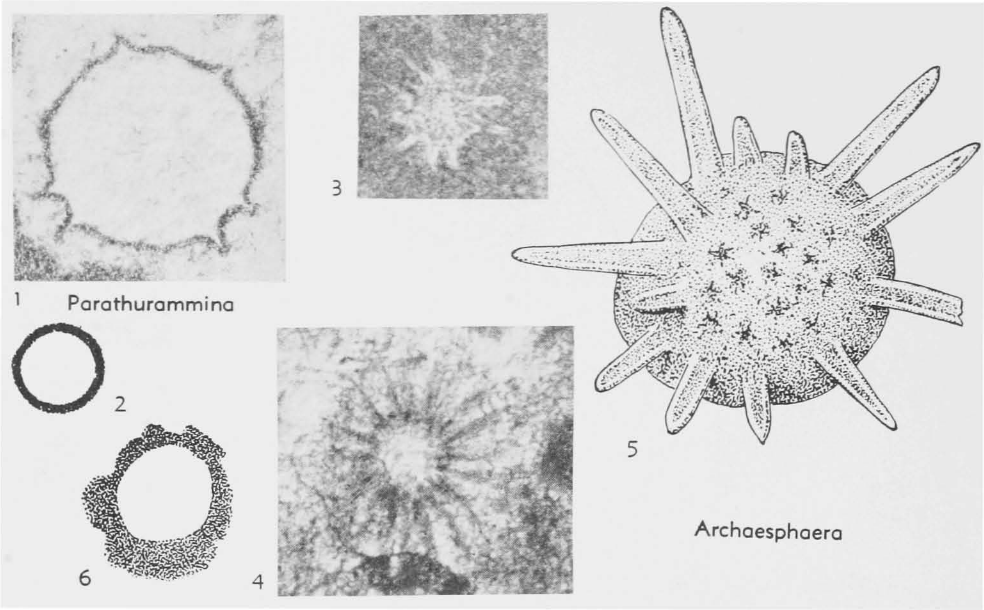


FIG. 225. Parathuramminidae; *1, Parathurammina; 2-6, Archaesphaera* (p. *C*314).

Parathurammina SULEYMANOV, 1945, *1851, p. 126 [**P. dagmarae*; OD] [=*Thurammina (Salpingothurammina)* POYARKOV in PURKIN, POYARKOV & ROZHANETS, 1961, *1490, p. 31 (type, *Parathurammina tuberculata* LIPINA, 1950, *1142, p. 118)]. Test free, globular, 0.2 to 0.45 mm. diam.; wall calcareous, granular, may appear striate in section, surface with numerous tubular protuberances; apertures at ends of protuberances. *Dev.-L.Carb. (L.Tournais.),* USSR(Volga-Ural area).——FIG. 225,*1*. **P. dagmarae,* U.Dev., USSR (W.Sib.); ×50 (*831).

[POYARKOV, 1961, *1490, regarded *Parathurammina* as composed of agglutinated calcareous particles and therefore a synonym of *Thurammina,* which has a similar shape. He did not regard the wall composition as having generic importance but subdivided *Thurammina* into 2 subgenera on the basis of apertural features. *Thurammina (Thurammina)* has papillate ("nipple-like") protuberances, whereas *Thurammina (Salpingothurammina)* has tubular projections upon which were situated the apertures. The species included in *Salpingothurammina* are those commonly placed in *Parathurammina;* hence a modified definition or emendation of that genus would have been sufficient. The new name proposed by POYARKOV is a junior synonym of *Parathurammina,* regardless of which criterion is considered for generic separation. POYARKOV stated that the apertural protuberances might reflect pseudopodial form, the papillate ones *(Thurammina)* formed by "lobopodia," and the tubular ones ("Salpingothurammina," =*Parathurammina*) due to "rhizopodia." No true Foraminiferida are known to have lobopodia, as these are found only in the Amoebida and Arcellinida; hence, the pseudopodial nature probably is not the cause of the different forms of apertural projections. *Parathurammina* is here considered to have a secreted granular wall, not an agglutinated one as in *Thurammina*.]

Archaesphaera SULEYMANOV, 1945, *1851, p. 126 [**A. minima*; OD] [=*Vicinesphaera* ANTROPOV, 1950, *25, p. 22 (type, *V. squalida*)]. Test free, globular, 0.08-0.34 mm. in diam., surface smooth; wall thin, calcareous, dark, uniform, finely granular; no pores or aperture observed. *Dev.-L.Carb.,* USSR(Ukraine).——FIG. 225,*2-5*. **A. minima,* L.Carb.(Tournais.), Ukraine; *2,* sec., ×80 (*1851); *3,4,* ×100; *5,* restoration, ×330 (*261). ——FIG. 225,*6*. *A. squalida* (ANTROPOV), Dev. (Famenn.), Tataria; ×60 (*1509).

[The original description is as given above. The genus was emended by E. V. BYKOVA (1955, *261), who stated that the spherical test has numerous spines projecting from the surface layer and that the wall is composed of 2 layers, the outer one being thin, obscure, finely granular, porous and not generally preserved, whereas the inner layer is clear, homogeneous, and radially striate owing to the coarse perforation. *Vicinesphaera* was described as differing from *Archaesphaera* in its more irregular wall, but this seems probably to be a result of the preservation.]

Bisphaera BIRINA, 1948, *139, p. 159 [**B. malevkensis;* OD]. Test comprising single chamber but with central constriction suggesting tendency toward double-chambered form; wall single layered, of finely granular calcite, porous; no aperture observed. *M.Dev.-L.Carb.(Tournais.),* USSR(W. Urals, Russian Platform).——FIG. 226,*1,2*. **B. malevkensis,* Dev., Bashkir, ASSR; *1,* sectioned specimen; *2,* reconstr., ×100 (*261).

Cribrosphaeroides REYTLINGER in RAUZER-CHERNOUSOVA & FURSENKO, 1959, *1509, p. 174 [**Cribrosphaera simplex* REYTLINGER, 1954, *1561, p. 65: OD] [=*Cribrosphaera* REYTLINGER, 1954, *1561, p. 65 (obj.) (*non Cribrosphaera* POPOFSKY, 1906); *Cribrosphaerella* PRONINA, 1960, *1485, pl. 25, fig. 1 (expl. of pl. 25 given as *Cribrosphaeroides*); *Cribsophaeroides* PRONINA, 1960, *1485, p. 140 *(nom. null.)*]. Test circular or irregular in form; wall granular, coarsely perforate; without apparent aperture. *Dev.(Frasn.),* USSR(Russian Platform).——FIG. 226,*3*. **C. simplex* (REYTLINGER); holotype, ×140 (*1561).

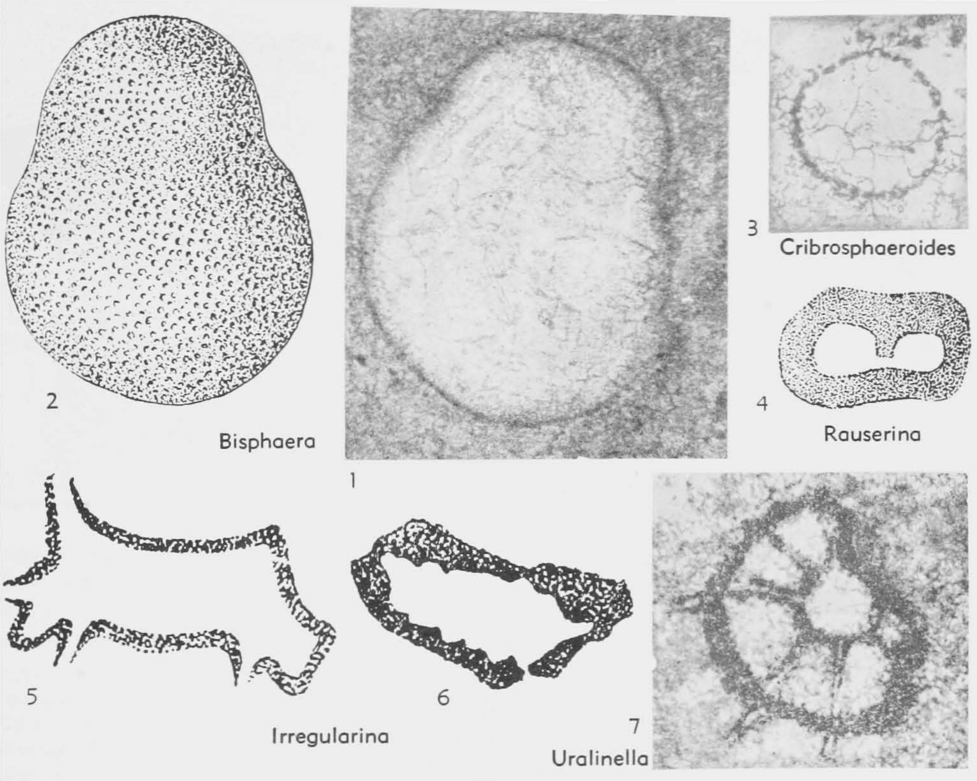


FIG. 226. Parathuramminidae; *1,2, Bisphaera; 3, Cribrosphaeroides; 4, Rauserina; 5,6, Irregularina; 7, Uralinella* (p. *C*314-*C*316).

Irregularina E. V. Bykova in Bykova & Polenova, 1955, *261, p. 21 [**I. karlensis* Vissarionova, 1950, *2010, p. 35; OD] [=*Irregularina* Vissarionova, 1950, *2010, p. 35 *(nom. nud.)*; *Corbis* Antropov, 1950, *25, p. 26 (type, *C. nodosus*) (*non* Cuvier, 1817); *Corbiella* Reytlinger, 1954, *1561, p. 62 *(nom. nud.)*; *Corbiella* Antropov in Rauzer-Chernousova & Fursenko, 1959, *1509, p. 175 (*nom. subst. pro Corbis* Antropov, 1950, obj.)]. Test free, consisting of single irregular chamber; wall calcareous; aperture at ends of necklike projections. *U.Dev.(Givet.) - L.Carb. (Tournais.)*, C.Asia-USSR(Russian Platform).——FIG. 226,*5*. **I. karlensis,* Dev.(Givet.), Baskiri; sectioned specimen, ×150 (*1509).——FIG. 226, *6*. *I. nodosa* (Antropov), U.Dev.(Frasn.), Tataria; sectioned specimen, ×120 (*1509).

[Vissarionova (1950, *2010) described *Irregularina* and included 3 species, *I. cardiformis, I. mopha* (listed as *I. morpha*, p. 30, and on figure explanation) and *I. karlensis* (as *Iiregularina karlensis* on p. 35). None was designated as type-species. The "genotype" species was stated to be *I. karlensis* by Bykova in Bykova & Polenova (1955, *261, p. 21); hence, the genus dates from 1955 and is credited to Bykova, according to the International Rules of Zoological Nomenclature. *Corbiella* was described as being irregular or boxlike, the aperture not being observed. Because of its irregular form, like that of *Irregularina*, it seems probable that nonoriented sections might not have intersected the aperture, and they are here regarded as synonymous.]

Palachemonella H. Beckmann, 1953, *104, p. 265 [**P. torleyi*; OD]. Test consisting of single ovate to globular or irregular chamber; wall of granular calcite, in sections with dark inner layer (pseudochitin?) and light outer layer, with small percentage of foreign matter?, apertures rounded, at ends of irregularly spaced necklike protuberances. *M.Dev.*, Eu.——FIG. 227. **P. torleyi,* Ger.; ×85 (*2117).

Petchorina Reytlinger, 1962 (see p. *C*796).

Quasituberitina Poyarkov in Purkin, Poyarkov & Rozhanets, 1961, *1490, p. 24 [**Q. magna;* OD] [=*Quasituberitina* Poyarkov, 1957, *1480, p. 33, 35 *(nom. nud.)*]. Test with small spherical proloculus followed by strongly enveloping larger second chamber, intercommunicating by means of relatively large opening; wall dark, finely granular, homogeneous and imperforate. [Originally placed in the Stegnamminidae, this genus is here transferred to the Parathuramminidae.] *Dev.(U. Famenn.)*, USSR.——FIG. 228. **Q. magna;* ×130 (*1490).

Rauserina Antropov, 1950, *25, p. 27 [**R. notata*; OD]. Test free, of 1 or 2 subglobular chambers; wall calcareous, finely granular; external aperture not observed but intercameral opening present. [*Rauserina* differs from *Archaesphaera* in having

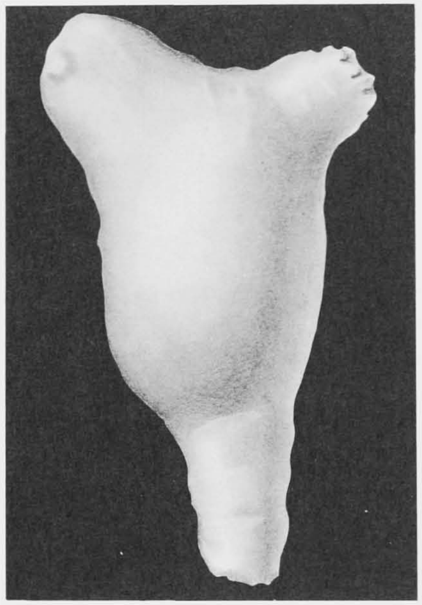


FIG. 227. Parathuramminidae; *Palachemonella* (p. C315).

