaceans are widespread in Asia and in islands of the Indian and Pacific Oceans. They occur in the Pennsylvanian of Mongolia, China, Japan, and possibly Vietnam. They are present in the Permian at numerous places in the western part of the Eastern Hemisphere, including Pamir, Armenia, Iran, Turkey, Syria, Afghanistan, Karakorum region, northern India, Malaya, Thailand, Vietnam, western, southern, and northern China, northeastern, southeastern, north-central, and extreme western Siberia, Japan, and many of the islands of the Indian Ocean area, including Sumatra, Timor, Letti, and North Borneo. They also have been found in several localities in the Salt Range of West Pakistan.

In the Western Hemisphere, fusulinaceans occur in rocks of Pennsylvanian age in large areas of the United States from Pennsylvania on the east to California on the west. Pennsylvanian fusulinaceans of similar age are known from Peru, Brazil, Bolivia, and southern Chile.

Permian fusulinaceans are widespread in North America, being known throughout much of the far western United States, Rocky Mountain area, south-central United States, and the mid-continent region. Outside of the United States, Permian fusulinaceans occur in western and northern Canada, Greenland, Alaska, across much of Mexico, Central America, Venezuela, Colombia, Peru, Bolivia, and Patagonia of southern Chile (\*639A).

It is evident that fusulinaceans occur over a large part of the present land areas of the globe. Because they seem to have been unusually sensitive to their physical surroundings, their widespread occurrence suggests that climates of the world during Pennsylvanian and Permian times may have been more uniform than they are today. It is fully realized, however, that the fusulinaceans were bottom-dwellers beyond shallow waters where they probably lived at depths that were moderately uniform in temperature and other physical conditions at almost all latitudes.

This may account for the same general nature of the Middle Pennsylvanian fusulinacean faunas found in southern South America, extreme northern Canada, and southern United States, without having

even to consider the present extremes of climatic conditions in nearby land areas of these different regions.

### STRATIGRAPHIC DISTRIBUTION

Comparison of fusulinacean faunas from many localities in North America, Europe, and Asia indicates that most larger groups developed along closely similar biological trends and in about the same stratigraphic order in all areas (Fig. 297). Species have been found very useful as index fossils for stratigraphic correlations in local areas. The ranges of genera are applicable for inter-regional and intercontinental correlations. Many primitive generic groups have long stratigraphic ranges in both hemispheres and are not recognized to be of much value for correlation. The stratigraphic ranges of some more highly specialized genera seem to be closely similar in all areas where studied in the Americas, and their stratigraphic limits seem to be approximately the same in the Eastern Hemisphere. At least it can be demonstrated that the stratigraphic ranges of these genera in Europe and Asia are in the same order as in North America and South America.

Fusulinacean faunal zones are defined by the predominance of generic groups or restriction of their stratigraphic range. The recognized zones are designated by the names of genera chosen as indices, in upward order: (1) *Millerella*, (2) *Profusulinella*, (3) *Fusulinella*, (4) *Fusulina*, (5) *Triticites*, (6) *Pseudoschwagerina*, (7) *Parafusulina*, (8) *Polydiexodina*, (9) *Verbeekina*, and (10) *Yabeina*.

#### ZONE OF MILLERELLA

*Millerella* is the most common genus of fusulinaceans found in Lower Pennsylvanian rocks of North America, and this part of the section is referred to as the fusulinacean Zone of *Millerella*. The genus had its beginning at an earlier time and it ranges into post-Lower Pennsylvanian deposits of North America, which are excluded from the Zone of *Millerella* because they also carry more advanced forms of fusulinaceans. *Millerella* occurs in Europe and probably in Asia, but its range there is not known.

#### ZONE OF PROFUSULINELLA

The genus *Profusulinella* is restricted in North America to rocks of early Middle Pennsylvanian age, and this part of the rock column is referred to as the Zone of *Profusulinella*. In sections of the northwestern Urals and Samara Bend of the Volga in USSR, *Profusulinella* is associated with fusulinaceans similar to those found in the Pennsylvanian beds of North America. Also, the *Profusulinella*-bearing part of the column in Europe is overlain by rocks containing a fusulinacean fauna that in broader aspects resembles the fusulinacean assemblage occurring immediately above the Zone of *Profusulinella* in North America. A similar occurrence of *Profusulinella* is found in upper Carboniferous rocks of China. It is therefore evident that the Zone of *Profusulinella* is represented in both hemispheres.

#### ZONE OF FUSULINELLA

The upper part of the lower Middle Pennsylvanian succession in North America is dominated by faunas of *Fusulinella* and is termed the Zone of *Fusulinella*. Although *Fusulinella* has a stratigraphic range higher in the section, the higher fusulinacean faunas that contain *Fusulinella* are dominated by the genus *Fusulina*, and the top of the Zone of *Fusulinella* is placed in North America just below the lowest occurrence of *Fusulina*. *Fusulinella* is widespread in Europe and Asia, and it occurs in rocks stratigraphically above the Zone of *Profusulinella*, at least in areas where *Profusulinella* has also been recognized.

#### ZONE OF FUSULINA

The genus *Fusulina* occurs throughout upper Middle Pennsylvanian rocks of North America above the Zone of *Fusulinella*, and this part of the section is referred to as the Zone of *Fusulina*. The lower boundary of the zone coincides with the top of the Zone of *Fusulinella*. The range of *Fusulinella* overlaps into the Zone of *Fusulina* in Europe, as it does in North America. The upper stratigraphic limit of *Fusulina* in Europe seems higher than west of the Atlantic, for *Fusulina* is reported to be associated with *Triticites* in the USSR

(Samara Bend and Moscow regions). Furthermore, the highest forms of *Fusulina* in Russia are more advanced biologically than the highest forms of *Fusulina* in North America. Therefore, the range of *Fusulina* in Europe probably includes more of the stratigraphic column than in North America. *Fusulina* is widespread geographically in China, and its upper and lower limits

in both North and South China seem to be equivalent to late Middle Pennsylvanian in age.

#### ZONE OF TRITICITES

The genus *Triticites* dominates fusulinacean faunas of the Upper Pennsylvanian Series in North America, and this part of the section accordingly is referred to as the

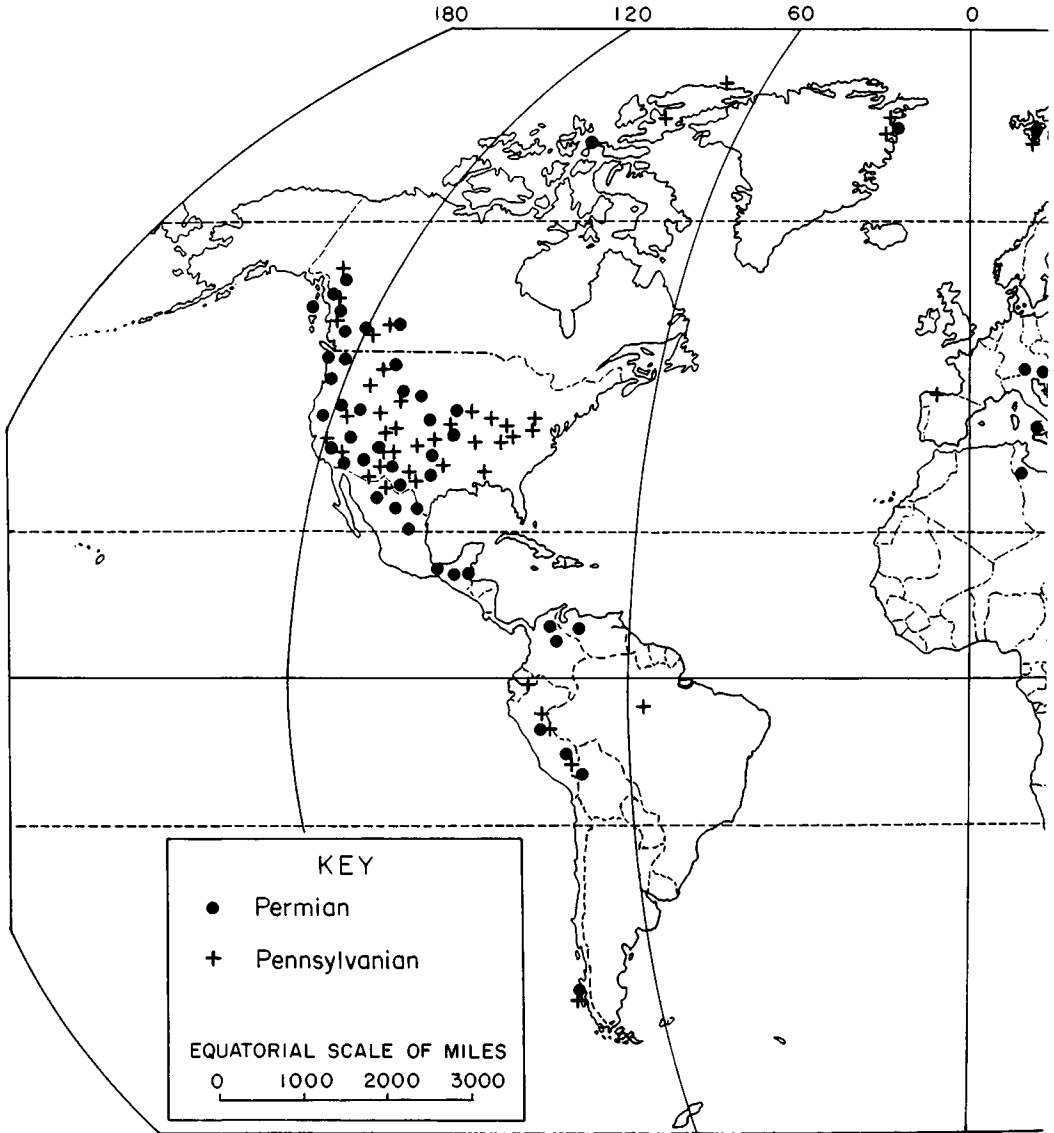


FIG. 296. Distribution of Pennsylvanian (Upper Carboniferous) and Permian fusulinaceans indicated by general localities from which they have been described or reported (\*2120B).

Zone of *Triticites*. The zone is distributed from Nevada in the west to Ohio in the east and contains some of the most prolific fusulinacean faunas of North America. Rocks referable to the Zone of *Triticites* have not been recognized in Central or South America or with certainty in Asia but are widespread in the central part of European USSR, where they may be

equivalent in age only to the lower part of the Zone of *Triticites* in North America. All evidence indicates that *Triticites* reached its greatest development in North America and its extreme limits as well as intermediate forms are best known here. The upper limit of the Zone of *Triticites* corresponds to the base of the Permian, as defined in North America, but the range of

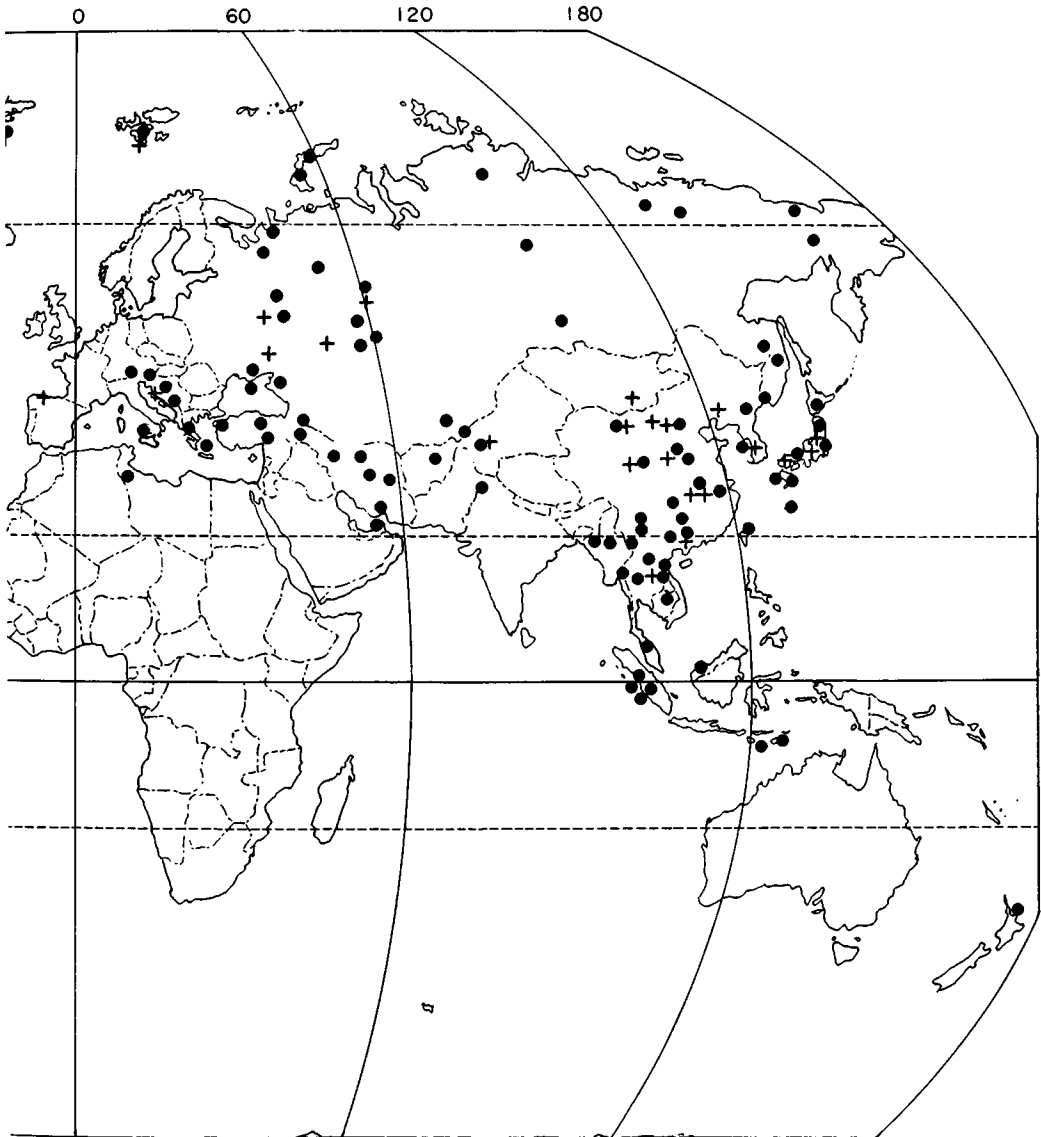


FIG. 296. (continued from facing page).

1. Paramillerella
2. Millerella
3. Nankinella
4. Eoschubertella
5. Fusiella
6. Akiyoshiella
7. Fusulinella
8. Profusulinella
9. Pseudostaffella
10. Pseudowedekindellina
11. Bartramella
12. Plectofusulina
13. Hidaella
14. Taitzeoella
15. Wedekindellina
16. Fusulina
17. Neostaffella
18. Staffella
19. Waeringella
20. Kansanella
21. Iowanella
22. Verella
23. Pseudofusulinella
24. Quasifusulina
25. Dunbarinella
26. Triticites
27. Oketaella
28. Schubertella
29. Pseudofusulina
30. Pseudoschwagerina
31. Rugosofusulina
32. Paraschwagerina
33. Mesoschubertella
34. Acervoschwagerina
35. Biwaella
36. Kwantoella
37. Ozawainella
38. Boultonia
39. Schwagerina
40. Parafusulina
41. Eoverbeekina
42. Toriyamaia
43. Nummulostegina
44. Pisolina
45. Sphaerulina
46. Dunbarula
47. Minojapanella
48. Palaeofusulina
49. Nipponitella
50. Nagatoella
51. Orientoschwagerina
52. Robustoschwagerina
53. Zella

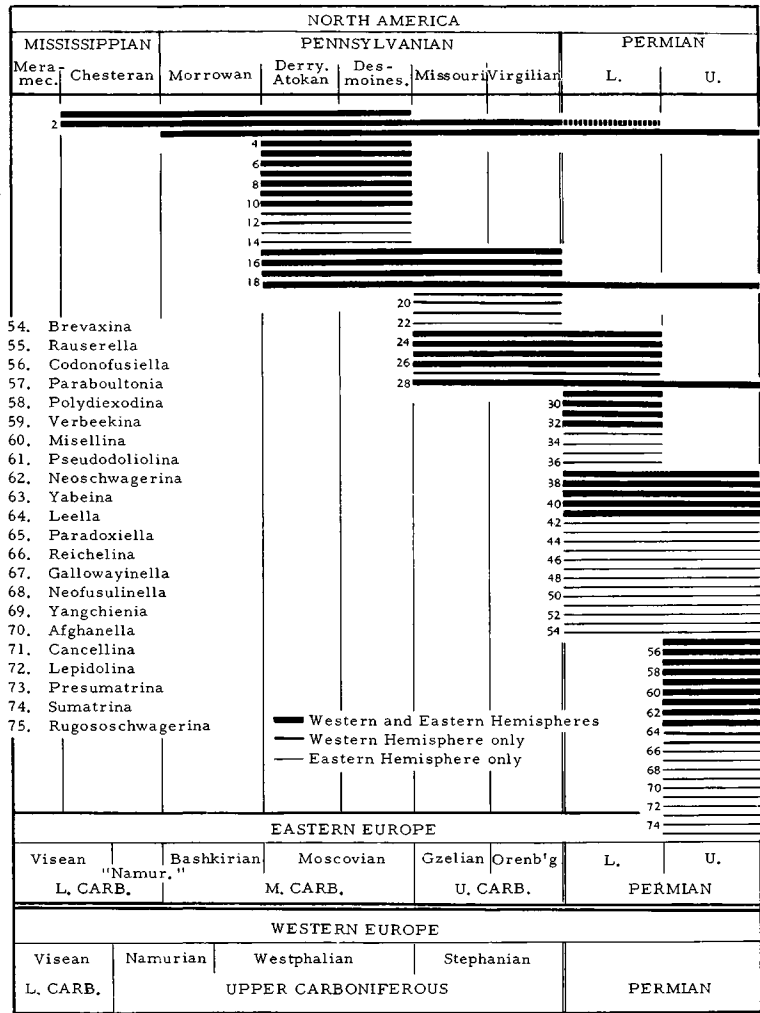


FIG. 297. Stratigraphic distribution of fusulinacean genera as recorded in *Treatise* text devoted to systematic descriptions. Attention is drawn to the fact that many ranges are plotted as spanning all of one or more stratigraphic divisions, whereas the actual ranges, if precisely known, may be appreciably shorter (Moore, n). An alphabetically arranged list of genera follows.

- |                      |                       |                         |
|----------------------|-----------------------|-------------------------|
| Acervoschwagerina—34 | Minojapanella—47      | Pseudofusulinella—23    |
| Akiyoshiella—6       | Misellina—60          | Pseudoschwagerina—30    |
| Bartramella—11       | Nagatoella—50         | Pseudostaffella—9       |
| Biwaella—35          | Nankinella—3          | Pseudowedekindellina—10 |
| Boultonia—38         | Neofusulinella—68     | Quasifusulina—24        |
| Brevaxina—54         | Neoschwagerina—62     | Rauserella—55           |
| Cancellina—71        | Neostaffella—17       | Reichelina—66           |
| Codonofusulina—56    | Nipponitella—49       | Robustoschwagerina—52   |
| Dunbarinella—25      | Nummulostegina—43     | Rugosofusulina—31       |
| Dunbarula—46         | Oketaella—27          | Rugoschwagerina—75      |
| Eoschubertella—4     | Orientoschwagerina—51 | Schubertella—28         |
| Eoverbeekina—41      | Ozawainella—37        | Schwagerina—39          |
| Fusiella—5           | Palaeofusulina—48     | Sphaerulina—45          |
| Fusulina—16          | Paraboultonia—57      | Staffella—18            |
| Fusulinella—7        | Paradoxiella—65       | Sumatrina—74            |
| Gallowayinella—67    | Parafusulina—40       | Taitzeoella—14          |
| Hidaella—13          | Paraschwagerina—32    | Toriyamaia—42           |
| Iowanella—21         | Pisolina—44           | Triticites—26           |
| Kansanella—20        | Plectofusulina—12     | Verbeekina—59           |
| Kwantoella—36        | Polydiexodina—58      | Verella—22              |
| Leella—64            | Presumatrina—73       | Waeringella—19          |
| Lepidolina—72        | Profusulinella—8      | Wedekindellina—15       |
| Mesoschubertella—33  | Pseudodoliolina—61    | Yabeina—63              |
| Millerella—2         | Pseudofusulina—29     | Yangchienia—69          |
|                      |                       | Zella—53                |



*Triticites* extends into Lower Permian rocks.

#### ZONE OF PSEUDOSCHWAGERINA

The genus *Pseudoschwagerina* (*Schwagerina* of authors prior to 1936) is considered by most paleontologists as an index to the Lower Permian. The genus ranges throughout most of the Wolfcampian in North America, and accordingly these rocks are designated as the Zone of *Pseudoschwagerina*. Until recently, the lowest known occurrence of *Pseudoschwagerina* in the Wolfcampian of the mid-continent region was in the Grenola Formation, about 300 feet above the base of rocks considered Permian. Undescribed specimens of *Pseudoschwagerina* now have been obtained in the Americus Limestone of Kansas (about 200 feet above the base of Wolfcampian strata in this region). *Pseudoschwagerina* is common in uppermost Wolfcampian rocks in the Hueco Mountains of Texas.

The so-called *Schwagerina* limestones of reports on Asia, Europe, and North America are really *Pseudoschwagerina* limestones; the use of fossil names for rock units is not good practice, as demonstrated by the erroneous stratigraphic use of *Schwagerina* for so many years.

Rocks of the Zone of *Pseudoschwagerina* occur in many widely separated areas, including Arctic Islands of the Eastern Hemisphere, European USSR, Austria, Sumatra, China, Japan, southeastern Asia, much of central and western USA, Peru, Bolivia, and possibly Greenland.

#### ZONE OF PARAFUSULINA

Stratigraphic limits of the genus *Parafusulina* overlap slightly those of *Pseudoschwagerina*, but in North America *Parafusulina* dominates the fusulinacean faunas of Leonardian and lower Guadalupian strata. This part of the American Permian, classed as Lower Permian, is referred to as the Zone of *Parafusulina*. In the Western Hemisphere, rocks referable to the Zone of *Parafusulina* occur in Colombia, Venezuela, Guatemala, southern and northern Mexico, western Texas, southern New Mexico, Washington, California, Oregon, British Columbia, and Alaska. The distribution of *Parafusulina* in the Eastern Hemisphere is not well known, largely

owing to the lack of illustrations in early reports of thin sections that are necessary to recognize the genus. Many species of *Parafusulina* may have been described, but from available information they cannot be referred to that genus with certainty. However, *Parafusulina* has been recognized in the Carnic Alps, Salt Range of West Pakistan, southern China, Japan, Karakorum region, and the western edge of the Ural Mountains.

#### ZONE OF POLYDIOXODINA

The genus *Polydiexodina* is restricted in North America to rocks of late Guadalupian age which are referred to as the fusulinacean Zone of *Polydiexodina*. This zone immediately overlies the Zone of *Parafusulina* in many places in North America. However, *Polydiexodina* has not been found in the Eastern Hemisphere at all localities immediately above rocks containing *Parafusulina*. In southern China, rocks bearing typical faunas of the Zone of *Parafusulina* are overlain by beds that carry a Tethys Sea type of fauna, including *Verbeekina* and *Neoschwagerina*. In Afghanistan, southern Turkey, and northern Iraq, *Polydiexodina* occurs associated with *Verbeekina* and several early members of Neoschwagerininae, including *Neoschwagerina*. Therefore, it seems possible that the Zone of *Polydiexodina* in North America is equivalent in age to at least part of the Tethyan Zone of *Verbeekina*. *Polydiexodina* occurs both in Asia (Darvaz region of USSR, Burma, Turkey, Iraq, Syria, Iran) and Europe (Aegean Islands of Greece). In the Aegean Islands, a questionable form of *Polydiexodina* is associated with a typical fauna of the Zone of *Verbeekina*.

#### ZONE OF VERBEEKINA

The lower part of the Tethys Sea fusulinacean faunas of the Eastern Hemisphere is typified by the genus *Verbeekina*, and this part of the stratigraphic section is referred to as the Zone of *Verbeekina*. Rocks referable to this zone are widespread in a relatively narrow belt extending from the Mediterranean area of southern Europe across Asia to Japan. Rocks that contain a lower Tethyan fusulinacean fauna have been discovered at many outcrops in this area, including localities in Sicily, Greece,

Turkey, Iraq, Iran, Arabia, Afghanistan, Thailand, Laos, western and southern China, Sumatra, and Japan.

The stratigraphic relationship between this faunal zone in the Eastern Hemisphere and the Zone of *Polydiexodina* in North America is not known. The association of *Polydiexodina* with *Verbeekina* in Afghanistan, in southern Turkey, and northern Iraq, and possibly in Greece, and the occurrence of *Verbeekina* faunas stratigraphically above typical *Parafusulina* faunas in southern China, strongly suggest that the Zone of *Polydiexodina* in North America is at least partly equivalent in age to the Zone of *Verbeekina*.

Ammonoids indicate that the Sosio Beds of Sicily are early Guadalupian (Wordian) in age (\*1280). The Sosio Beds contain several fusulinacean genera that occur in other areas in the Zone of *Verbeekina*, and therefore it seems probable that this Tethys Sea faunal zone is in part slightly older than the Zone of *Polydiexodina* in North America.

#### ZONE OF YABEINA

The genus *Yabeina* occurs in some of the highest fusulinacean-bearing Permian rocks in the Eastern Hemisphere and has been found in British Columbia, Washington, and Oregon in the Western Hemisphere. *Yabeina* has been identified at numerous localities in the Eastern Hemisphere, including Tunisia, Crimea, South China, Cambodia, Thailand, and Japan. At several places *Yabeina* is known to occur stratigraphically above faunas of *Verbeekina*. Furthermore, the biologic stage of development of *Yabeina* and *Lepidolina* suggests that they are younger than early *Neoschwagerina*. Rocks of Late Permian age that contain faunas of *Yabeina* and *Lepidolina* are referred to the Zone of *Yabeina*. It seems probable that the Zone of *Yabeina* represents the youngest fusulinacean-bearing rocks in the Eastern Hemisphere, and that the fusulinaceans became extinct in the narrow belt of Tethys that extended from Oregon in North America, westward across the northern Pacific region to southern Asia, and farther west at least to Tunisia in the Mediterranean area.

## SYSTEMATIC DESCRIPTIONS

### Superfamily FUSULINACEA

von Möller, 1878

[*nom. correct.* LOEBLICH & TAPPAN, 1961, p. 287 (*pro* superfamily Fusulinoidea CIRY in PIVETEAU, 1952, p. 179)]  
 [In synonymic citations superscript numbers indicate taxonomic rank assigned by authors (<sup>1</sup>superfamily, <sup>2</sup>family group); dagger (†) indicates *partim*]—[<sup>1</sup>=Orthoklinostegiat EIMER & FICKERT, 1899, p. 685 (*nom. nud.*); <sup>2</sup>=Rotaliariidae RHUMBLER in KÜENTHAL & KRUMBACH, 1923, p. 88; <sup>1</sup>Fusulinaceae MIKLUKHO-MAKLAY, 1957, p. 96; <sup>1</sup>Neoschwagerinaceae MIKLUKHO-MAKLAY, 1957, p. 109; <sup>1</sup>Fusulinidea POKORNÝ, 1958, p. 220; <sup>1</sup>Verbeekinacea MIKLUKHO-MAKLAY, 1958, p. 7; <sup>1</sup>Verbeekinidea MIKLUKHO-MAKLAY, RAUZER-CHERNOUSOVA & ROSOVSKAYA, 1958, p. 17]

Shell discoidal, spherical, fusiform, or subcylindrical in shape, most commonly irregularly fusiform, calcareous, perforate; planispiral except for aberrant members and for early volutions of some primitive members. Axis of coiling mostly coincident with maximum diameter of test. Proloculus small and spherical, with single proloculus pore located flush with surface or at base of conical depression. Spirotheca composed of one or several layers. Antetheca composed of single layer or of several layers, vertical in attitude, anteriorly arcuate and plane, or plicated to fluted at base in end zones, throughout length of shell, or throughout height and along entire length, fluting less intense at top of antetheca and in center of shell; antethecal pores (septal pores) abundant in most but seemingly irregularly distributed. Chambers numerous and short. Tunnel, tunnels, or foramina resorbed at center and at base of septa or as multiple tunnels throughout length of shell. Secondary deposits in form of chomata, parachomata, tectoria, or axial fillings (\*1295). *U.Miss.-U.Perm.*

#### Family OZAWAINELLIDAE

Thompson & Foster, 1937

[*nom. transl.* A. D. MIKLUKHO-MAKLAY, 1958, p. 13 (*ex* subfamily Ozawainellinae THOMPSON & FOSTER, 1937, p. 132)]  
 [=Reichelinae A. D. MIKLUKHO-MAKLAY, 1959, p. 630]

Shell umbilicate to spherical or elongate, evolute in early forms, involute or irregularly uncoiled in later ones, axis of coiling short or long, first few volutions discoidal, others spherical to unevenly elongate; spirotheca composed of tectum with upper and lower tectoria in early forms but diaphanotheca occurring below tectum and above lower tectorium in later ones; septa plane; shell generally planispiral but may be asym-

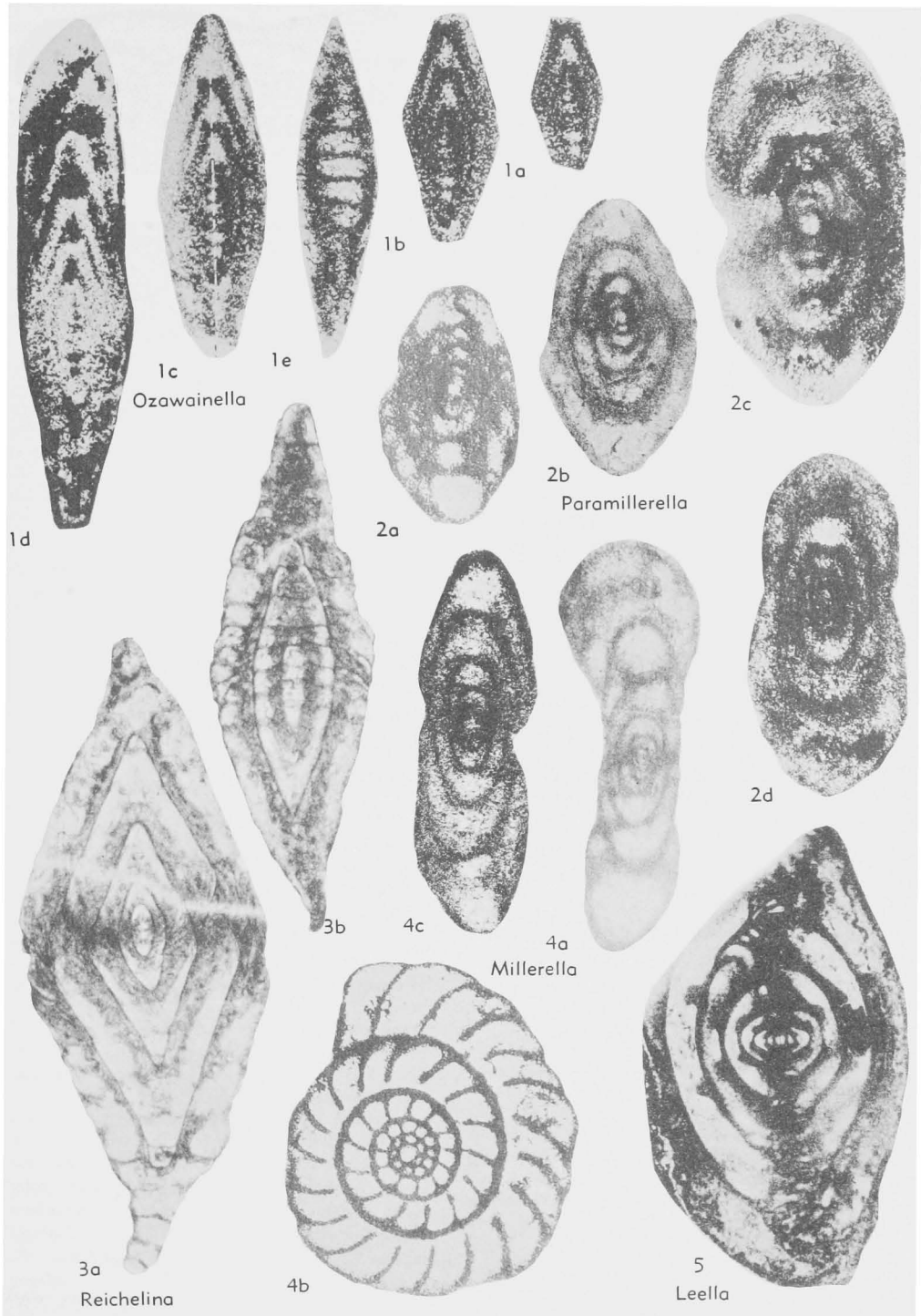


FIG. 298. Ozawainellidae; 1, *Ozawainella*; 2, *Paramillerella*; 3, *Reichelina*; 4, *Millerella*; 5, *Leella* (p. C396-C397).

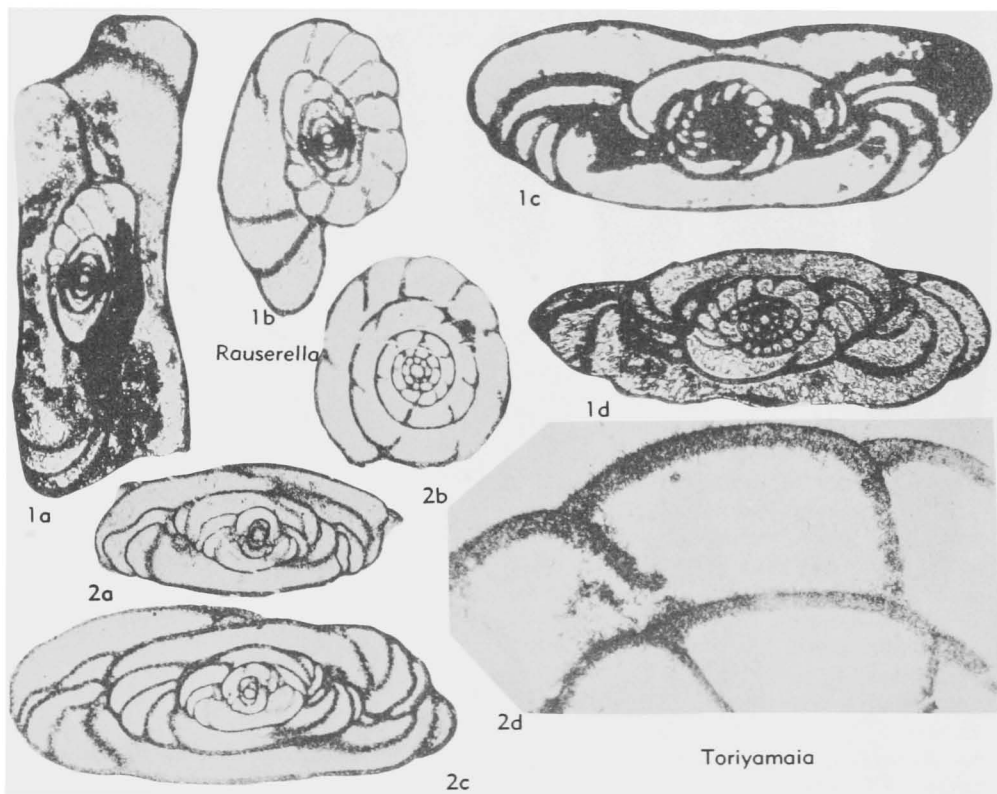


FIG. 299. Ozawainellidae; 1, *Rauserella*; 2, *Toriyamaia* (p. C397).

metrical, discoidal in at least part of shell with coiling axis in shortest diameter; tunnel singular (\*1929). *U.Miss-U.Perm.*

**Ozawainella** THOMPSON, 1935, \*1912, p. 114 [*Fusulinella angulata* COLANI, 1924, \*354, p. 74; OD]. Test discoidal, involute, with angular periphery; wall as in *Millerella*; chomata moderate to massive (\*1913, \*1929). *L.Perm.-U.Perm.*, Arctic Is.-Asia-Eu.-N. Am. — FIG. 298.1. \**O. angulata* (COLANI), *L.Perm.*, N.Vietnam; 1a-c, axial secs. of holotype,  $\times 45$ ; 1d, axial sec. of paratype,  $\times 45$ ; 1e, tang. sec. of paratype,  $\times 50$  (\*1922).

**Leella** DUNBAR & SKINNER, 1937, \*646, p. 603 [*L. bellula*; OD]. Shell symmetrical throughout growth, discoidal in early volutions, becoming inflated-fusiform at maturity; spirotheca of tectum, diaphanotheca, and upper and lower tectoria; septa plane; chomata asymmetrical, high, and narrow (\*646). *U.Perm.*, N.Am. — FIG. 298.5. \**L. bellula*, Capitan Ls., USA(Tex.); axial sec. of holotype,  $\times 25$  (\*1922).

**Millerella** THOMPSON, 1942, \*1919, p. 404 [*M. marblensis*; OD]. Shell minute, involute to partly evolute, axis in smallest diameter through proloculus; spirotheca of tectum with upper and

lower tectoria; septa arcuate forward; chomata indistinct to massive, their periphery narrowly rounded (\*1919, \*1922, \*1925). *U.Miss.-U.Penn.*, ?*L.Perm.* (*Millerella* Z.), N.Am.-Eu.-Asia. — FIG. 298.4a,b. \**M. marblensis*, M.Penn.(Marble Falls Ls.), USA(Tex.); 4a, axial sec. of holotype,  $\times 100$  (\*1922); 4b, sagittal sec.,  $\times 100$  (\*1926). — FIG. 298.4c. *M. pressa* THOMPSON, L.Penn. (Kearny F.), USA (Kans.); axial sec. of holotype,  $\times 100$  (\*1922). [See also Fig. 294.1,2.]

**Paramillerella** THOMPSON, 1951, \*1925, p. 115 [*Millerella?* *advena* THOMPSON, 1944, \*1920, p. 427; OD] [= ?*Staffella* (*Eostaffella*) RAUZER-CHERNOUSOVA, 1948, \*1505, p. 14 (type, *S. (E.) parastruvei*; OD); ?*Mediocris* ROZOVSKAYA, 1961, \*1593, p. 20 (type, *Eostaffella medicris* VISSARIONOVA, 1948, \*2009A, p. 222; OD)]. Shell discoidal, minute, slightly evolute to involute; polar ends slightly umbilicate to rounded; spirotheca of tectum with upper and lower tectoria; chomata massive (\*1920, \*1925). *U.Miss.-M.Penn.*, N. Am.-Asia-Eu. — FIG. 298.2a. \**P. advena* (THOMPSON), L.Penn.(Morrowan), USA(NW. Ark.); axial sec. of holotype,  $\times 100$  (\*1926). — FIG. 298.2b. *P. ampla* (THOMPSON), L.Penn. Kearny F.), USA(Kans.); axial sec. of holotype,

×75 (\*1922).—FIG. 298,2c. *P. circuli* (THOMPSON), L.Penn.(Belden F.), USA(Utah); axial sec. of holotype, ×100 (\*1926).—FIG. 298,2d. *P. pinguis* (THOMPSON), L.Penn.(Bloyd Sh., USA(Ark.)); axial sec. of holotype, ×75 (\*1920). [See also Fig. 294,3-5.]

**Rauserella** DUNBAR, 1944, \*638, p. 37 [\**R. erratica*; OD]. Early volutions discoidal, later ones irregularly subcylindrical and coiled at large angle to early volutions; mature shell small; septa plane; wall of tectum with upper and lower tectoria in inner volutions, of tectum and diaphanotheca in outer volutions (\*638, \*1012, \*1047). *U.Perm.*, N.Am.(Tex.-Mex.)-Japan.—FIG. 299,1. \**R. erratica*, Delaware F., Mex.(La Difunta); 1a, axial sec. through proloculus, ×25; 1b, sagittal sec. through proloculus, ×25; 1c, parallel sec., ×25; 1d, axial sec. through proloculus showing erratic coiling, ×25 (\*1922).

**Reichelina** ERK, 1941[1942], \*709, p. 249 [\**R. cribrosepta*; OD]. Shell small, discoidal, divisible into 3 parts, first 1 or 2 volutions evolute, next 3 involute, with narrowly rounded periphery, outer part of last volution somewhat uncoiled; spirotheca composed of tectum and diaphanotheca; tunnel triangular in cross section, with flat bottom tangent to sharp edge of preceding volution; chomata broad, extending from tunnel to polar area, seemingly becoming thicker toward umbilicus (\*709). *U.Perm.*, SW.Asia(Turkey)-Japan-China-USSR.—FIG. 298,3. \**R. cribrosepta*, Turkey; 3a, axial sec. of holotype, ×70 (\*1926); 3b, tang. sec. of paratype, ×70 (\*1926).

**Toriyamaia** KANMERA, 1956, \*1013, p. 251 [\**T. laxisepta*; OD]. Shell small, elongate-fusiform to subcylindrical, with bluntly to broadly rounded polar ends; first 1 or 2 volutions discoidal, evolute, and coiled at right angles to outer cylindrical volutions; mature shape of shell reached in about first 4 volutions; proloculus minute, spherical; spirotheca thin, composed of tectum and less dense, structureless lower layer; septa very broadly spaced, unfluted, only 7 to each volution in outer part of shell (\*1013). *Perm.*, Japan.—FIG. 299,2. \**T. laxisepta*, Kozaki F., Kyushu; 2a, axial sec. of holotype, ×25; 2b, sagittal sec. of paratype, ×25; 2c, axial sec. of paratype, ×25; 2d, part of sagittal sec. showing structure of spirotheca, ×100 (\*1013).

### Family STAFFELLIDAE Miklukho-Maklay, 1949

[*nom. transl.* A. D. MIKLUKHO-MAKLAY, 1957, p. 96 (ex subfamily Staffellininae A. D. MIKLUKHO-MAKLAY, 1949, p. 46, *nom. imperf.*)] [=Staffellinidae A. D. MIKLUKHO-MAKLAY, 1957, p. 96 (*nom. imperf.*); =Staffellidae A. D. MIKLUKHO-MAKLAY, 1958, p. 11; =Staffellinae ROZOVSKAYA, 1950, p. 378; =Staffellininae POKORNÝ, 1958, p. 233 (*nom. van.*)]

Shell small, spherical to discoidal, with umbilicate or flush axial ends; septa strongly arched forward, closely spaced, and

totally unfluted from end to end; tunnel singular, bordered by distinctly asymmetrical chomata except in terminal part of last volution; walls composed of upper and lower layers that are in turn underlain and overlain by secondary deposits in most forms, except for outer part of last volution (\*1261). [The shells of most fossil forms have been replaced by silica and other mineral matter.] *L.Penn.-Perm.*

**Staffella** OZAWA, 1925, \*1401, p. 24 [\**Staffella sphaerica* VON MÖLLER" (= "*Fusulinella sphaerica* ABICH" VON MÖLLER, 1878, \*1295, p. 114, = "*Fusulina sphaerica* ABICH, 1859, \*1A, p. 439, 528); OD]. Test subspherical at maturity, discoidal in early volutions; wall as in *Nankinella*; septa plane (\*1912, \*1922). *U.Carb.(M.Penn.)-Perm.*, Eu.-Asia-E.Indies-S.Am.-C.Am.-N.Am. — FIG. 300,2a,b. *S. moellerana* THOMPSON, *U.Perm.* (Djulfa Beds), Armenia; 2a, ext. view, ×10; 2b, axial sec., ×15 (\*1922).—FIG. 300,2c. *S. expansa* THOMPSON, M.Penn.(Marble Falls Ls.), USA(Tex.); axial sec. of holotype, ×50 (\*1922).

[The fact that OZAWA (\*1401, p. 24) in designating *Staffella sphaerica* as the type-species of *Staffella* erroneously cited von Möller as the author of this species cannot be construed under stipulations of the Zoological Code (1961) to refer to fossils in the hands of von Möller (1878, \*1295, p. 114) which he designated as *Fusulinella sphaerica* ABICH (1858) [1859], = *Fusulina sphaerica* ABICH, 1858 [1859]. DUNBAR (1933, \*637A, p. 131; 1940, \*637B, p. 138) and subsequently THOMPSON (1935, \*1912, p. 113) were mistaken in judging that specimens described and illustrated by von Möller, rather than ABICH's *Fusulina sphaerica*, must be recognized in defining characters of *Staffella*. In the first place, it is a named species, whatever its authorship and date, not specimens identified by some later worker as belonging to this species, that governs fixation of the type-species of a nominal genus. OZAWA'S (1928, \*1401C, p. 131) citation of the type-species of *Staffella* as "genoholotype, *Fusulina sphaerica* ABICH" is germane only as an indication of his intent, because the original publication containing an explicit type-species designation is sole authority and evidence for distinguishing it (Zool. Code, 67, f). THOMPSON (1935, \*1912, p. 113) concluded that von Möller's *Fusulinella sphaerica* and ABICH's *Fusulina sphaerica* are congeneric, both belonging to *Staffella*, but in his opinion they are not at all conspecific; therefore, in order to avoid homonymy of specific names he published *Staffella moellerana* as designation for von Möller's specimens. *S. moellerana* THOMPSON is not the type-species of *Staffella*, despite OZAWA'S admission, quoted by DUNBAR (1940, \*637B, p. 138), that he based his choice of type-species on a spheroidal form treated in von Möller's paper; it is OZAWA'S action (1925) in designating *Staffella sphaerica* (= *Fusulina sphaerica* ABICH, 1859) as the type-species that governs. This is not subsequently alterable by him or anyone else.]

**Nankinella** LEE, 1933[1934], \*1120, p. 14 [\**Staffella discoides* LEE, 1931, \*1119A, p. 286; OD] [= *Hayasakaina* FUJIMOTO & KAWADA, 1953, \*756, p. 119 (type, *H. kotakiensis*; OD)]. Test discoidal, with umbilicate axial areas, periphery angular to rounded in early part, angular at maturity; wall of tectum and diaphanotheca mineralized in all known forms, their original construction unknown; septa plane; chomata distinct (\*756, \*1120, \*1922). *L.Penn.-U.Perm.*, N. Am.-Eu.-Asia.—FIG. 300,1a. *N. sp.*, M.Penn. (Green Canyon Ls), USA(Tex., Powwow Can-

yon); outline drawing,  $\times 40$  (\*1922).—FIG. 300,1b,c. *N. plummeri* THOMPSON, M.Penn. (Marble Falls Ls.), USA(Tex.); 1b, axial sec.

of holotype,  $\times 50$  (\*1922); 1c, tang. sec. of paratype,  $\times 50$  (\*1922).—FIG. 300,1d. \**N. discooides* (LEE), Perm.(Chihhsia Ls.), China(Nan-

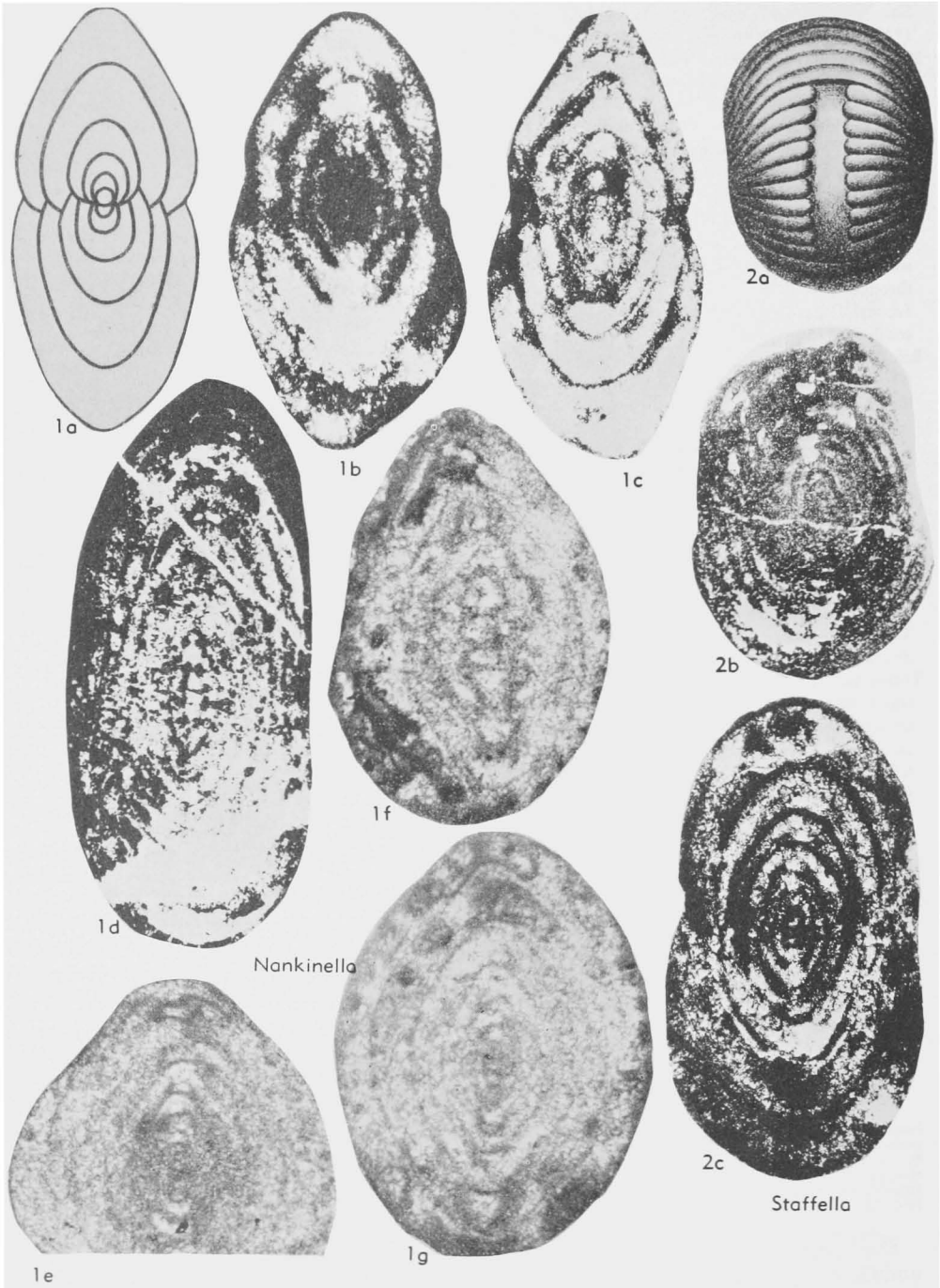
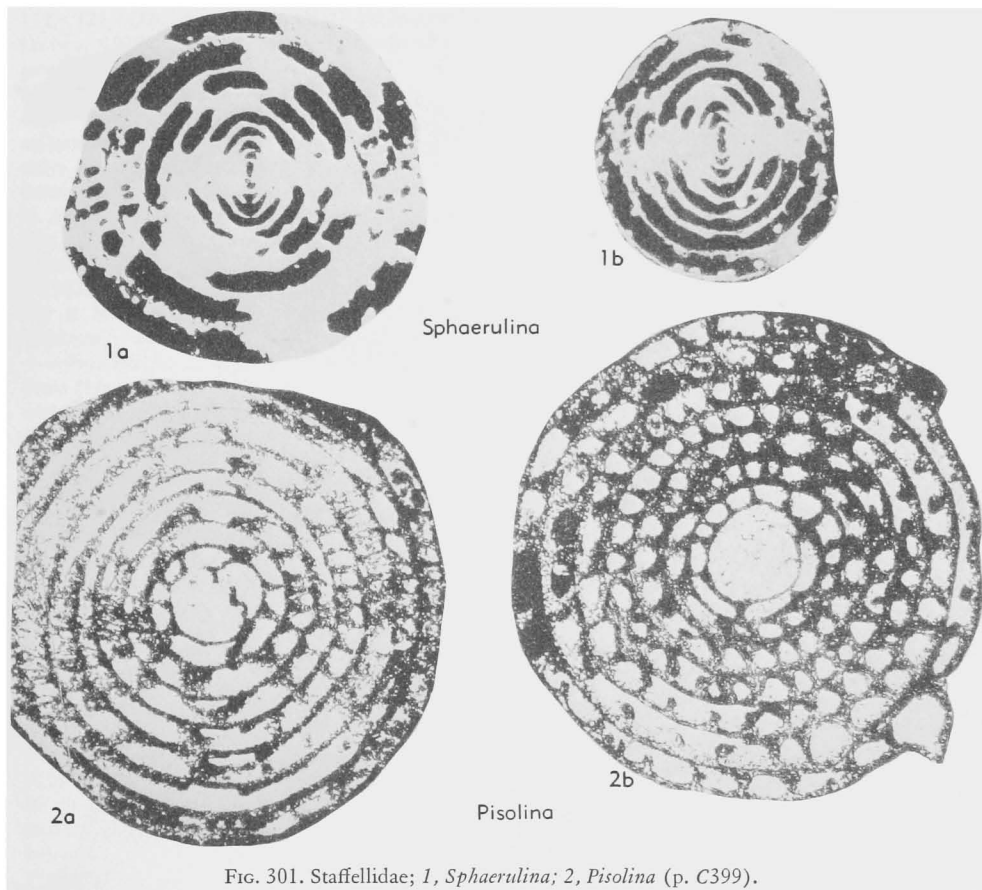


FIG. 300. Staffellidae; 1, *Nankinella*; 2, *Staffella* (p. C397-C399).



FIG. 301. Staffellidae; 1, *Sphaerulina*; 2, *Pisolina* (p. C399).

king); tang. sec. of holotype,  $\times 15$  (\*1922).—FIG. 300, *le-g*. *N. kotaqiensis* (FUJIMOTO & KAWADA), L.Perm.(Omi Ls.), Japan(Niigata Pref.); *le*, near-centered axial sec.,  $\times 40$ ; *lf*, eccentric axial sec.,  $\times 40$ ; *lg*, axial sec.,  $\times 40$  (\*756).

**Nummulostegina** SCHUBERT, 1907, \*1685, p. 212 [*\*N. velebitana* SCHUBERT, 1908, \*1686, p. 377; SD]. Test subdiscoidal, planispiral, periphery narrowly rounded; septa plane but other internal features poorly known (\*1008, \*1685). *Perm.*, Eu.—FIG. 274, *1a,b*. *\*N. velebitana*, Yugo.; *1a,b*, lateral and apert. views of holotype,  $\times 20$  (\*1922).

**Pisolina** LEE, 1933[1934], \*1120, p. 19 [*\*P. excessa*]; OD]. Shell small, spherical throughout; spirotheca composed of tectum and ?keriotheca, possibly as in *Staffella*; septa widely spaced, plane; tunnel singular, chomata distinct; proloculus large (\*1120). *Perm.*, Asia(China-Armenia).—FIG. 301,2. *\*P. excessa*, Wushan Ls., China (Mitsang Gorge); *2a*, axial sec. of holotype,  $\times 15$ ; *2b*, sagittal sec. of paratype,  $\times 15$  (\*1922).

**Sphaerulina** LEE, 1933[1934], \*1120, p. 16 [*\*S. crassispira*]; OD]. Minute, mature shell spherical and slightly umbilicate, composed of about 10

volutions discoidal; spirotheca composed of tectum and alveolar ?keriotheca; septa plane (\*1120). *Perm.*, Asia(China).—FIG. 301,1. *\*S. crassispira*, Kweichow; *1a*, axial sec. of holotype,  $\times 30$ ; *1b*, axial sec. of paratype,  $\times 30$  (\*1922).

#### Family FUSULINIDAE von Möller, 1878

[Fusulinidae VON MÖLLER, 1878, p. 133]—[All names cited are of family rank]—[=Fusulinina LANKESTER, 1885, p. 848; =Fusulininae DELAGE & HÉROUARD, 1896, p. 148; =Fusulinidae CALKINS, 1926, p. 356 (*nom. null.*); =Fusulinida HAECKEL, 1894, p. 185 (*nom. van.*)]—[=Nautiloida SCHULTZE, 1854, p. 53 (*partim*) (*nom. nud.*); =Schwagerinidae DUNBAR & HENBEST, 1930, p. 363; =Schubertellidae A. D. MIKLUKHO-MAKLAY, RAUZER-CHERNOUSOVA & ROZOVSKAYA, 1958, p. 17; =Schubertellinidae A. D. MIKLUKHO-MAKLAY, RAUZER-CHERNOUSOVA, & ROZOVSKAYA, 1958, fig. 2 on p. 7 (*nom. null.*)]

Shell spherical, fusiform or subcylindrical, most commonly irregularly fusiform; calcareous, perforate, planispiral, except for aberrant genera, and early stages of a few genera. Spirothecal structure of several sorts, including (1) tectum with upper and lower tectorium (2) tectum and diaphanotheca with upper and lower tectorium; (3) tectum and diaphanotheca, with discontinu-

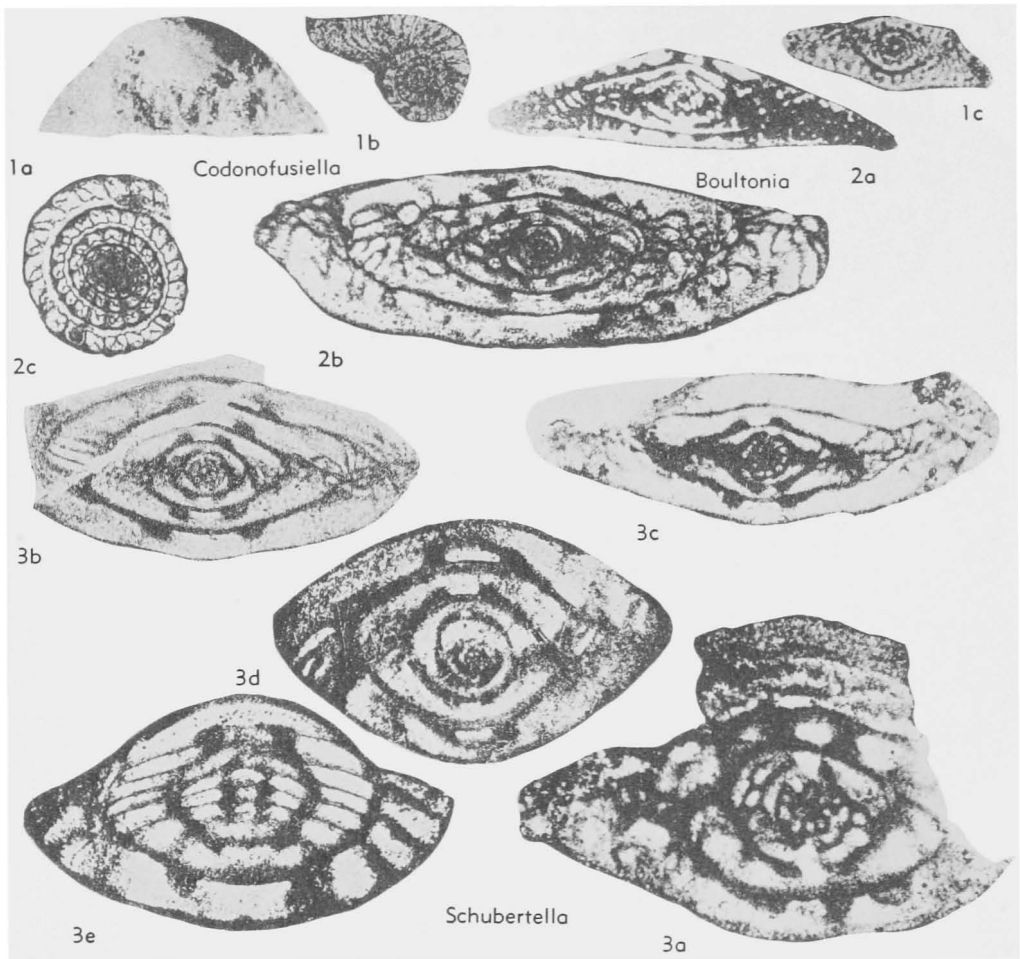


FIG. 302. Fusulinidae (Schubertellinae; 1, *Codonofusiella*; 2, *Boultonia*; 3, *Schubertella*) (p. C400-C401).

ous upper or lower tectorium; (4) tectum and structureless lower layer; and (5) tectum with alveolar keriotheca. Axis of coiling generally coincident with maximum diameter of shell. Antetheca composed of single layer that is plicated or fluted in various degrees ranging from unfluted to intensely fluted throughout length of septa. Septal pores found in all forms. Tunnel singular in most, with chomata along borders of tunnel, multiple tunnels in some. Secondary deposits commonly present, including chomata, axial fillings, and tectoria (\*1295). *U.Carb.(M.Penn.)-U.Perm.*

**Subfamily SCHUBERTELLINAE Skinner, 1931**

[Schubertellinae SKINNER, 1931, p. 257 (Although introduced conditionally, this name with authorship and date given

is valid; Zoological Code, 1961, Art. 17.8)] [All names cited are of subfamily rank]—[=Boultoniinae SKINNER & WILDE, 1954, p. 437; =Schubertellinae ROZOVSKAYA, 1950, p. 376 (nom. van.)]

Shell minute, elongate-fusiform, ellipsoidal or irregular in shape, first few volutions coiled at large angle to outer ones; spirotheca composed of (1) tectum with upper and lower tectoria or (2) tectum with diaphanotheca and tectoria, or (3) tectum with lower layer only, or (4) consisting of single thin layer; septa plane in primitive forms, fluted in end zones of more advanced forms, and fluted throughout length of shell in some advanced members; tunnel singular; chomata small or distinct (\*1295, \*1929). *U.Carb.(M.Penn.)-U.Perm.*

*Schubertella* STAFF & WEDEKIND, 1910, \*1832, p.

- 112, 121 [\**S. transitoria*; OD] [= *Depratella* OZAWA, 1928, \*1402, p. 9 (type, *Neofusulinella giraudi* DEPRAT, 1915, \*587A, p. 11; OD)]. Shell fusiform, first 1 to 3 volutions discoidal, coiled at large angle to outer volutions; spirotheca of tectum with lower layer or of single thin layer only; septa unfluted; chomata large, highly asymmetrical (\*1402, \*1918, \*1922). *U. Penn.-U. Perm., N. Am.-S. Am.-Eu.-Asia-Arctic Is.-E. Indies.* — FIG. 302,3a. \**S. transitoria*, L. Perm., Spitz. (Tempel Bay); axial sec. of toptotype,  $\times 83$  (\*1922). — FIG. 302,3b. *S. mulleriedi* THOMPSON & MILLER, L. Perm. (Paso Hondo F.), Mex. (Chiapas); axial sec. of syntype,  $\times 20$  (\*1922). — FIG. 302,3c. *S. kingi* DUNBAR & SKINNER, L. Perm. (Hueco Ls.), USA (Tex.); axial sec. of syntype,  $\times 50$  (\*1922). — FIG. 302,3d,e. *S. giraudi* (DEPRAT), L. Perm., Laos (Cammon); 3d, axial sec. of holotype,  $\times 45$  (\*1922); 3e, tang. sec. of paratype showing lack of septal fluting,  $\times 45$  (\*1922).
- Boultonia** LEE, 1927, \*1119, p. 10 [\**B. willsi*; OD]. Shell minute, elongate-fusiform, first 1 or 2 volutions discoidal, coiled at large angle to outer fusiform volutions; spirotheca of tectum and faintly porous lower layer; septa fluted throughout; chomata asymmetrical throughout fusiform part of shell (\*1119, \*1795). *Perm., Asia (China-Cambodia)-Eu. (Aus.)-USA (Wash.-Nev.-Tex.)*. — FIG. 302,2a. \**B. willsi*, L. Perm. (Taiyuan Ser.), N. China; axial sec. of holotype,  $\times 53$  (\*1922). — FIG. 302,2b,c. *B. guadalupensis* SKINNER & WILDE, L. Perm. (Parafusulina Z., Bone Spring Ls.), USA (Tex.); 2b, axial sec. of holotype,  $\times 40$ ; 2c, sagittal sec. of paratype,  $\times 40$  (\*1795).
- Codonofusiella** DUNBAR & SKINNER, 1937, \*646, p. 606 [\**C. paradoxica*; OD]. Shell minute, first 4 volutions tightly coiled, outer ones irregularly uncoiled to rectilinear, first 1 or 2 volutions planispiral around minute proloculus with short axis of coiling and coiled at large angle to next 2 or 3 fusiform-elongate volutions; spirotheca thin; septa also thin, intensely fluted throughout fusiform and later rectilinear uncoiled part of shell; chomata distinct but not massive (\*646). *U. Perm., USA (Tex.)-Can. (B.C.)-Japan-Asia (Turkey-Cambodia-Crimea)*. — FIG. 302,1. \**C. paradoxica*, Capitan Ls., Tex.; 1a, external view of paratype; 1b, sagittal sec. of holotype; 1c, axial sec. of paratype; all  $\times 22$  (\*1922).
- Dunbarula** CIRY, 1948, \*342, p. 108 [\**D. mathieui*; OD]. Shell ellipsoidal to subcylindrical, with rounded polar ends; spirotheca composed of tectum and thin, finely porous diaphanotheca; septa fluted throughout length of shell and to tops of chambers, septal pores closely spaced and arranged in diagonal pattern (\*342, \*1926). [Shell structure like that of *Rauserella* except for fluted septa.] *Perm., N. Afr.* — FIG. 303,3. \**D. mathieui*, S. Tunisia; 3a, axial sec. of toptotype showing diagonal arrangement of septal pores,  $\times 40$ ; 3b, part of sagittal sec. showing structure of spirotheca,  $\times 150$ ; 3c, part of axial sec. of 3a showing diagonal arrangement of septal pores,  $\times 130$  (\*1926).
- Eoschubertella** THOMPSON, 1937, \*1918, p. 123 [\**Schubertella lata* LEE & CHEN in LEE, CHEN & CHU, 1930, \*1121, p. 111; OD]. Shell small, inflated-ellipsoidal to fusiform; first 1 or 2 volutions coiled at large angle to outer ones; spirotheca composed of tectum with upper and lower tectoria; septa plane; tunnel broad for shell size, bordered by low chomata (\*1121, \*1918). *U. Carb. (M. Penn.), N. Am.-Asia-Eu.-S. Am.* — FIG. 303,4. \**E. lata* (LEE & CHEN), Huanglung Ls., China (Lungtan); axial sec. of holotype,  $\times 30$  (\*1922). [See also Fig. 294,6.]
- Fusiella** LEE & CHEN, in LEE, CHEN & CHU, 1930, \*1121, p. 107 [\**F. typica*; OD]. Shell small, elongate-fusiform; first 1 or 2 volutions discoidal, coiled at large angle to outer fusiform volutions, axial fillings distinct; spirotheca composed of tectum with upper and lower tectoria (\*1121, \*1922). *U. Carb. (M. Penn.), N. Am.-USSR-Asia (China)-Japan*. — FIG. 303,1. \**F. typica*, Huanglung Ls., China (Lungtan); 1a, axial sec. of holotype,  $\times 30$ ; 1b, sagittal sec. of paratype,  $\times 30$  (\*1922).
- Mesoschubertella** KANUMA & SAKAGAMI, 1957, \*1014, p. 42 [\**M. thompsoni* SAKAGAMI in KANUMA & SAKAGAMI, 1957; OD]. Shell minute, inflated-fusiform, with form ratio of about 1:1.5, lateral slopes distinctly convex, mature shells of 4 or 5 volutions 1-2 mm. long and 1 mm. wide, inner 2 or 3 volutions evolute and coiled at large angle to outer ones; spirotheca composed of tectum and alveolar keriotheca, seemingly with coating on its lower surface; septa unfluted; chomata asymmetrical and distinct, tunnel singular (\*1014). *L. Perm., Japan*. — FIG. 303,2. \**M. thompsoni* SAKAGAMI, Amanouchi Ls., Yagooki; 2a,b, axial secs. of paratype and holotype,  $\times 30$ ; 2c, tang. sec. of paratype,  $\times 30$ ; 2d, part of axial sec. of holotype showing structure of spirotheca,  $\times 100$  (\*1014).
- Minojapanella** FUJIMOTO & KANUMA, 1953, \*755, p. 150 [\**M. elongata*; OD]. Shell minute, highly elongate-fusiform, first 1 or 2 volutions discoidal around large, spherical proloculus and coiled at large angle to outer 5 or 6 greatly elongated, fusiform volutions; spirotheca thin, indistinct; septa closely spaced, intensely fluted throughout fusiform part of shell, axial fillings in at least outer 5 volutions but not massive; tunnel singular but not clearly defined (\*755, \*1926). [Shell of only known species not well preserved and poorly understood.] *Perm., Japan*. — FIG. 304,2. \**M. elongata*, Chichibu Ser.; 2a,c, axial secs. of holotype and toptotype,  $\times 30$ ,  $\times 40$ ; 2b, sagittal sec. of toptotype,  $\times 40$ ; 2d, tang. sec. of paratype showing septal fluting,  $\times 150$  (\*1926).
- Paraboultonia** SKINNER & WILDE, 1954, \*1795, p.

441 [*P. splendens*; OD] [=?*Tavajzites* TUMAN-SKAYA, 1953, \*1955, p. 22 (type, *Fusulina ?pseudo-prisca* var. *delicata* COLANI, 1924, \*354, p. 180; OD)]. Shell small, elongate-subcylindrical at maturity, with blunt polar ends and uncoiled to rectilinear at gerontic stage, first 1 or 1.5 volu-

tions discoidal and coiled at right angle to outer fusiform volutions; spirotheca thin, composed of tectum and diaphanotheca; septa thin, intensely fluted throughout length, cuniculi at base of septa developed in outer part of shell; tunnel singular, narrow, with erratic path, not observed

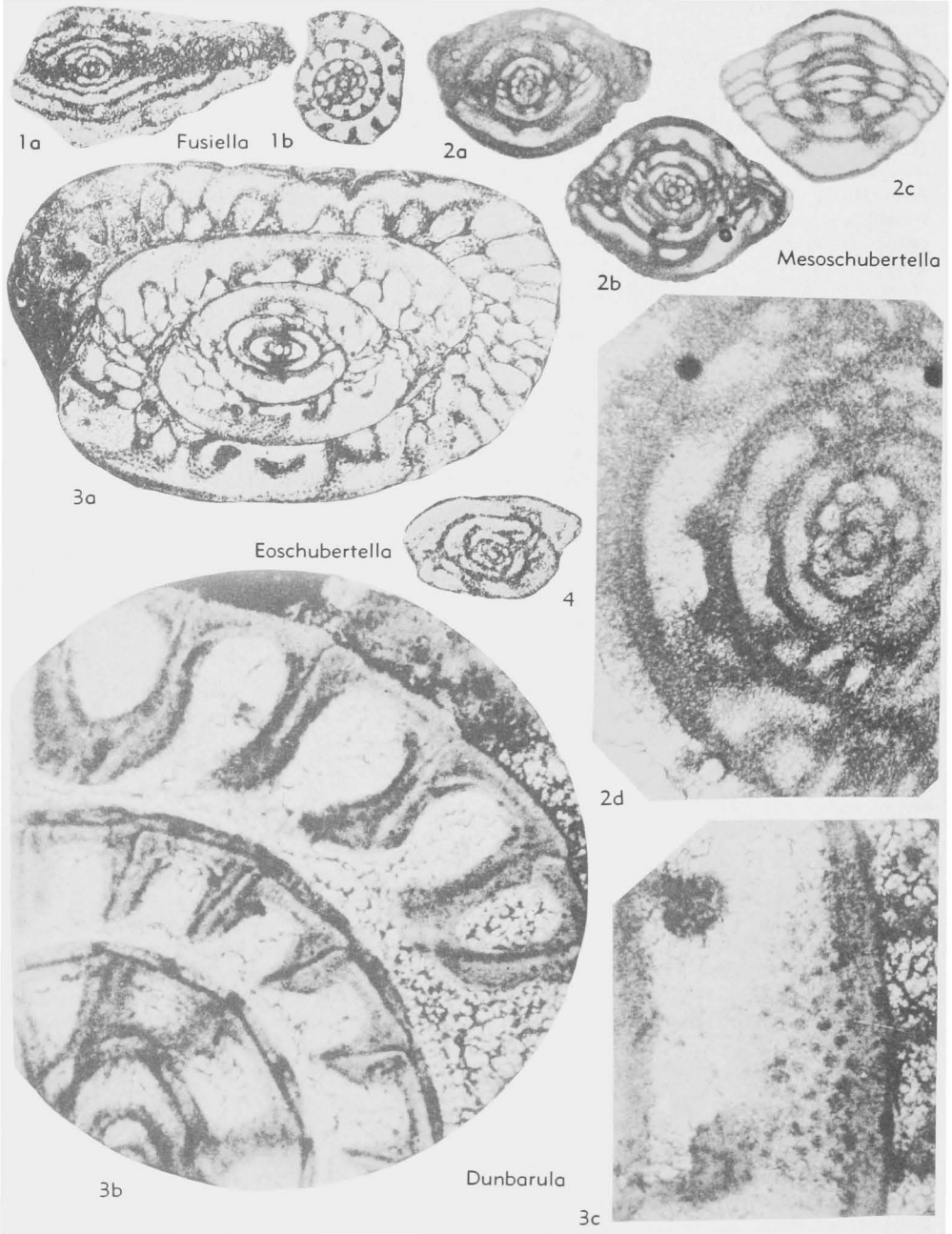


FIG. 303. Fusulinidae (Schubertellinae; 1, *Fusiella*; 2, *Mesoschubertella*; 3, *Dunbarula*; 4, *Eoschubertella*) (p. C401).

in outer part of shell (\*1795, \*1946). [Presence of axial fillings is strongly suggested in several of SKINNER & WILDE's type-specimens of this genus (Fig. 304, 1b; \*1795, pl. 44, fig. 2,3).] *U.Perm.*, N.Am.-Asia (China).—FIG. 304, 1a-c. \**P. splendens*, Bell Canyon F., USA (Tex.); 1a, sagittal sec. of paratype,  $\times 40$ ; 1b, axial sec. of holotype,

$\times 40$ ; 1c, tang. sec. of paratype showing cuniculi,  $\times 100$  (\*1795).—FIG. 304, 1d. *P. delicata* (COLANI), type-sp. of *Tavajsites*, China (Yunnan); slightly oblique axial sec.,  $\times 100$  (\*354).

**Paradoxiella** SKINNER & WILDE, 1955, \*1797, p. 934 [\**P. pratti*; OD]. Shell minute, composed of several planispirally coiled volutions followed

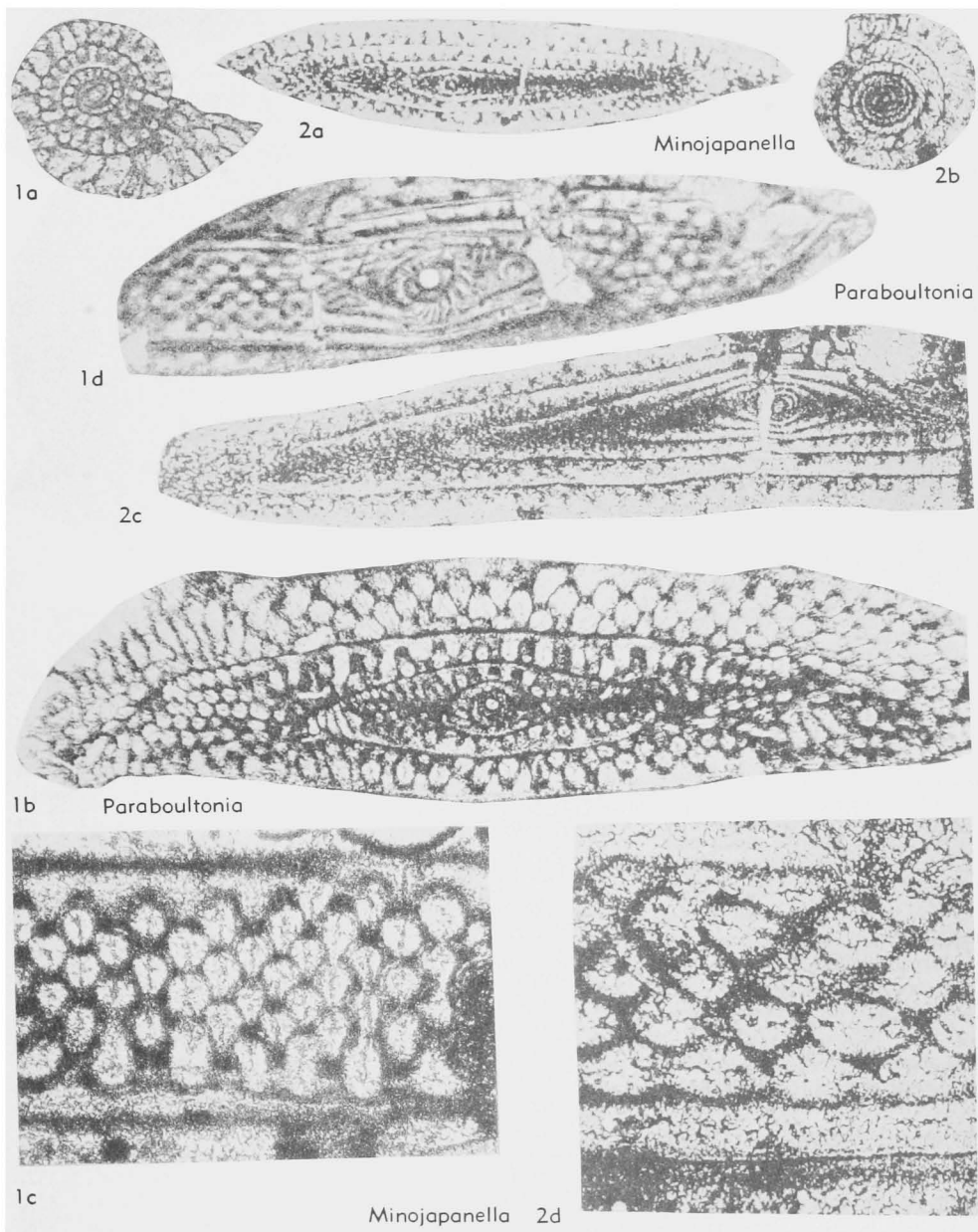


FIG. 304. Fusulinidae (Schubertellinae; 1, *Paraboultonia*; 2, *Minojapanella*) (p. C401-C403).



FIG. 305. Fusulinidae (Schubertellinae; 1, *Paradoxiella*) (p. C403-C404).

by uncoiled, rapidly expanding flared portion that is virtually tangential to final coil of shell; spirotheca thin, consisting of tectum and diaphanotheca; septa composed of same elements as spirotheca, but with thick epithelial layer on anterior and posterior surfaces near center of shell, septa intensely fluted throughout, developing what seem to be cuculi, septal pores numerous (\*1797). [Descriptive terms have been proposed for orientation of shells belonging to this genus (e.g., sagittal view, dorsal view, vertical axial section, inclined axial section, horizontal axial section, and many other possible directional sections). Such terms are not generally applicable to fusulinids but are employed for many other foraminifers (see Glossary).] *U.Perm.*, USA (Tex.).—FIG. 305, 1. \**P. pratti*, Bell Canyon F. (Lamar Ls.); 1a, b, sagittal and vert. axial secs. of paratypes,  $\times 30$ ; 1c, d, horiz. axial secs. of paratype and holotype,  $\times 30$  (\*1797).

#### Subfamily FUSULININAE von Möller, 1878

[Subfamily Fusulinidae (*sic*) BÜTSCHLI in BRONN, 1880, p. 213 (*nom. transl.* ex family Fusulinidae von MÖLLER, 1878)] —[All names cited are of subfamily rank] —[=Fusulininae BRADY, 1884, p. 74; =Fusulinellinae STAFF & WEDEKIND, 1910, p. 112; =Pseudotriticitinae PUTRYA, 1948, p. 112; =Quasifusulininae PUTRYA, 1956, p. 467; =Pseudostaffellinae PUTRYA, 1956, p. 395; =Hemifusulininae PUTRYA,

1956, p. 467; =Eofusulininae RAUZER-CHERNOUSOVA & ROZOVSKAYA in MIKLUKHO-MAKLAY, RAUZER-CHERNOUSOVA & ROZOVSKAYA, 1958, p. 17]

Shell spherical to elongate-fusiform or irregularly subcylindrical, early volution coils at large angle to outer ones in primitive genera, planispiral throughout in others; spirotheca generally composed of tectum with upper and lower tectoria, but many genera with diaphanotheca below tectum, and few having spirotheca of single dense, thin layer; septa plane in most primitive genera, first becoming fluted in polar regions and later becoming fluted completely across shell and to top of antetheca; tunnel singular, chomata massive to slight (\*1295). *U.Carb.* (M.Penn.)-*U.Perm.*

**Fusulina** FISCHER DE WALDHEIM, 1829, \*720A, p. 330 [\**F. cylindrica* FISCHER DE WALDHEIM, 1837, \*720B, p. 126; SD MEEK & HAYDEN, 1865, \*1252, p. 13] [=*Hemifusulina* von MÖLLER, 1877, \*1294, p. 146 (type, *H. bocki* von MÖLLER, 1878, \*1295, p. 76; SD); *Hemifusina* von MÖLLER, 1877, \*1294, p. 144 (*nom. null.*); *Schellwienia* STAFF & WEDEKIND, 1910, \*1832, p. 109,



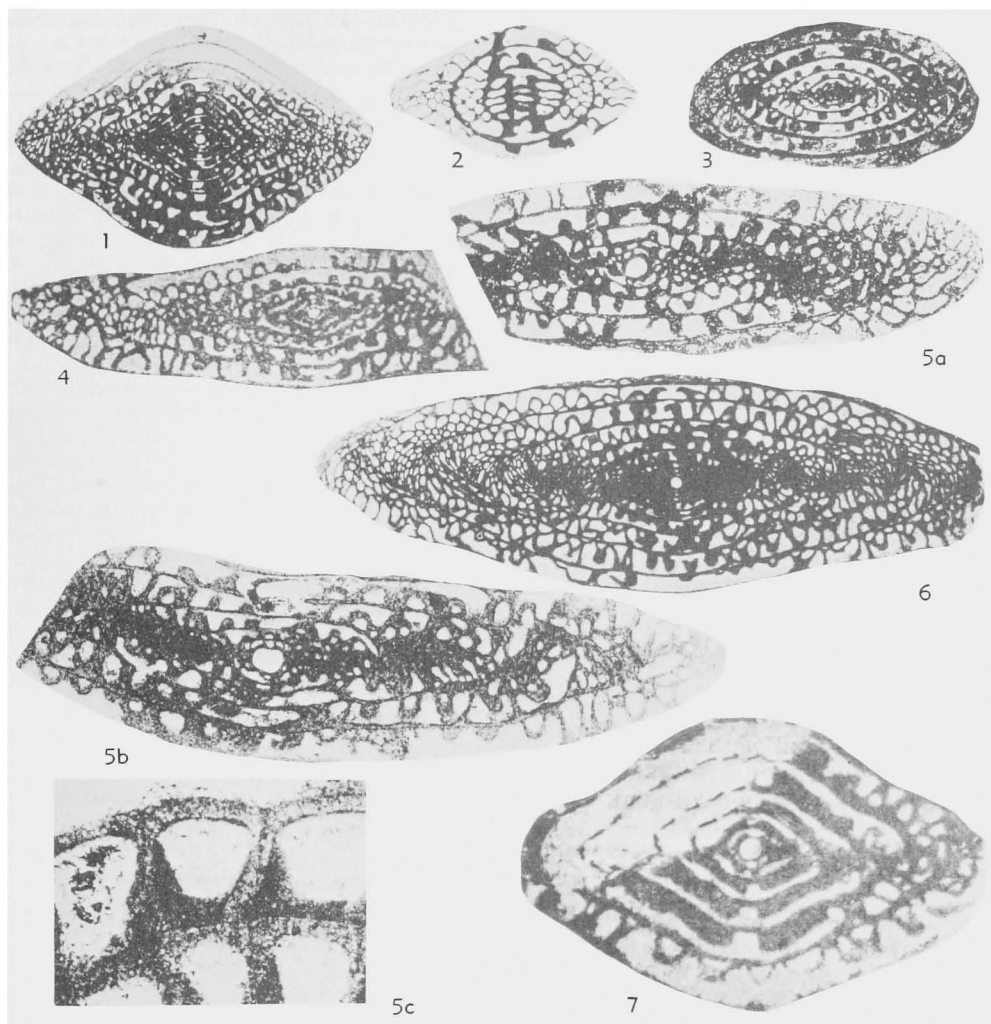


FIG. 306. Fusulinidae (Fusulininae; 1-7, *Fusulina*) (p. C404-C406).

113 (obj.); *Beedeina* GALLOWAY, 1933, \*762, p. 401 (type, *Fusulinella girtyi* DUNBAR & CONDRA, 1927[1928], \*640, p. 76; OD); *Pseudotriticites* PUTRYA, 1940, \*1491, p. 62 (type, *Fusulina? donbassica* PUTRYA, 1939, \*1490B, p. 139; OD); *?Eofusulina* RAUZER-CHERNOUSOVA, 1951, \*1507, p. 268 (type, *Fusulina triangula* RAUZER-CHERNOUSOVA & BELYAEV, 1936, in RAUZER-CHERNOUSOVA, BELYAEV & REYTLINGER, 1936, \*1507, p. 185; OD); *Dagmarella* SOLOVIEVA, 1955, \*1812, p. 945 (type, *D. prima*; OD); *Dutkevichella* PUTRYA, 1956, \*1494, p. 460 (type, *Fusulina dutkevichi* PUTRYA, 1937, \*1490A, p. 68; OD); *?Eofusulina (Paraeofusulina) PUTRYA*, 1956, \*1494, p. 458 (type, *E. (P.) trianguliformis*; OD)]. Shell fusiform to subcylindrical, planispiral in all volu-

tions; spirotheca of tectum and diaphanotheca with upper and lower tectoria; septa fluted throughout but more intense and higher near polar ends, axial filling in late forms; chomata massive to weak (\*762, \*1294, \*1491, \*1812, \*1832, \*1917, \*2083). *U.Carb.(M.Penn.-U.Penn.) (Fusulina Z.)*, N.Am.(USA-Can.-Greenl.)-S.Am.(Peru - Brazil - Chile) - Asia (China-Japan)-USSR-Eu.(Spain).—FIG. 306.1. *F. girtyi* (DUNBAR & CONDRA), M.Penn.(Brereton Ls.), USA(Ill.); axial sec.,  $\times 10$  (\*1922).—FIG. 306.2. *F. sp.*, M. Penn.(Garcia F.), USA(N.Mex.); tang. sec.,  $\times 10$  (\*1922).—FIG. 306.3. *F. minima* SCHELLWIEN (= *Hemifusulina bocki* von MÖLLER, 1878), Moscow, USSR(Tver); axial sec. of holotype,  $\times 15$  (\*1922).—FIG. 306.4. *F. donbassica* (PUTRYA),

Moscow., USSR (Donets Basin); axial sec. of syntype,  $\times 12$  (\*1491).—FIG. 306,5. \**F. cylindrica* FISCHER DE WALDHEIM, Moscow. (Myachkovo Ls.), USSR (Myachkovo Quarry); *5a,b*, axial secs. of topotypes,  $\times 15$ ,  $\times 20$ ; *5c*, part of sagittal sec. of topotype,  $\times 100$  (\*1922) (see also FIG. 280,3).—FIG. 306,6. *F. mysticensis* THOMPSON, M.Penn. (Worland Ls.), USA (Iowa); axial sec. of syntype,  $\times 10$  (\*1922) (see also FIG. 294,9).—FIG. 306,7. *F. prima* (SOLOVIEVA), Moscow. (Kachir Horizon), USSR (Noura-Taou); axial sec. of holotype,  $\times 35$  (\*1812).—FIG. 328A,2. *F. triangula* RAUZER-CHERNOUSOVA & BELYAEV, Moscow. (Podolsk Horizon), USSR (Skar-Yu River, Sib.); axial sec. of holotype,  $\times 10$  (\*1507). [See also FIG. 274,2. *F. girtyi*; 280,2; 294,10.]

[*Eofusulina*, according to illustrations and authors' description, has an elongate-fusiform to irregular shell, loosely coiled throughout, composed of large proloculus and 3 or 4 inflated volutions; septa fluted throughout length, fluting extending to tops of chambers; septal spacing unknown; spirotheca thin, composed of tectum, discontinuous middle layer and discontinuous lower layer; axial fillings throughout all parts of shell except terminal part of last volution; tunnel wide in 2nd and 3rd volutions; chomata absent, except in 1st and possibly 2nd volution. The characters indicated are essentially those of *Fusulina* as shown by its type-species, *F. cylindrica*. Accordingly, *Eofusulina* is here considered to be a probable synonym of *Fusulina*.]

**Akiyoshiella** TORIYAMA, 1953, \*19+1, p. 251 [*\*A. ozawai*; OD]. Shell small, elongate-fusiform, planispiral except for highly asymmetrical end regions of some gerontic individuals, loosely coiled throughout; spirotheca like *Fusulina*; septa numerous, highly and narrowly fluted throughout length of shell so as almost to form cuniculi; chomata heavy and spreading to massive axial fillings that spread onto septa and spirotheca (\*1930, \*1941). *U.Carb.* (M.Penn.), Japan-N.Am. (Can.).—FIG. 307,3. \**A. ozawai*, Akiyoshi Ls., Japan (SW. Honshu); *3a*, axial sec. of holotype,  $\times 20$ ; *3b*, tang. sec. of paratype showing asymmetry of outer volutions,  $\times 20$  (\*1926).

**Bartramella** VERVILLE, THOMPSON & LOKKE, 1956, \*2004, p. 1278 [*\*B. bartrami*, OD]. Shell small, elongate-subcylindrical to fusiform, planispiral and symmetrical throughout; spirotheca composed of tectum and lower porous layer; septa thin, narrowly and highly fluted throughout shell length and to tops of chambers, axial fillings massive in all volutions; chomata high asymmetrical, with steep slope on tunnel sides, extending to join with axial fillings toward polar areas (\*2004). *M.Penn.*, USA (Nev.-N.Mex.-Idaho).—FIG. 307,1. \**B. bartrami*, Ely Ls., Nev.; axial sec. of holotype,  $\times 20$  (\*2004).

**Fusulinella** VON MÖLLER, 1877, \*1294, p. 144 [*\*F. bocki* VON MÖLLER, 1878, \*1295, p. 104; SD DOUVILLÉ, 1906, \*617, p. 584] [= *Atetsuella* OKIMURA, 1958, \*1386, p. 251 (type, *A. imamura*; OD)]. Shell small, planispiral, and fusiform; spirotheca composed of tectum and diaphanotheca with upper and lower tectoria; septa fluted only in polar regions; chomata massive

(\*1294, \*1386, \*1922). *U.Carb.* (M.Penn.), N.Am. (USA-Can.-Mex.)-S.Am. (Peru-Chile)-Asia (China Japan)-USSR-Spitzb.-Greenl.—FIG. 307,2a. *F. juncea* THOMPSON, Cuchillo Negro F., USA (N. Mex.); axial sec. of paratype,  $\times 20$  (\*1922).—FIG. 307,2b. *F. imamura* (OKIMURA), Atetu Ls., Japan (Okayama Pref.); part of axial sec.,  $\times 250$  (\*1386).—FIG. 307,2c. \**F. bocki* VON MÖLLER, USSR (Tver, Kresty); axial sec. of topotype,  $\times 40$  (\*1922).—FIG. 307,2d. *F. iowensis* THOMPSON, Cherokee equiv., USA (Iowa); axial sec. of holotype,  $\times 20$  (\*1910).—FIG. 307,2e. *F. jamula* THOMPSON, Cuchillo Negro F., USA (N. Mex.); part of sagittal sec. of paratype showing 4-layered spirotheca,  $\times 100$  (\*1922). [See also FIG. 294,8.]

**Gallowayinella** CHEN in DUNBAR & SKINNER, 1937, \*333, p. 571 [*nom. correct.* THOMPSON, herein (*pro Gallowainella* CHEN, 1937, *nom. subst. pro Gallowainella* CHEN, 1934, \*331, p. 237, = *Gallowayina* CHEN, 1934, *nom. correct.*, *non Gallowayina* ELLIS, 1932, \*699, p. 1)] [*\*Gallowainella meitienensis* CHEN, 1934, \*331, p. 237; OD]. Shell elongate-subcylindrical to inflated-fusiform; spirotheca consisting of single dense layer; axial fillings massive, confined to axial zone; septa narrowly and highly fluted throughout (\*331, \*333). *U.Perm.*, Asia (S.China).—FIG. 308,4. \**G. meitienensis*, Meitien Ls., Hunan; *4a,b*, axial secs. of holotype,  $\times 15$ ,  $\times 40$  (\*1922).

[Decision as to the correct name of this genus depends on determination of the status of the original spelling in relation to regulations contained in Art. 32.a.ii, of the Code. The spelling *Gallowainella*, in which the terminal letter of the name Galloway (referring to Professor J. J. Galloway) is changed to "i," may be construed as an inadvertent error in spelling this surname as a base for the generic name. If this is agreed to, as seems most reasonable, then *Gallowainella* CHEN, 1934, is an incorrect original spelling which has neither separate status in nomenclature nor enters into homonymy (Art. 32.c). It is automatically correctable to *Gallowayina*, in which form it is a junior homonym of *Gallowayina* ELLIS, 1932, and a substitute name is called for. *Gallowainella* CHEN in DUNBAR & SKINNER, 1937, is such a name, but it is defective in the same ways as *Gallowainella*, since it contains the same, presumably inadvertent, error in changed spelling of the surname. This may be emended to *Gallowayinella* and this form seems to be most acceptable. Otherwise, it would be necessary to recognize the validity of *Gallowainella*, since it differs by a single letter from *Gallowayina* (Art. 56.a).]

**Hidaella** FUJIMOTO & Igo, 1955, \*754, p. 45 [*\*H. kameii*; OD]. Shell small, elongate-fusiform to subcylindrical, with 5 to 7 volutions, central portions slightly inflated, axial length approx. 3 mm. and axial width approx. 1.3 mm., first 2 or 3 volutions tightly coiled, outer ones inflated; spirotheca composed of thin, dense tectum, diaphanotheca, and less dense upper and lower tectoria, surface of spirotheca undulating throughout length; tunnel singular, chomata massive and high (\*754). *U.Carb.*, Central Japan.—FIG. 308,1. \**H. kameii*, Ichinotani F., Hida Mountainland; *1a*, parallel sec. of paratype; *1b*, axial sec. of holotype; *1c*, tang. sec. of paratype; all  $\times 20$  (\*754).

**Neofusulinella** DEPRAT, 1912, \*585, p. 1549 [*\*N.*

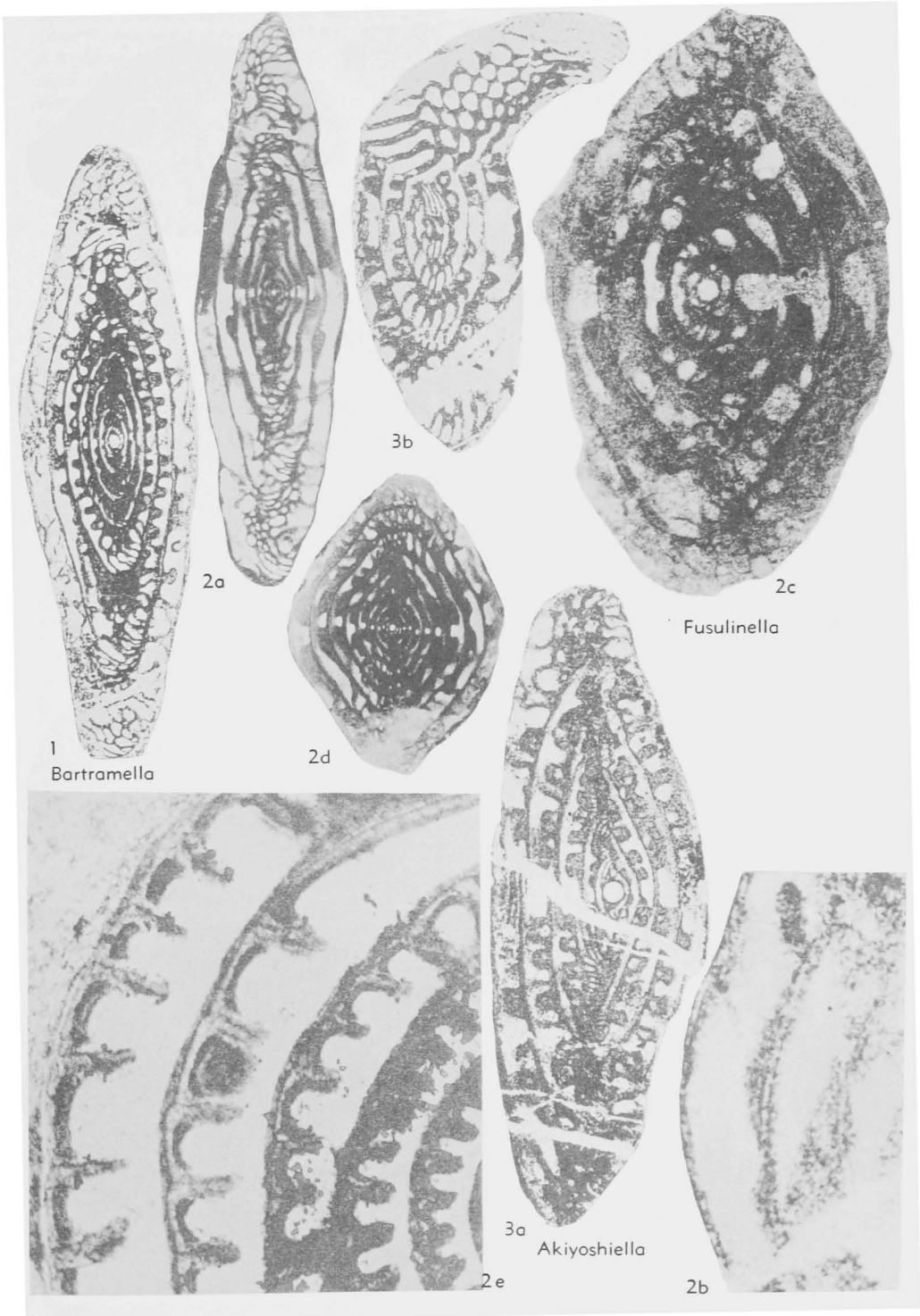


FIG. 307. Fusulinidae (Fusulininae; 1, *Bartramella*; 2, *Fusulinella*; 3, *Akiyoshiella*) (p. C406).

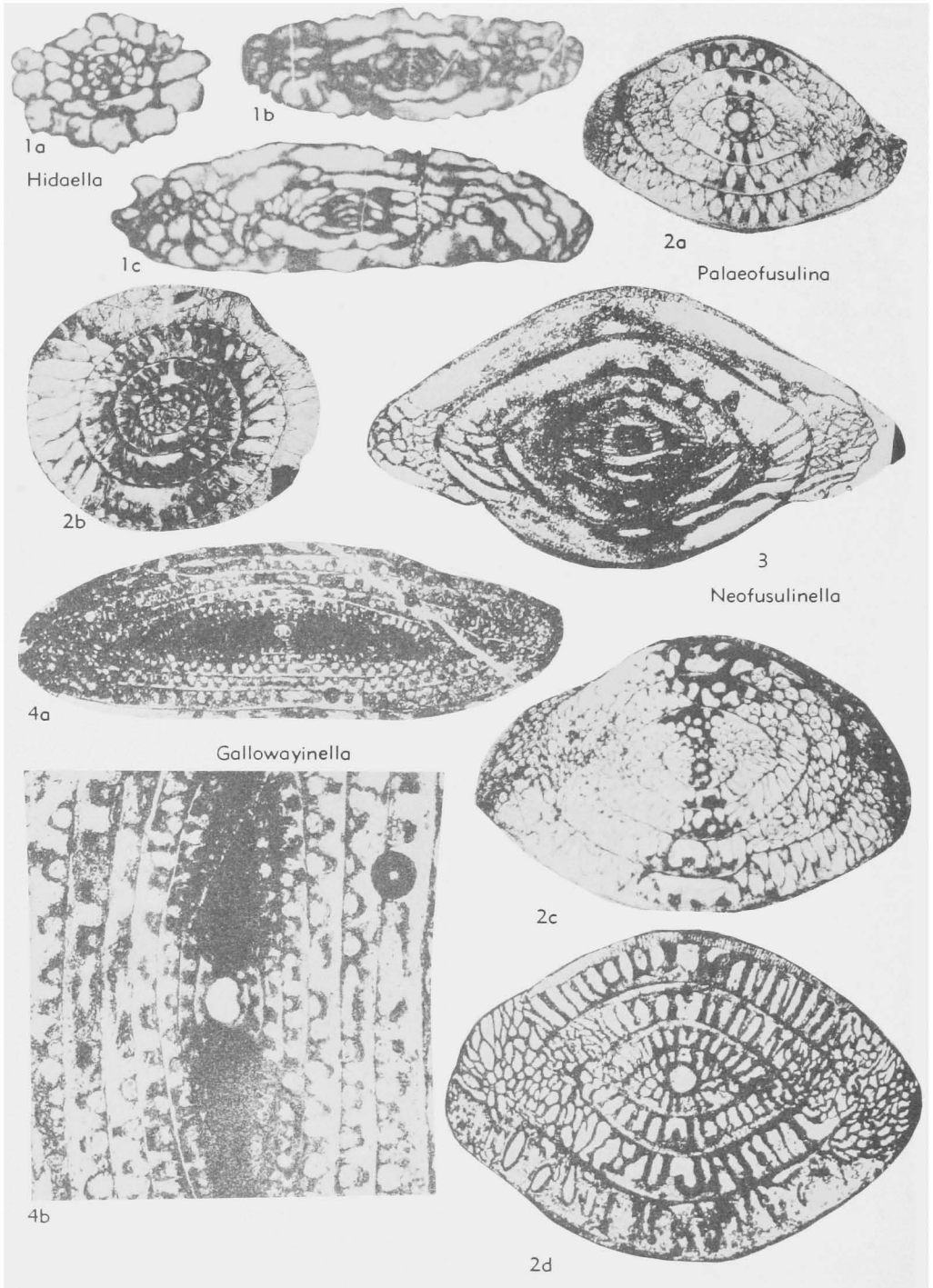


FIG. 308. Fusulinidae (Fusulininae; 1, *Hidaella*; 2, *Palaeofusulina*; 3, *Neofusulinella*; 4, *Gallowayinella* (p. C406-C409)).

*lantenoisi* DEPRAT, 1913, \*586, p. 90); OD (M)] [*non N. praecursor* DEPRAT, 1913 (SD GALLOWAY & RYNIKER, 1930, \*765, p. 23)]. Shell small, planispiral throughout, inflated-fusiform, early volutions discoidal; spirotheca composed of tectum and lower transparent layer without obvious alveoli; septa fluted in end zones; chomata narrow to massive (\*765, \*1910, \*1922, \*1929, \*1934). *U.Perm.*, "Fr. Indochina"—China-Japan.—FIG. 308,3. *N. lantenoisi* DEPRAT, Laos; tang. sec. of holotype,  $\times 20$  (1922).

[When DEPRAT (1912, \*585, p. 1549) proposed the name *Neofusulinella* he stated that it was for a form from the Permian limestones at Ban-Na-Mat, between Sam-Neua and Luang-Prabang, writing as follows: "*Neofusulinella*. J'ai trouvé dans les calcaires rapportés de Ban-Na-Mat (entre Sam-Neua et Luang-Prabang), par M. MANSUY, un autre Fusulinidé constituant indiscutablement un genre nouveau. . . . Malgré le grand nombre de caractères génériques qui la rapprochent de *Fusulinella*, l'allongement oblige à faire de cette forme un genre nouveau auquel convient l'appellation de *Neofusulinella*. . . ."—Thus it is clear that *Neofusulinella* was proposed for a described but unnamed form from the Permian limestones of Laos. It then became our problem to decide what this form was called when given a formal specific name. No mention was made by DEPRAT in 1912 of specimens from Indochina which he described in 1913 (\*586, p. 40-44) as *Neofusulinella praecursor* and *N. schwaegerinoides*. DEPRAT's 1913 paper contains the following: "*Neofusulinella* nov. gen. J'ai signalé il y a quelque temps un nouveau genre de Fusulinidés dans les calcaires rapportés de Ban-Na-Mat, entre Sam-neua et Luang-Prabang (Laos) par mon ami et collègue M. MANSUY. Depuis j'ai découvert deux autres espèces, l'une dans les calcaires rapportés du Tran-ninh, au N. de Xieng-khouang, par notre collaborateur le lieutenant Roux, l'autre des calcaires du Cammon, recueillis par le Commandant DUSSAULT dans des conditions très bonnes au point de vue de la situation stratigraphique. . . . Je décrirai maintenant les trois espèces de mon nouveau genre. . . . *Neofusulinella praecursor* n. sp. se trouve à la base du Moscovien. . . . *Neofusulinella lantenoisi* n. sp. . . . se trouve dans un calcaire clair de Ban-Na-Mat (Laos) recueilli par M. MANSUY. . . . *Neofusulinella schwaegerinoides* n. sp. est la seule espèce représentée dans un niveau moscovien des calcaires du Cammon. . . ."—The selection of the type-species of *Neofusulinella* must be governed by the International Rules of Zoological Nomenclature in effect in 1912. Article 30,1 of these Rules reads: "Cases in which the generic type is accepted solely upon the basis of the original publication." Case c, Article 30,1 states "A genus proposed with a single original species takes that species as its type. (Monotypical genera.)" The Rules do not state that the form must be a nominal species. The species for which DEPRAT proposed *Neofusulinella* was redescribed and named in 1913 as *N. lantenoisi* Deprat (\*586, p. 90). GALLOWAY & RYNIKER in 1930 (\*765, p. 23) designated *Neofusulinella praecursor* as the type-species of *Neofusulinella*. In order for *Neofusulinella praecursor* to be designated as a substitute for *N. lantenoisi*, plenary action would be required by the ICZN, and no such action has been requested.] [Note by R. C. MOORE.—One cannot disagree with THOMPSON's statement of the record concerning *Neofusulinella* as just given or with his conclusion that DEPRAT actually based his recognition and initial description of this genus on the species later named *N. lantenoisi*. Even so, all this is irrelevant in applying the explicit stipulations given in Article 69(a)(ii)(3) of the Zoological Code (1961): Prior to 1931, "If an author established a nominal genus but did not designate or indicate its type-species, any zoologist may subsequently designate as the type-species one of the originally included nominal species, or, if there were no original nominal species, one of those first subsequently referred to the genus. . . . If no nominal species were included at the time the genus was established, the nominal species-group taxa that were first subsequently and expressly referred to it are to be treated as the only originally included species. . . . If two or more nominal species were simultaneously referred to a nominal genus, all are equally eligible for subsequent type-designation." Thus, in the case of *Neofusulinella* "the only originally included species" are *N. praecursor*, *N. lantenoisi*, and *N. schwaegerinoides* and each of them is equally eligible for designation as the type-species by a first subsequent reviser. It happens that GALLOWAY & RYNIKER in 1930 (\*765, p. 23) selected *N. praecursor*, thereby fixing the type-species in manner that is alterable only by ICZN using its plenary powers. THOMPSON has declined to

accept advice that the Rules must be followed in this way, holding the view (quite untenable in my opinion) that *Neofusulinella* is a monotypic genus based on a species unnamed in DEPRAT's original publication but found to be one of three species described and named by this author in 1913. It is unnecessary to challenge THOMPSON's curious interpretation of Article 30 of old rules because the XV International Congress of Zoology (London, 1958) abrogated all such old rules when, in adopting the new Code, it included the regulation "This Code comes into force on the day of its publication (6 November 1961) and all previous editions of the International Rules of Zoological Nomenclature are thereby superseded" (Art. 84). Accordingly, the type-species of *Neofusulinella* and the mode of its fixation are incorrectly given by THOMPSON as printed above; the correct citation should read "*N. praecursor* DEPRAT, 1913, \*586, p. 40; SD GALLOWAY & RYNIKER, 1930, \*765, p. 23."]

**Neostaffella** A. D. MIKLUKHO-MAKLAY, 1959, \*1270, p. 630 [*Melonia* (*Borelis*) *sphaeroidea* EHRENBERG, 1842, \*669A, p. 274; OD]. Shell spherical to subspherical, polar areas flush to deeply umbilicate; chomata distinct, septa totally unfluted, axis of coiling of most volutions almost parallel (\*1270). [MIKLUKHO-MAKLAY in the original diagnosis pointed out that all known species of *Neostaffella* were approximately twice as large as most forms of *Pseudostaffella*, some of which we now recognize as belonging to *Neostaffella*. The chief feature of *Neostaffella* is its 4-layered spirotheca, which has a diaphanotheca below the tectum from the 3rd volution to maturity.] *J. Carb.* (*M.Penn.*-*U.Penn.*), Eu.-Asia-N. Am.—FIG. 311,2a. *N. paradoxa* (DUTKEVITCH), Myachkovo Horizon, USSR (Polazna); axial sec.,  $\times 20$  (\*1509A).—FIG. 311,2b. *N. ozawai compacta* (MANUKALOVA), Podolsk Horizon, USSR (Nyтва); axial sec.,  $\times 20$  (\*1509A).—FIG. 311,2c. *N. sphaeroidea* (EHRENBERG), Podolsk Horizon, USSR (Andreyev Gorge); axial sec.,  $\times 20$  (\*1509A).

**Palaeofusulina** DEPRAT, 1912, \*585, p. 1548 [*P. prisca* DEPRAT, 1913, \*586, p. 37 (= *Fusulina pseudo-prisca* COLANI, 1924, \*354, p. 79); SD (SM)]. Shell small, inflated-subcylindrical to fusiform; spirotheca consisting of single dense layer; septa narrowly and highly fluted throughout (\*354, \*585, \*586, \*1137, \*1728, \*1922). *Perm.*, Asia (Caucasia—"French Indochina"—China)-Japan-Malay Arch. (Timor).—FIG. 308,2. *P. pseudo-prisca* (COLANI), "French Indochina" (Lang-nac); 2a, centered axial sec.,  $\times 20$ ; 2b, sagittal sec.,  $\times 20$ ; 2c, axial sec. tangent to proloculus,  $\times 20$  (\*354); 2d, axial sec. of holotype of *P. pseudo-prisca* (COLANI), seemingly retouched,  $\times 25$  (\*1922).

**Plectofusulina** STEWART, 1958, \*1839, p. 1056 [*P. franklinensis*; OD]. Shell minute, short, ellipsoidal, inflated, mature shell with about 4 volutions; spirotheca composed of tectum and diaphanotheca with upper and lower tectoria; proloculus large; septa strongly sinuous, chambers inflated; chomata massive (\*1839). *M.Penn.*, N. Am. (USA).—FIG. 309,1. *P. franklinensis*, Bishops Cap Ls., Tex.; 1a, axial sec. of holotype,  $\times 70$ ; 1b, sagittal sec. of paratype,  $\times 70$ ; 1c, part of sagittal sec. showing structure of spirotheca,  $\times 600$  (\*1839).

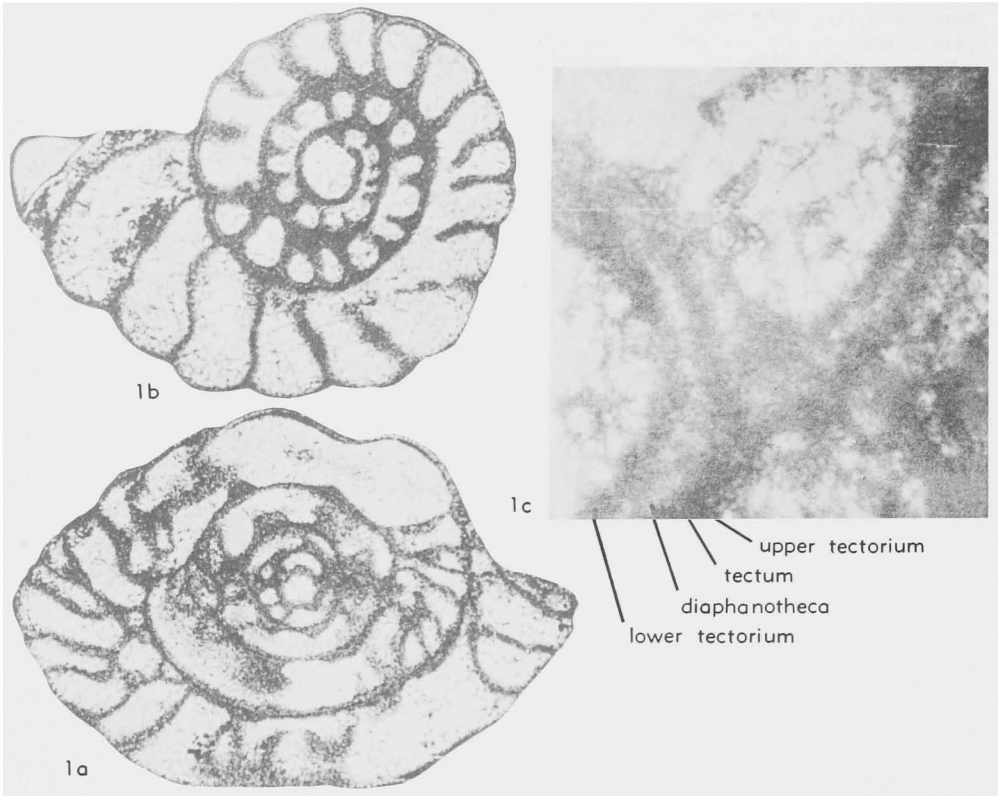


FIG. 309. Fusulinidae (Fusulininae; 1, *Plectofusulina*) (p. C409).

**Profusulinella** RAUZER-CHERNOUSOVA & BELYAEV in RAUZER-CHERNOUSOVA, BELYAEV & REYTLINGER, 1936, \*1507, p. 175, 220 [*P. pararhomboides*: OD] [= *Aljutovella* RAUZER-CHERNOUSOVA in RAUZER-CHERNOUSOVA, *et al.*, 1951, \*1509A, p. 182 (type, *Profusulinella aljutovica* RAUZER-CHERNOUSOVA, 1938, \*1501, p. 97: OD)]. Shell fusiform or ellipsoidal, early volutions asymmetrical in some, symmetrical throughout in most; spirotheca composed of tectum with upper and lower tectoria; septa fluted in polar regions (\*1501, \*1507, \*1922). *U. Carb.* (M. Penn.), N. Am.-S. Am. (Peru)-USSR-China-Japan. — FIG. 310.1. *P. aljutovica* RAUZER-CHERNOUSOVA, Vereia Horizon, USSR (Samara Bend, Volga River); 1a, b, axial secs. of paratype and holotype,  $\times 30$  (\*1501); 1c, part of axial sec. showing structure of spirotheca,  $\times 100$ ; 1d, thin section of limestone containing several sections of *P. aljutovica* associated with forms of *Pseudostaffella* and *Millerella* (not shown), depth of 515.9-518.65 meters, well no. 402, Samara Bend, USSR,  $\times 20$  (\*1922). — FIG. 310.2. \**P. pararhomboides*, Moscov., USSR (N. Urals); axial sec. of holotype,  $\times 50$  (\*1922). — FIG. 310.3. *P. regia* THOMPSON, USA (W. Tex., Powwow Canyon); part of sagittal sec. of paratype showing spirothecal structure,  $\times 100$  (\*1922)

(see also Fig. 294,7). — FIG. 310.4. *P. decora* THOMPSON, USA (W. Tex., Powwow Canyon); part of axial sec. of paratype showing structure of spirotheca,  $\times 100$  (\*1922). [See also Fig. 280,1.] **Pseudofusulinella** THOMPSON, 1951, \*1925, p. 117 [*Neofusulinella occidentalis* THOMPSON & WHEELER in THOMPSON, WHEELER & HAZZARD, 1946, \*1934, p. 25; OD]. Shell inflated-fusiform, volutions expanding uniformly from small proloculus; spirotheca composed of upper layer, tectum, and thin lower porous layer; septa closely spaced and fluted in polar ends of shell; axial fillings throughout shell, becoming thin in last few volutions; chomata massive, asymmetrical, with steep tunnel sides and low lateral slopes (\*1925). *U. Carb.* (U. Penn.)-L. Perm., N. Am.-Japan. — FIG. 311.4a-c. \**P. occidentalis* (THOMPSON & WHEELER), L. Perm. (McCloud Ls.), USA (Calif.); 4a, axial sec. of holotype,  $\times 20$ ; 4b, sagittal sec. of paratype,  $\times 20$ ; 4c, tang. sec. of paratype with fluted septa in polar regions,  $\times 20$  (\*1926). — FIG. 311.4d. *P. utahensis* THOMPSON & BISSELL, L. Perm. (Oquirrh F.), USA (Utah); axial sec. of holotype,  $\times 20$  (\*1926).

**Pseudostaffella** THOMPSON, 1942, \*1919, p. 407 [*P. needhami*: OD]. Shell spherical, umbilicate, early volutions of most species asymmetrical to



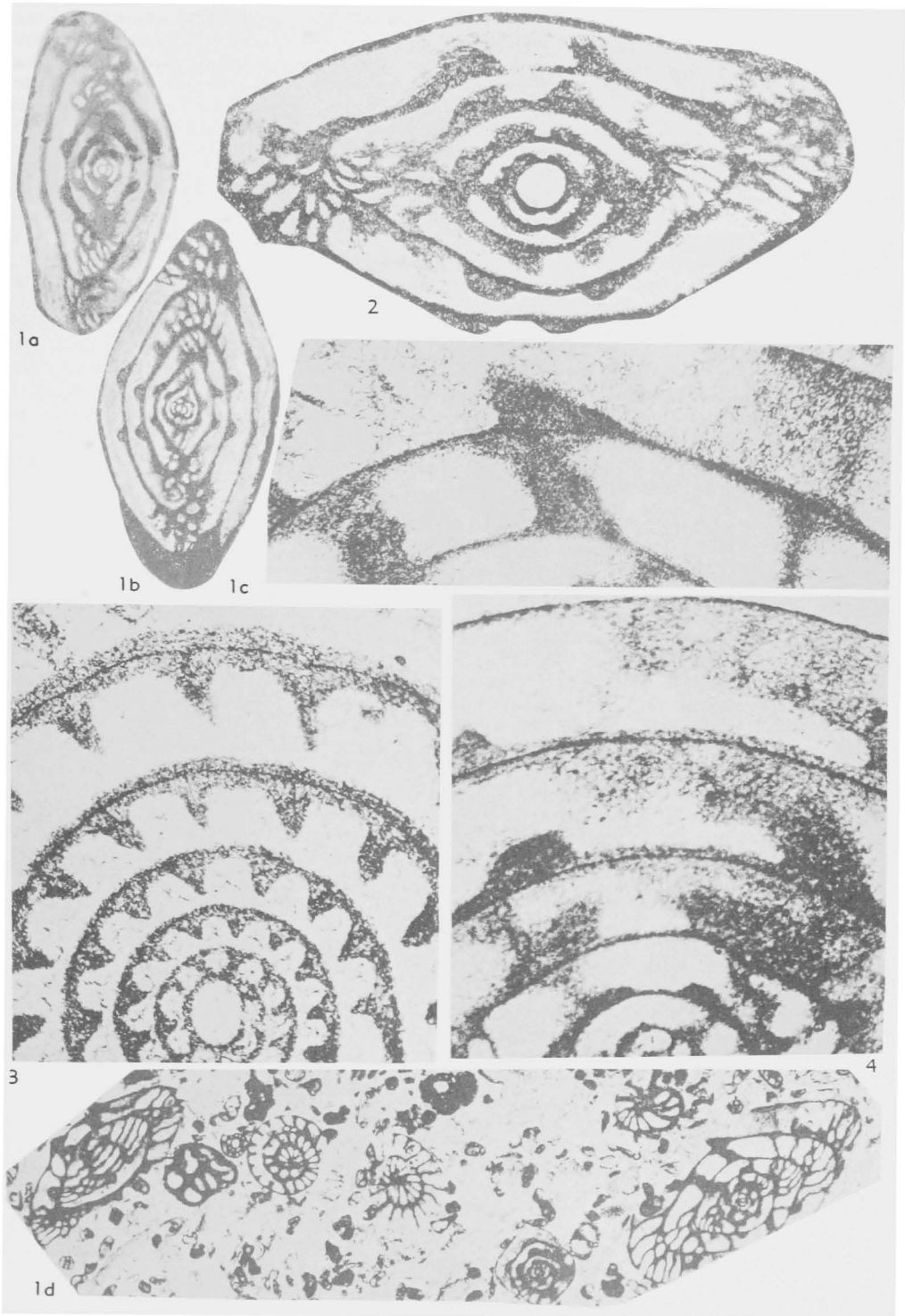


FIG. 310. Fusulinidae (Fusulininae; 1-4, *Profusulinella*) (p. C409-C410).

outer ones but symmetrical in some forms; spirotheca composed of tectum with upper and lower tectoria, or, in advanced forms, of tectum and diaphanotheca with upper and lower tectoria; septa unfluted; chomata massive, large (\*1919, \*1928). *U.Carb.(M.Penn.)*, N.Am.-S.Am.-Eu.-Asia.—FIG. 311,3a-c. \**P. needhami*, Cuchillo Negro F., USA(N.Mex.); 3a,b, axial secs. of paratypes,  $\times 50$ ; 3c, axial sec. of holotype,  $\times 50$  (\*1922).

**Pseudowedekindellina** SHENG, 1958, \*1729, p. 87 [*\*P. proluxa*; OD] [= *Fruventella* STEWART, 1958, \*1839, p. 1055 (type, *F. exampla*; OD)]. Shell small, highly elongate-fusiform, composed of 4 or 5 volutions at maturity with form ratio of shell up to 5.0; with slightly convex lateral slopes, sharply pointed polar ends, and straight to slightly irregular axis of coiling; spirotheca composed of 3 layers comprising tectum with upper and lower tectoria; septa closely fluted at very base, plane in middle and upper part; axial fillings rather heavy throughout length of shell; chomata prominent, highly asymmetrical, broad (\*1729, \*1839). *U.Carb.(M.Penn.)*, Asia(China)-USA.—FIG. 311,1a,b. *P. exampla* (STEWART), Bishops Cap Ls., USA(Tex.); 1a,b, axial secs. of holotype and paratype,  $\times 70$  (\*1839).—FIG. 311,1c,d. \**P. proluxa*, Penchi Ser.(Hsiaoshih Ls.), China; 1c,d, axial sec. of holotype and enlarged part,  $\times 20$ ,  $\times 100$  (\*1729) (see also Fig 279,1).

**Quasifusulina** CHEN, 1934, \*332, p. 91 [*\*Fusulina longissima* VON MÖLLER, 1878, \*1295, p. 59; OD] [= *Epifusulina* CHEN, 1936 (*fade* GRABAU, 1936, \*809A, p. 21, footnote) (obj.)]. Shell elongate, irregularly subcylindrical; wall composed of tectum and diaphanotheca; septa intensely fluted throughout length, axial fillings heavy, cuniculi possibly present in some forms (\*332). *U.Carb.(U.Penn.)-L.Perm.*, Eu.-Asia-Can.(B.C.).—FIG. 279,2. \**Q. longissima* (VON MÖLLER), *U.Carb.(C<sub>s</sub>)*, USSR(Tsarev Kurgan); axial sec. of holotype,  $\times 10.5$  (\*1922).

**Taitzeoella** SHENG, 1951, \*1727, p. 79 [*\*T. taitzeoensis*; OD]. Shell small, caltrop-like in shape at maturity, median part highly inflated, lateral slopes concave, poles sharp to bluntly pointed, coiling divisible into early stage with short axis and endothyroid arrangement, and later stage with straight axis of coiling oriented differently from early stage; spirotheca thin, composed of 2 layers of tectum and lower less dense layer; septa straight, axial fillings slight but present throughout entire shell; tunnel quadrate in cross section, chomata asymmetrical, high (\*1727). *U.Carb.(Moscov.)*, China-Greenl.—FIG 312,3. \**T. taitzeoensis*, Penchi Ser.; 3a, axial sec. of holotype,  $\times 25$ ; 3b, oblique sec. of paratype,  $\times 35$  (\*1727).

**Varella** DALMATSKAYA, 1951, \*551, p. 194 [*\*V. warsanofievie*; OD]. Shell minute, highly elongate-fusiform, axis of coiling arcuate to straight with as many as 4 volutions; proloculus large;

spirotheca thin, composed of tectum and distinct protheca, layers poorly differentiated; septa fluted at base in outer volutions, axial fillings distinct in all volutions except in outer part of last volution; tunnel singular, chomata asymmetrical and distinct (\*551). *U.Carb.*, USSR.—FIG. 312,4a. \**V. warsanofievie*, Kaial Stage, Penza Oblast (Kikina); axial sec. of holotype showing fluting at base of septa,  $\times 30$  (\*551).—FIG. 312,4b. *V. spicata* DALMATSKAYA, Kaial Stage, Penza Oblast(Kikina); axial sec. of holotype,  $\times 30$  (\*551).

**Waringella** THOMPSON, 1942, \*1919, p. 413 [*\*W. spiveyi*; OD]. Shell minute, elongate-fusiform, with inflated central area; spirotheca composed of tectum with upper and lower layers; septa fluted in polar regions, axial fillings heavy (\*1919, \*1931). *U.Penn.*, USA(Tex.-Utah).—FIG. 312, 1. \**W. spiveyi*, Salem School Ls., Tex.; 1a, ext. view of paratype,  $\times 10$ ; 1b, sagittal sec. of paratype,  $\times 20$ ; 1c,d, axial sec. of holotype and part enlarged to show 3 layers of spirotheca,  $\times 20$ ,  $\times 100$  (\*1922) (see also Fig. 274,3).

**Wedekindellina** DUNBAR & HENBEST in CUSHMAN, 1933, \*461, p. 134 [*nom. subst. pro Wedekindia* DUNBAR & HENBEST, 1931 (*non* SCHINDEWOLF, 1925)] [*\*Fusulinella euthysepta* HENBEST, 1928, \*893A, p. 80; OD] [= *Wedekindella* DUNBAR & HENBEST, 1930, \*641, p. 362 (obj.) (*non* SCHINDEWOLF, 1928); *Wedekindia* DUNBAR & HENBEST, 1931, \*642, p. 458 (*nom. subst. pro Wedekindella* DUNBAR & HENBEST, 1930) (obj.) (*non* SCHINDEWOLF, 1928); *Parawedekindellina* SAFONOVA in RAUZER-CHERNOUSOVA *et al.*, 1951, \*1509A, p. 240 (type, *P. kamensis*; OD)]. Shell highly elongate-fusiform, axis of coiling straight, polar ends sharply pointed; spirotheca composed of tectum and diaphanotheca with upper and lower tectoria; septa unfluted, axial fillings massive throughout shell except for last part of last volution; chomata massive and broad (\*641, \*642, \*643, \*1610, \*1922). *U.Carb.(M.Penn.-U.Penn.)*, N.Am(USA-Can.-Greenl.) - USSR - Japan-?China.—FIG. 312,2a,b. *W. kamensis* (SAFONOVA), Podolsk Horizon, USSR(Polazna); 2a, axial sec. of holotype,  $\times 20$ ; 2b, typical specimen from Myachkovo beds at Levshino,  $\times 20$  (\*1509A).—FIG. 312,2c. *W. mattwa* THOMPSON, M.Penn. Youghall F.), USA(Utah); axial sec. of holotype,  $\times 20$  (\*1922).—FIG. 312,2d,e. \**W. euthysepta* (HENBEST), M.Penn.(Stonefort Ls.), USA(Ill.); 2d,e, axial sec. of holotype and part showing wall pore at *p*,  $\times 40$ ,  $\times 250$  (\*1922) (see also Fig. 275,3).

**Yangchienia** LEE, 1933[1934], \*1120, p. 14 [*\*Y. iniqua*; OD] [= *Jangchienia* A. D. MIKLUKHO-MAKLAY, 1953, \*1263, p. 21 (*nom. van.*)]. Shell small, inflated-fusiform, inner 3 or 4 volutions discoidal, with asymmetrical to fusiform outer volutions; spirotheca consisting of tectum and diaphanotheca with thick lower and upper tec-

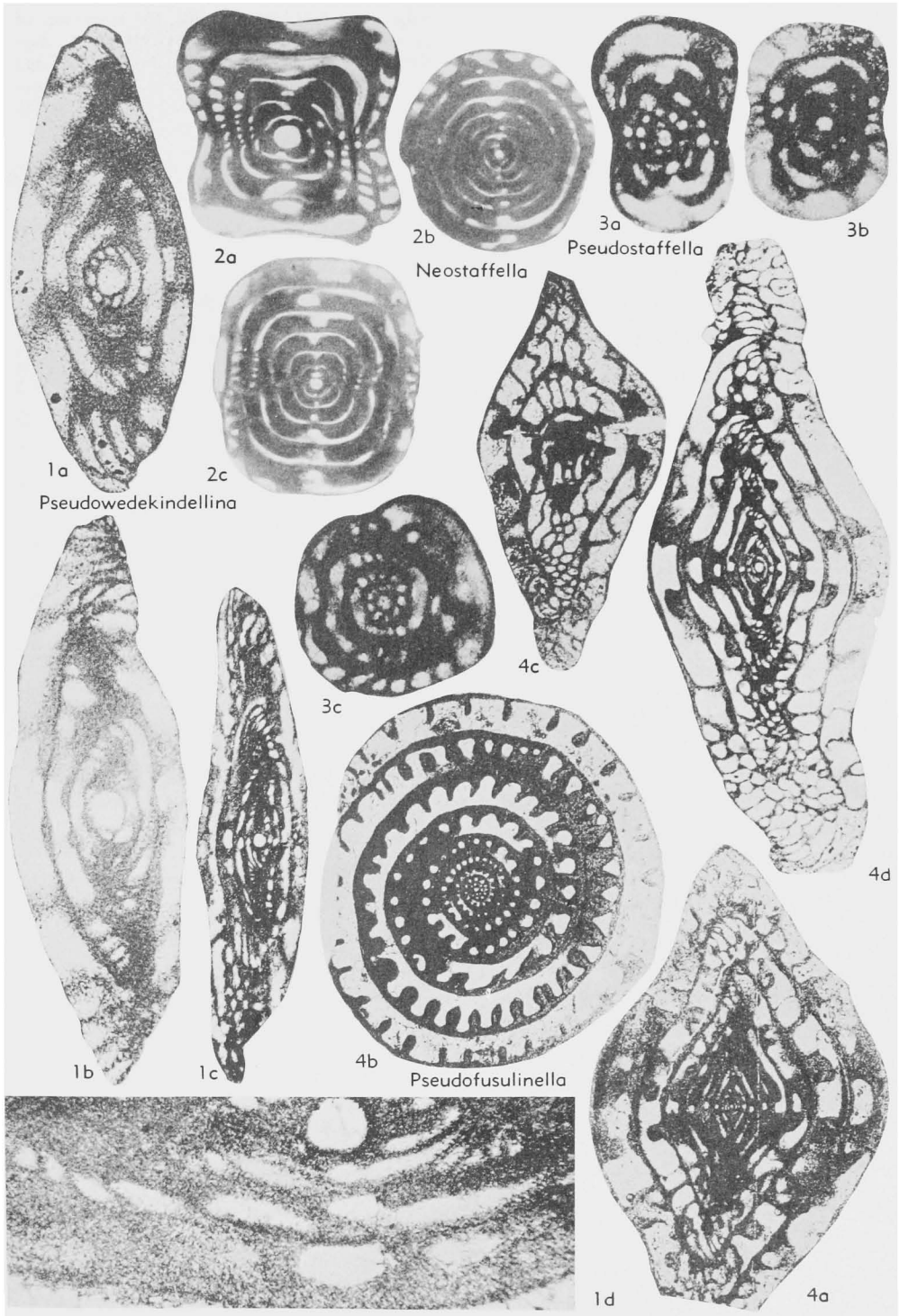


FIG. 311. Fusulinidae (Fusulininae; 1, *Pseudowedekindellina*, 2, *Neostaffella*, 3, *Pseudostaffella*; 4, *Pseudofusulinella*) (p. C409-C412).

toria; septa unfluted; chomata massive, extending almost to polar ends (\*1269, \*1911, \*1922). *U. Perm.* (*Verbeekina* Z.), Eu. (Sicily-Greece) - Asia (China-AsiaM.-Afghan.).—FIG. 313,1. \**Y. ini-qua*, Chihhsia Ls., China (E. of Chusanshan); 1a,

axial sec. of holotype,  $\times 40$ ; 1b, tang. sec. of paratype,  $\times 40$  (\*1922).—FIG. 313,2 *Y. haydeni* THOMPSON, U. Perm. (Bamian Ls.), Afghan.; 2a, axial sec. of holotype,  $\times 20$ ; 2b, enlargement of 2a showing chomata structure,  $\times 100$  (\*1922).

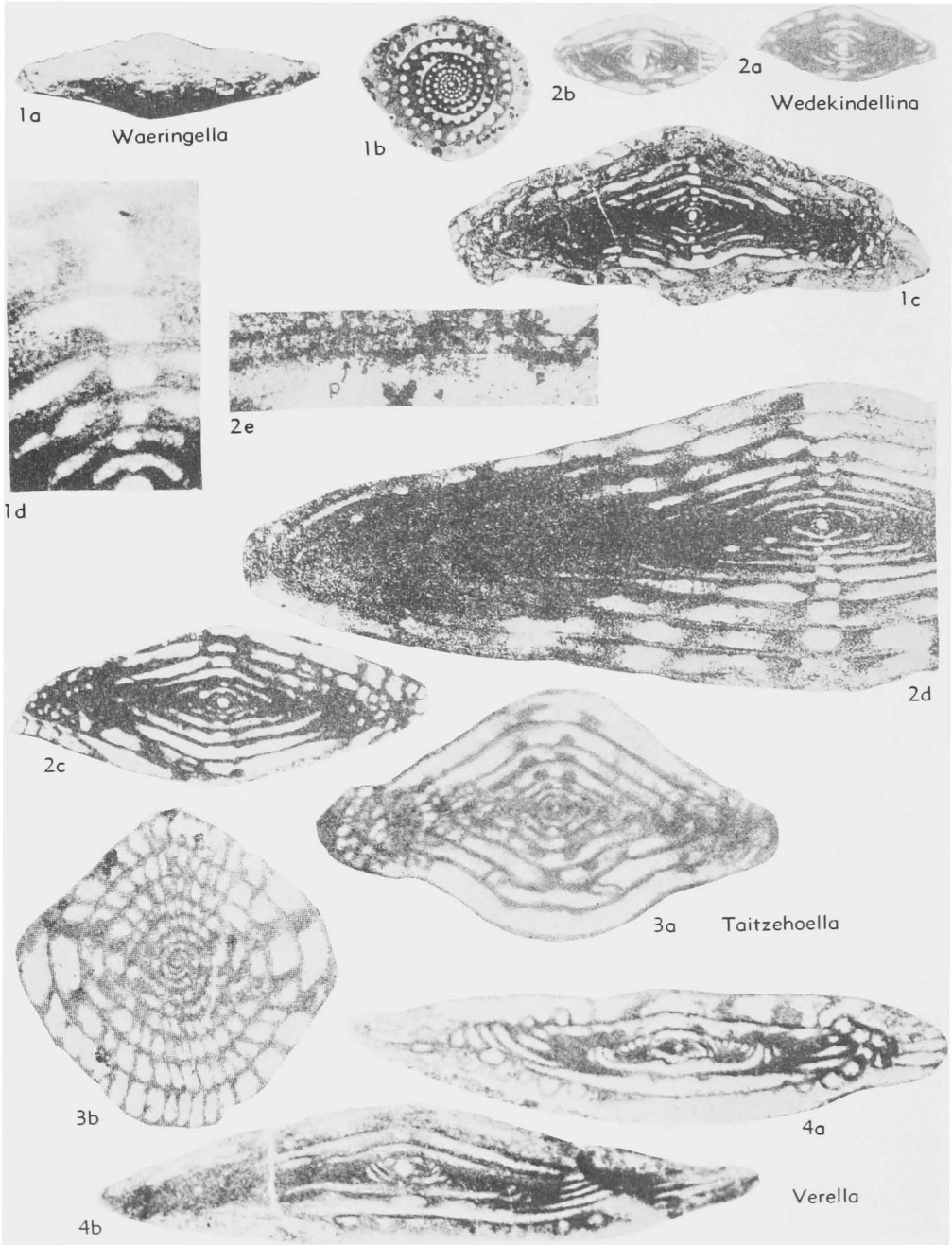


FIG. 312. Fusulinidae (Fusulininae: 1, *Waeringella*; 2, *Wedekindellina*; 3, *Taitzehoella*; 4, *Verella*) (p. C412).

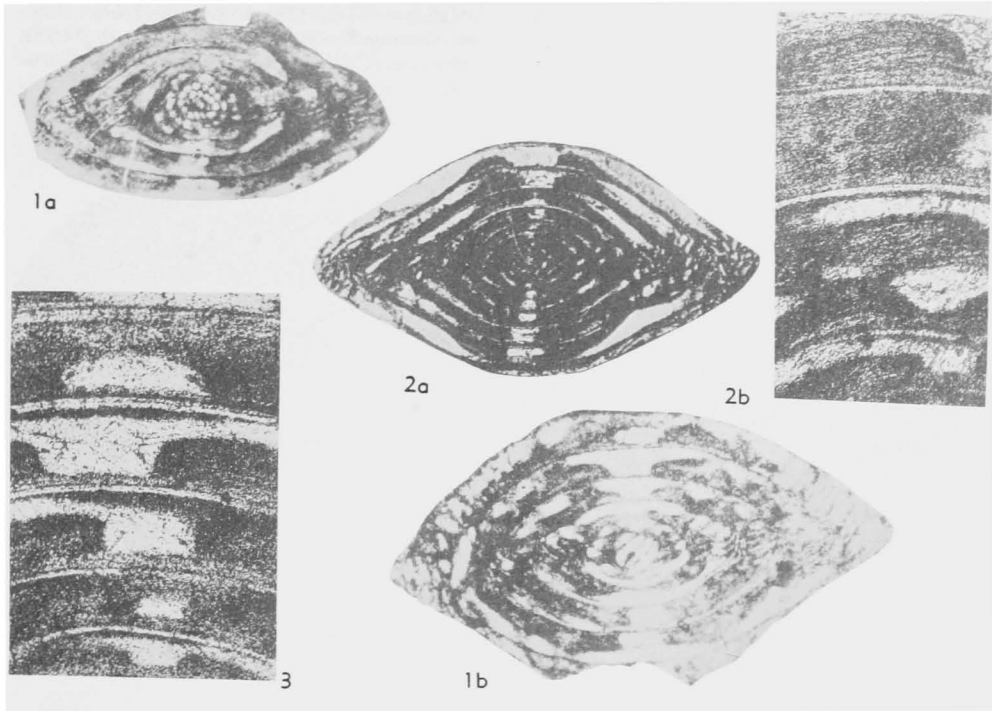


FIG. 313. Fusulinidae (Fusulininae; 1-3, *Yangchienia*) (p. C412-C414).

—FIG. 313,3. *Y. tobleri* THOMPSON, U.Perm. (Sosio Beds), Sicily (Castellamare del Golpo); part of axial sec. showing structure of spirotheca,  $\times 100$  (\*1922) (see also Fig. 275,2).

#### Subfamily SCHWAGERININAE Dunbar & Henbest, 1930

[*nom. transl.* YABE & HANZAWA, 1932, p. 42 (ex family Schwagerinidae DUNBAR & HENBEST, 1930)] [=Pseudofusulininae DUTKEVICH, 1934, p. 53; =Polydiexodininae A. D. MIKLUKHO-MAKLAY, 1953, p. 21]

Shell large, fusiform to irregularly cylindrical, planispiral, involute in most, irregularly uncoiled in some; spirotheca thick, composed of tectum and alveolar keriotheca; septa fluted in end zones of primitive genera, fluted completely across shell and to tops of chambers of more advanced genera; tunnel singular in most forms or multiple in one genus, axial fillings absent to massive; chomata massive to slight (\*641, \*1295). *U.Carb.* (*M.Penn.*)-*U.Perm.*

*Schwagerina* VON MÖLLER, 1877, \*1294, p. 143 [\**Borelis princeps* EHRENBERG, 1842, \*669A, p. 274; OD (M)] [= *Chusenella* LEE, 1942, \*1120A, p. 171 (*nom. nud.*); *Chusenella* Hsu, 1942, \*973, p. 175 (type, *C. ishanensis*); *Triticites (jigulites)* ROZOVSKAYA, 1948, \*1590, p. 1638 (type, *Triticites jigulensis* RAUZER-CHERNOUSOVA, 1938, \*1501, p. 120, 157; OD); *Daixina* ROZOVSKAYA, 1949, \*1591,

p. 252 (type, *D. ruzhencevi*; OD); *Triticites (Rauserites)* ROZOVSKAYA, 1948, \*1590, p. 1637 (*nom. nud.*); *T. (Rauserites)* ROZOVSKAYA, 1950, \*1591A, p. 30 (type, *Triticites stuckenbergi* RAUZER-CHERNOUSOVA, 1938, \*1501, p. 110, 155); *Codonoschwagerina* VIËN, 1959, \*2005A, p. 111 (type, *C. thuanai*; OD)]. Shell fusiform to sub-cylindrical; spirotheca thick and composed of tectum and alveolar keriotheca; septa fluted throughout length of shell, fluting intense to tops of septa in some, only in lower parts of septa of others, axial fillings highly variable; chomata distinct or thin and discontinuous (\*645, \*973, \*1294, \*1591). *Perm.*, Eu. - Asia - N. Afr. - N.Am. - C.Am. - S.Am.—FIG. 314,1. *S. fax* THOMPSON & WHEELER, L.Perm. (McCloud Ls.), USA (Calif.); 1a, tang. sec. of syntype showing septal fluting,  $\times 10$ ; 1b, centered axial sec. of syntype,  $\times 10$  (\*1922) (see also Fig. 276,3).—FIG. 314,2. *S. princeps* (EHRENBERG), L.Perm. (Mountain Ls.), USSR (Pinega Archangel); 2a, sagittal sec. of paratype,  $\times 10$ ; 2b, axial sec. of holotype,  $\times 10$ ; 2c, etched surface of paratype showing fluting of septa across specimen,  $\times 10$  (\*1922).—FIG. 314,3. *S. jigulensis* (RAUZER-CHERNOUSOVA), L.Perm., USSR (Samara Bend); axial sec. of holotype,  $\times 15$  (\*1926).—FIG. 314,4. *S. ruzhencevi* (ROZOVSKAYA), C<sub>3</sub><sup>1-c</sup> Horizon, USSR (Ural River); axial sec. of holotype,  $\times 9$  (\*1926).—FIG. 314,5. *S. gruperensis* THOMP-

SON & MILLER, L.Perm.(Grupera F.), Mex. (Chiapas); axial sec. of syntype,  $\times 10$  (\*1922).  
 —FIG. 314,6. *S. ishanensis* (Hsu), Chungkuh Ls., China(Kuangsi); axial sec. of holotype,  $\times 10$

(\*1922).—FIG. 328A,3. *S. stuckenbergi* (RAUZER-CHERNOUSOVA), Horizon I<sub>1</sub>, U.Carb., USSR (Shiryayev, Samara Bend) (type-sp. of *Rauserites*); axial sec. of holotype,  $\times 15$  (\*1501).—

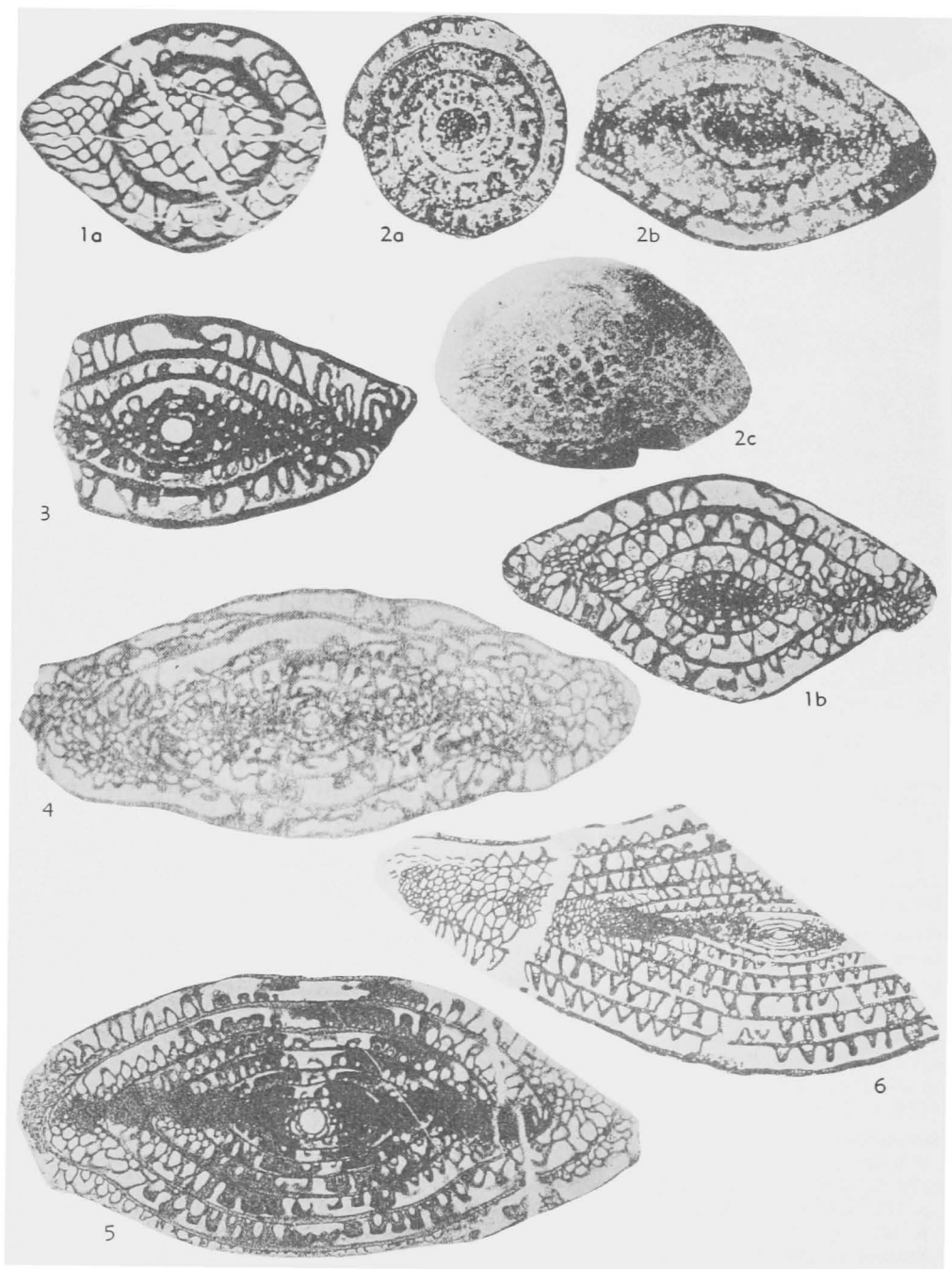


FIG. 314. Fusulinidae (Schwagerininae: 1-6, *Schwagerina*) (p. C415-C416).



FIG. 328A. *S. thuanæ* (VIÊN), Perm., Asia (S. Vietnam) (type-sp. of *Codonoschwagerina*); sec. cut through proloculus,  $\times 5$  (\*2005A). [See also Fig. 277, 1, 3; 280, 6; 281.]

*Acervoschwagerina* HANZAWA, 1949, \*871, p. 207 [*\*Paraschwagerina* (*Acervoschwagerina*) *endoi*;

OD]. Shell large, elongate-fusiform, surface broadly irregular, with 5 or 6 volutions, first 2 or 3 tightly coiled with elongate axis, outer volutions greatly inflated; spirotheca thin, with structure as in *Schwagerina*; septa broadly and irregularly fluted throughout length and height, flut-

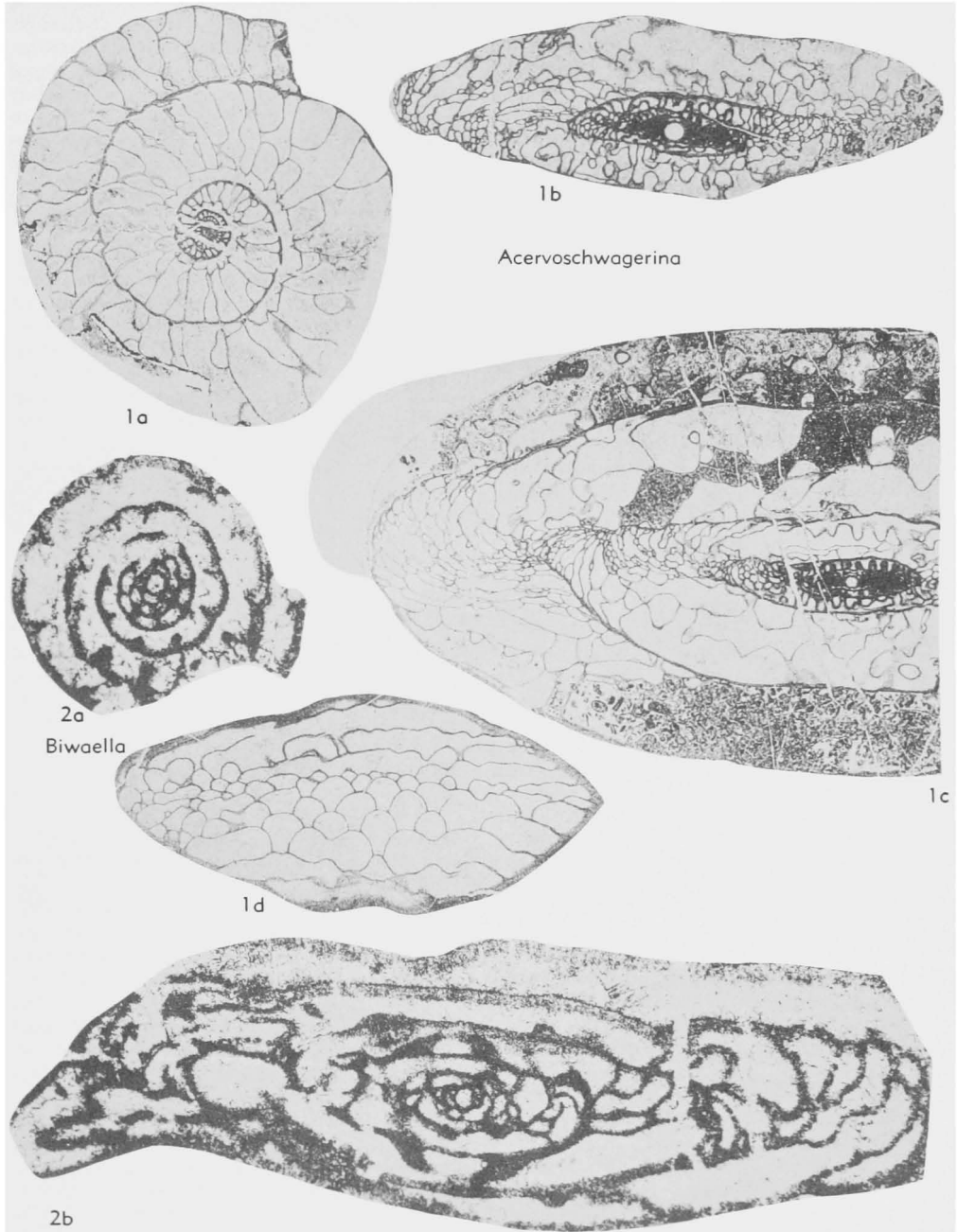


FIG. 315. Fusulinidae (Schwagerininae; 1, *Acervoschwagerina*; 2, *Biwaella*) (p. C417-C418).



- ing in broad irregular contortions, with irregular spacing and without uniform patterns; tunnel singular, enclosed in irregular phrenotheca, bordered by asymmetrical chomata in tightly coiled early part of shell (\*871, \*1926). *L.Perm.*, Japan.—FIG. 315, *l*. \**A. endoi* (HANZAWA), Gombo Ls., Gifu Pref.; *1a*, sagittal sec. of topotype showing phrenotheca over tunnel,  $\times 10$ ; *1b*, axial sec. of submature topotype,  $\times 10$ ; *1c*, axial sec. of mature topotype,  $\times 10$ ; *1d*, tang. sec. of topotype showing irregular fluting of septa,  $\times 10$  (\*1926).
- Biwaella** MORIKAWA & ISOMI, 1960, \*1313, p. 301 [*\*B. omiensis*, OD]. Shell minute, elongate-fusiform, lateral slopes broadly convex, external furrows distinct, more broadly spaced than in most other fusulinids of similar size; axis of coiling straight to irregularly arcuate, first 1 or 2 volutions evolute and coiled at right angles to outer fusiform volutions, shell becoming ellipsoidal at second to third volution and then fusiform, rapidly attaining mature shape; spirotheca thick, composed of tectum and thicker porous lower layer (?keriotheca); septa widely spaced, slightly fluted in polar regions; chomata distinct throughout fusiform part of shell, overhanging along sides of tunnel (\*1313). *L.Perm.*, Japan.—FIG. 315, 2. \**B. omiensis*, Honshu Is.; *2a, b*, sagittal and axial sec. of paratype and holotype,  $\times 50$  (\*1313).
- Dunbarinella** THOMPSON, 1942, \*1919, p. 416 [*\*D. erwinensis*; OD]. Shell moderately large, fusiform, with pointed polar ends; spirotheca composed of tectum and keriotheca; septa highly fluted throughout length, higher in end zones than central region, axial fillings thick in all except last 1 or 2 volutions (\*1919, \*1926). *U.Carb.* (*U. Penn.*)-*L. Perm.*, N. Am.-S. Am. (Peru)-Asia (China-Karakorum)-Japan-Eu.—FIG. 316, *3a-c*. \**D. erwinensis*, U.Penn. (Ervine Creek Sh.), USA (Okla.); *3a*, external view of paratype; *3b*, sagittal sec. of paratype; *3c*, axial sec. of holotype; all  $\times 10$  (\*1922).—FIG. 316, *3d*. *D. eoextenta* THOMPSON, *L.Perm.* (Waldrip No. 1 Ls.), USA (Tex.); axial sec. of paratype,  $\times 10$  (\*1926).—FIG. 316, *3e, f*. *D. tumida* (SKINNER), *L.Perm.* (Neva Ls.), USA (Kans.); *3e, f*, axial and sagittal secs.,  $\times 10$  (\*1926).
- Kansanella** THOMPSON, 1957, \*1927, p. 299 [*\*K. (Kansanella) joensis*; OD]. Shell large, inflated-fusiform to elongate-fusiform; wall of tectum and keriotheca; septa irregularly fluted throughout length and height, axial fillings throughout shell in elongate-fusiform species; chomata prominent in all species, massive throughout shell in inflated forms (\*1927). *U.Penn.*, N. Am.
- K. (Kansanella)** THOMPSON, 1957, \*1927, p. 303. Shell elongate, irregularly fusiform, axis of coiling irregular and shifting; spirotheca thin, composed of tectum and keriotheca; septa thin, closely spaced, fluted throughout their length and height, fluting irregularly spaced both vertically and horizontally, axial fillings throughout most of shell; chomata distinct, broad (\*1927). *U.Penn.*, N. Am.—FIG. 316, *1*. \**K. (K.) joensis*, Iatan Ls., USA (Mo.); *1a*, tang. sec. of paratype showing septal fluting,  $\times 10$ ; *1b*, axial sec. of holotype,  $\times 20$  (\*1927).
- K. (Iowanella)** THOMPSON, 1957, \*1927, p. 301 [*\*Triticites winterensis* THOMPSON, VERVILLE & LOKKE, 1956, \*1932, p. 807; OD]. Shell large, inflated-fusiform; wall structure as in *Triticites*, except thin for shell size; septa irregularly fluted throughout length and to top of chamber; chomata massive, extending to poles in first 5 or 6 volutions (\*1927, \*1932). *U.Penn.*, N. Am.—FIG. 316, 2. \**K. (I.) winterensis* (THOMPSON, VERVILLE & LOKKE), Winterset Ls., USA (Iowa); *2a*, tang. sec. of paratype,  $\times 10$ ; *2b*, axial sec. of holotype,  $\times 20$  (\*1927).
- Kwantoella** SAKAGAMI & OMATA, 1957, \*1621, p. 251 [*\*K. fujimotoi*; OD]. Shell minute, elongate-subcylindrical to fusiform; coiling planispiral about large proloculus; composed of 5 or 6 volutions; spirotheca composed of tectum and keriotheca; septa plane in most of shell, fluting confined to end regions and base of septa, axial fillings thickest in extreme ends but more massive in 2nd to 5th volutions; chomata distinct (\*1621). *L. Perm.*, Japan.—FIG. 317, *4*. \**K. fujimotoi*, Shiraiwa Ls., Ome, Tokyo Pref.; *4a, c*, axial sec. of holotype and enlarged part,  $\times 30$ ,  $\times 100$ ; *4b*, sagittal sec. of paratype,  $\times 30$  (\*1621).
- Nagatoella** THOMPSON, 1936, \*1916, p. 196 [*\*Fusulina (Schellwieinia) ellipsoidalis* var. *orientis* OZAWA, 1925; \*1401A, p. 22; OD]. Shell ellipsoidal, polar ends rounded; spirotheca composed of tectum and thick keriotheca; septa fluted at base, axial fillings thick, widespread (\*1013, \*1916). *Perm.*, Japan.—FIG. 317, *3a*. \**N. orientis* (OZAWA), Akiyoshi Ls., Yamaguchi Pref.; *3a*, axial sec. of holotype,  $\times 10$  (\*1922).—FIG. 317, *3b, c*. *N. Kobayashii* THOMPSON, Akiyoshi Ls., Yamaguchi Pref.; *3b*, tang. sec. of holotype,  $\times 10$  (\*1916); *3c*, axial sec.,  $\times 10$  (\*1013).
- Nipponitella** HANZAWA, 1938, \*868, p. 256 [*\*N. explicata*; OD]. Early shell fusiform, coiled like *Triticites*, gerontic stage irregularly and loosely uncoiled; spirothecal structure like that in *Triticites*; septa fluted at base across fusiform part, irregularly and highly fluted in uncoiled part, giving forward arcuate attitude in uncoiled part (\*868). *Perm.*, NE. Japan.—FIG. 317, *1*. \**N. explicata*, Maiya Gr., Rikuzen Prov.; *1a*, axial sec. of paratype; *1b, c*, tang. secs. of paratype and holotype; all  $\times 10$  (\*1922) (see also Fig. 284, *1b*). [See Fig. 284, *1a*, *N. auricula*.]
- Oketaella** THOMPSON, 1951, \*1925, p. 116 [*\*O. fryei*; OD]. Shell minute, inflated-ellipsoidal to fusiform; proloculus large, shell loosely coiled; spirotheca composed of tectum and alveolar keriotheca; tunnel singular, chomata distinct (\*1925, \*1926). *U.Penn.-L. Perm.*, N. Am.—FIG. 317, 2. \**O. fryei*, L.Perm. (Oketo Sh.), USA (Kans.); *2a*,

axial sec. of holotype,  $\times 50$ ; 2*b*, sagittal sec. of topotype,  $\times 50$  (\*1926).

*Orientoschwagerina* A. D. MIKLUKHO-MAKLAY, 1955, \*1264, p. 573 [*O. abichi*; OD]. Shell

large, inflated-fusiform, first few volutions tightly coiled, highly elongate, outer ones greatly inflated, last volution slightly more tightly coiled than those preceding; wall composed of three layers?,

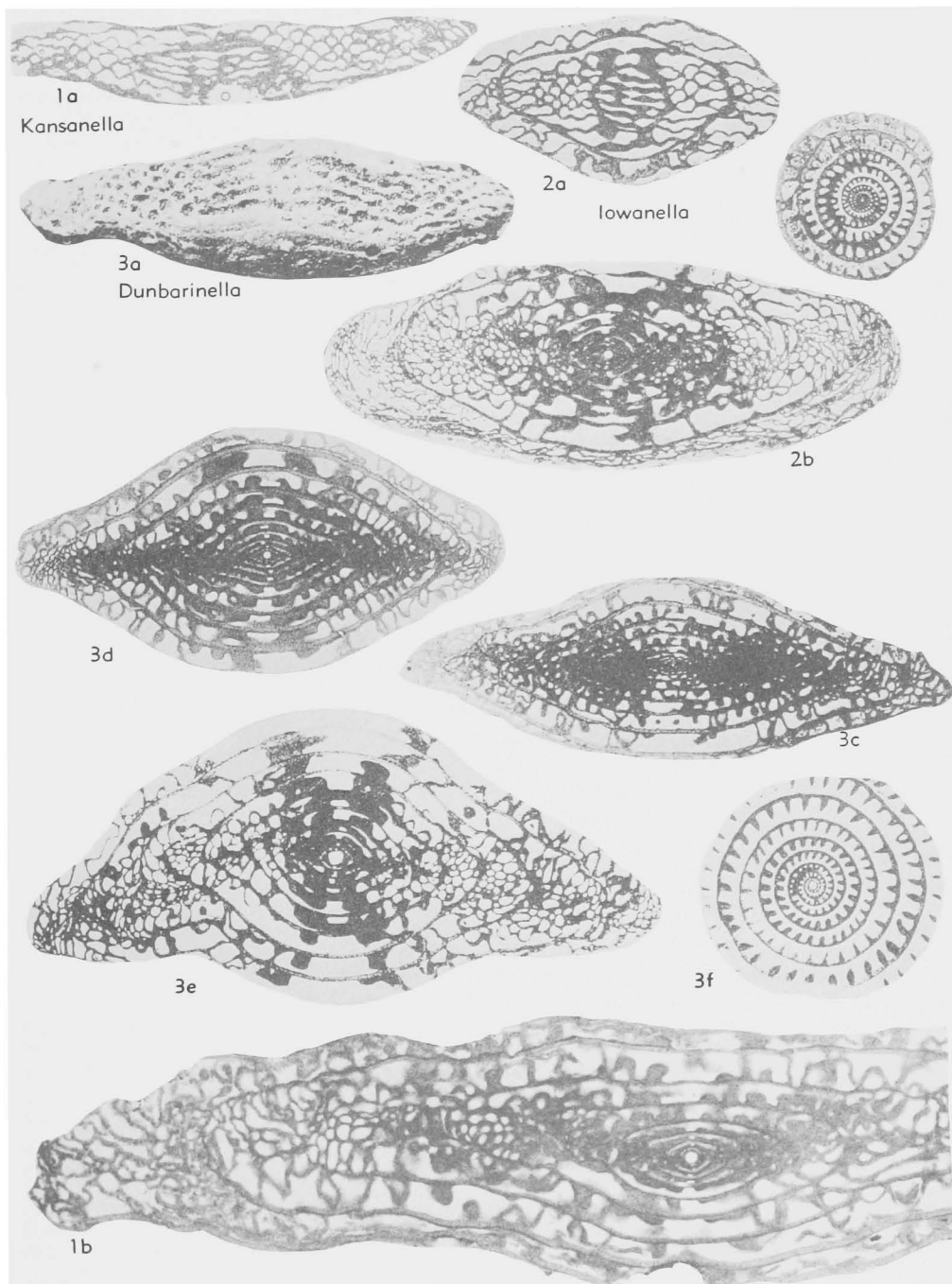


FIG. 316. Fusulinidae [Schwagerininae; 1, *Kansanella* (*Kansanella*); 2, *K. (lowanella)*; 3, *Dunbarinella*] (p. C418).