2 chambers and from *Eovolutina* in the chambers being adjacent rather than concentric.] *M.Dev.(Givet.) - U.Dev.(Famenn.)*, USSR(Russian Platform).——FIG. 226,4. **R. notata*, U.Dev.(Frasn.); sectioned specimen, ×140 (*1509).

Uralinella E. V. BYKOVA, 1952, *257, p. 15 [**U. bicamerata*; OD]. Test with 2 chambers, globular proloculus nearly completely surrounded by outer 2nd chamber; wall calcareous, finely granular; 5 to 8 apertures at periphery of proloculus, with elongate tubular necks which extend through interior of embracing 2nd chamber and continue as similar necks and openings at surface of final chamber. [Groups of specimens may be found closely adjacent in thin sections, suggesting possible colonial development.] *U.Dev.*, USSR(Urals: Bashkir-Tartar).——FIG. 226,7. **U. bicamerata*; thin section of holotype, ×100 (*257).

Uslonia ANTROPOV, 1959, *25A, p. 28 [**U. permira*; OD]. Test consisting of single irregular chamber 0.5 to 2.0 mm. in length; wall calcareous, homogeneous, perforate; aperture not observed. *U.Dev.(U.Frasn.)*, USSR(Bashkir - Tatar - Udmurt).——FIG. 228A,*1*. **U. permira*; *1a*, holotype, sec.; *1b*, paratype, ×14 (*25A).

[Originally placed in the Saccamminidae, the genus is known only from nonoriented sections of the type-species and was thought possibly to be an attached form. It is here transferred to the Parathuramminidae. The test is quite similar in appearance to that of the Devonian *Palachemonella*, and if additional material shows the presence of apertures at ends of the irregular projections it would probably be congeneric.]

FIG. 228. Parathuramminidae; *Quasituberitina* (p. C315).

Family CALIGELLIDAE Reytlinger, 1959

[Caligellidae REYTLINGER in RAUZER-CHERNOUSOVA & FURSENKO, 1959, p. 175]

Test tubular or enrolled, may have irregular constrictions or projections from wall, tending to become septate in advanced forms; aperture simple or irregular. *U.Dev.-L.Carb.*

Caligella ANTROPOV, 1950, *25, p. 28 [**C. borovkensis*; OD] [=*Evlania* E. V. BYKOVA, 1952, *257, p. 20 (type, *E. transversa*); *Baituganella* LIPINA, 1955, *1143, p. 19 (type, *B. chernyshinensis*); *Paracaligella* LIPINA, 1955, *1143, p. 26 (type, *P. antropovi*)]. Test free? or attached, tubular, early portion may be slightly coiled, later portion uncoiling; partially divided by incomplete septa, or more rarely complete septa, into irregularly sized chambers; wall calcareous, aperture rounded, terminal, may have thickened margin or neck. [Modifications of the basic form have been the basis for 4 generic names, which include a total of 7 species, most of which are known only from thin sections. Their differences are here regarded as of only specific rather than generic importance.]

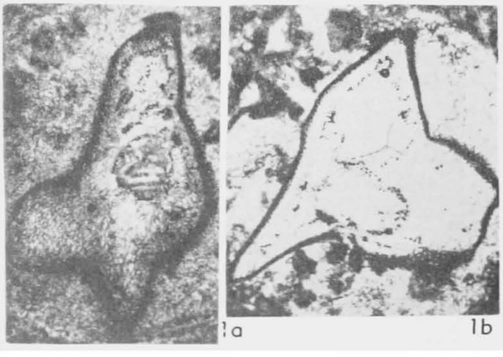


FIG. 228A. Parathuramminidae; *1, Uslonia* (p. C316).

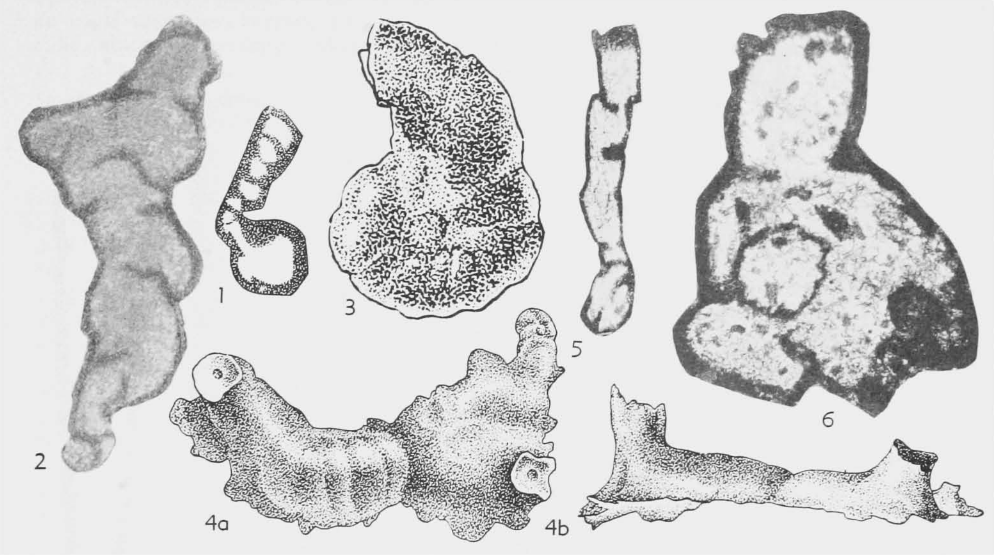


Fig. 229. Caligellidae; *1-6, Caligella* (p. *C*316-*C*317).

U.Dev.(Frasn.-Famenn.)-L.Carb.(Tournais.),USSR (Russian Platform-Volga-Ural Region).——Fig. 229,*1*. **C. borovkensis*, U.Dev., ×66 (*1509).——Fig. 229,*2-4*. *C. transversa* (E. V. Bykova), M. Dev., USSR(Voronez Distr.); *2*, holotype, ×66; *3*, paratype, early enrolled stage, ×160; *4a,b*, top, edge views of paratype, ×66 (*257).——Fig. 229, *5*. *C. antropovi* (Lipina), U.Dev.; holotype, ×47 (*1143).——Fig. 229,*6*. *C. chernyshinensis* (Lipina), L.Carb.(Tournais.), holotype, ×47 (*1143).

Shuguria Antropov, 1950, *25, p. 30 [**S. flabelliformis;* OD]. Test free, flattened, flabelliform, to 0.84 mm. in length; chambers of early stage planispiral, later biserial and finally multiserial, with somewhat separated series; wall calcareous, structure obscure; apertures as openings at periphery. *U.Dev.(Frasn.)*, Russian Platform.——Fig. 230. **S. flabelliformis;* enlarged (*25).

Family MORAVAMMINIDAE
Pokorný, 1951

[*nom. transl.* Loeblich & Tappan, 1961, p. 283 (*ex* subfamily Moravammininae Pokorný, 1951)] [=Earlandiidae Cummings, 1955, p. 227]

Test globular to tubular and nonseptate, free or attached; aperture simple and terminal. *Ord.-Carb.*

Subfamily EARLANDIINAE Cummings, 1955

[*nom. transl.* Pokorný, 1958, p. 169 (*ex* family Earlandiidae Cummings, 1955)]

Test free, tubular or uniserial. *Ord.-Carb.*

Earlandia Plummer, 1930, *1462, p. 12 [**E. perparva*; OD] [=*Syzrania* Reytlinger, 1950, *1560, p. 92 (type, *S. bella*)]. Test free, elongate, with globular proloculus followed by long nonseptate tubular chamber; wall of finely granular calcite; aperture at open end of tube. *Dev.-Penn.*, Brit.I.-USA(Tex.)-USSR.——Fig. 231,*1,2*. **E. perparva*, Penn., USA(Tex.); *1*, topotype, ×90 (*2117); *2*, diagram. long. sec., ×50 (*400).——Fig. 231,*3*. *E. bella* (Reytlinger), U.Carb., USSR (Syzran); sectioned holotype showing nonseptate tube, ×96 (*1560).

Earlandinita Cummings, 1955, *400, p. 230 [**Nodosinella perelegans* Plummer, 1930, *1462, p. 14; OD]. Test free, elongate, uniserial, straight or slightly arcuate; septa and chambers well defined; wall calcareous, finely granular; aperture terminal, rounded. [*Earlandinita* differs from *Paratikhinella* in having complete septa and from *Nodosinella* in its single-layered wall.] *L.Carb.(Avon.)*, Brit.I.; *Penn.*, USA(Tex.).——Fig. 231,*8-10*. **E. perelegans* (Plummer), Penn., USA(Tex.); *8,9*, holotype and paratype, ×100 (*1462); *10*, diagram. sec., ×90 (*400).

Fig. 230. Caligellidae; *Shuguria* (p. *C*317).

Lugtonia Cummings, 1955, *400, p. 231 [**Nodosinella concinna* Brady, 1876, *193, p. 106; OD]. Test free, small, tapering, globular chambers in rectilinear arrangement; sutures constricted, septa domed internally; original wall composition uncertain, replaced by amorphous or crystalline silica;

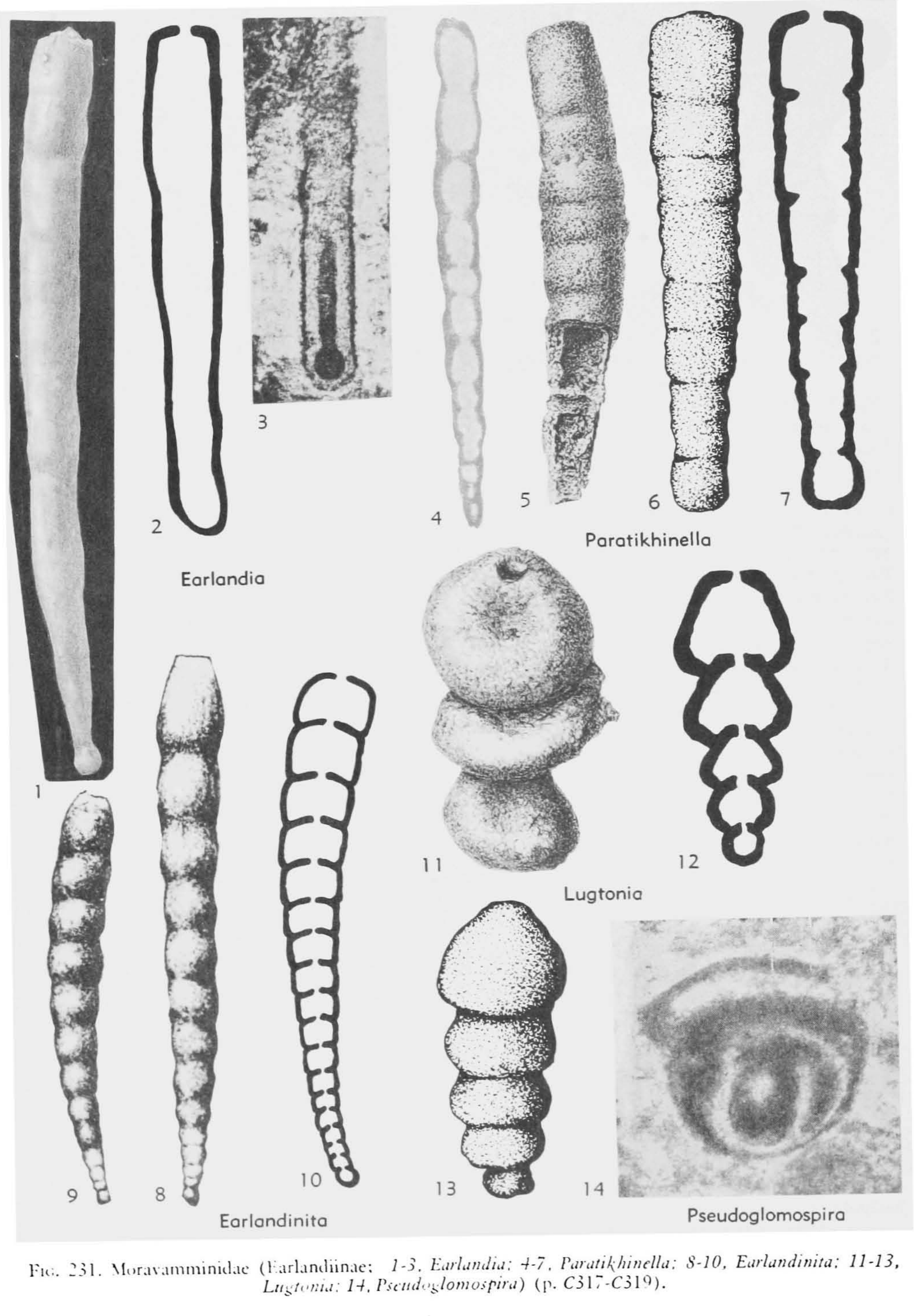


Fig. 231. Moravamminidae (Earlandiinae; *1-3, Earlandia; 4-7, Paratikhinella; 8-10, Earlandinita; 11-13, Lugtonia; 14, Pseudoglomospira*) (p. *C*317-*C*319).

aperture terminal, rounded. [Known only from sediments where secondary silicification has occurred, but there associated with secondarily silicified species belonging to the Parathuramminacea and Endothyracea.] *L.Carb.(Visean-Namur.)*, Brit. I.——FIG. 231,*11-13*. **L. concinna* (BRADY); *11, 12,* side view and sectioned specimen, ×45 (*400); *13,* side view of holotype, ×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, ×100 (*257).——FIG. 231,*5-7*. *P. cylindrica* (BRADY), L.Carb., Eng.; *5,* lectotype, ×30 (*193); *6,7,* side view and sectioned specimen, ×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, ×100 (*261).