- spirotheca increasing in thickness only slightly during early, tightly coiled part of shell, becoming thinner in next 2 or 3 volutions, and then distinctly thicker in outer part of shell, keriotheca composed of upper and lower layers; septa closely spaced in tightly coiled inner part of shell, more widely spaced in outer volutions; chomata distinct in early part of shell, very faint and indistinct in outer inflated volutions (\*1264). *Perm.*, USSR.—FIG. 317,5. \**O. abichi*, Transcaucasia; 5a,b, axial sec. of holotype and enlargement of internal part,  $\times 15$ ,  $\times 40$  (\*1264).
- Parafusulina** DUNBAR & SKINNER, 1931, \*644, p. 258 [*\*P. wordensis*; OD] [= *Monodiexodina* SOSNINA in KIPARISOVA *et al.*, 1956, \*1040, p. 24 (type, *Schwagerina wanneri sutschanica* DUTKEVITCH in LIKHAREV, *et al.*, 1939, \*1138, p. 39; OD); *P. (Eoparafusulina)* COOGAN, 1960, \*381, p. 262 (type, *Fusulina gracilis* MEEK, 1862, \*1257A, p. 4; OD); *P. (Skinnerella)* COOGAN, 1960, \*381, p. 262 (type, *P. schucherti* DUNBAR & SKINNER, 1937, \*646, p. 672; OD)]. Shell elongate, cylindrical to irregular in shape; spirotheca composed of tectum and alveolar keriotheca, abnormally thin for size of shell; septa intensely fluted, forming cuniculi; axial fillings heavy (\*381, \*644, \*1816, \*1922). *Perm.*, S.Am. (Peru-Colombia-Venez.)-C.Am. (Guatemala)-Mex.-USA-N.Can.-W.Can.-Malay Arch. (Indonesia-Malaya)-Japan-Asia (N.India-China).—FIG. 318,1a. *P. sutschanica* (DUTKEVITCH), Perm. (Doliolinovaya F.), USSR (Ussuriy Region); axial sec., approx.  $\times 6.8$  (\*1816).—FIG. 318,1b. *P. gracilis* (MEEK), L.Perm. (McCloud Ls.), USA (Calif.); axial sec.,  $\times 10$  (\*1934) (see also Fig. 276,1b).—FIG. 318,1c-e. *P. nosonensis* THOMPSON & WHEELER, L. Perm. (Nosoni F.), USA (Calif.); 1c, axial sec. of holotype; 1d, sagittal sec. of paratype; 1e, tang. sec. of paratype showing development of cuniculi; all  $\times 10$  (\*1922) (see also Fig. 275,6a, 276,1a, 287).—FIG. 318,1f. *P. schucherti* DUNBAR & SKINNER, L.Perm. (Bone Spring F.), USA (Tex.); axial sec. of lectotype,  $\times 10$  (\*646). [See also Fig. 275,6b, *P. wanneri*; 278, \**P. wordensis*; 282,1-6.]
- Paraschwagerina** DUNBAR & SKINNER, 1936, \*645, p. 89 [*\*Schwagerina gigantea* WHITE, 1932, \*2056, p. 82; OD]. Shell inflated, fusiform, first 2 or 3 volutions tightly coiled and elongate-fusiform; outer volutions distinctly inflated-fusiform; spirothecal structure as in *Schwagerina*; septa highly fluted throughout (\*645, \*1926). *L.Perm.*, N.Am.-C.Am.-Asia.—FIG. 318.2. \**P. gigantea* (WHITE), Wolfcamp. F., USA (Tex.); 2a, axial sec. of holotype,  $\times 10$  (\*1922); 2b, tang. sec.,  $\times 10$  (\*1926) (see also Fig. 284,2).
- Polydiexodina** DUNBAR & SKINNER, 1931, \*644, p. 263 [*\*P. capitansensis*; OD]. Shell highly elongate-subcylindrical; spirothecal structure as in *Parafusulina*; cuniculi throughout shell; multiple tunnels; axial fillings heavy (\*644, \*1921). *U. Perm.*, USA (Tex.-N.Mex.)-Mex.-Eu. (Greece-Turkey-Yugo.-Crimea)-Asia (Afghan.-Iran-Iraq-India)-USSR (Darvaz).—FIG. 319,2a,b. *P. afghanensis* THOMPSON, Bamian Ls., Afghan.; 2a, tang. sec. of paratype showing numerous auxiliary tunnels,  $\times 10$ ; 2b, enlarged part of axial sec. showing structure of spirotheca,  $\times 100$  (\*1922) (see also Fig. 285,1a).—FIG. 319,2c. \**P. capitansensis*, Capitan Ls., USA (Tex.); axial sec. of holotype,  $\times 10$  (\*1922) (see also Fig. 285,1b).
- Pseudofusulina** DUNBAR & SKINNER, 1931, \*644, p. 252 [*\*P. huecoensis*; OD] [= *Grabauina* LEE, 1924, \*1118, p. 51 (type, *G. disca*; OD); *Leeina* GALLOWAY, 1933, \*762, p. 406 (type, *Fusulina vulgaris fusiformis* SCHELLWIEN in DYHRENFURTH, 1909, \*650A, p. 165; OD)]. Shell fusiform, large, loosely coiled throughout; spirotheca thick, with structure like *Schwagerina*; septa broadly but highly fluted, axial fillings light in some, absent in most, phrenothecae abundant (\*644, \*762, \*1118, \*1922). *L.Perm.*, N.Am.-S.Am.-C.Am.-Eu.-Asia-Japan-Asia Minor.—FIG. 319,1a. \**P. huecoensis*, Hueco Ls., USA (Tex.); tang. sec. of paratype, approx.  $\times 10$  (\*1922) (see also Fig. 291,2, holotype).—FIG. 319,1b. *P. disca* (LEE), Taiyuan Ser., China; axial sec. of holotype,  $\times 30$  (\*1922).—FIG. 319,1c. *P. vulgaris fusiformis* (SCHELLWIEN), USSR (Darvaz Ser.); axial sec. of holotype,  $\times 15$  (\*1922). [See also Fig. 291,1, *P. nelsoni*.]
- Pseudoschwagerina** DUNBAR & SKINNER, 1936, \*645, p. 89 [*\*Schwagerina uddeni* BEEDE & KNIKER, 1924, \*105, p. 27; OD] [= *Occidentoschwagerina* A. D. MIKLUKHO-MAKLAY, 1959, \*1271, p. 166 (type *Schwagerina fusulinoides* SCHELLWIEN, 1898, \*1644, p. 259; OD); *Parazellia RAUZER-CHERNOUSOVA*, 1961, \*1506, p. 9 (type, *Fusulina muongthensis* DEPRAT, 1915, \*587A, p. 5; OD)]. Shell inflated-fusiform, first 2 or 3 volutions tightly coiled, outer ones inflated; spirotheca as in *Schwagerina*; septa fluted at base, closely spaced at first, widely spaced later (\*645, \*1271, \*1506, \*1926). *L.Perm.*, N.Am.-S.Am.-Eu.-Asia-Malay Arch.-Japan-Arct. Is.—FIG. 320,1a. *P. roesleri* THOMPSON & HAZZARD, Bird Spring F., USA (Calif.); axial sec. of holotype,  $\times 8.3$  (\*1922).—FIG. 320,1b. *P. fusulinoides* (SCHELLWIEN), Uggowitz Breccie, Aus. (Carnic Alps); polished axial sec.,  $\times 8.3$  (\*1644).—FIG. 320,1c. \**P. uddeni* (BEEDE & KNIKER), Hueco Ls., USA (Tex.); axial sec. of holotype,  $\times 8.3$  (\*1922). [See also Fig. 284,4, *P. muongthensis*.]
- Robustoschwagerina** A. D. MIKLUKHO-MAKLAY, 1959, \*1271, p. 160 [*\*Pseudoschwagerina tumida* LIKHAREV, 1939, \*1138, p. 41; OD] [= *Robustoschwagerina* A. D. MIKLUKHO-MAKLAY, 1956, \*1265, p. 1154 (nom. nud.)]. Shell large, deeply umbilicate, highly inflated, first 2 or 3 volutions distinctly fusiform in shape, moderately tightly coiled, and containing prominent chomata, next 3 volutions greatly inflated, deeply umbili-

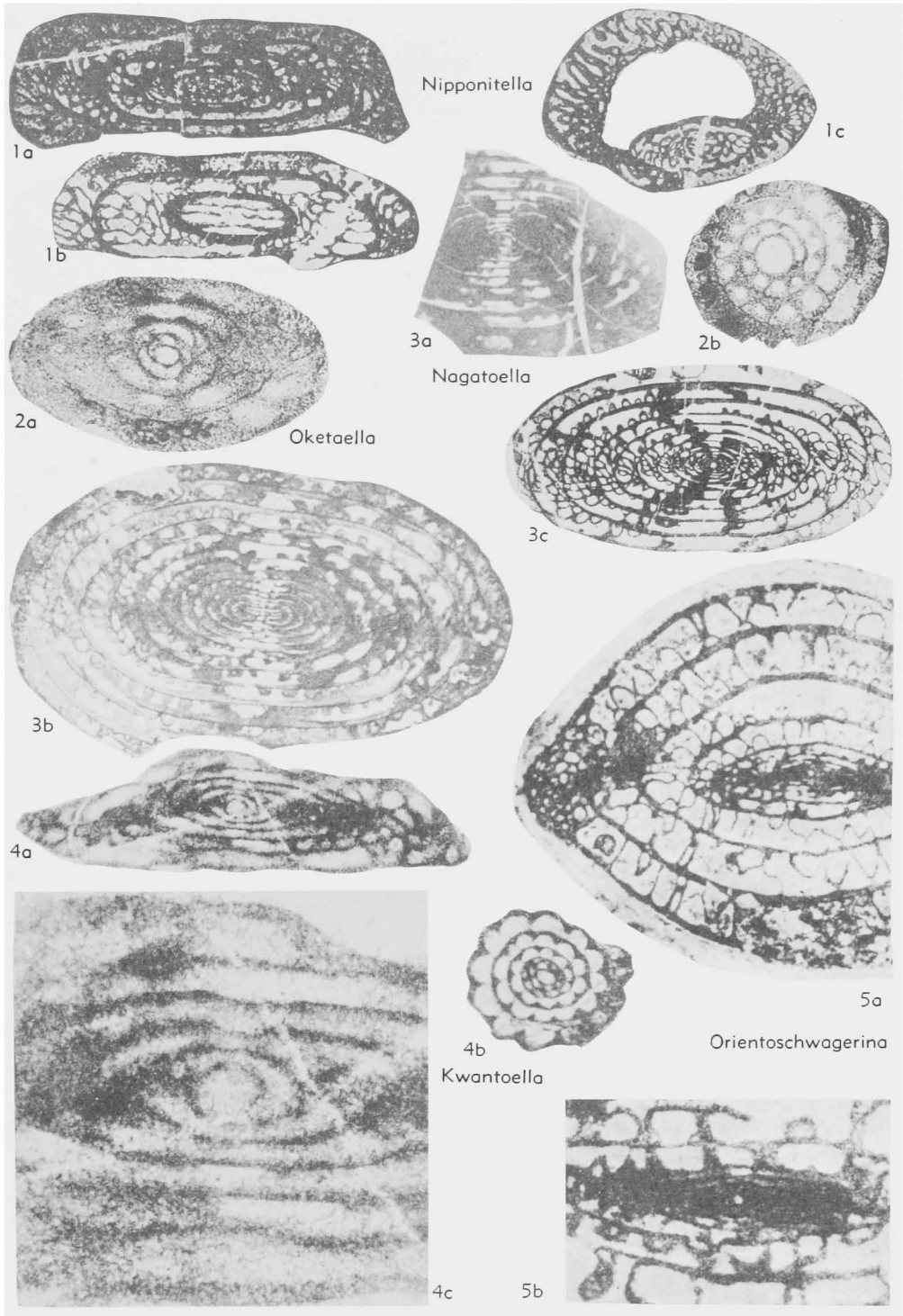


FIG. 317. Fusulinidae (Schwagerininae: 1, *Nipponitella*; 2, *Oketaella*; 3, *Nagatoella*; 4, *Kwantoella*; 5, *Orientoschwagerina*) (p. C418-C420).

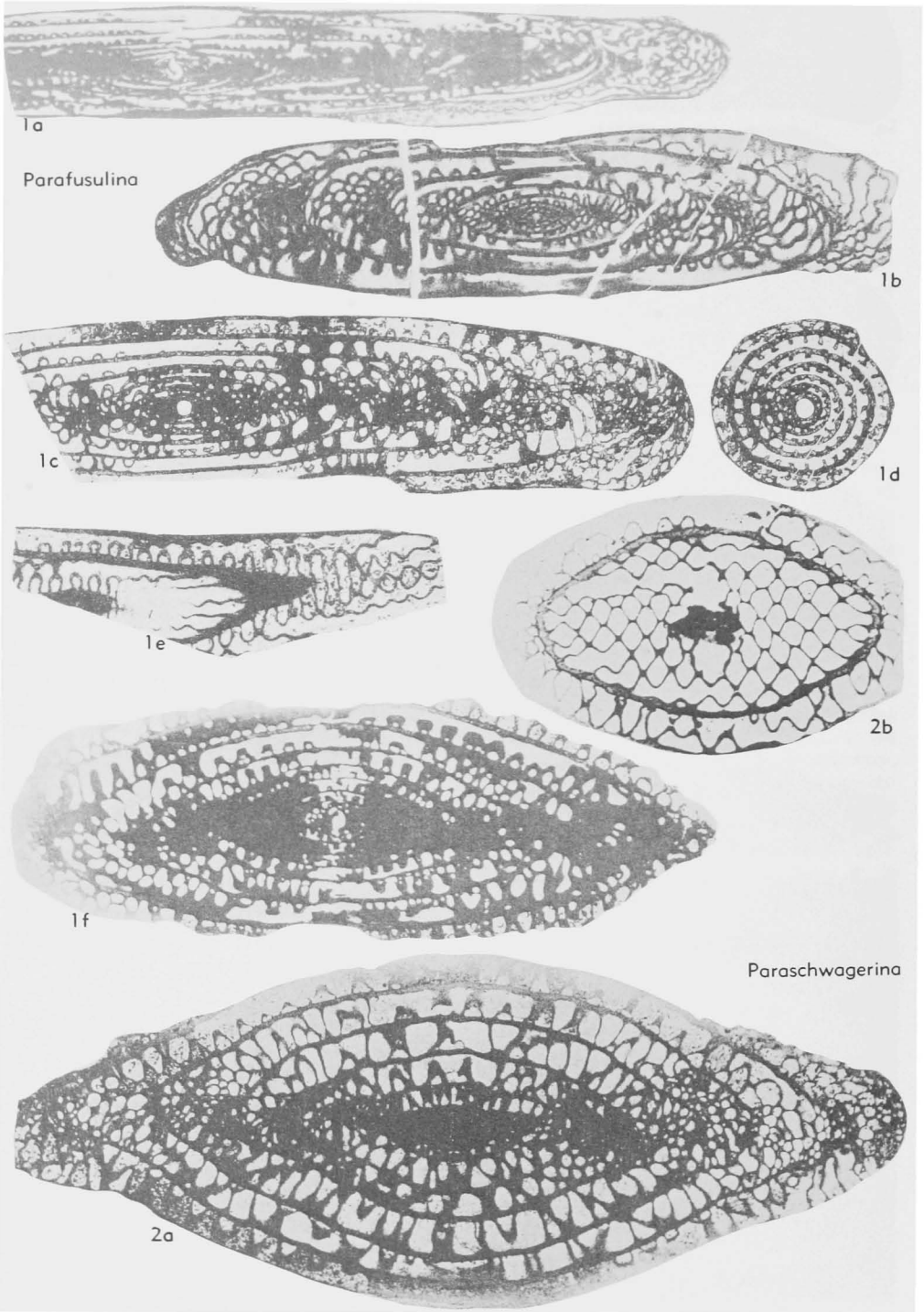


FIG. 318. Fusulinidae (Schwagerininae; 1, *Parafusulina*; 2, *Paraschwagerina*) (p. C420).

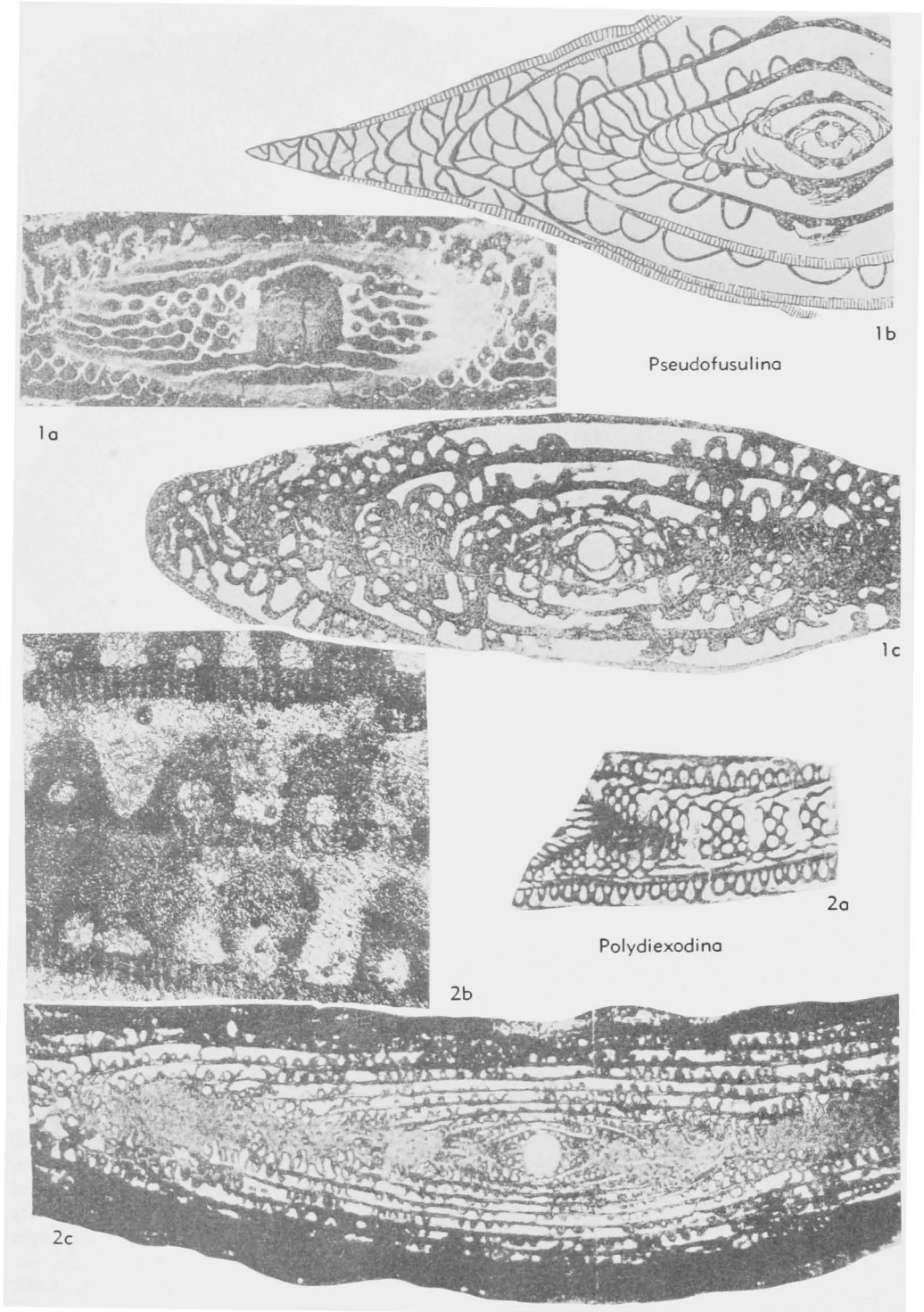


FIG. 319. Fusulinidae (Schwagerininae; 1, *Pseudofusulina*; 2, *Polydiexodina*) (p. C420).



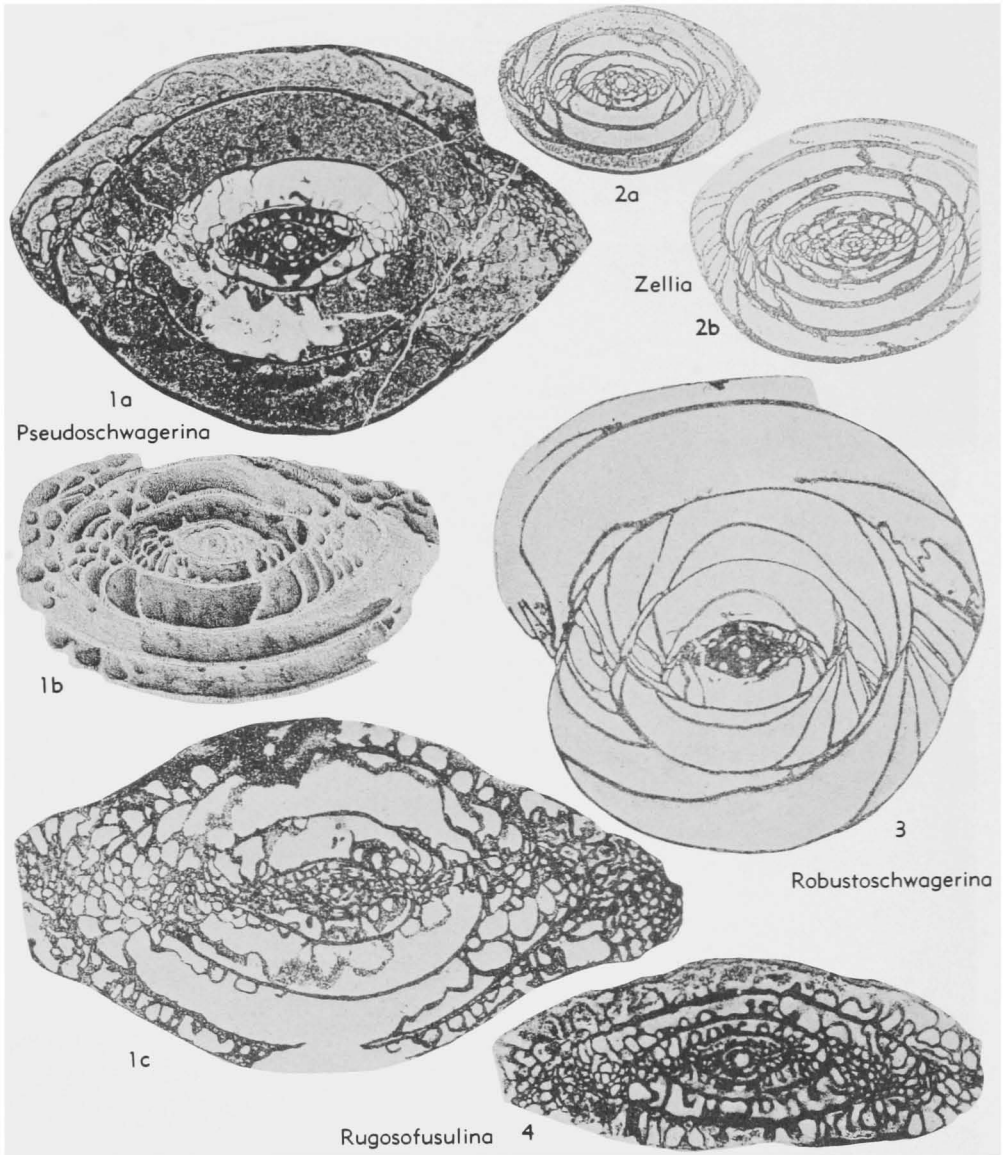


FIG. 320. Fusulinidae (Schwagerininae; 1, *Pseudoschwagerina*; 2, *Zellia*; 3, *Robustoschwagerina*; 4, *Rugosofusulina*) (p. C420-C424, C426).

cate, with very faint chomata against widely spaced septa, outer part of last volution more tightly coiled and with moderately thick spirotheca (\*1138, \*1265). *Perm.*, USSR.—FIG. 320, 3. \**R. tumida* (LIKHAREV), Darvaz Ser., Darvaz; axial sec. of holotype,  $\times 8.3$  (\*1138) (see also Fig. 284,3).

**Rugosofusulina** RAUZER-CHERNOUSOVA, 1937, \*1500, p. 11 [*\*Alveolina prisca* EHRENBERG, 1842, \*669A, p. 274; OD] [= *Rugofusulina* DUNBAR in CUSHMAN, 1940, \*637B, p. 146 (*nom. null.*)]. Shell

irregularly fusiform; spirotheca thick, composed of tectum and alveolar keriotheca, surface of spirotheca undulating in somewhat uniformly spaced rugae; septa moderately highly and irregularly fluted throughout length of shell; chomata slight to heavy (\*1500). *L.Perm.*, Eu.-Asia-N.Am.—FIG. 320,4. \**R. prisca* (EHRENBERG), USSR (Tsarev Kurgan); axial sec. of one of VON MÖLLER's specimens used in defining genus,  $\times 12.5$  (\*1922).



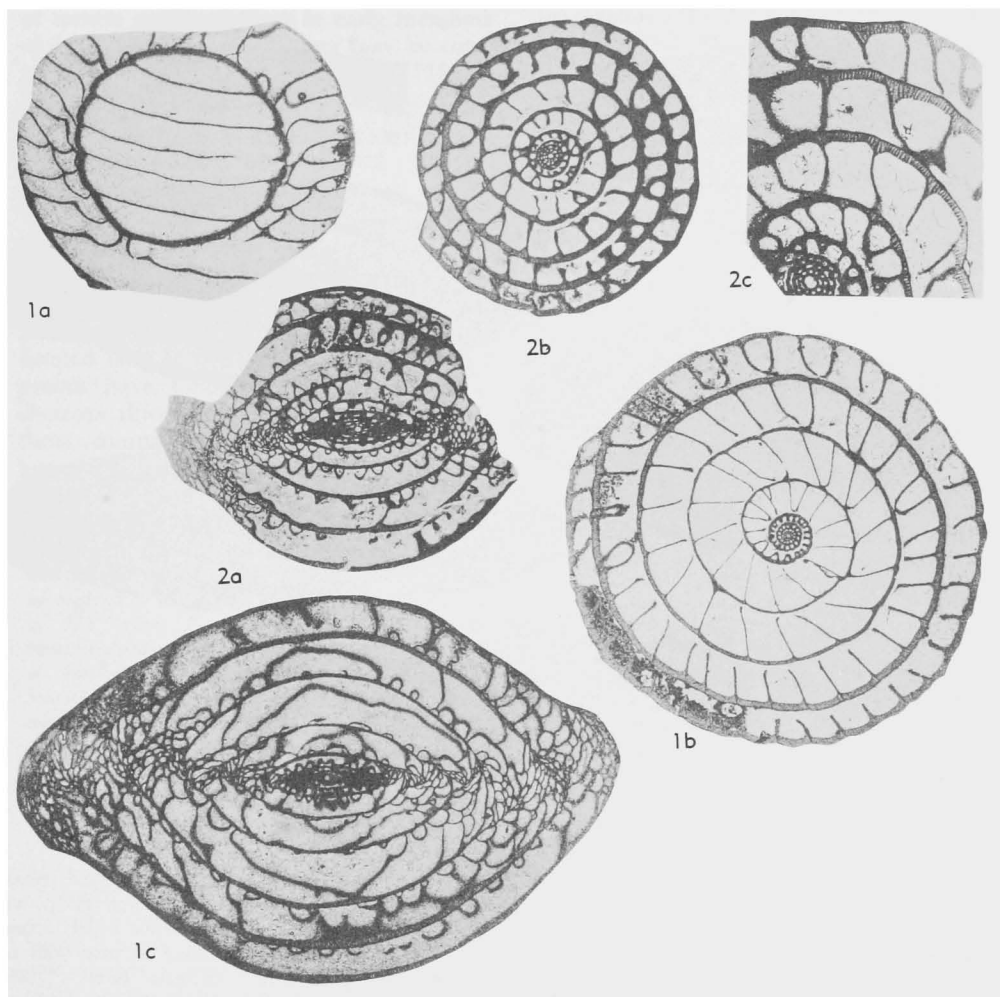


FIG. 321. Fusulinidae (Schwagerininae; 1,2, *Rugososchwagerina*) (p. C425).

**Rugososchwagerina** A. D. MIKLUKHO-MAKLAY, 1959, \*1271, p. 160 [*Schwagerina yabei* STAFF, 1909, \*1830, p. 463; OD] [= *Rugososchwagerina* A. D. MIKLUKHO-MAKLAY, 1956, \*1265, p. 1154 (*nom. nud.*)]. Shell inflated-fusi-form, first 3 or 4 volutions tightly coiled, elongate-fusi-form, outer volutions greatly inflated; spirotheca with structure as in *Schwagerina*, moderately thin in early, tightly coiled part of shell and next 1 or 2 volutions, becoming rather thick and more coarsely alveolar in outer 2 or 3 volutions; septa closely spaced in first 3 or 4 volutions, more widely spaced in next 2 or 3 and then more closely spaced again in outer 1 or 2; chomata moderately well developed but somewhat discontinuous throughout most of shell, absent in outer volution (\*1271). *U. Perm.* (*Verbeekina* Z.), Eu. (Sicily)-Asia (Iran-Iraq-Afghan.-W. China-Asia

Minor).—FIG. 321, 1a-c. \**R. yabei* (STAFF), Sosio Beds, Sicily; 1a-c, tang., sagittal, and axial secs.,  $\times 8$  (\*1922).—FIG. 321.2. *R. fosteri* (THOMPSON & MILLER), Yanghsin Ls., W. China; 2a, axial sec. of lectotype,  $\times 8$ ; 2b,c, sagittal sec. of paratype,  $\times 8$ ,  $\times 16$  (\*1922).

**Triticites** GIRTY, 1904, \*789, p. 234 [*Miliolites secalicus* SAY in JAMES, 1823, \*984A, p. 328; OD] [= *Girtyina* STAFF 1909, \*1830, p. 490 (type, *Fusulina cylindrica* var. *ventricosa* MEEK & HAYDEN, 1859, \*1251B, p. 261; OD); *Triticites (Montiparus)* ROZOVSKAYA, 1948, \*1590, p. 1637 (type, *Alveolina montipara* EHRENBERG, 1854, \*680, p. xxxviii; OD); *Protriticites* PUTRYA, 1948, \*1492, p. 91 (type *P. globulus*; OD); ?*Obsoletes* KIREEVA, 1950, \*1040B, p. 201 (type, *Fusulina obsoleta* SCHELLWIEN, 1908, \*1645A, p. 186; OD); *Ferganites* A. D. MIKLUKHO-MAKLAY, 1959,

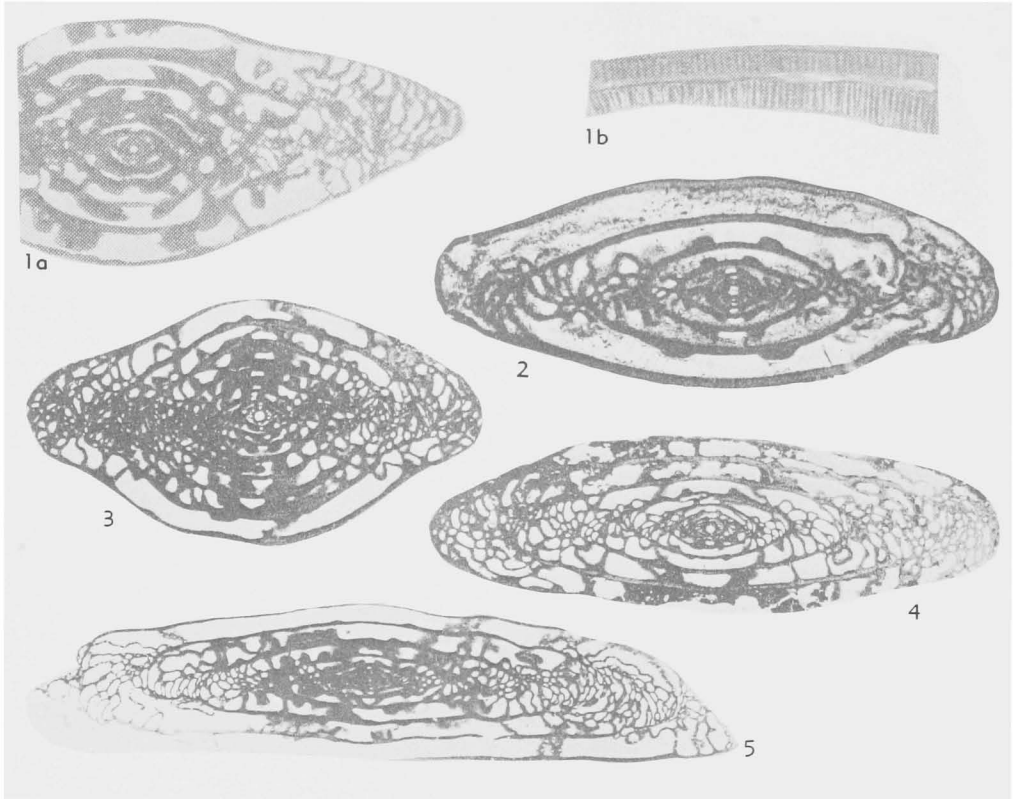


FIG. 322. Fusulinidae (Schwagerininae; 1-5, *Triticites*) (p. C425-C426).

\*1270A, p. 16 (type, *Triticites ferganensis* A. D. MIKLUKHO-MAKLAY, 1950, \*1261A, p. 61,68; OD]. Shell fusiform to subcylindrical, planispiral throughout; spirotheca composed of tectum and alveolar keriotheca; septa fluted in end zones but less highly fluted in center of shell; chomata distinct (\*789, \*1270A, \*1492, \*1590, \*1830). U. Carb. (U. Penn.) - L. Perm., N. Am. (USA-Can.) - ?China-Japan-USSR-S. Am. (Chile-Peru). — FIG. 322, 1. *T. globulus* (PUTRYA), C<sub>3</sub>F., USSR (European); 1a, axial sec. of holotype,  $\times 15$ ; 1b, apparent double wall of "*Protriticites*" *globulus*, approx.  $\times 80$  (\*1492). — FIG. 322, 2. *T. milleri* THOMPSON, U. Penn. (Hartville Ls.), USA (Wyo.); axial sec. of syntype,  $\times 20$  (\*1922). — FIG. 322, 3. *T. beedei* DUNBAR & CONDRA, U. Penn. (Ervine Creek Ls.), USA (Kans.); axial sec. of syntype,  $\times 10$  (\*1922). — FIG. 322, 4. *T. secalicus* (SAY), U. Penn. (Plattsmouth Ls.), USA (Neb.); axial sec.,  $\times 10$  (\*1922). — FIG. 322, 5. *T. ohioensis* THOMPSON, U. Penn. (Cambridge Ls.), USA (Ohio); axial sec. of syntype,  $\times 10$  (\*1922). [See also Fig. 274, 4, 275, 4, 277, 2, *T. ventricosus*; 280, 4, 5.]

*Zellia* KAHLER & KAHLER, 1937, \*1009, p. 20 [\**Pseudoschwagerina* (*Zellia*) *heritschi* var. *heritschi*; OD]. Shell inflated-sub-spherical, slightly umbilicate; proloculus large, chambers expanding

uniformly in first 2 or 3 volutions, then remaining inflated to maturity; spirotheca thick, with coarsely alveolar keriotheca; septa widely spaced, plane except for slight fluting at base with numerous septal pores; chomata faint (\*1009). Perm., Eu. (Aus. - Yugo.) - USSR (Darvaz)-Japan-Asia (Vietnam-China). — FIG. 320, 2. *\*Z. heritschi* (KAHLER & KAHLER), L. Perm., Aus. (Carnic Alps); 2a, axial sec. of paratype,  $\times 8.3$ ; 2b, tang. sec. of holotype,  $\times 7.5$  (\*1922).

#### Family VERBEEKINIDAE Staff & Wedekind, 1910

[*nom. transl.* A. D. MIKLUKHO-MAKLAY, 1957, p. 110 (ex subfamily Verbeekiniinae STAFF & WEDEKIND, 1910)] [= Neoschwagerinidae DUNBAR in CUSHMAN, 1948, p. 164]

Shell of medium size, spherical, ellipsoidal to elongate-ellipsoidal, or distinctly fusiform. Closely spaced foramina through the bases of all septa. Parachomata discontinuous in early forms, becoming extended completely across chambers in later forms. Axial and transverse septula hang from spirotheca of some later genera. Axial fillings present in most forms, becoming prominent in some. Spirotheca composed

of tectum and keriotheca in early members of family but in later genera may be composed of single homogeneous layer (\*1832). *Perm.*

**Subfamily VERBEEKININAE**  
von Staff & Wedekind, 1910

[Verbeekinae STAFF & WEDEKIND, 1910, p. 114] [=Doliolininae GUBLER, 1935, p. 9; =Misellininae A. D. MIKLUKHO-MAKLAY, 1958, p. 9]

Shell large, subspherical to elongate-ellipsoidal, completely involute, planispiral; early genera with tunnel in first few volutions, later ones with multiple tunnels, and last-formed ones with foramina, but advanced genera have foramina bordered by parachomata throughout length of shell; spirotheca composed of tectum and alveolar keriotheca or of single thin layer (\*1832). *Perm.*

**Verbeekina** STAFF, 1909, \*1830, p. 468, 476 [\**Fusulina verbeeki* GEINITZ in GEINITZ & VON DER MARCK, 1876, \*776A, p. 400; OD] [=*Paraverbeekina* A. D. MIKLUKHO-MAKLAY, 1955, \*1264, p. 574 (type, *P. pontica*); *Armenina* A. D. MIKLUKHO-MAKLAY, 1955, \*1264, p. 576 (type, *A. karinae*)]. Shell spherical to slightly ellipsoidal; symmetrical in all volutions; foramina throughout length of septa, parachomata discontinuous in inner volutions and continuous across chambers in outer volutions; spirotheca composed of tectum and finely alveolar keriotheca (\*1264, \*1401, \*1865, \*1914, \*1922). *U.Perm.* (*Verbeekina* Z.), Eu. (Sicily-Greece-Yugo.)-Asia (Asia Minor-S., SE. Asia-Indonesia)-Japan-N.Am. (Can., B.C.-USA, Wash.).—FIG. 323, *1a-d*. \**V. verbeeki* (GEINITZ), Sumatra (Boekit Besi); *1a*, broken topotype showing parachomata developed only adjacent to septa in 10th volution,  $\times 8$ ; *1b*, etched surface of the same topotype (*1a*) showing development of parachomata in outer volution,  $\times 8$ ; *1c*, central part of axial sec. of topotype,  $\times 32$ ; *1d*, axial sec. of topotype,  $\times 8$  (\*1922) (see also Fig. 274, 5, 288, 3).—FIG. 323, *1e*. *V. grabaui* THOMPSON & FOSTER, Yanghsin Ls., China (Szechuan); axial sec. of syntype,  $\times 8$  (\*1922).—FIG. 323, *1f*. *V. karinae* (A. D. MIKLUKHO-MAKLAY), USSR (Transcaucasia); axial sec.,  $\times 12$  (\*1264).—FIG. 323, *1g*. *V. pontica* (A. D. MIKLUKHO-MAKLAY), USSR (Crimea); axial sec. of holotype,  $\times 12$  (\*1264).

**Brevaxina** SCHENCK & THOMPSON, 1940, \*1646, p. 587 [\**Doliolina compressa* DEPRAT, 1915, \*587A, p. 14; OD]. Shell small, subspherical, axis of coiling in shortest diameter through proloculus, polar ends deeply umbilicate; spirotheca thick, with structure as in *Misellina*; parachomata high, extending more than half height of chambers; foramina circular in section, located near lower part of chamber, numerous (as many as 24) in

last volution (\*1646). *Perm.*, Asia (Laos-USSR).—FIG. 323, 2. \**B. compressa* (DEPRAT), Laos (Cammon); *2a*, sagittal sec. of paratype,  $\times 12$ ; *2b*, axial sec. of holotype,  $\times 12$  (\*1922).

**Eoverbeekina** LEE, 1933 [1934], \*1120, p. 18 [\**E. intermedia*; OD]. Shell subspherical; tunnel singular in early volutions, dividing into 2 at 5th volution, foramina throughout length of shell in outer volutions; narrow chomata in inner volutions, rudimentary parachomata in outer volutions; spirotheca composed of tectum and keriotheca (\*1120). *Perm.*, C.Am.-Asia (China)-Japan.—FIG. 323, 3. \**E. intermedia*, Chihsia Ls., China; axial sec. of holotype,  $\times 12$  (\*1922).

**Misellina** SCHENCK & THOMPSON, 1940, \*1646, p. 587 [\**Doliolina ovalis* DEPRAT, 1915, \*587A, p. 15; OD] [= *Moellerina* SCHELLWIEN, 1898, \*1644, p. 238, 257, 281 (type, *Schwagerina lepida* SCHWAGER, 1883, \*1706, p. 138) (*non Moellerina* ULRICH, 1886, *nec* EIMER & FICKERT, 1899); *Doliolina* SCHELLWIEN, 1902, \*1645, p. 67 (type, *Schwagerina lepida* (*nom. subst. pro Moellerina* SCHELLWIEN, 1898) (*non Doliolina* BORGERT, 1894)]. Shell ellipsoidal, axis of coiling in greatest diameter; spirotheca thick, composed of tectum and thick keriotheca; foramina throughout shell; parachomata high, extending across chamber (\*1644, \*1645, \*1646). *U.Perm.*, SE.Eu.-SE. Asia (Laos-China)-Japan-Malay Arch. (Sumatra)-?NW.N.Am.—FIG. 324, 1. \**M. ovalis* (DEPRAT), Laos (Cammon); *1a, b*, tang. and parallel secs. of paratype,  $\times 15$ ; *1c*, axial sec. of holotype,  $\times 15$  (\*1922).

**Pseudodoliolina** YABE & HANZAWA, 1932, \*2094, p. 41 [\**P. ozawai*; OD] [= *Metadoliolina* ISHII & NOGAMI, 1961, \*978A, p. 162 (type, *Pseudodoliolina pseudolepida gravitesta* KANMERA, 1954, \*1012, p. 12)]. Shell elongate-cylindrical, uniformly expanding, with bluntly rounded polar ends; spirotheca thin in inner 10 volutions where it seems composed of single thin layer, from 12th volution to maturity spirotheca thin but can be recognized in some specimens as composed of tectum, thin inner layer, and middle layer with dark lines normal to its surfaces that may be comparable to alveoli of other fusulinids; septa plane, composed of single, dense layer; foramina closely spaced; parachomata narrow, high, with circular lateral openings (\*1929, \*2094). *U.Perm.* (*Verbeekina* Z.), N.Am. (W.Can.-NW.USA)-E. Indies-Japan-Asia (Afghan.-S., E. China-Asia Minor)-Eu. (Yugo.-Crimea).—FIG. 324, 2a, b. *P. pseudolepida* (DEPRAT), China (Szechuan); *2a, b*, sagittal and axial secs.,  $\times 10$  (\*1922).—FIG. 324, 2c, d. \**P. ozawai*, Akasaka Ls., Japan (Mino Prov.); *2c, d*, axial and sagittal secs. of topotypes,  $\times 20$  (\*1922).

**Subfamily NEOSCHWAGERININAE**  
Dunbar & Condra, 1928

[Neoschwagerininae DUNBAR & CONDRA, 1927 [1928], p. 74] [= Sumatrininae KÄHLER & KÄHLER, 1946, p. 170; = Lepidolininae A. D. MIKLUKHO-MAKLAY, 1958, p. 10]

Shell planispiral, fusiform to ellipsoidal; spirotheca composed of tectum and alveolar keriotheca or of a single dense layer; foramina throughout length of shell; parachomata high, extending across chambers;

transverse septula in all members, axial septula and transverse septula in later members, secondary transverse septula in latest members (\*640, \*1832). *U.Perm.*

*Neoschwagerina* YABE, 1903, \*2083, p. 3 [*Schwag-*

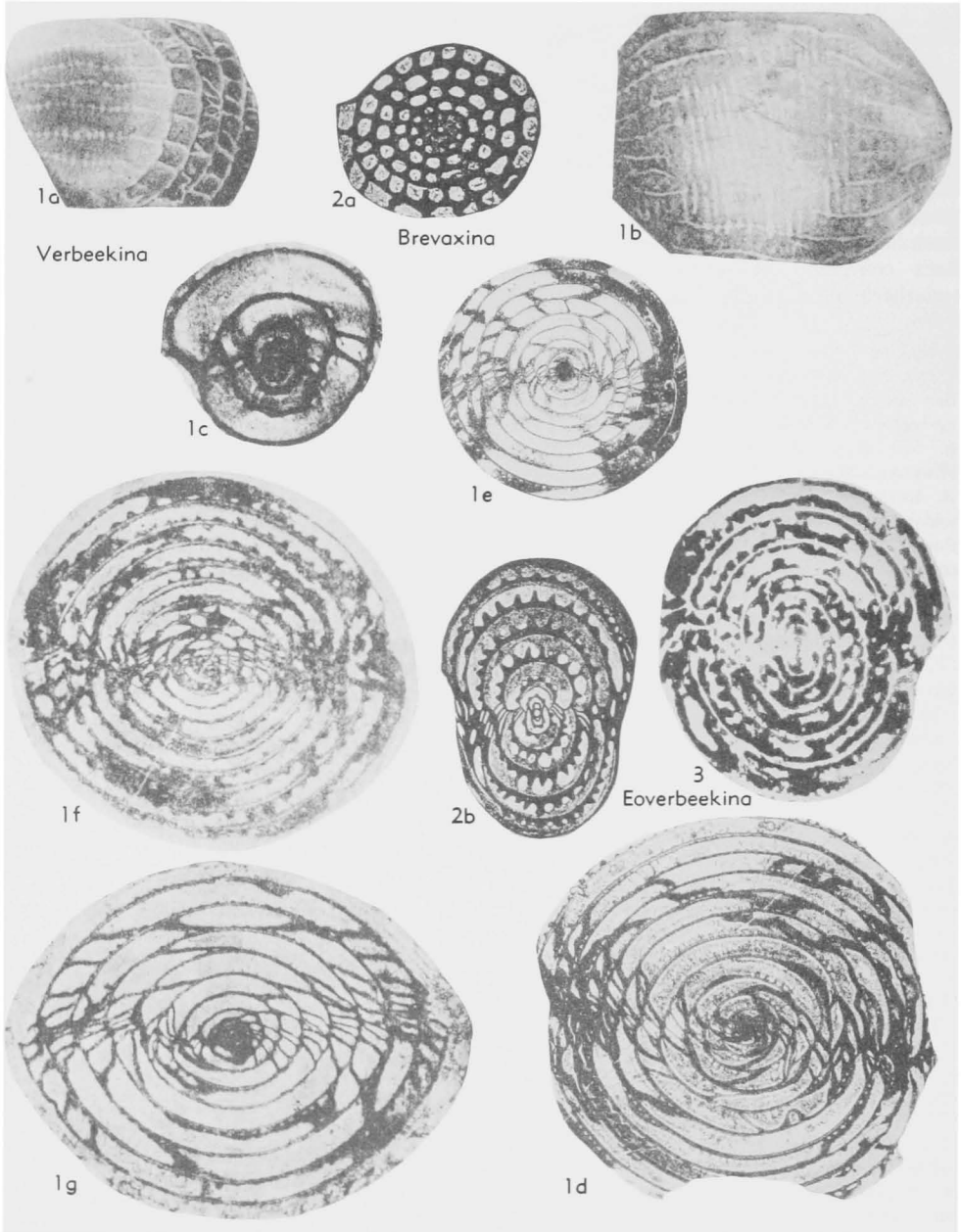


FIG. 323. Verbeekinae (Verbeekinae: 1, *Verbeekina*; 2, *Brevaxina*; 3, *Eoverbeekina*) (p. C427).

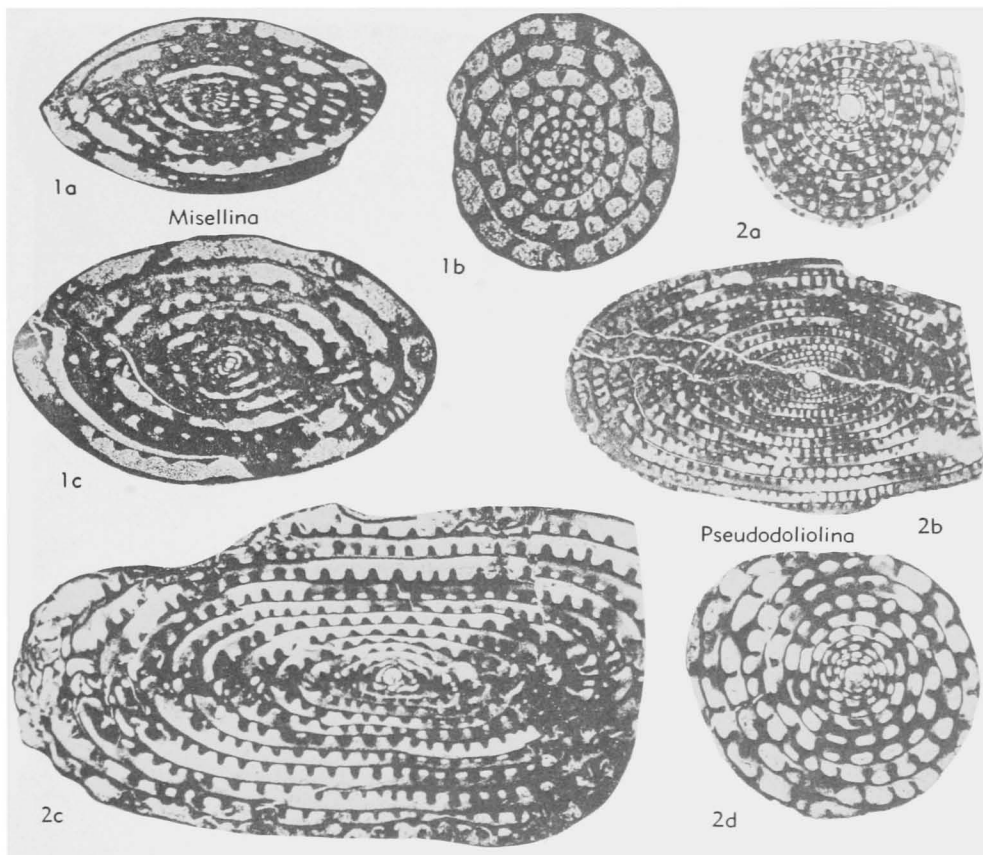


FIG. 324. Verbeekiniidae (Verbeekinae; 1, *Misellina*; 2, *Pseudodoliolina*) (p. C427).

*erina craticulifera* SCHWAGER, 1883, \*1706, p. 140; OD] [= *Crimellina* TUMANSKAYA, 1953, \*1955, p. 4 (type *C. verae*); *Metaschwagerina* MINATO & HONJO, 1958, \*1287, frontispiece (type, *M. ovalis* MINATO & HONJO); *Minoella* HONJO, 1959, \*954, p. 124 (type, *Neoschwagerina* (*Cancellina*) *nipponica* OZAWA, 1927, \*1401B, p. 160); *Gifuella* HONJO, 1959, \*954, p. 131 (type, *G. gifuensis*)]. Shell large, inflated-fusiform to ellipsoidal; wall thick, composed of tectum and alveolar keriotheca, alveoli to base of septula; one transverse septulum to each foramen, reaching parachomata adjacent to septa, as many as 3 axial septula between septa (\*954, \*1287, \*1922, \*1955). *U. Perm.* (*Verbeekina* Z.), Eurasia (Tethys)-S.Eu.-N. Afr.-S. SE. Asia-N. Am. (NW. USA-W. Can.).—FIG. 325.1a,b. *N. nipponica* (OZAWA), Akasaka Ls., Japan, Gifu Pref.; 1a, sagittal sec. of paratype,  $\times 10$ ; 1b, oblique sec. of holotype,  $\times 10$  (\*1401B).—FIG. 325.1c,d. *N. gifuensis* (HONJO), Akasaka Ls., Japan, Gifu Pref.; 1c, axial sec. of holotype,

$\times 15$ ; 1d, sagittal sec. of paratype,  $\times 15$  (\*954).—FIG. 325.1e. *N. haydeni* DUTKEVICH & KHABAKOV, Bamian Ls., Afghan.; axial sec. of holotype,  $\times 20$  (\*1922) (see also Fig. 290.1).—FIG. 325.1f. *N. verae* (TUMANSKAYA), USSR (Crimea); axial sec. of holotype,  $\times 15$  (\*1955). [See also Fig. 275.1, 276.2, \**N. craticulifera*, holotype, paratype; 288.1, *N. ovalis*.]

*Afghanella* THOMPSON, 1946, \*1921 p. 152 [*A. schencki*; OD] [= *Pseudosumatrina* TUMANSKAYA, 1950, \*1954A, p. 91 (type, *Neoschwagerina sumatrinaeformis* GUBLER, 1935, \*838, p. 123); *Arganella* A. D. MIKLUKHO-MAKLAY, 1953, \*1263, p. 21 (*nom. van.*)]. Shell of medium size, inflated-fusiform; spirotheca thin, finely alveolar; parachomata high; septula thin, secondary transverse septula from 4th or 5th volution to maturity, axial septula uniform in length from 3rd volution to maturity, and as many as 4 between septa in outer volutions (\*838, \*1921, \*1945). *U. Perm.* (*Verbeekina* Z. — *Polydiexodina* Z.), Eu. (Greece-

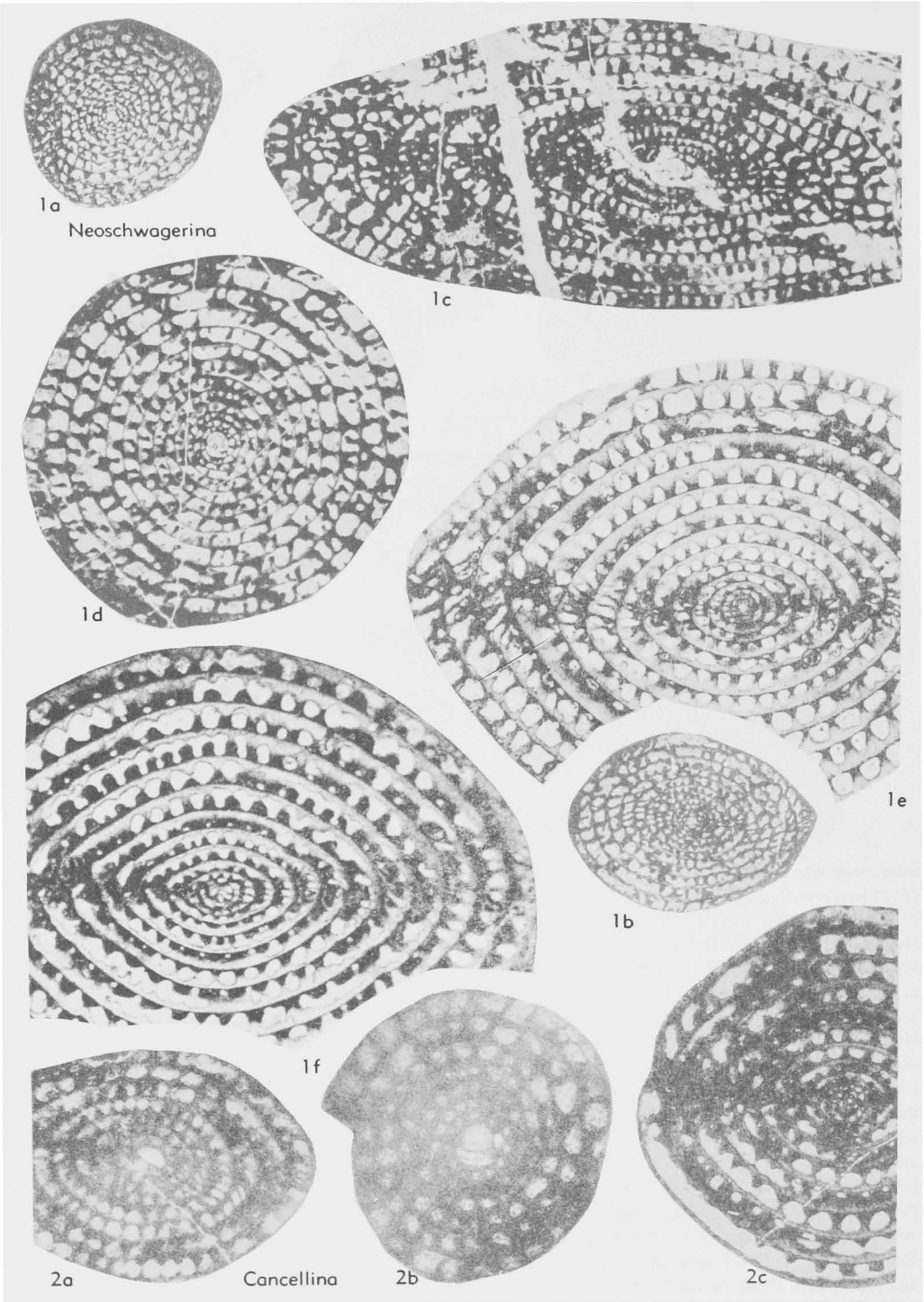


FIG. 325. Verbeekinidae (Neoschwagerininae: 1, *Neoschwagerina*; 2, *Cancellina*) (p. C428-C431).



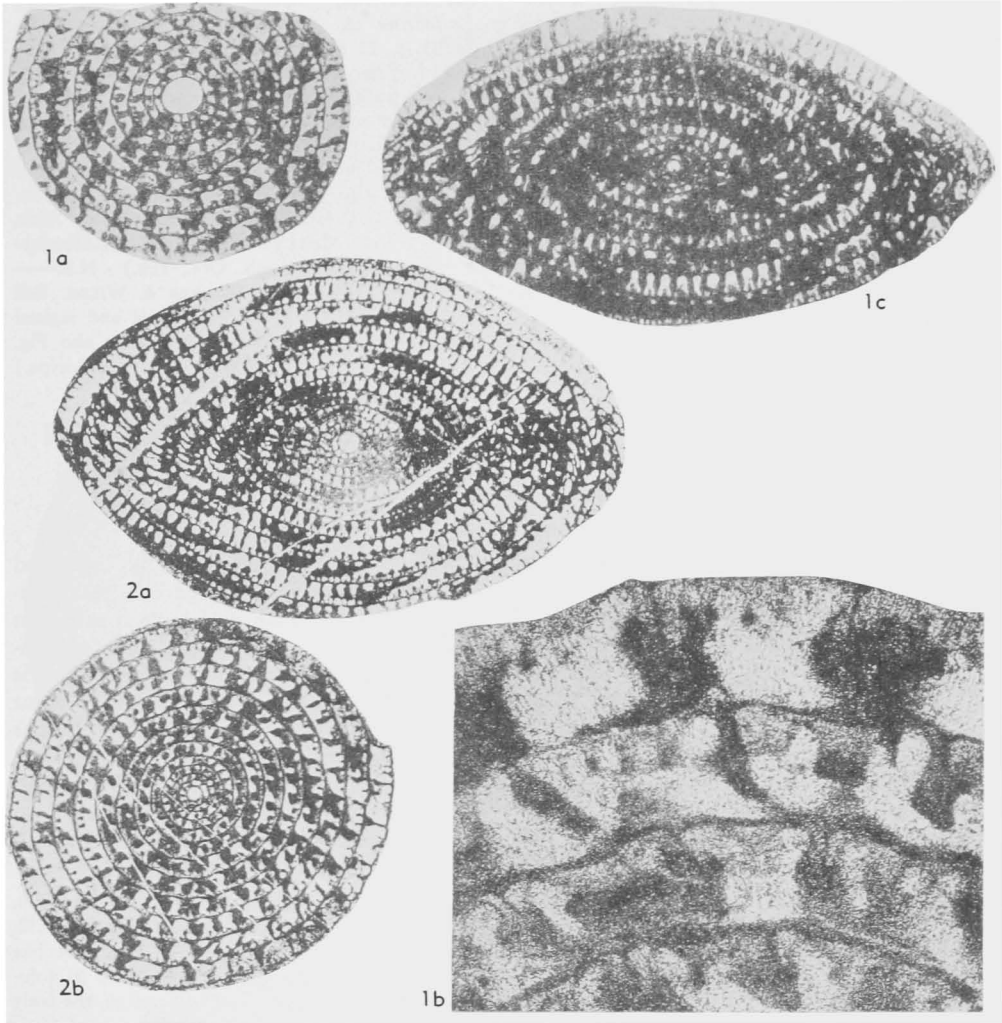


FIG. 326. Verbeekinidae (Neoschwagerininae: 1,2, *Afghanella*) (p. C429-C431).

Crimea-Yugo.)-Asia (Afghan.-Turkey-Pamir-Laos)-Japan.—FIG. 326.1. *A. schencki*, Bamian Ls., Afghan.; 1a,b, sagittal sec. of paratype and enlarged part,  $\times 20$ ,  $\times 100$ ; 1c, axial sec. of holotype,  $\times 20$  (\*1922).—FIG. 326.2. *A. sumatri-naeformis* (GÜBLER), Laos (Pong Oua); 2a,b, axial and sagittal secs.,  $\times 15$  (\*838).

**Cancellina** HAYDEN, 1909, \*885, p. 244 [*Neoschwagerina primigena* HAYDEN, 1909: SD OZAWA, 1925, \*1401, p. 26]. Shell small, inflated-ellipsoidal; spirotheca thick, coarsely alveolar, alveoli extending to base of septula; parachomata high, continuing to tops of chambers adjacent to septa; transverse septula short and broad, one above each

parachomata, as many as 20 foramina and parachomata in last volution; secondary deposits filling extreme polar ends of chambers (\*885, \*1922). *U. Perm.*, Asia (Iran-Afghan.)-Japan.—FIG. 325. 2. *C. primigena* (HAYDEN), Bamian Ls., Afghan. (2a,b), Iran (2c); 2a, oblique axial sec. of holotype,  $\times 17$ ; 2b, sagittal sec. of paratype,  $\times 20$ ; 2c, axial sec.,  $\times 20$  (\*1922) (see also Fig. 288, 2, 293).

**Lepidolina** LEE, 1933[1934], \*1120, p. 21 [*Neoschwagerina (Sumatrana) multiseptata* DEPRAT, 1912, \*584, p. 53; OD] [= *Colania* LEE, 1933 [1934], \*1120, p. 20 (type, *C. kwangsiana*); *Gublerina* MINATO & HONJO, 1959, \*1288, p. 331

non KIKOÏNE, 1948) (type, *Neoschwagerina elongata* GUBLER, 1935, \*838, p. 108)]. Shell large, inflated-fusiform; spirotheca thin, dense; septula thin, irregular in length and shape, thickest at their lower margins, secondary transverse septula first appearing in inner 1st to 3rd volution, as many as 2 between transverse septula of outer volutions, as many as 7 axial septula in outer volutions (\*584, \*1120, \*1288, \*1922). *U.Perm.* (*Yabeina* Z.), Japan-SE. Asia-Eu. (Crimea).—FIG. 327,1. *L. kwangsiensis* (LEE), China (Chienkiang, Kwangsi); axial sec. of holotype,  $\times 15$  (\*1922).—FIG. 327,2. \**L. multiseptata* (DEPRAT), Akasaka Ls., Japan, Gifu Pref. (2a,b), Cambodia (2c); 2a, sagittal sec. of paratype,  $\times 15$ ; 2b, axial sec.,  $\times 15$ ; 2c, tang. sec.,  $\times 10$  (\*1922) (see also Fig. 283,1, holotype, paratype; 292,2). [See also Fig. 275,5, 276,4. *L. elongata*.]

**Presumatrina** TUMANSKAYA, 1950, \*1954A, p. 77 [\**Doliolina schellwieni* DEPRAT, 1913, \*586, p. 51; OD] [= *Praesumatrina* A. D. MIKLUKHO-MAKLAY, RAUZER-CHERNOUSOVA & ROZOVSKAYA in RAUZER-CHERNOUSOVA & FURSENKO, 1959, \*1509, p. 206 (*nom. van.*)]. Shell small, elongate-ellipsoidal, with convex lateral slopes; spirotheca thin, seemingly composed of single thin layer, with extensions wedged down surfaces of septa and down septula; septula system composed of 1 transverse septulum alternating with foramina, and axial septula system composed of 1 or possibly 2 secondary axial septula alternating with septa; transverse septula extending down to join with tops of parachomata (\*586, \*1954A). *U.Perm.*, Asia (Vietnam-S.China)-Eu. (Crimea).—FIG. 328A,1. \**P. schellwieni* (DEPRAT), Dong-Hoi Prov.; axial sec.,  $\times 20$  (\*586).

[The "correct original spelling" of this nominal genus unquestionably is *Presumatrina*, for the name in this form appears in three places and no other spelling was given. Subsequent alteration to *Praesumatrina* (e.g., A. D. MIKLUKHO-MAKLAY *et al.*, 1958, \*1275) constitutes an "incorrect subsequent spelling."]

**Sumatrina** VOLZ, 1904, \*2024, p. 182 [\**S. annae*; OD] [= *Pseudolepidolina* TUMANSKAYA, 1953, \*1955, p. 14 (type, *Neoschwagerina (Sumatrina) longissima* DEPRAT, 1914, \*587, p. 36)]. Shell elongate-subcylindrical, most volutions loosely coiled; spirotheca consisting of single dense layer; proloculus large; secondary transverse and axial septula uniform in length, pendant-shaped, present throughout shell, as many as 4 secondary transverse septula between primary septula, and as many as 7 axial septula to each chamber; some axial fillings in all except last part of last volution (\*587, \*838, \*1921, \*1954A). *U.Perm.* (*Verbeekina* Z.), S.Eu.-Asia Minor-S.Asia-Japan-Malay Arch. (Sumatra).—FIG. 328.2. *S. longissima* DEPRAT, Cambodia (type-sp. of *Pseudolepidolina*); axial sec.,  $\times 15$  (\*1922) (see also Fig. 289,1a). [See Fig. 289, 1b, 292,3, \**S. annae*, holotype, paratype.]

**Yabeina** DEPRAT, 1914, \*587, p. 30 [\**Neoschwagerina*

(*Yabeina*) *inouyei* DEPRAT; OD (M)] [= *Jabeina* A. D. MIKLUKHO-MAKLAY, 1953, \*1263, p. 21 (*nom. van.*)]. Shell large, inflated-fusiform; spirotheca thin, alveolar; secondary transverse septula between some primary transverse septula, as many as 3 between primary transverse septula in outer volutions of late forms, as many as 9 axial septula between septa in outer volutions of later forms (\*587, \*1921, \*1933). *U.Perm.* (*Yabeina* Z.), Japan-SE.Asia (China)-Malay Arch. Eu. (Crimea)-Africa (Tunisia)-USSR (SE.Siberia)-Can. (B.C.) - USA (Wash., Ore., Tex.) - N.Z.—FIG. 328,1. *Y. texana* SKINNER & WILDE, Bell Canyon F., USA (Tex.); 1a,b, axial and sagittal secs. of paratypes,  $\times 20$  (\*1797). [See also Fig. 290,2, 292,1, \**Y. inouyei*, paratype, holotype.]

## NOMINAL FUSULINACEAN GENERA OF UNCERTAIN STATUS

The following alphabetically arranged nominal genera of fusulinacean foraminifers are those for which I have insufficient information for analysis or thorough understanding. For such completeness as is possible now, I record what I know about them. These names were brought together by M. L. THOMPSON and R. TORIYAMA in Japan, and by A. R. LOEBLICH, JR., and HELEN TAPPAN. Special thanks are extended to the LOEBLICHs for their help in assembling and discussing this group.

**Chenella** A. D. MIKLUKHO-MAKLAY, 1959, \*1270, p. 628 [\**Orobias kweichihensis* CHEN, 1934, \*332, p. 15; OD]. "The chenella shell is just like that of *Eostaffelloides*, but the height of its volution is abruptly higher, and the wall of the body whorls has a diaphanotheca." [The quoted statement was given in a footnote. The genus was stated to belong in the Ozawainellinae.] *Carb.*, S.China.

**Codonofusiella (Lantschichites)** TUMANSKAYA, 1953, \*1955, p. 20 [\**C. (L.) maslennikovii*; OD]. *Lantschichites* was elevated to generic status by RAUZER-CHERNOUSOVA & FURSENKO (1959, \*1509, p. 212), where it was also regarded as including *Paraboultonia* SKINNER & WILDE, 1954, in synonymy. TUMANSKAYA gave the following diagnosis: "The new subgenus *Lantschichtes* differs from the genus *Codonofusiella* by the different form of its shell: by its elongated, almost cylindrical form and broadly rounded sides at the poles. The septal folding is considerably more developed and septa occupy almost all of a volution. Similar features are: the small size of the shell, the endothyroid structure of the early volutions, the small

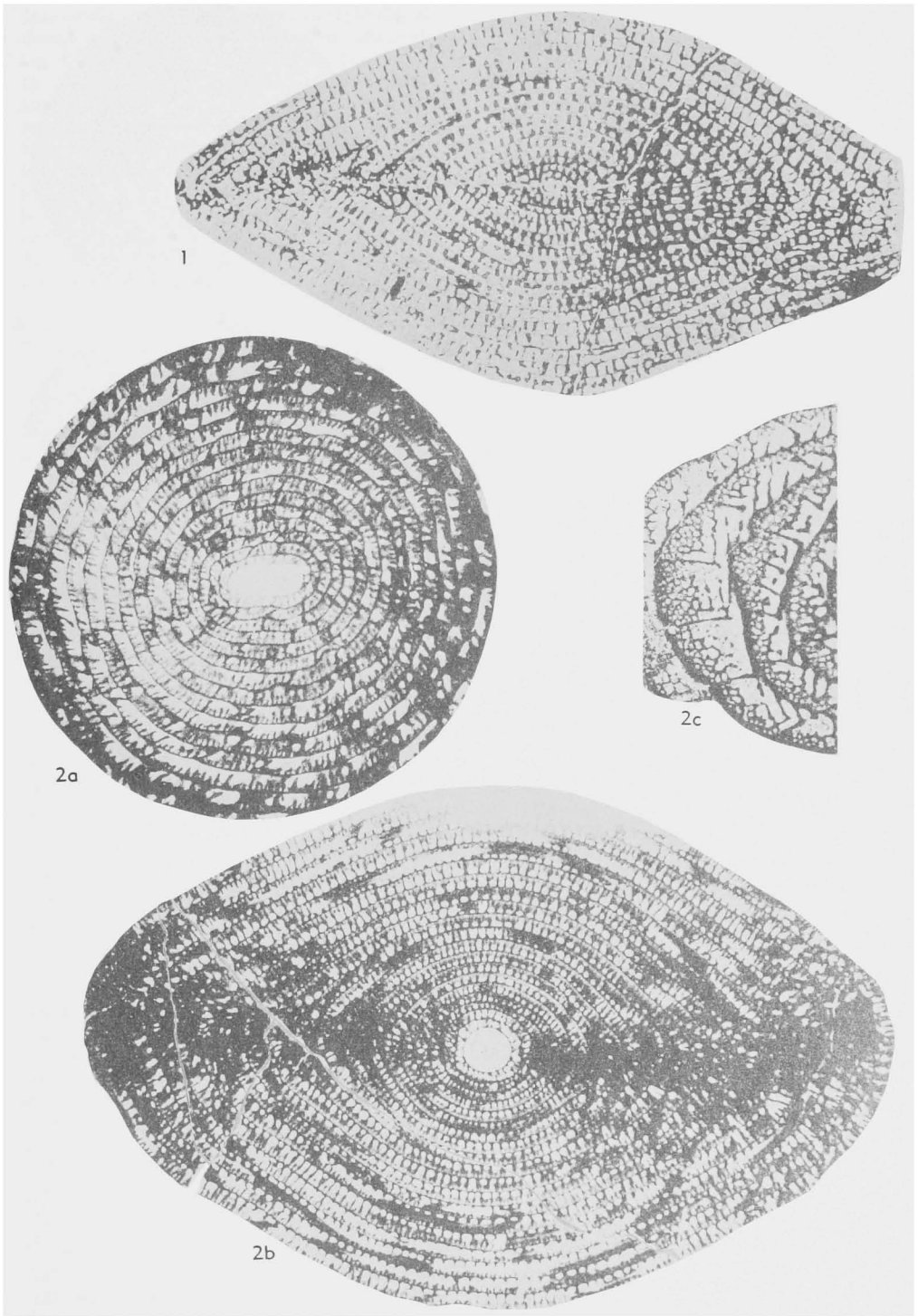


FIG. 327. Verbeekinidae (Neoschwagerininae; 1,2, *Lepidolina*) (p. C431-C432).

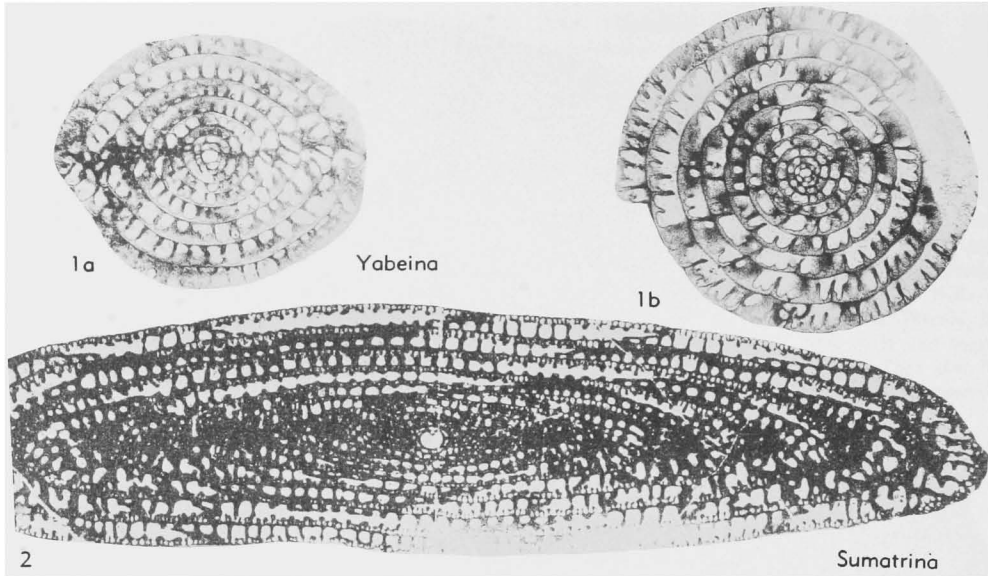


FIG. 328. Verbeekiniidae (Neoschwagerininae; 1, *Yabeina*; 2, *Sumatrina*) (p. C432).

dimensions of the embryonic chamber and, principally, the same kind of straightening and expansion of the terminal volution as in the genus *Codonofusiella*. Age. Upper Permian." She compares the subgenus to forms described by SCHUBERT (1915, \*1693A, p. 78) from Timor as *Fusulina weberi*, which were referred by THOMPSON (1949, \*1923, p. 186) to *Palaeofusulina* DEPRAT, 1912. I cannot determine all of the morphological features of *Lantschichites* significant for generic determination from TUMANSKAYA's illustrations of the type-species. *U.Perm.*, USSR.

**Darvasites** A. D. MIKLUKHO-MAKLAY, 1959, \*1270A, p. 12, 13, 16 [*Triticites ordinatus* var. *daroni* A. D. MIKLUKHO-MAKLAY, 1949, \*1261, p. 70; OD] [= *Darvasites* A. D. MIKLUKHO-MAKLAY, 1957, \*1267, p. 108 (obj.) (*nom. nud.*, name and type-species cited but no diagnosis given)]. Originally placed in Schwagerinidae. [I have seen CHEN's (1934) illustrations of *Triticites ordinatus* but not of *T. ordinatus daroni*, though HELEN TAPPAN has kindly furnished me with a translation of the description of this subspecies by A. D. MIKLUKHO-MAKLAY (1949). From this it is strongly suggested that the genus *Darvasites* may be referable to *Schwagerina* VON MÖLLER, 1877. The main feature in the original description which would indicate some difference from the type of *Schwagerina* is the occurrence of massive chomata in all whorls of *Darvasites daroni*.] *L.Perm.*, Darvaz, Asia (USSR).

**Eostaffelloides** A. D. MIKLUKHO-MAKLAY, 1959, \*1270, p. 629 [*E. orientalis*; OD]. *Eostaffelloides* resembles *Chenella* in most respects except that *Eostaffelloides* does not have an abrupt increase

in height of the last volution and the wall of the body whorls does not contain a diaphanotheca. The shell is lens-shaped and measures about 0.4 mm. in axial length and 0.7 mm. in width. The diameter of the proloculus of one specimen was given as 0.03 mm. and heights of succeeding volutions as 0.06 (1st), 0.11 (2nd), 0.20 (3rd), 0.37 (4th), and 0.70 (5th). The chomata are triangular in outline. The genus originally was placed in the *Ozawainellinae*. *U.Perm.*, Asia (USSR).

**Fujimotoella** MORIKAWA, 1952, \*1312A, p. 36 [*F. umblicata*; OD]. The type-specimens of *F. umblicata* are badly crushed. They are large and have large proloculi. The shell is loosely coiled throughout. The septa are closely spaced and seem to be entirely unfluted. Considerable evidence is shown on many of the illustrations that the axial areas are highly filled with dense calcite which is closely similar to axial fillings in specimens of *Wedekindellina* DUNBAR & HENBEST, 1933. The author described *Fujimotoella* as being like *Triticites* GIRTY, 1904, but the types seem to be too poorly preserved for comparison or for generic definition. *Perm.*, Japan.

**Moscoviella** K. V. MIKLUKHO-MAKLAY, 1952, \*1276, p. 991 [*Ozawainella mosquensis* RAUZER-CHERNOUSOVA in RAUZER-CHERNOUSOVA *et al.*, 1951, \*1509A, p. 136; OD] [= *Moscovella* THOMPSON, 1954, \*1926, p. 12 (*nom. van.*)]. The designation of type-species was somewhat ambiguous, as an error in typesetting placed the line "Tip roda *Reichelina cribroseptata* ERK, 1941" [1942] in two places (p. 991, line 25 and line 37) erroneously indicating it as type of both

*Moscoviella* and *Reichelina* ERK, 1941[1942], although most of the article consisted of distinguishing the two genera. Nevertheless, lines 16-20 (p. 991, preceding the above-mentioned error) stated definitely that the new name *Moscoviella* was there proposed for the group of Carboniferous foraminifers, for which the type is *Ozawainella mosquensis*. According to RAUZER-CHERNOUSOVA & FURSENKO (1959, \*1509, p. 208) *Moscoviella* is a junior synonym of *Ozawainella* THOMPSON, 1935. Therefore, in view of the fact that most Russian paleontologists have not accepted *Moscoviella* as an established genus, I concur in their decision. *U.Carb.*, Eu.-Asia.