Saccamminopsis SOLLAS, 1921, *1811, p. 193, 211 [**Saccammina 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 labyrinthic appearance.] *Ord.-Carb.*, Brit.I.——FIG. 232,*1,2*. **S. fusulinaformis* (M'COY); *1,* exterior of various specimens, ×2 (*193); *2,* sectioned specimen, ×16 (*1811).

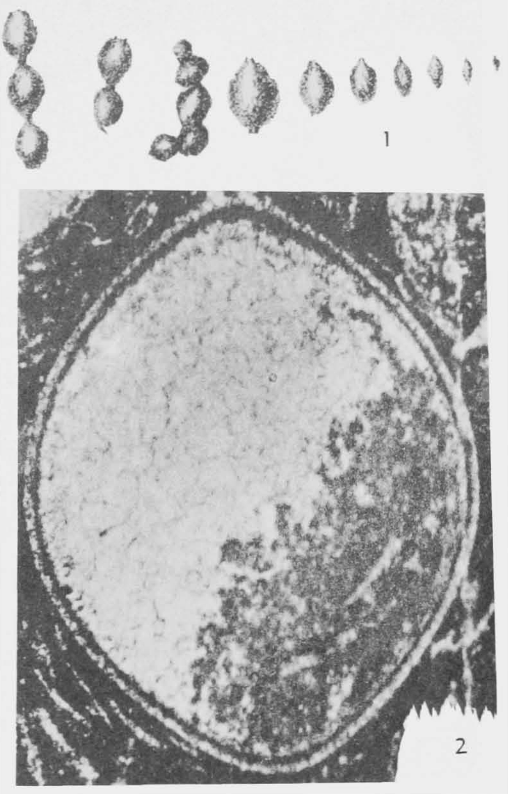


FIG. 232. Moravamminidae (Earlandiinae; *1,2*, *Saccamminopsis*) (p. C319).

Subfamily MORAVAMMININAE Pokorný, 1951

[Moravammininae POKORNÝ, 1951, p. 7]

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

Moravammina POKORNÝ, 1951, *1472, p. 7 [**M. segmentata*; OD] [=*Litya* E. V. BYKOVA in E. V. BYKOVA & POLENOVA, 1955, *261, p. 27 (type, *L. sizranensis*)]. Test tubular, attached by proloculus, may be enrolled about attachment, later uncoiled and erect; chambers separated by equally spaced thin septa; wall calcareous, finely granular; aperture rounded, terminal. [*Litya* was regarded as differing from *Moravammina* 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, ×59 (*2117).——FIG. 233,*2-4*. *M. sizranensis* (E. V. BYKOVA), U.Dev., USSR; *2,* holotype; *3a,b,* side, edge views of paratype; *4,* sec. showing septation; all ×66 (*261).

Kettnerammina 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 *Moravammina* 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, ×28 (*2117).——FIG. 233,*8,9*. *K. trivirgulina* (E. V. BYKOVA), U.Dev.(Frasn.), USSR; *8,* holotype; *9,* paratype, ×66 (*261).

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

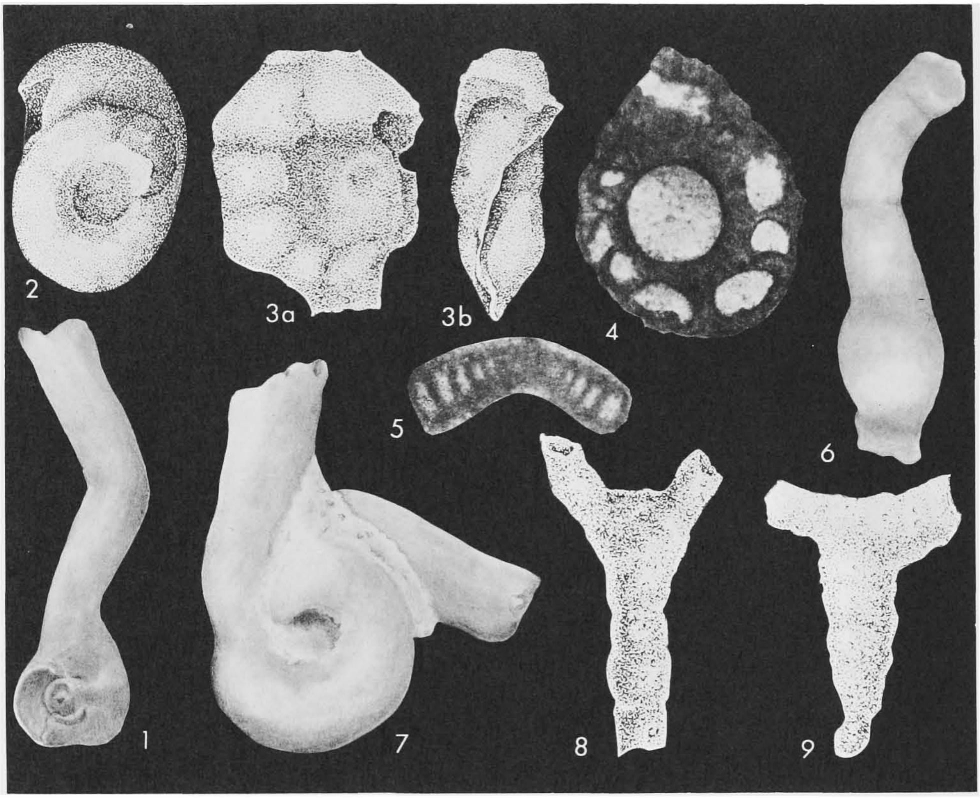


FIG. 233. Moravamminidae (Moravammininae; *1-4, Moravammina; 5, Turrispiroides; 6, Vasicekia; 7-9, Kettnerammina*) (p. *C*319-*C*320).

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, ×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, ×86 (*2117).

Superfamily ENDOTHYRACEA Brady, 1884

[*nom. correct.* LOEBLICH & TAPPAN, 1961, p. 284 (*pro* superfamily Endothyridea GLAESSNER, 1945, p. 107)]——[In synonymic citations superscript numbers indicate taxonomic rank assigned by authors (^{1}superfamily, ^{2}family group); dagger(†) indicates *partim*]——[=^{1}Orthoklinostegia† EIMER & FICKERT, 1899, p. 685; =Basistoma† SCHUBERT, 1921, p. 148; =^{2}Archi-Monothalamidia† RHUMBLER in KÜKENTHAL & KRUMBACH, 1923, p. 85; =^{2}Nodosalidia† RHUMBLER in KÜKENTHAL & KRUMBACH, 1923, p. 86; =^{2}Rotaliaridia† RHUMBLER in KÜKENTHAL & KRUMBACH, 1923, p. 88; =^{2}Textulinidia† RHUMBLER in KÜKENTHAL & KRUMBACH, 1923, p. 88; =^{1}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*]——[=Nodosamminidae† RHUMBLER, 1913, p. 339 (*nom. nud.*); =Nodosinellida COPELAND, 1956, p. 186 (*nom. van.*); =Tuberitinidae MIKLUKHO-MAKLAY, 1958, p. 134]

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

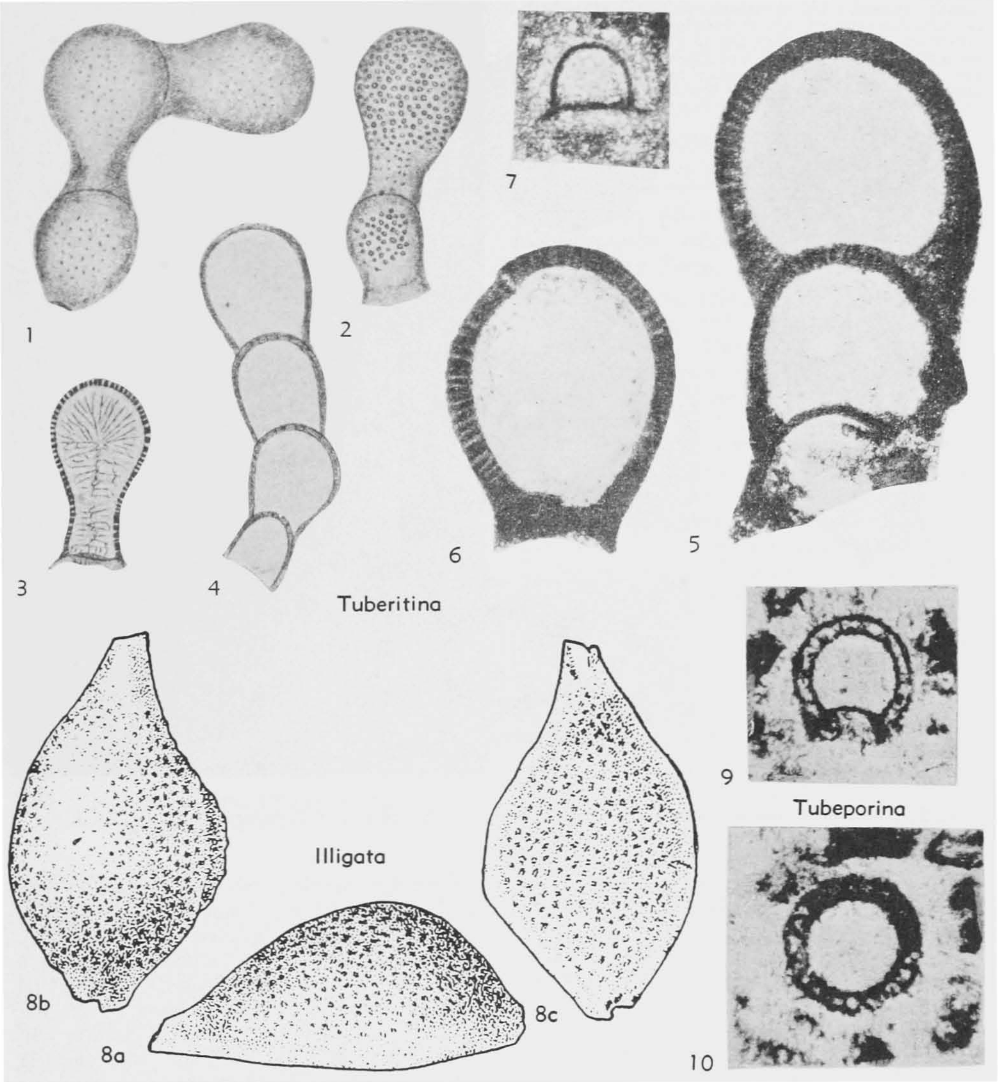


Fig. 234. Nodosinellidae (Tuberitininae; *1-7, Tuberitina; 8, Illigata; 9,10, Tubeporina*) (p. *C*321-*C*322).

Subfamily TUBERITININAE Miklukho-Maklay, 1958

[*nom. transl.* Loeblich & Tappan, 1961, p. 284 (*ex* family Tuberitinidae 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.,*

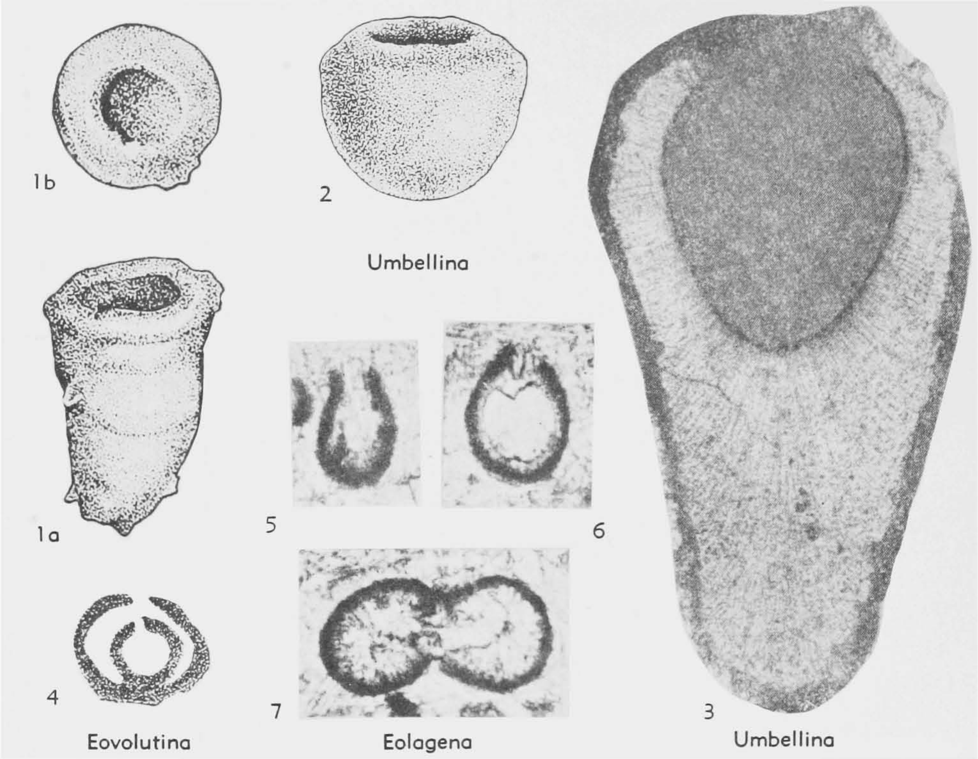


FIG. 235. Nodosinellidae (Umbellininae; *1-3, Umbellina; 4, Eovolutina; 5-7, Eolagena*) (p. C322-C323).