**Parareichelina** K. V. MIKLUKHO-MAKLAY in RAUZER-CHERNOUSOVA & FURSENKO, 1959, \*1509, p. 208 [\**P. reticulata*; OD] [= *Parareichelina* K. V. MIKLUKHO-MAKLAY in A. D. MIKLUKHO-MAKLAY, RAUZER-CHERNOUSOVA & ROZOVSKAYA, 1958, \*1275, p. 17 (*nom. nud.*)]. *Parareichelina* differs from *Reichelina* ERK, 1941[1942], principally in the last stages of the uncoiled part of the shell. The detailed differences here mainly concern attitude of the septa. The genus originally was placed in the *Ozawainellinae*. *U.Perm.*, USSR (N. Caucasus-Ussuriy).

**Præparafusulina** TUMANSKAYA, 1962, \*1955A, p. 1397 [\**Parafusulina pseudojaponica* DUTKEVITCH in GORSKY, 1939, \*809, p. 43; OD].

**Pseudoendothyra** MIKHAYLOV, 1939, \*1260, p. 54,60 [\**Fusulinella struvii* VON MÖLLER, 1879, \*1296, p. 22; OD] [= *Parastaffella* RAUZER-CHERNOUSOVA, 1948, \*1505, p. 14 (*obj.*)]. It is found that in the original publication on *Fusulinella struvii* illustrations were given of external views and drawings of thin sections. The wall structures are shown in part to be identical to those in *Millerella* THOMPSON, 1942, and *Paramillerella* THOMPSON, 1951. However, no chomata are seen in the figures of *F. struvii* and, indeed, no secondary deposits of any kind. Furthermore, some of the illustrations given by MIKHAYLOV (1939) are copies of those published by VON MÖLLER. One thin section figured by MIKHAYLOV (\*1260, pl. 4, fig. 4) shows a foraminifer resembling an ozawainellid, but the section is not well centered. The other illustrations do not seem to be of fusulinaceans. *Carb.-L.Perm.*, USSR-W.Eu.-Asia-N.Am.

**Putrella** RAUZER-CHERNOUSOVA, 1951, \*1509A, p. 319 [\**Pseudotriticites brazhnikovae* PUTRYA, 1948, \*1493, p. 98; OD]. *Putrella* was proposed to include specimens that RAUZER-CHERNOUSOVA described from the upper part of the Moscovian stage, base of Podolsk Horizon, and uppermost part of the Kashir Horizon. The type-species is reported to have features like those of some variants of highly advanced *Fusulina* FISCHER DE WALDHEIM, 1829, and the genus was classed in the *Fusulininae*. It is my judgment that the type-

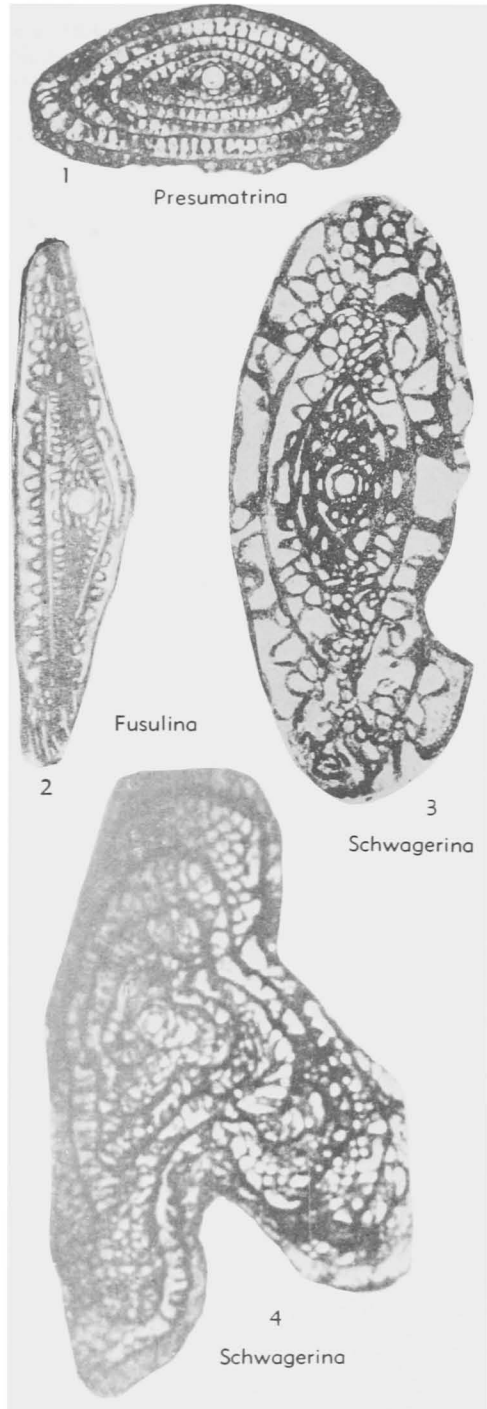


FIG. 328A. Verbeekiniidae (Neoschwagerininae; 1, *Presumatrina*); Fusulinidae (Fusulininae; 2, *Fusulina*); Fusulinidae (Schwagerininae; 3, 4, *Schwagerina*) (p. C404, C415, C432).

species of *Putrella* may properly be included in a broad understanding of *Fusulina*. However, it may possibly be somewhat like some of the forms that have been referred to *Quasifusulina* CHEN, 1934.

**Quasifusulinoides** RAUZER-CHERNOUSOVA & ROZOVSKAYA in RAUZER-CHERNOUSOVA & FURSENKO, 1959, \*1509, p. 210 [*\*Pseudotriticites fusiformis* ROZOVSKAYA, 1952, \*1592A, p. 29; OD] [= *Quasifusulinoides* RAUZER-CHERNOUSOVA & ROZOVSKAYA in A. D. MIKLUKHO-MAKLAY, RAUZER-CHERNOUSOVA & ROZOVSKAYA, 1958, \*1275, p. 17 (*nom. nud.*)]. An enlargement of the wall structure illustrated by RAUZER-CHERNOUSOVA & FURSENKO (1959, \*1509, pl. 7, fig 15B), shows it to be rather typical of the Fusulininae group of forms that occur from the upper part of the Myachkovo Horizon to the bottom of the Upper Carboniferous, southern Urals, Russian Platform. No axial fillings are visible in the axial section (*loc. cit.*, pl. 7, fig. 15A) and the septa are intensely fluted. The details by which this genus differs from *Quasifusulina* CHEN, 1934, are not understood by me.

**Russiella** A. D. MIKLUKHO-MAKLAY, 1957, \*1267, p. 98 [*\*R. pulchra*; OD]. The illustrations of *R. pulchra* show a highly elongate shell with intensely fluted septa and rather massive axial fillings. The holotype has about 5 volutions. The minute size of the shell and rather indistinct details of its internal structure suggest that it may be related to *Minojapanella* FUJIMOTO & KANUMA, 1953. *Russiella* originally was placed in the "Boultoniinae." *U. Perm.*, USSR (Crimea).

**Sichotenella** TUMANSKAYA, 1953, \*1955, p. 22 [*\*S. sutchanica*; OD]. Shells of *Sichotenella* are small, discoidal forms with an angular periphery. The last part of the shell, according to the author, becomes straightened out or uncoiled, the uncoiled part of the last volution being greater in volume than the entire coiled stages. Originally referred to the Fusulininae. *U. Perm.*, USSR (Yuzhno-Ussuriy region).

**Sphaeroschwagerina** A. D. MIKLUKHO-MAKLAY, 1959, \*1271, p. 157 [*\*Schwagerina princeps* (EHRENBERG) SCHELLWIEN, 1898, \*1644, p. 258 (*non Borelis princeps* EHRENBERG, 1842, \*669A, p. 274) (= *Schwagerina sphaerica* SHCHERBOVICH var. *kanica* SHCHERBOVICH in RAUZER-CHERNOUSOVA & SHCHERBOVICH, 1949, \*1509B, p. 102); OD] [= *Sphaeroschwagerina* A. D. MIKLUKHO-MAKLAY, 1956, \*1265, p. 1154 (*nom. nud.*, type designated but no generic description) (*obj.*)]. An outline sketch of a typical specimen of *Sphaeroschwagerina* 1959, \*1271, p. 159, suggests relationship to *Robustoschwagerina tumida* (LIKHAREV), 1939. Originally placed in the Schwagerinidae. *L. Perm.* (*U. Karachatyur Horizon P<sub>1</sub>*).

## NOMINA NUDA (FUSULINACEANS)

**Armeniella** A. D. MIKLUKHO-MAKLAY, 1953 (\*1263, p. 20).

**Carina** A. D. MIKLUKHO-MAKLAY, 1953 (\*1263, p. 18).

**Eozawainella** A. D. MIKLUKHO-MAKLAY, 1953 (\*1263, p. 18).

**Orientella** A. D. MIKLUKHO-MAKLAY, 1953 (\*1263, p. 21).

**Pseudoyabeina** TUMANSKAYA, 1955 (cited in A. D. MIKLUKHO-MAKLAY, 1958, \*1268, p. 6, 10).

## NOMEN INQUIRENDUM (FUSULINACEANS)

**Eoparastaffella** VDOVENKO, 1954 [*vide* RAUZER-CHERNOUSOVA & FURSENKO, 1959, \*1509, p. 207, a synonym of *Pseudoendothyra* MIKHAYLOV, 1939].

## Suborder MILIOLINA

### Delage & Hérouard, 1896

[*nom. correct.* LOEBLICH & TAPPAN, 1961, p. 219 (*pro* suborder Miliolidae DELAGE & HÉROUARD, 1896, p. 117)]—[In synonymic citations superscript numbers indicate taxonomic rank assigned by authors (order, <sup>2</sup>suborder, <sup>3</sup>group, <sup>4</sup>division, <sup>5</sup>subclass); dagger(†) indicates *partim*]—[=<sup>2</sup>Monothalamiat EHRENBERG, 1839; table opp. p. 120; =Monothalamiat SCHULTZE, 1854, p. 52; =Foraminifera Monomerat REUSS, 1862, p. 362; =Monothalamiat MARRIOTT, 1878, p. 30; =<sup>1</sup>Monothalamiat HAECKEL, 1894, p. 164]—[=<sup>1</sup>Agathistegues d'ORBIGNY in DE LA SAGRA, 1839, p. xxxix, 153 (*nom. neg.*); =<sup>1</sup>Entomostegues d'ORBIGNY in DE LA SAGRA, 1839, p. xxxix, 113 (*nom. neg.*); =<sup>1</sup>Cyclostegest d'ORBIGNY, 1851, p. 192 (*nom. neg.*); =<sup>2</sup>Helicoidea SCHULTZE, 1854, p. 53; =Nautiloidea REUSS, 1860, p. 151]—[=<sup>2</sup>Imperforata CARPENTER, 1861, p. 469; =<sup>2</sup>Imperforata CLAUS, 1872, p. 108; =<sup>2</sup>Imperforat LANKESTER, 1885, p. 845; =<sup>1</sup>Imperforida DELAGE & HÉROUARD, 1896, p. 107; =<sup>2</sup>Imperforinat CALKINS, 1901, p. 106]—[=<sup>1</sup>Foraminifera Polymerat REUSS, 1862, p. 365; =<sup>2</sup>Polystegiat HAECKEL, 1894, p. 164; =<sup>2</sup>Biloculinideat SIGAL in PIVETEAU, 1952, p. 157; =<sup>1</sup>Pluriloculinideat SIGAL in PIVETEAU, 1952, p. 160]—[=<sup>1</sup>Porcellanea CARPENTER, 1879, p. 375, 376; =<sup>1</sup>Flexostyliadiat CALKINS, 1926, p. 355; =<sup>2</sup>Flexostyli (Imperforata) SILVESTRI, 1937, p. 77]—[=<sup>1</sup>Miliolidea LANKESTER, 1885, p. 846; =<sup>1</sup>Miliolidae HARTOG in HARMER & SHIPLEY, 1906, p. 59; =<sup>1</sup>Miliolida CALKINS, 1909, p. 39]—[=<sup>1</sup>Hellenoideat WEDEKIND, 1937, p. 79; =<sup>2</sup>Cornuspiroidea WEDEKIND, 1937, p. 87; =<sup>2</sup>Cristellariaceat WEDEKIND, 1937, p. 93; =<sup>2</sup>Orbitolitea WEDEKIND, 1937, p. 120; =<sup>2</sup>Cornuspiroidea JIROVEC, 1953, p. 335]

Test calcareous, porcelaneous, commonly with pseudochitinous lining, may also include some adventitious material in wall, imperforate in post-embryonic stages. *Carb.-Rec.*

## Superfamily MILIOLACEA Ehrenberg, 1839

[*nom. correct.* LOEBLICH & TAPPAN, 1961, p. 289 (*pro* superfamily Miliolidae GLAESSNER, 1945, p. 116, and Miliolicea EASTON, 1960, p. 65, 76)]—[In synonymic citations superscript numbers indicate taxonomic rank assigned by authors (tribu, <sup>2</sup>superfamily, <sup>3</sup>family group); dagger(†) indicates *partim*]—[=<sup>2</sup>Milleporitae LATREILLE, 1825, p. 166; =<sup>2</sup>Orthocerata LATREILLE, 1825, p. 162; =<sup>2</sup>Polycyclicae LATREILLE, 1825, p. 164]—[=<sup>2</sup>Orthoklinostegiat EIMER & FICKERT, 1899, p. 185; =<sup>3</sup>Archi-Monothalamidiat RHUMBLER in KÜENTHAL & KRUMBACH, 1923, p. 85; =<sup>3</sup>Flexostyliadiat RHUMBLER in KÜENTHAL & KRUMBACH, 1923, p. 87; =<sup>2</sup>Alveolinidea VOLOSHINOVA in RAUZER-CHERNOUSOVA & FURSENKO, 1959, p. 244]

Wall porcelaneous, commonly with pseudochitinous inner lining, and may have adventitious material on exterior, imperfor-



ate at least in postembryonic stages; proloculus with spiral passage followed by numerous chambers which may be planispiral-

ly coiled or arranged in definite planes; aperture terminal, single or cribrate and may be variously modified. *Carb.-Rec.*

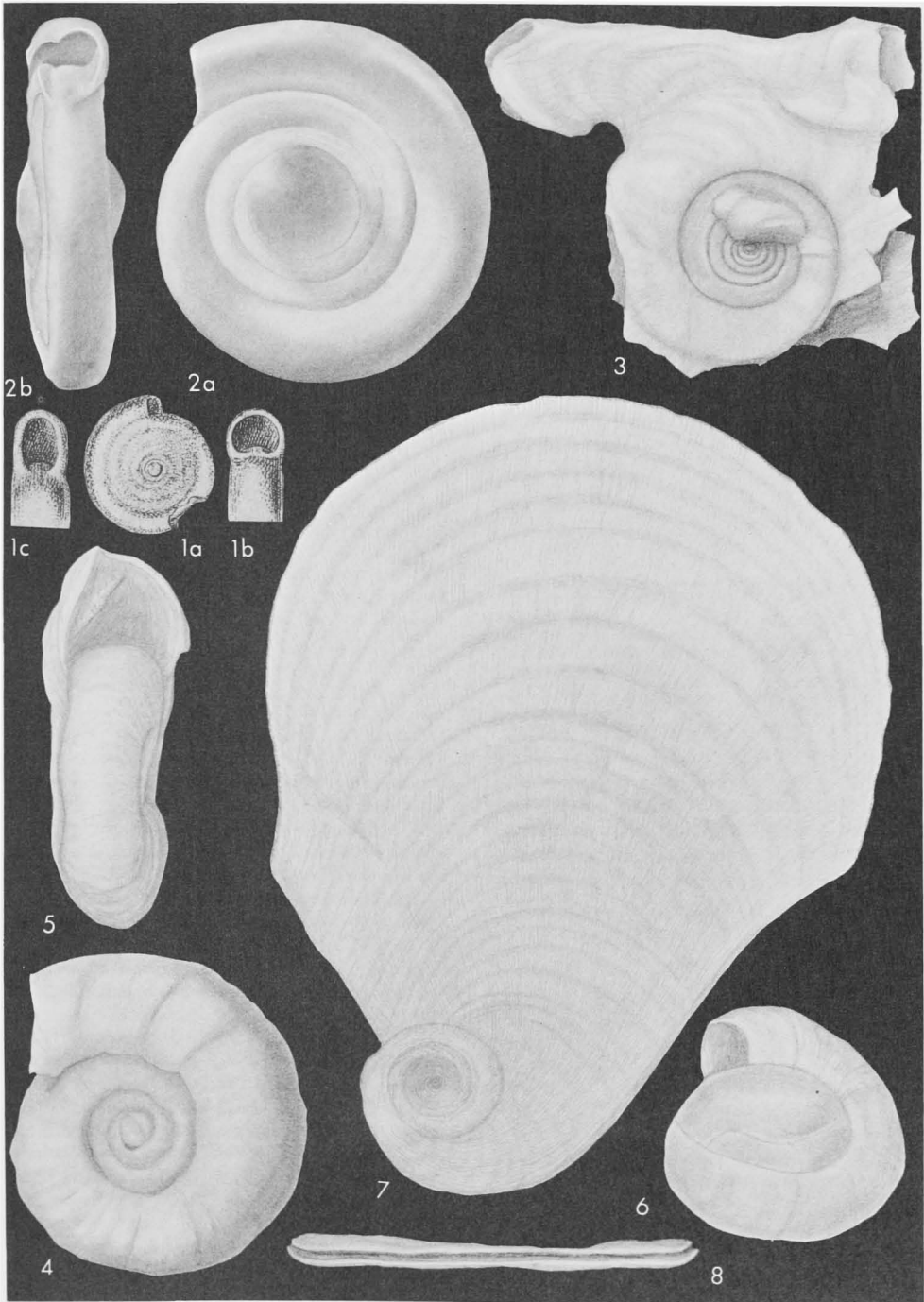


FIG. 329. Fischerinidae (Cyclogyrinae; 1,2, *Cyclogyra*; 3, *Cornuspirella*; 4-6, *Gordiospira*; 7,8, *Cornuspiroides*) (p. C438-C439).

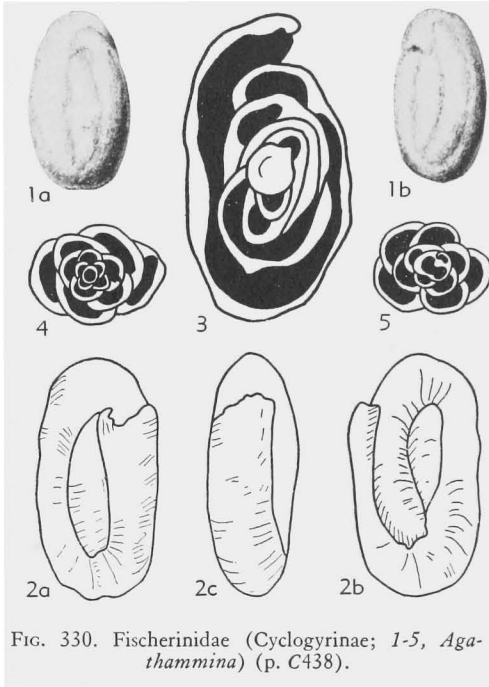


FIG. 330. Fischerinidae (Cyclogyrinae; 1-5, *Agathammina*) (p. C438).

### Family FISCHERINIDAE Millett, 1898

[*nom. transl.* CUSHMAN, 1927, p. 40 (*ex subfamily* Fischerinidae MILLETT, 1898, p. 611)]—[All names referred to are of family rank]—[=*Cornuspirida* SCHULTZE, 1854, p. 52; =*Cornuspiridae* REUSS, 1860, p. 177; =*Cornuspiridea* REUSS, 1862, p. 364, 394; =*Cornuspiridae* GÜMBEL, 1870, p. 26; =*Cornuspirida* HAECKEL, 1894, p. 185]

Test free or attached, proloculus followed by undivided tubular or spreading second chamber; wall calcareous, porcelaneous; aperture terminal, rounded or slitlike. [As redefined herein the Fischerinidae includes the subfamilies Cyclogyrinae, Fischerininae, and Calcivertellinae and differs from the Nubeculariidae in lacking development of separate chambers after the early cyclogyrine development.] *Carb.-Rec.*

#### Subfamily CYCLOGYRINAE Loeblich & Tappan, 1961

[Cyclogyrinae LOEBLICH & TAPPAN, 1961, p. 290 (*nom. subst. pro subfamily* Cornuspirinae RHUMBLER, 1904, p. 284)]—[=*Arcornuspirinia* RHUMBLER, 1913, p. 387 (*nom. van.*); =*Cornuspirininae* CUSHMAN, 1919, p. 633 (*nom. van.*)]

Proloculus followed by undivided second chamber; generally tubular and coiled, but adult variable; free or attached. *Carb.-Rec.*

*Cyclogyra* WOOD, 1842, \*2077, p. 458 [*\*C. multiplex*; OD (M)] [= *Cornuspira* SCHULTZE, 1854, \*1695, p. 40 (type, *Orbis foliaceus* PHILIPPI, 1844, \*1452A, p. 147); SD CUSHMAN, 1917, \*404f, p. 24; *Arcornuspirum* RHUMBLER, 1913, \*1572b, p.

387 (*nom. van.*); *Conicocornuspira* MARIE in DELEAU & MARIE, 1961, \*580A, p. 74 (type, *C. conica* MARIE, 1961)]. Test free, discoidal, consisting of globular proloculus and long undivided planispirally wound tubular second chamber, partly or wholly evolute; wall calcareous, imperforate, porcelaneous; aperture at the open end of the tube. *Carb.-Rec.*, cosmop.—FIG. 329,1. *\*C. multiplex*, Plio., Eng.; 1a, side view of holotype,  $\times 5.5$ ; 1b, c, apert. views, enlarged (\*2077).—FIG. 329,2. *C. planorbis* (SCHULTZE), Rec., Gulf Mex.; 2a, b, side and apert. views of hypotype,  $\times 224$  (\*2117).

[The synonymy of *Cornuspira* with *Cyclogyra* was noted by LOEBLICH & TAPPAN (1961, \*1177, p. 290), and had been indicated questionably by GALLOWAY (1933, \*762, p. 109). *Orbis foliaceus* PHILIPPI, 1844, was designated by CUSHMAN, 1917 as type-species of *Cornuspira*, but in 1927, CUSHMAN (\*433, p. 188) changed the type designation to *Cornuspira planorbis* SCHULTZE, 1854, stating that the previous designation was in error, as *C. foliaceus* was not one of the names used by SCHULTZE. However, as SCHULTZE, 1854, p. 41 (footnote) definitely included *Orbis foliaceus* in the genus, the original designation of CUSHMAN must stand. The two species are not conspecific.]

*Agathammina* NEUMAYR, 1887, \*1354, p. 171 [*\*Serpula pusilla* GEINITZ in GEINITZ & GUTBIER, 1848, \*776, p. 6; SD CUSHMAN, 1927, \*433, p. 188]. Test ovate; globular proloculus followed by enrolled, nonseptate tubular second chamber, which coils in quinqueloculine manner; wall calcareous, imperforate with growth lines on surface but no internal subdivisions; aperture simple, terminal, may have thickened rim. [Commonly placed in the Miliolidae because of its quinqueloculine appearance, *Agathammina* has been shown to be nonseptate and is here transferred to the Cyclogyrinae. Agglutinated species placed herein by various authors should be re-allocated, in the Ammodiscidae.] *Carb.-Perm.*, ?Trias., ?Jur., C.Eu.—FIG. 330,1-5. *\*A. pusilla* (GEINITZ), U.Carb.(Namur.), Czech.; 1a, b, opposite sides,  $\times 117$  (\*1985); 2a-c, opposite sides and edge view showing nonseptate character,  $\times 25$ ; 3, long. sec. of megalospheric form,  $\times 55$ ; 4, 5, transv. secs. of microspheric and megalospheric forms,  $\times 25$  (\*2070).

*Cornuspirella* CUSHMAN, 1928, \*436, p. 4 [*\*Cornuspira diffusa* HERON-ALLEN & EARLAND, 1913, \*908, p. 272; OD]. Early portion as in *Cyclogyra*, planispiral and evolute, later rectilinear, spreading and branching in various directions but in plane of original coiling; aperture elongate, narrow, at ends of flattened branches. Rec., N.Atl.—FIG. 329,3. *\*C. diffusa* (HERON-ALLEN & EARLAND); lectotype (BMNH-ZF3578) from Gold-seeker Station 41A, Haul 8265 at lat.  $56^{\circ}48'N$ , long.  $1^{\circ}19'E$ , at 94 m., showing branches in 2 directions and broken areas where other branches had formerly occurred,  $\times 48$  (\*2117).

*Cornuspiroides* CUSHMAN, 1928, \*436, p. 3 [*\*Cornuspira striolata* BRADY in TIZARD & MURRAY, 1882, \*1936, p. 713; OD]. Test free, large, flabelliform, early portion planispiral with coils increasing very gradually in diameter, later portion

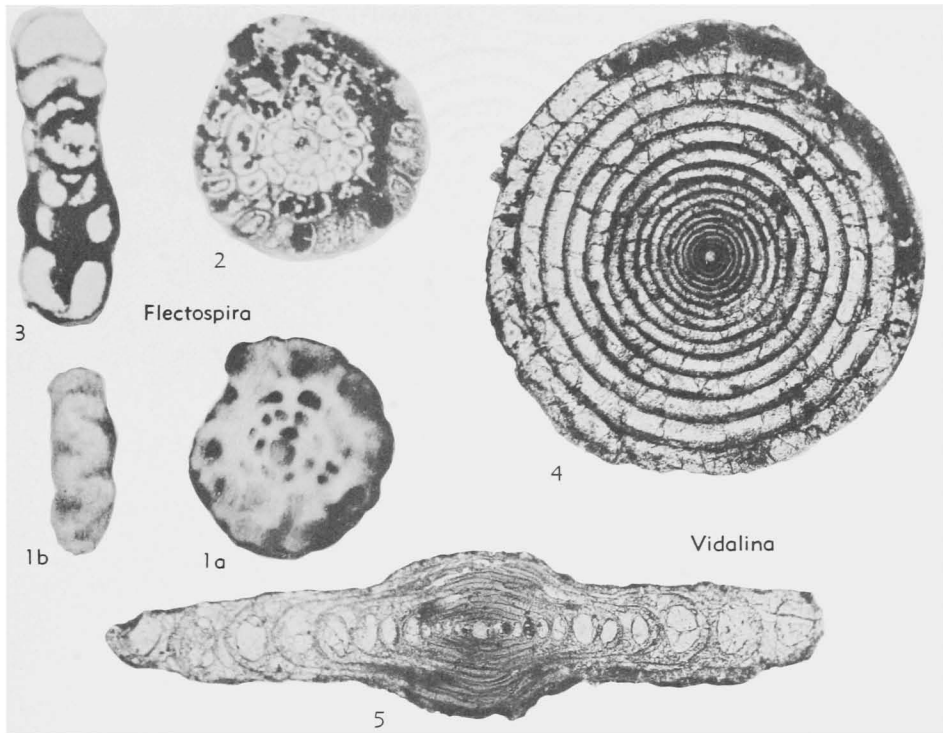


FIG. 331. Fischerinidae (Cyclogyrinae; 1-3, *Flectospira*; 4, 5, *Vidalina*) (p. C439-C441).

of coil increasing very rapidly in height and spreading out into an uncoiled, flattened and flabelliform portion, nonseptate but with distinct transverse growth lines and in type-species with fine vertical striae on surface; wall calcareous, milky white, imperforate; aperture narrow elongate slit at open end of expanded, flattened test. [*Cornuspiroides* differs from *Cyclogyra* in its later uncoiled, flabelliform development and from *Cornuspirella* CUSHMAN in being unbranched in the later portion.] *Rec.*, Atl.—FIG. 329, 7, 8. \**C. striolata* (BRADY); 7, side view of hypotype,  $\times 5$ ; 8, apert. view of hypotype,  $\times 5.5$  (\*2117).

**Flectospira** CRESPIN & BELFORD, 1957, \*395, p. 76 [\**F. prima*; OD]. Test discoidal, similar to *Meandrospira* in development but evolutely coiled, so that earlier whorls of zigzagging tubular second chamber are visible; aperture large, rounded, at open end of tube. *L.Perm.*(*Artinsk.*), W. Australia.—FIG. 331, 1-3. \**F. prima*; 1a, b, side, edge views of holotype; 2, equat. sec.; 3, axial sec.; all  $\times 77$  (\*395).

**Gordiospira** HERON-ALLEN & EARLAND, 1932, \*914d, p. 254 [\**G. fragilis*; OD (M)]. Test free, consisting of proloculus and long undivided second chamber, early portion coiling about pro-

loculus in varying planes, becoming planispiral and partially involute in later portion; wall calcareous, imperforate, with numerous transverse wrinkles; aperture comprising broad arch at open end of tube. *Rec.*, Antarctic-Arctic.—FIG. 329, 4-6. \**G. fragilis*, S. Georgia Is.; 4, large microspheric paratype,  $\times 64$ ; 5, edge view (\*914d, pl. 6, fig. 13), redrawn, showing crushing of test in the apertural region simulating a triangular aperture,  $\times 64$ ; 6, small megalospheric paratype showing early irregular coiling and arched aperture,  $\times 146$  (\*2117).

[*Gordiospira* differs from *Hemigordius* SCHUBERT in possessing a thin, delicate test wall and in lacking lateral secondary thickening. It differs from *Cyclogyra* in the glomospiroid early coiling. CUSHMAN (1948, \*486, p. 193) stated that the aperture is "somewhat triangular." This was shown by the original figures and also by the edge view of the figure herein given of the same specimen, but it is due to the broken, slightly collapsed wall, which gives a pseudotriangular appearance. On uncrushed specimens the aperture is merely a broadly arched opening. The original specimens figured in side view are broken in the British Museum slides. Those here illustrated are from the same slide, however (BMNH-ZF3284).]

**Hemigordiopsis** REICHEL, 1945, \*1516, p. 528 [\**H. renzi*; OD]. Test globular, consisting of globular proloculus followed by nonseptate second chamber, coiling streptospiral in early portion and later planispiral, involute, so that only final whorl is

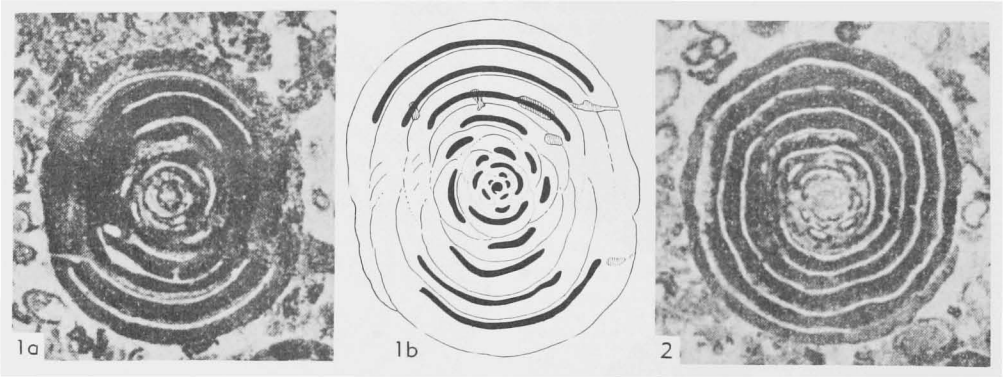


FIG. 332. Fischerinidae (Cyclogyrinae; 1,2, *Hemigordiopsis*) (p. C439-C440).

visible externally; wall calcareous, porcelaneous, thick, chamber cavity much reduced. [*Hemigordiopsis* is similar to *Vidalina* and *Hemigordius* in its involute, later planispiral development, but differs from *Vidalina* in early streptospiral coiling, and differs from *Vidalina* and *Hemigordius* in its globular test resulting from very broad and low chambers.] *Perm.*, E.Medit.(Cyprus).—FIG. 332,1,2. \**H. renzi*; 1a, axial sec. of holotype (wall appears dark and chamber cavity light); 1b, holotype, diagrammatic to show early streptospiral development and later planispiral coiling,  $\times 20$ ; 2, equat. sec. of paratype showing non-septate tube,  $\times 20$  (\*1516).

**Hemigordius** SCHUBERT, 1908, \*1686, p. 381 [\**Cornuspira schlumbergeri* HOWCHIN, 1895, \*967, p. 195] [= *Hemigordiella* MARIE in DELEAU & MARIE, 1961, \*580A, p. 75 (type, *Hemigordius calcarea* CUSHMAN & WATERS, 1928, \*535, p. 44); *Ondogordius* MARIE in DELEAU & MARIE, 1961, \*580A, p. 78 (type, *O. campanula* MARIE, 1961); *Neoangulodiscus* KRISTAN-TOLLMANN, 1962, \*1059A, p. 230 (type, *N. leischneri*)]. Test similar to *Gordiospira*, with early whorls glomospiroid, later planispiral, but whorls involute, resulting in umbonal thickening. *Carb.-L.Jur.(Lias.)*, Australia-N.Am.-Eu.-USSR.—FIG. 333,1. \**H. schlumbergeri* (HOWCHIN), *Carb.*, Australia; 1a-c, opposite sides and edge of toptotype,  $\times 62$  (\*2117). **Meandrospira** LOEBLICH & TAPPAN, 1946, \*1154, p. 248 [\**M. washitensis*; OD] [= *Streblospira* CRESPIN & BELFORD, 1957, \*395, p. 74 (type, *S. meandrina*)]. Test free, small, composed of proloculus followed by tubular second chamber, which spirals streptospirally and involutely about proloculus in short zigzag bends, so that side view shows numerous loops reaching toward umbilicus, loops being formed by tubular chamber swinging back upon itself and only those of final whorl visible externally; wall calcareous, imperforate; aperture simple, terminal. *L.Perm.*

(*Artinsk.*)-*Rec.*, N.Am.-Eu.-N.Afr.-Australia.—FIG. 333,3. \**M. washitensis*, *L.Cret.(Alb.)*, USA (Tex.); 3a-c, holotype, opposite sides and edge views,  $\times 211$  (\*2117).—FIG. 333,4-6. *M. meandrina* (CRESPIN & BELFORD). *U.Perm.*, Australia; 4a-c, opposite sides and edge views of holotype (in glycerine),  $\times 53$ ; 5, equat. sec.,  $\times 90$ ; 6, axial sec.,  $\times 95$  (\*395).

[*Meandrospira* differs from *Calcitonella* and *Calciwertella*, both of which have a zigzag tubular second chamber, in being free living and enrolled, rather than attached to a flat substratum. *Sreblospira* (L.Perm.) is a synonym and *Glomospira glomerata* HÖGLUND (Rec., Sweden) also belongs to *Meandrospira*.]

**Orthovertella** CUSHMAN & WATERS, 1928, \*535, p. 45 [\**O. protea*; OD]. Proloculus followed by undivided tubular second chamber, streptospirally coiled in early portion, later becoming uncoiled; aperture at open end of tube. [REYTLINGER (1950, \*1560, p. 22) regarded *Orthovertella* as a synonym of *Lituotuba*, but *Orthovertella* has a porcelaneous rather than agglutinated wall.] *Penn.-Perm.*, N. Am.—FIG. 333,2. \**O. protea*, *Penn.*, USA (Tex.); 2a,b, side, edge views of holotype,  $\times 122$  (\*2117).

**Rectocornuspira** WARTHIN, 1930, \*2040, p. 15 [\**R. lituiformis*; OD]. Test differing from *Orthovertella* in being completely planispiral, rather than streptospiral in early stage, later portion uncoiled; wall porcelaneous; aperture rounded at open end of tube. *Penn.*, N.Am.—FIG. 333,7. \**R. lituiformis*, USA (Okla.); 7a,b, side, edge views,  $\times 63$  (\*2117).

**Vidalina** SCHLUMBERGER, 1900, \*1660, p. 459, 460 [\**V. hispanica*; OD (M)] [= *Arvidaloum* RHUMBLER, 1913, \*1572b, p. 388 (obj.) (*nom. van.*)]. Test large, to 1.5 mm. in diam., with proloculus followed by planispirally enrolled, involute, nonseptate, tubular second chamber, involute whorls resulting in umbonal thickening; wall calcareous, imperforate; aperture at open end of tube. *U.Cret.*, Eu.—FIG. 331,4,5; 333,8,9. \**V. hispanica*, Santon., Spain; 331,4, equat.

sec.,  $\times 45$ ; 331,5, axial sec.,  $\times 85$  (\*1660); 333, 8a,b, side, edge views of large paratype,  $\times 23$  (\*2117); 333,9a,b, side, edge views of small hypotype,  $\times 55$  (\*2117).

**Subfamily FISCHERININAE Millett, 1899**

[Fischerininae MILLETT, 1899, p. 611]

Few tubular chambers to whorl, planispiral or in conical spire; aperture at open end of final chamber. *Jur.-Rec.*

*Fischerina* TERQUEM, 1878, \*1889, p. 80 (*non* STUCKENBERG, 1904) [*\*F. rhodiensis*; OD (M)] [= *Planispirina* SEGUENZA, 1880, \*1713, p. 310 (type, *P. communis*); *Trisegmentina* WIESNER, 1920, \*2061, p. 18 (type, *T. compressa* WIESNER, 1931, \*2063, p. 70, = *Hauerina compressa* SIDEBOTTOM, 1904, *non H. compressa* D'ORBIGNY, 1846, = *T. sidebottomi* CUSHMAN, 1933)]. Test free, globular proloculus followed by enrolled nonseptate tubular chamber of nearly full coil in

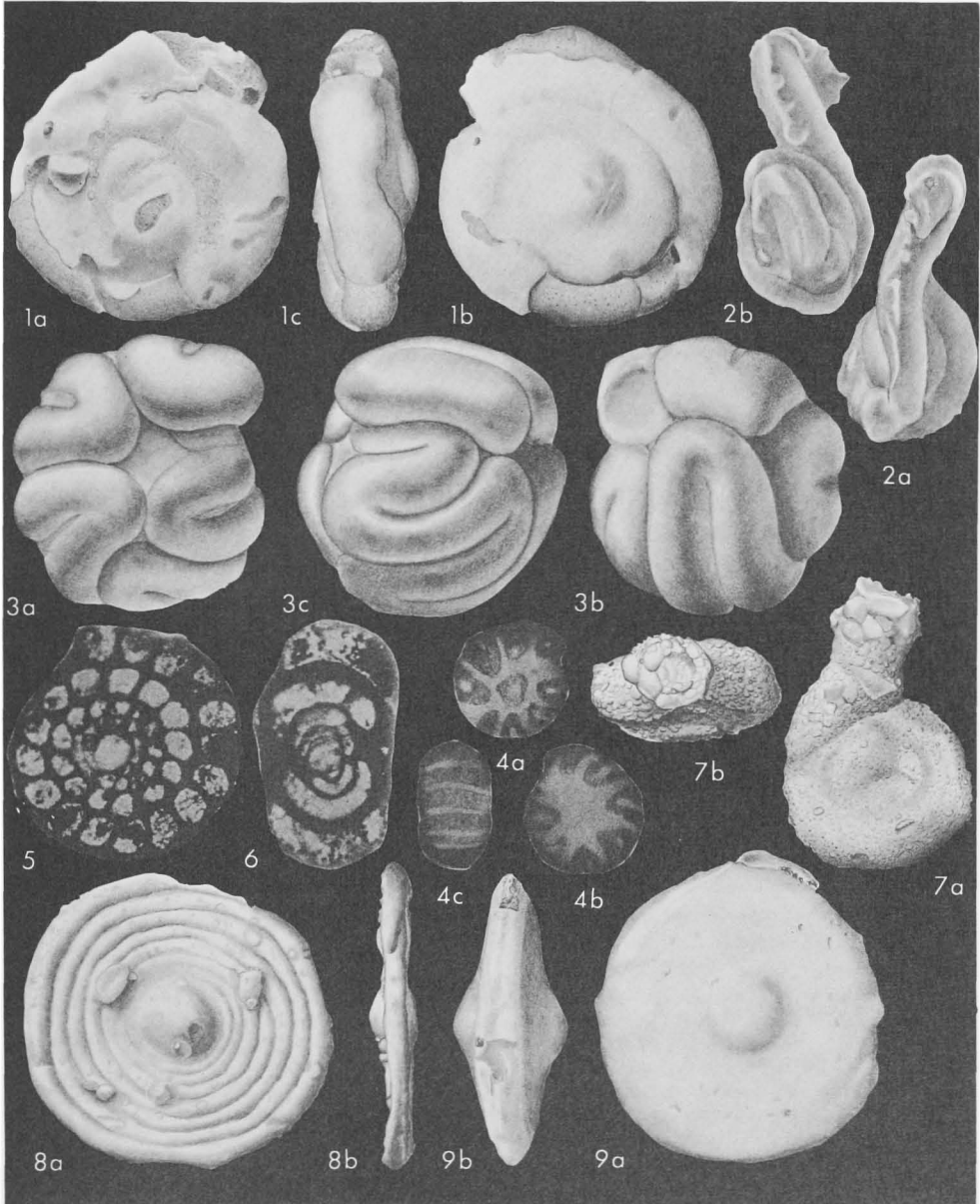


FIG. 333. Fischerinidae (Cyclogyrinae); 1, *Hemigordius*; 2, *Orthovertella*; 3-6, *Meandrospira*; 7, *Rectocornuspira*; 8,9, *Vidalina* (p. C440-C441).



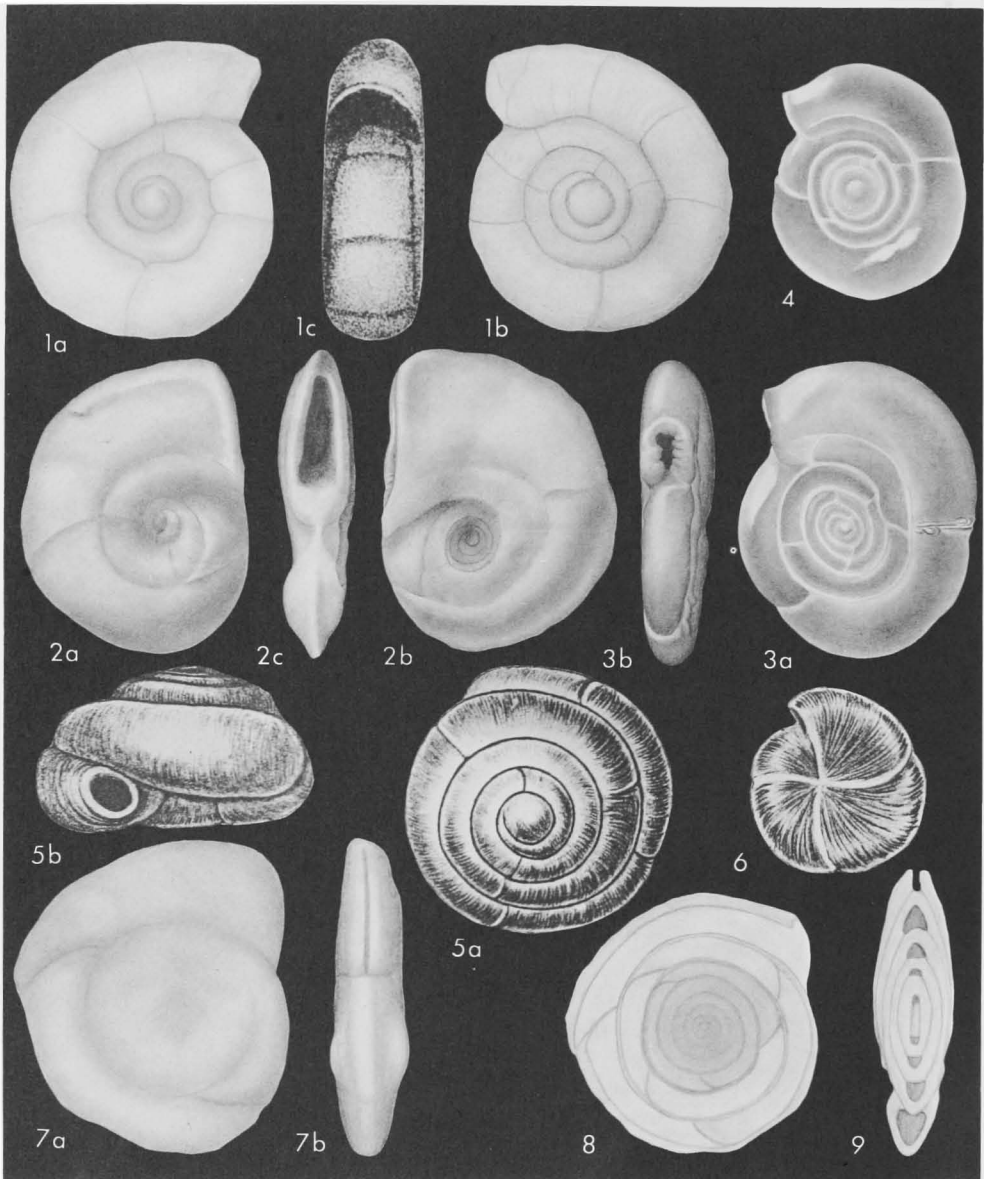


FIG. 334. Fischerinidae (Fischerininae; 1-4, *Fischerina*; 5,6, *Fischerinella*; 7-9, *Planispirinella*) (p. C441-C443).

length, later chambers continuing about proloculus in planispiral coil; wall calcareous, thin, imperforate; aperture at open end of tube. ?*Paleoc.*, *Oligo.-Rec.*, cosmop.—FIG. 334.1. \**F. rhodiensis*, *Rec.*, *Medit.*; 1*a,b*, opposite sides of holotype,  $\times 79$  (\*2117); 1*c*, edge view,  $\times 79$  (\*1889).—FIG. 334.2. *F. communis* (SEGUENZA), *Pleist.*, USA (Calif.); 2*a-c*, opposite sides and edge views,  $\times 115$  (\*2117).—FIG. 334.3,4. *F. compressa* (WIESNER), *Rec.*, *Medit.*

of microspheric topotype; 4, side view of megalo-spheric topotype; all  $\times 111$  (\*2117).

[Although *Fischerina* is commonly described as trochospiral, with involute umbilical side, the holotype of the type-species, preserved in the Museum National d'Histoire Naturelle, Paris, is completely planispiral. *Fischerina* is therefore similar to *Cyclogyra*, but septate. *Trisegmentina* WIESNER was previously shown to be a junior synonym of *Planispirina* by LOEBLICH & TAPPAN (1955, \*1166, p. 15), but with the redefinition of *Fischerina* TERQUEM to conform to the type-species, both *Trisegmentina* and *Planispirina* become synonyms of *Fischerina*. The original type of *Fischerina* was from the Pliocene, Isle of Rhodes, that of *Planispirina communis* from the Pliocene (Astian) of Sici-



ly, and that of *Trisegmentina compressa* WIESNER from Recent of the Mediterranean. The nomenclature of this last species is discussed by LOEBLICH & TAPPAN (1955, \*1166, p. 16). *P. communis* differs only in having somewhat more rapidly enlarging chambers and thus a higher arched opening, but the relative proportions are regarded as of specific importance only.]

**Fischerinella** LOEBLICH & TAPPAN, 1962, \*1185, p. 108 [*Fischerina helix* HERON-ALLEN & EARLAND, 1915, \*910b, p. 591; OD]. Test similar to *Fischerina* but with trochospiral coiling and involute umbilical side. *Rec.*, E.Afr.(Kerimba Arch.).—FIG. 334,5,6. \**F. helix* (HERON-ALLEN & EARLAND); 5*a,b*, spiral and edge views of large specimen; 6, umbilical view of smaller form, all  $\times 49$  (\*910b).

**Nautiloculina** MOHLER, 1938, \*1297, p. 18 [\**N. oolithica*; OD]. Test free, planispirally enrolled, with numerous chambers in each whorl, completely involute and bilaterally symmetrical; wall calcareous, imperforate; aperture crescentic equatorial interiomarginal slit. [*Nautiloculina* differs from *Planispirinella* in its robust rather than flattened form and basal slitlike aperture, instead of a high vertical slit in the apertural face.] *Jur.*, Eu.(Switz.).—FIG. 335,1-3. \**N. oolithica*, Raurac. (1,2), Sequan. (3); 1, equat. sec.,  $\times 75$ ; 2, equat. sec., central portion enlarged to show planispiral development,  $\times 230$ ; 3, axial secs.,  $\times 75$  (\*1297).

**Planispirinella** WIESNER, 1931, \*2063, p. 69 [*Hauerina exigua* BRADY, 1879, \*196b, p. 267; OD]. Test free, discoidal, planispiral and involute; proloculus followed by low, broad spiraling chambers, about 3 to whorl; sutures obscure, internal septa very thin and oblique; wall calcareous, imperforate, porcelaneous, composed of successive laminae developed with addition of each chamber, laminae each covering entire test, obscuring early chamber divisions externally; aperture high, elongate, subtriangular or slitlike opening extending up face of final chamber. *Tert.-Rec.*, Pac.O.—FIG. 334,7-9. \**P. exigua* (BRADY), *Rec.*, *Challenger* Station 187-A, off Booby Island at 8 fathoms; 7*a,b*, side, apert. views of lectotype, here designated and redrawn (BMNH-ZF3616 ex ZF2107); 8, equat. sec. (BMNH-ZF2110); 9, axial sec. (BMNH-ZF2108),  $\times 79$  (\*2117).

#### Subfamily CALCIVERTELLINAE

Loeblich & Tappan, n. subfam.

Test attached, proloculus followed by nonseptate tubular second chamber. *Penn.-Jur.*

**Calcivertella** CUSHMAN & WATERS, 1928, \*535, p. 48 [\**C. adherens*; OD]. Test attached, with proloculus partially encircled by nonseptate tubular second chamber, which then has rectilinear development in closely appressed zigzag across attachment, and finally tends to spread; wall calcareous, porcelaneous; aperture at open end of tube. [*Calcivertella* differs from *Plummevinella* in having a rectilinear, rather than enrolled, zigzag

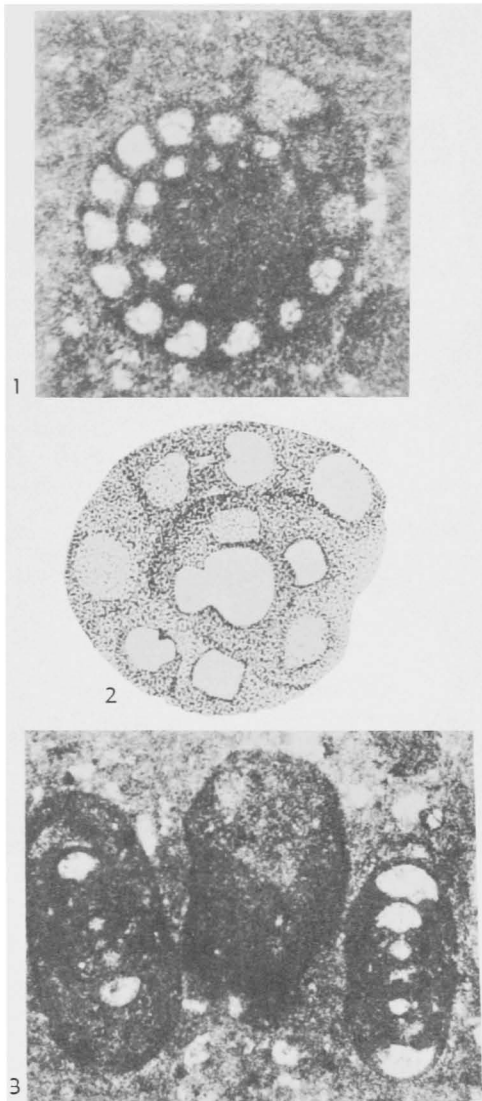


FIG. 335. Fischerinidae (Eischerininae; 1-3, *Nautiloculina*) (p. C443).

development of chamber.] *Penn.-Perm.*, N.Am.—FIG. 336,1. \**C. adherens*, Penn., USA(Tex.); holotype,  $\times 47$  (\*2117).

**Calcitornella** CUSHMAN & WATERS, 1928, \*535, p. 45 [\**C. elongata*; OD] [= *Apterrinella* CUSHMAN & WATERS, 1928, \*536, p. 64 (type, *Tolypamina grahamensis* HARLTON, 1928, \*880, p. 305)]. Test attached, proloculus followed by nonseptate enrolled portion, later uncoiling and winding irregularly across attachment; wall calcareous, porcelaneous; aperture terminal. [The attached side of the holotype of *Calcitornella elongata* shows irregularly spaced transverse thickenings which give the appearance of septa in the early portion,

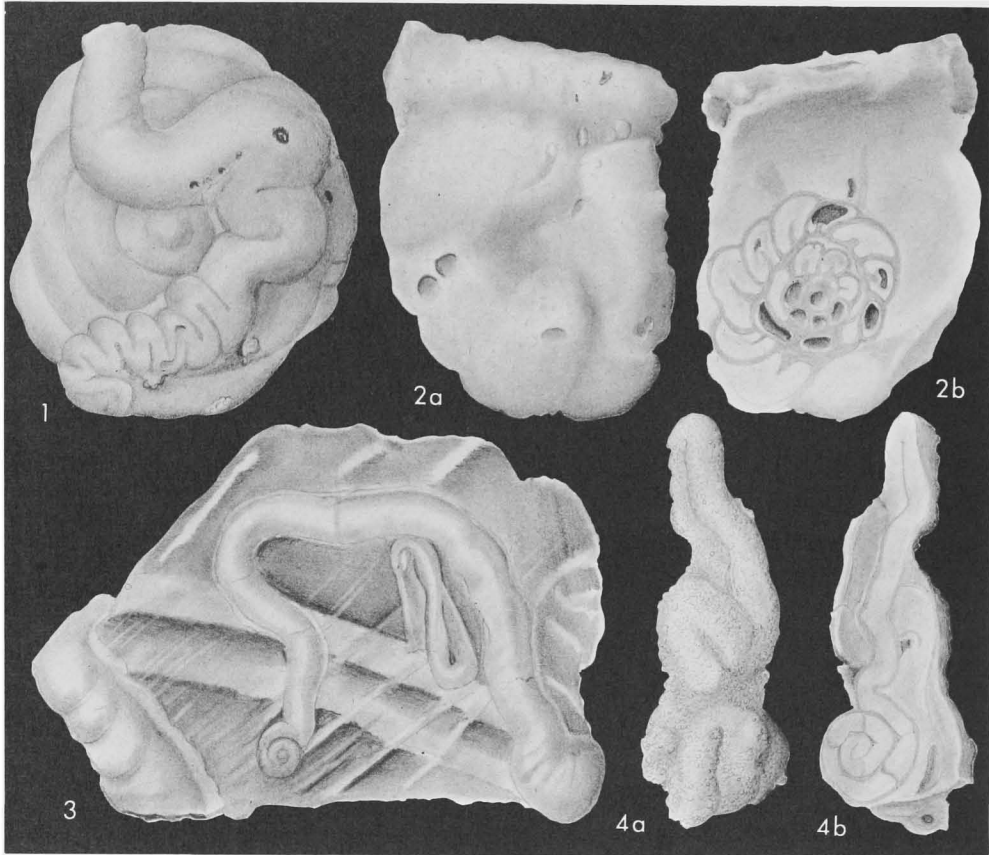


FIG. 336. Fischerinidae (Calcivertellinae; 1, *Calcivertella*; 2, *Plummerinella*; 3, 4, *Calcitornella*) (p. C443-C444).

but apparently are only thickenings of the attached wall and not true septa. The later portion is definitely nonseptate. *Apterrinella* is here regarded as a synonym of *Calcitornella*, as the two are similar in all respects. The actual form of the test depends largely on the area of the attachment and both type-species grow back upon themselves to some extent.] *Penn.-Jur.*, N.Am.-Eu.—FIG. 336,3. *C. grahamensis* (HARLTON), Penn., USA(Tex.); holotype,  $\times 35$  (\*2117).—FIG. 336,4. \**C. elongata*, Penn., USA(Tex.); 4a,b, free and attached sides of holotype,  $\times 53$  (\*2117).

*Carixia* MACFADYEN, 1941, \*1200, p. 27 [\**C. langi*; OD]. Test attached, consisting of unsegmented tubes radiating from central point and anastomosing over surface of substratum; wall calcareous, imperforate, with attachment of calcareous cement; apertures formed by simple open ends of tubes. *Jur.*, G.Brit.(Eng.).—FIG. 337,1. \**C. langi*, Lias., hypotype,  $\times 80$  (\*2117).

*Planinvoluta* LEISCHNER, 1961, \*1128, p. 11 [\**P. carinata*; OD]. Test flattened, discoidal, probably originally attached; with globular proloculus and

nonseptate planispirally enrolled second chamber, evolute on one side, involute on opposite side, which as a result is centrally inflated. [Described from thin sections, the genus is not completely known. As the flattened side suggests an attached condition, the genus is here placed in the Calcivertellinae.] *U.Trias.(Rhaet.)*, Eu.(Aus.).—FIG. 337,3-5. \**P. carinata*; 3, axial sec. of holotype; 4,5, equat. secs.,  $\times 100$  (\*1128).

*Plummerinella* CUSHMAN & WATERS, 1928, \*535, p. 49 [\**P. complexa*; OD]. Test attached, development otherwise similar to *Meandrospira* in early stage, with tubular nonseptate second chamber enrolled about proloculus in zigzag pattern, later spreading and tending to uncoil; wall calcareous, porcelainous; aperture at open end of tube. *Penn.*, N.Am.—FIG. 336,2. \**P. complexa*, USA(Tex.); 2a,b, opposite sides of holotype,  $\times 73$  (\*2117).

#### Family SQUAMULINIDAE Reuss, 1862

[*nom. correct.* LOEBLICH & TAPPAN, herein (*pro* family Squamulinidea REUSS, 1862, p. 364, and Squamulinida HAECKEL, 1894, p. 190)]

Test single-chambered, attached. *Rec.*

*Squamulina* SCHULTZE, 1854, \*1695, p. 56 [\*S.

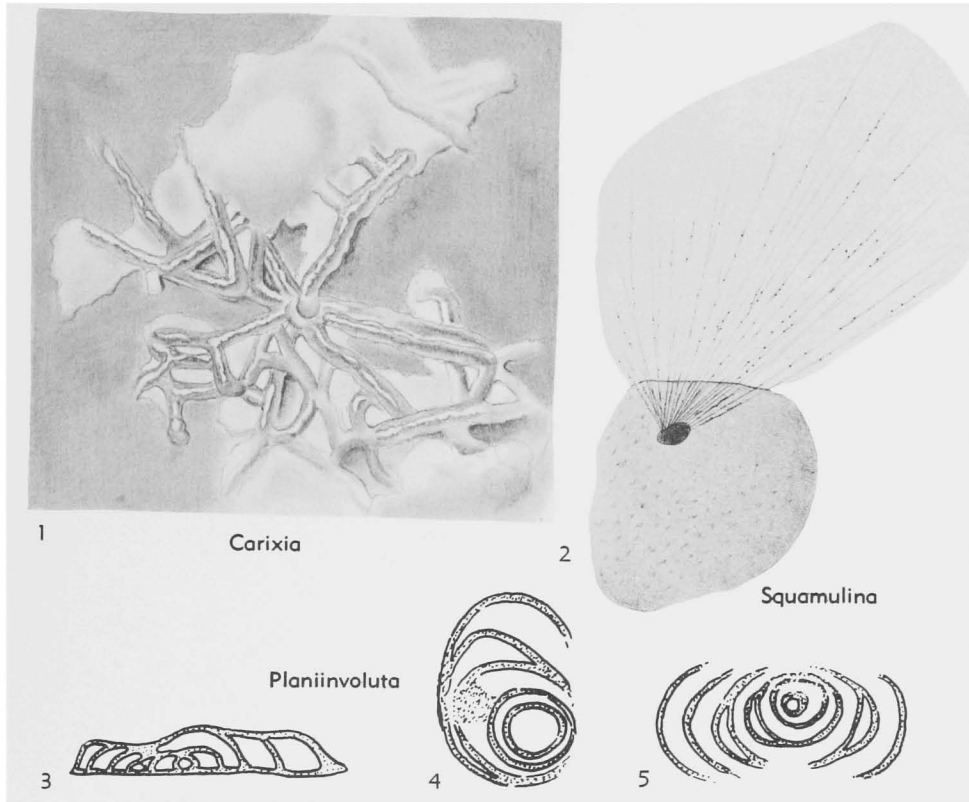


FIG. 337. Fischerinidae (Calcivertellinae); 1, *Carixia*; 3-5, *Planiinvoluta*; Squamulinidae; 2, *Squamulina* (p.C444-C445).

*laevis*; OD(M)] [= *Arsquamulum* RHUMBLER, 1913, \*1572b, p. 346 (obj.) (nom. van.)]. Test attached, consisting of single inflated chamber with calcareous imperforate wall; aperture rounded on upper surface. *Rec.*, Eu. (Baltic Sea).—FIG. 337.2. \**S. laevis*;  $\times 72$  (\*1695).

### Family NUBECULARIIDAE Jones, 1875

[*nom. correct.* AVNIMELECH & REISS in AVNIMELECH, PARNES & REISS, 1954, p. 838 (*pro* family Nubecularida JONES in GRIFFITH & HENFREY, 1875, p. 319, and Nubecularidae LISTER in LANKESTER, 1903, p. 143)]—[All names referred to are of family rank]—[=Inequilateralidae D'ORBIGNY in DE LA SAGRA, 1839, p. 26 (*nom. nud.*); =Inaequilateralidae D'ORBIGNY, 1846, p. 73 (*nom. nud.*); =Ovulinetta HAECKEL, 1894, p. 164 (*nom. nud.*)]—[=Nubecularina LANKESTER, 1885, p. 846; =Nubecularinae DELAGE & HÉROUARD, 1896, p. 122]—[=Ophthalmidiidae CUSHMAN, 1927, p. 36; (*nom. imperf.*); =Ophthalmidiidae CUSHMAN, 1928, p. 159; =Ophthalmidiidae LE CALVEZ, 1935, p. 96 (*nom. van.*); =Ophthalmidiidae DOGEL, 1951, p. 464 (*nom. van.*); =Vertebralinidae POKORNÝ, 1958, p. 251; =Calcitubida HAECKEL, 1894, p. 185]

Test free or attached, planispiral or irregularly coiled, at least in early stages, later spreading or branched; aperture simple, rounded or slitlike or more rarely cribrate. *M.Carb.-Rec.*

### Subfamily NUBECULARIINAE Jones, 1875

[*nom. correct.* CHAPMAN, 1901, p. 169 (*pro* subfamily Nubecularinae BRADY, 1884, p. 61, *nom. transl. ex* family Nubecularida JONES, 1875)] [=Nubeculinellinae AVNIMELECH & REISS in AVNIMELECH, PARNES & REISS, 1954, p. 838]

Test attached, early stage coiled, later may be irregular. *Jur.-Rec.*

*Nubecularia* DEFRANCE, 1825, \*579f, p. 210 [\**N. lucifuga*; OD (M)]. Test attached, early portion in cornuspirine coil, later stage chambered, may continue coiling or become linear but varies considerably in shape according to substratum, terminal portion may grow away from substratum as tubular projection; wall calcareous, imperforate, commonly incorporates small grains of sand; aperture elongate slit at attachment when specimen is attached, but becoming rounded with lateral toothlike infoldings of walls when growing free. *Jur.-Rec.*, cosmop.—FIG. 338,1-3. \**N. lucifuga*, M.Eoc.(Lutet.), Fr.; 1, specimen showing attached side; 2, specimen with free-growing final portion and infolded apertural margin; 3, top view of specimen showing restricted aperture,  $\times 25$  (\*2117).

[GALLOWAY (1933, \*762, p. 116) stated that the genus does not have a lower wall. However, specimens of the type-species show a complete lower wall, others show various

stages between this and an absence of a lower wall, so that it seems that this character may be due to nature of the substratum. Apparently, infolding of the apertural wall has not been previously noted for this species, although it is shown on approximately half of the specimens from the Lutetian at Grignon, France. The original illustrations of DEFRANCE were at very low magnification and did not show this feature. Most other references to the species have been to Recent specimens, which prob-

ably belong to a distinct species, as some show much closer coiling, with more numerous chambers, and others are coarsely agglutinated. The original types were from the *Calcaire coquillier grossier* (Lutetian) at *la falunière de Hauteville, Dept. de la Manche, France.*

**Calcituba** VON ROBOZ, 1884, \*1580, p. 420 [\**C. polymorpha*; OD]. Test attached to algae, con-

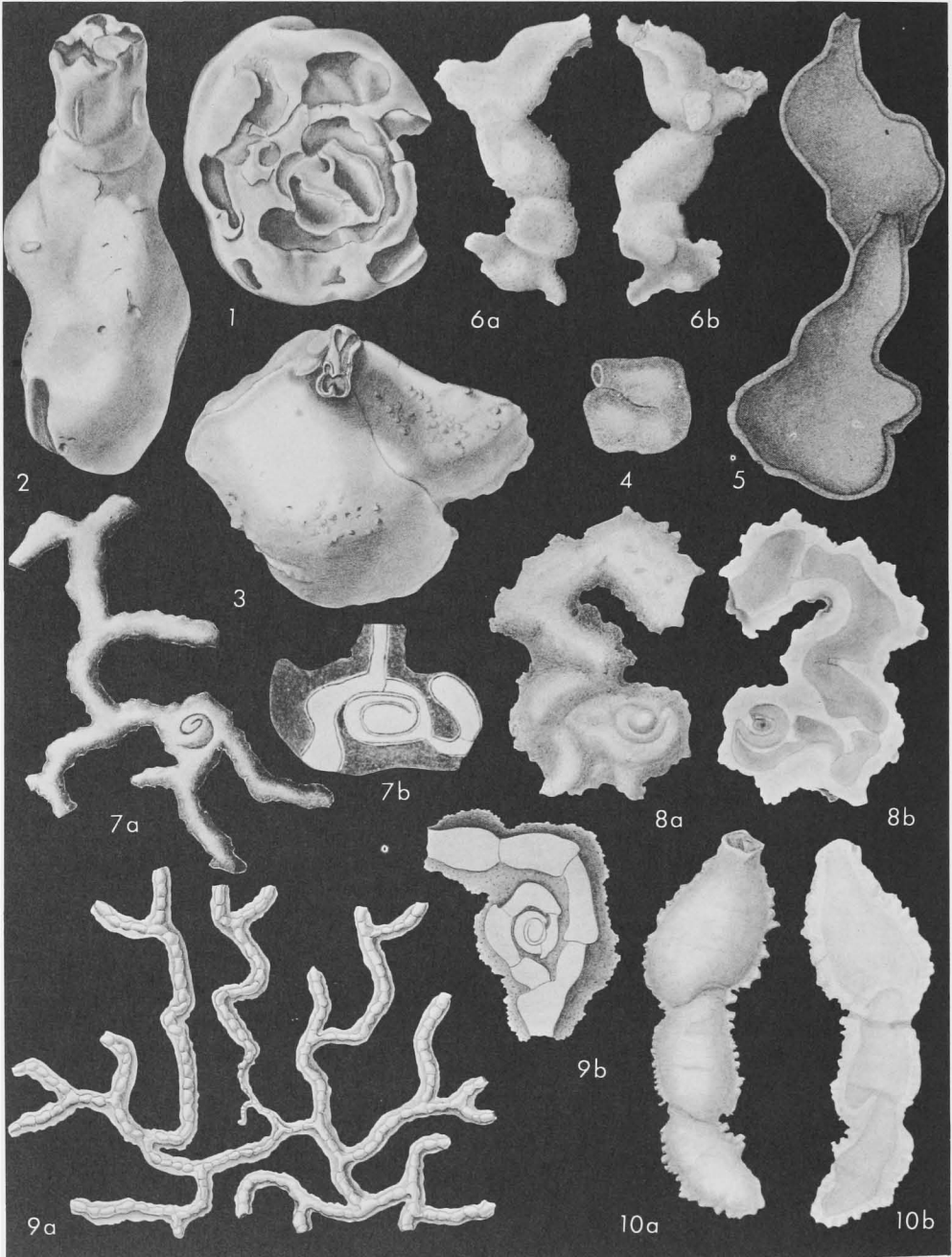


FIG. 338. Nubeculariidae (Nubeculariinae; 1-3, *Nubecularia*; 4-6, *Calcituba*; 7-9, *Cornuspiramia*; 10, *Web-bina*) (p. C445-C448).

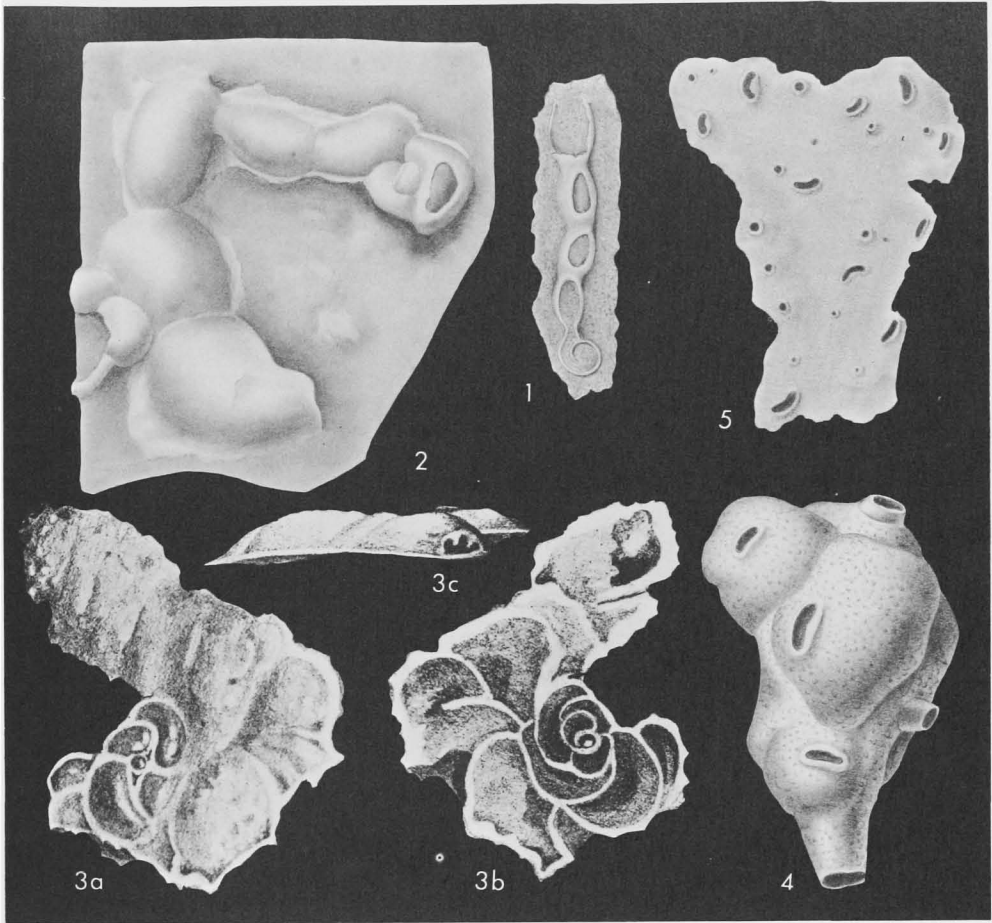


FIG. 339. Nubeculariidae (Nubeculariinae; 1,2, *Nubeculinella*; 3, *Nubeculopsis*; 4,5, *Sinzowella*) (p. C447-C448).

sisting of irregular elongate chambers, uniserial or branching; wall calcareous, porcelaneous; aperture rounded, terminal, on one or more chambers. *Rec.*, Adriatic Sea-Gulf Mex.—FIG. 338, 4-6. \**C. polymorpha*, Adriatic (4,5), Gulf Mex. (6); 4, young form showing spiral appearance,  $\times 50$ ; 5, optical sec. of 2-chambered form,  $\times 150$  (\*1580); 6a,b, opposite sides of larger specimen,  $\times 56$  (\*2117).

**Cornuspiramia** CUSHMAN, 1928, \*436, p. 4 [\**Nubecularia antillarum* CUSHMAN, 1922, \*416, p. 58; OD] [= *Rhizonubecula* J. LE CALVEZ, 1935, \*1102, p. 96 (type, *R. adherens*)]. Test attached, proloculus followed by enrolled tubular second chamber of nearly 1 complete volution in length, and later subpyriform chambers in irregularly rectilinear series, later dichotomously branching over substrate. [*Cornuspiramia* was originally described as a nonchambered, tubular, attached form, as the chambers are difficult to distinguish externally on attached specimens. On specimens which have broken free of attachment the cham-

ber development can be seen.] *Rec.*, Gulf Mex.-Carib.-Medit.—FIG. 338,7,8. \**C. antillarum* (CUSHMAN), Gulf Mex. (7), Carib. (8); 7a,b, ext. and attached side, enlarged (\*436); 8a,b, dorsal and attached surfaces showing chamber development,  $\times 73$  (\*2117).—FIG. 338,9. *C. adherens* (J. LE CALVEZ), Medit.; 9a, entire specimen,  $\times 7$ ; 9b, early portion enlarged to show chamber development,  $\times 50$  (\*1102).

**Nubeculinella** CUSHMAN, 1930, \*446, p. 133 [\**N. bigoti*; OD]. Test attached, consisting of proloculus followed by second chamber coiling around first, varying from half coil to one and one-half coils in length, forms with smaller proloculus followed by longer and more enrolled second chamber, later chambers elongate-ovate to irregular in outline, uniserially arranged but winding somewhat upon shell fragments to which they attach; wall calcareous, imperforate, milky white; aperture semi-circular opening against substratum. [Differs from *Nubecularia* in its more regular chamber development, with early coil followed by un-

- coiled portion.] *U. Jur.*, Eu.—FIG. 339,1,2. \**N. bigoti*, Oxford., Fr.; 1, holotype (\*446); 2, paratype,  $\times 65$  (\*2117).
- Nubeculopsis** COLLINS, 1958, \*375, p. 375 [\**N. queenslandica*; OD]. Test attached, similar to *Nubeculinella* but early portion with arcuate chambers forming early coil, instead of nonseptate tube coiling around proloculus, later chambers tending to uncoil; aperture terminal arch against attachment, with infolded teeth, similar to those in *Nubeculina*. *Rec.*, Australia.—FIG. 339,3. \**N. queenslandica*; 3a, upper surface of holotype; 3b, surface of attachment; 3c, top view showing apert. teeth; all  $\times 66$  (\*375).
- Sinzowella** CUSHMAN, 1933, \*458, p. 33 [\**Nubecularia novorossica* var. *deformis* KARRER & SINZOW, 1877, \*1024, p. 283; OD]. Test to 10 mm. in length, attached, early stage planispiral as in *Cyclogyra*, later with globular chambers forming irregular mass; wall calcareous, porcelaneous, thick; elongate reniform aperture with bordering lip on each of globular chambers. *Mio.*, Eu.—FIG. 339,4,5. \**S. deformis* (KARRER & SINZOW), Sarmat., Rumania; 4, ext. showing globular chambers and apertures; 5, long. sec. showing thick walls, enlarged (\*1024).
- Webbina** D'ORBIGNY DE LA SAGRA, 1839, \*1611, p. 26 [\**W. rugosa* D'ORBIGNY in BARKER-WEBB & BERTHELOT, 1839, \*86, p. 126; SD (SM)] [= *Webbum* RHUMBLER, 1913, \*1572b, p. 444 (type, *Webbina rugosa* D'ORBIGNY, SD LOEBLICH & TAPPAN, herein); *Arwebbum* RHUMBLER, 1913, \*1572b, p. 445 (*nom. van.*)]. Test attached by entire lower surface, chambers few in number, inflated, surface marked by faint transverse "growth lines," margins of chambers bordered by fimbriate "keel"; wall thin, calcareous, appearing milky white and imperforate, surface smooth except for transverse wrinkles; aperture terminal, with bordering lip. *Rec.*, Atl.-Timor Sea.—FIG. 338,10. \**W. rugosa*, Atl.; 10a,b, holotype, showing convex chambers on free side and opposite side flattened against attachment,  $\times 58$  (\*2117).
- [Although commonly placed with the perforate calcareous genera, in the Cibicidinae (\*762, p. 296; \*486, p. 339; \*1509, p. 287), the holotype, in the Museum National d'Histoire Naturelle, Paris, has a porcelaneous and imperforate wall, the "rugose" appearance being due merely to surface wrinkles. The genus was redefined by LOEBLICH & TAPPAN (\*1166, p. 23) and is here transferred to the Nubeculariinae. Specimens of *Webbina* recently have been obtained from the Sahul Shelf, northern Australia, at a depth of 72 fathoms.]
- Subfamily OPHTHALMIDIINAE** Wiesner, 1920  
[Ophthalmidiinae WIESNER, 1920, p. 17]—[All names of subfamily rank]—[=Trisegmentiniinae WIESNER, 1920, p. 17, 18; =Miliolidae holostreptae EIMER & FICKERT, 1899, p. 688 (*nom. nud.*); =Ophthalmidiinae CUSHMAN, 1927, p. 37 (*nom. van.*); =Planispirinellinae WIESNER, 1931, p. 58, 60, 69, 110]
- Test free, proloculus and undivided planispirally coiled chamber followed by irregular later chambers. *M. Carb. Rec.*
- Ophthalmidium** KÜBLER & ZWINGLI, 1870, \*1061, p. 46 [*pro Oculina* KÜBLER & ZWINGLI, 1866, \*1060, p. 11 (*non* LAMARCK, 1816)] [\**Oculina liasica* KÜBLER & ZWINGLI, 1866, \*1060, p. 11; OD] [= *Spirophthalmidium* CUSHMAN, 1927, \*431, p. 37 (*nom. imperf.*) (type, *Spiroloculina acutimargo* BRADY, 1884, \*200, p. 154); *Spirophthalmidium* GALLOWAY, 1933, \*762, p. 112 (*nom. correct.*, obj.)]. Test free, ovate to fusiform in outline, flattened, consisting of globular proloculus followed by spirally wound second chamber of one-half to complete whorl in length, later chambers one-half coil in length and regularly added, chambers may taper slightly from early portion to oral end, and may be loosely coiled with flattened plate between whorls; wall calcareous, imperforate, porcelaneous; aperture rounded to ovate, at end of final chamber. *U. Trias. Rec.*, cosmop.—FIG. 340,1. \**O. liasica* (KÜBLER & ZWINGLI), U. Lias., Eu. (Switz.); holotype (small megalospheric specimen),  $\times 14$  (\*2071).—FIG. 340,2. *O. acutimargo* (BRADY), *Rec.*, S. Atl. O.; 2a,b, side and top views of toptype,  $\times 48$  (\*2117).
- Cornuloculina** BURBACH, 1886, \*253b, p. 497 [\**Hauerina inconstans* BRADY, 1879, \*196b, p. 268; SD LOEBLICH & TAPPAN, herein] [= *Hauerinella* SCHUBERT, 1921, \*1694, p. 162 (obj.)]. Test free, planispirally coiled and evolute, globular proloculus followed by planispirally wound tubular second chamber of up to 3 whorls, followed by chambers of approximately one-half coil in length, or slightly less, resulting in 2.5 to 3 chambers to whorl in later stages, chambers somewhat loosely coiled, those of adjacent whorls being separated by thin plate; wall calcareous, imperforate; aperture at open end of final chamber. [*Cornuloculina* is separated from *Ophthalmidium* in the less regular coiling with more than 2 chambers in each whorl.] *Jur. Rec.*, S. Atl. O.-S. Pac. O.-Eu.—FIG. 340,3-7. \**C. inconstans* (BRADY), off Brazil (3-6), S. Pac. (7); 3-5, toptypes, showing various stages of development from early planispiral tubular chamber to 2 or more chambers to whorl,  $\times 31$  (\*2117); 6, microspheric toptype in transmitted light,  $\times 30$ ; 7, megalospheric hypotype in transmitted light,  $\times 50$  (\*207+).
- Edentostomina** COLLINS, 1958, \*375, p. 370 [\**Miliolina cultrata* BRADY, 1879, \*196c, p. 45; OD]. Test compressed, ovate, apparently planispiral, with chambers one-half coil in length; wall porcelaneous, surface smooth, longitudinally striate or pitted; aperture terminal, commonly somewhat produced, with thickened rim, without apertural teeth, but may be ovate, slitlike, or cruciform. *Rec.*, Indo-Pac. O.—FIG. 341,1. \**E. cultrata* (BRADY), Malay Arch.; 1a-c, opposite sides and apert. view showing planispiral development,  $\times 40$  (\*1284a).—FIG. 341,2. *E. milletti* (CUSHMAN); specimen mounted in balsam and viewed in transmitted light to show chamber arrangement, exterior suture lines omitted,  $\times 40$  (\*1284a).



[The original description stated in part, "Test triloculine or biloculine . . . last two chambers added at approximately 180°, . . . aperture oval with a thickened rim

and no tooth." In addition to the type-species, *Miliolina durrandii* MILLETT, *Miliolina rupertiana* BRADY, and *Biloculina milletti* CUSHMAN were transferred to *Edentostomina*.