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 ×35 (*763).——FIG. 234,*5,6*. *T. collosa* REYTLINGER, M.Carb.(U.Moscov.), USSR; holotype and paratype, ×90 (*700).——FIG. 234,*7*. *T. reitlingerae* (A. D. MIKLUKHO-MAKLAY), M.Carb., USSR; holotype, ×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, ×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 Tuberitininae. BYKOVA (*258, p. 22) stated that *Thurammina 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 *Tuberitina* 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, ×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

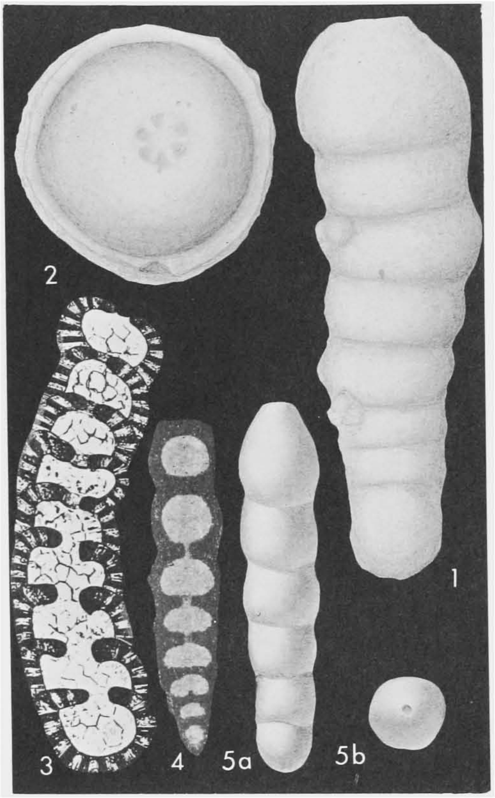


FIG. 236. Nodosinellidae (Nodosinellinae; *1-5*, *Nodosinella*) (p. *C323-C324*).

Platform-W.Urals-Kazakh.).——FIG. 235,*1-3*. **U. bella* (MASLOV); *1a,b,* side, top views of elongate specimen, ×85; *2,* side view of subglobular form, ×100; *3,* long. sec. of large specimen showing thick radially perforate wall, ×100 (*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 ×140 (*1144).

Eovolutina ANTROPOV, 1950, *25, p. 29 [**E. elementa*; OD]. Test globular, wtih 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, ×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 micrgranular 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.) nodosariformis*); *Eonodosaria* LIPINA, 1950, *1142, p. 126 (type, *E. evlanensis*); *Tiḳhinella* E. V. BYKOVA, 1952, *257, p. 29 (type, *T. measpis*); *Protonodosaria* GERKE, 1959, *779, p. 42 (type, *Nodosaria proceraformis* 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, ×48; 236,*2*, top view of broken paratype (BMNH-P41658) showing apparently multiple aperture in septum, not terminal face, ×48 (*2117); 237,*1a*, diagram.

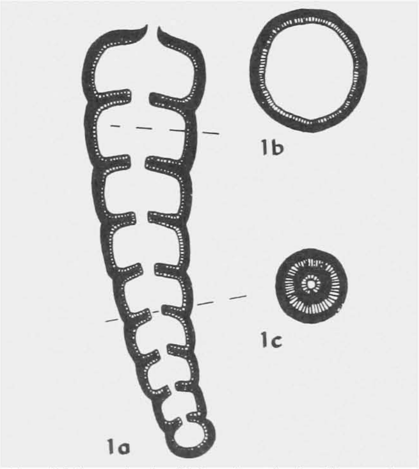


FIG. 237. Nodosinellidae (Nodosinellinae; *1*, *Nodosinella*) (p. *C323-C324*).

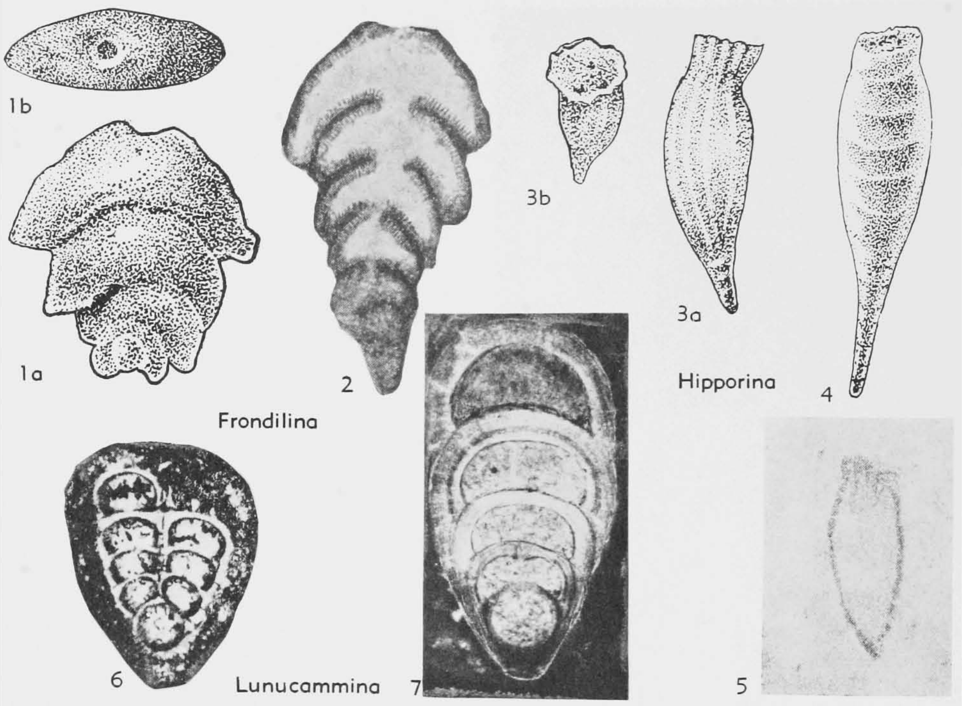


FIG. 238. Nodosinellidae (Nodosinellinae; *1,2, Frondilina; 3-5, Hipporina; 6,7, Lunucammina*) (p. *C324-C326*).

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

Frondilina 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 *Frondilina,* whereas the inner layer is granular in *Lunucammina.* Permian specimens referred to *Frondicularia* (*1264) belong to *Frondilina.*] *U.Dev.(Frasn.)-Perm.,* USSR (Urals).——FIG. 238,*1,2.* **F. devexis*; *1a,b,* side, top views of holotype, ×100; *2,* long. sec. of paratype, ×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; 3a,b,* side and oblique top views of holotype; *4,* paratype; *5,* sectioned specimen; all ×100 (*261).

Lunucammina SPANDEL, 1898, *1821, p. 8 [**Geinitzella (Lunucammina) permiana:* OD] [=*Geinit-*

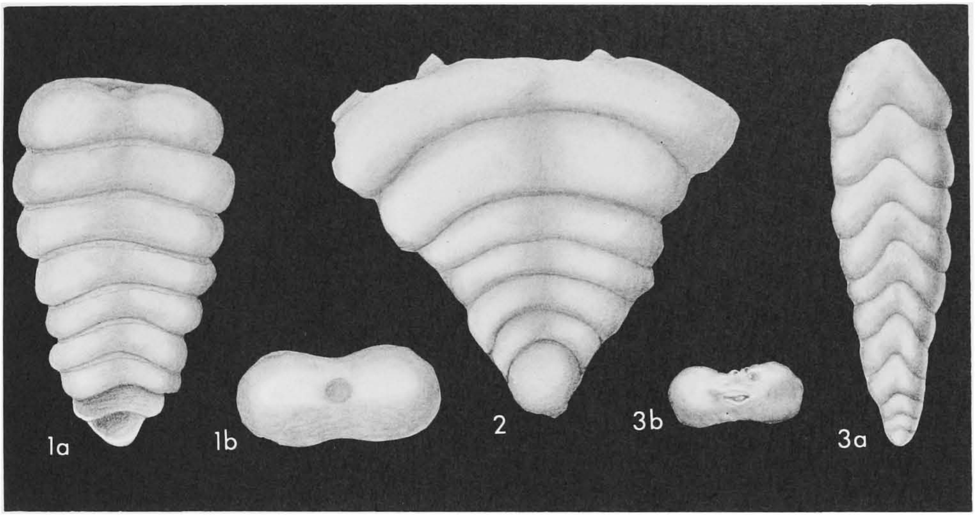


FIG. 239. Nodosinellidae (Nodosinellinae; *1-3, Lunucammina*) (p. *C*324-*C*326).

zella (Lunucammina) 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 *Frondicularia;* 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, ×105 (*2117).——FIG. 239,*2*. *L. jonesi* (BRADY), Perm., Eng.; side view (BMNH-P35421), ×105 (*2117).——FIG. 239,*3*. *L. excavata* (CUSHMAN & WATERS), Perm., USA(Tex.); side, top views of holotype, ×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, ×65 (*1277).——FIG. 238,*7*. *L. perforata* (LANGE), M.Perm., Indonesia; lat. long., but not axial sec., ×30 (*1091).

[*Lunucammina* 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. *Lunucammina* 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 wth *Lunucammina*. *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 *Lunucammina*. Species re-

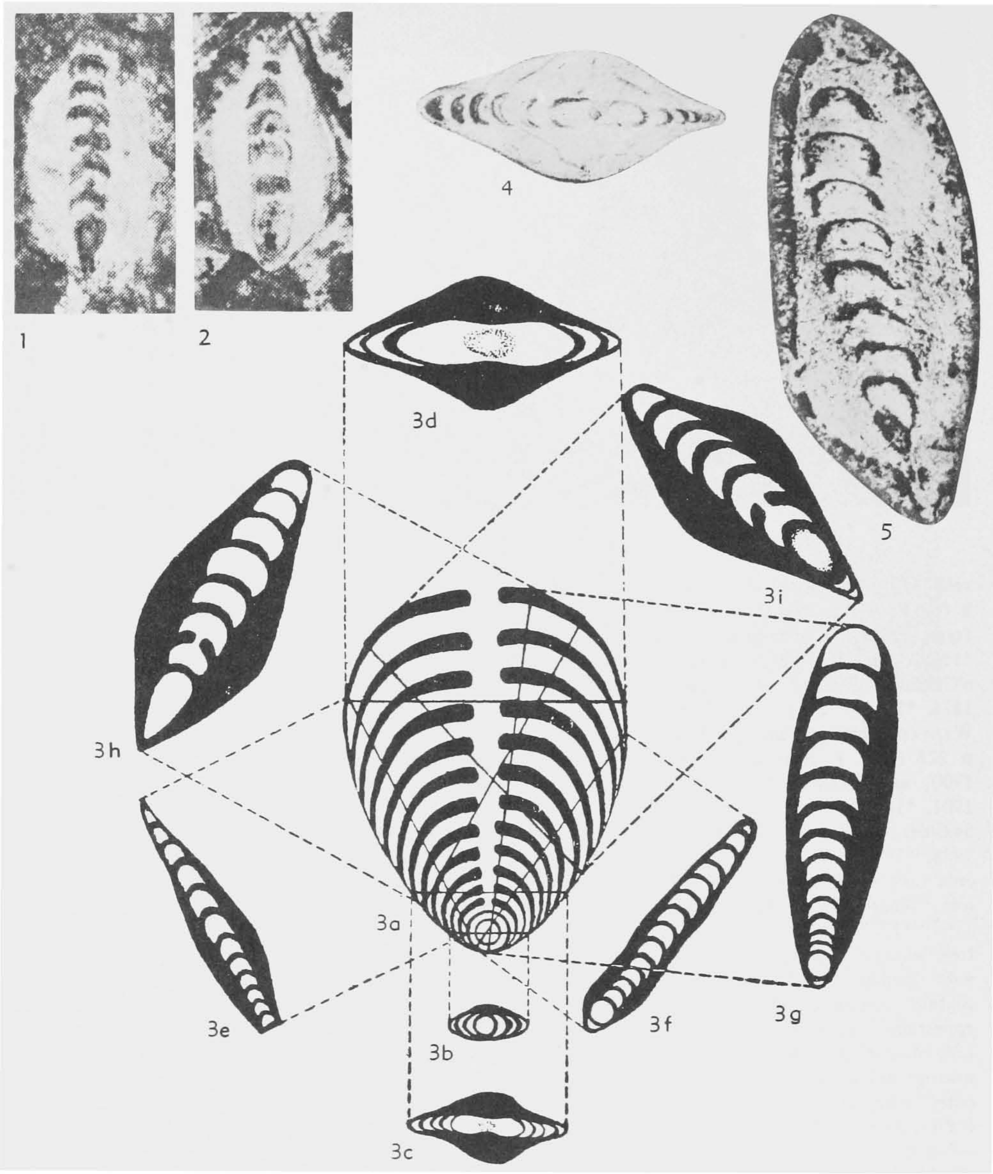


FIG. 240. Nodosinellidae (Nodosinellinae; *1-5, Pachyphloia*) (p. *C326-C328*).

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, regularly 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, epecially 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

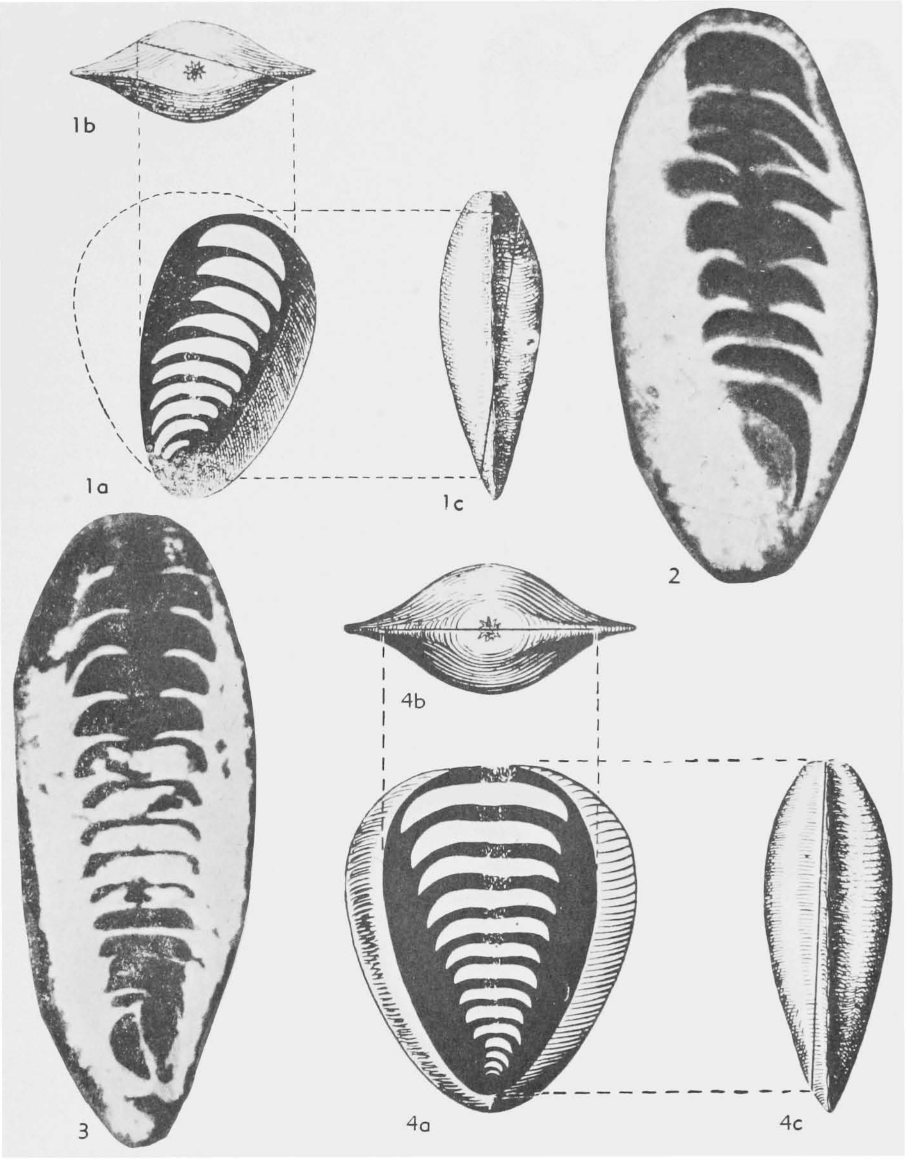


FIG. 241. Nodosinellidae (Nodosinellinae; *1-4, Pachyphloia*) (p. C326-C328).

lat. secs., ×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 represent axial sec. of a discoidal genus, ×47 (*1262).——FIG. 240,*5*. *P. asymmetrica* (K. V. MIKLUKHO-MAKLAY), U.Perm., C.Caucasus; holotype, slightly oblique lat. sec. (as in *3g,h*), ×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*), ×47 (*1277).——FIG. 241,*3*. *P. magna* (K. V. MIKLUKHO-MAKLAY), U.Perm., C.Caucasus, tang. sec. of holotype (as in *4a*), ×65 (*1277).——FIG.

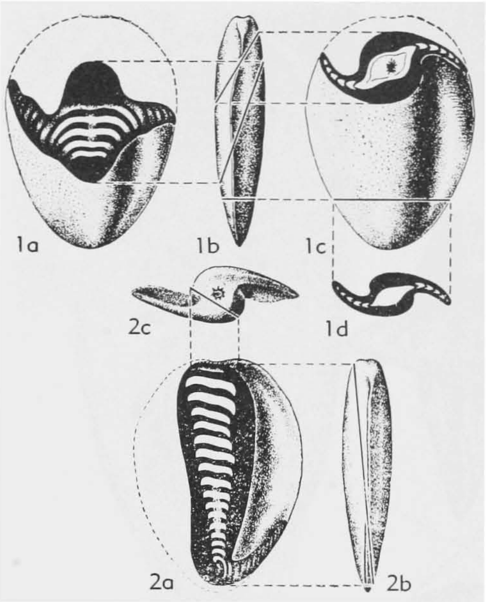


FIG. 242. Nodosinellidae (Nodosinellinae; *1,2, Pachyphloia*) (p. *C*326-*C*328).

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 COLANIELLIDAE 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 subcylindrical, uniserial and rectilinear, with broad, low and strongly domed chambers which are strongly overlapping for as much as half length of test; interior wtih 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., ×50; *2*, axial sec., ×100; *3*, transv. sec. near middle of test, strongly overlapping chambers resulting in appearance of small chamberlets, ×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., ×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., ×133; *2*, paratype, horiz. sec. showing 2 layers of wall and vertical partial partitions, ×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. ×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

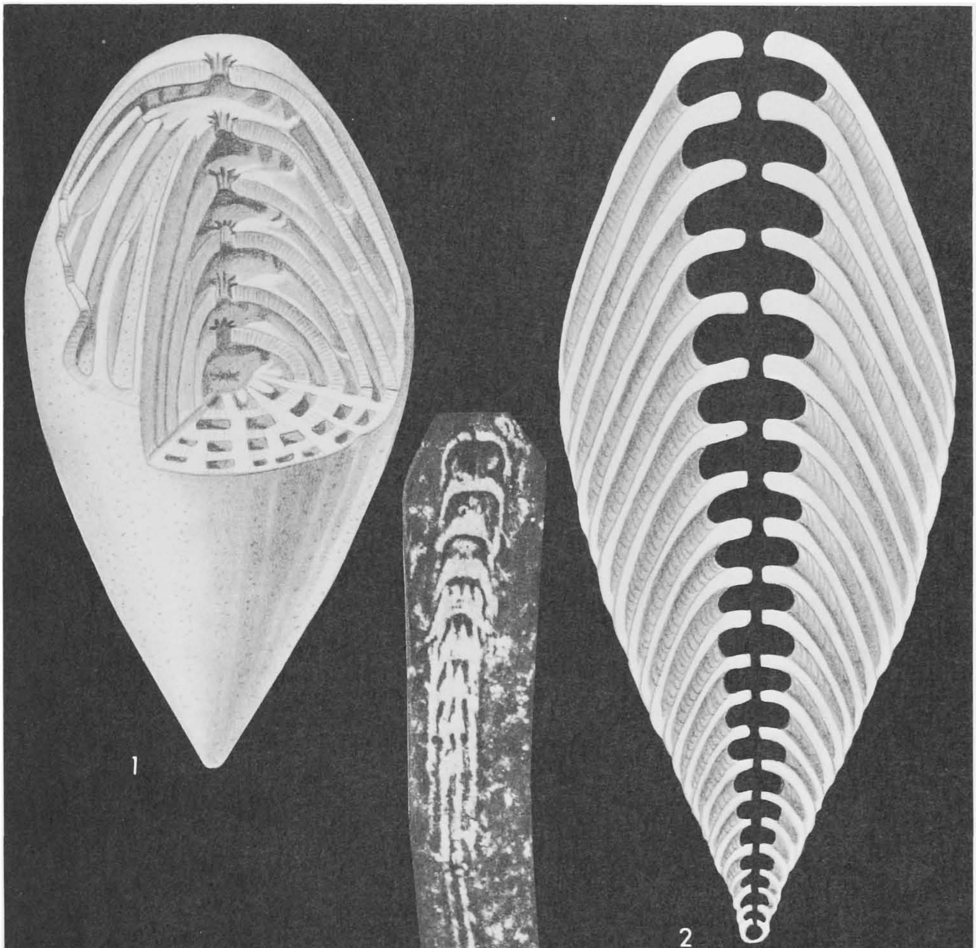


FIG. 243. Colaniellidae; *1-5, Colaniella* (p. C328).

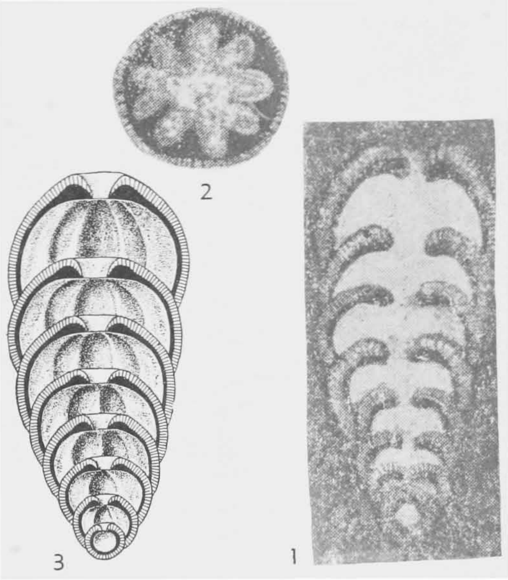


FIG. 244. Colaniellidae; *1-3, Multiseptida* (p. C328).

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, ×9 (*1966); *3*, specimen, ×20 (*696).

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, ×64 (*2117); *2*, sectioned paratype (BMNH-P35507, =*193, pl. 7, fig. 21), redrawn, ×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

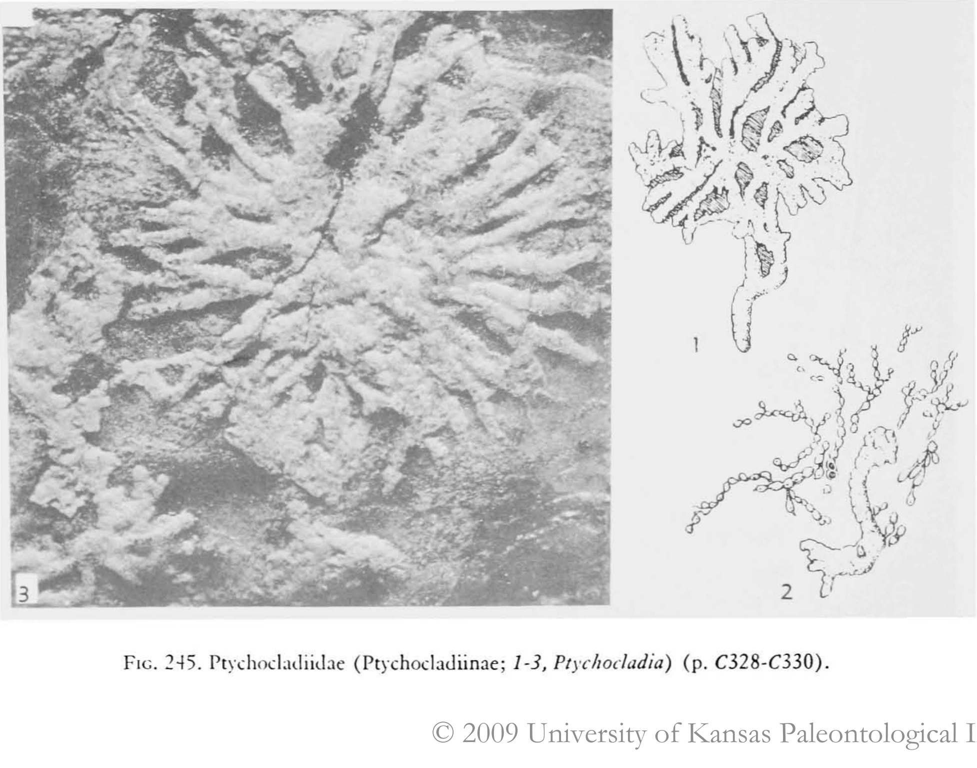


FIG. 245. Ptychocladiidae (Ptychocladiinae; *1-3, Ptychocladia*) (p. C328-C330).