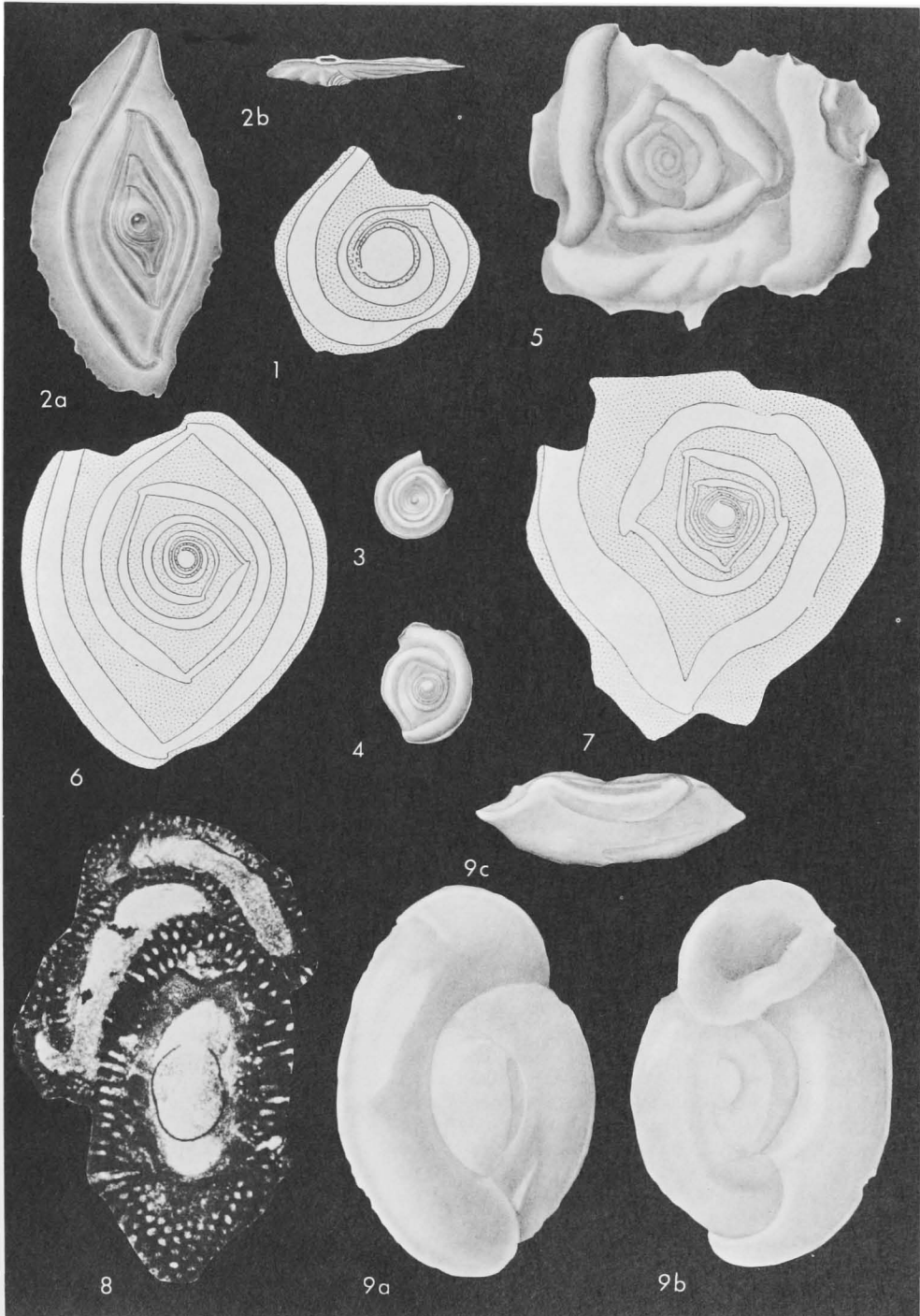


FIG. 3-10. Nubeculariidae (Ophthalmidiinae; 1, 2, *Ophthalmidium*; 3-7, *Cornuloculina*; 8, *Pseudovermiporella*; 9, *Wiesnerella*) (p. C448, C450-C452).

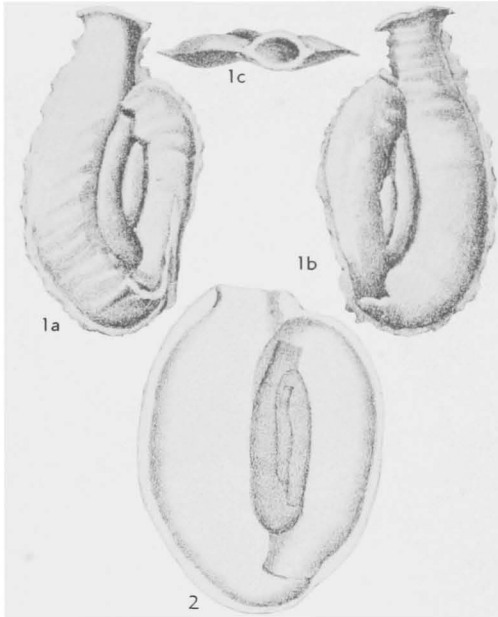


FIG. 341. Nubeculariidae (Ophthalmitiinae; 1, 2, *Edentostomina*) (p. C448-C450).

None of these species shows a typical trilocoline development or is typically miliolid, since in most species the same number of chambers is visible on both sides (4 on each side in *E. durrandii*, and in MILLETT's specimens of *E. cultrata* whereas BRADY figured one side only of 2 different specimens, and 2 on each side in *E. milletti*). Only in *Miliolina rupertiana* does a suggestion of asymmetry appear, although no figures have been published showing both sides of a single specimen. The views of *E. milletti* in transmitted light given by MILLETT (Fig. 341,2) also appear to show a planispiral development. For this reason, and because of the absence of an apertural tooth, *Edentostomina* is here transferred to the Ophthalmitiinae.]

**Eosigmoilina** GANELINA in KIPARISOVA, *et al.*, 1956, \*1040, p. 17 [*E. explicata*; OD]. Test compressed-ovate, globular proloculus followed by nonseptate tubular second chamber in glomospirine coil, later portion with 2 chambers to whorl and development as in *Sigmoilina*, with plane of coiling gradually changing to form sigmoid curve as seen in transverse section; septa very thin; wall calcareous, imperforate, thin, aperture simple rounded opening at end of final chamber. [Originally placed in the Miliolidae, this genus is here transferred to the Ophthalmitiinae, family Nubeculariidae, because of its nonseptate enrolled second chamber and later milioline development, and the simple apertural opening.] *M. Carb.*, USSR (Dnieper-Donets Basin)-Eu. (Czech.).—FIG. 342, 1, 2. \**E. explicata*, USSR; 1a-c, opposite sides and edge views of paratype,  $\times 100$ ; 2, long. sec. showing change in axis of coiling,  $\times 150$  (\*1040).

**Galeanella** KRISTAN, 1958, \*1058, p. 114 [*pro Galea* KRISTAN, 1957, \*1057, p. 291 (*non* MEUSCHEN, 1787; *nec* MEYER, 1833; *nec* MOERCH, 1852)] [*\*Galea tollmanni* KRISTAN, 1957, \*1057, p. 291;

OD]. Test consisting of globular proloculus and enrolled close-coiled later chambers, which taper distally as in *Ophthalmitidium*, whorls or chambers scarcely perceptible from exterior; wall calcareous, porcelainous and thick, leaving only small chamber cavities, may form thickened rim or keel of test; in thin section few large pore canals seen to pierce thickened wall; aperture rounded opening with radial grooves radiating from it across depressed apertural face. *U. Trias. (Rhaet.)*, Eu. (Aus.).—FIG. 342, 6-8. \**G. tollmanni* (KRISTAN); 6a-d, opposite sides and opposite edge views of holotype; 7a, tang. sec. showing pore canals leading from proloculus; 7b, parallel but deeper section, showing numerous tapering chambers, thick walls and pore canals; 8, vert. long. sec.; all  $\times 35$  (\*1057).

**Glomulina** RHUMBLER, 1936, \*1575, p. 198 [*\*G. fistulescens*; OD]. Test free, globular, proloculus followed by cyclogyrine tubular second chamber, later streptospirally coiled with chambers half coil in length; wall calcareous, imperforate; aperture rounded, terminal. *Rec.*, Baltic Sea.—FIG. 342, 3. \**G. fistulescens*; 3a, b, opposite sides; 3c, specimen viewed as in 3a but in transmitted light to show chamber arrangement,  $\times 45$  (\*1575).

[The genus was described as having secondary apertures on fistulose projections along the final chamber, as can be seen in the figure. It is uncertain, however, whether this is a characteristic of the foraminifer, or due to a parasite or other abnormal growth.]

**Ophthalmina** RHUMBLER, 1936, \*1575, p. 217 [*\*O. kilianensis*; OD]. Test compressed, planispiral, proloculus followed by nonseptate cyclogyrine stage and later with 2 chambers to whorl; wall calcareous, imperforate; aperture at open end of final chamber. [*Ophthalmina* superficially resembles *Wellmanella* and *Pseudomassilina* but differs in having an early planispiral stage instead of early milioline one, and differs from *Pseudomassilina* in the simple, nonpitted or canalliculate wall. It differs from *Hauerinella* and *Zoyanella* in having only 2 chambers to each whorl.] *Rec.*, Eu. (N.Ger.).—FIG. 342, 9-11. \**O. kilianensis*; 9a, b, opposite sides,  $\times 50$ ; 10, ext.,  $\times 70$ ; 11, axial sec.,  $\times 70$  (\*1575).

**Pseudovermiporella** ELLIOTT, 1958, \*698, p. 419 [*\*P. sodalica*; OD]. Test large, irregular, consisting of meandriform tubes, to 1.4 mm. diam., which may be free-growing and circular in section or closely appressed or attached and hemispherical in form; wall of finely crystalline calcite, pierced by numerous, closely set perforations, about 50 visible in single transverse section, in tangential section coarse pores appear to form round-pored mesh, inner continuous solid dark calcareous layer occurring within outer radially perforated layer, probably of secondary origin. [Originally regarded as questionably a primitive dasyclad alga, although also compared to foraminifers and bryozoans, this genus was later regarded as a true foraminifer (HENBEST, 1960, \*898, p. B387).] *Perm.*, SW. Asia (Arabia)-N. Afr. (? Tunisia)-

Japan.—FIG. 340,8. \**P. sodalica*, Arabia; holotype showing meandriform tubes and coarse per-

forations appearing as mesh in tang. section,  $\times 28$  (\*698).

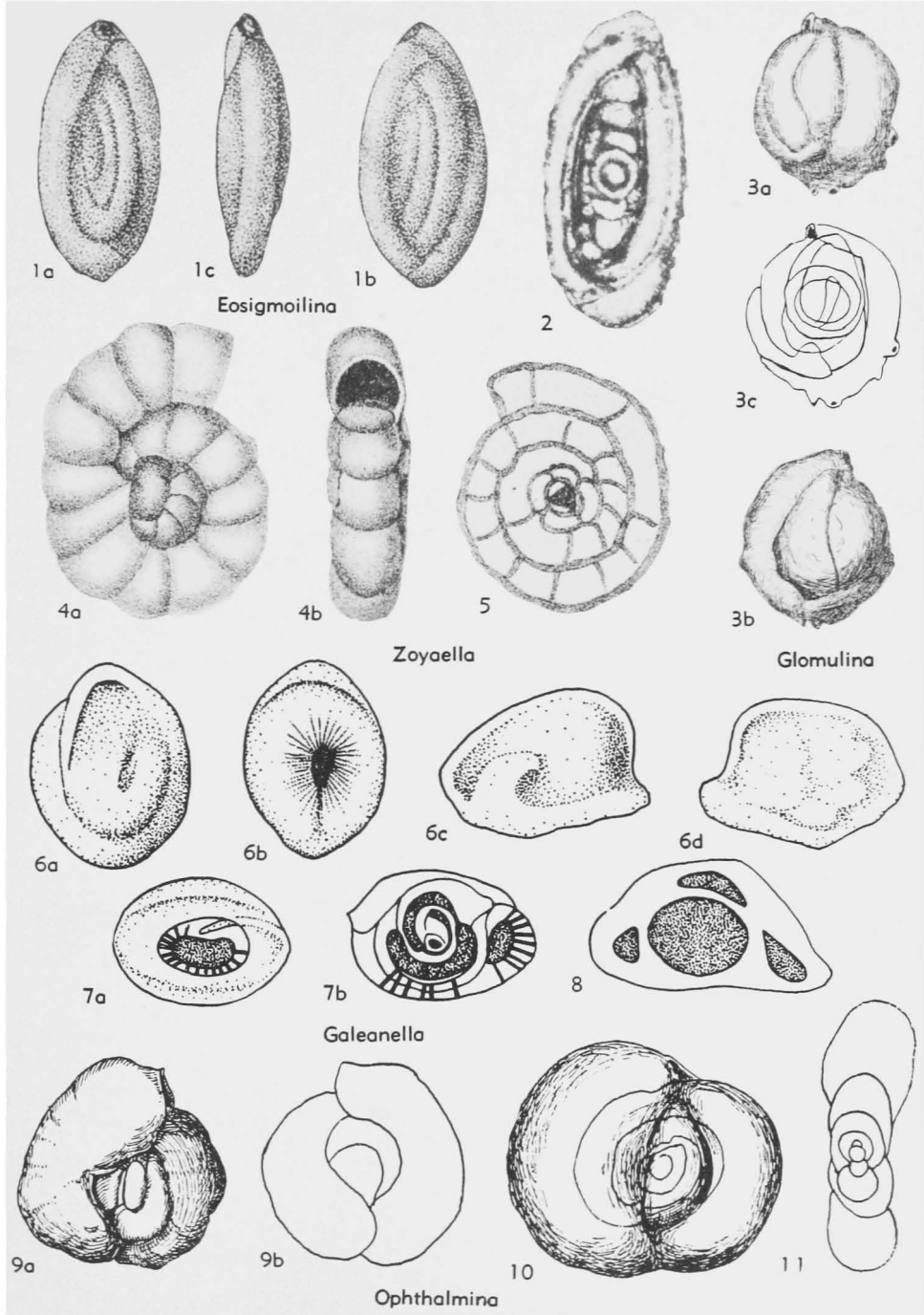


FIG. 342. Nubeculariidae (Ophthalmiidiinae: 1,2, *Eosigmoilina*: 3, *Glomulina*: 4,5, *Zoyaella*: 6-8, *Galeanella*: 9-11, *Ophthalmina*) (p. C450, C453).

*Wiesnerella* CUSHMAN, 1933, \*458, p. 33 [*Planispirina auriculata* EGGER, 1893, \*658, p. 245; OD]. Test planispiral in early stage, later cham-

bers somewhat embracing, each one-half coil in length; wall thin, porcelaneous; aperture large, rounded, with everted lip. *Rec.*, Atl.O.-Gulf Mex.

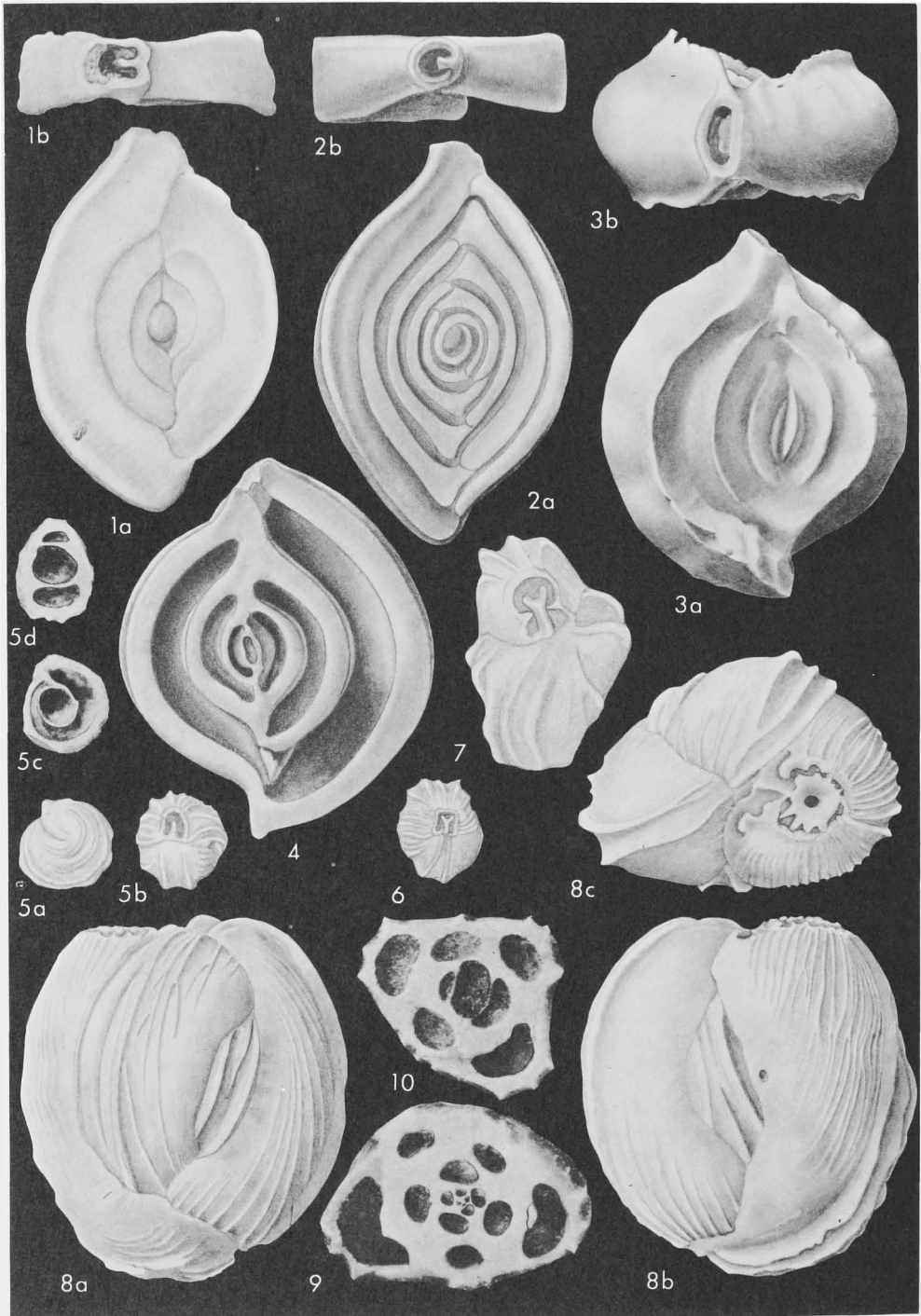


FIG. 343. Nubeculariidae (Spiroloculinae; 1-4, *Spiroloculina*; 5-10, *Cribrolinoides*) (p. C453).

—FIG. 340,9. \**W. auriculata* (EGGER), Gulf Mex.; 9a-c, opposite sides, top view,  $\times 174$  (\*2117).

**Zoyaella** LOEBLICH & TAPPAN, 1962, \*1185, p. 109 [pro *Ceratina* GOËS, 1894, \*804, p. 122 (non LATREILLE, 1802; nec MENGE, 1868)] [*Ceratina trochamminoides* GOËS, 1894, \*804, p. 122; OD]. Test free, discoidal, proloculus followed by tubular second chamber, then streptospirally enrolled as in *Glomulina*, and finally planispiral, involute, with numerous chambers to whorl; wall calcareous, porcelaneous; aperture high arch at open end of final chamber. [*Zoyaella* differs from *Fischerina* in its early streptospiral stage, and from *Glomulina* in its later planispiral stage.] *Rec.*, N.Atl.O.(Azores).—FIG. 342,4,5. \**Z. trochamminoides* (GOËS); 4a,b, side, edge views of holotype,  $\times 21$ ; 5, equat. sec. showing chamber arrangement,  $\times 37$  (\*804).

#### Subfamily SPIROLOCULININAE Wiesner, 1920

[Spiroloculininae WIESNER, 1920, p. 17, 18]

Proloculus followed by cornuspirine coil, adult chambers one-half coil in length; aperture commonly with phialine lip and with simple or bifid tooth. *U.Cret.-Rec.*

**Spiroloculina** D'ORBIGNY, 1826, \*1391, p. 298 [\**S. depressa*; SD CUSHMAN, 1917, \*404f, p. 29] [= *Spirolocunina*, *Spiroloculina* STÖHR, 1877, \*1840, p. 640 (nom. null.); *Flintia* SCHUBERT, 1911, \*1689b, p. 124 (type, *Spiroloculina robusta* BRADY, 1884, \*200, p. 150)]. Test free, commonly with flattened sides and lanceolate or fusiform outline, earliest stage may consist of single chamber completely encircling proloculus, later chambers (or all chambers in megalospheric forms) being added 2 to whorl on alternate sides and in single plane; wall calcareous, imperforate, porcelaneous; aperture at open end of final chamber, with simple or bifid tooth. *U.Cret.-Rec.*, cosmop.—FIG. 343, 1,2. \**S. depressa*, Plio., Eu.(Italy); 1a,b, side, top views of megalospheric topotype,  $\times 41$ ; 2a,b, side, top views of microspheric hypotype showing early cyclogyrine coil,  $\times 105$  (\*2117).—FIG. 343,3,4. *S. robusta* BRADY; *Rec.*, Carib. (3), Gulf Mex. (4); 3a,b, side and top views of topotype,  $\times 25$ ; 4, sectioned hypotype showing early stage,  $\times 31$  (\*2117).

[Differs from *Massilina* in having a planispiral early stage, as can be seen in the figures, and all chambers are added in a single plane, whereas *Massilina* is quinqueloculine in the early stage. *Flintia* was described as differing from *Massilina* in being biloculine throughout, rather than having an early quinqueloculine stage. GALLOWAY (1933, \*762) regarded *Flintia* as a synonym of *Massilina*, but because of the absence of an early milioline stage in the type-species of *Flintia*, it is here regarded as a synonym of *Spiroloculina*.]

**Cribrolinoides** CUSHMAN & LEROY, 1939, \*510, p. 15 [\**Quinqueloculina disparilis* D'ORBIGNY var. *curta* CUSHMAN, 1917, \*404f, p. 49; OD]. Test quinqueloculine in adult, but early stage with planispirally wound second chamber forming

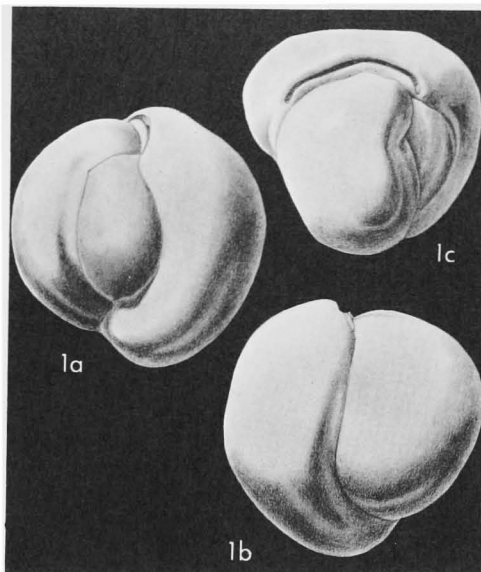


FIG. 344. Nubeculariidae (Spiroloculininae; 1, *Planispirinoides*) (p. C453-C455).

complete volution around proloculus; aperture terminal, with simple linear tooth in earliest stages, later bifid and then with bifid tips elongating and fusing in ring, toothlike projections from ring then attaching first to opposite side of opening and then in various places, resulting in complex cribrate aperture. [Because of the early cyclogyrine coil, *Cribrolinoides* is here transferred from the Miliolidae to the Nubeculariidae, subfamily Spiroloculininae.] *Plio.-Rec.*, Indo-Pac.O. —FIG. 343,5-10. \**C. curta* (CUSHMAN), Plio., Java; 5-8, specimens showing changes in apert. development from 2-chambered stage with simple tooth to quinqueloculine stage developing apert. ring; 5a-d, side and apert. views, long. and axial secs. of 2-chambered stage,  $\times 15$  (\*510); 6,7, intermediate stages showing aperture,  $\times 15$  (\*510); 8a-c, opposite sides and apert. view of adult specimen,  $\times 15$  (\*2117); 9,10, axial secs. of microspheric and megalospheric adults; all  $\times 15$  (\*510).

**Planispirinoides** PARR, 1950, \*1429, p. 287 [\**Miliolina bucculenta* BRADY, 1884, \*200, p. 170; OD]. Test free, early stage planispirally coiled as in *Cyclogyra*, later chambers coiled in plane perpendicular to original plane of coiling and final chambers triloculine in same plane; wall calcareous, porcelaneous, imperforate; aperture an elongate slit, with a broad flaplike lip. [*Planispirinoides* differs from *Planispirina* in having the chambers of later stages coiled in a different plane and in development of a broad flaplike tooth. It differs from *Miliolinella* in possessing an early *Cyclogyra* stage.] *Rec.*, Atl.O.-Antarctic-Australia-



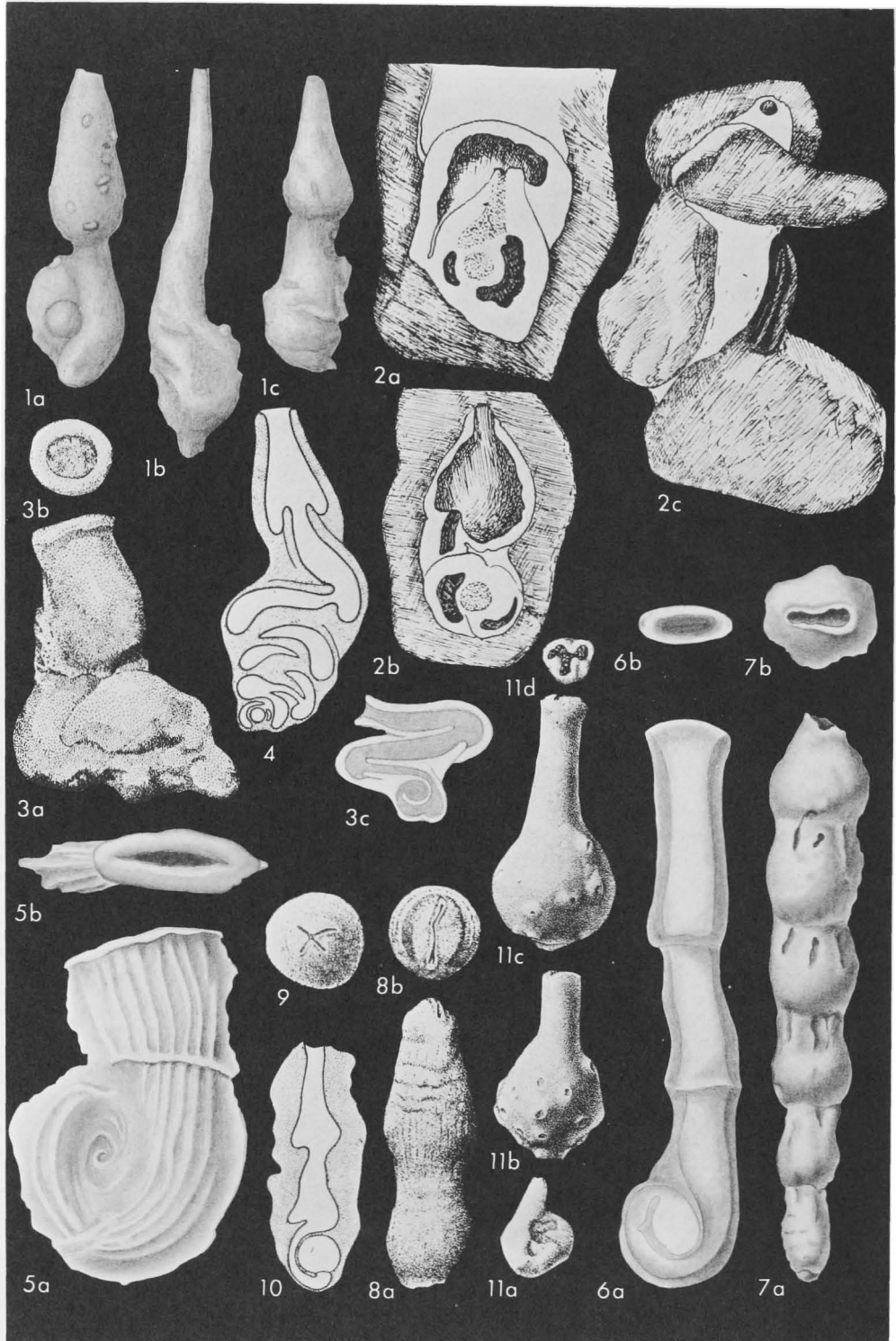


FIG. 345. Nubeculariidae (Nodobaculariinae; 1,2, *Nodobacularia*; 3,4, *Meandroloculina*; 5, *Nodobaculariella*; 6-11, *Nodophthalmidium*) (p. C455-C456).



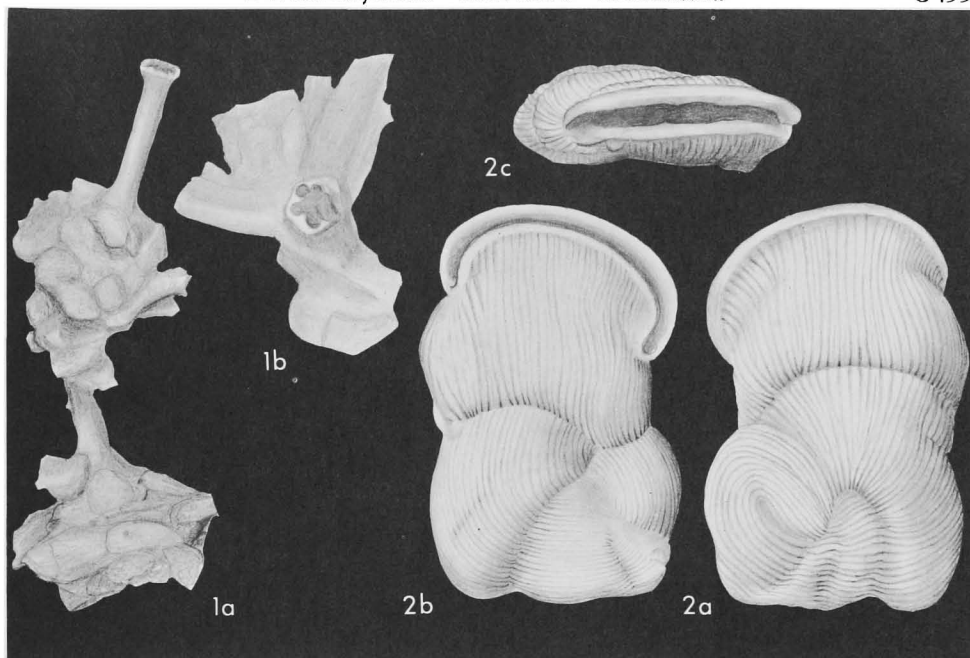


FIG. 346. Nubeculariidae (Nodobaculariinae; 1, *Nubeculina*; 2, *Vertebralina*) (p. C456-C457).

Kerguelen Is.—FIG. 344.1. \**P. bucculenta* (BRADY), Atl.; 1a-c, opposite sides, top view,  $\times 10$  (\*2117).

#### Subfamily NODOBACULARIINAE Cushman, 1927

[Nodobaculariinae CUSHMAN, 1927, p. 36] [=Nodophthalmidiinae CUSHMAN, 1940, p. 179]

Early portion planispiral, later chambers uncoiling. *Jur.-Rec.*

**Nodobacularia** RHUMBLER, 1895, \*1568A, p. 87 [\**Nubecularia tibia* JONES & PARKER, 1860, \*999, p. 455; OD (M)] [=Pseudonubeculina BARTENSTEIN & BRAND, 1949, \*94, p. 670 (type, *Nubecularia nodulosa* CHAPMAN, 1891, \*308, p. 573); *Gymnesina* COLOM, 1959, \*377, p. 16 (type, *G. glomerosa*)]. Test attached, consisting of globular proloculus surrounded by single coil of 2 or rarely 3 chambers which may not be discernible except in section, later portion uniserial, with chambers or chamber cavity pyriform in outline; wall calcareous and imperforate, and incorporating occasional sand grains; aperture at open tubular end of final chamber. *Jur.-Rec.*, cosmop.—FIG. 345.1. \**N. tibia* (JONES & PARKER), L.Jur.(Lias.), Eng.; 1a, lectotype (\*999, fig. 51) showing early coil and pyriform later rectilinear chambers; 1b,c, paratypes (\*999, fig. 48, 49) showing generally obscure appearance of early coil,  $\times 146$  (\*2117). —FIG. 345.2. *N. glomerosa* (COLOM), Rec., Medit. Sea; 2a, holotype showing early chamber arrangement,  $\times 30$ ; 2b, paratype showing early development,  $\times 30$ ; 2c, paratype showing coarsely agglutinated test,  $\times 17$  (\*377).

[MACFADYEN (1939, \*1199, p. 167) considered *Nubecularia tibia* as identical with *Bullopora rostrata* QUENSTEDT, basing his opinion on English Jurassic specimens, which he thought to be identical with QUENSTEDT's species. Topotypes of QUENSTEDT's species have perforate calcareous walls, however, and never include agglutinated material, and are thus generically distinct from the imperforate to agglutinated *Nodobacularia* with early coil and typically pyriform later uniserial chambers. *Pseudonubeculina* was described as completely uniserial, although no early stages were described, all tests being broken in the European Lower Cretaceous material studied. Early coiled stages were found in *Lagenammia pyriformis* TAPPAN, later transferred to *Nodophthalmidium*, from the Albian of Texas (\*1154), a species which is probably conspecific with *Nubecularia nodulosa*. The thin connecting necks commonly result in broken tests. *Gymnesina glomerosa* differs from typical *Nodobacularia* only in coarseness of the agglutinated fragments and is therefore here regarded as congeneric. *Nodobacularia* differs from *Nubeculina* in lacking the phialine apertural lip and teeth, and from *Nodophthalmidium* in its simple aperture and agglutinated covering. The types of *Nubecularia tibia* JONES & PARKER are in the PARKER collection of the British Museum (Natural History). The lectotype, here designated (BMNH-P41672), and paratypes (BMNH-P41671) were isolated and mounted by us in 1953 from the original material of JONES & PARKER in the British Museum. Originally described as from the Triassic at Chellaston near Derby, this material was actually from the Lias of Leicestershire, England, according to the Catalogue of Foraminifera of the Parker Collection (Index to Boxes I-XLV, by T. RUPERT JONES). Three of the original specimens are here illustrated.]

**Meandroloculina** BOGDANOVICH, 1935, \*151, p. 695 [\**M. bogatschovi*; OD]. Proloculus followed by cyclogyrine second chamber, later chambers elongate and alternating in uncoiled zigzag, pseudobiserial manner, finally becoming rectilinear, with subpyriform chambers; wall calcareous, imperforate, thick; aperture terminal, rounded or irregular, with thick bordering lip. *Mio.*(*L.Sarmat.*), USSR (Trans.-Caucasus). — FIG. 345.3. \**M. bogatschovi*; 3a,b, side, top views of holotype,  $\times 33$  (\*152); 3c, long. sec. showing early cham-

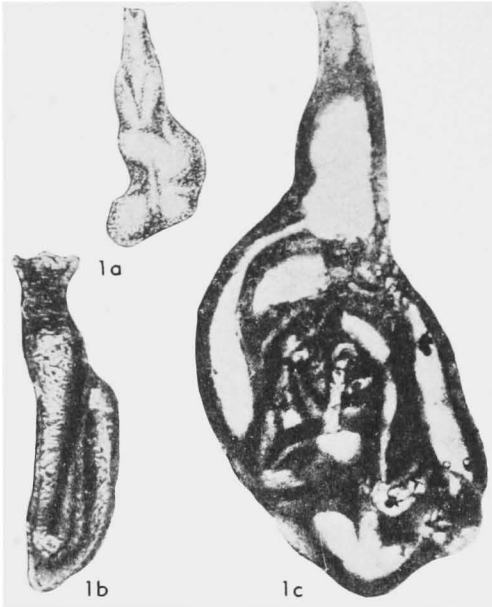


FIG. 347. Nubeculariidae (Nodobaculariinae; *I. Orthella*) (p. C456).

ber development,  $\times 60$  (\*151).—FIG. 345,4. *M. litoralis* BOGDANOVICH; long. sec. showing early zigzag chambers and later tendency to become rectilinear, enlarged (\*152).

**Nodobaculariella** CUSHMAN & HANZAWA, 1937, \*505, p. 41 [*N. japonica*; OD]. Test similar to *Vertebralina*, but early coil completely planispiral and terminal aperture symmetrically placed. [The holotype was originally stated to be in the Institute of Geology and Paleontology, Tohoku Imperial University, Sendai, Japan, but the specimen figured as holotype (\*505, pl. 5) is in the CUSHMAN collection, U.S. National Museum.] *Plio-Pleist.*, Japan (Ryukyu Is.).—FIG. 345,5. \**N. japonica*; 5a,b, side and apert. views of holotype,  $\times 44$  (\*2117).

**Nodophthalmidium** MACFADYEN, 1939, \*1199, p. 167 [*Nodobacularia compressa* RHUMBLER, 1906; \*1571, p. 38; OD] [= *Sarmatiella* BOGDANOVICH, 1952, \*152, p. 217 (type, *S. costata*); *Foraminella* BOGDANOVICH, 1960, \*153, p. 19 (type, *F. obscura*) (non *Foraminella* SOWERBY, 1835; nec LEVINSEN, 1909)]. Test free, proloculus rounded or ovate, followed by planispiral second chamber approximately half coil in length, adult chambers uniserial in development; wall calcareous, imperforate; aperture terminal, rounded or slitlike with lip, triradiate or cruciform. *Paleog.-Rec.*, Adriatic Sea-Medit. Sea-USSR.—FIG. 345,6. \**N. compressum* (RHUMBLER), *Rec.*, Adriatic Sea; 6a,b, side, top views of holotype,  $\times 200$  (\*1571).—FIG. 345,7. *N. costatum* (BOGDANOVICH), Mio. (M.Sarmat.), USSR (Caucasus); 7a, side view; 7b,

top view of different specimen; both  $\times 70$  (\*152).—FIG. 345,8-10. *N. primum* (BOGDANOVICH), Mio. (M.Sarmat.), USSR (pre-Caucasus); 8a,b, 9, side view and apert. views of 2 specimens, originally described as *Sarmatiella*, showing variation from slit to cruciform aperture,  $\times 53$ ; 10, sec. showing early chamber arrangement,  $\times 100$  (\*152).—FIG. 345,11. *N. obscurum* (BOGDANOVICH), Paleog., USSR (Kuban); 11a, holotype showing early coil; 11b-d, side and apert. views of final chamber of holotype showing parasitic borings,  $\times 55$  (\*153).

[*Nodophthalmidium* differs from *Articulina* D'ORBIGNY in having a planispiral rather than milioline early stage. *Sarmatiella* differs only in surface ornamentation from the type of *Nodophthalmidium*, although in addition, some species of *Sarmatiella* develop a triradiate or cruciform aperture. *Foraminella* was described as having an early planispiral coil around the globular proloculus, followed by rectilinear chambers, the distinguishing character being the additional openings on the nipple-like protuberances occurring over the chambers and said to connect with the chamber interior by means of canals. As these openings seem obviously the result of a boring predator or parasite and are found in specimens of many species and genera, they are not considered a valid basis for generic separation, and the species *Foraminella obscura* is here placed in *Nodophthalmidium*. *Foraminella* is also a homonym of *Foraminella* SOWERBY, 1835, and of LEVINSEN, 1909.]

**Nubeculina** CUSHMAN, 1924, \*418, p. 52 [*Sagrina divaricata* BRADY, 1879, \*196b, p. 276; OD]. Test free, or possibly attached in early portion; second chamber coiling around globular proloculus, later chambers inflated and in rectilinear or slightly arcuate uniserial arrangement, may be separated by slender stolon-like necks; wall calcareous, imperforate, milky white, with much coarse agglutinated material on exterior of chambers; aperture terminal on tubular neck, with phialine lip and few inwardly directed teeth. *Rec.*, Pac.O.—FIG. 346,1. \**N. divaricata* (BRADY); 1a, lectotype, showing agglutinated wall and stolon-like apert. necks,  $\times 105$ ; 1b, top view of another specimen (broken chamber) showing apert. teeth,  $\times 146$  (\*2117).

[*Nubeculina* differs from *Nodobacularia* in having an aperture with phialine lip and inwardly pointing teeth. The original syntypes of *Sagrina divaricata* BRADY are in the British Museum (Natural History), and a lectotype is here designated (BMNH-ZF3615, ex ZF2004, BRADY, 1884, \*200, pl. 76, fig. 13) with paratypes (BMNH-ZF2004 and ZF2005), all from *Challenger* station 217A, Humboldt Bay, Papua, at 37 fathoms.]

**Orthella** E. V. BYKOVA in KIPARISOVA, *et al.*, 1956, \*1040, p. 19 [*O. paalzowi*; OD]. Test with globular proloculus followed by streptospirally wound tubular chambers, coiling partially to entirely involute, whorl divisions obscure externally, final portion becoming uncoiled, with no distinct internal septa but chambers thickened basally and tapering distally into elongate necklike extension, thus separating chambers; wall calcareous, imperforate; aperture simple, rounded opening. *U. Jur. (U.Oxford.)*, USSR.—FIG. 347,1. \**O. paalzowi*; 1a,b, ext. views of paratypes,  $\times 80$ ,  $\times 100$ ; 1c, long. sec. approx.  $\times 200$  (\*1040).

**Vertebralina** D'ORBIGNY, 1826, \*1391, p. 282 [*V. striata*; OD (M)]. Test free, flattened, early

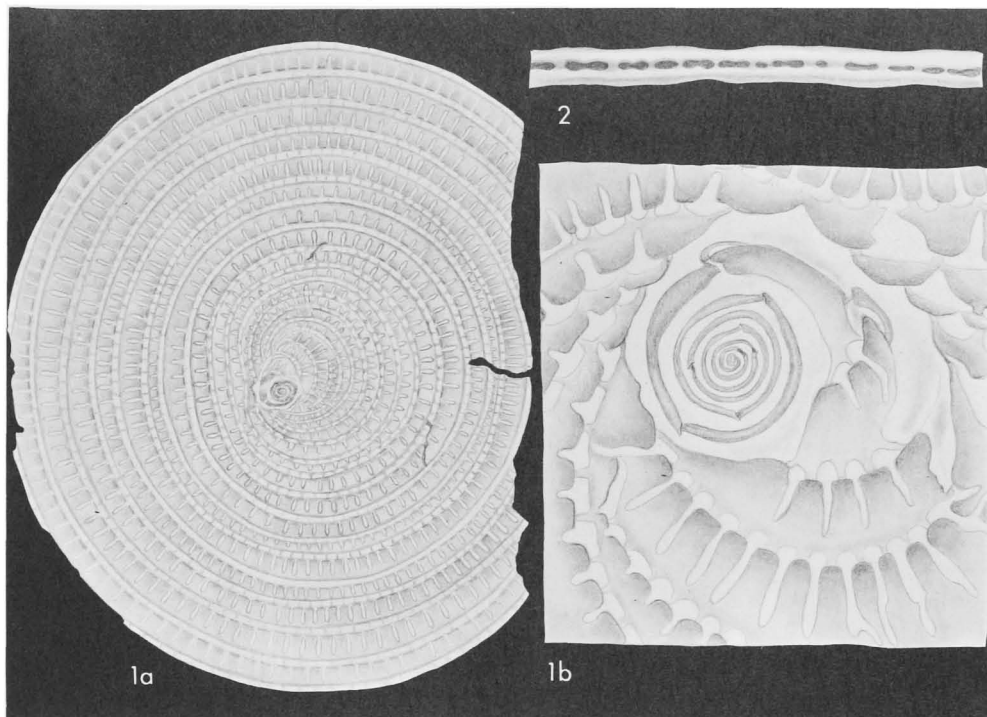


FIG. 348. Nubeculariidae (Discospirinae; 1, 2, *Discospirina*) (p. C457).

portion trochospiral, later uncoiling; wall calcareous, porcelaneous, surface may have longitudinal ribs or striae; aperture terminal, narrow, elongate slit with bordering lip, aperture most evident from umbilical side of coil. *Rec.*, Atl.O.-Pac.O.-Medit. Sea.—FIG. 346, 2. \**V. striata*, Delos Is., Grecian Arch.; 2*a, b*, opposite sides showing trochospiral coil and aperture turned toward umbilical side; 2*c*, top view showing simple slit-like aperture,  $\times 64$  (\*2117).

#### Subfamily DISCOSPIRININAE Wiesner, 1931

[*nom. correct.* LOEBLICH & TAPPAN, 1961, p. 291 (pro subfamily Discospiriniinae WIESNER, 1931, p. 60, 73)]  
[=Krumbachiniinae WIESNER, 1920, p. 17]

Test discoidal, thin, proloculus followed by cornuspirine coil of several volutions, later chambers one-half coil in length and finally annular, may be incompletely divided into chamberlets; aperture comprising row of pores at margin of final chamber. *M.Mio.-Rec.*

*Discospirina* MUNIER-CHALMAS, 1902, \*1328, p. 353 [\**Orbitolites tenuissimus* CARPENTER in CARPENTER & JEFFREYS, 1870 (\*279, p. 155, name and reference to description), CARPENTER in CARPENTER, JEFFREYS & THOMSON, 1870 (\*280, p. 421, description only) =*Pavonina italica* COSTA, 1856 (\*392, p. 178); OD] [=*Cyclophthalmidium* LISTER in LANKESTER, 1903 (\*1094, p. 108) (obj.); *Krumbachina* WIESNER, 1920 (\*2061, p.

14) (obj.); *Discospirina* CUSHMAN, 1927 (\*431, p. 37) (*nom. null.*)]. Test free, discoidal; globular proloculus followed by undivided coil of about 1.5 whorls and series of elongate tubular chambers, which at first comprise nearly complete coil in length, becoming progressively shorter to about one-half coil in length, this early nucleocoil projecting somewhat above general surface, chambers then abruptly becoming higher, flaring and flabelliform, and subdivided by few vertical partitions, at first only 3 or 4 partitions, which arise from basal wall, then chambers becoming more enveloping and finally annular, with increasingly numerous partitions that extend only partially toward chamber roof, leaving continuous open area just below roof for chamberlet intercommunication, chamberlets also connected with previous annular chambers and with exterior by slitlike apertural pores; sutures nearly flush to slightly limbate, best visible when specimen is dampened; wall calcareous, imperforate; aperture single row of slits around entire periphery. *M.Mio.-Rec.*, Eu.-Medit. Sea (Cyprus)-Atl.O.—FIG. 348, 1, 2. \**D. italica* (COSTA), *Rec.*, Atl.; 1*a*, sectioned specimen showing chamber development,  $\times 11$ ; 1*b*, central portion,  $\times 58$ ; 2, edge view of portion of hypotype showing apertures,  $\times 44$  (\*2117).

[*Discospirina* is similar to *Cornuspiroides* in its early cyclogyrine portion and later flabelliform development but differs in being chambered, in having secondary septa, and in its multiple aperture of peripheral slits, *Cornuspiroides* being nonseptate in the flabelliform stage and having a single elongate, terminal slitlike aperture.]

## Family MILIOLIDAE Ehrenberg, 1839

[*nom. correct.* D'ORBIGNY in DE LA SAGRA, 1839, p. xxxix, 160 (*pro* family Miliolina EHRENBURG, 1839, table opp. p. 120)]—[All names referred to are of family rank; dagger (†) indicates *parim*]—[=Polythalamat LATREILLE, 1825, p. 161; (*nom. nud.*); =Agathistégues D'ORBIGNY, 1826, p. 297 (*nom. nud.*; *nom. neg.*); =Enthomostégues D'ORBIGNY, 1826, p. 304 (*nom. nud.*; *nom. neg.*); =Plicatilia EHRENBURG, 1839, table opp. p. 120 (*nom. nud.*); =Fabularina EHRENBURG, 1839, table opp. p. 120; =Helicosorinat EHRENBURG, 1839, table opp. p. 120; =Multiloculidae D'ORBIGNY in DE LA SAGRA, 1839, p. xxxix, 169 (*nom. nud.*); =Rhizopodest DUJARDIN, 1841, p. 126, 240 (*nom. neg.*; *nom. nud.*); =Tubularina AGASSIZ, 1844, p. 10 (*nom. nud.*); =Nautiloidat SCHULTZE, 1854, p. 53 (*nom. nud.*); =Multiloculidaceen ABICH, 1859, p. 106 (*nom. neg.*); =Multiloculidaceen ABICH, 1859, p. 105 (*nom. null.*)]—[=Spherulaceat, Sphérulacéste de BLAINVILLE, 1825, p. 369; =Sphaerulatat CROUCH, 1827, p. 40 (*nom. nud.*); =Spherulidact BRODERIP, 1839, p. 321 (*nom. nud.*)]—[=Miliolida SCHULTZE, 1854, p. 52; =Miliolitiidae PARKER, 1858, p. 53; =Miliolidea REUSS, 1862, p. 374; Miliolidee SCHWAGER, 1876, p. 476, 483; =Miliolidina BÜTSCHLI in BRONN, 1880, p. 189; =Miliolletta HAECKEL, 1894, p. 164; =Miliolinidae RHUMBLER, 1895, p. 86; =Milioliniace DELAGE & HÉROUARD, 1896, p. 122; =Armiliolidae RHUMBLER, 1913, p. 341 (*nom. van.*)]—[=Haueriniidae SCHWAGER, 1876, p. 483; =Haueriniidae STEINMANN, 1881, p. 41; =Hauerinina LANKESTER, 1885, p. 846; =Hauerinae DELAGE & HÉROUARD, 1896, p. 124]

Test free, septate, typically with 2 chambers to whorl arranged in varying planes about longitudinal axis, may become recitilinear or involute, or may be subdivided into chamberlets; aperture terminal, simple, or with spatulate or bifid tooth, or cribrate. *Jur.-Rec.*

Subfamily QUINQUELOCULINAE  
Cushman, 1917

[Quinqueloculininae CUSHMAN, 1917, p. 41]—[All names cited of subfamily rank]—[=Miliolidea genuina REUSS, 1862, p. 374 (*nom. nud.*); =Miliolidae opisthostreptae EIMER & FICKERT, 1899, p. 687 (*nom. nud.*); =Massilinifées LACROIX, p. 1 (*nom. neg.*); =Massilininae THALMANN, 1941, p. 682; =Sigmoilopsinae VELLA, 1957, p. 18]

Wall simple; aperture with bifid tooth or modification of such. *Jur.-Rec.*

*Quinqueloculina* D'ORBIGNY, 1826, \*1391, p. 301 [*nom. conserv.* proposed LOEBLICH & TAPPAN, 1962, \*1184, p. 123 (ICZN pend.)] [\**Serpula seminulum* LINNÉ, 1758, \*1140, p. 786; SD PARKER & JONES, 1859, \*1417a, p. 480] [=Retorta WALKER & BOYS, 1784, \*2033, p. 3 (*nom. reject.* ICZN Op. 558); *Frumentarium* FICHTEL & MOLL, 1798, \*716, p. 16 (*obj.*) (*nom. reject.*, proposed LOEBLICH & TAPPAN, 1962, \*1184, p. 123, ICZN pend.); *Pollontes* DE MONTFORT, 1808, \*1305, p. 247 (type, *P. vesicularis*) (*nom. reject.*, proposed LOEBLICH & TAPPAN, 1962, \*1184, p. 123, ICZN pend.); *Adelosina* D'ORBIGNY, 1826, \*1391, p. 303 (type, *A. laevigata*, non *Quinqueloculina laevigata* D'ORBIGNY, 1826, =*Q. longirostra* D'ORBIGNY, 1826, \*1391, p. 303); *Uniloculina* D'ORBIGNY in DE LA SAGRA, 1839, \*1611, p. 161 (type, *U. indica*); *Multiloculina* ABICH, 1859, \*1, p. 105, 150 (type, *Serpula seminulum* LINNÉ, SD LOEBLICH & TAPPAN, herein); *Pollontes* BRADY, 1884, \*200, p. 156 (*nom. van. pro Pollontes* DE MONTFORT, 1808); *Quinqueloculina* (*Lachlanella*)

VELLA, 1957, \*2001, p. 24 (type, *Q. (L.) cooki*)]. Test coiled, with chambers one-half coil in length and alternating regularly in 5 planes of coiling 72° apart, but with successive chambers in planes 144° apart, so that 3 chambers are visible from exterior on one side of test and 4 visible from opposite side; wall calcareous, porcelaneous, imperforate, with inner pseudochitinous layer, rarely with some agglutinated grains added to exterior; aperture terminal, rounded, with simple or bifid tooth. *Jur.-Rec.*, cosmop.—FIG. 349,1. \**Q. seminulum* (LINNÉ), Rec., shore sands at Rimini, Italy; 1a-c, opposite sides and apert. views of neotype (USNM), ×35 (\*2117).—FIG. 349,2,3. *Q. longirostra* D'ORBIGNY, Plio., Italy; 2a-c, opposite sides and top view of lectotype (MNH) of *Adelosina laevigata* D'ORBIGNY; 3, paratype consisting of proloculus only of *A. laevigata*, ×36 (\*2117).—FIG. 349,4. *Q. cooki* VELLA, Rec., N.Z.; 4a-c, opposite sides and apert. view of holotype, ×30 (\*2001).

[A proposal was submitted to ICZN by LOEBLICH & TAPPAN (1962, \*1184) to suppress the generic names *Frumentarium* FICHTEL & MOLL, 1798, and *Pollontes* DE MONTFORT, 1808, which would otherwise have priority over the more widely used *Quinqueloculina*. Because of the wide variety of forms included in *Q. seminulum* by various authors, the inadequate original description and figures, and loss of the original type, a neotype was designated from the original type locality and is here figured. The young megalospheric forms of *Quinqueloculina* were given the generic name *Adelosina* by D'ORBIGNY, 1826. The original types of *A. laevigata* D'ORBIGNY are in the Museum National d'Histoire Naturelle, Paris. A lectotype is here designated (\*1395, pl. 20, figs. 22-24) and redrawn. The original figures show a distinct apertural tooth, but this was apparently broken away since the time of the original description; the tooth does not appear in the present figures. The 2-chambered lectotype and figured paratype, consisting of proloculus only, are from the Pliocene (Piacenzan) at Castell'Arquato, Italy. *A. laevigata* is the megalospheric generation of *Q. longirostra* D'ORBIGNY, 1826, also described from Castell'Arquato. *Lachlanella* was proposed as a subgenus of *Quinqueloculina* for species with subquadrate chambers, and a high, narrow aperture with elongate, narrow tooth. As these distinctions consist solely of relative dimensions, *Lachlanella* is here regarded as synonymous with *Quinqueloculina*.]

*Cruciloculina* D'ORBIGNY in DE LA SAGRA, 1839, \*1611, p. 182 [\**C. triangularis* D'ORBIGNY, 1839, \*1393, p. 72; SD (SM) D'ORBIGNY, 1839, \*1393, p. 72]. Test free, chambers one-half coil in length, with longitudinal planes of successive chambers added 120° apart as in *Triloculina*, test rounded to triangular in section; sutures distinct, depressed; wall calcareous, imperforate, smooth or faintly striate; aperture complex, varying in shape from triradial in young to cruciform or dendritic in adult, bordered by narrow lip, but without distinct tooth. [Differs from *Triloculina* in lacking the distinct tooth and developing a cruciform or dendritic aperture in the adult.] *Plio.-Rec.*, N.Atl.-S.Atl.O.-Japan.—FIG. 349,5,6. \**C. triangularis*, Rec., Falk Is. (5), S. Georgia Is. (6); 5a,b, side, top views of lectotype, ×26 (\*1173); 6a-c, opposite sides and top view of another specimen, ×20 (\*1173).

*Dentostomina* CARMAN, 1933, \*270, p. 31 [\**D. bermudiana*; OD]. Test free, quinqueloculine in

plan; wall with imperforate calcareous porcelaneous inner layer, external agglutinated layer of grains embedded in calcareous cement; aper-

ture terminal, circular, with crenulate margin and bifid tooth. *Rec.*, N.Atl.O. (Bermuda Is.)-W. Indies (Cuba).—FIG. 350, 1. \**D. bermudiana*,

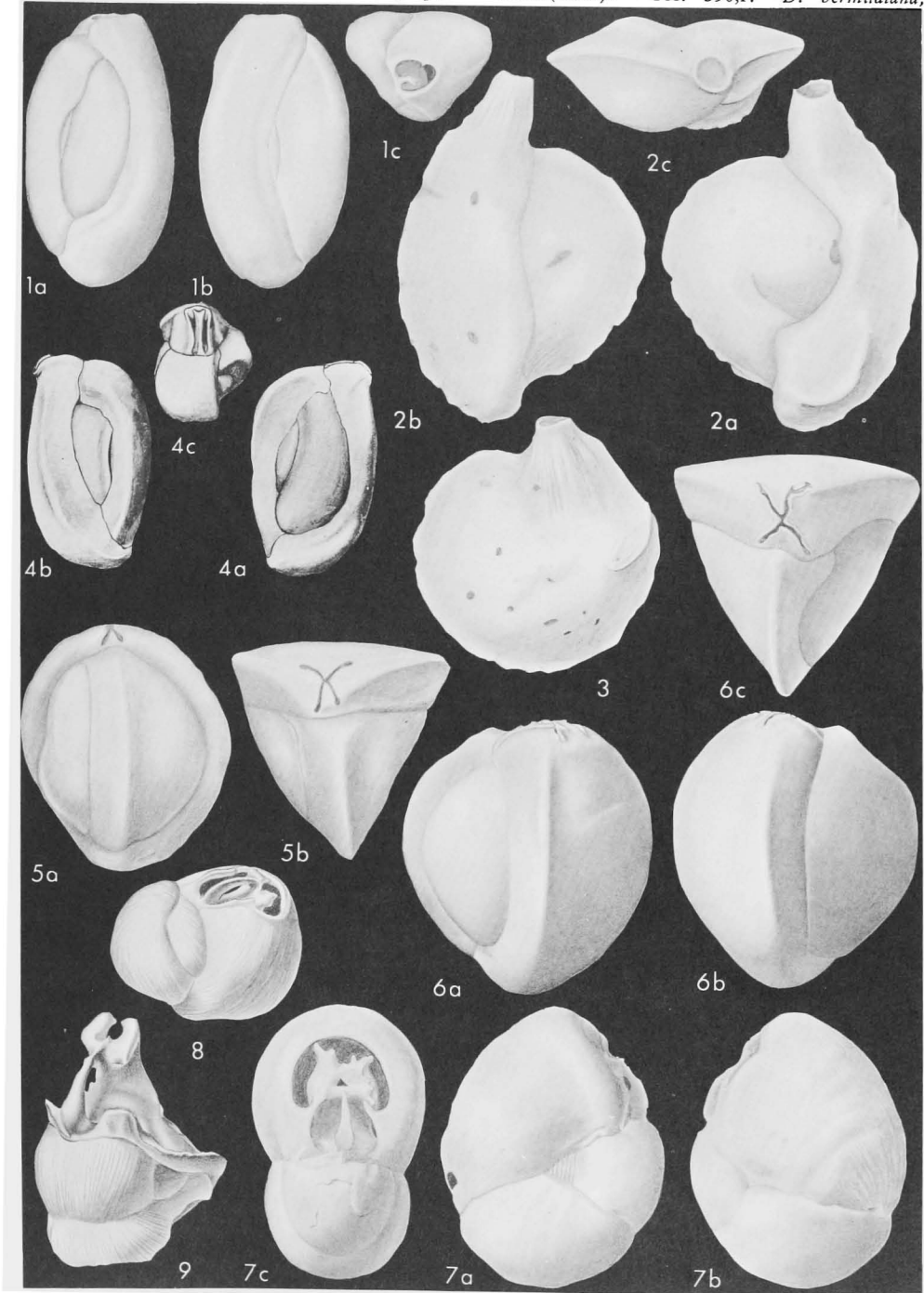


FIG. 349. Miliolidae (Quinqueloculininae; 1-4, *Quinqueloculina*; 5, 6, *Cruciloculina*; 7-9, *Flintina*) (p. C458, C461-C462).

off Bermuda; 1a-c, opposite sides and top views of holotype,  $\times 20$  (\*2117).  
 [Differs from *Quinqueloculina* in having a denticulate or

crenulate apertural border and in its external agglutinated layer of the wall, which is less common in *Quinqueloculina*.  
 In the original figures (\*270, pl. 3, fig. 6c) the apertural view is shown as a mirror image of the true appearance,

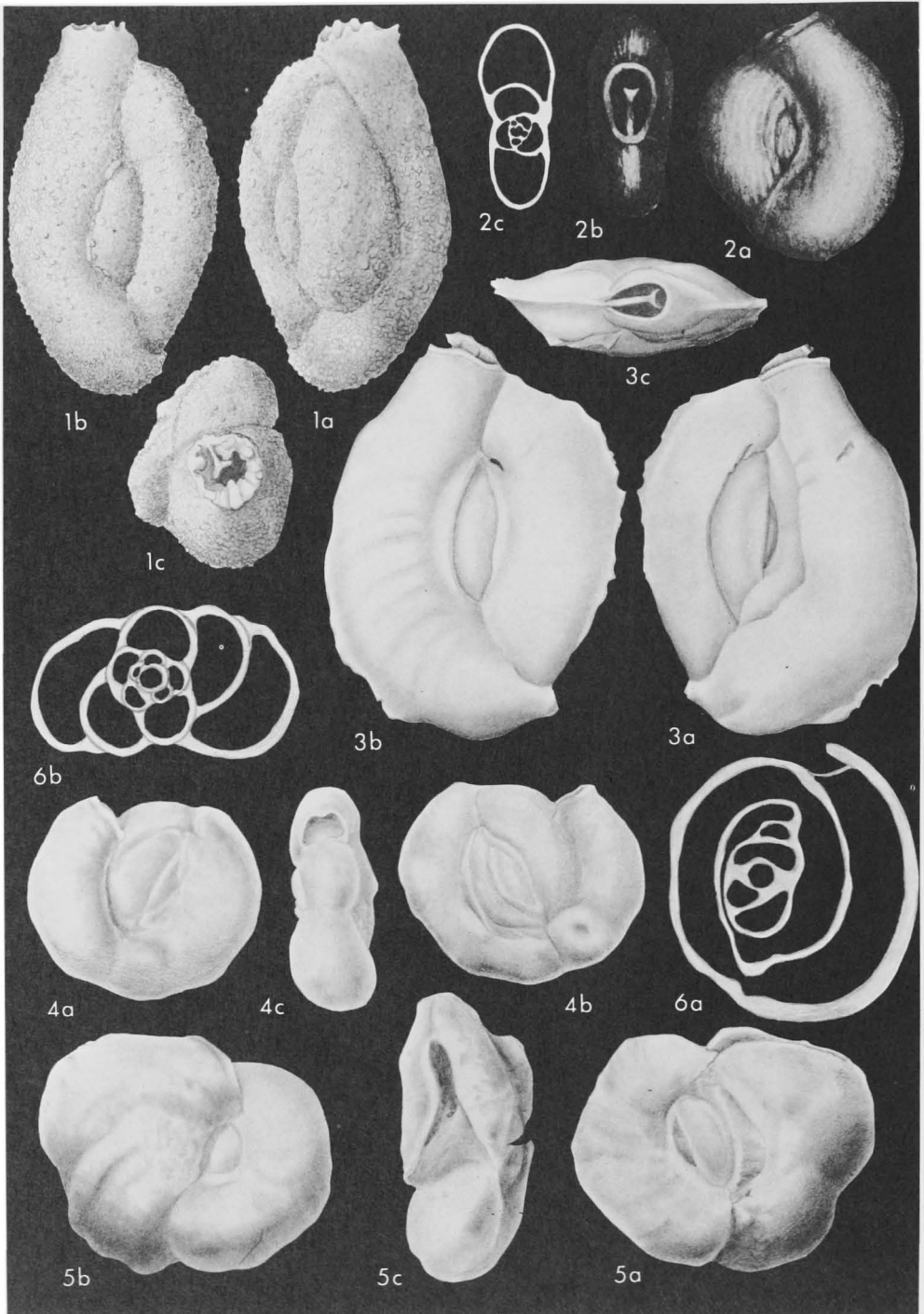


FIG. 350. Miliolidae (Quinqueloculininae; 1, *Dentostomina*; 2,3, *Massilina*; 4-6, *Pateoris*) (p. C458-C462).



as can be seen by comparing figures 6b and 6c, for the final chamber (and aperture) of the holotype is at the right when viewed from the side where 4 chambers are visible. Therefore, in apertural view, the final chamber is at the left when the flatter side is at the bottom of the illustration.]

*Flintina* CUSHMAN, 1921, \*415, p. 465 [*F. bradyana* = *Miliolina fichteliana* BRADY, 1884, \*200, p. 169 (non D'ORBIGNY, 1839); OD]. Test free, ovate to rounded in outline, early portion with 2

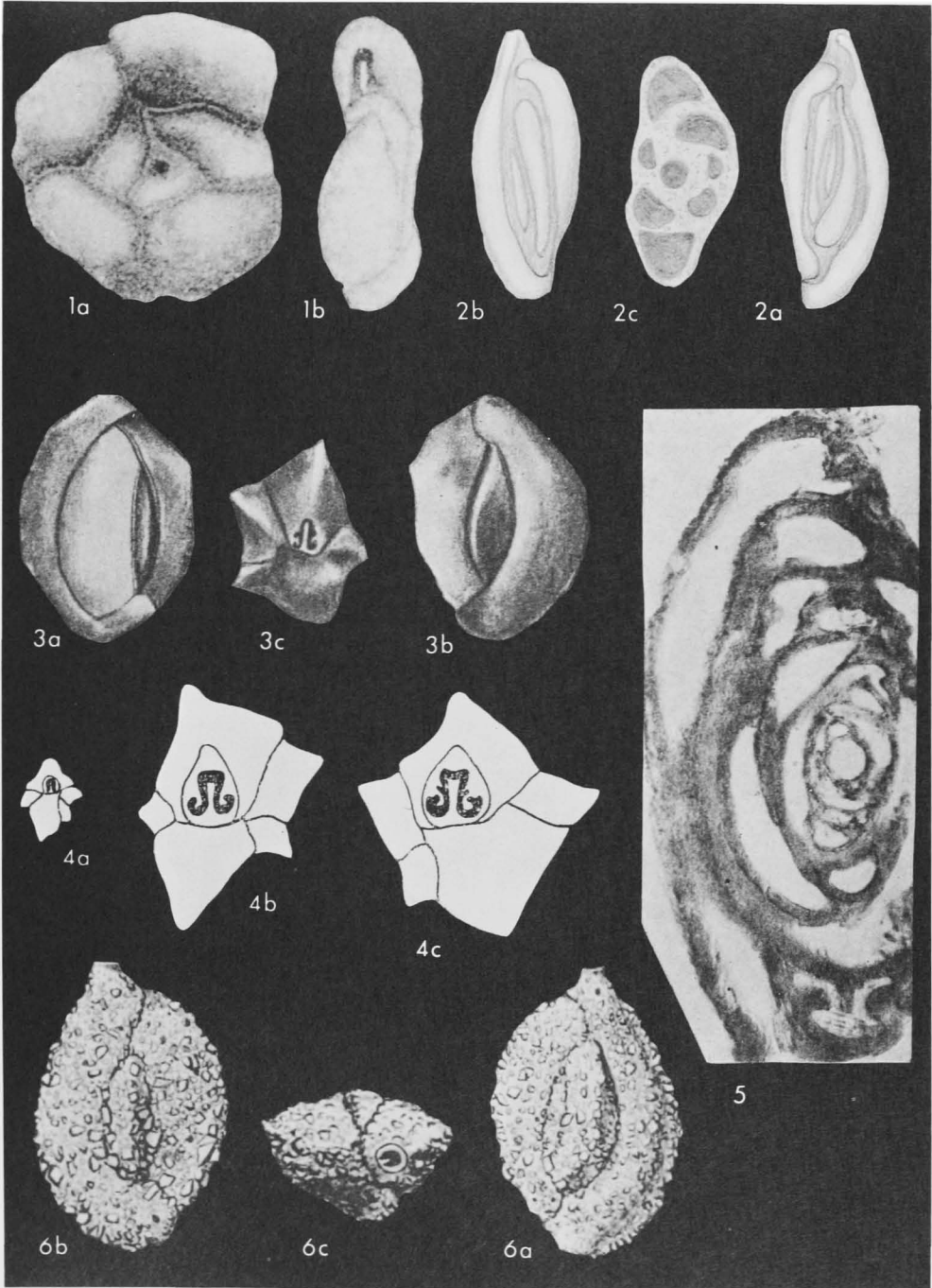


FIG. 351. Miliolidae (Quinqueloculinae; 1, *Flintinella*; 2, *Palaeomiliolina*; 3-5, *Podolia*; 6, *Siphonaperta*) (p. C462, C466).

chambers to whorl in triloculine arrangement, later increasing to 3 in each whorl and tending to become planispiral, as in *Hauerina*: wall calcareous, imperforate, porcelaneous; aperture large, high, ovate opening partially filled by bifid tooth in young stage, later becoming keyhole-shaped, somewhat narrower against earlier chambers and expanding abruptly about one-third of distance up face, outer margin of aperture at this point acutely angled and acuminate, tooth in adult of type-species becoming very complex, 2 modified branches of early bifid tooth being much enlarged, many-pronged, curving up and around to rejoin above, with arched plate extending back within chamber from beginning of bifurcation to attach to interior of chamber, lower portion of tooth remaining bladellike at surface in lower portion of opening, but also expanding basally within final chamber to form broad, triangular attachment occupying almost one-third of chamber, only central area of this tooth being free. *Rec.*, Pac.O.—FIG. 349,7-9. \**F. bradyana*, Philip. (Cebu Is.); 7*a-c*, opposite sides and apert. view of holotype,  $\times 15$ ; 8, oblique apert. view showing arched plate connecting bifid tooth to test wall; 9, partially dissected specimen, outer wall of final chamber removed to show complex apert. tooth within,  $\times 16$  (\*2117).

[Differs from *Triloculina* in its later subplanispiral development with three chambers per whorl, and in the more complex aperture and apertural tooth. It resembles *Hauerina* in the early milioline stage and later planispiral development but differs in being more involute and in having an open aperture and complex tooth, whereas *Hauerina* has a trematophore or sieve plate completely filling the apertural region. *Involvohaerina* differs in having a multiple cribrate aperture rather than an open aperture and complex tooth.]

**Flintinella** DIDKOVSKIY, 1960, \*595, p. 1433 [\**F. volhynica*; OD]. Test free, compressed, early stage similar to *Quinqueloculina*, with 2 chambers to whorl, later increasing to 3, resembling *Wellmanella* and *Pateoris*, with up to 6 chambers in final whorl, coiling partially involute, up to 5 whorls may be present, periphery rounded; sutures depressed, curved, nearly radial; wall calcareous, porcelaneous, smooth; aperture elongate opening at open end of final chamber, with lateral margins somewhat thickened and infolded, elongate, simple tooth occupying more than 0.75 length of apertural opening. [*Flintinella* differs from *Pateoris* in having an elongate simple apertural tooth.] *Mio.*(*M.Sarmat.*), USSR (Ukraine).—FIG. 351,1. \**F. volhynica*; 1*a,b*, side, edge views of holotype,  $\times 40$  (\*595).

**Massilina** SCHLUMBERGER, 1893, \*1655, p. 76 [\**Quinqueloculina secans* D'ORBIGNY, 1826, \*1391, p. 303; SD CUSHMAN, 1917, \*404f, p. 56] [= *Proemassilina* LACROIX, 1938, \*1079, p. 3 (type, *Massilina rugosa* SIDEBOTTOM, 1904, \*1738, p. 18)]. Test free, ovate in outline, somewhat flattened, proloculus followed by chambers one-half coil in length, early ones in quinqueloculine arrangement, later chambers added in single plane, on alternate sides, as in *Spiroloculina*; wall cal-

careous, porcelaneous, imperforate; aperture at open end of final chamber, with bifid tooth. *L. Cret.-Rec.*, cosmop.—FIG. 350,2. *M. rugosa* SIDEBOTTOM, *Rec.*, Delos Is.; 2*a,b*, side, apert. views of holotype; 2*c*, sec. showing chamber arrangement.  $\times 33$  (\*1738).—FIG. 350,3. \**M. secans* (D'ORBIGNY), *Rec.*, Greece (Delos Is.); 3*a-c*, opposite sides, apert. views,  $\times 24$  (\*2117).

**Palaeomiliolina** LOEBLICH & TAPPAN, n. gen. (Proposed by BOGDANOVICH, 1952 (\*152, p. 41, 77, 86) without description or citation of included species and described by ANTONOVA, 1958 (\*23, p. 915) with 3 included species, but without citation of type-species, hence a *nomen nudum* requiring type designation for validation.) [\**Spirophthalmidium occultum* ANTONOVA, 1958, \*24, p. 52; designated herein] [= *Palaeomiliolina* BOGDANOVICH, 1952, \*152, p. 41, 77, 86 (*nom. nud.*); *Palaeomiliolina* ANTONOVA, 1958, \*23, p. 915 (*nom. nud.*)]. Test similar to *Massilina*, but aperture lacking apertural tooth. *Jur.* (*Bajoc.-Oxford.*), Eu.—FIG. 351,2. \**P. occulta* (ANTONOVA), Bajoc., USSR (C.Caucasus); 2*a,b*, opposite sides,  $\times 160$ ; 2*c*, transv. sec.,  $\times 320$  (\*24).

**Pateoris** LOEBLICH & TAPPAN, 1953, \*1162, p. 42 [\**Quinqueloculina stubrotunda* (MONTAGU) forma *hauerinoides* RHUMBLER, 1936, \*1575, p. 206, 217, 226; OD]. Test quinqueloculine in early stage, with chambers one-half coil in length, later planispiral, with gradually shortened chambers so that slightly more than 2 chambers to coil may occur; wall porcelaneous; aperture at open end of chamber, varying from low arch to high, narrow slit with lateral margins somewhat infolded. *Rec.*, N.Sea-Pac.O. (Alaska).—FIG. 350, 4-6. \**P. hauerinoides* (RHUMBLER), *Rec.*, Alaska; 4*a-c*, 5*a-c*, opposite sides and edge views of hypotypes showing variation in chamber length and height of aperture,  $\times 44$ ; 6*a,b*, long. and axial secs. showing early quinqueloculine development and later planispiral stage,  $\times 66$  (\*1162).

[*Pateoris* differs from *Pseudomassilina* in its smooth, rather than punctate or canalliculate, wall. It is very similar to *Wellmanella* in the adult stage but quinqueloculine in the early stage, whereas *Wellmanella* was described as triloculine in the early stage without a quinqueloculine stage. No sections have been published for *Wellmanella*, and if a restudy of the type-species of *Wellmanella* shows a quinqueloculine stage to be present, *Pateoris* would become a junior synonym.]

**Podolia** SEROVA, 1961, \*1720, p. 56 [\**Hauerina lyra* SEROVA, 1955, \*1719, p. 329 (= *Hauerina lyra* SEROVA, 1953, \*1718, p. 63 (*nom. nud.*); OD]. Test similar to *Quinqueloculina* in form and chamber arrangement, aperture lyre-shaped, with narrow, straight normal tooth and 2 lateral supplementary teeth projecting into opening. *Mio.*(*U.Torton.*), USSR (Ukraine).—FIG. 351,3-5. \**P. lyra* (SEROVA); 3*a-c*, opposite sides and apert. view of holotype,  $\times 40$ ; 4*a-c*, outline views of ontogenetic stages, showing development of complex aperture in adult (\*1720); 5, long. sec.,  $\times 250$  (\*1721).

**Pseudomassilina** LACROIX, 1938, \*1079, p. 3 [*\*Massilina australis* CUSHMAN, 1932, \*455, p. 32; OD]. Test broad and compressed, early chambers quinqueloculine, with 2 chambers to whorl, later

planispiral, as in *Pateoris*, with gradually shortening chambers; wall porcelaneous, with interior network of fine canals opening into tiny pores in small pits at surface, but not opening into cham-

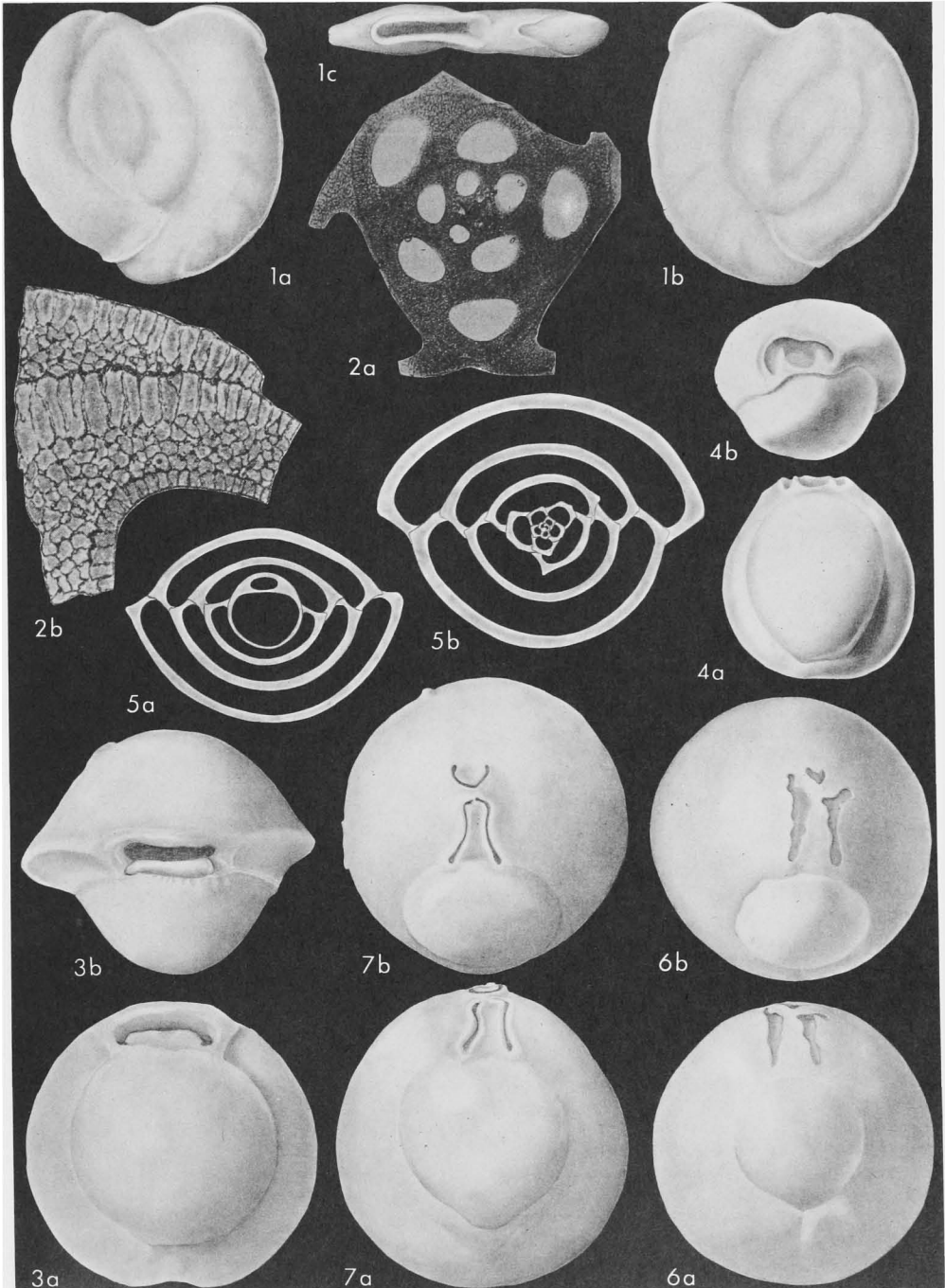


FIG. 352. Miliolidae (Quinqueloculininae; 1, 2, *Pseudomassilina*; 3-5, *Pyrgo*; 6, 7, *Pyrgoella*) (p. C463-C465).