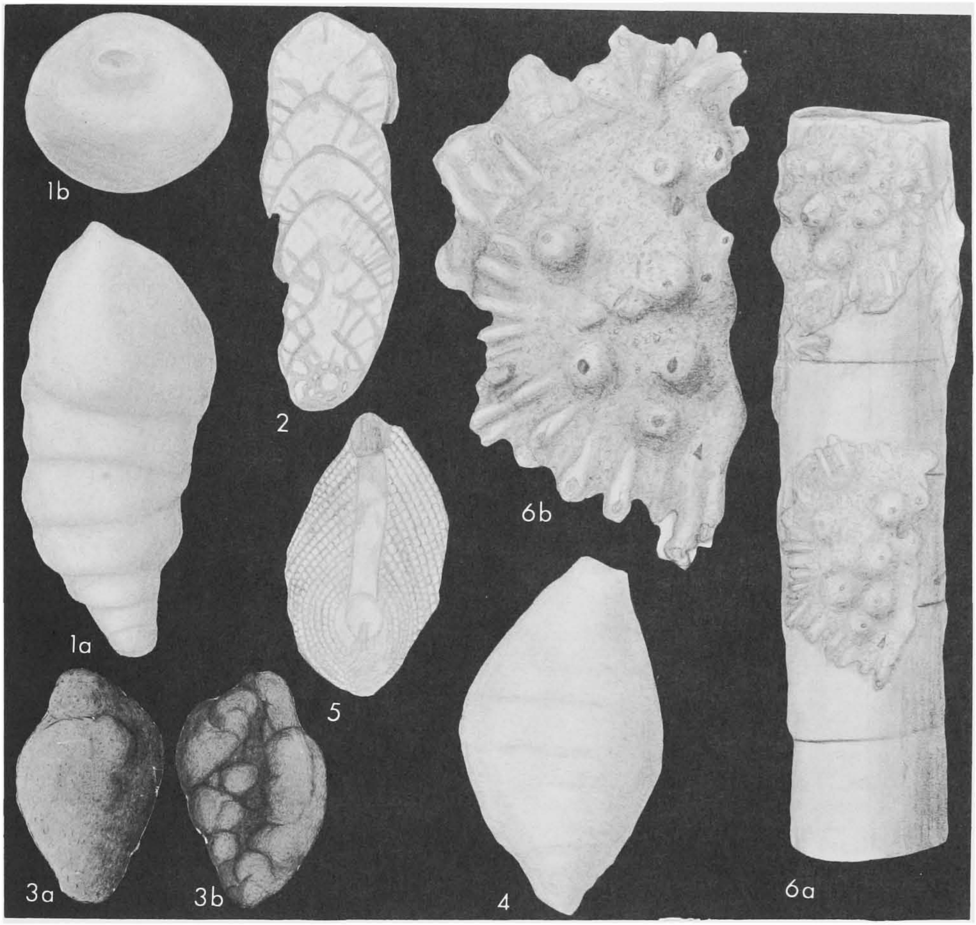


FIG. 246. Ptychocladiidae (Stacheiinae; *1,2, Stacheia; 3-5, Fourstonella; 6, Stacheoides*) (p. *C*330-*C*332).

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., ×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. *Aoujgalia* 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 *Aoujgalia* 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 mammilate 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, ×44 (*398); *4,* lectotype (BMNH-P41654, *ex*

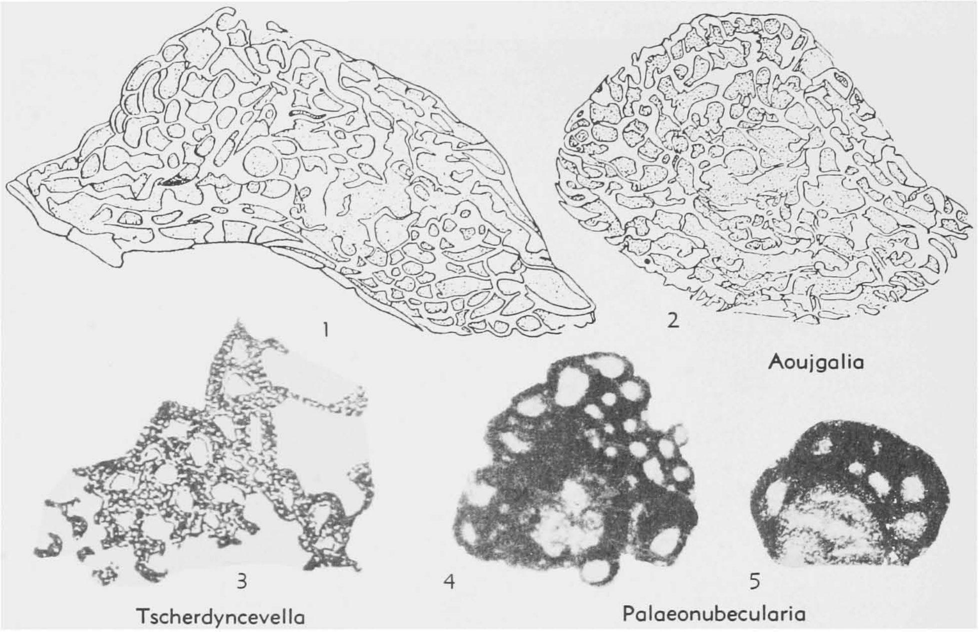


Fig. 247. Ptychocladiidae (Stacheiinae; *1,2, Aoujgalia; 3, Tscherdyncevella; 4,5, Palaeonubecularia*) (p. *C*330-*C*332).

P35458), redrawn; *5*, sectioned paratype (BMNH-P35509), redrawn; both ×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, ×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 mammilate protuberances; wall calcareous, finely granular, may have few quartz grains 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, ×10, ×22 (*2117); 248, diagram. sec. of chamberlets on an attachment, ×18 (*399).

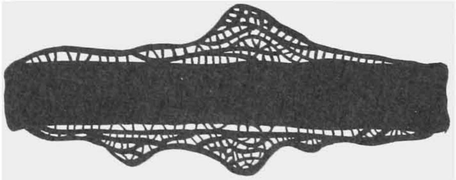


Fig. 248. Ptychocladiidae (Stacheiinae; *Stacheoides*) (p. *C*332).

[*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, ×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

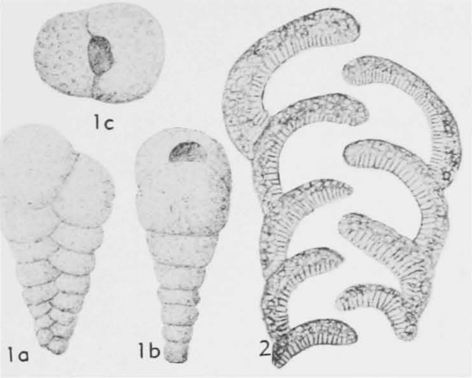


FIG. 249. Palaeotextulariidae; *1,2, Palaeotextularia* (p. *C*333).

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 Cribrostomum 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, ×35; *2,* portion of long. axial sec. showing 2 layers of wall, ×110 (*765).

Climacammina BRADY in ETHERIDGE, 1873, *711, p. 94 [**Textularia antiqua* BRADY in YOUNG & ARMSTRONG, 1871, *2097, p. 13; OD (M)] [=*Cribrostomum* MÖLLER, 1879, *1296, p. 39 (type, *C. textulariforme*); *Climaccamina* SCUDDER, 1882, *1709a, p. 77 *(nom. van.)*; *Moellerina* EIMER & FICKERT, 1899, *692, p. 677 (type, *Cribrostomum 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 terminal 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, ×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, ×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., ×22 (*1509).

[Four generic names have been based on species which we consider to belong to *Climacammina.* MÖLLER (1879) described *Cribrostomum* with 8 species, of which *C. textulariforme* MÖLLER was later selected as type. CUSHMAN separated *Cribrostomum* 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" *Cribrostomum textulariforme* "is without doubt the immature form of one of the five biformed species in the group of eight 'species' recorded in the same paper with the description of *Cribrostomum. C. commune* MÖLLER is recorded from the same localities as *C. textulariforme* and can well be the mature form of the species." PLUMMER considered *Cribrostomum* 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 *Cribrostomum* 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 *Cribrostomum* 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 *Cribrostomum gracile* MÖLLER. This species was originally placed in *Cribrostomum* and is typical of that genus. Furthermore, the

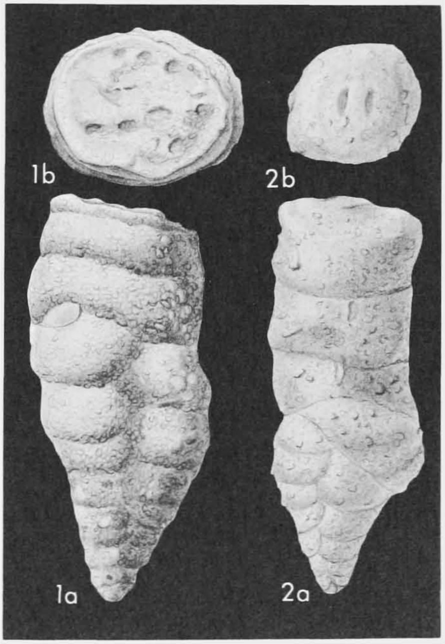


FIG. 250. Palaeotextulariidae; *1,2, Climacammina* (p. *C*333-*C*334).

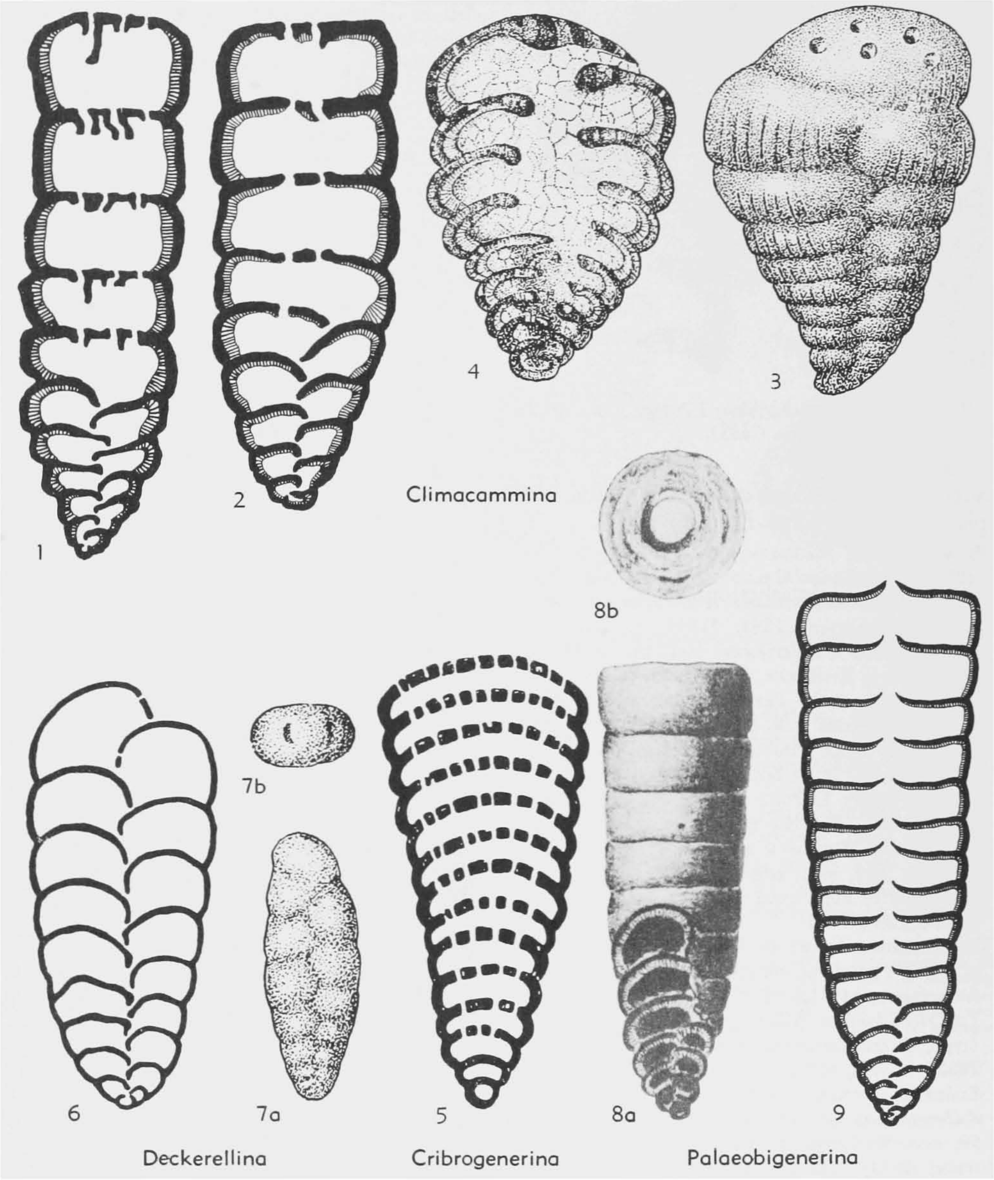


FIG. 251. Palaeotextulariidae; *1-4, Climacammina; 5, Cribrogenerina; 6,7, Deckerellina; 8,9, Palaeobigenerina* (p. C333-C335).

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, ×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

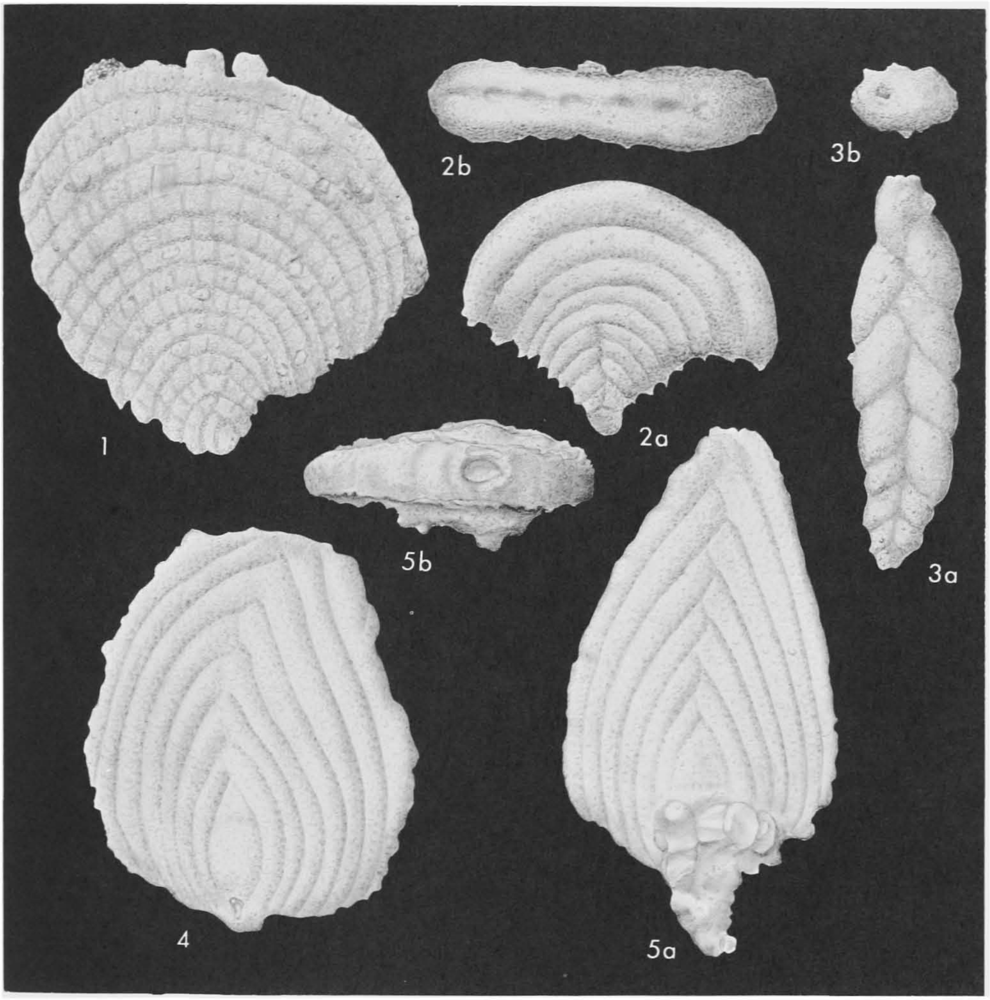


FIG. 252. Semitextulariidae; *1,2, Semitextularia; 3, Paratextularia; 4,5, Pseudopalmula* (p. C335-C337).

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 *Climacammina*. 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, ×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, ×25 (*700); *9,* diagram. long. axial sec. (*401).

Family SEMITEXTULARIIDAE Pokorný, 1956

[Semitextulariidae POKORNÝ, 1956, p. 284; Pseudopalmulidae E. V. BYKOVA in RAUZER-CHERNOUSOVA & 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,

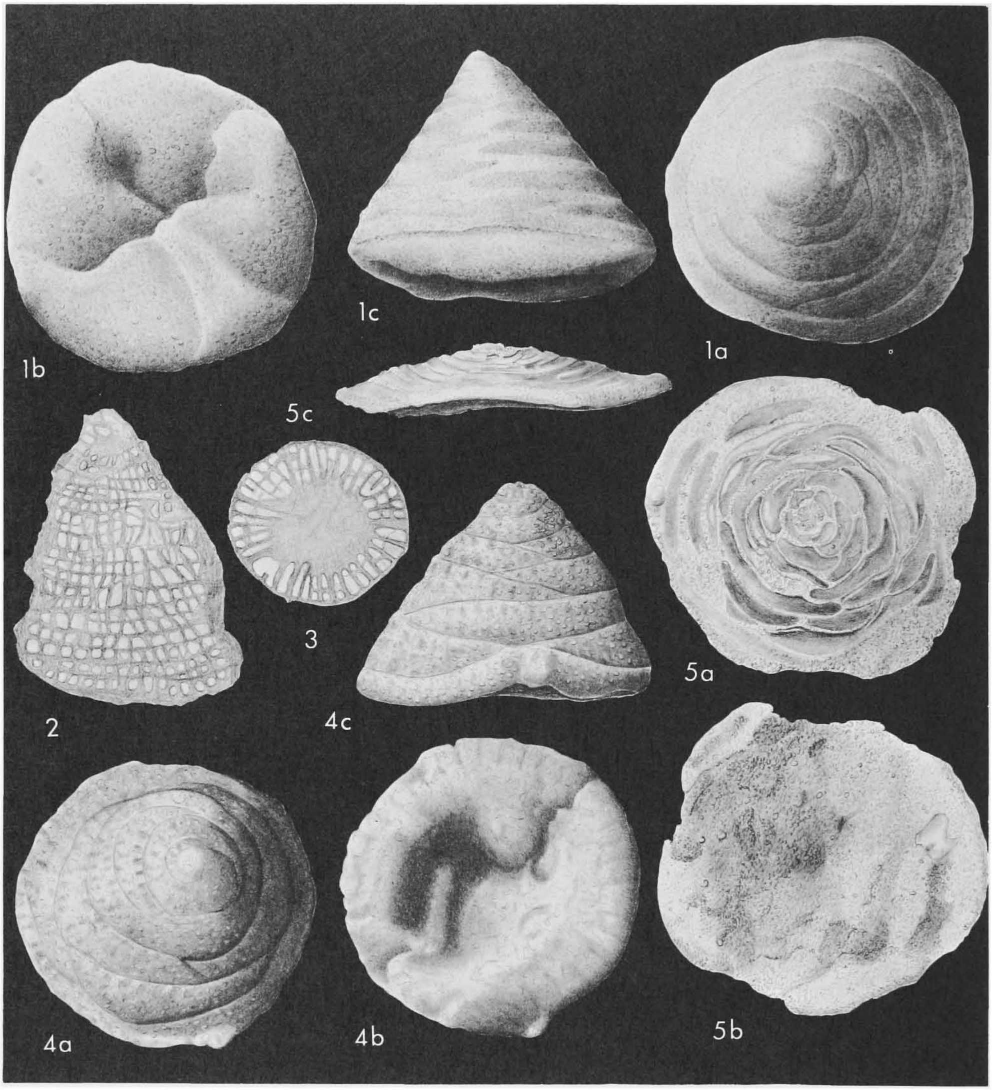


FIG. 253. Tetrataxidae; *1, Tetrataxis; 2-4, Valvulinella; 5, Polytaxis* (p. C337).

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 ×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] [=*Cremsia* 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, ×109 (*2117).

[*Paratextularia* and *Cremsia* 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

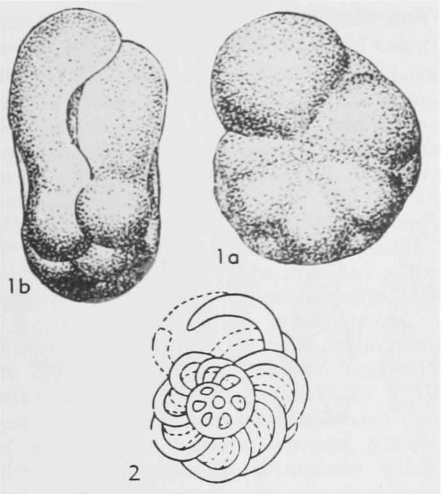


FIG. 254. Biseriamminidae; *1,2, Biseriammina* (p. C338).

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, ×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, ×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, ×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-

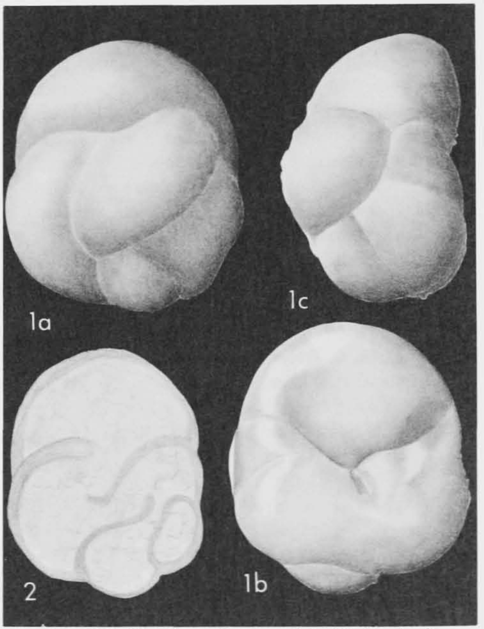


FIG. 255. Biseriamminidae; *1,2, Globivalvulina* (p. C338).

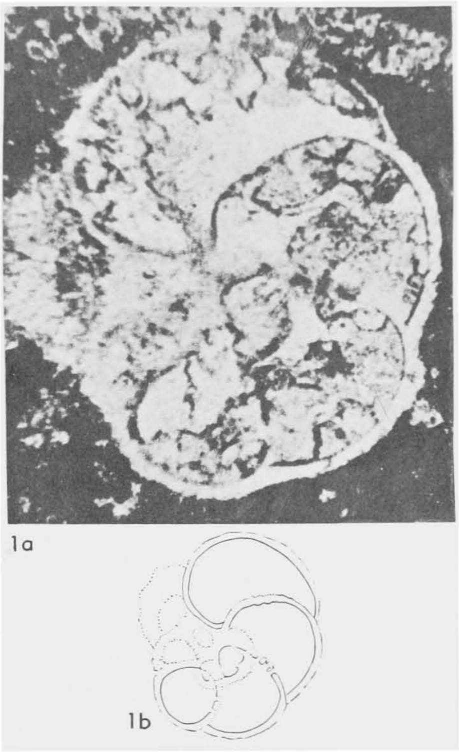


FIG. 256. Biseriamminidae; *1, Olympina* (p. C338).

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), ×47 (*2117); *3*, transv. sec. (*193, pl. 4, fig. 9), ×47 (*2117); *4a-c*, spiral, umbilical, and edge views, ×65 (*2117).

Family BISERIAMMINIDAE Chernysheva, 1941

[Biseriamminidae CHERNYSHEVA, 1941, p. 70] [=Globivalvulinae 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, ×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, ×93; *2*, sec. of syntype, redrawn (BMNH-P35518, *193, pl. 4, fig. 14), ×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., ×55; *1b*, sketch from photograph showing chambers and septal aperture, ×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 (^{1}family, ^{2}subfamily)] ——[=^{2}Glomospirellinae REYTLINGER, 1950, p. 26 *(nom. nud.)*; =^{2}Tournayellinae DAIN in DAIN & GROZDILOVA, 1953, p. 20; =^{2}Tournauellinae DAIN in DAIN & GROZDILOVA, 1953, p. 21 *(nom. null.)*; =^{2}Forschiinae DAIN in DAIN & GROZDILOVA, 1953, p. 20, 38; =^{1}Forschiidae GROZDILOVA & LEBEDEVA, 1954, p. 36; =^{2}Forshiinae REYTLINGER, 1953, p. 60 *(nom. null.)*; =^{1}Teurnayellidae REYTLINGER, 1958, p. 60 *(nom. null.)*]