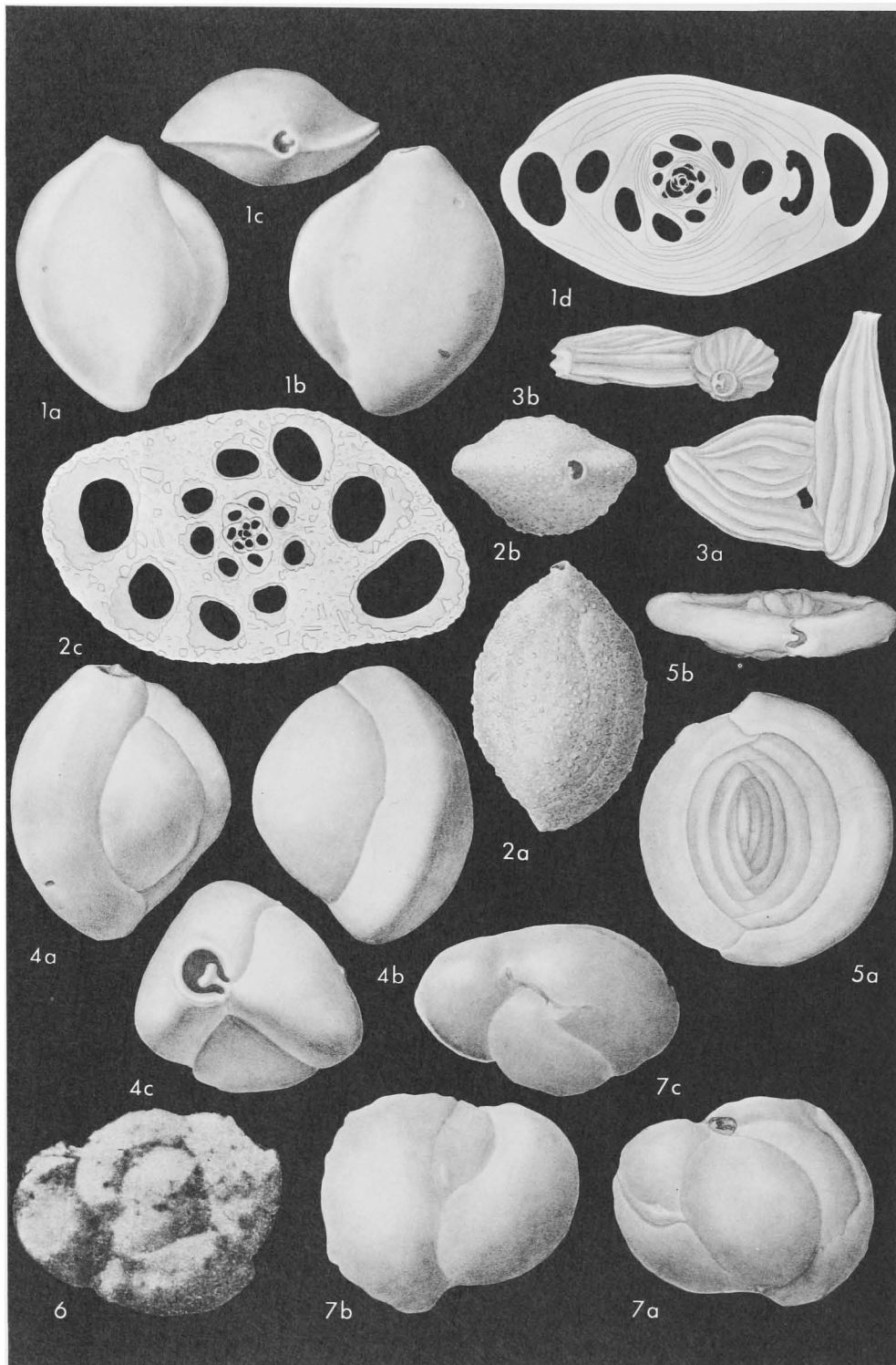


FIG. 353. Miliolidae (Quinqueloculininae; 1, *Sigmoidina*; 2, *Sigmoidopsis*; 3, *Ptychomiliola*; 4, *Triloculina*; 5, *Spirosigmoidina*; 6, 7, *Wellmanella*) (p. C465-C466).

ber cavity, being separated from it by imperforate pseudochitinous layer; aperture high slit with bordering lip, similar to that of *Pateoris*, without tooth. [Differs from *Pateoris* in its characteristic wall texture.] *Rec.*, Australia-Asia (Indochina)-Pac.O.-Red Sea (Gulf Aqaba)-E.Afr. (Kerimba Arch.).—FIG. 352,1,2. \**P. australis* (CUSHMAN), *Rec.*, Cook Is.; 1a-c, opposite sides and apert. views of holotype,  $\times 50$  (\*2117); 2a, enlarged photograph of central portion of axial sec. showing wall structure; 2b, portion of wall enlarged, diagram showing crystalline pseudofibrous outer layer with vertical canals and inner layer with irregularly granular appearance (\*1078).

**Ptychomiliola** EIMER & FICKERT, 1899, \*692, p. 687 [\**Miliolina separans* BRADY, 1881, \*196c, p. 45; SD CUSHMAN, 1928, \*439, p. 154]. Test free, early chambers milioline in arrangement, later ones planispiral and evolute, about 3 to whorl, some rare specimens uniserial; wall calcareous, porcelaneous, imperforate, may be longitudinally costate; aperture terminal, rounded, produced on neck, with lip and distinct bifid tooth. [Differs from *Hauerina* in being more evolute, and in having apertural tooth instead of apertural pore plate or trematophore.] *Rec.*, S.Pac.O.—FIG. 353,3. \**P. separans* (BRADY), lectotype (here designated, BMNH-ZF 1902) from Storm Bay, Tasm.; 3a,b, side, apert. views,  $\times 16$  (\*2117).

**Pyrgo** DEFANCE, 1824, \*597c, p. 273 [\**P. laevis*; OD (M)] [= *Biloculina* D'ORBIGNY, 1826, \*1391, p. 297 (type, *B. bulloides*); *Praelacazina* HOFKER, 1959, \*952, p. 372 (type, *Biloculina fragilis* HOFKER, 1927, \*927, p. 173)]. Test free, inflated, discoidal to ovate, proloculus followed by chambers one-half coil in length; in microspheric form early chambers arranged in quinqueloculine pattern, later triloculine, and finally biloculine; megalospheric forms may be biloculine throughout development, with successive discoidal to hemispherical chambers opposing each other; wall calcareous, imperforate, porcelaneous; aperture terminal, near junction of 2 last chambers, rounded to elongate, with distinct and commonly bifid tooth. [*Pyrgo* differs from *Biloculinella* in having a bifid tooth instead of a broad apertural flap nearly filling the aperture. No locality or horizon was given in the original description of *Pyrgo laevis*.] *Iur.-Rec.*, cosmop.—FIG. 352,3. \**P. laevis*, Plio. (Piacenz.), Eu. (Italy); 3a,b, side and apert. views showing relatively broad tooth of this species,  $\times 38$  (\*2117).—FIG. 352,4. *P. williamsoni* (SILVESTRI), *Rec.*, N.Am. (Alaska); 4a,b, side and apert. views of species with distinctly bifid tooth,  $\times 33$  (\*1162).—FIG. 352,5. *P. sarsi* (SCHLUMBERGER), *Rec.*, Eu. (N. Sea); 5a,b, secs. of megalospheric and microspheric forms showing chamber arrangement,  $\times 20$  (\*1654).

**Pyrgoella** CUSHMAN & E. M. WHITE, 1936, \*540, p. 90 [\**Biloculina sphaera* D'ORBIGNY, 1839, \*1393, p. 66; OD]. Test free, subglobular, with



FIG. 354. Miliolidae (Quinqueloculininae; *Triloculina*) (p. C466).

strongly overlapping chambers in biloculine arrangement, as in *Pyrgo*; wall calcareous, imperforate, porcelaneous; aperture in young with large triangular tooth, in adult V-shaped opening may be divided into 2 elongate openings with original tooth attached at both ends, with one or more supplementary sinuate, straight, or chevron-shaped openings also present. [*Pyrgoella* resembles *Pyrgo* and *Biloculinella* in chamber development but differs in having a more complex aperture, like that of *Cruciloculina*. *Cribropyrgo* is like the present genus, but has a regularly cribrate aperture with numerous small openings in place of the cruciform or chevron-like openings of *Pyrgoella*.] *Pleist.-Rec.*, S.Atl.O.-USA (Calif.)-Gulf Mex.—FIG. 352,6,7. \**P. sphaera* (D'ORBIGNY), *Pleist.*, USA (Calif.) (6), *Rec.*, Gulf Mex. (7); 6a,b, side and apert. views,  $\times 48$ ; 7a,b, side and apert. views of hypotype,  $\times 48$  (\*2117).

**Sigmoilina** SCHLUMBERGER, 1887, \*1651, p. 118 [\**Planispirina sigmoidea* BRADY, 1884, \*200, p. 197; SD CUSHMAN, 1917, \*404f, p. 60]. Test free, ovate in outline, in microspheric generation with earliest chambers opposite, then with plane of chamber addition changing so that it forms sigmoid curve, successive chambers at first in planes about  $120^\circ$  apart but angle gradually enlarging to  $180^\circ$  in adult stage, chambers with broad lateral extensions which obscure all preceding chambers except penultimate one, giving external biloculine appearance; wall calcareous, thick, imperforate, porcelaneous; aperture terminal, rounded, with tooth. [Differs from *Pyrgo* in having a gradual change from a pseudoquinqueloculine stage to one with chambers added  $180^\circ$  apart, so that the changing plane of coiling forms a sigmoid curve.] *M.Eoc.-Rec.*, cosmop.—FIG. 353,1. \**S. sigmoidea* (BRADY), *Rec.*, Carib.; 1a-c, opposite sides and top view of hypo-

type,  $\times 46$  (\*2117); *1d*, sec. showing chamber arrangement,  $\times 55$  (\*1651).

**Sigmoilopsis** FINLAY, 1947, \*717e, p. 270 [*Sigmoilina schlumbergeri* SILVESTRI, 1904, \*1760, p. 267; OD]. Test free, ovate, with chambers one-half coil in length, at first quinqueloculine in arrangement, then with increasing angle between planes of coiling of successive chambers, so that chambers are nearly opposing, but changing plane of coils results in early sigmoid curve, extremities of curve spiraling outward, much as in *Sigmoilina*; wall agglutinated with calcareous cement enclosing sand, calcareous shell fragments and sponge spicules; aperture terminal, rounded, with small tooth. *Mio.-Rec.*, Eu.-Atl.O.-Carib.-Australia-N.Z.—FIG. 353,2. \**S. schlumbergeri* (SILVESTRI), *Rec.*, Atl.; *2a,b*, side and apert. views of hypotype showing small bifid tooth,  $\times 48$  (\*2117); *2c*, horiz. sec. showing chamber arrangement, originally referred to *Sigmoilina celata* (COSTA),  $\times 42$  (\*1651).

[Differs from *Sigmoilina* in having an agglutinated wall and less enveloping chambers so that more than the final pair are visible externally and the interior does not have the laminated appearance of *Sigmoilina*. Originally it was described (\*717e, p. 270) as differing further in its possession of an apertural tooth, but one is also here shown to be present in *Sigmoilina*. THALMANN (1961, \*1905, p. 321) cited the reference to *Sigmoilina schlumbergeri* SILVESTRI, 1904, and commented "Probably a nomen nudum." *Sigmoilina schlumbergeri* SILVESTRI, 1904, was defined as a *nom. nov.*, but actually was a new species including *Miliolina celata* (COSTA) of BRADY in TIZARD & MURRAY, 1882, and *Planispirina celata* of BRADY, 1884, SILVESTRI, 1893, and FLINT, 1899, and *Sigmoilina (Planispirina) celata* SCHLUMBERGER, 1887 (*non Spiroloculina celata* COSTA, 1856). Although no illustrations were published by SILVESTRI (1904) for this new species, a description was given and a reference was made to illustrations by BRADY, 1884, FLINT, 1899, and SCHLUMBERGER, 1887 (including that here refigured). Hence, this is a valid species and not a *nomen nudum*. No type-specimen was selected for the present species, although FINLAY, 1947, defined *Sigmoilopsis* for *S. schlumbergeri* as interpreted and figured by CUSHMAN, 1946, and BRADY, 1884. A lectotype is here designated as the specimen figured by BRADY, 1884 \*200, pl. 8, figs. 1a,b) from *Porcupine* station 23, west of Ireland at 630 fathoms, and in the BMNH.]

**Siphonaperta** VELLA, 1957, \*2001, p. 19 [*S. macbeathi*; OD]. Test with chamber arrangements as in *Quinqueloculina*, but wall agglutinated as in *Sigmoilopsis* and with simple ridgelike tooth and porcelaneous phialine lip. *Pleist.-Rec.*, Australia-N.Z.—FIG. 351,6. \**S. macbeathi*, L.Pleist., N.Z.; *6a-c*, opposite sides and apert. views of holotype,  $\times 36$  (\*2001).

**Spirosigmoilina** PARR, 1942, \*1426, p. 361 [*Spiroloculina tateana* HOWCHIN, 1889, \*966, p. 3; OD]. Test with early chambers in sigmoid arrangement as in *Sigmoilina*, later chambers  $180^\circ$  apart, as in *Massilina*; wall porcelaneous; aperture terminal, with short tooth. *Mio.*, Australia.—FIG. 353,5. \**S. tateana* (HOWCHIN); side, apert. views of topotype,  $\times 115$  (\*2117).

**Triloculina** D'ORBIGNY, 1826, \*1391, p. 299 [*Miliolites trigonula* LAMARCK, 1804, \*1085c, p. 351; SD CUSHMAN, 1917, \*404f, p. 65] [= *Renoidea* BROWN, 1827, \*244, p. 1 (type, *R. glabra*); *Spirodestomella* COSTA, 1856, \*392, p. 370 (type, *S.*

*globulifera*); *Miliolina* WILLIAMSON, 1858, \*2065, p. 83 (type, *Triloculina laevigata* D'ORBIGNY, 1826, \*1391, p. 300); *Trillina* MUNIER-CHALMAS, 1882, \*1322, p. 424 (type, *Triloculina strigillata* D'ORBIGNY, 1850, \*1397b, p. 409)]. Test free, with chambers each one-half coil in length, early chambers at least in microspheric generation in quinqueloculine arrangement, later triloculine, with successive chambers added in planes  $120^\circ$  apart, only final 3 chambers visible externally; wall calcareous, imperforate, porcelaneous, or rarely with surficial agglutinated layer; aperture terminal, typically with bifid tooth; gametes biflagellate, with axostyle. [*Triloculina* differs from *Quinqueloculina* in its later triloculine development, from *Miliolinella* in having a bifid tooth instead of a broad apertural flap, and from *Cruciloculina* in having a simple, rounded aperture with a bifid tooth.] *Jur.-Rec.*, cosmop.—FIG. 353,4. \**T. trigonula* (LAMARCK), *Eoc.* (Lutet.), Eu. (Hauteville, Fr.); *4a-c*, opposite sides, apert. view,  $\times 31$  (\*2117).—FIG. 354. *T. rotunda* D'ORBIGNY, *Rec.*, Atl.O.; biflagellate gamete with axostyle,  $\times 6,000$  (\*820a).

**Wellmanella** FINLAY, 1947, \*717e, p. 270 [*\*W. kaiata*; OD] [= *Hechtina* BARTENSTEIN & BRAND, 1949, \*94, p. 669 (type, *H. praecantiqua*)]. Test similar to *Pateoris* but with triloculine, rather than quinqueloculine, early stage, and later stage with 3 or 4 chambers to whorl, aperture at open end of final chamber, varying from low arch to slit with infolded margins, as in *Pateoris*. [No sections showing early growth stages have been published, hence it is possible that an early quinqueloculine stage may be present and that *Pateoris* thus is a junior synonym of *Wellmanella*.] *L.Cret. (M. Valangin.)-U.Eoc.*, N.Z.-Ger.—FIG. 353,6. \**W. kaiata*, U.Eoc., N.Z.; holotype,  $\times 35$  (\*717e).—FIG. 353,7. *W. praecantiqua* (BARTENSTEIN & BRAND), *L.Cret. (U. Valangin.)*, Ger.; *7a-c*, opposite sides and edge of topotypes,  $\times 111$  (\*2117).

#### Subfamily MILIOLINELLINAE Vella, 1957

[Miliolinellinae VELLA, 1957, p. 20]

Wall simple, with broad, flat tooth or flap partially closing aperture. *Eoc.-Rec.*

**Miliolinella** WIESNER, 1931, \*2063, p. 63, 65, 107 [*Vermiculium subrotundum* MONTAGU, 1803, \*1298, p. 521; OD] [= *Triloculinella* RICCIO, 1950, \*1577, p. 90 (type, *T. obliquinodus*)]. Test free, triloculine in chamber arrangement; sutures distinct; wall calcareous, porcelaneous, imperforate; aperture at open end of chamber, partially covered by broad, low flap which leaves only crescentic opening. [Differs from *Triloculina* in possessing a large broad, flaplike tooth constricting the aperture rather than a simple or bifid tooth.] *Oligo.-Rec.*, Eu.-N.Am.-Pac.O.-Antarctic.—FIG. 355,1,2. \**M. subrotunda* (MONTAGU); *Rec.*, Ire. (1), Delos Is., Greece (2); *1a-c*, opposite sides



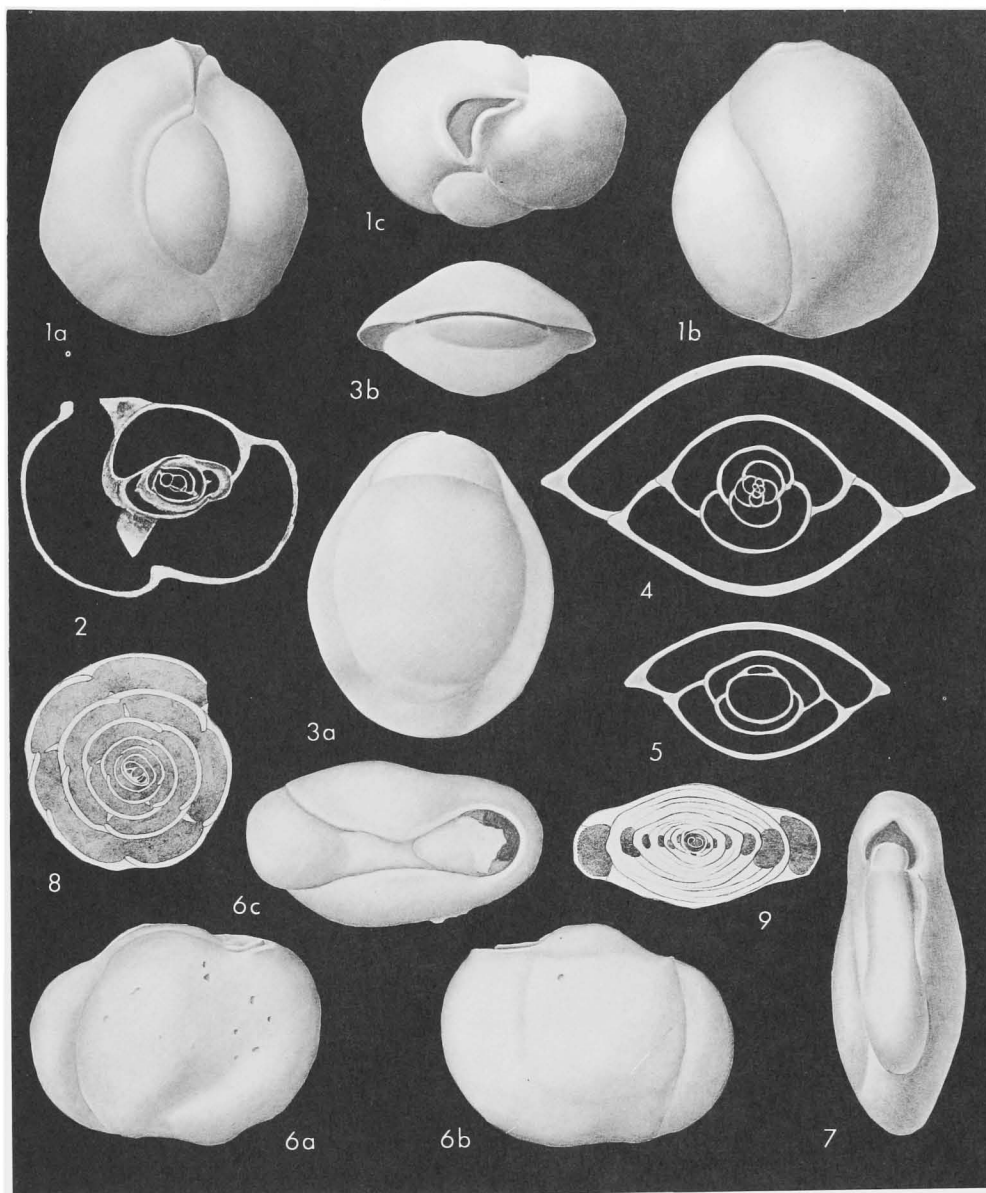


FIG. 355. Miliolidae (Miliolinellinae; 1,2, *Miliolinella*; 3-5, *Biloculinella*; 6-9, *Nummoloculina*) (p. C466-C468).

and top view showing apert. flap,  $\times 73$  (\*2117); 2, horiz. sec.,  $\times 56$  (\*1738).

***Biloculinella*** WIESNER, 1931, \*2063, p. 69 [*\*Biloculinella labiata* SCHLUMBERGER, 1891, \*1654, p. 556; OD]. Test free, discoidal to ovate, proloculus followed by chambers one-half coil in length, early chambers in microspheric form arranged in quinqueloculine pattern, later chambers in triloculine arrangement and finally biloculine, with involute coiling, leaving only final pair of chambers visible, megalospheric form may be

biloculine throughout development; wall calcareous, imperforate, porcelaneous; aperture terminal, nearly covered by broad flap, so that only narrow crescentic opening remains. [*Biloculinella* differs from *Pyrgo* in having a broad, flaplike lip, instead of a bifid apertural tooth. The lectotype and paratypes of *Biloculinella labiata* SCHLUMBERGER are in the collections of the Sorbonne, University of Paris.] *Eoc. - Rec.*, Medit. Sea-Antarctic-N. Am. —FIG. 355,3-5. *\*B. labiata* (SCHLUMBERGER), *Rec.*, *Medit.*; 3a,b, side, top views of paratype,

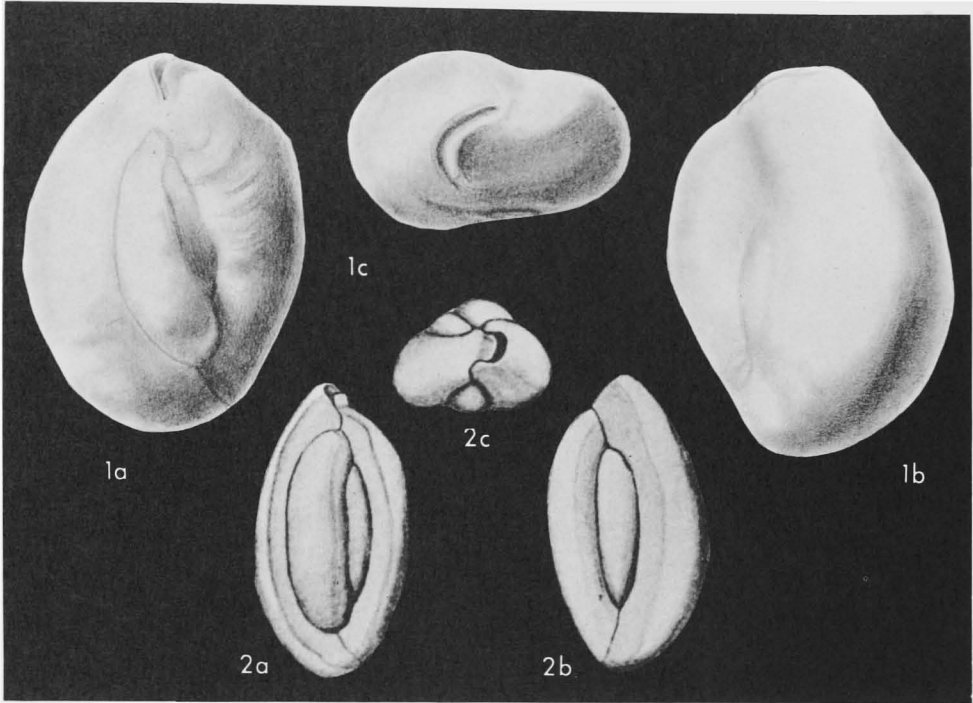


FIG. 356. Miliolidae (Miliolinellinae; 1,2, *Scutuloris*) (p. C468).

×70 (\*2117); 4, microspheric test sectioned to show early quinqueloculine stage, ×87 (\*1654); 5, megalospheric test, sectioned to show biloculine development throughout, ×85 (\*1654).

**Nummoloculina** STEINMANN, 1881, \*1837, p. 31 [*Biloculina contraria* D'ORBIGNY, 1846, \*1395, p. 266; OD]. Test free, discoidal to biconvex, early portion in milioline arrangement with 2 chambers to whorl, later planispiral with 3 chambers to whorl, increasing in adult to 5 or 6 low, broad chambers to whorl; sutures obscure; wall calcareous, imperforate, composed of successive laminae added over entire test, thickening wall and obscuring chamber division; aperture at open end of final chamber, semicircular in outline, but largely filled by broad spatulate tooth extending upward from base of opening and leaving open only small crescentic remnant of aperture. [*Nummoloculina* differs from *Fischerina* in having a broad spatulate flap in the aperture, instead of a high open aperture. *Hauerina* has a cribrate trematophore in the aperture, instead of a simple tooth.] *Mio.-Rec.*, Eu.-Atl.O.-Medit.Sea-Indo-Pac. — FIG. 355,6-9. \**N. contraria* (D'ORBIGNY), *Mio.*, Aus. (6), *Rec.*, Scot. (off Skye) (7-9); 6a-c, opposite sides and edges of topotype, apert. flap slightly broken, ×48 (\*2117); 7, edge view showing well-preserved apert. flap, ×20 (\*200); 8,9, equat. and axial secs. enlarged (\*1837).

**Scutuloris** LOEBLICH & TAPPAN, 1953, \*1162, p. 41 [*S. tegminis*; OD] [= *Quinquinella* VELLA,

1957, \*2001, p. 21 (type, *Q. hornibrooki*)]. Test free, chambers in quinqueloculine arrangement; wall calcareous, imperforate; aperture at end of chamber and nearly filled by broad, low flap. [*Scutuloris* differs from *Miliolinella* in having a quinqueloculine chamber arrangement and from *Quinqueloculina* in having a broad flap filling the aperture, in place of the bifid tooth characteristic of the latter.] *Rec.*, Arctic.-Pac.O. — FIG. 356,1. \**S. tegminis*, Alaska; 1a-c, opposite sides and top view of holotype, ×66 (\*1162). — FIG. 356,2. *S. hornibrooki* (VELLA), N.Z. (Cook Strait); 2a-c, opposite sides and top view of holotype, ×60 (\*2001).

#### Subfamily MILIOLINAE Ehrenberg, 1839

[*nom. transl.* RHUMBLER, 1895, p. 87 (ex family Miliolina EHRENBURG, 1839)] [= Miliolininae BRADY, 1881, p. 43; = Hauerininae BRADY, 1884, p. 62; = Trematoforininae SILVESTRI, 1937, p. 80 (*nom. nud.*)]

Wall simple; with cribrate aperture (trematophore). *U.Cret.-Rec.*

**Miliola** LAMARCK, 1804, \*1085c, p. 349 [*Miliolites saxorum* LAMARCK, 1804; SD CUSHMAN, 1927, \*432, p. 125 [= *Miliolites* LAMARCK, 1804, \*1085c, p. 349 (type, *M. saxorum*, SD LOEBLICH & TAPPAN, herein) (obj.); *Miliolithes* CUVIER, 1817, \*542a, p. 376 (*nom. van. pro Miliolites* LAMARCK) (obj.); *Saxicolina* DESHAYES, 1830, \*590, p. 231 (*nom. neg.*) (obj.); *Pentellina* MUNIER-CHALMAS, 1882, \*1322, p. 424 (obj.); *Saxicolina* SHERBORN, 1896, \*1731b, p. 404 (*nom. correct. pro Saxicolina* DESHAYES, 1830) (obj.)]. Test with quinquelo-

culine chamber arrangement; aperture with trematophore (cribrate). *Eoc.*, Eu.-N.Am.—FIG. 357,2,3. \**M. saxorum* (LAMARCK), *Eoc.* (Lutet.),

Fr.; 2a-c, opposite sides and apert. view,  $\times 26$  (\*2117); 3, transv. sec. showing chamber arrangement,  $\times 50$  (\*1664).

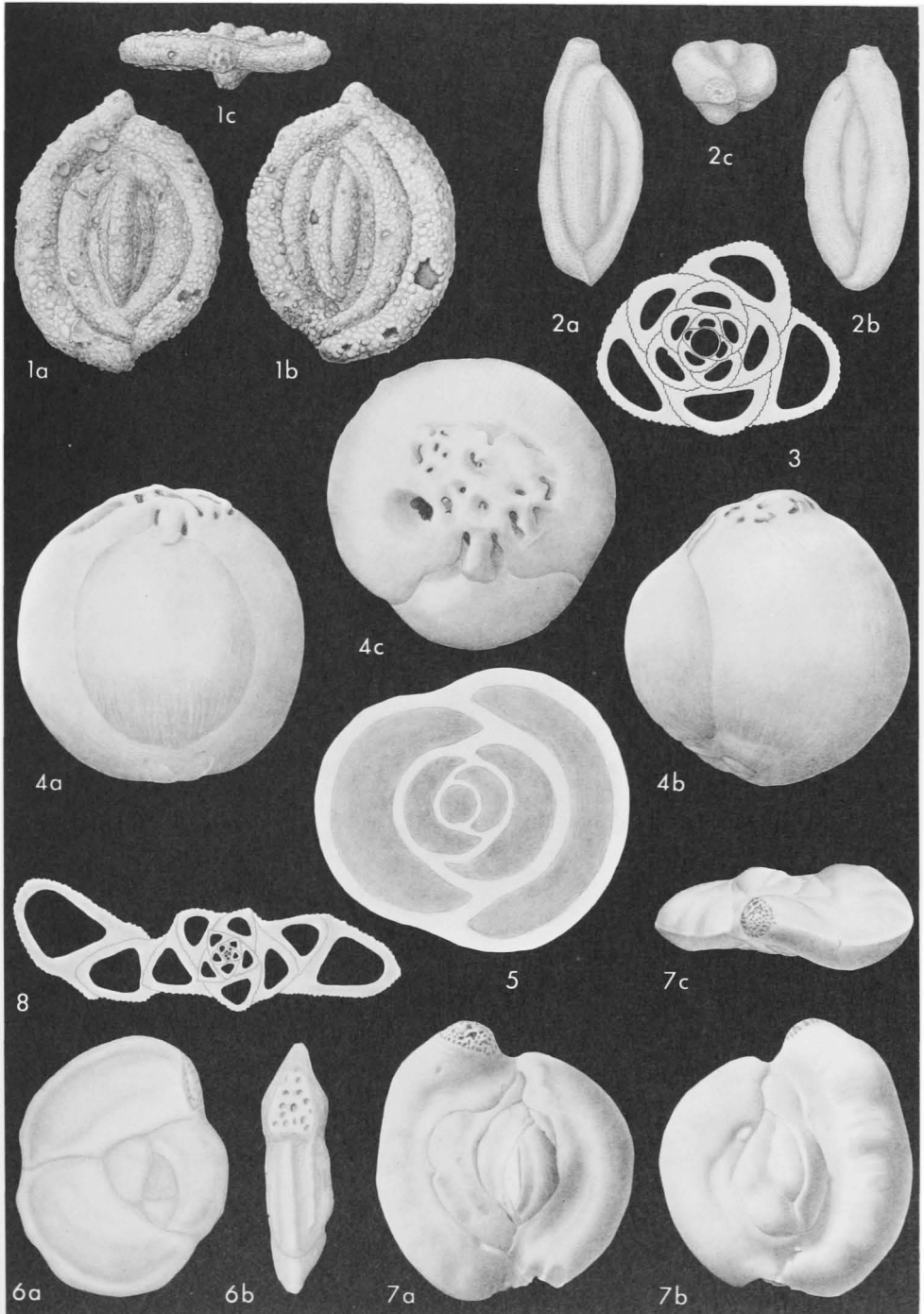


FIG. 357. Miliolidae (Miliolinae; 1, *Ammomassilina*; 2,3, *Miliola*; 4,5, *Cribropyrgo*; 6, *Hauerina*; 7,8, *Heterillina*) (p. C468-C470).



FIG. 358. Miliolidae (Miliolinae; 1, *Dogielina*) (p. C470).

**Ammomassilina** CUSHMAN, 1933, \*458, p. 32 [*Massilina alveoliniformis* MILLETT, 1898, \*1284b, p. 609; OD]. Test free, early chambers milioline in development, later chambers added in single plane; wall agglutinated; aperture with trematophore. [Differs from *Schlumbergerina* in having later chambers added in a single plane.] *Rec.*, Malay Arch. (Malay).—FIG. 357, 1. \**A. alveoliniformis* (MILLETT); 1a-c, opposite sides and apert. view,  $\times 29$  (\*2117).

**Cribropyrgo** CUSHMAN & BERNÚDEZ, 1946, \*493, p. 119 [*C. robusta*; OD]. Test free, subglobular, chamber arrangement as in *Pyrgo*; aperture cribrate, consisting of numerous irregular openings scattered over protruding terminal portion of final chamber. [Differs from *Pyrgoella* in having a cribrate, rather than chevron-shaped or cruciform aperture, and from *Fabularia* in having a simple interior.] *Rec.*, Carib.—FIG. 357, 4, 5. \**C. ro-*

*busta*, Cuba; 4a-c, side, edge, and top views of holotype; 5, sectioned paratype, all  $\times 17$  (\*2117). **Dogielina** BOGDANOVICH & VOLOSHINOVA, 1949, \*154, p. 185 (non *Dogielina* RAABE, 1959) [*D. sarmatica*; OD]. Test with early chambers in milioline arrangement, as in *Quinqueloculina*, later uncoiling, with rectilinear chambers; wall calcareous, spongy in structure, surface with pits and grooves; aperture terminal, with toothlike infoldings from apertural wall giving radiate appearance. *U. Mio.* (Sarmat.), Carpath.—FIG. 358, 1. \**D. sarmatica*; 1a, side view of holotype,  $\times 47$ ; 1b, surface of uniserial chamber,  $\times 115$ ; 1c, apert. view showing infolded wall,  $\times 115$ ; 1d, partial section of wall showing spongy structure,  $\times 150$  (\*154).

**Hauerina** D'ORBIGNY in DE LA SAGRA, 1839, \*1611, p. xxxviii [*H. compressa* D'ORBIGNY, 1846, \*1395, p. 119; SD (SM)]. Test free, lenticular to discoidal, compressed, subcircular in outline, early stages quinqueloculine, later planispiral with 3 or more chambers to whorl; aperture series of pores in the sievelike trematophore. [Differs from *Heterillina* in having 3 or more chambers to whorl in adults, rather than 2.] *Eoc.-Rec.*, cosmop.—FIG. 357, 6. \**H. compressa*, Mio., Eu. (Aus.); 6a, b, side, apert. views of holotype,  $\times 57$  (\*1166).

**Heterillina** MUNIER-CHALMAS & SCHLUMBERGER in SCHLUMBERGER, 1905, \*1664, p. 131 [*H. guespellensis* SCHLUMBERGER, 1905; SD CUSHMAN, 1928, \*439, p. 150] [= *Heterillina* MUNIER-CHALMAS & SCHLUMBERGER, 1883, \*1329, p. 862 (nom. nud.)]. Test free, ovate in outline, flattened, chambers one-half coil in length, at first in quinqueloculine arrangement, later added on opposite sides as in *Spiroloculina*; sutures depressed; aperture terminal, multiple, with trematophore. [*Heterillina* differs from *Massilina* in having an apertural plate with numerous pores, and in lacking a bifid tooth. It differs from *Hauerina* in having all chambers one-half coil in length, whereas in adult *Hauerina* 3 chambers occur in each whorl. The types of *H. guespellensis* are from the middle Eocene at Le Guespelle, France, and are deposited in collections of the Sorbonne, University of Paris, France. Figured paratypes are from this locality.] *M. Eoc.-Oligo.*, Eu. (Fr.).—FIG. 357, 7, 8. \**H. guespellensis*, M. Eoc.; 7a-c, opposite sides and apert. view of paratype,  $\times 27$  (\*2117); 8, transv. sec. showing chamber arrangement,  $\times 30$  (\*1664).

**Idalina** SCHLUMBERGER & MUNIER-CHALMAS, 1884, \*1668, p. 629 (non NORMAN, 1890) [*I. antiqua* SCHLUMBERGER & MUNIER-CHALMAS, 1884, = *Biloculina antiqua* D'ORBIGNY, 1850, \*1397b, p. 210 (nom. nud.), = *Triloculina cretacea* D'ORBIGNY, 1850, \*1397b, p. 210 (nom. nud.)] [*I. antiqua* KARRER, 1867; OD (M)]. Test free, ovoid, initial stage quinqueloculine followed successively by triloculine and biloculine stages and finally with completely enveloping chambers in adult, one or more of early stages may be lacking in some specimens; aperture in quinqueloculine stage

with simple tooth, in triloculine stage with crenulate border in addition to tooth, in biloculine stage with more strongly marked crenulations and

adult with raised trematophore pierced by numerous irregular openings. *U.Cret.(Senon.)*, Eu. —FIG. 359,1-5. \**I. antiqua*, topotypes, Fr.;

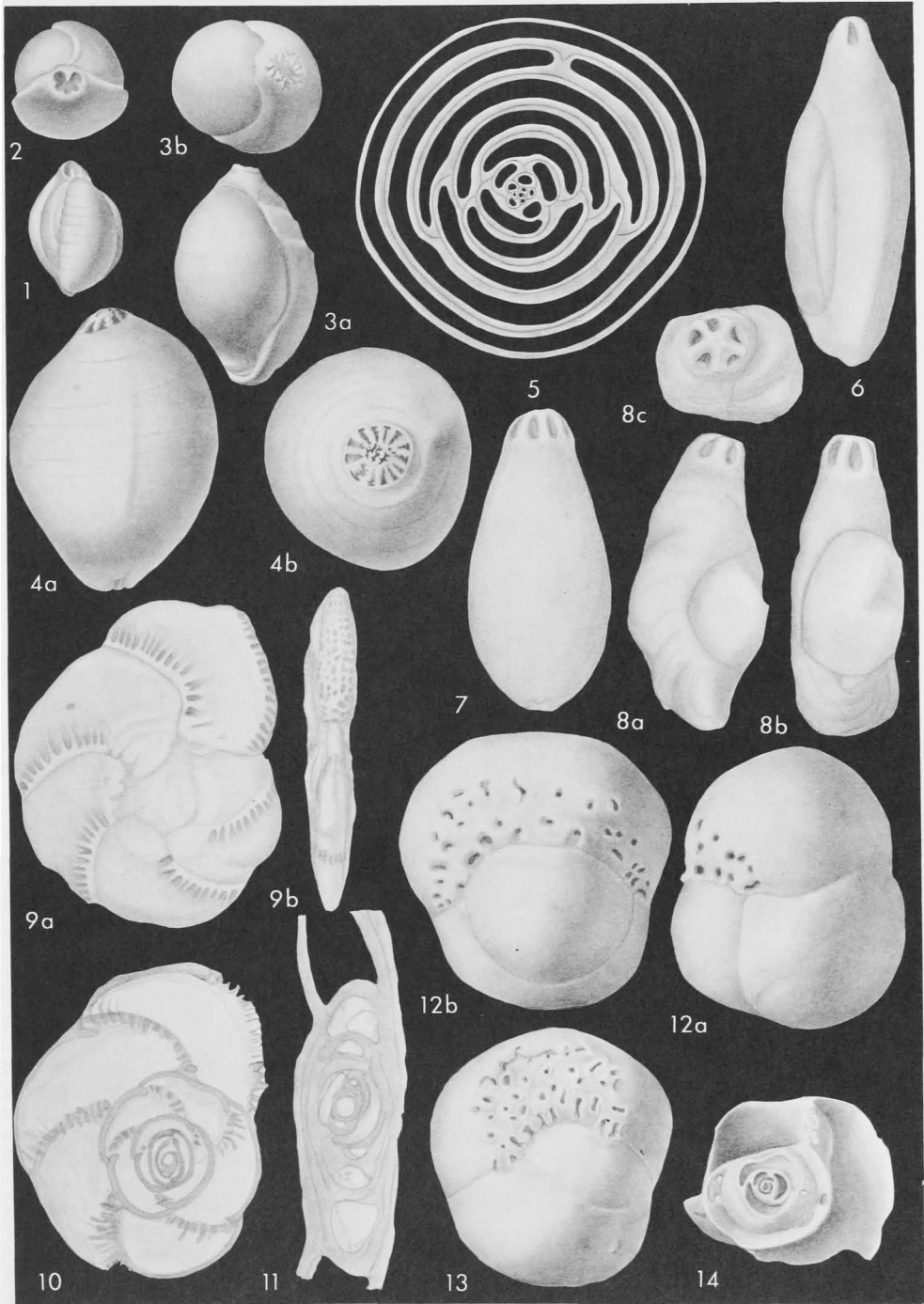


FIG. 359. Miliolidae (Miliolinae; 1-5, *Idalina*; 6-8, *Nevillina*; 9-11, *Polysegmentina*; 12-14, *Involvohauerina*) (p. C470-C472).



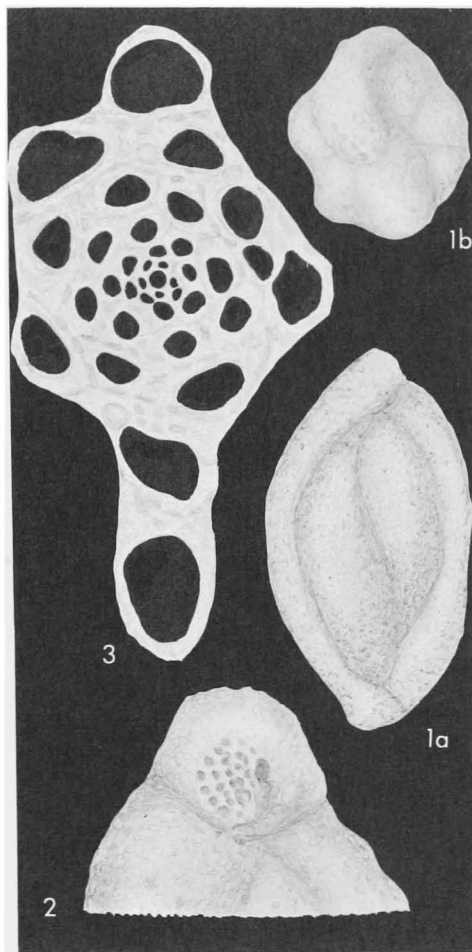


FIG. 360. Miliolidae (Miliolinae; 1-3, *Schlumbergerina*) (p. C472-C473).

1, young quinqueloculine specimen with simple tooth,  $\times 17$  (\*1330); 2, triloculine specimen with crenulate apertural border,  $\times 11$  (\*1330); 3a,b, biloculine specimen, side and top views showing dendritic aperture,  $\times 15$  (\*2117); 4a,b, side, top views of adult with completely overlapping chambers and complex apert. trematophore,  $\times 8$  (\*2117); 5, horiz. sec. of adult showing chamber development,  $\times 16$  (\*1330).

[*Idalina* was validly described in 1884 (although not figured) and the type-species by monotypy was referred to as "*Idalina antiqua*, d'Orb." SCHLUMBERGER & MUNIER-CHALMAS stated (\*1668, p. 630), "*L'Idalina antiqua*, d'Orb. sp., comprend les deux genres *Biloculina antiqua* et *Triloculina cretacea* mentionnés par d'ORBIGNY dans son Prodrôme (Étage 21<sup>e</sup>, n<sup>os</sup> 353 et 359)." The species *Biloculina antiqua* and *Triloculina cretacea* were *nomina nuda*, however, and the species *I. antiqua* correctly should be credited to SCHLUMBERGER & MUNIER-CHALMAS who first described it. *Idalina* differs from *Fabularia* in having a final enveloping stage and in lacking the labyrinthic interior. The holotype was from the Senonian, zone of *Hippurites cornuaccinum* and *H. organisans*, Étang de Berre, near Martigues, Dept. Bouche du Rhône, France.]

*Involvohaerina* LOEBLICH & TAPPAN, 1955, \*1166, p. 14 [*I. globularis*; OD]. Test free, early portion quinqueloculine, later tending to become planispiral and involute with 3 chambers to whorl and only those chambers of last whorl visible; aperture areal, cribrate, with numerous irregularly shaped pores. [Differs from *Hauerina* in being almost globular, rather than compressed, and in being involutely coiled, rather than evolute.] *Rec.*, Atl.O.-Pac.O.—FIG. 359,12-14. \**I. globularis*, Atl.; 12a,b, side, apert. views of holotype; 13, apert. view of paratype showing more complex aperture; 14, dissected paratype showing chamber development; all  $\times 20$  (\*1166).

*Nevillina* SIDEBOTTOM, 1905, \*1739, p. 1 [*Biloculina coronata* MILLETT, 1898, \*1284a, p. 263; OD (M)]. Test free, pyriform in outline, early chambers triloculine in plan, later biloculine, adult chambers completely embracing early ones, aperture of each succeeding chamber at opposite ends of test; wall smooth or marked by some transverse wrinkles; aperture terminal, rounded opening surrounded by additional radiating slits, between incurved lamellae which meet in ring around small central opening. [The holotype of *Biloculina coronata* is in the BMNH-ZF3626, from the Malay Archipelago. The original reference states that it occurred at Station 18, but the slide is labeled Station 19.] *Rec.*, Malay Arch. (Malay)-Ind.O.—FIG. 359,6-8. \**N. coronata* (MILLETT), Malay; 6, triloculine specimen,  $\times 79$ ; 7, adult specimen with completely overlapping chambers,  $\times 36$ ; 8a-c, side, edge and top views of holotype,  $\times 79$  (\*2117).

*Polysegmentina* CUSHMAN, 1946, \*483, p. 1 [*Hauerina circinata* BRADY, 1881, \*196c, p. 47; OD]. Test free, discoidal, early portion milioline in plan, later planispiral and slightly involute, with 3 to 6 chambers in final whorl, later chambers being relatively shorter, so that number per whorl gradually increases; wall thickened, calcareous, imperforate; aperture consisting of numerous irregular pores in trematophore, marginal row of pores being left exposed in earlier chambers and remaining as sutural pores connecting with interior. [Differs from *Hauerina* in its peculiar sutural retral processes bordering the relict lateral pores of previous apertures, which continue to connect with the interior.] *Rec.*, Pac.O.—FIG. 359,9-11. \**P. circinata* (BRADY); 9a,b, side, edge views of lectotype,  $\times 47$ ; 10, horiz. sec. showing chamber arrangement and apertural pores,  $\times 47$ ; 11, axial sec. of central area showing early chamber arrangement and lamellar wall,  $\times 109$  (\*1166).

*Schlumbergerina* MUNIER-CHALMAS, 1882, \*1322, p. 424 [*S. areniphora*; OD]. Test free, milioline in development, but with chambers added in more than 5 planes; wall agglutinated; aperture with trematophore, lateral rather than terminal in position. [MUNIER-CHALMAS described this form



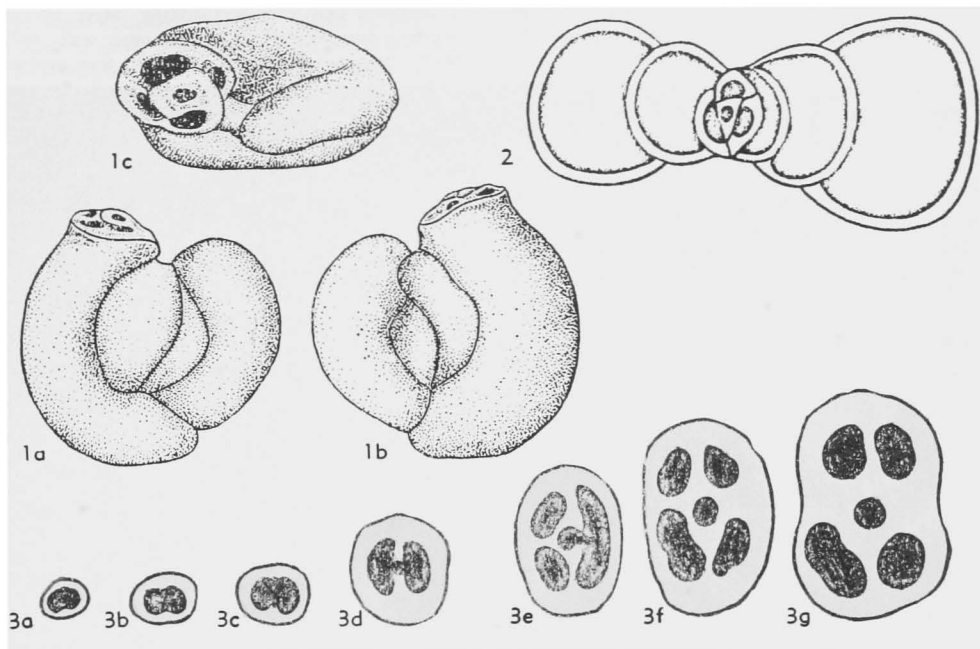


FIG. 361. Miliolidae (Miliolinae; 1-3, *Tortonella*) (p. C473).

as having 5 chambers externally, but in his figure of the type, 5 chambers are visible from one side of the test. None of the types of MUNIER-CHALMAS preserved in collections of the Sorbonne, Paris, France, show a test with only 5 chambers externally. Even in the early stage no quinqueloculine development is seen. *Schlumbergerina* differs from *Ammomassilina* in having chambers added in many planes, rather than in a single plane in the adult.] *Rec.*, Pac.O.-Gulf Mex.—FIG. 360, 1-3. \**S. areniphora*; Samoa (1), Torres Straits (2), Philip. (3); 1a, b, side, top views of lectotype,  $\times 28$ ; 2, apert. region of paratype,  $\times 64$ ; 3, sectioned specimen showing chambers added in numerous planes,  $\times 64$  (\*2117).

**Tortonella** DIDKOVSKIY, 1957, \*593, p. 1138 [\**T. bondartschuki*; OD]. Test free, flattened, early stage triloculine, later chambers added in single plane, 2 chambers to whorl or more rarely spreading somewhat so that 2 chambers do not quite complete volution; aperture large and rounded, with modified tooth, resulting in central perforation surrounded by 4 additional openings. *Mio.*(*Torton.*), USSR (Ukraine).—FIG. 361, 1-3. \**T. bondartschuki*; 1a-c, opposite sides and apert. view of holotype,  $\times 25$ ; 2, transv. sec. showing early triloculine stage, followed by planispiral stage,  $\times 48$ ; 3a-g, diagram. outlines of apertures of progressively larger specimens showing change from simple to bifid tooth to ringlike tooth attached in 4 places to leave 5 openings,  $\times 55$  (\*593).

[*Tortonella* is close in appearance to *Cribrolinoidea*, and apparently has a similar apertural development from simple opening and tooth to ringlike apertural tooth, and finally multiple openings. Although the definition of *Tortonella* stated that the early stage was quinqueloculine (which would make it a synonym of *Cribrolinoidea*), the sectioned specimen figured shows only a triloculine early stage; hence both are provisionally recognized.]

#### Subfamily FABULARIINAE Ehrenberg, 1839

[*nom. correct.* LOEBLICH & TAPPAN, 1961, p. 293 (pro subfamily Fabulariidea REUSS, 1862, p. 375)]

Interior complex; chambers subdivided into chamberlets; aperture multiple. *U.Cret.* (*Senon.*)-*Rec.*

**Fabularia** DEFRANCE, 1820, \*579a, p. 557 [\**F. discolites* DEFRANCE in BRONN, 1825, \*209, p. 43 (= *Nummulites ovata* DE ROISSY, 1805, \*1584, p. 59); SD (SM) DEFRANCE in BRONN, 1825, \*209, p. 43]. Test free, large, early stage biloculine in megalospheric form, at first quinqueloculine in microspheric forms, then triloculine, adults biloculine; wall thick, interior subdivided by secondary partitions; surface ornamented by fine striae and punctations; aperture with large trematophore pierced with numerous irregular openings. *M.Eoc.*(*Lutet.*)-*Rec.*, Eu.(Fr.)-Afr.-N.Am.—FIG. 362, 1-4. \**F. ovata* (DE ROISSY), *M.Eoc.* (*Lutet.*), Fr.; 1a-c, opposite sides and apert. view of juvenile triloculine specimen,  $\times 10$  (\*2117); 2a, b, side, edge views of biloculine specimen, surface abraded to show wall characters,  $\times 10$  (\*2117); 3, horiz. sec. of microspheric specimen,  $\times 41$ ; 4, horiz. sec. of megalospheric specimen,  $\times 35$  (\*1664).

*Austrotrillina* PARR, 1942, \*1426, p. 361 [*Trillina howchini* SCHLUMBERGER, 1893, \*1656, p. 119, 123; ODJ]. Test with chamber arrangement as in

*Triloculina*, new chambers adding layers against previous ones as well as new chamber wall; wall thick, new outer portion alveolar, that against

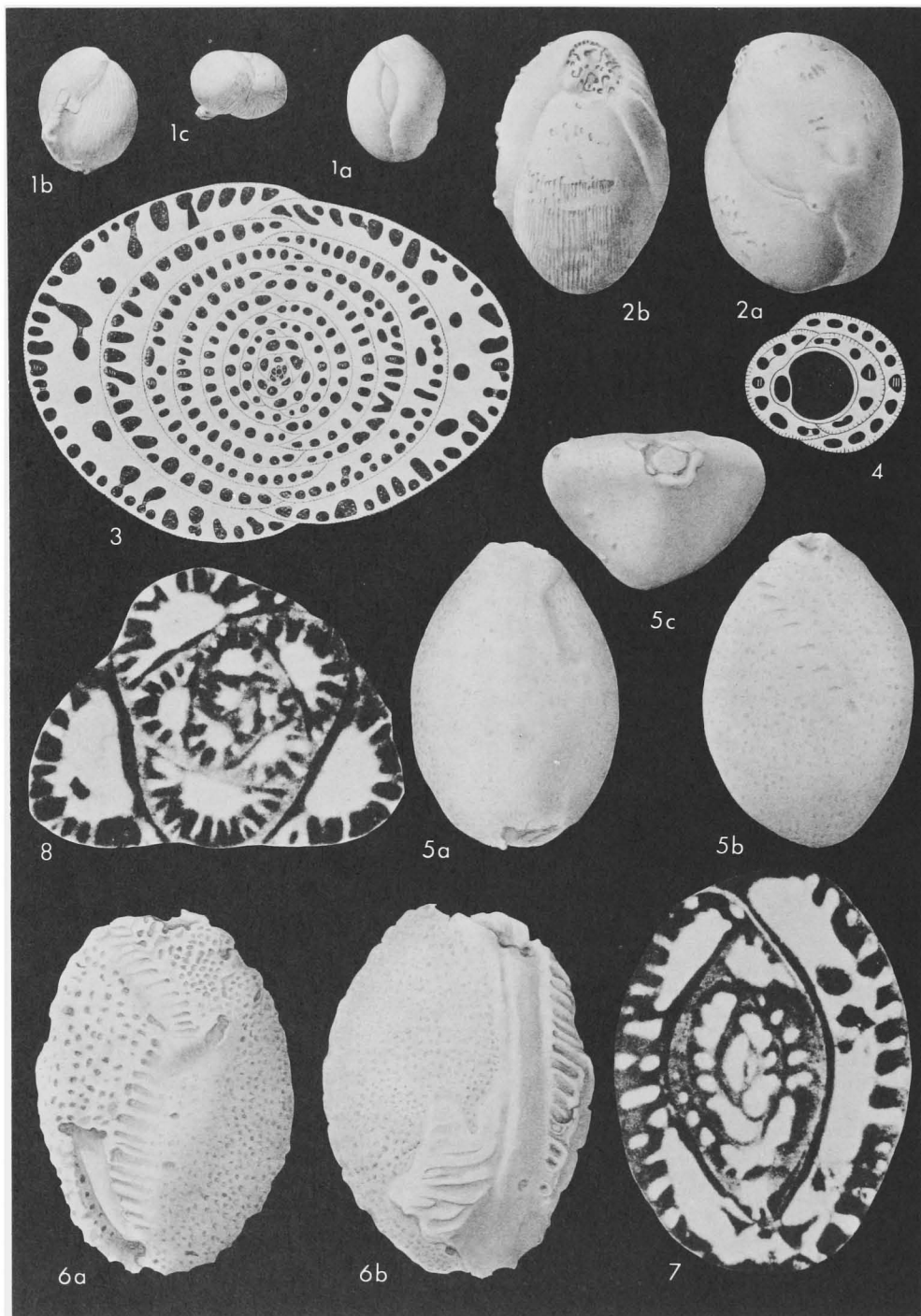


FIG. 362. Miliolidae (Fabulariinae; 1-4, *Fabularia*; 5-8, *Austrotrillina*) (p. C473-C476).

previous chambers thin and simple in structure; chamber cavity undivided; aperture terminal, with trematophore. [*Austrotrillina* was defined to in-

clude some of the species placed by SCHLUMBERGER in *Trillina*, the type-species of which (*T. strigilata* D'ORBIGNY) is a true *Triloculina*; hence,

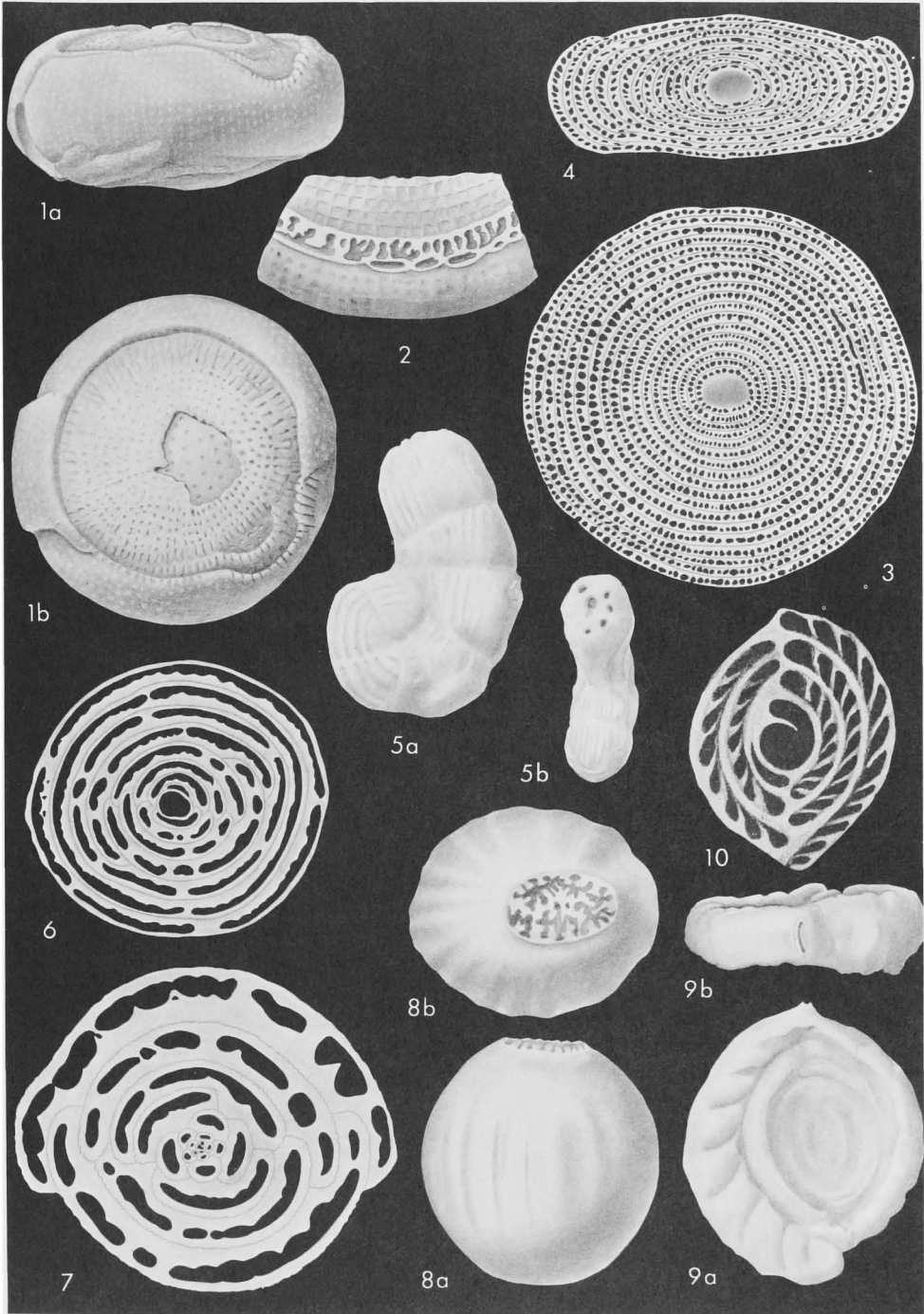


FIG. 363. Miliolidae (Fabulariinae; 1-4, *Lacazina*; 5, *Raadshoovenia*; 6-8, *Periloculina*; 9-10, *Riveroia*) (p. C476-C477).

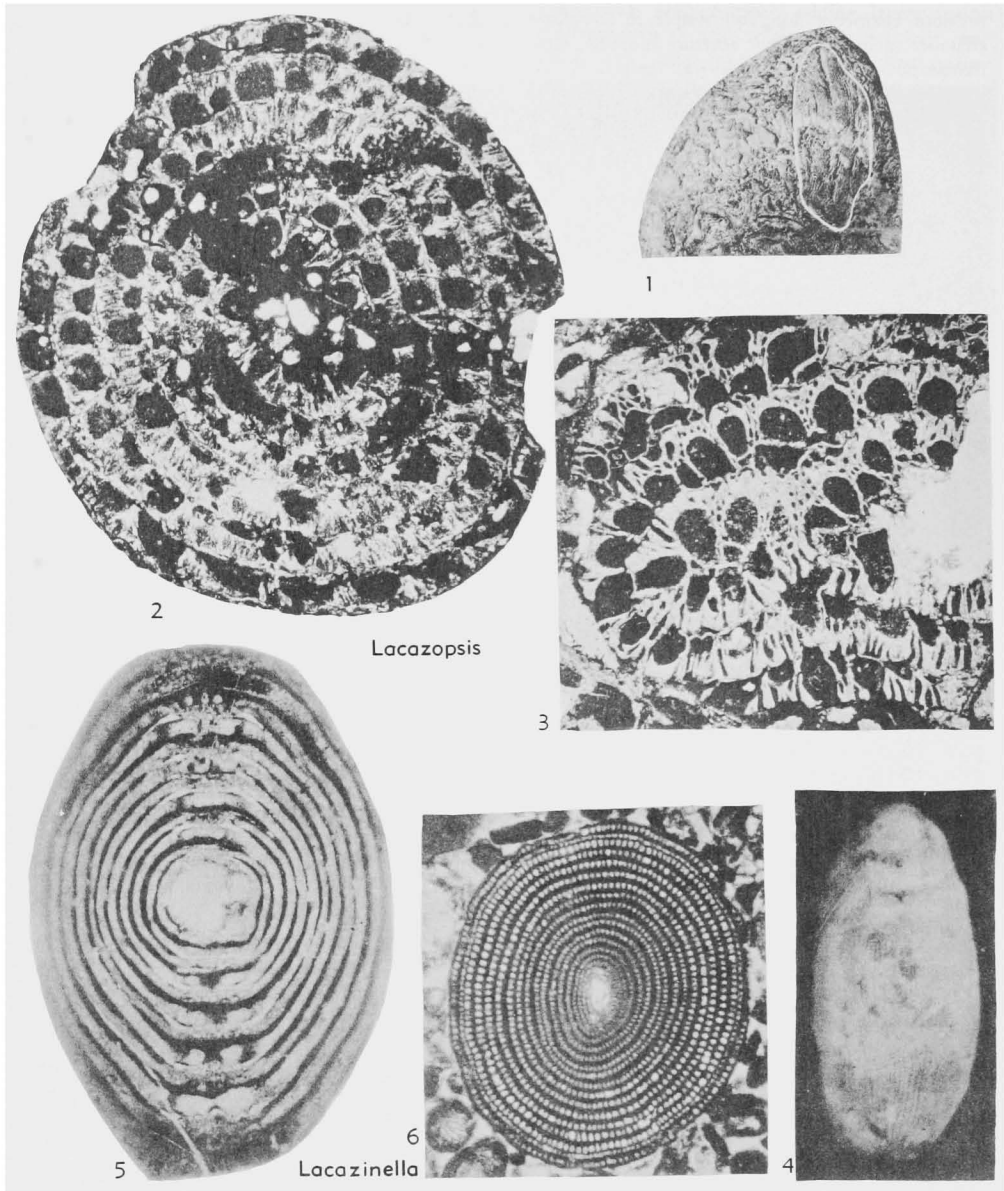


FIG. 364. Miliolidae (Fabulariinae; 1-3, *Lacazopsis*; 4-6, *Lacazinella*) (p. C477).

*Trillina* is a junior synonym of *Triloculina*.] *Eoc-Mio.*, Pac.O.-Australia-Asia (Iraq.)-E.Afr. (Somaliland).—FIG. 362,5-8. \**A. howchini* (SCHLUMBERGER), Mio., Australia; 5*a-c*, opposite sides and top view of specimen,  $\times 35$  (\*2117); 6*a,b*, opposite sides of eroded specimen in which alveolar wall character is evident,  $\times 35$  (\*2117); 7,8, long. and transv. secs.,  $\times 53$  (\*361).

*Lacazina* MUNIER-CHALMAS, 1882, \*1324, p. 472 [\**Alveolina compressa* D'ORBIGNY, 1850, \*1397b,

p. 210; OD]. Test free, discoidal; chambers biloculine, being added alternately on each side of test, subdivided by numerous small longitudinal pillars; aperture large, circular, ringlike, at entire margin of final chamber, covered by similarly ringlike trematophore with irregular openings separated by anastomosing denticulations. [*Lacazina* differs from *Periloculina* in having a ringlike aperture and trematophore instead of a small circular aperture and discoidal trematophore.

D'ORBIGNY's types are from the Senonian, Martigues and La Fare, Dept. Bouche du Rhône, France.] *U.Cret.(Senon.)*, Eu.—FIG. 363,1-4.

\**L. compressa* (D'ORBIGNY), Santon., Sp. (1), Senon., Fr. (2-4); 1a,b, edge and apert. views,  $\times 8$  (\*2117); 2, part of test showing trematophore,  $\times 15$ ; 3A, horiz. and axial secs., enlarged (\*1330).

**Lacazinella** CRESPIN, 1962, \*394A, p. 337 [*Lacazina wichmanni* SCHLUMBERGER, 1894, \*1656A, p. 295; OD]. Test large, 2-3 mm. in length, elongate-ovate in outline, circular in section, each chamber completely enveloping test, only final chamber visible externally, proloculus subspherical, each successive chamber with aperture at opposite end of test from that of preceding one, chamber interiors partially filled by longitudinal internal perforated ribs which anastomose somewhat below apertural region; wall calcareous, porcelaneous, imperforate, surface smooth or longitudinally grooved; aperture terminal cribrate, consisting of trematophore at one end of long axis. [Differs from *Lacazina* in having completely embracing chambers, elongate axis, and endoskeleton of ribs, rather than pillars, and from *Periloculina* in lacking an early milioline development.] *U.Eoc.*, ?*Oligo.*, W.Pac.O. (New Guinea-Moluccas Is.).—FIG. 364,4-6. \**L. wichmanni* (SCHLUMBERGER); 4, side view,  $\times 14$ ; 5, vert. sec. showing completely enveloping chambers with apertures at alternate ends and sectioned trematophore,  $\times 20$ ; 6, horiz. sec. showing radiating vert. ribs,  $\times 18$  (\*394A).

**Lacazopsis** DOUVILLÉ, 1930, \*629, p. 247 [*L. termieri*; OD (M)]. Test free, to 22 mm. in length, regularly fusiform, with completely enveloping chambers that alternate from pole to pole, subdivided into chamberlets by longitudinal and transverse interseptal partitions; wall calcareous, agglutinated, outer regular layer thin, inner layer with anastomosing pillars that form irregular network, tangential section appearing reticulate, and perpendicular section showing nearly parallel pillars; aperture terminal, cribrate. [*Lacazopsis* has the general form of *Lacazina* but is much larger. The wall was described as finely agglutinated and reticulate, rather than calcareous imperforate. It was originally placed with the trematophorate miliolids, but restudy of the wall character is necessary to determine if it actually is porcelaneous. The Fiche-Type H. DOUVILLÉ 37 (4), Institut Français du Pétrole, stated that the chamber appearance suggested a cheilostome bryozoan.] *U.Cret.(Senon.)*, N.Afr. (Morocco).—FIG. 364, 1-3. \**L. termieri*; 1, specimen (outlined) on pebble,  $\times 2$ ; 2, transv. sec. showing annular chambers and interseptal partitions,  $\times 20$ ; 3, oblique sec. showing at left interseptal pillars perpendicular to surface and at right alveolar structure,  $\times 20$  (\*629).

**Periloculina** MUNIER-CHALMAS & SCHLUMBERGER,

1885, \*1330, p. 308 [*P. zitteli*; OD (M)]. Test free, ovoid, in adult consisting of completely embracing chambers, microspheric form with initial quinqueloculine stage followed by triloculine, biloculine, and finally embracing development, megalospheric form either triloculine or biloculine in young; wall commonly with longitudinal ornamentation, internal wall of chambers with longitudinal ridges which may become sufficiently produced to touch opposite wall and secondarily subdivide chamber; aperture elongate and crescentic with denticulate margin in early stage, with trematophore pierced by irregular anastomosing openings in adults. [Differs from *Idalina* in having the interior of the chambers subdivided by internal longitudinal ribs. It differs from *Lacazina* in having a plate-like, instead of ringlike, trematophore and in having internal ribs instead of the radiating pillars characteristic of *Lacazina*.] *U.Cret.(Senon.)*, Eu. (Fr.).—FIG. 363,6-8. \**P. zitteli*; 6,7, transv. secs. of megalospheric ( $\times 18$ ) and microspheric ( $\times 42$ ) forms; 8a,b, side, apert. views,  $\times 12$  (\*1330).

**Raadshoovenia** VAN DEN BOLD, 1946, \*155, p. 123 [*R. guatemalensis*; OD]. Test free, early chambers in quinqueloculine arrangement, later 4 to 6 chambers to whorl in planispiral coil, adult uncoiling and rectilinear; later chambers with secondary interseptal partitions, visible as ridges at surface of slightly eroded specimens; aperture terminal, multiple. *L.Eoc.*, C.Am. (Guat.).—FIG. 363,5. \**R. guatemalensis*; 5a,b, side, top views,  $\times 15$  (\*2117).

**Riveroia** BERMÚDEZ, 1939, \*121b, p. 248 [*R. caribaea*; OD]. Test free, planispiral, with chambers one-half coil in length, as in *Spiroloculina*, but interior of chambers with oblique secondary septa, those of each chamber projecting toward its apertural end; aperture terminal, single, elongate curved slit. *Rec.*, Carib. Sea.—FIG. 363, 9,10. \**R. caribaea*; 9a,b, side, apert. views of paratype,  $\times 76$  (\*2117); 10, sectioned paratype,  $\times 50$  (\*121b).

#### Subfamily TUBINELLINAE Rumbler, 1906

[*Tubinellinae* RHUMBLER, 1906, p. 25] [= *Artubinia* RHUMBLER, 1913, p. 352 (*nom. van.*)]

Early milioline stage reduced; later portion uniserial, with rudimentary septa; aperture formed by open end of final chamber. *M.Eoc.-Rec.*

**Tubinella** RHUMBLER, 1906, \*1571, p. 25 [*Articulina funalis* var. *inornata* BRADY, 1884, \*200, p. 186; SD CUSHMAN, 1928, \*439, p. 151] [= *Artubinum* RHUMBLER, 1913, \*1572b, p. 352 (*obj.*) (*nom. van.*); *Tubinellina* WIESNER, 1931, \*2063, p. 67 (type, *Articulina funalis* BRADY, 1884, \*200, p. 185)]. Test free, with vestigial early milioline stage consisting of bulbous proloculus and closely appressed second chamber, reversing direction of growth; later chambers

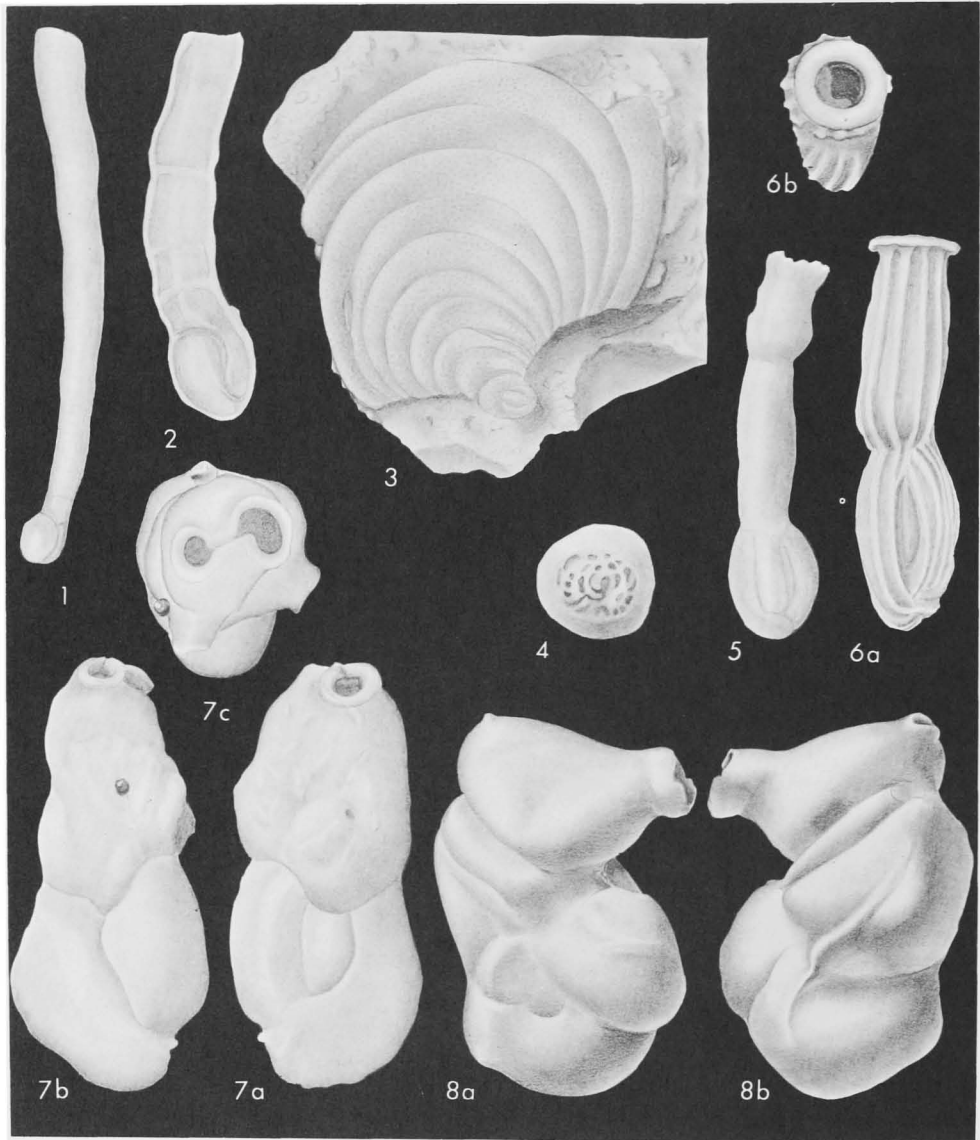


FIG. 365. Miliolidae (Tubinellinae; 1,2, *Tubinella*; 3, *Pavoninoides*; 4,5, *Poroarticulina*; 6, *Articulina*; 7,8, *Parrina*) (p. C477-C480).

cylindrical, uniseriably arranged; septa vestigial, consisting of slight transverse thickenings of wall, visible in transmitted light; aperture at open end of tube. [*Tubinella* is very close to *Articulina* in possessing a milioline early stage, although much reduced, and is probably derived from *Articulina* by reduction of the septa to mere wall thickenings.] *Rec.*, Pac.O.-Atl.O.—FIG. 365,1,2. \**T. inornata* (BRADY), *Rec.*, Ind.O.(Kerguelen Is.); 1, side view of lectotype,  $\times 48$ ; 2, paratype,  $\times 105$  (\*1166).

**Articulina** D'ORBIGNY, 1826, \*1391, p. 300 [*A. nitida*; OD (M)] [= *Ceratospirulina* EHRENBERG,

1858, \*683, p. 11 (type, *C. spratti*)]. Test in early stage milioline, later rectilinear, ornamentation may consist of longitudinal costae; aperture in adult terminal, rounded, with everted margin. *M.Eoc.-Rec.*, cosmop.—FIG. 365,6. \**A. nitida*, *M.Eoc.*(Lutet.), Eu.(Fr.); 6a,b, side, top views of topotype,  $\times 83$  (\*2117).

**Parrina** CUSHMAN, 1931, \*448, p. 20 [= *pro Silvestria* SCHUBERT, 1921, \*1694, p. 166 (non VERHOEFF, 1895; nec BRIAN, 1902)] [*Nubecularia bradyi* MILLETT, 1898, \*1284a, p. 261; OD] [= *Erichsenella* TINOCO, 1955, \*1935, p. 19 (type, *E. kegeli*)]. Test with early stage milioline, later



chambers irregularly uniserial; aperture rounded, without tooth and commonly with more than one aperture on terminal chamber. [*Parrina* was de-

finied by CUSHMAN as "irregularly coiled" in the early stage, but both the type-species of *Parrina* and that of *Erichsenella* have a more or less well-

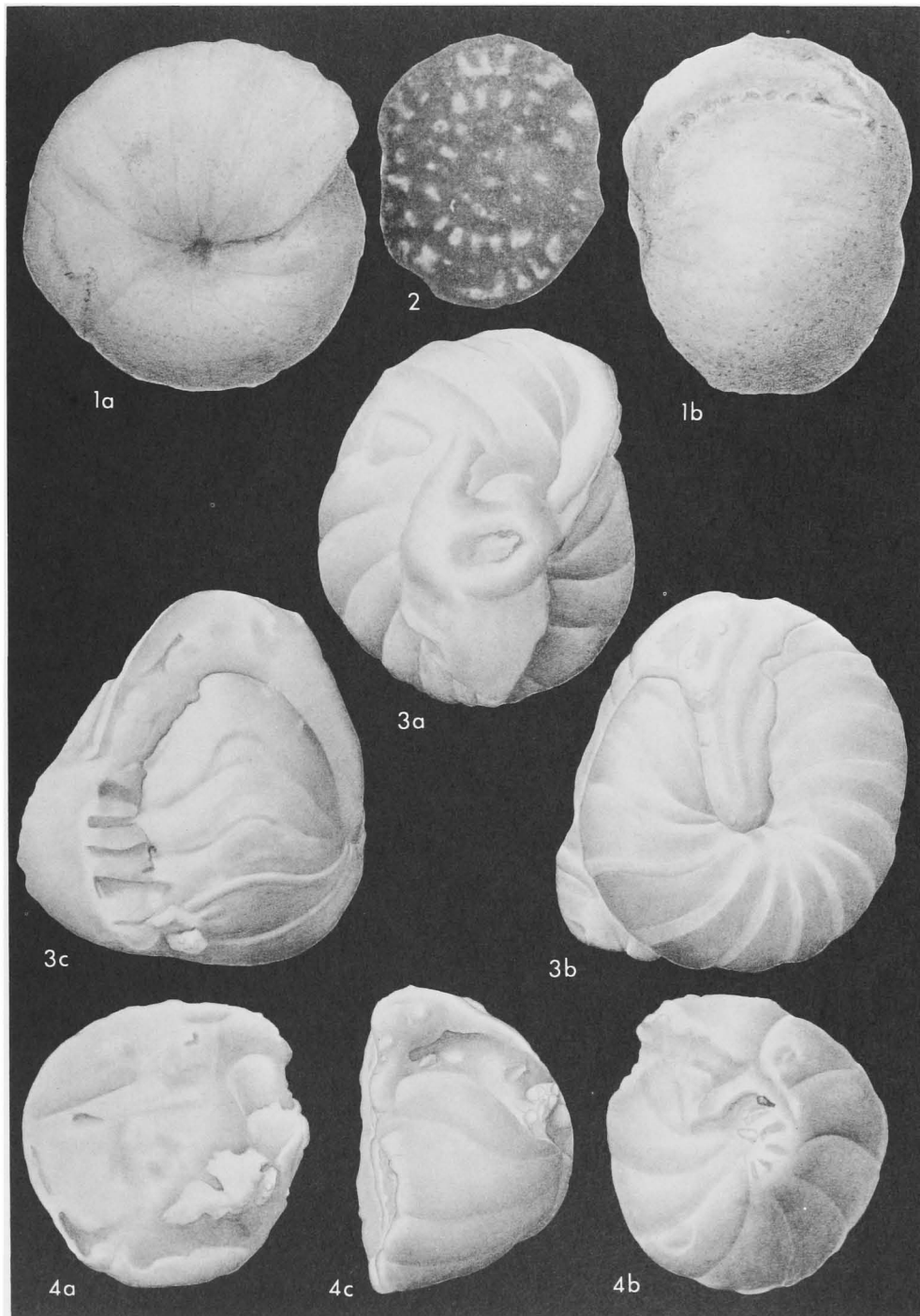


FIG. 366. Barkerinidae; 1,2, *Barkerina*; 3,4, *Rabaniina* (p. C481-C482).

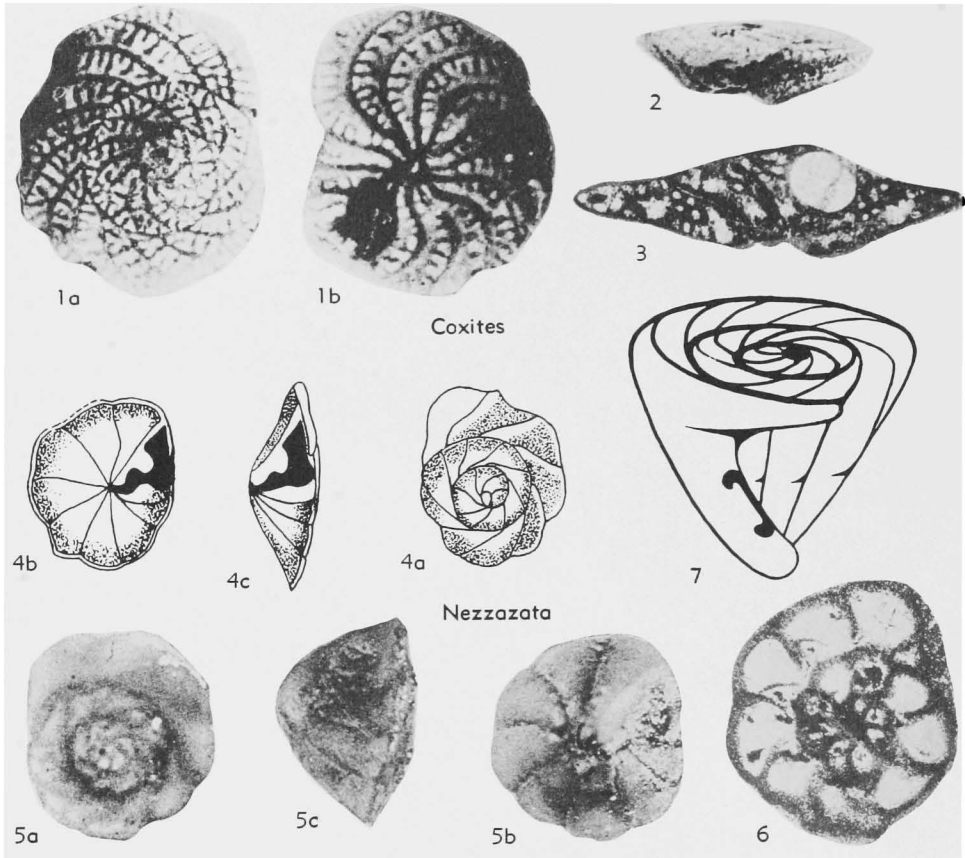


FIG. 367. Barkerinidae; 1-3, *Coxites*; 4-7, *Nezzazata* (p. C481).

developed milioline stage, although this may be somewhat obscured by the irregular later chambers. *Parrina* differs from *Articulina* in being irregular in later development and in having more than one asymmetrically placed aperture.] *Rec.*, W.Pac.O.-Atl.O.—FIG. 365,7. \**P. bradyi* (MILLET), *Rec.*, W.Pac.(Fiji Is.); 7a-c, opposite sides and top view of hypotype, showing milioline early stage and numerous apertures on final chamber,  $\times 89$  (\*2117).—FIG. 365,8. *P. kegeli* (TINOCO), *Rec.*, Atl.O.(Brazil); 8a,b, opposite sides of topotype,  $\times 99$  (\*2117).

**Pavoninoides** BERMÚDEZ, 1949, \*123, p. 58 [\**P. panamensis*; OD]. Test flabelliform, chambers in early stage in triloculine arrangement, later uniserial, with rapidly increasing breadth; wall calcareous, imperforate, but with surface pitting; aperture multiple, single row of pores on peripheral margin of final chamber. *U.Eoc.*, C.Am.(Panama).—FIG. 365,3. \**P. panamensis*; side view of holotype,  $\times 28$  (\*2117).

**Poroarticulina** CUSHMAN, 1944, \*479, p. 52 [\**P. glabra*; OD]. Test with early chambers in quinqueloculine arrangement, later uniserial, rectilinear;

aperture in early stage with tooth, in uniserial stage terminal, cribrate. *Mio.*, Eu.(Rumania).—FIG. 365,4,5. \**P. glabra*; 4, top view of holotype; 5, side view of paratype,  $\times 74$  (\*2117).

#### Family BARKERINIDAE Smout, 1956

[Barkerinidae SMOUT, 1956, p. 342] [=Barkerininae LOEBLICH & TAPPAN, 1961, p. 280 (*nom. transl. ex family Barkerinidae* SMOUT, 1956)]

Test trochospiral in early stage, later planispiral and involute, or planispiral throughout; chambers subdivided by transverse partitions; wall imperforate, calcareous, microgranular (?recrystallized); aperture single or multiple. *Cret.*(*Alb.-Turon.*).

[As defined by SMOUT, the Barkerinidae included only *Barkerina*, *Coxites*, and *Rabanitina*, all characterized by a complexly folded plate subdividing the chambers. Although this is represented only by a small tooth plate in *Nezzazata*, the similarity in the imperforate granular wall and the *Nezzazata*-like juvenile stage of *Rabanitina* suggests such a relationship. The Barkerinidae are stated not to be agglutinated, the granular, commonly recrystallized imperforate wall suggesting a relationship to the porcelaneous foraminifers, as noted by SMOUT (\*1805). The proloculus is not followed by a spiral passage as in the Nubeculariidae nor are the chambers coiled about an elongate axis as in the Miliolidae. The family Barkerinidae is here placed in the Miliolacea. The subdivided cham-

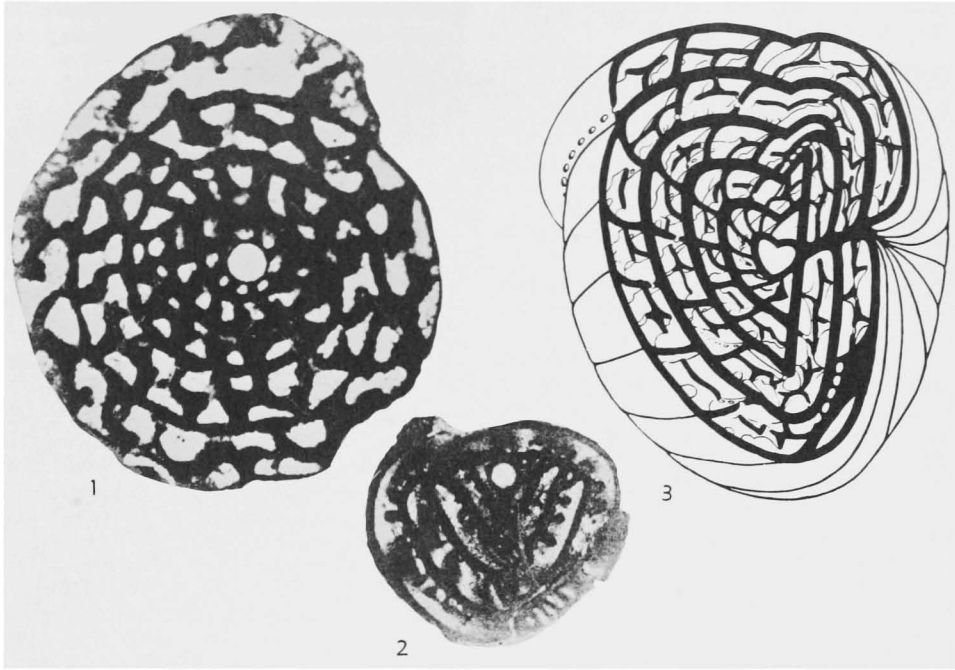


FIG. 368. Barkerinidae; 1-3, *Rabanitina* (p. C482).

bers are similar to the Soritidae and Alveolinidae, but the early trochospiral development is distinct.]

**Barkerina** FRIZZELL & SCHWARTZ, 1950, \*753, p. 5 [*B. barkerensis*; OD]. Test planispirally coiled, involute; chambers numerous, low and broad, subdivided internally by transverse partitions, visible on eroded specimens; wall of microgranular calcite; aperture comprising row of arched openings at base of septal face. *L.Cret.(Alb.)*, USA (Tex.).—FIG. 366,1,2. \**B. barkerensis*; 1a,b, side, edge views of holotype,  $\times 86$  (\*2117); 2, sec. showing subdivided chambers,  $\times 60$  (\*753).

**Coxites** SMOUT, 1956, \*1805, p. 342 [*C. zubairensis*; OD]. Test trochospiral, unequally biconvex, with all whorls visible on flattened spiral side, only final whorl visible on low conical umbilicate opposite side, periphery acute; chambers numerous, low and curved, with long marginal prolongation as in *Nezzazata*, with incomplete oblique longitudinal plate extending from roof to floor of each chamber, transverse partitions in all chambers, commonly simple, more rarely forked; sutures curved, flush but distinct; wall of thin, imperforate, granular calcite, without arenaceous particles, internal structure visible through thin, almost transparent wall; apertural characters unknown as apertural face is broken in all specimens observed. *U.Cret.(Turon.)*, SW. Asia(Iraq).—FIG. 367,1-3. \**C. zubairensis*; 1a,b, opposite sides of holotype; 2, edge view of paratype; 3, axial sec.,  $\times 40$  (\*1805).

**Nezzazata** OMARA, 1956, \*1389, p. 887 [*N. simplex*; OD] [= *Begia* SMOUT, 1956, \*1805, p. 339 (type, *B. gyra*)]. Test trochospiral, plano-convex to unequally biconvex, all whorls visible from flattened to slightly convex spiral side, only those of final whorl visible around closed umbilical region; chambers with projection at periphery similar to tectum of *Alabamina*; wall calcareous, imperforate (\*1805, \*1527) or possibly finely perforate (\*1389), microgranular in structure, described as nonlamellar, septa single (monolamellar); aperture a narrow interiomarginal opening from near umbilicus to periphery, bending up apertural face parallel to peripheral margin, internal tooth plate extending between adjacent septa may attach to outer chamber wall where it shows as slight indentation of suture. *Cret.(Alb.-Turon.)*, Afr.-Asia (Israel-Iraq).—FIG. 367,4. \**N. simplex*, *U.Cret.(Cenoman.)*, Egypt; 4a-c, opposite sides and edge view of holotype,  $\times 38$  (\*1389).—FIG. 367,5-7. *N. gyra* (SMOUT), *U. Cret.(Turon.)*, Iraq; 5a-c, opposite sides and edge view of holotype,  $\times 40$ ; 6, horiz. sec., showing tooth plates,  $\times 40$ ; 7, oblique diagram of exterior, showing tectum, angled aperture and apert. tooth, enlarged (\*1805).

[The position of this genus is doubtful. It was placed in the Ceratobulminidae by SMOUT (\*1805), though it lacks an aragonitic wall. It was compared to the "Rotallidea" by OMARA (\*1389) but regarded as differing from that superfamily in its granular wall. REISS (\*1527) referred the genus to the Barkerinidae. The photomicrographs given by SMOUT and REISS suggest the recrystallized porcelaneous

wall as figured by Wood (\*2073, pl. 13, fig. 2) for *Alveolina*, and the family Barkeriidae is here regarded as having a porcelaneous wall.]

**Rabanitina** SMOUT, 1956, \*1805, p. 343 [\**R. basraensis*; OD]. Test subspherical, early stage trochospiral, plano-convex and umbilicate on elevated umbilical side, then changing abruptly to completely involute, globular form; in all adult chambers, complex longitudinal perforated plate roughly parallels spiral wall, but it is twisted and buttressed to chamber floor and roof; sutures flush or slightly depressed, septa radial; shell calcareous, nonlamellar, microgranular, without arenaceous matter, porcelaneous, imperforate, but shell material altered in described specimens, surface not ornamented; aperture not observed. [*Rabanitina* is similar to *Barkerina* in the adult, but differs in having an early conical trochospiral stage.] *U.Cret. (L.Cenom.)*, Iraq.—FIG. 366,3,4; 368,1-3. \**R. basraensis*; 366,3a-c, opposite sides and edge view of involute adult specimen,  $\times 40$  (\*2117); 366,4a-c, opposite sides and edge view of young trochospiral specimen,  $\times 40$  (\*2117); 368,1,2, subequat. and axial secs.,  $\times 30$ ; 3, block diagram showing relationship of axial and equat. secs., enlarged (\*1805).

### Family SORITIDAE Ehrenberg, 1839

[*nom. correct.* GALLOWAY, 1933, p. 132 (pro family Soritina EHRENBURG, 1839, table opposite p. 120)]—[All names cited are of family rank; dagger(†) indicates *partim*]—[=Planulacea and Planulacés DE BLAINVILLE, 1825, p. 370 (*nom. nud.*); =Polythalamat LATREILLE, 1825, p. 161 (*nom. nud.*); =Cristata CROUCH, 1827, p. 40 (*nom. nud.*); =Helicostéguest D'ORBIGNY, 1826, p. 268 (*nom. nud.*); =Enthomostéguest D'ORBIGNY, 1826, p. 304 (*nom. nud.*); =Enthomostéguest BRODERIP, 1839, p. 321 (*nom. nud.*); =Helicosorinat EHRENBURG, 1839, table opp. p. 120 (*nom. nud.*); =Asterodiscinat EHRENBURG, 1839, table opp. p. 120; =Myrioporina AGASSIZ, 1844, p. 16 (*nom. nud.*); =Nautiloidat SCHULTZE, 1854, p. 53 (*nom. nud.*); =Helicostégiate REUSS, 1860, p. 151, 205 (*nom. nud.*)]—[=Orbitolitidae GRAY, 1840, *vide* AGASSIZ, 1844, p. 19 (cited in error as GRAY, 1804); =Orbitulitidae REUSS, 1862, p. 376; =Orbitulitidae GÜMBEL, 1870, p. 27; =Orbitulinida JONES in GRIFFITH & HENFREY, 1875, p. 319; =Orbitulitidae SCHWAGER, 1876, p. 483; =Orbitulita MARRIOTT, 1878, p. 31; =Orbitolitina BÜTSCHLI in BRONN, 1880, p. 192; =Familie des Orbitolites DOUVILLÉ, 1902, p. 290 (*nom. neg.*); =Familie des Orbitulines DOUVILLÉ, 1902, p. 297 (*nom. neg.*)]—[=Soritida SCHULTZE, 1854, p. 53]—[=Peneropliidae REUSS, 1860, p. 151; =Peneropliidae REUSS, 1860, p. 217; =Peneropliidae REUSS, 1862, p. 379; =Peneropliida SCHMARDA, 1871, p. 165; =Peneropliidae SCHWAGER, 1876, p. 483; =Peneropliida BÜTSCHLI in BRONN, 1880, p. 190; =Peneropliinae DELAGE & HÉROUARD, 1896, p. 124; =Peneropliidae LISTER in LANKESTER, 1903, p. 143]—[=Cristellaridae REUSS, 1860, p. 151, 205; =Cristellaridae REUSS, 1862, p. 307, 335, 368; =Cristellaridae GÜMBEL, 1870, p. 54; =Cristellarida SCHMARDA, 1871, p. 165; =Cristellaroidi SCHWAGER, 1876, p. 477; =Cristellarioidea SCHWAGER, 1877, p. 19; =Cristellaridae WEDEKIND, 1937, p. 98]—[=Poritida SCHMARDA, 1871, p. 165; =Keramospharina LANKESTER, 1885, p. 847; =Keramospharinae DELAGE & HÉROUARD, 1896, p. 127; =Keramospharinae LISTER in LANKESTER, 1903, p. 143; =Meandropsinidae HENSON, 1948, p. 77]—[=Soritina EHRENBURG, 1838, p. 200 (*nom. nud.*); genus invalid until 1840] [Also =Orbitulitida HAECKEL, 1894, p. 185]

Wall calcareous, porcelaneous, may be pitted or perforated in early stage; chambers planispiral, later serial, flabelliform or cyclical; interior simple or labyrinthic; aperture single and simple, dendritic, or multiple. [Because of its type-species, *Cristel-*

*laria* is a synonym of *Peneroplis*, hence the family and subfamily names based on *Cristellaria* are included here.] *U.Trias-Rec.*

### Subfamily PENEROPLINAE Schultze, 1854

[*nom. correct.* CUSHMAN in EASTMAN, 1913, p. 39 (pro subfamily Peneroplida SCHULTZE, 1854, p. 53)]—[All names cited are of subfamily rank]—[=Cristellarida SCHULTZE, 1854, p. 53; =Cristellarinae RHUMBLER, 1895, p. 91; =Peneropliidae BRADY, 1884, p. 62; =Sporoliminae CUSHMAN, 1927, p. 54]

Test close-coiled in early stage, later may be uncoiled or annular; chambers simple, not divided into chamberlets; aperture rounded, slitlike, or series of pores on final septal face. *U.Trias-Rec.*

**Peneroplis** DE MONTFORT, 1808, \*1305, p. 258 [\**Nautilus planatus* FICHTEL & MOLL, 1798, \*716, p. 91; OD] [=Cristellaria LAMARCK, 1816, \*1089, p. 14 (type, *Nautilus planatus* FICHTEL & MOLL, =*C. squammula* LAMARCK, 1822, \*1090, p. 607 (obj.), SD CHILDREN, 1823, \*337, p. 117=153); *P. (Peneroplis)* D'ORBIGNY in DE LA SAGRA, 1839, \*1611, p. 59 (obj.); *Archiacina* MUNIER-CHALMAS in VASSEUR, 1878, \*1987, p. 1049 (type, *Cyclolina armorica* D'ARCHIAC in TOURNOUR, 1868, \*1947, p. 376); *Laevipeneroplis* ŠULC, 1936, \*1850, p. 161 (type, *Peneroplis karveri* WIESNER, 1923, \*2062, p. 95, 96); *Puteolus* HOFKER, 1950, \*933a, p. 394 (type, *Peneroplis protea* D'ORBIGNY, 1839, \*1611, p. 60) (*non Puteolus* MONTEROSATO, 1888); *Puteolina* HOFKER, 1952, \*933c, p. 450 (*nov. nom. pro Puteolus* HOFKER, 1950, *non* MONTEROSATO, 1888)]. Test compressed, planispirally enrolled at least in early stages, later may be uncoiled and flaring, external form variable; chambers broad, low, not subdivided; wall porcelaneous, surface smooth, pitted, or more commonly, longitudinally striate; aperture terminal, row of slits in slight depression along the apertural face. [*Puteolus* (=Puteolina) was based on a species with pitted rather than striate surface ornamentation. We do not regard ornamentation as of generic importance.] ?*U.Cret.*, *Eoc.-Rec.*, cosmop.—FIG. 369,1. \**P. planatus* (FICHTEL & MOLL), *Rec.*, *Medit. Sea*; *lab.*, side, edge views,  $\times 45$  (\*2117).—FIG. 369,2,3. *P. proteus* D'ORBIGNY; *Rec.*, W.Indies (2), Bermuda (3); side views,  $\times 30$  (\*200).—FIG. 369,4,5. *P. armorica* (D'ARCHIAC), M.Oligo., Eu.(Fr.); topotypes, showing tendency of species to become cyclical,  $\times 37$  (\*2117).

**Dendritina** D'ORBIGNY, 1826, \*1391, p. 285 [\**D. arbuscula*; SD CUSHMAN, 1927, \*433, p. 189] [=Peneroplis (*Dendritina*) D'ORBIGNY in DE LA SAGRA, 1839, \*1611, p. 58 (obj.); *Meneghinia* O. SILVESTRI, 1889, \*1792, p. 53 (*non Meneghinia* FUCINI, 1931) (type, *M. nautiliformis*); *Neopeneroplis* DIDKOVSKIY, 1958, \*594, p. 1252 (type, *N. sarmaticus*)]. Test free, planispirally enrolled,

nearly or completely involute; chambers simple, not subdivided; surface smooth or striate; aperture dendritic, on apertural face. *Eoc.-Rec.*, Eu-

Carib.-Afr.-Atl.O.—FIG. 370,1. \**D. arbuscula*, Mio., Fr.; 1a,b, side, apert. views, enlarged (\*1391).

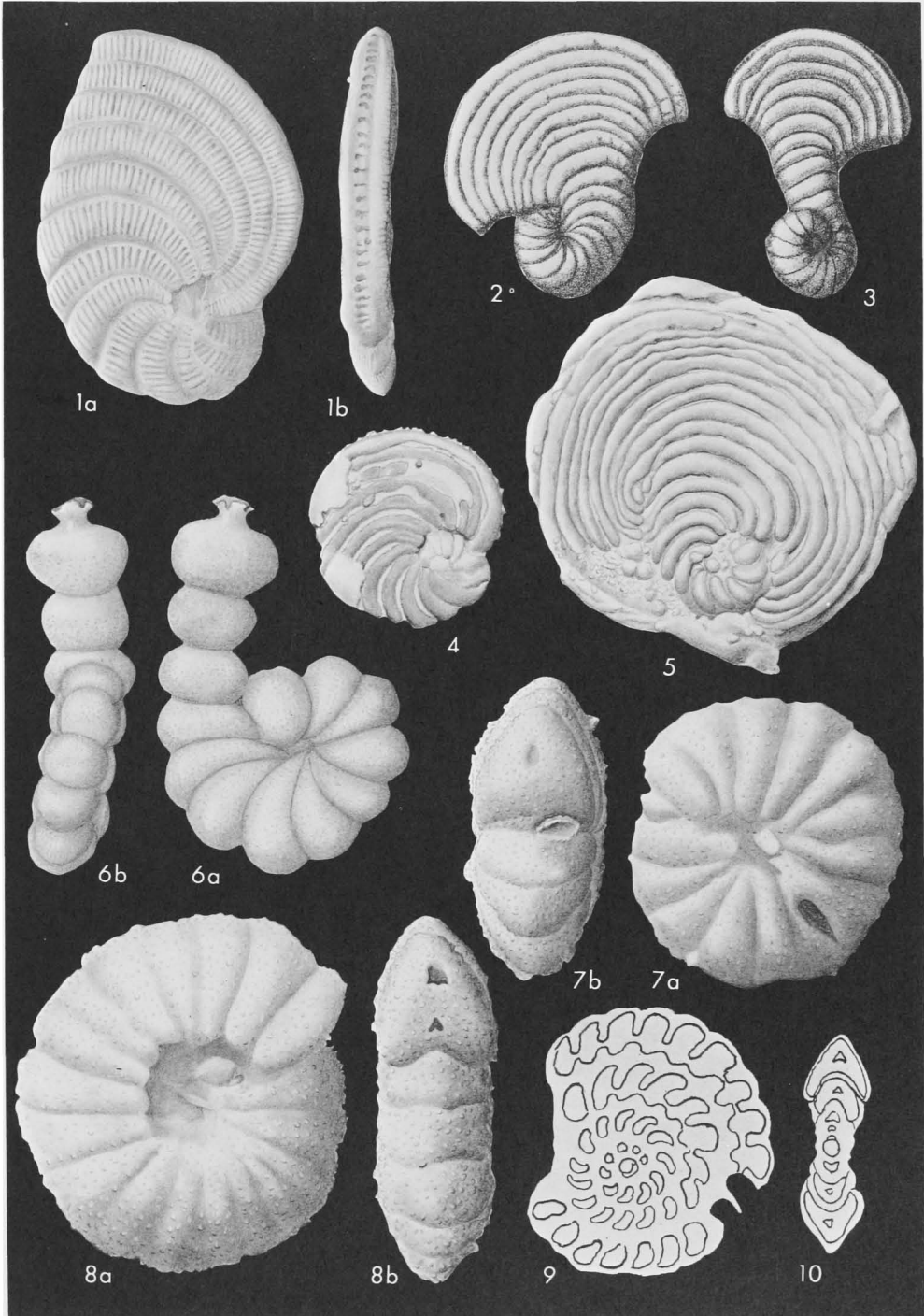


FIG. 369. Soritidae (Peneroplinae; 1-5, *Peneroplis*; 6, *Monalysidium*; 7-10, *Praepeneroplis*) (p. C482, C484).

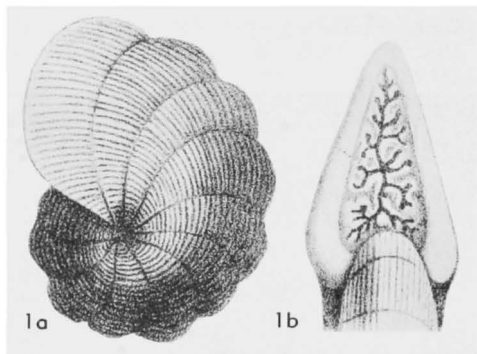


FIG. 370. Soritidae (Peneroplinae; 1, *Dendritina*) (p. C482-C483).

**Monalysidium** CHAPMAN, 1900, \*314, p. 3 [*\*Peneroplis* (*Monalysidium*) *sollasi*; OD] [= *Peneroplis* (*Monalysidium*) CHAPMAN, 1900, \*314, p. 3 (obj.)]. Test free, with early subglobular chambers arranged in evolute planispiral coil, later uncoiled and rectilinear; wall calcareous, distinctly perforate in appearance; aperture terminal, somewhat produced on neck with phialine, fimbriate lip. *Rec.*, Pac.O.—FIG. 369,6. *\*M. sollasi*, Funafuti Atoll; 6*a,b*, side, edge view of holotype,  $\times 105$  (\*1166).

**Praepeneroplis** HOFKER, 1952, \*933c, p. 463 [*pro Protopeneroplis* HOFKER, 1950, \*933a, p. 393 (non WEYNSCHENCK, 1950)] [*\*Peneroplis senoniensis* HOFKER, 1949, \*931, p. 41; OD]. Test free, closely enrolled, planispiral, slightly evolute, with numerous chambers to whorl of triangular transverse section; sutures radial, depressed; wall porcelaneous; aperture areal, simple, ovate, or with a toothlike projection from lower margin resulting in triangular opening. [*Praepeneroplis* is similar to *Dendritina* in its close-coiled planispiral test but differs in the simple areal, rather than dendritic, aperture.] *U.Cret.* (*Senon.*), Eu. (Neth.).—FIG. 369,7-10. *\*P. senoniensis* (HOFKER); 7*a,b*, 8*a,b*, side and edge views,  $\times 86$  (\*2117); 9,10, equat. and axial secs.,  $\times 50$  (\*933b).

**Renulina** LAMARCK, 1804, \*1085c, p. 353 (non DE BLAINVILLE, 1825; nec BLAKE, 1876) [*\*R. opercularia*; OD (M)] [= *Renulites* LAMARCK, 1804, \*1085c, p. 353 (obj.); *Renulinites* LAMARCK, 1804, \*1085c, p. 353 (nom. null.)]. Test enrolled in early stage, with tubular chambers nearly full whorl in length, later reduced to 2 or 3 to whorl, then expanding in height and rapidly expanding in breadth, resulting in flabelliform test; surface of type-species smooth; aperture single narrow elongate slit extending length of terminal face. [Differs from *Peneroplis* in having a single slitlike aperture rather than a row of pores.] *M.Eoc.* (*Lutet.*), Eu. (Fr.).—FIG. 371,1. *\*R. opercularia*; 1*a,b*, side, apert. views,  $\times 62$  (\*2117). **Spirulina** LAMARCK, 1804, \*1085c, p. 244 [*\*S. cyl-*

*indracea*; SD CUSHMAN, 1927, \*432, p. 125] [= *Spirolinites* LAMARCK, 1804, \*1085c, p. 245 (obj.); *Coscinospira* EHRENBERG, 1839, \*667, p. 110, 131 (type, *C. hemprichii*, SD LOEBLICH & TAPPAN, herein); *Spirulina* EHRENBERG, 1843, \*670, p. 167 (nom. van., pro *Spirolina* LAMARCK, 1804, non *Spirulina* BORY, 1826); *Spiralina* BROWN, 1944, \*246, p. 145 (nom. van. pro *Spirolina* LAMARCK, 1804) (non *Spiralina* HARTMANN, 1840; nec CHASTER, 1898; nec MARTENS, 1899)]. Test planispirally enrolled and biumbilicate in early stage, later uncoiling and cylindrical; chambers short; wall calcareous, porcelaneous, surface smooth or many be longitudinally striate; aperture terminal, rounded, with numerous toothlike projections extending into opening. *Eoc.-Rec.*, Eu.-N.Am.-Medit. Sea-Carib. Sea-Atl.O.-Pac.O.—FIG. 371,2. *\*S. cylindracea*, *M.Eoc.* (*Lutet.*), Fr.; 2*a,b*, side, top views of topotype,  $\times 54$  (\*2117).

**Triasina** MAYZON, 1954, \*1205, p. 245 [*\*T. hantkeni*; OD]. Test free, numerous small chambers planispirally arranged in 7 to 9 whorls; short radial septa; wall calcareous, porcelaneous, imperforate, surface with small nodes; apertural character unknown. *U.Trias.*, Eu. (Hung.).—FIG. 372,1-3. *\*T. hantkeni*; 1,2, ext.,  $\times 138$ ; 3, equat. sec.,  $\times 150$  (\*1205).

**Vandenbroeckia** MARIE, 1958, \*1223, p. 128 (nom. correct. ELLIS & MESSINA, 1940, \*700, pro *Vandenbroeckia* MARIE, 1958, nom. imperf.) [*\*V. munieri*; OD]. Test compressed, early stage en-

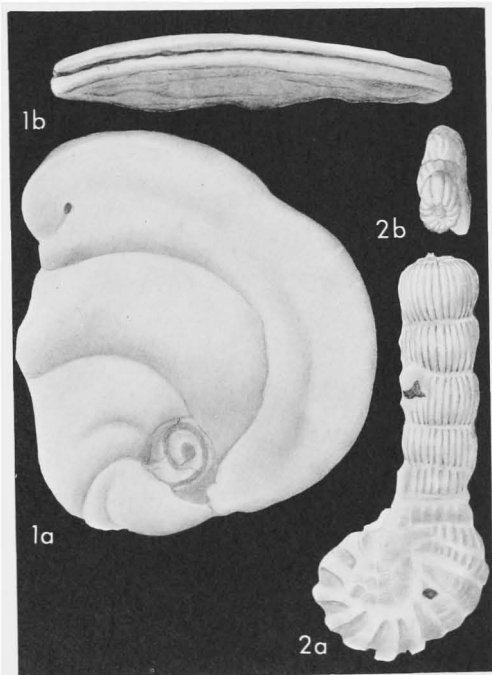


FIG. 371. Soritidae (Peneroplinae; 1, *Renulina*; 2, *Spirulina*) (p. C484).



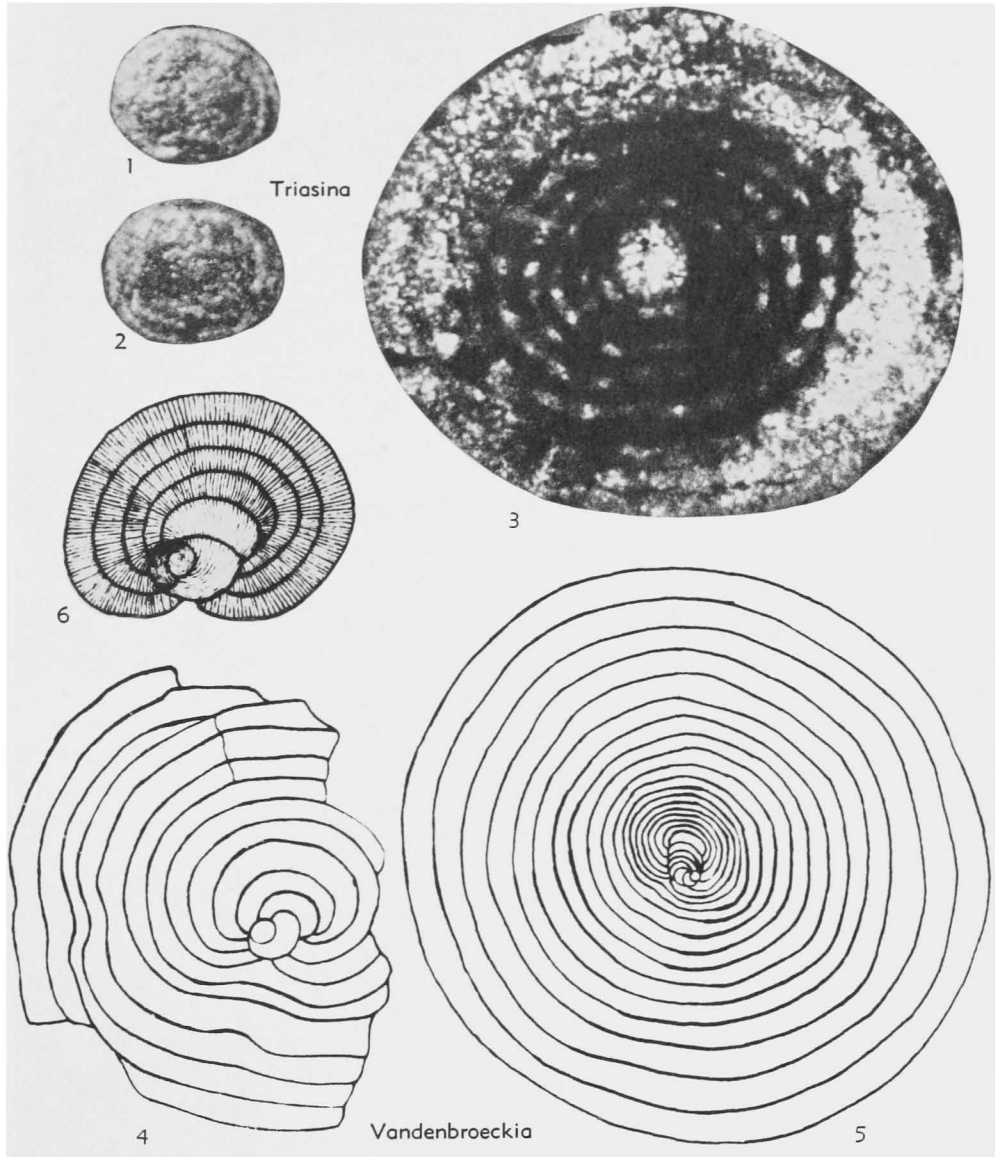


FIG. 372. Soritidae (Peneroplinae; 1-3, *Triasina*; 4-6, *Vandenbroeckia*) (p. C484-C485).

rolled, later with chambers increasing rapidly in breadth and finally cyclical, interior not subdivided; surface may have longitudinal striae; aperture row of circular perforations on periphery. *U.Cret.(Senon.)*, Eu.(Fr.).—FIG. 372,4-6. \**V. munieri*; 4, outline of megalospheric holotype,  $\times 13.5$ ; 5, microspheric test,  $\times 13.5$ ; 6, early portion of megalospheric test showing ornamentation,  $\times 19$  (\*1223).

**Subfamily MEANDROPSININAE Henson, 1948**

[*nom. transl.* SIGAL in PIVETEAU, 1952, p. 202 (ex family Meandropsinidae HENSON, 1948)] [=Broekininae MARIE, 1958, p. 128]

Early stage planispirally coiled, later may be discoidal, operculiform, flabelliform, cylindrical or conical in shape; subepidermal chamberlets in marginal zone, with interseptal pillars; aperture commonly cribrate. *U.Cret.-Paleoc.*

**Meandropsina** MUNIER-CHALMAS in SCHLUMBERGER, 1898, \*1658, p. 336 [*M. vidali* SCHLUMBERGER, 1898, \*1658, p. 337; SD CUSHMAN, 1928, \*439, p. 220] [=Cyclomeandropsina HENSON, 1950, \*903, p. 5, 18 (*nom. nud.*)]. Test discoidal, en-rolled, with very low and numerous chambers

containing many incomplete transverse partitions; outer margin of chambers may become meandri-form; aperture multiple, in rows on periphery.

*U.Cret. (Senon.)*, Eu.-SW.Asia.—FIG. 373, 1-3.  
\**M. vidali* SCHLUMBERGER, Sp.; 1*a,b*, ext. and portion showing surface,  $\times 4$ ,  $\times 10$ ; 2, equat.

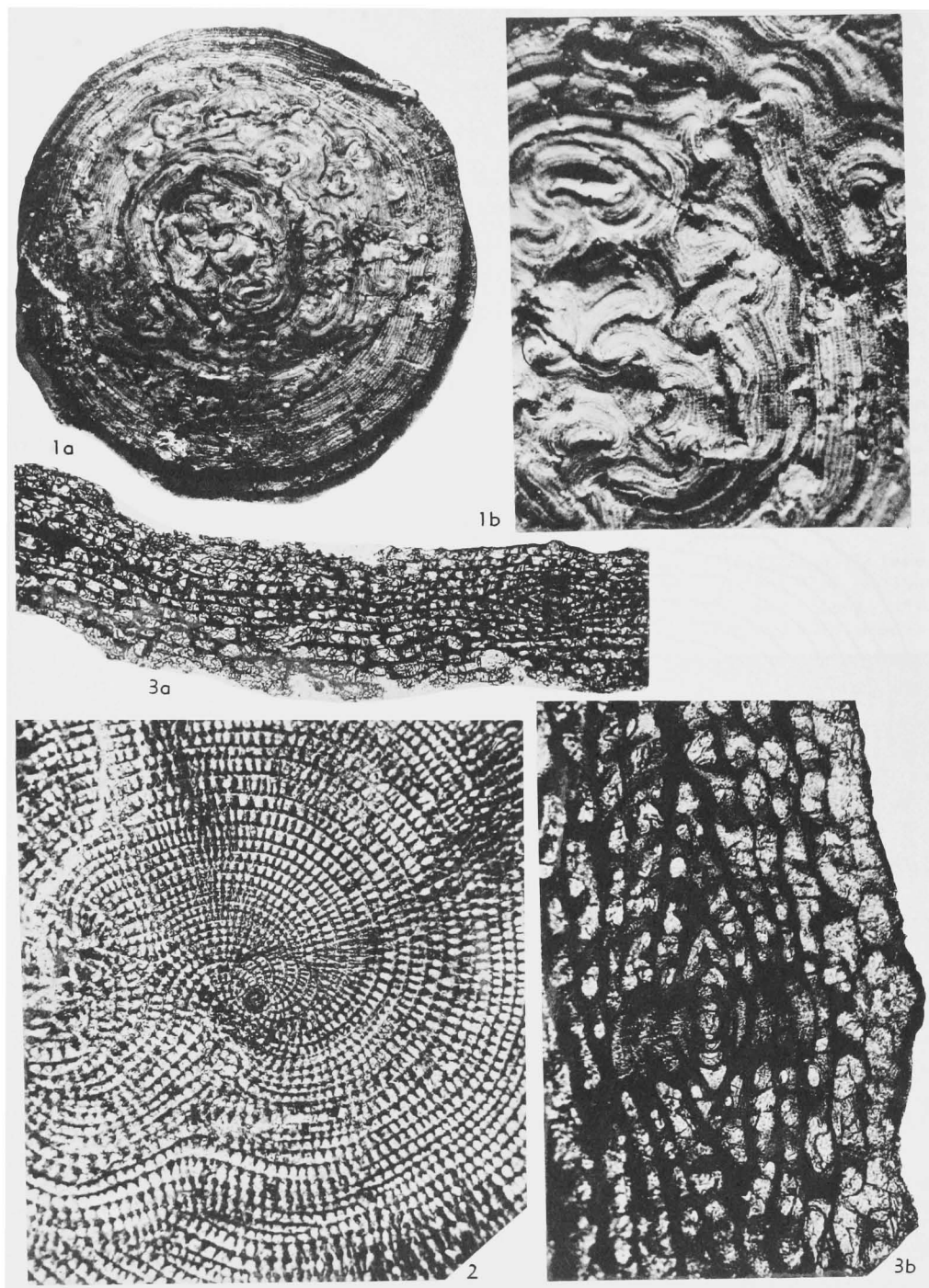


FIG. 373. Soritidae (Meandropsininae; 1-3, *Meandropsina*) (p. C485-C487).

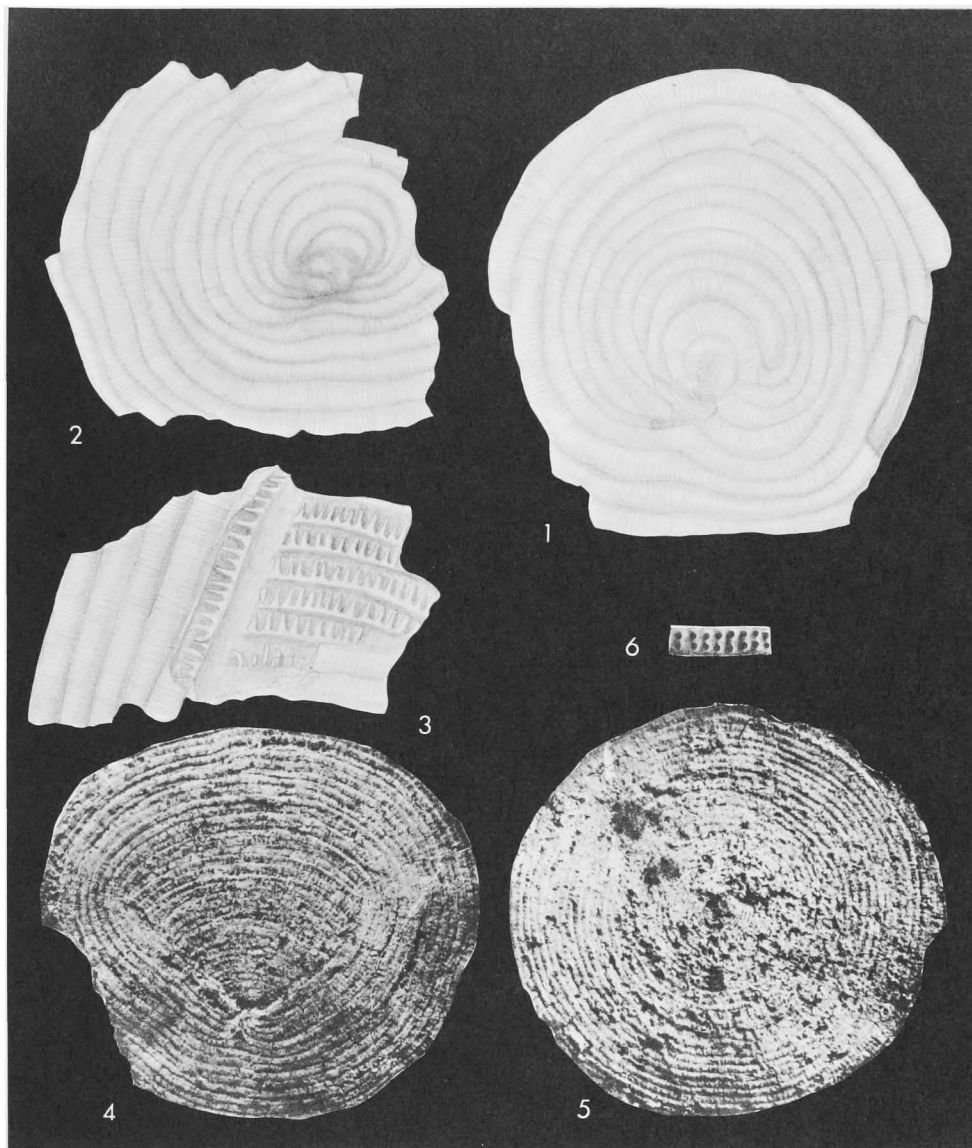


FIG. 374. Soritidae (Meandropsininae; 1-6, *Broeckina*) (p. C487).

sec.,  $\times 4.5$ ; 3a,b, axial sec. and portion showing initial coil,  $\times 40$ ,  $\times 185$  (\*1658).

**Broeckina** MUNIER-CHALMAS, 1882, \*1323, p. 471 [\**Cyclolina dufresnoyi* D'ARCHIAC in D'ARCHIAC & HAIME, 1854, \*39, p. 205; OD] [= *Praesorites* DOUVILLÉ, 1902, \*614, p. 291 (type, *P. moureti*); *Broeckina* MARIE, 1958, \*1223, p. 125 (nom. van.)]. Test discoidal, early stage with more or less well-developed coil of few chambers, which enlarge rapidly in breadth to become cyclical; interior complex, with secondary incomplete transverse partitions; wall porcelaneous; aperture consisting of 2 rows of circular openings on peripheral margin of final chamber. [The synonymy of

*Broeckina* and *Praesorites* was noted by MARIE (1958, \*1223). *Praesorites* is here suppressed as it is a junior synonym.] *U.Cret. (Senon.)*, Eu. —FIG. 374,1,2. \**B. dufresnoyi* (D'ARCHIAC), Fr. (side views of specimens of MUNIER-CHALMAS, Paris); 1,  $\times 17$ ; 2,  $\times 10$  (\*2117). —FIG. 374,3-6. *B. moureti* (DOUVILLÉ), L. Campan., Fr.; 3, holotype, fragment with surface partially abraded showing chamberlets,  $\times 12$  (\*2117); 4,5, paratype,  $\times 5$ ; 6, portion of margin showing aperture,  $\times 24$  (\*614).

**Edomia** HENSON, 1948, \*902, p. 84 [\**E. reicheli*; OD]. Test large, flattened; chambers numerous, microspheric form apparently cyclogyrine in early

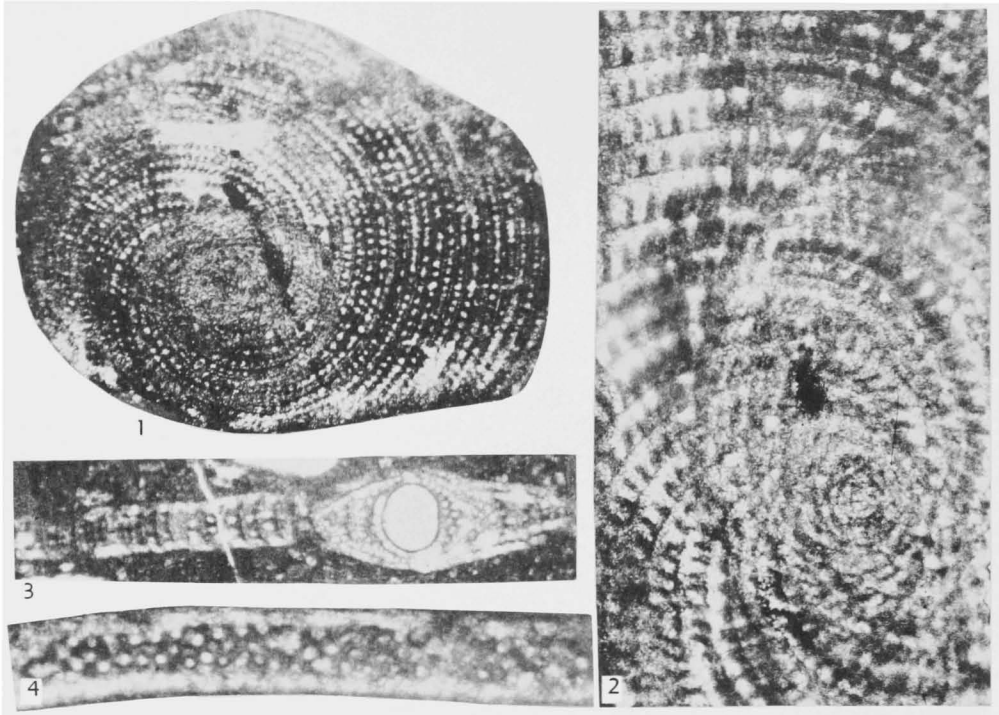


FIG. 375. Soritidae (Meandropsininae; 1-4, *Edomia*) (p. C487-C488).

stage, megalospheric form with spherical proloculus and long, tubular second chamber, then numerous planispiral, involute chambers as in *Meandropsina*, with incomplete transverse interseptal partitions projecting inward from both surfaces of test, those of succeeding chambers aligned, irregularly distributed interseptal pillars occurring in central layers of later chambers; large pores pierce septa between pillars. *U.Cret.* (*Cenom.-Turon.*), SW.Asia (Palest.-Iran).—FIG. 375, 1-4. \**E. reicheli*, *Cenom.*, Palest.; 1, equat. sec. of paratype,  $\times 26$ ; 2, slightly oblique equat. sec. showing interseptal partitions,  $\times 70$ ; 3, axial sec. of megalospheric form,  $\times 36$ ; 4, tang. sec. parallel to septum showing apert. pores,  $\times 60$  (\*2115).

**Fallotia** DOUVILLÉ, 1902, \*614, p. 298 [\**F. jacquoti*; OD] [= *Fascipira* A. SILVESTRI, 1940, \*1789, p. 230 (type, *F. colomi*); *Ayalaina* SEIGLIE, 1961, \*1715, p. 346 (type, *Meandropsina? rutteni* PALMER, 1934, \*1408, p. 252)]. Test lenticular, planispirally enrolled and involute, chambers low, numerous, and internally subdivided by transverse partitions but not compressed and annular as in *Meandropsina*, although rarely chambers become meandriiform, number of whorls numerous; aperture row of pores at basal margin of apertural face. *U.Cret.*, Eu.-W.Indies (Cuba).—FIG. 376, 1-3. \**F. jacquoti*, Fr.; 1, side view of holotype,  $\times 7.5$ ; 2, fragment showing mar-

ginal meandriiform deformation of chambers,  $\times 3$ ; 3a,b, transv. sec. parallel to axis showing minute chamberlets and portion, enlarged,  $\times 6.3$ ,  $\times 18$  (\*2117).—FIG. 376, 4. *F. colomi* (A. SILVESTRI), Maastricht., Sp.; 4a,b, side, apert. views of topotype,  $\times 47$  (\*2117).

**Nummofallotia** BARRIER & NEUMANN, 1959, \*89, p. 228 [\**Nonionina cretacea* SCHLUMBERGER, 1899, \*1660, p. 460 (= *Goupillaudina sanctipetri* MARIE, 1957, \*1222b, p. 869); OD]. Test planispirally enrolled and involute; chambers numerous, apparently subdivided by secondary, transverse septa; originally type-species described as having calcareous perforate umbilical "button" later shown to be a product of recrystallization, when present resulting in umbilically inflated test; wall calcareous, imperforate; aperture interior marginal. *U. Cret.* (*Senon.*), Eu.—FIG. 377, 1-6. \**N. cretacea* (SCHLUMBERGER), Sp. (1,2), Fr. (3-6); 1, equat. sec.,  $\times 85$ ; 2, axial sec. showing umbilical "buttons" on both sides of test,  $\times 100$  (\*1660); 3, axial sec. showing lenticular original form and very small amount of recrystallization, stated to be  $\times 30$  [doubtful]; 4, axial sec. of specimen with advanced stage of recrystallization (umbilical "button" appearing white) and original internal structure almost completely resorbed,  $\times 30$ ; 5, equat. sec. of free specimen,  $\times 50$ ; 6, detached umbilical "button,"  $\times 50$  (\*89).

[The umbilical "button," due to recrystallization of the test, tends to become detached from the remainder of the

shell and has been described as various "species" of different rotaliform genera. The "buttons" have been shown in thin sections to be varied in development, sometimes appearing on only one side of the test, though commonly

they are developed to a variable degree on both sides. They are best observed in axial sections. The original internal structure of the test is not well known, no free specimens occurring without the recrystallized central

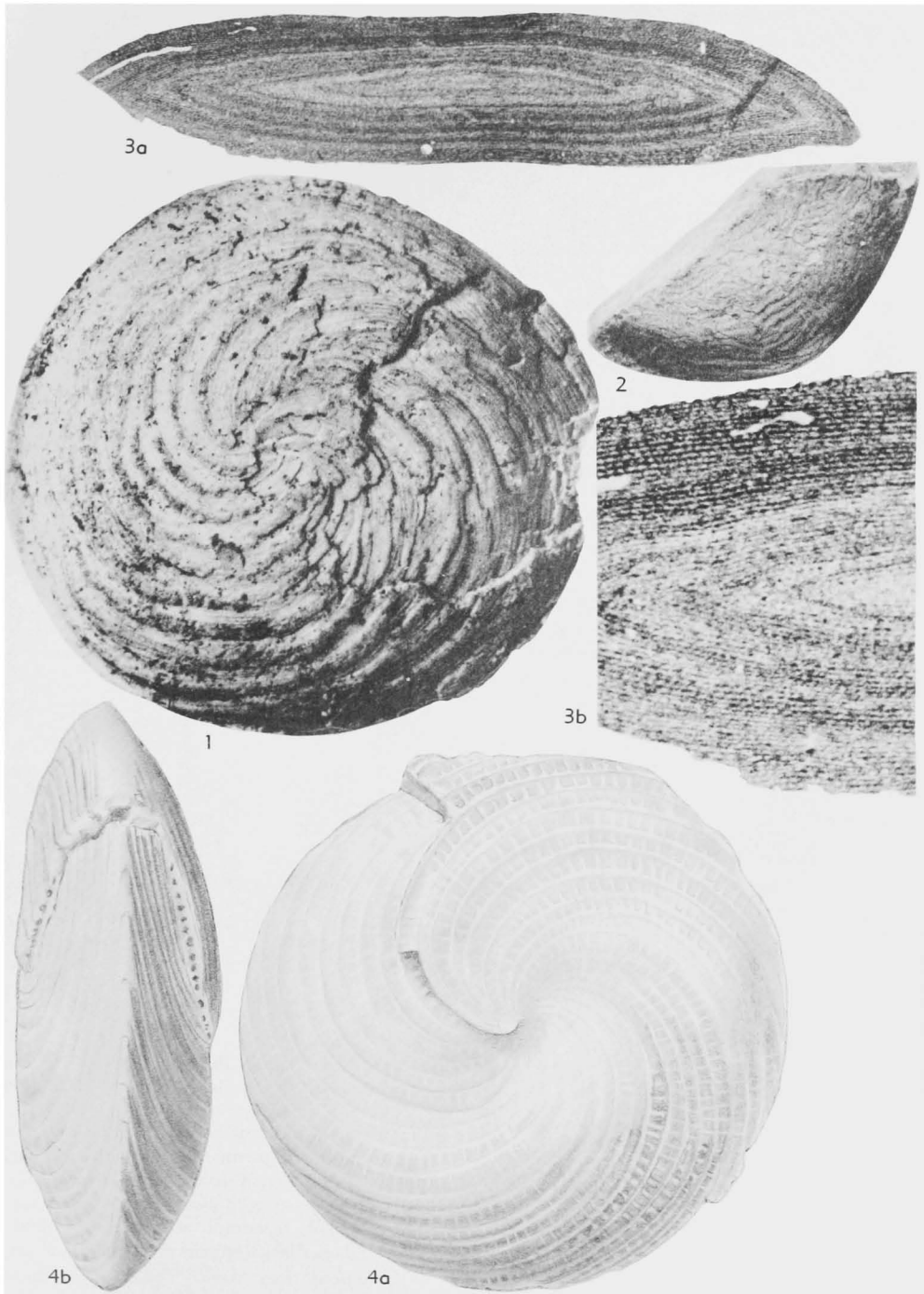


FIG. 376. Soritidae (Meandropsininae; 1-4, *Fallotia*) (p. C488).



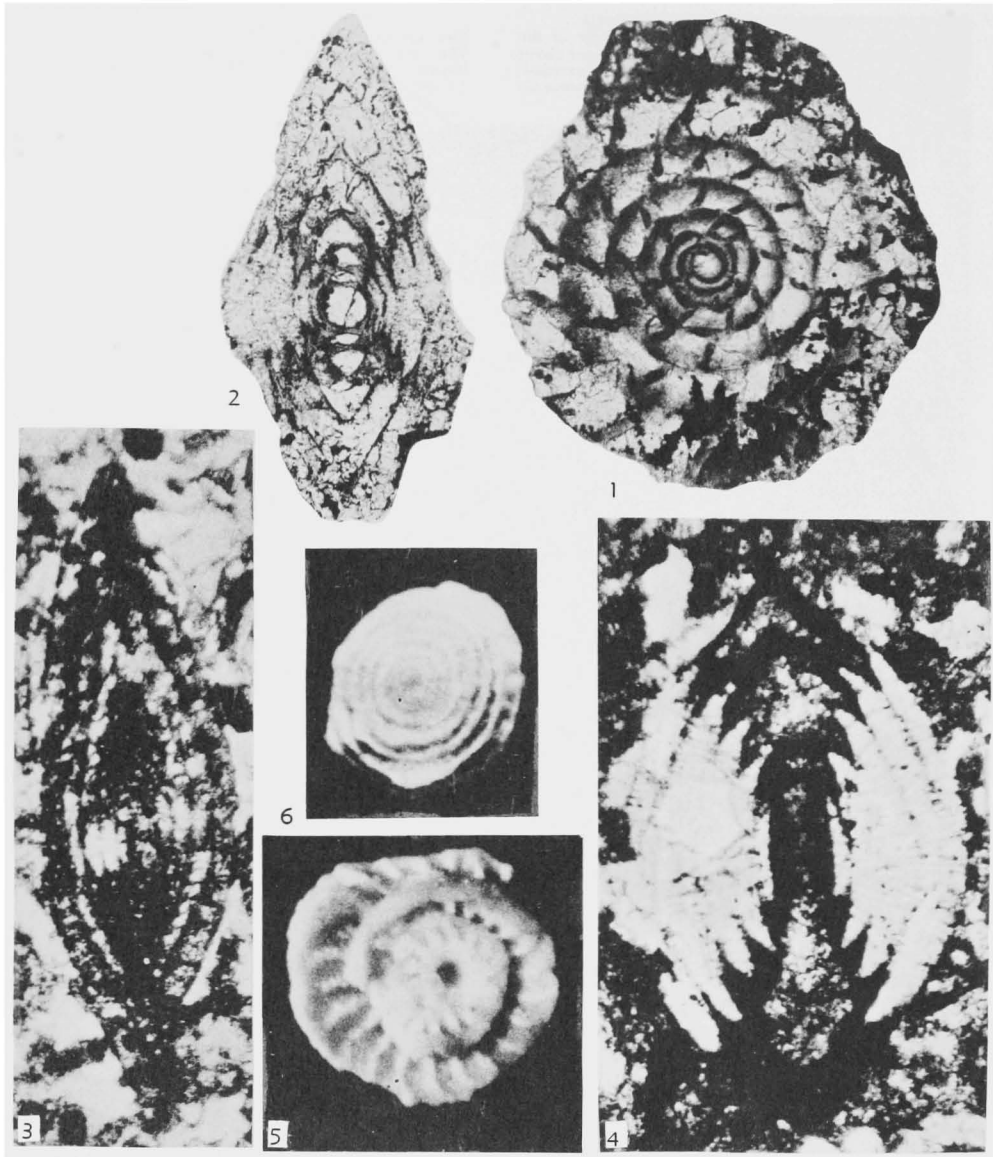


FIG. 377. Soritidae (Meandropsininae; 1-6, *Nummofallotia*) (p. C488-C490).

area. Some axial sections indicate the presence of secondary transverse septa, but these are apparently not observable on free specimens. A noticeable similarity of *Nummofallotia* to sections of *Praepeneroplis senoniensis* (HÖFKER) from the Senonian of the Netherlands is observed but the recrystallization phenomenon has not been noted in *Praepeneroplis*, which also lacks indications of secondary transverse septa. The exterior of *Nummofallotia* is unknown. Additional study is required in order to determine if *Nummofallotia* is a junior synonym of *Praepeneroplis*. The stated magnification of the accompanying figured sections of the French specimens seems questionable, as the figures of axial sections appear nearly twice the diameter of equatorial sections; the original plate explanation stated them to be half this magnification. No test measurements were given for the French specimens but those from Spain were stated to be approximately 0.8 mm. in diameter, indicating that the axial sections probably are about  $\times 100$ , not  $\times 30$ .]

**Pseudedomia** HENSON, 1948, \*902, p. 95 [*\*P. multistriata*; OD]. Test flattened, early stage planispiral, evolute, bilaterally symmetrical, later flabelliform, with uniserial chambers; numerous transverse secondary partitions project short distance into chambers from outer wall, median region of each chamber with single row of large interseptal pillars; apertures not observed. [Differs from *Edomia* in its evolute early planispiral stage and uniserial later stage. The genus is known only from the holotype of the type-species.] *U. Cret.*(Maastricht.), Asia(Arabia, Qatar Penin.).



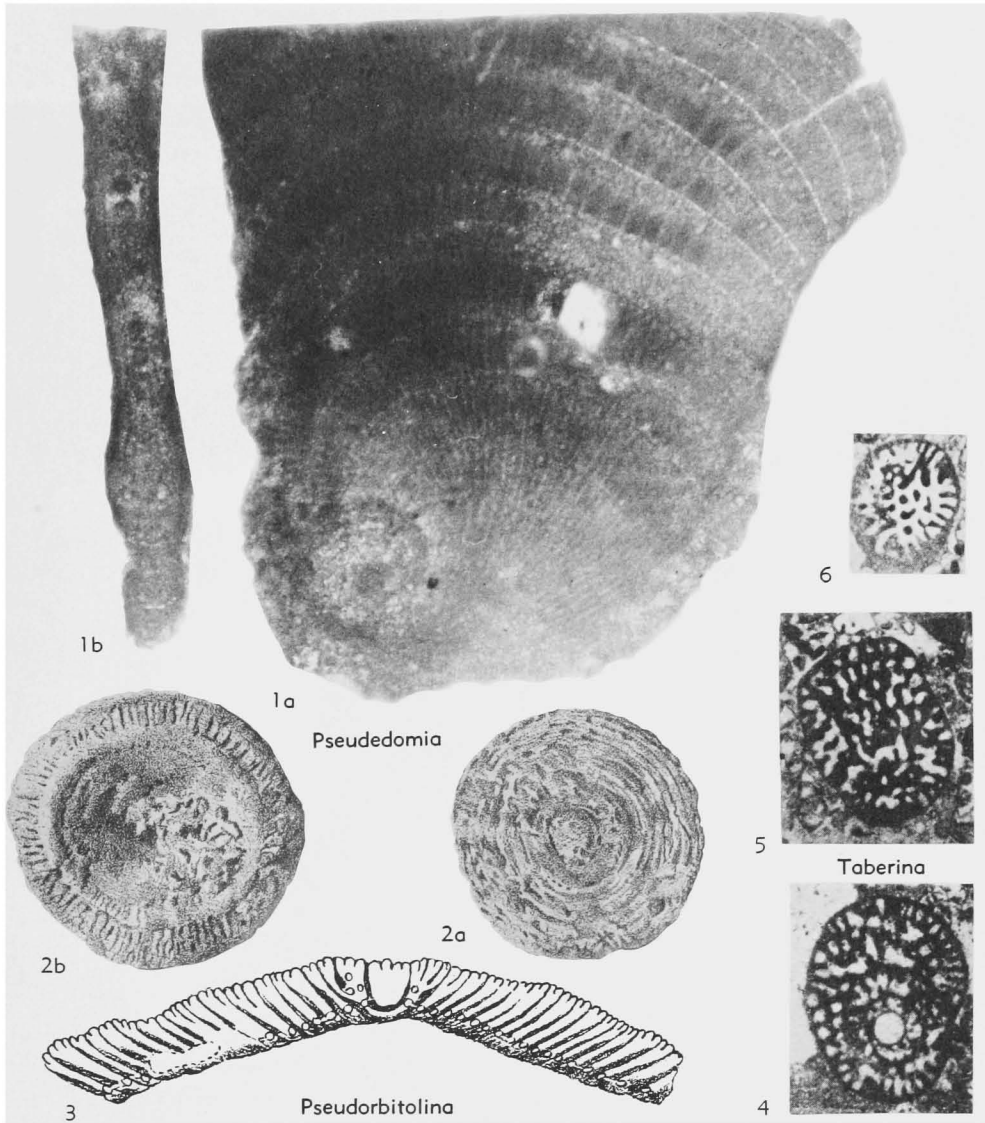


FIG. 378. Soritidae (Meandropsininae; 1, *Pseudedomia*; 2,3, *Pseudorbitolina*; 4-6, *Taberina*) (p. C490-C493).

—FIG. 378,1. \**P. multistriata*; 1a, equat. sec. of holotype,  $\times 41$ ; 1b, transv. sec. of fragment of holotype cutting through interseptal pillars,  $\times 45$  (\*2115).

***Pseudorbitolina*** DOUVILLÉ, 1910, \*619, p. 57 [\**P. marthae*; OD]. Test low conical to concavoconvex; with transverse and parallel subepidermal partitions on one side of test, transverse partitions thickening inward to form chamberlets; wall agglutinated, convex side with concentric growth lines and reticulate surface; aperture consisting of single row of openings near periphery of concave side, which open into annular canal. *U.Cret.*

(Maastricht.)-Eoc., Fr.-Arabia-Carib.—FIG. 378, 2,3. \**P. marthae*, *U.Cret.*(Dordon.), Fr.; 2a,b, convex upper and concave lower surfaces showing peripheral row of openings,  $\times 10$ ; 3, axial sec. showing partitions and canal openings,  $\times 27$  (\*619).

***Taberina*** KEIJZER, 1945, \*1030, p. 200 [\**T. cubana*; OD]. Early stage planispiral, later uncoiling and circular in section; coiled stage dominant, with short radial septa, interior with incomplete transverse interseptal partitions and interseptal pillars; aperture multiple, of pores in chamber face. [*Taberina* has both the subepidermal parti-

tions characteristic of *Meandropsina* and the interseptal pillars such as occur in *Archaias*.] *U.Cret.* (Cenoman.)-*Paleoc.* (Dan.), Cuba-Iran-Syria-Palest.

—FIG. 378,4-6. \**T. cubana*, Paleoc.(Dan.), Cuba; 4, median sec. perpendicular to axis of coiling; 5, tang. sec. parallel to axis of coiling;

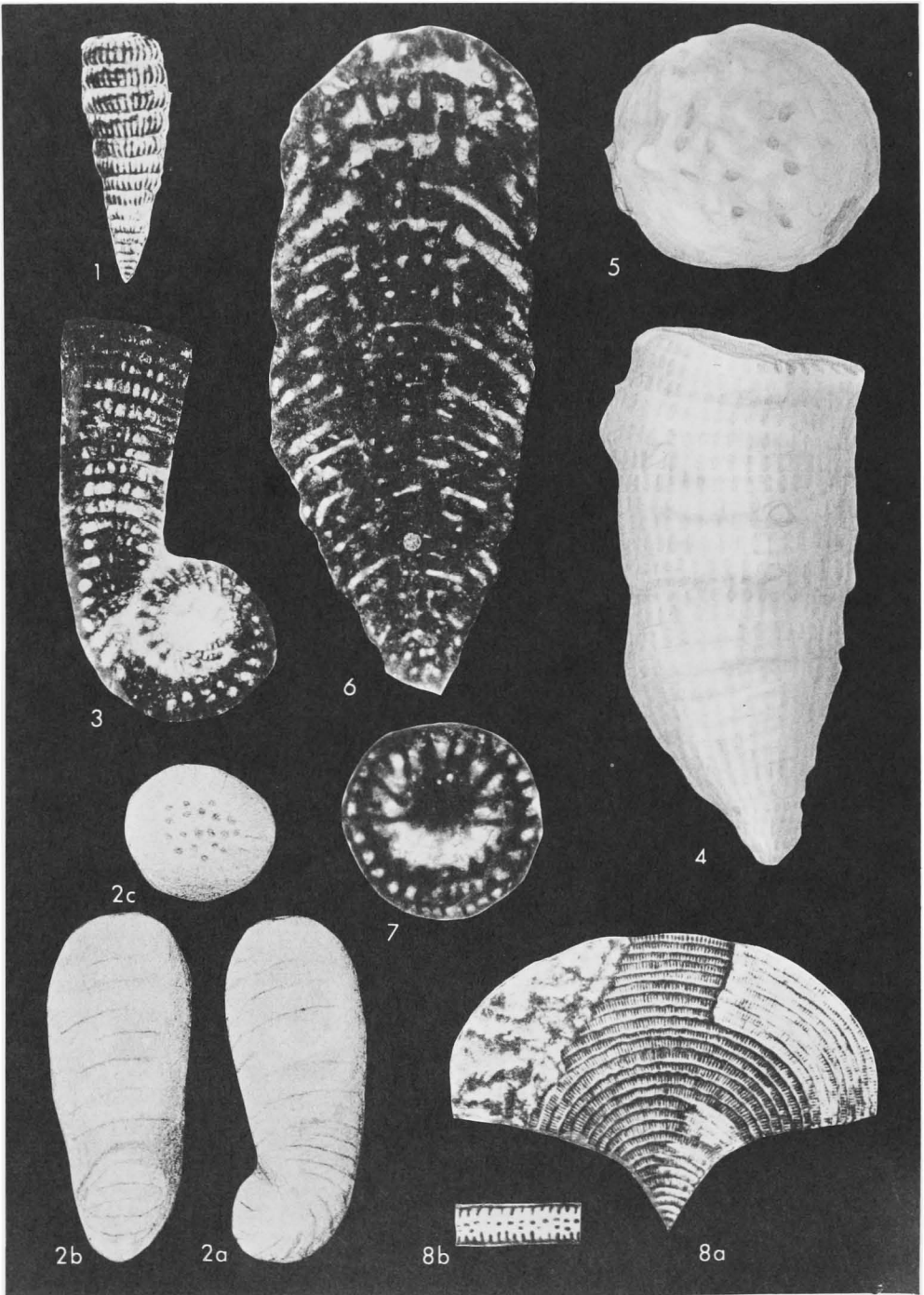


FIG. 379. Soritidae (Rhapydioninae; 1-7, *Rhapydionina*; 8, *Rhipidionina*) (p. C493).

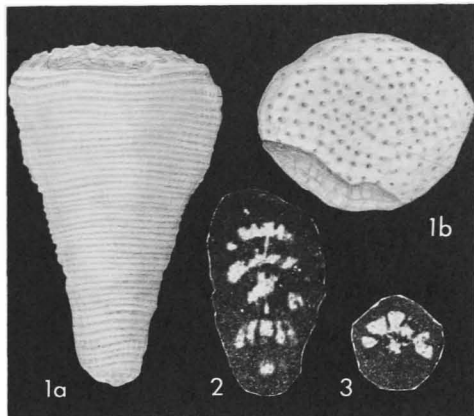


FIG. 380. Soritidae (Rhapydionininae; 1, *Ripacubana*; 2,3, *Praerhapydionina*) (p. C493).

6, transv. sec. through terminal stage, showing apert. pores, pillars and radial partitions,  $\times 25$  (\*1030).

#### Subfamily RHAPYDIONININAE Keijzer, 1945

[Rhapydionininae KEIJZER, 1945, p. 200]

Test elongate, conical; chambers in reticulate series, subdivided into chamberlets; aperture terminal, cribrate. *Jur.-Rec.*

**Rhapydionina** STACHE, 1913, \*1829, p. 661 [*Peneroplis liburnica* STACHE, 1889, \*1828, p. 89; OD (M)] [= *Rhapydionina* VAN DEN BOLD, 1946, \*155, p. 123 (*nom. van.*); *Haurania* HENSON, 1948, \*902, p. 11 (type, *H. deserta*)]. Test elongate, conical, early stage may have involute planispiral coil, later uniserial; chamber interior subdivided by transverse subepidermal partitions; aperture terminal, cribrate. [*Haurania* was originally included in the Lituolidae, but regarded (\*902, p. 11) as "almost an isomorph of *Rhapydionina*." It is here regarded as a synonym.] *Jur.-M.Eoc.*, Istria-Iraq-Cuba-C.Am.—FIG. 379,1. \**R. liburnica* (STACHE), L.Eoc., Yugosl.(Istria); holotype, enlarged (\*700).—FIG. 379,2,3. *R. uensis* HENSON, M.Eoc., Iraq; 2a-c, opposite sides and top view of holotype,  $\times 15$ ; 3, long. tang. sec. showing subepidermal partitions,  $\times 18$  (\*902).—FIG. 379,4-7. *R. deserta* (HENSON), *Jur.*, Iraq; 4, side view of holotype,  $\times 41$ ; 5, apert. view of paratype,  $\times 72$  (\*2117); 6, long. sec. of paratype; 7, transv. sec. of paratype,  $\times 40$  (\*2115).

**Craterites** HERON-ALLEN & EARLAND, 1924, \*912, p. 611 [*\*C. rectus*; OD (M)]. Test attached, club-shaped, narrowing slightly just above basal expansion and then gradually enlarging in diameter, upper surface convex, perforated; trunklike portion composed of 10 or 12 superimposed layers of polygonal chamberlets, which increase in number with expanding diameter of test; wall calcareous, nonperforate except for large apertural openings; aperture consisting of numerous large

pores on upper surface, which open into chamberlets, and where upper surface has been broken away similar openings may be seen in preceding layer of chamberlets. [This genus is represented by a single known specimen, the holotype of the type-species in the British Museum (Natural History) (BMNH-ZF3613), from between tidemarks as "Middle Beach," lat.  $31^{\circ}31'30''$ S., long.  $159^{\circ}15'28''$ E., on the east side of Lord Howe Island, South Pacific. As no additional material was available, sections could not be made for a study of the internal structure.] *Rec.*, S.Pac.—FIG. 381, 1. \**C. rectus*; 1a,b, side, top views of holotype,  $\times 36$  (\*2117).

**Praerhapydionina** VAN WESSEM, 1943, \*1980, p. 43 [*\*P. cubana*; OD]. Test similar to *Rhapydionina* in form and internal structure, differing in having single terminal aperture instead of cribrate one. *U.Cret.-Oligo.*, Cuba-Iraq.—FIG. 380,2,3. \**P. cubana*, Maastricht, Cuba; 2, long. deep tang. sec., showing part of subepidermal partitions; 3, transv. sec. partially cutting septum, showing subepidermal partitions at margins and central aperture,  $\times 22$  (\*700).

**Rhipidionina** STACHE, 1913, \*1829, p. 661 [*\*Pavonina liburnica* STACHE, 1889, \*1828, p. 85; OD (M)]. Test compressed, flabelliform, early stage with abbreviated and involute planispiral coil followed by numerous uniserially arranged broad, low chambers, with transverse subepidermal partitions; aperture consists of numerous pores in the terminal face. *L.Eoc.-M.Eoc.*, Yugosl.(Istria)-Iraq.—FIG. 379,8. \**R. liburnica* (STACHE), L.Eoc., Yugosl.; 8a, ext.,  $\times 5$ ; 8b, apert. surface, enlarged (\*700).

**Ripacubana** LOEBLICH & TAPPAN, *nom. nov.* [*pro Conulina* D'ORBIGNY in DE LA SAGRA, 1839, \*1611, p. 24 (*non* BRONN, 1836)] [*\*Conulina conica* D'ORBIGNY in DE LA SAGRA, 1839, \*1611, p. 24, here designated as type-species]. Test free, conical, early stages unknown as only specimen is broken, chambers numerous, low and broad, uniserial in later stage, subdivided by vertical partitions into chamberlets; sutures horizontal, closely appressed;

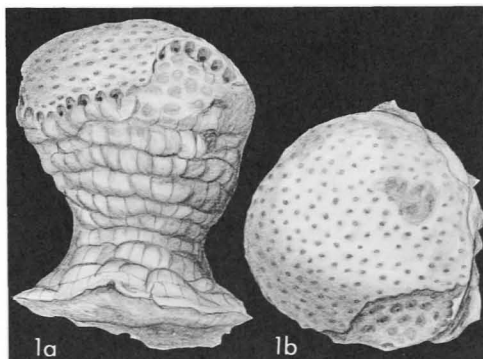


FIG. 381. Soritidae (Rhapydionininae; 1, *Craterites*) (p. C493).

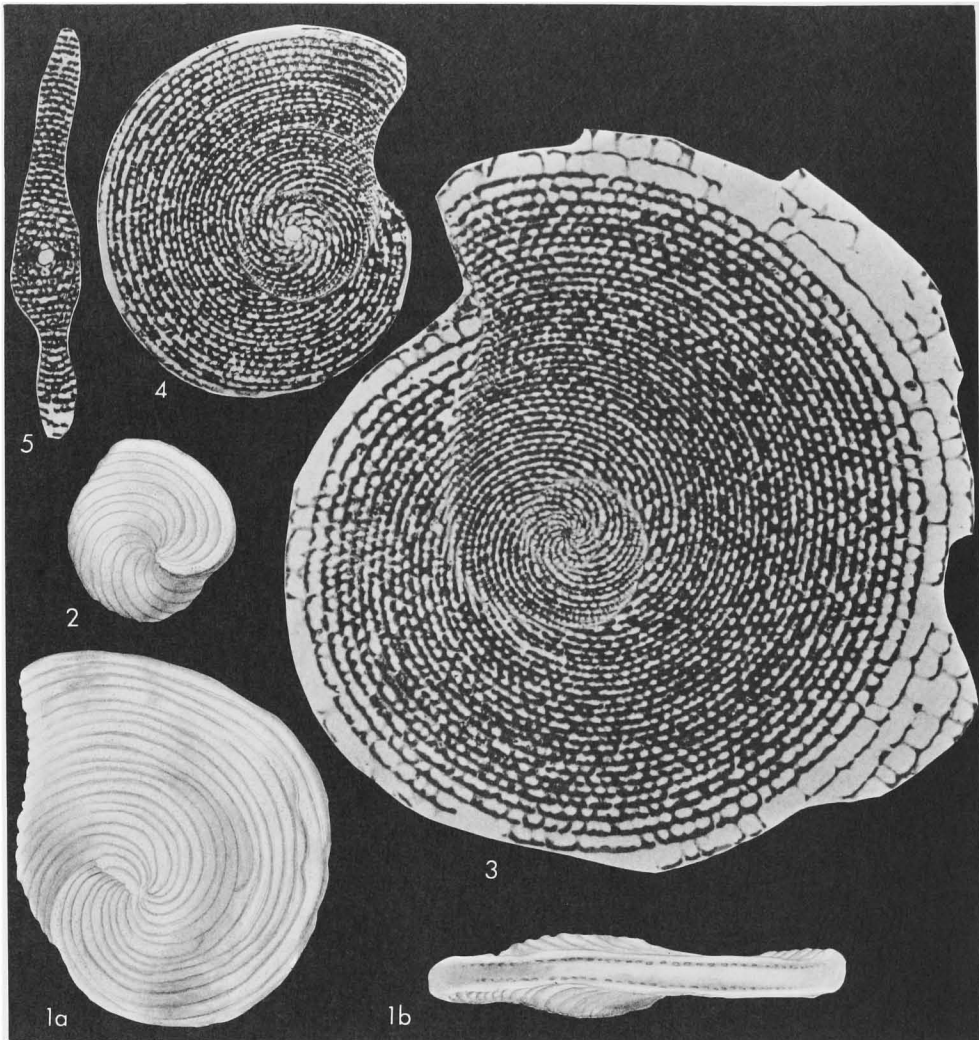


FIG. 382. Soritidae (Archaiasinae; 1-5, *Archaias*) (p. C494-C495).

wall appearing calcareous; aperture terminal, consisting of numerous equally spaced small pores on broad face, opening into chamberlets. [D'ORBIGNY based this genus on the single specimen of his type-species. It has not been recognized since, and as only the holotype is known, no sections are available to determine more exactly its internal characters. Although considered by D'ORBIGNY to be a living species (Rec.), it is probable that the specimen may represent a reworked fossil form. The holotype of *R. conica*, here refigured, is preserved in the Muséum National d'Histoire Naturelle, Paris, and is from Recent sand of Cuba. *Ripacubana* is from *ripa* (Lat., shore or bank)+Cuba, and refers to the only locality from which the genus has been recorded, shore sands of Cuba.] ?Rec., Cuba.—FIG. 380, I. \**R. conica* (D'ORBIGNY); 1a, b, side, top views of holotype,  $\times 17$  (\*2117).

#### Subfamily ARCHAIASINAE Cushman, 1927

[Archaiasinae CUSHMAN, 1927, p. 55] [=Orbiculininae SCHUBERT, 1920, p. 168; WIESNER, 1920, p. 17; Archaiadinae WIESNER, 1931, p. 60, 74, 111]

Test planispiral, later may become annular; chambers divided into rectangular chamberlets which do not alternate regularly with those of adjacent chambers; aperture commonly double row of pores on peripheral face of last chamber. *M.Eoc.-Rec.*

Archaias DE MONTFORT, 1808, \*1305, p. 190 [*A. spirans* (= *Nautilus angulatus* FICHEL & MOLL, 1798, \*716, p. 113); OD] [= *Helenis* DE MONTFORT, 1808, \*1305, p. 194 (type, *H. spatosus*, = *Nautilus aduncus* FICHEL & MOLL, 1798, \*716, p. 115); *Iletes* DE MONTFORT, 1808, \*1305, p. 198 (type, *I. rotalitus*, = *Nautilus orbiculus*

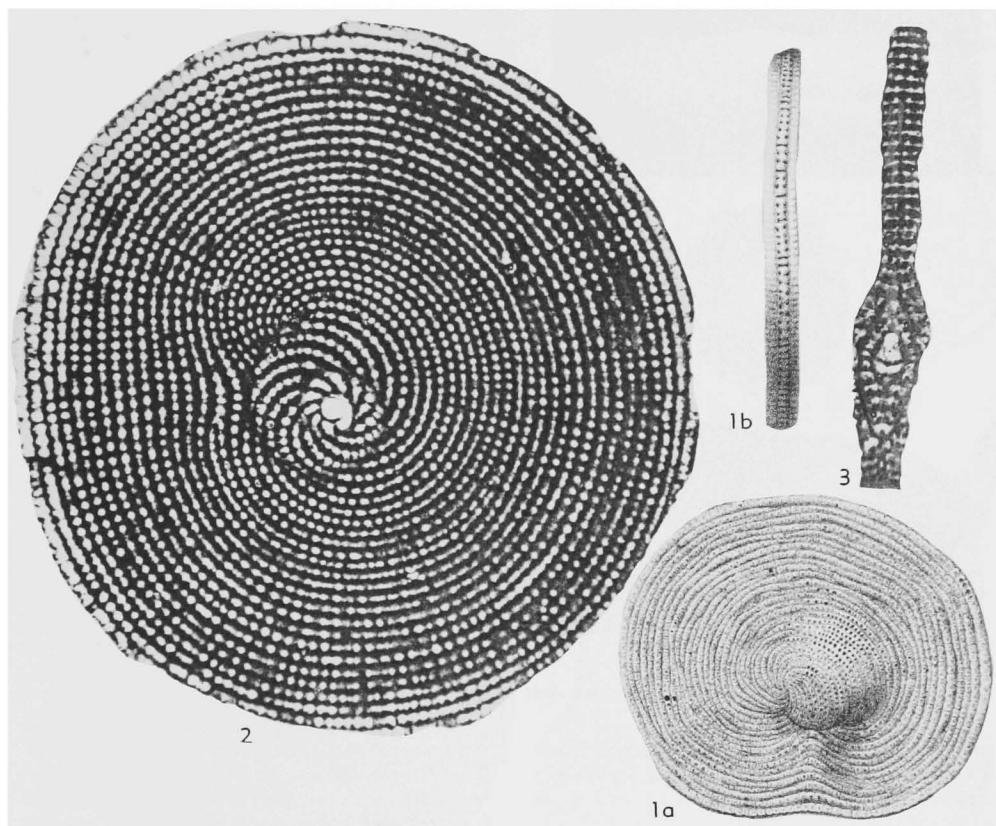


FIG. 383. Soritidae (Archaiasinae; 1-3, *Cyclorbiculina*) (p. C495).

FICHTEL & MOLL, 1798, \*716, p. 112); *Archais* OKEN, 1815, \*1385, p. 322 (*nom. null.*); *Orbiculina* LAMARCK, 1816, \*1089, p. 14 (type, *O. nummata*, = *Nautilus orbiculus* FICHTEL & MOLL, 1798, \*716, p. 112) (*non N. orbiculus* FORSKÅL, 1775); *Archais* AGASSIZ, 1844, \*5, p. 3 (*nom. van.*); *Elenis* AGASSIZ, 1844, \*5, p. 9 (*nom. van. pro Helenis* DE MONTFORT, 1808); *Nemophora* CONRAD, 1865, \*380, p. 74 (type, *Nummulites (Assilina) floridanus* CONRAD, 1846, \*379, p. 399) (*non Nemophora* ILLIGER, 1798; *nec* HUEBNER, 1825; *nec* DAHLBOM, 1854)]. Test compressed, early stage planispiral, involute, later chambers flaring, becoming evolute to cyclical; interior of chambers with interseptal pillars; aperture multiple, with rows of pores on terminal face of final chamber. *M.Eoc.-Rec.*, cosmop.—FIG. 382, 1-5. \**A. angulatus* (FICHTEL & MOLL), *Rec.*, Bermuda (1,2), Barbados (3-5); 1a,b, side, apert. views,  $\times 19$  (\*2117); 2, side view of juvenile specimen,  $\times 19$ ; 3, equat. sec. of microspheric test,  $\times 8$ ; 4, equat. sec. of megalospheric test,  $\times 13$ ; 5, axial sec. of megalospheric test,  $\times 13$  (\*1806).

*Cyclorbiculina* A. SILVESTRI, 1937, \*1787, p. 88 [*\*Orbiculina compressa* D'ORBIGNY IN DE LA SAGRA,

1839, \*1611, p. 66; OD (M)]. Early stage close-coiled and involute, later chambers evolute, flabelliform, and finally cyclical; interior with distinct subepidermal partitions and with interseptal pillars in central zone; apertures consisting of pores on periphery. [SMOUT & EAMES, 1958 (\*1806, p. 222) differentiated *Archais* with interseptal pillars only from *Cyclorbiculina* with both interseptal pillars and subepidermal partitions.] *U. Oligo.-Rec.*, Carib.-GulfMex.-Atl.-Panama.—FIG. 383, 1-3. \**C. compressa* (D'ORBIGNY); *Rec.*, Atl.; 1a,b, side, apert. views of cyclical form, showing transverse partitions,  $\times 13$  (\*200); 2, equat. sec.,  $\times 13$ ; 3, axial sec.,  $\times 27$  (\*363).

*Fusarchais* REICHEL, 1952, \*1523, p. 459 [*\*F. bermudezi*; OD] [= *Fusarchais* REICHEL, 1949, \*1520, p. 148 (*nom. nud.*)]. Test elongate, fusiform, planispirally enrolled, elongated axially, externally similar to *Alveolinella*; chambers numerous, with interseptal pillars perpendicular to septa similar to *Archais*; aperture consisting of circular multiple openings on terminal face, alternating in position between pillars. *Oligo.-Mio.*, Cuba.—FIG. 384, 1-4. \**F. bermudezi*; 1, holotype,  $\times 13$ ; 2, axial sec. showing interseptal pil-



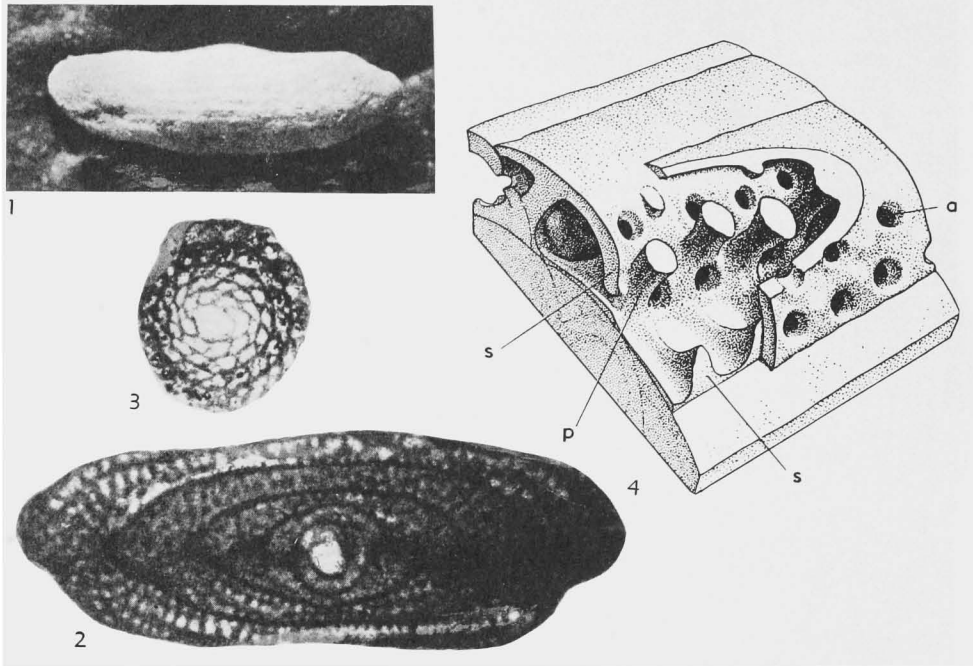


FIG. 384. Soritidae (Archaiasinae; 1-4, *Fusarchaias*) (p. C495-C496).

lars; 3, equat. sec.,  $\times 30$ ; 4, reconstruction showing structure, section of parts of last 3 chambers showing apertures (*a*), pillars (*p*), and septa (*s*) (\*1523).

#### Subfamily SORITINAE Ehrenberg, 1839

[*nom. transl.* WIESNER, 1931, p. 60, 74, 111 (ex family Soritina EHRENBURG, 1839)]—[All names are of subfamily rank]—[=Orbitulinidea REUSS, 1862, p. 320; =Orbitolitinae BRADY, 1881, p. 43; =Orbitolitidinae WIESNER, 1920, p. 17]

Growth occurs by addition of numerous small chambers in arcuate or annular series, without intercommunications between those of single series, apertures connect adjacent chambers of successive series. *Eoc.-Rec.*

**Sorites** EHRENBURG, 1839, \*667, chart opposite p. 120 [\**S. dominicensis* (=Orbitulites *marginalis* LAMARCK, 1816, \*1088, p. 196); SD CUSHMAN, 1927, \*433, p. 190] [=Taramellina MUNIER-CHALMAS, 1902, \*1328, p. 353 (type, *Sorites dominicensis* EHRENBURG, 1839, \*667, p. 134); SD LOEBLICH & TAPPAN, herein (obj.)]. Test discoidal, early stage with proloculus followed by tubular enrolled second chamber of nearly complete coil in length, later chambers added simultaneously in flaring peneropline series and finally in annular series in single layer; adjacent chambers of series interconnected by stolons; apertures connecting each chamber with 2 chambers in preceding and 2 in succeeding series. [Although reported from the Miocene of Venezuela (\*1535)

the type-species of *Sorites* has not been recorded from Recent deposits of this area, but has undoubtedly been reported as *Sorites marginalis* from the Dominican area (\*614), Cuba, and the Atlantic. The types of EHRENBURG were not available for restudy, and were neither figured adequately nor described originally. *Sorites dominicensis* EHRENBURG, 1839 (nominally the type-species) is here regarded as a junior synonym of *S. marginalis* (LAMARCK), 1816, and the generic name is retained on the basis of this latter well-known species.] *Mio.-Rec.*, Carib.-Cyprus-Red Sea-Pac.-Atl.-S.Am.—FIG. 385, 1, 2. \**S. marginalis* (LAMARCK), L.Mio., Venez. (1), Rec., N.Pac. (2); 1*a, b*, side, edge views,  $\times 33$  (\*1535); 2, optical section of early stages of megalospheric form showing chamber development,  $\times 50$  (\*404f).

**Amphisorus** EHRENBURG, 1839, \*667, chart opposite p. 120 [\**A. hemprichii*; OD] [=Bradyella MUNIER-CHALMAS, 1902, \*1328, p. 353 (type, *Orbitulites duplex* CARPENTER, 1883, \*271c, p. 561 (=A. *hemprichii*)]. Test discoidal, biconcave, embryonic region of megalospheric form may be slightly inflated, embryonic apparatus of megalospheric form consisting of globular proloculus, followed by tubular chamber (flexostyle) and then by broadly overlapping chamber with marginal openings that lead into chamberlets of first cyclical series; later chambers cyclical, with 2 layers of chamberlets alternating in position with those of previous cycle and those of same cycle alternating



in position when viewed from periphery; a single annular canal in equat. position visible at center of axial sections and in equat. secs. appearing as

undivided area adjacent to previous chamber wall (Fig. 386,1); apertures in 2 alternating rows on periphery in small sutural depressions and open-

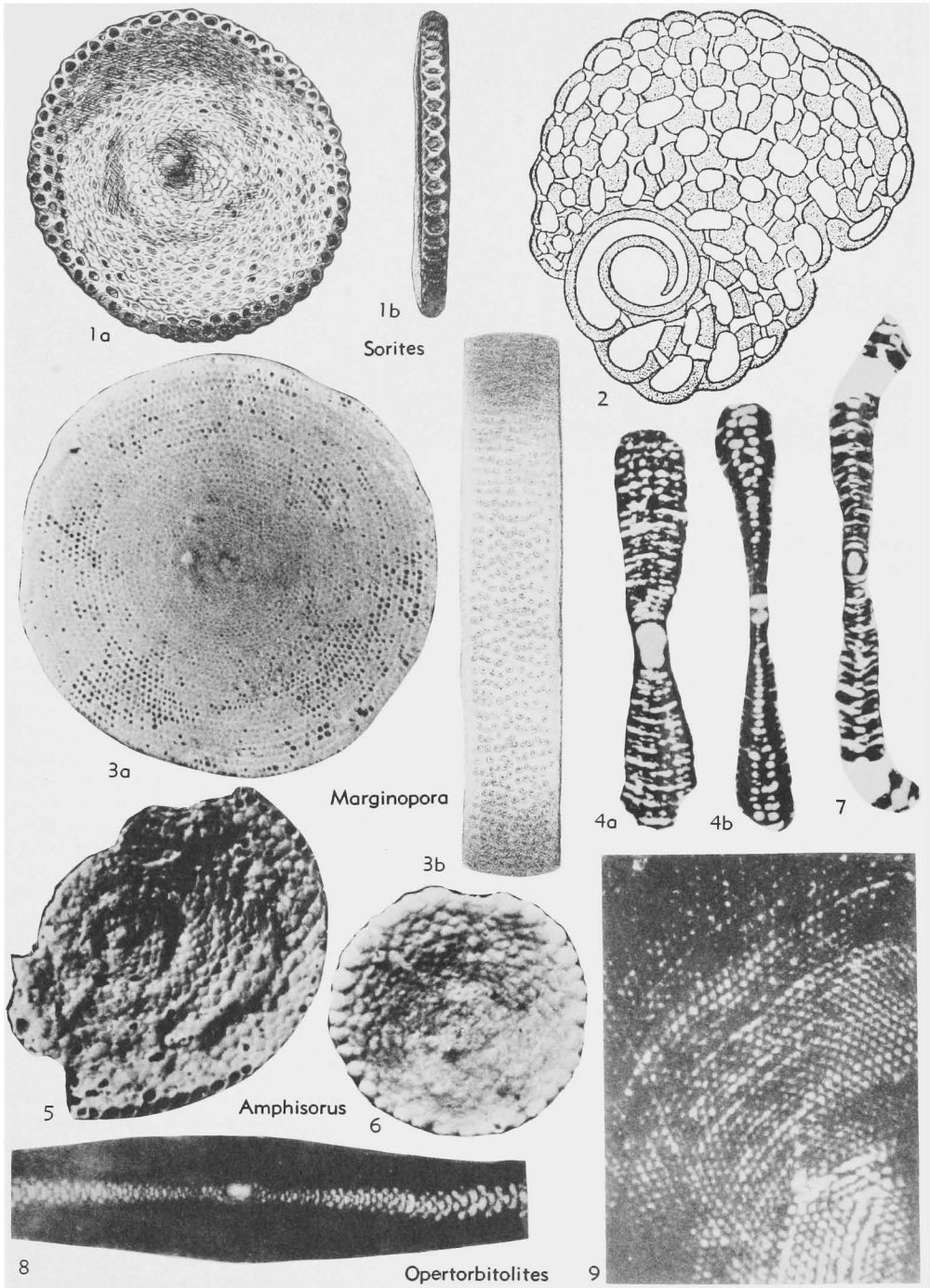


FIG. 385. Soritidae (Soritinae; 1,2, *Sorites*; 3,4, *Marginopora*; 5-7, *Amphisorus*; 8,9, *Opertorbitolites*) (p. C496-C498).

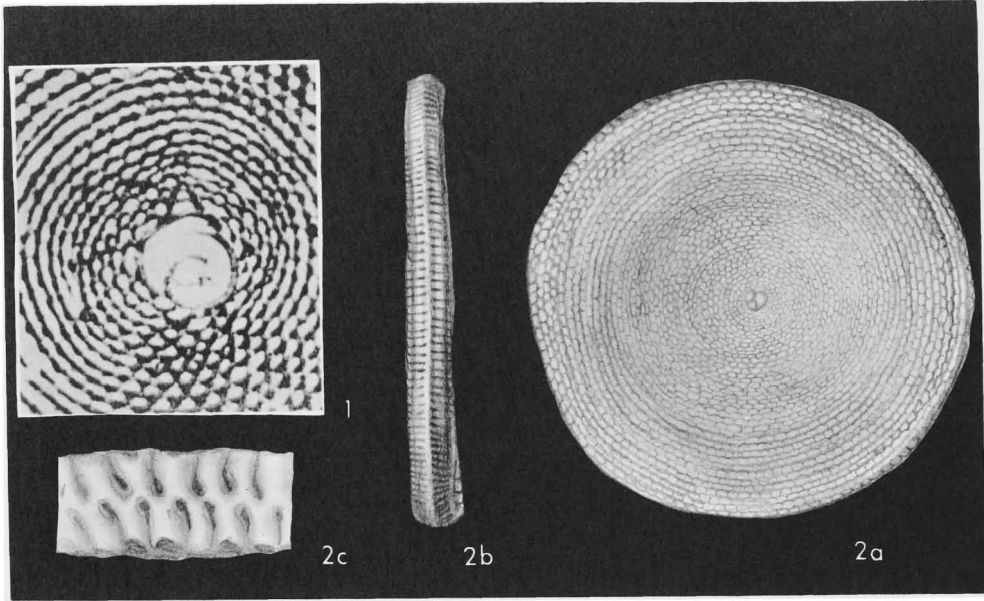


FIG. 386. Soritidae (Soritinae; 1, 2, *Amphisorus*) (p. C496-C498).

ing into stolons which lead obliquely into annular canal. *Mio.-Rec.*, Medit.-Pac.-Carib.-N.Am.-S.Am.-Eu.—FIG. 385,5-7; 386,1,2. \**A. hemprichii* Rec., Bermuda (385,5,6), Bikini Atoll (385,7), Kei Is. (386,1), Ifaluk Atoll (386,2); 385,5,6, side views,  $\times 20$  (\*444); 385,7, axial sec. originally figured as *Marginopora*, but showing equatorial annular canal and alternating intersection of chamber cavity at one side and septum on opposite side, characteristic of alternating chamberlets of *Amphisorus*,  $\times 20$  (\*361); 386,1, equat. sec. of megalospheric form, showing embryonic apparatus in center, equatorial annular canal intersected in median part of section, remainder of section slightly tangential to equatorial plane and intersecting chamber walls,  $\times 50$  (\*1122); 386,2a,b, side, edge views,  $\times 15$  (\*2117); 386,2c, portion of edge view, enlarged to show position of apertures,  $\times 41$  (\*2117).

**Marginopora** QUOY & GAIMARD in DE BLAINVILLE, 1830, \*141d, p. 377 [*M. vertebralis*; OD (M)]. Test discoidal, biconcave, ovate proloculus followed by cyclic chambers, without distinct flexostyle such as occurs in *Amphisorus* and *Sorites*; chambers similar to *Orbitolites* but less regular, annular canals connecting chamberlets, as in *Amphisorus*, but with one at each side of main chamber in all but first 1 or 2 cyclical chambers, stolons interconnecting primary chamberlets, smaller lateral chamberlets not interconnected, but joined to main chamberlets by stolons; numerous apertural pores in rows in slight depressions on periphery, as in *Orbitolites*, but more irregularly arranged. *Mio.-Rec.*, Atl.-Pac.-Red Sea.—FIG. 385,3,4. \**M. vertebralis*, Rec., Fiji (3a), Rec., Pac. (3b), U.Mio., Bikini Atoll (4a), Plio.-Rec.,

Bikini Atoll (4b); 3a, side,  $\times 8$  (\*462); 3b, edge,  $\times 20$  (\*200); 4a,b, axial secs.,  $\times 20$  (\*361).

**Opertorbitolites** NUTTALL, 1925, \*1368, p. 447 [*O. douvillei*; OD]. Test lenticular, with median layer of annular chambers similar to *Orbitolites*, chambers of successive annuli arranged alternately but with thick imperforate laminae on either side of chamber layer, laminae closely adjacent rather than enclosing vacuoles, as in *Somalina*. *L. Eoc.*, Baluch.—FIG. 385,8,9. \**O. douvillei*; 8, central portion of axial sec. of holotype; 9, equat. sec. passing through chambers in median plane; both  $\times 16$  (\*1368).

**Orbitolites** LAMARCK, 1801, \*1084, p. 376 [*O. complanata*; SD DOUVILLÉ, 1902, \*614, p. 296] [= *Discolithes* FORTIS, 1801, \*735, p. 106 (*nom. neg.*); *Discolithes* FORTIS, 1802, \*735A, p. 97 (*obj.*); *Discolites* DE MONTFORT, 1808, \*1305, p. 186 (type, *D. concentricus*, = *Orbitolites complanata* LAMARCK); *Orbitolithes* OKEN, 1815, \*1385, p. 827; *Orbitulites* BRONN in BRONN & ROEMER, 1854, \*214b, p. 254 (*nom. van.*) (non BERTHOLD, 1827, *nec* EICHWALD, 1829, *nec* GRIFFITH & PIDGEON, 1834)]. Test discoidal, similar to *Sorites*, megalospheric form with large globular multilocular nucleocoach, surrounded by numerous chambers in annular series, chambers in successive alternate series, each chamber with pores connecting those of preceding and succeeding annulae only, but without stolons interconnecting chambers of single series; annulae poorly defined in later stages and chamberlets separated by thick oblique walls; apertures on periphery in rows perpendicular to median plane. *U.Paleoc.-Eoc.*, Eu.—FIG. 387,1-4. \**O. complanata*, *M. Eoc.* (Lutet.), Fr.; 1a,b, opposite sides of micro-

spheric toptotype, with external wall preserved in center, abraded, showing chamberlets at margins,  $\times 5$ ; *1c*, edge view; *1d*, portion of side showing

opened nucleoconch,  $\times 10$ ; *2a,b*, opposite sides of smaller megalospheric toptotype,  $\times 5$ ; *2c*, central portion of *2b* showing opened nucleoconch

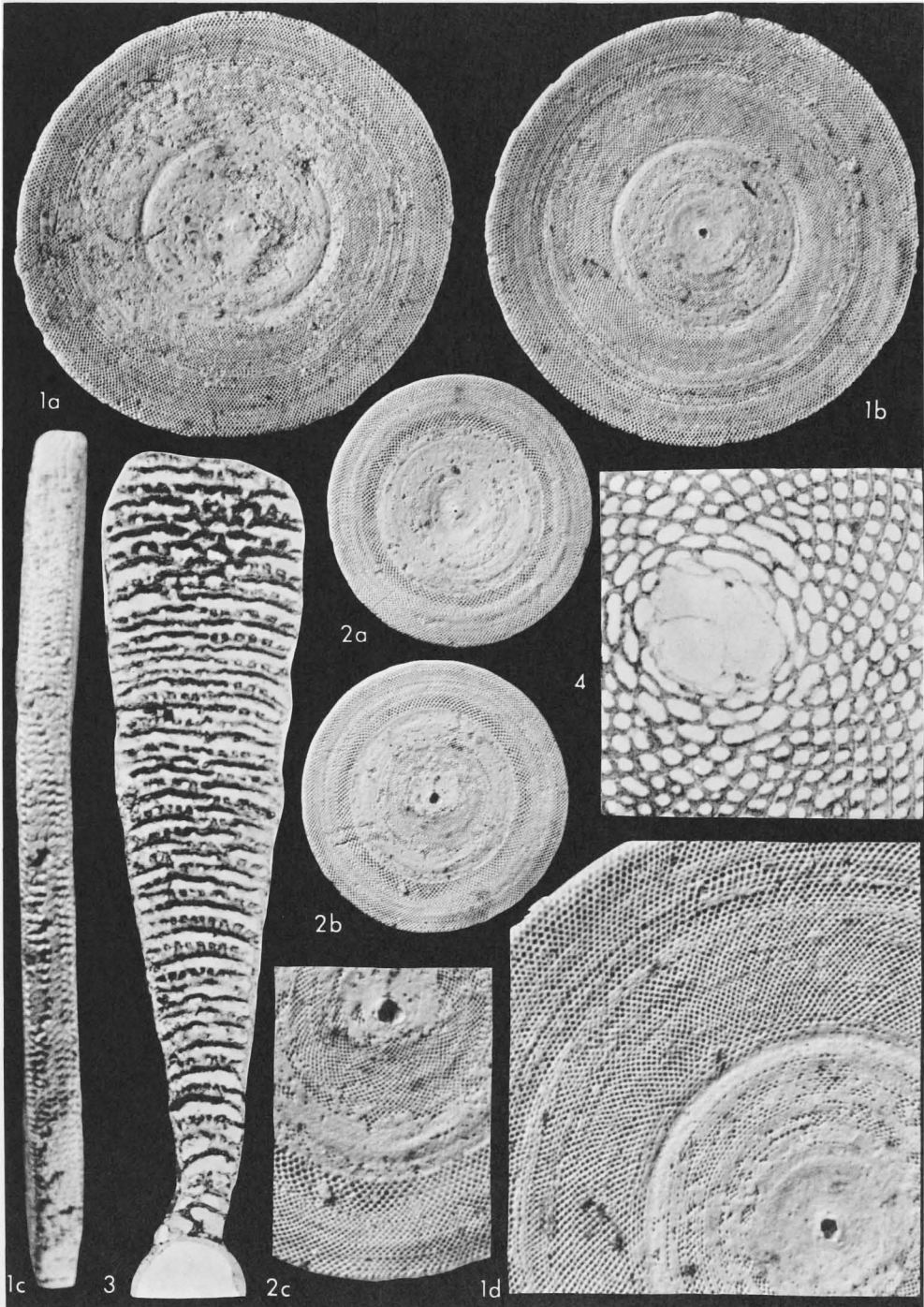


FIG. 387. Soritidae (Soritinae; 1-4, *Orbitolites*) (p. C498-C500).

and chamberlets where external wall is abraded,  $\times 10$  (1,2, \*2117); 3,4, portions of axial and horiz. secs.,  $\times 50$  (\*1122).

*Somalina* A. SILVESTRI, 1939, \*1788b, p. 51 [\**S. stefaninii*; OD (M)] [= *Somalina* A. SILVESTRI, 1938, \*1788a, p. 59, 64 (*nom. nud.*)]. Test dis-

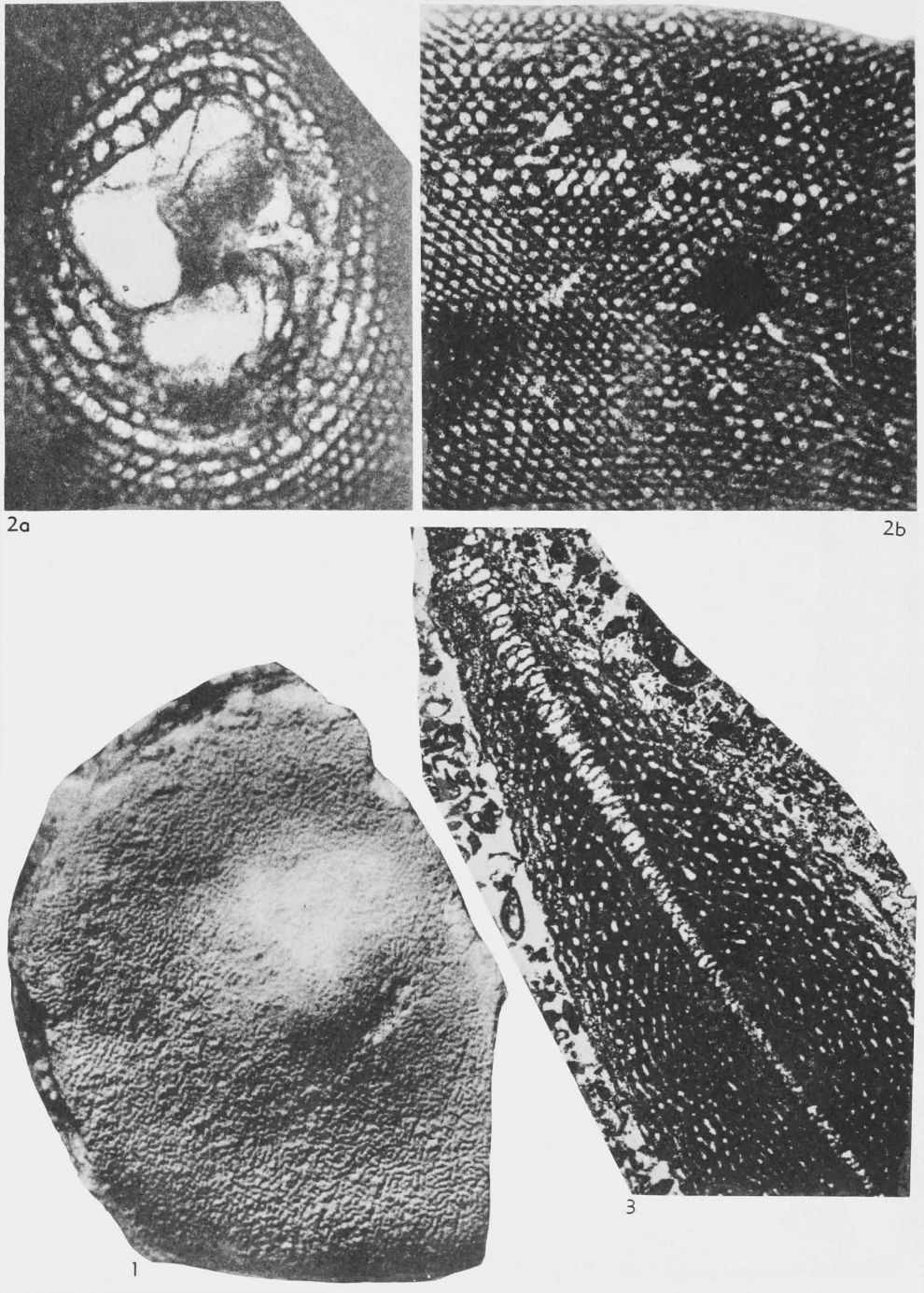


FIG. 388. Soritidae (Soritinae; 1-3, *Somalina*) (p. C500-C501).



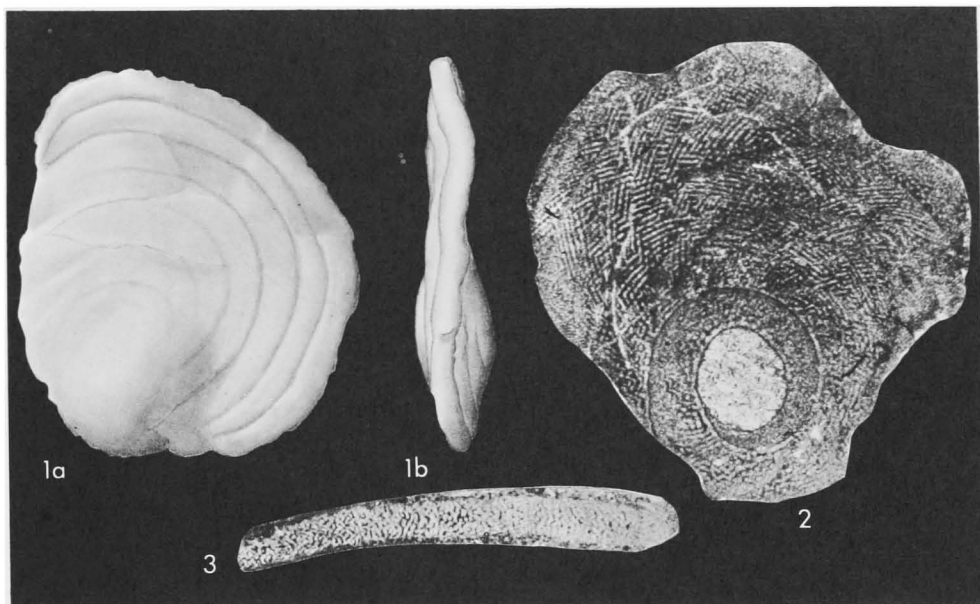


FIG. 389. Soritidae (Soritinae; 1-3, *Yaberinella*) (p. C501).

coidal to lenticular, similar to *Orbitolites* in absence of stolons between adjacent chambers of single annular series, chambers forming equatorial layer similar to *Opertorbitolites* but with lateral layers of shell material enclosing vacuoles, superficially resembling chamberlets, but apparently without communication between vacuoles. *Eoc.*, Somali-Egypt-Iraq.—FIG. 388, 1-3. \**S. stefaninii*, L.Eoc., Somali; 1, ext.,  $\times 5$ ; 2a,b, central and marginal parts of equat. sec. of megalospheric test showing "nucleoconch" of large chambers, and small peripheral chambers,  $\times 31$  (\*1788b); 3, axial sec.,  $\times 20$  (\*1788a).

**Yaberinella** VAUGHAN, 1928, \*1989, p. 7 [\**Y. jamaicensis*; OD]. Test large, operculine to discoidal in plan, up to 50 mm. diam., early stage peneropline, with very broad, low chambers, which may become cyclical, especially in microspheric form; chambers subdivided into secondary chamberlets; septula numerous, intersecting at low angles to give hachured appearance in section; aperture apparently a series of pores on apertural face, chamberlets communicating through stolons, which occur in 3 planes. *M.Eoc.-U.Eoc.*, Carib. (Jamaica).—FIG. 389, 1-3. \**Y. jamaicensis*, M. Eoc.; 1a,b, side, edge views of lectotype (here designated, one of VAUGHAN's figured specimens),  $\times 9$  (\*2117); 2, horiz. sec. of megalospheric paratype, showing fine radial surface striations at sides, and interwoven appearance of septula in central portion,  $\times 13$ ; 3, vert. sec. of microspheric specimen,  $\times 7$  (\*1989).

**Subfamily KERAMOSPHAERINAE** Brady, 1884

[*Keramosphaerinae* BRADY, 1884, p. 63]

Test globular, concentric chambers subdivided into chamberlets; pores between chambers of same series and between those of successive series. *Mio.-Rec.*

**Keramosphaera** BRADY, 1882, \*198, p. 242 [\**K. murrayi*; OD (M)] [= *Orbulinaria* RHUMBLER, 1906, \*1571, p. 23 (type, *O. fallax* RHUMBLER in EGGER, 1909, \*662, p. 11); *Arbulinarium* RHUMBLER, 1913, \*1572b, p. 347 (nom. van. pro *Orbulinaria* RHUMBLER, 1906)]. Test free, spherical, to 2.5 mm. diam., with numerous somewhat inflated chamberlets of irregular outline added in concentric spherical series, chamberlets of each layer with short lateral stolons for intercommunication, chamberlets of successive layers neither directly superposed nor regularly alternating in position; apertures consisting of pore at margin of each chamberlet, previous apertures serving for intercameral connections between chamberlets of successive layers. *Rec.*, S.Atl.-W.Pac.-N.Sea.—FIG. 390, 1. \**K. murrayi*, SW.Australia; 1a, ext., holotype,  $\times 25$  (\*2117); 1b, part of median sec.,  $\times 50$  (\*198).—FIG. 390, 2. *K. fallax* (RHUMBLER), S.Atl.; ext.,  $\times 218$  (\*1572a).

[*Orbulinaria* was placed with the agglutinated genera by GALLOWAY (1933, \*762) and CUSHMAN (1948, \*486) but was originally stated to be entirely calcareous, with scaly meandrine surface and scattered pores according to RHUMBLER. This is identical to *Keramosphaera*, and the type-species of the 2 differ only in size. Although the Cretaceous spheres (= *Oligostegina*) were included in *Orbulinaria* by RHUMBLER, the type is *O. fallax*, a Recent form from the South Atlantic, Ascension Island.]

**Kanakaia** HANZAWA, 1957, \*873, p. 38 [\**K. marianensis*; OD]. Test encrusting, to 4 mm. diam., with chambers in layers similar to those of *Keramosphaera*; stolons through septa connecting cham-

bers of same series and oblique stolons connecting chambers with those of preceding and succeeding layers. *Mio.(Aquitan.)*, Saipan-Tinian-Rota.—

FIG. 390,3-5. \**K. marianensis*, Saipan; 3,4, horiz. and vert. secs.,  $\times 20$ ; 5, vert. sec. through proloculus,  $\times 80$  (\*873).

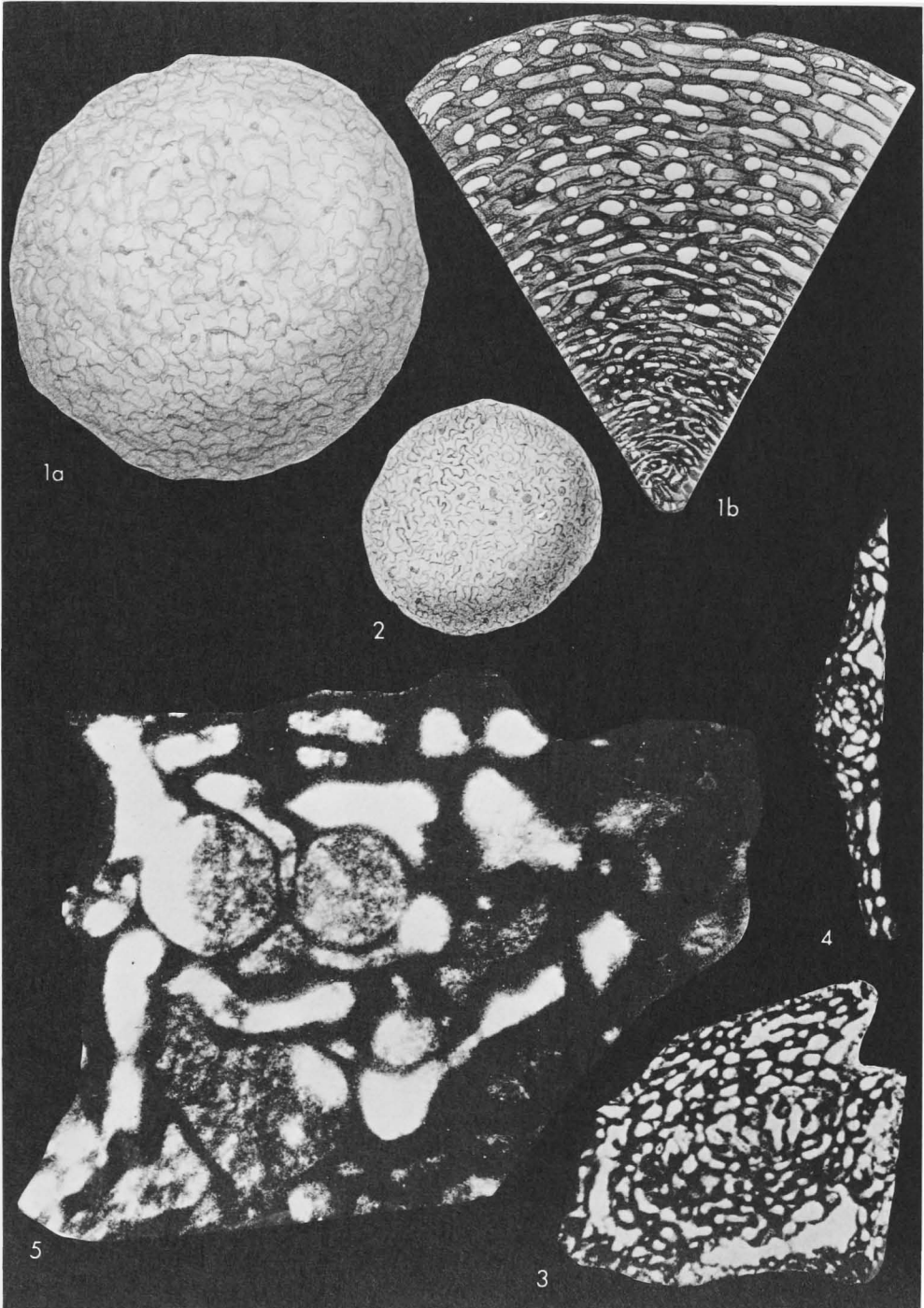


FIG. 390. Soritidae (Keramosphaerinae; 1,2, *Keramosphaera*; 3-5, *Kanakiaia*) (p. C501-C502).



## ALVEOLINIDAE

By MANFRED REICHEL

[Bernoullianum, Universität Basel]

Family ALVEOLINIDAE Ehrenberg,  
1839

[*nom. correct.* STEINMANN, 1881, p. 41 (*pro* Alveolina EHRENBURG, 1839, table opp. p. 120; type-genus *Alveolina* D'ORBIGNY, 1826, which is junior objective synonym of *Borelis* DE MONTFORT, 1808)]—[In following citations superscript numbers indicate taxonomic rank assigned by authors as follows: <sup>1</sup>family, <sup>2</sup>subfamily; dagger (†) indicates *partim*]—[=<sup>1</sup>Polythalamat LATREILLE, 1825, p. 161 (*nom. nud.*); =<sup>1</sup>Enthomostegest D'ORBIGNY, 1826, p. 304 (*nom. nud.*); =<sup>1</sup>Fasciolitidae BARR, 1932, p. 257]—[=<sup>1</sup>Alveolinida SCHULTZE, 1854, p. 53; =<sup>2</sup>Alveolininae BRADY, 1884, p. 62; =<sup>1</sup>Alveolinina LANKESTER, 1885, p. 847; =<sup>1</sup>Alveolininae DELAGE & HÉROUARD, 1896, p. 127]—[=<sup>1</sup>Borelida SCHMarda, 1871, p. 165; =<sup>2</sup>Borelidae WIESNER, 1931, p. 60, 75; =<sup>1</sup>Borelidae HANZAWA, 1932, p. 36, 102]—[=<sup>1</sup>Alveolinellidae CUSHMAN, 1927, p. 58; =<sup>2</sup>Alveolinellinae GALLOWAY, 1933, p. 148]

Wall porcelaneous, imperforate. Test free, usually large, coiled about elongate axis, subcylindrical, fusiform, ellipsoidal or spherical, rarely somewhat nautiloid. Proloculus followed by spiral tube (flexostyle). Juvenile volutions commonly coiled irregularly, at least in microspheric form. Chambers numerous, divided into tubular chamberlets by means of secondary partitions (septula) parallel to direction of coiling; chamberlets may occur in several layers. Apertures numerous, arranged in one or more rows, exceptionally fused into horizontal slit. *L.Cret.-Rec.*

These features make of the Alveolinidae a morphologically well-defined family but probably not a phylogenetic unit. Some of the genera that followed each other in the course of geological epochs surely did not evolve one from another.

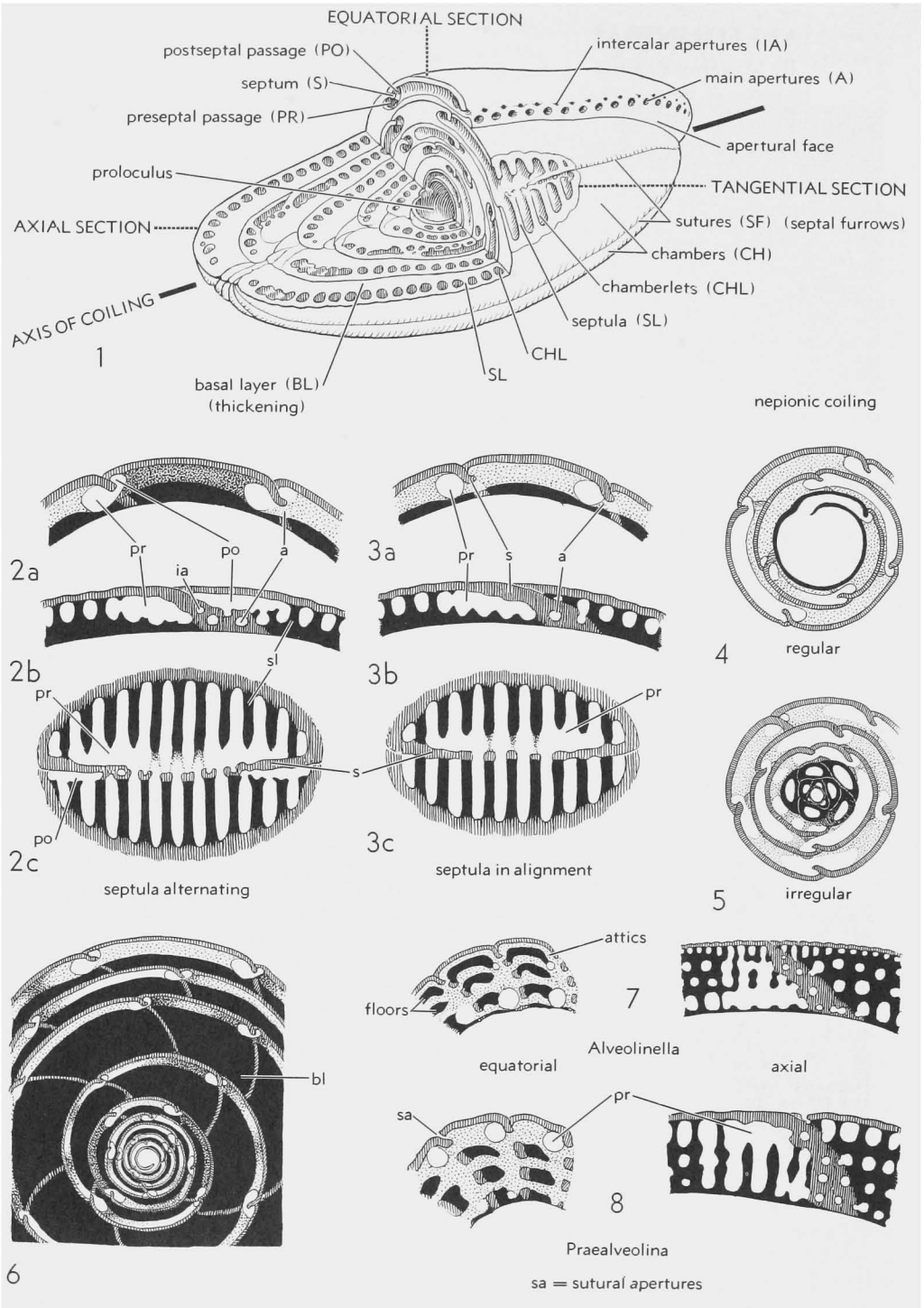
In their general shape the alveolinids are somewhat isomorphous with fusulinids but between these families no genetic relations exist. The irregular coiling of the first volutions found in the microspheric forms of nearly all genera and species shows that the Alveolinidae are closely related to the Miliolidae. Their relationship with the Peneropliidae is smaller. Yet in Recent *Alveolinella*, HOFKER has observed pores in the wall of the proloculus and peneropline-like coiled first volutions in the microspheric form. It is therefore possible that this genus evolved independently from a peneropline ancestor. Nevertheless, for practical reasons I have placed it in the Alveolinidae. Further study will be needed of the relations between

*Alveolinella* which appears in the Miocene, and the structurally very similar Miocene genus *Flosculinella*, the microspheric form of which we still do not know.

The essential feature of the family—axial elongation of the shell—is extremely variable. As a rule, the axial diameter is greater than equatorial diameter, but very commonly both are of the same length (globular tests) and rarely the equatorial diameter is greatest. The ratio of elongation may reach 9:1 in most elongate shells. The shape of the test also varies greatly. Some genera with only small species (e.g., *Ovalveolina*, *Bullaveolina*, *Borelis*) are represented by shells with axial diameter of 1 to 2 mm. Other genera comprise small as well as large forms (e.g., *Praealveolina*, *Subalveolina*, *Fasciolites*). The largest tests occur in microspheric specimens of *Fasciolites*, which may attain a length of 100 mm. (e.g., *F. levantina*, from the Mediterranean region).

Internal structure furnishes the most important taxonomic features for distinction of genera (Fig. 391,1-8). Almost invariably a definite type of structure is found to characterize the alveolinids of a given time-stratigraphic division. In the endoskeleton we may distinguish: (1) the basal layer (basal thickening), usually well developed in the axial region and in some shells enormously thickened (e.g., "*Flosculina*") (Fig. 391,6); (2) the secondary partitions or septula which are arranged in the direction of coiling; and (3) the floors which divide several layers of chamberlets (e.g., *Praealveolina*, *Alveolinella*) (Fig. 391,7,8).

The septula of two adjacent chambers show either an alternating or a continuous arrangement (Fig. 391,2,3). A section across the chamberlets is circular or oval. The chamberlets of the uppermost layers in *Flosculinella* and *Alveolinella* are half the size of those of the lower layers and may be compared with the attics (Fr., *mansardes*) of a building. Alveoli are blind chamberlets without an opening at their front. At the back, they are connected with the preceding chamber by means of secondary apertures (e.g., *Subalveolina*, *Bullalveolina*). Irregularly arranged supplementary chamberlets are sometimes seen in the basal layer of certain species of *Fascio-*



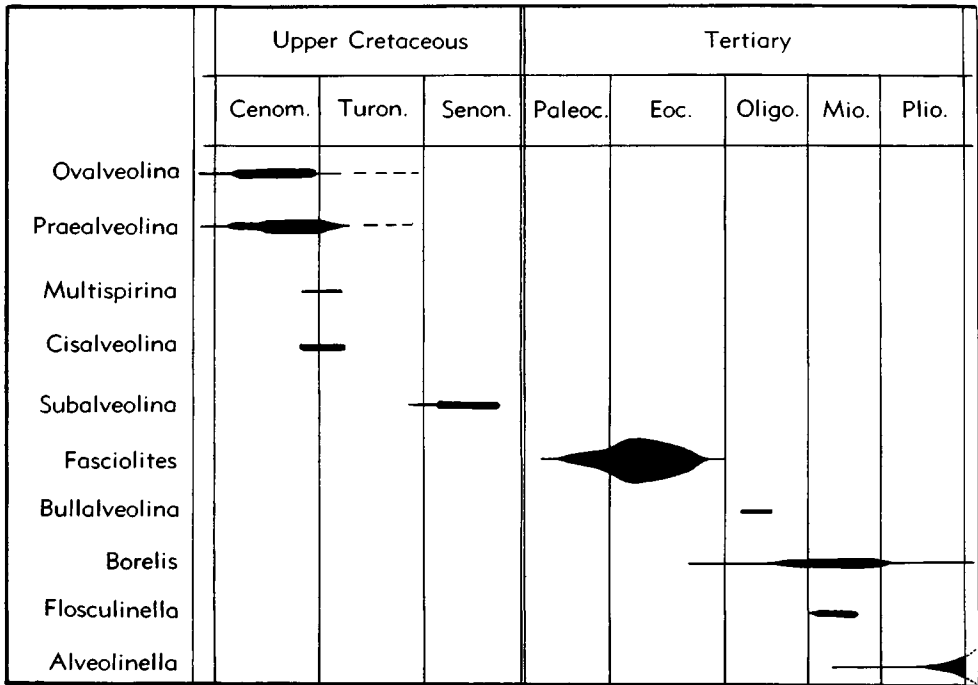


FIG. 392. Stratigraphic distribution of Alveolinidae (\*2119A).

lites ("subgenus *Eovalveolinella*"). All chamberlets of the same chamber are connected by a preseptal passage, located in the anterior part of the chamber. A postseptal passage appears in *Fasciolites* in the angle between wall and septum at the back of the chamber. In *Cisalveolina* it occupies the whole posterior part of the chamber and then the preseptal passage is extremely reduced.

In a single genus (*Multispirina*) several spires may be observed. In the megalo-spheric generation the first spires begin on the proloculus, which possesses several rows of apertures. All species of medium and large size show a clear dimorphism and some exhibit trimorphism.

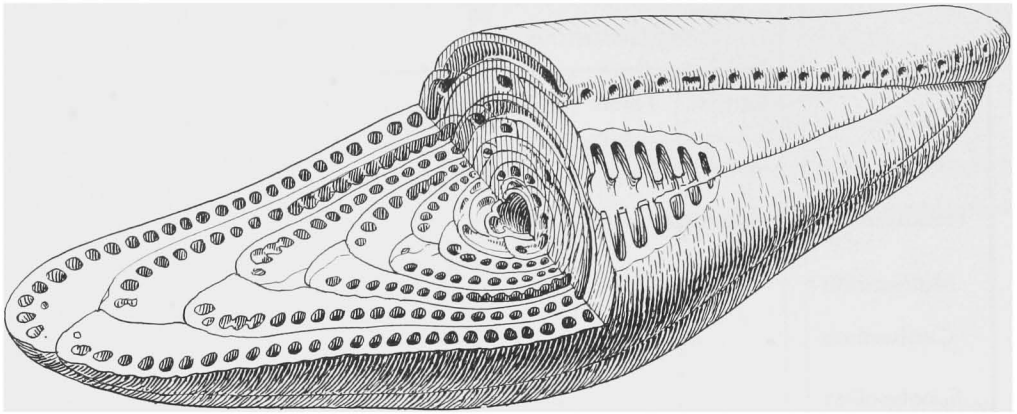
Fossil alveolinids are only found in neritic sediments where they may be associated with miliolids and calcareous algae. Many large species occur in great abundance and are therefore rock-builders (*Praealveolina*, Cenomanian; *Fasciolites*, Eocene).

*Alveolinella* lives in tropical seas at depths of 10 to 80 m. *Borelis* has been found to a depth of 411 m.

Stratigraphic distribution of alveolinid genera is indicated in Fig. 392.

**Borelis** DE MONTFORT, 1808, \*1305, p. 170 [\**B. melonoides* = \**Nautilus melo* var.  $\beta$  FICHEL & MOLL, 1798; OD] [non *Borelis* OKEN, 1815] [= *Clausulus* DE MONTFORT, 1808, \*1305, p. 178 (type, *C. indicator*, = *Nautilus melo* FICHEL & MOLL, 1798); *Melonites* LAMARCK, 1812, \*1087, p. 122 (type, *M. sphaerica* LAMARCK, 1816, \*1089,

FIG. 391. (Facing page.) Morphological features of alveolinid tests and terminology applied to them.—1. *Fasciolites* ( $\times 32.5$ ), oblique view of partially sectioned test showing morphological nomenclature.—2,3. Types of septula illustrated by much-enlarged sections (2a,3a, equatorial; 2b,3b, slightly oblique axial showing septal part; 2c,3c, tangential); 2, *Fasciolites*, with alternating septula; 3, *Borelis*, with continuous, aligned septula [wall and septa, hatched; septula and basal layer, stippled and black].—4. Proloculus and regularly coiled first whorls of *Fasciolites* (*Fasciolites*) *schwageri*.—5. Proloculus and irregularly coiled first whorls of *Fasciolites* (*Glomalveolina*) *primaeva*.—6. Equatorial section of *Fasciolites* (*Fasciolites*) *pasticillatus* showing very thick basal layer of "Flosculina" type.—7,8. Parts of equatorial and axial sections of *Alveolinella quoyi* (7) and *Praealveolina cretacea* (8) showing chambers with several rows of chamberlets (\*2119A).



Borelis

FIG. 393. Alveolinidae; *Borelis* (p. C505-C506).

p. 469, =*Nautilus melo* FICHTEL & MOLL, 1798, SD GALLOWAY, 1933, \*762, p. 150); *Melonia* LAMARCK, 1822, \*1090, p. 615 (type, *Melonites sphaerica* LAMARCK, 1816, =*Nautilus melo* FICHTEL & MOLL, 1798, SD GALLOWAY, 1933, \*762, p. 150); *Alveolina* D'ORBIGNY, 1826, \*1391, p. 306 (type, *Nautilus melo* FICHTEL & MOLL, 1798, SD PARKER & JONES, 1860, \*1417c, p. 182); *Borelia* AGASSIZ, 1844, \*5, p. 4 (*nom. van. pro Borelis* DE MONTFORT, 1808); *Neoalveolina* SILVESTRI, 1928, \*1783, p. 35 (type, *Alveolina bradyi* SILVESTRI, 1927, \*1782, p. 227, SD BAKX, 1932, \*68, p. 208, =*Nautilus melo* FICHTEL & MOLL, 1798]. Test minute, spheroidal to fusiform, with septula in continuous arrangement; in some tests, chamberlets of same chamber alternately large and small, with latter displaced toward exterior, septula therefore developing Y-shape; without post-septal passage, first whorls irregularly coiled. *U. Eoc.-Rec.*, Eu.-Asia-Afr.—FIG. 393. *B. schlumbergeri* (REICHEL), Rec., Mayotte Is. (NW of Madagascar);  $\times 75$  (\*2119A).—FIG. 394, 2. *B. melo curdica* (REICHEL), *U. Mio.*, E. Turkey;  $\times 85$  (\*2119A).

[The nominal genus *Alveolina* D'ORBIGNY, 1826, from which the family containing *Borelis* has been named and become widely known, is unquestionably a junior objective synonym, since *Nautilus melo* FICHTEL & MOLL, 1798, according to provisions of the international Rules of Nomenclature, is the type-species of both. For *Borelis* this is fixed by original designation. D'ORBIGNY did not designate any of the 7 species assigned by him to *Alveolina* as type-species and therefore the first author who selected one of these eligible species to be the type established it unalterably. Such first valid designation was made by PARKER & JONES, 1860, when they chose *Nautilus melo*, one of the original 7 species named by D'ORBIGNY, as type-species of *Alveolina*.—R. C. MOORE.]

*Alveolinella* DOUVILLÉ, 1906 [1907] \*617, p. 585 [*\*Alveolina quoyi* D'ORBIGNY, 1826, \*1391, p. 307]; OD]. Fusiform, very elongate, septa continuously arranged, with several layers of chamberlets, preseptal passages on floor of chambers;

last whorls may have small secondary preseptal passages; apertures in several rows, with attics at top of uppermost ones, as in *Flosculinella*. *Mio.-Rec.*, IndoPac.—FIG. 395, 1. *\*A. quoyi* (D'ORBIGNY), Rec., Torres Str.;  $\times 45$  (\*2119A).

[D'ORBIGNY's spelling of the specific name "*quoyi*," referring to the surgeon and student of corals J. R. C. QUOY, is indubitably an inadvertent error in which the last letter of the surname was incorrectly changed from 'y' to 'i.' The Code (Art. 32.a.ii) provides for automatic correction to "*quoyi*," as adopted by DOUVILLÉ, CUSHMAN, GALLOWAY, and other authors.—R. C. MOORE.]

*Bullalveolina* REICHEL, 1936, \*1513, p. 140 [*\*Alveolina bulloides* D'ORBIGNY in DE LA SAGRA, 1839, \*1611, p. 70 =*A. bulloides* D'ORBIGNY, 1826, (\*1391, p. 306) (*nom. nud.*); OD]. Test minute, subspherical, with several rows of apertures, upper ones opening into alveoli which occupy rear part of chambers; septula alternating, first coils irregular. *Oligo.*, Eu.(S.Fr.-Italy).—FIG. 394, 1. *\*B. bulloides* (D'ORBIGNY), *L.Oligo.*, Fr.(Gaas);  $\times 80$  (\*2119A).

*Cisalveolina* REICHEL, 1941, \*1515, p. 255 [*\*C. fallax*; OD]. Test ovoid, spherical, or nautiloid, septula alternating, with spacious postseptal passages but preseptal passages greatly reduced; aperture comprising long slit that extends from pole to pole, its upper edge fluted; juvenile coiling of microspheric forms irregular. *U.Cret.(U.Cenoman.-L. Turon.)*, M.East.—FIG. 396, 2. *\*C. fallax*, Cenoman., Iran;  $\times 35$  (\*2119A).

*Fasciolites* PARKINSON, 1811, \*1420, p. 158 [*\*Alveolina oblonga* D'ORBIGNY, 1826, \*1391, p. 306, =PARKINSON's figured specimen, \*1420, pl. 10, figs. 28-31; SD (SM) D'ORBIGNY, 1826, \*1391, p. 306] [= *Miliolites* DE MONTFORT, 1808, \*1305, p. 175 (type, *M. sabulosus*) (*non Miliolites* LAMARCK, 1804); *Oryzaria* DEFRANCE in BRONN, 1825, \*209, p. 30 (type, *O. boscii*); *Alveolina* AUCTT. (*partim*) (*non* D'ORBIGNY, 1826 =*Borelis* DE MONTFORT, 1808); *Flosculina* STACHE, 1880,

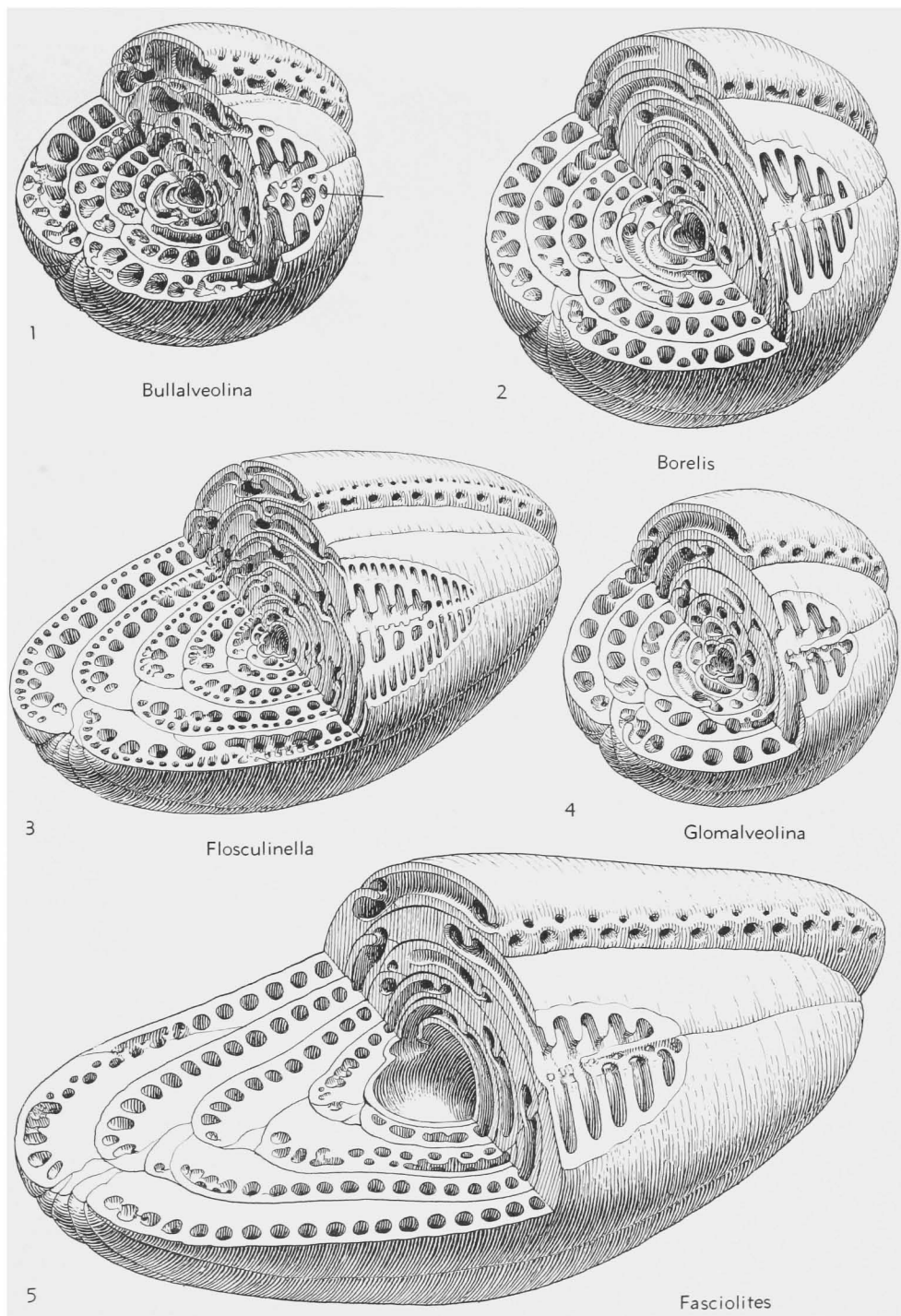


FIG. 394. Alveolinidae; 1, *Bullalveolina*; 2, *Borelis*, 3, *Flosculinella*; 4, *Fasciolites* (*Glomalveolina*); 5, *F.* (*Fasciolites*) (p. C505-C510).

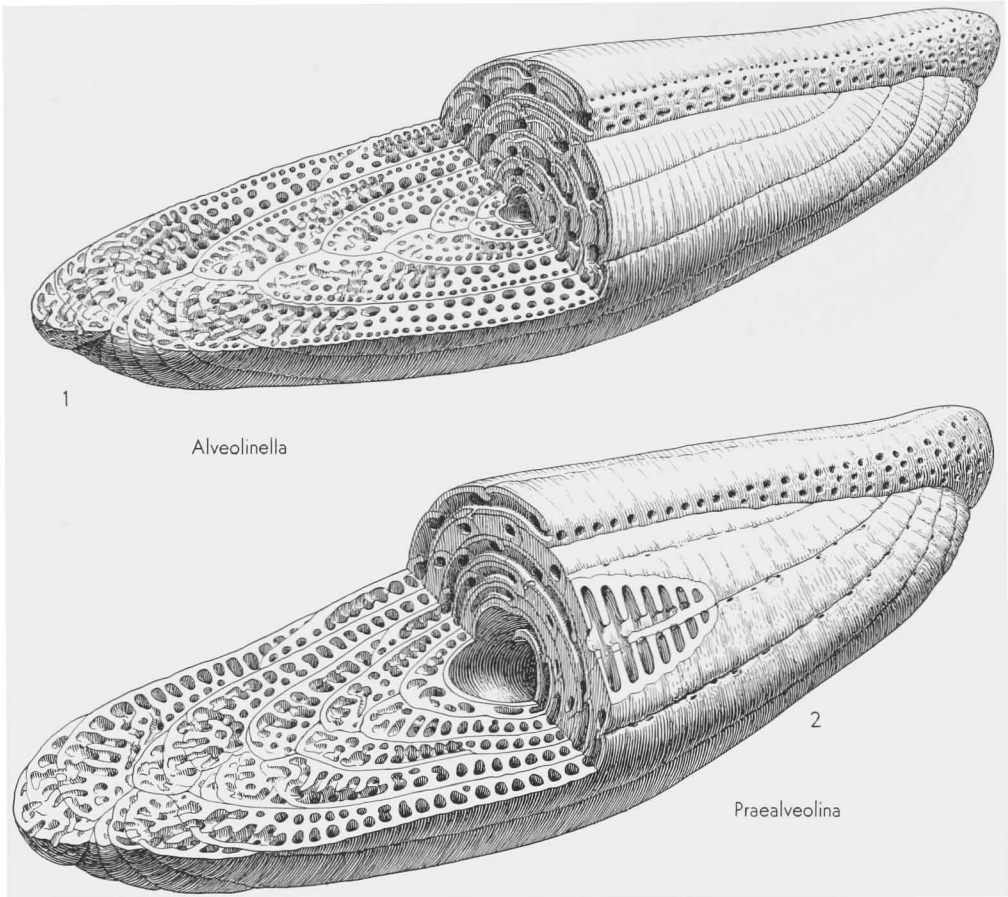


FIG. 395. Alveolinidae; 1, *Alveolinella*; 2, *P. (Praelveolina)* (p. C506, C510).

\*1827, p. 199 (*nom. nud.*); *Flosculina* STACHE in SCHWAGER, 1883, \*1707, p. 102 (type, *F. decipiens* SCHWAGER, 1883, SD GALLOWAY, 1933, \*762, p. 151); *Flosculina (Semiflosculina)* DONCIEUX, 1905, \*608, p. 124, no species named; *Eoalveolinella* SILVESTRI, 1928, \*1783, p. 35 (type, *Alveolina violae* CHECCHIA-RISPOLI, 1905, \*329, p. 165; *Flosculina (Checchiaites)* SORRENTINO, 1935, \*1815, p. 137 (type, *Flosculina daunica* CHECCHIA-RISPOLI, 1912); *Alveolina (Fasciolites)* REICHEL, 1936, \*1514, p. 80 (obj.)). Test spherical, ellipsoidal, fusiform, or cylindrical; septula alternating in adjacent chambers, with pre- and post-septal passages; coiling of first whorls irregular in microspheric form of all species but regular in megalospheric form of most species; 2 rows of apertures alternating in position; may show enormous basal thickening in several internal whorls (e.g., "*Flosculina*") or secondary apertures and chamberlets irregularly distributed in axial zone and mostly not connected with preseptal

passages (e.g., "*Eoalveolinella*"). [Many species are important as rock-builders.] *Paleoc.-Eoc.*, Eu.-Asia-Afr.

[No named species originally were included in *Fasciolites*. *Alveolina oblonga* D'ORBIGNY was based on specimens collected by him from the Eocene (Cuisian) of France, and *Fasciolites* PARKINSON was mentioned by D'ORBIGNY as a synonym of *Alveolina*. GALLOWAY (1933, \*762, p. 150) regarded this as constituting subsequent monotypy (ICZN, Art. 2, Op. 46).] [Note by REICHEL.—Because of strong preference, ingrained by many years of usage, especially on the part of European paleontologists, including me, I have endeavored to find ways of conserving the name *Alveolina*, hallowed by tradition. This is because (1) all authors describing Eocene species from Africa and Europe have used it; (2) since adoption of *Alveolina* for recognition in my structural studies (1931, 1936-37) of the tests, the name has become the symbol of a well-defined and characteristic morphological type that is common to all observed Paleocene and Eocene species; (3) deserving respect are the attempts of D'ORBIGNY to establish priority of the name *Alveolina* since "*Alvéolite de Bosc*" was the oldest name (DESHAYES, 1828, p. 228) without doubt assigned to an Eocene form (*Alvéolite grain de fétusque*) figured 9 years before the *Fasciolites* of PARKINSON; and (4) it has seemed desirable to avoid use of *Fasciolites* as defined by GALLOWAY on the basis solely of test proportions and size of chamberlets. But unfortunately these arguments are insufficient for the Rules of Nomenclature. The term *Alvéolite*



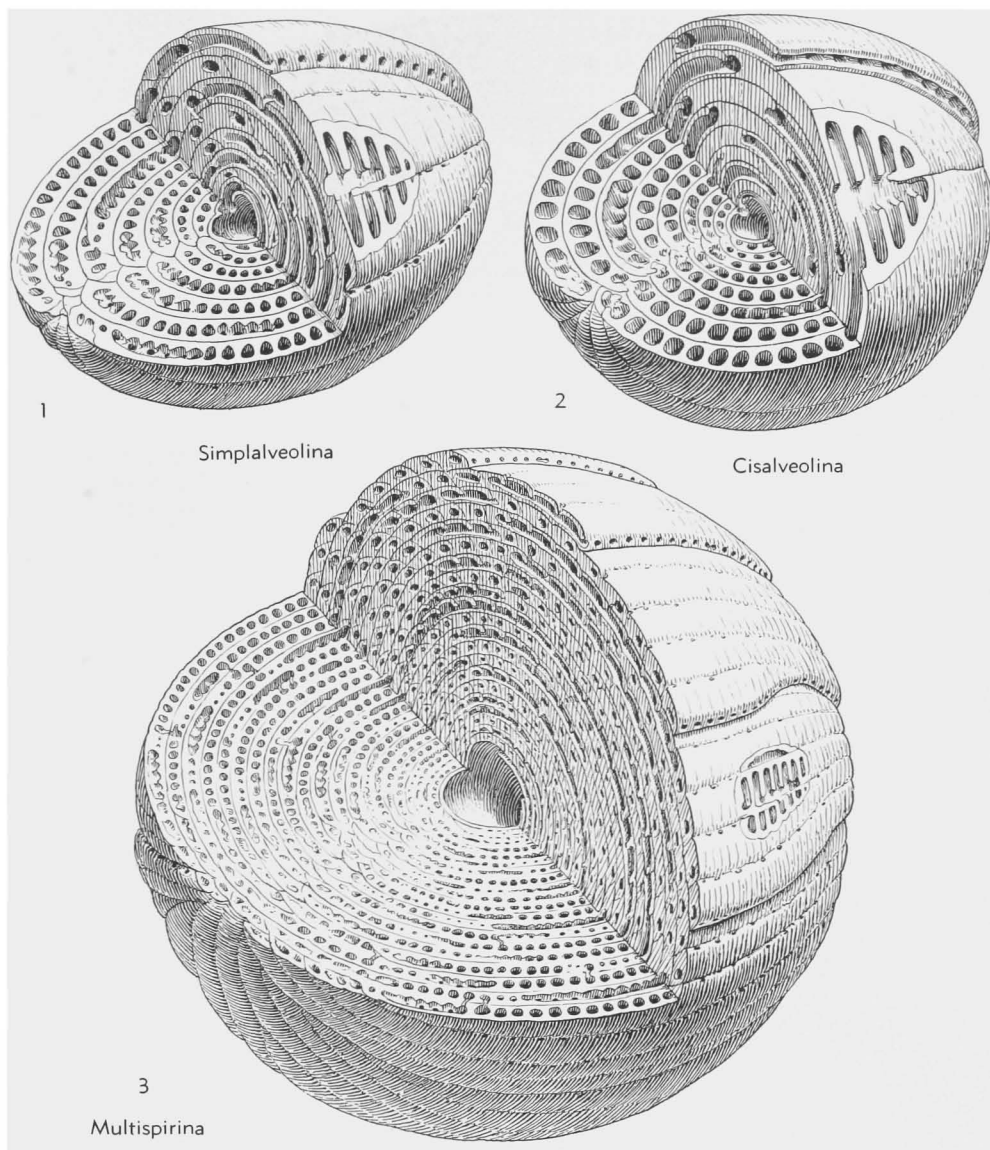


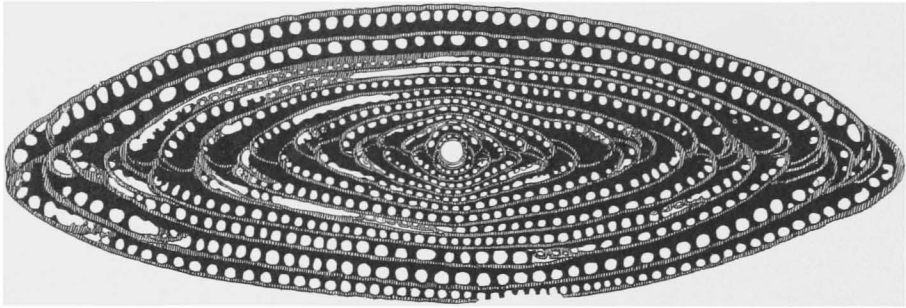
FIG. 396. Alveolinidae; 1, *Praealveolina* (*Simplalveolina*); 2, *Cisalveolina*; 3, *Multispirina* (p. C506, C510).

lite of Bosc is a vernacular name; d'ORBIGNY'S figures intended for publication with his 1826 text were not published until much later. Readers should be warned that *Fasciolites* refers only to forms of the structural type of *Alveolina* of REICHEL (1931, 1936-37) and not to all elongate-ovoid, fusiform, and cylindrical tests with a single layer of chamberlets, as defined by GALLOWAY.]

**F. (Fasciolites).** Coiling of first whorls regular in megalospheric form; test generally ellipsoidal to fusiform or cylindrical, but may be spherical, *U. Paleoc.-Eoc.*, Eu.-Asia-Afr.—FIG. 397. *F. (F.) boscii* (DEFRANCE), *Eoc.* (Lutet.), Fr. (Grignon); axial sec. of topotype,  $\times 40$  (\*2119A).—FIG. 394,5. *F. (F.) schwageri*

(CHECCHIA), *L.Eoc.*, N. Italy (Vicentino); first whorls,  $\times 55$  (\*2119A).

**F. (Glomalveolina)** HOTTINGER, 1962, \*962, p. 54 [*Alveolina dacheiensis* SCHWAGER, 1883, \*1707, p. 96; OD] [= *Alveolina (Glomalveolina)* REICHEL, 1936, \*1514, p. 80 (*nom. nud.*) (type, *Alveolina ovulum* STACHE, in SCHWAGER, 1883, p. 95, *nom. nud.*, = *A. cf. ovulum* SCHWAGER, 1883, \*1707, p. 95, *nom. nud.*)]. Test very small, spherical to ovoid, with irregularly coiled first whorls in both micro- and megalospheric forms. *Paleoc.-Eoc.*, Eu.-Afr.-?Asia.—FIG. 394,4. *F.*



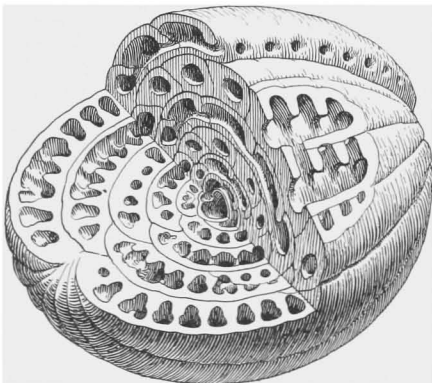
Fasciolites

FIG. 397. Alveolinidae; *Fasciolites* (p. C506-C509).

(*G.* *primaeva* (REICHEL), Paleoc., S.Fr.;  $\times 55$  (\*2119A).

[REICHEL's (1936) publication of the nominal subgenus *Glomalveolina* failed to comply with requirements of nomenclatural rules (Zool. Code, 1961, Art. 13,b) relating to generic names published after 1930. These must be accompanied by definite fixation of a (valid) type-species. *Glomalveolina* had the status of a *nomen nudum* because its originally designated type-species was (and remains) a *nomen nudum*. This generic name was first validated in 1962 by HOTTINGER with designation of *Alveolina dacheleensis* SCHWAGER as its type-species. The provisional use of *A. dacheleensis* by SCHWAGER and attribution of *Glomalveolina* to REICHEL by HOTTINGER have no effect on the validity of *A. dacheleensis* and recognition of HOTTINGER as author of *Glomalveolina*. Also, the date of this nominal subgenus must be given as 1962—not 1936. An unimportant detail is the designation of SCHWAGER, rather than bystander STACHE, as the author of *Alveolina* cf. *ovulum*.—R. C. MOORE.]

**Flosculinella** SCHUBERT in RICHARZ, 1910, \*1578, p. 533 [*\*Alveolinella bontangensis* RUTTEN, 1913, \*1597, p. 221; SD GALLOWAY, 1933, \*762, p. 151]. Test globular to fusiform, septula alternating; apertures in 2 rows, upper ones small, leading into narrow chamberlets; first whorls irregularly coiled, *Mio.*, E.Indies-Australia.—FIG. 394,3. *\*F. bontangensis* (RUTTEN), Burdigal., Borneo;  $\times 60$  (\*2119A).



Ovalveolina

FIG. 398. Alveolinidae; *Ovalveolina* (p. C510).

**Multispirina** REICHEL, 1947, \*1518, p. 2 [*\*M. iranensis*; OD]. Test spherical, with several spires and numerous sutural apertures; internal structure as in *Praealveolina* (*Simplealveolina*). *U.Cret.*, Iran.—FIG. 396,3. *\*M. iranensis*, Cenoman.;  $\times 40$  (\*2119A).

**Ovalveolina** REICHEL, 1936, \*1514, p. 69 [*\*Alveolina ovum* D'ORBIGNY, 1850, \*1397b, p. 185; OD]. Test spherical to ovoid, chambers numerous, septula continuous, short and widely spaced, apertures in single row; coiling regular throughout. *L.Cret.* (*U.Alb.*)-*U.Cret.* (*Cenoman.*-*Turon.*), Eu. (Fr.-Sp.-Port.)-N.Afr.—FIG. 398. *\*O. ovum* (D'ORBIGNY), *U.Cret.* (*Cenoman.*), SW.Fr. (Île Madame);  $\times 50$  (\*2119A).

**Praealveolina** REICHEL, 1933, \*1512, p. 270 [*\*P. tenuis* (= *?Alveolina cretacea* D'ARCHIAC, 1837, \*35, p. 191, unfigured); OD]. Test ovoid, fusiform, or cylindrical; septula of 2 adjacent chambers continuously arranged, with several rows of chamberlets (and apertures) below main row; at least in microspheric form of elongate species, chamberlets of layers belonging to same chamber connected by radial passages which extend downward from preseptal passage; narrow sutural apertures connecting successive whorls, most species regularly coiled throughout (although microspheric form slightly irregular). *L.Cret.* (*U.Alb.*)-*U.Cret.* (*Cenoman.*-*Turon.*), N.Afr.-Eu. (Fr.-Spain-Port.)-Asia (M.East-India).

**P. (Praealveolina)**. Microspheric form at least provided with secondary chamberlets. *U.Cret.* (*Cenoman.*), Fr. (Beaussset).—FIG. 395,2. *\*P. (P.) tenuis*;  $\times 45$  (\*2119A).

**P. (Simplealveolina)** REICHEL, n.subgen., herein [*\*P. simplex* REICHEL, 1936, \*1514, p. 67]. Secondary chamberlets lacking in both micro- and megalospheric generation. *U.Cret.* (*Cenoman.*), Eu. (Fr).—FIG. 396,1. *\*P. (S.) simplex*, Île Madame;  $\times 55$  (\*2119A).

**Subalveolina** REICHEL, 1936, \*1514, p. 73 [*\*S. dordonica*; OD]. Test fusiform in type-species, spherical in smallest ones; septula without definite arrangement, with small alveoli instead of postseptal