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

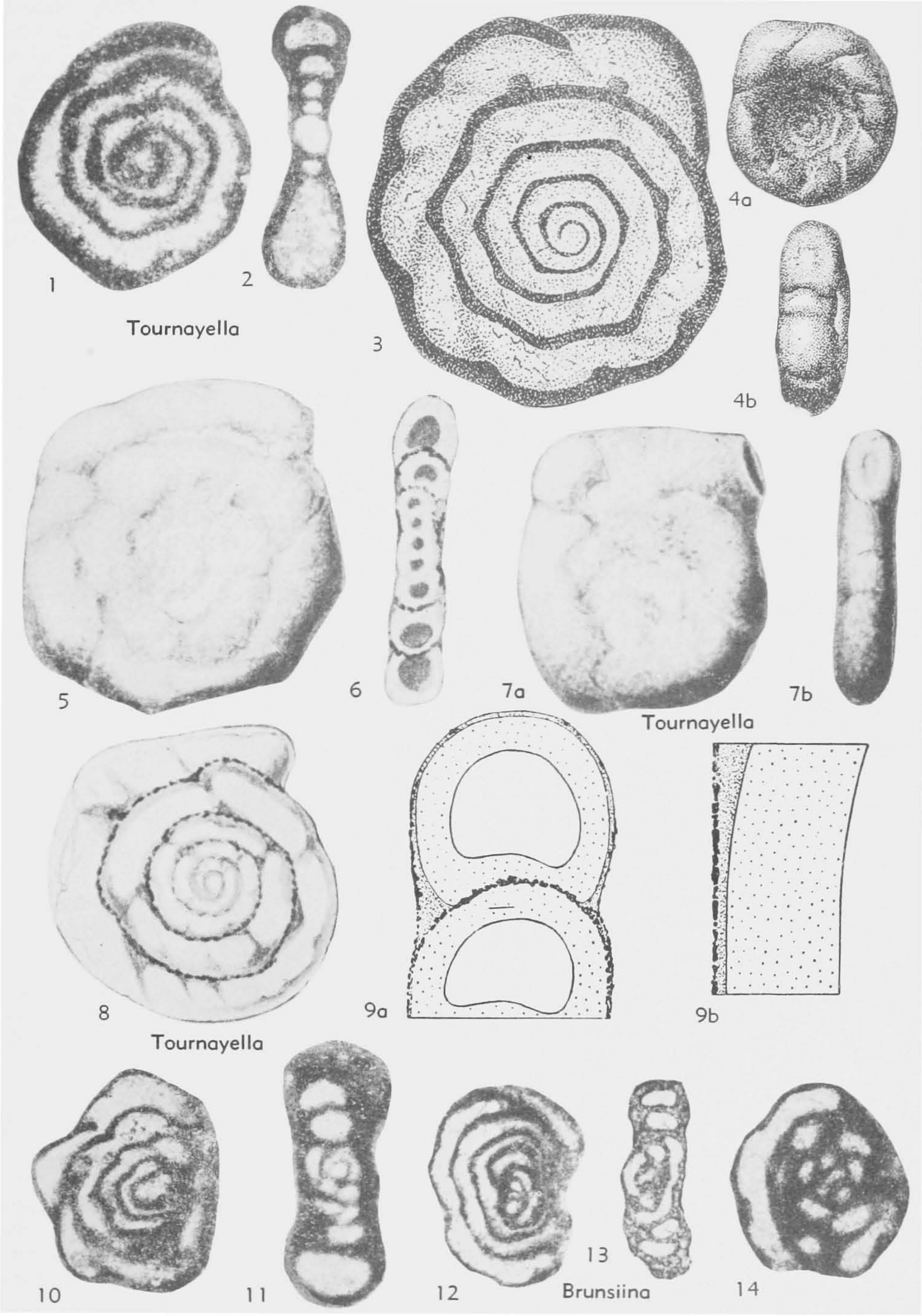


Fig. 257. Tournayellidae; *1-11, Tournayella; 12-14, Brunsiina* (p. C339-C340).

1955, *1143, p. 36 (type, *Tournayella segmentata* Dain in Dain & Grozdilova, 1953, *550, p. 34); *Cepekia* Vašíček & 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 ×100 (*550).——Fig. 257,*3,4*. *T. spectabilis* (Dain), Tournais., USSR(Donets Basin); *3,* equat. sec., ×60 (*550); *4a,b,* side, edge views of holotype, ×43 (*550).——Fig. 257,*5-9*. *T. cepeki* (Vašíček & Ružička), Namur., Czech.; *5,7a,b,* side, edge views of paratypes; *6,8,* axial and equat. secs. of paratypes, ×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., ×70 (*1143); *11,* axial sec., ×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 ×100 (*550).——Fig. 257,*14*. *B. asiatica* (Lipina), Tournais., Sib.; equat. sec. of holotype, ×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., ×60 (*1509); *2,* axial sec., ×20 (*1509); *3,* axial sec., ×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, ×59 (*769).

Glomospiroides Reytlinger, 1950, *1560, p. 28 [**G. fursenki* (*nom. imperf.*, =*G. fursenkoi*, *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.(Moscov.),* USSR.——Fig. 258, *4,5*. **G. fursenkoi*; *4,* long. sec. of holotype; *5,* targ. sec., ×76 (*1560).——Fig. 258,*6*. *G. borealis* (Reytlinger), holotype, ×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, ×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, ×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

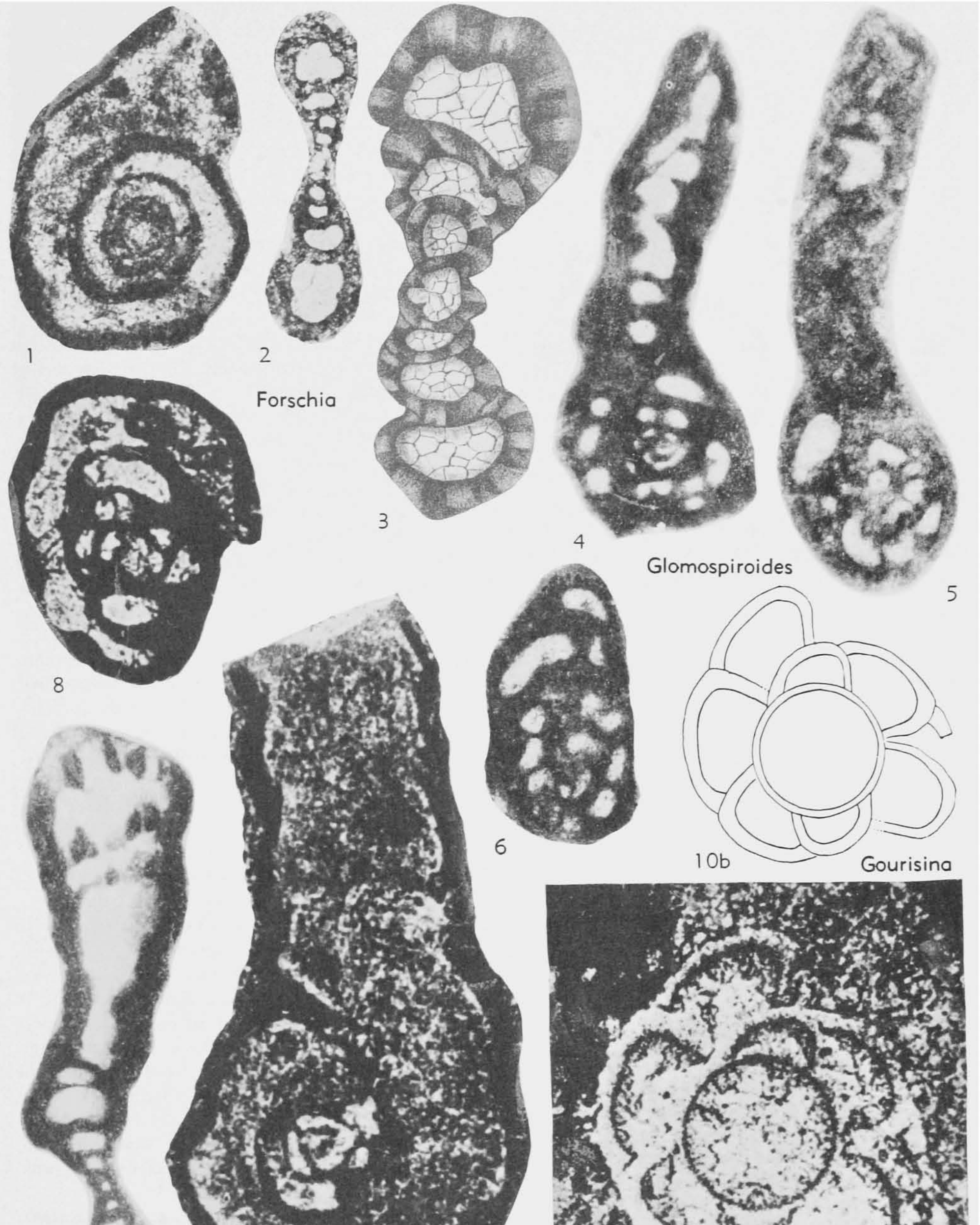


Fig. 258. Tournayellidae; *1-3, Forschia; 4-6, Glomospiroides; 7, Forschiella; 8,9, Lituotubella; 10, Gourisina* (p. C340).

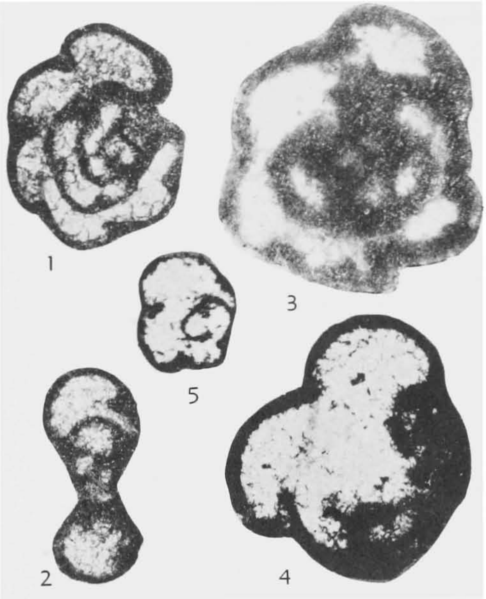


Fig. 259. Tournayellidae; *1-5, Septabrunsiina* (p. C341-C342).

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. krainica* (Lipina), Tournais.; *1,* equat. sec.; *2,* axial sec.; both ×70 (*1143).——Fig. 259,*3*. *S. primaeva* (Rauzer-Chernousova), Tournais.; ×100 (*550).——Fig. 259,*4,5*. *S. vulgaris* (Lipina), L.Carb.; *4,* subequat. sec. of paratype (early coil poorly seen); *5,* equat. sec. of smaller paratype showing early spire, ×70 (*1143).

Family ENDOTHYRIDAE Brady, 1884

[*nom. correct.* Rhumbler, 1895, p. 92 (*pro* family Endothyrina Lankester, 1885, p. 847)]——[All names referred to are of family rank]——[=Endothyrinae Delage & Hérouard, 1896, p. 133; =Cribrospiridae Wedekind, 1937, p. 79; =Plectogyridae Reytlinger MS in Poyarkov, 1957, p. 29; =Bradyinidae Reytlinger, 1958, p. 57]

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

Subfamily LOEBLICHIINAE 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, ×64 (*2117); 261,*1a,* axial sec. (where septa are cut area appears darker), ×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 enlarging 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, ×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, ×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. ×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

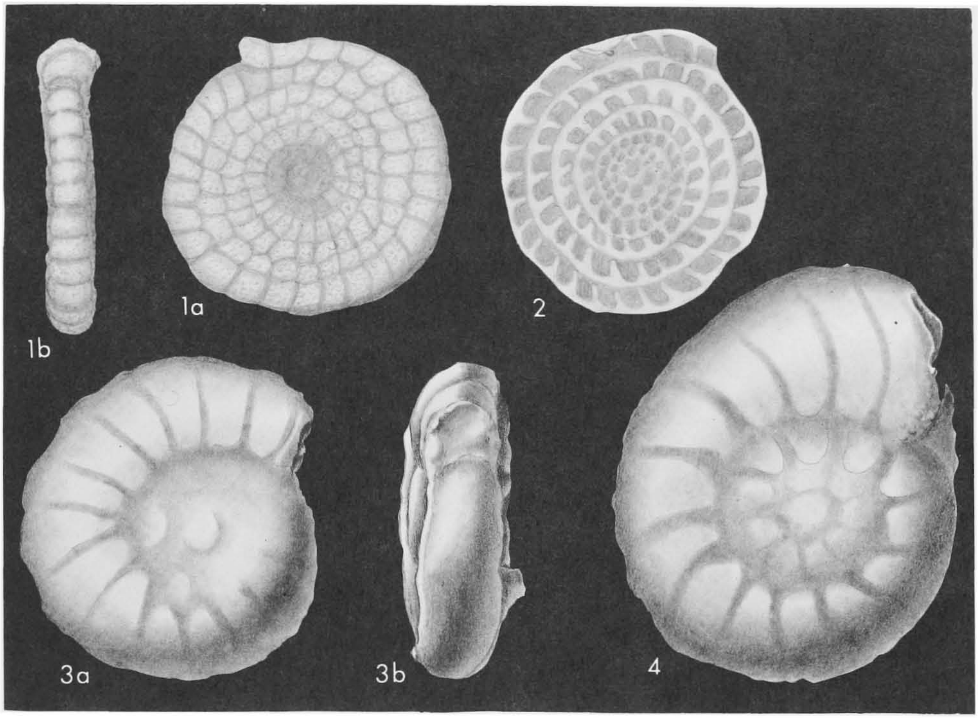


FIG. 260. Endothyridae (Loeblichiinae; *1,2, Loeblichia; 3,4, Nanicella*) (p. *C*342).

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 ×100 (*1517).——FIG. 261,*7*. *R. orientalis* (K. V. MIKLUKHO-MAKLAY), USSR(Caucasus), axial sec. of holotype, ×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* GUDE, 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°-90°, may turn gradually as in plectogyral coiling, or abruptly nearly 90°, few chambers to whorl, whorls few; wall calcareous, with 2 layers, thin dark outer layer (tectum) and thicker, fibrous alveolar, inner layer (diaphanotheca); 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, ×82; *2,* equat. sec. (BRADY's specimen BMNH-P41674 *ex* P35440) showing coiling, ×64 (*2117).——FIG. 262,*3*. *E. plectogyra* (ZELLER), U.Miss.(Meramec.), USA(Mo.); equat. sec. of holotype, ×66 (*2103).——FIG. 262,*4,5*. *E.* sp., U.Miss.(Meramec.), USA(Mo.); *4,* axial sec., ×66 (*2103); *5,* equat. sec. showing well-developed hook-shaped secondary deposit in final chamber, ×66 (*2103).——Fig. 262,*6,7*. *E. fomichaensis* Lebedeva, L.Carb.(Visean), USSR; *6*, equat. sec. of paratype, ×33 (*1100); *7*, axial sec., ×20 (*1509).——Fig. 263,*8*. *E.* sp., diagram of wall structure (*398).

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

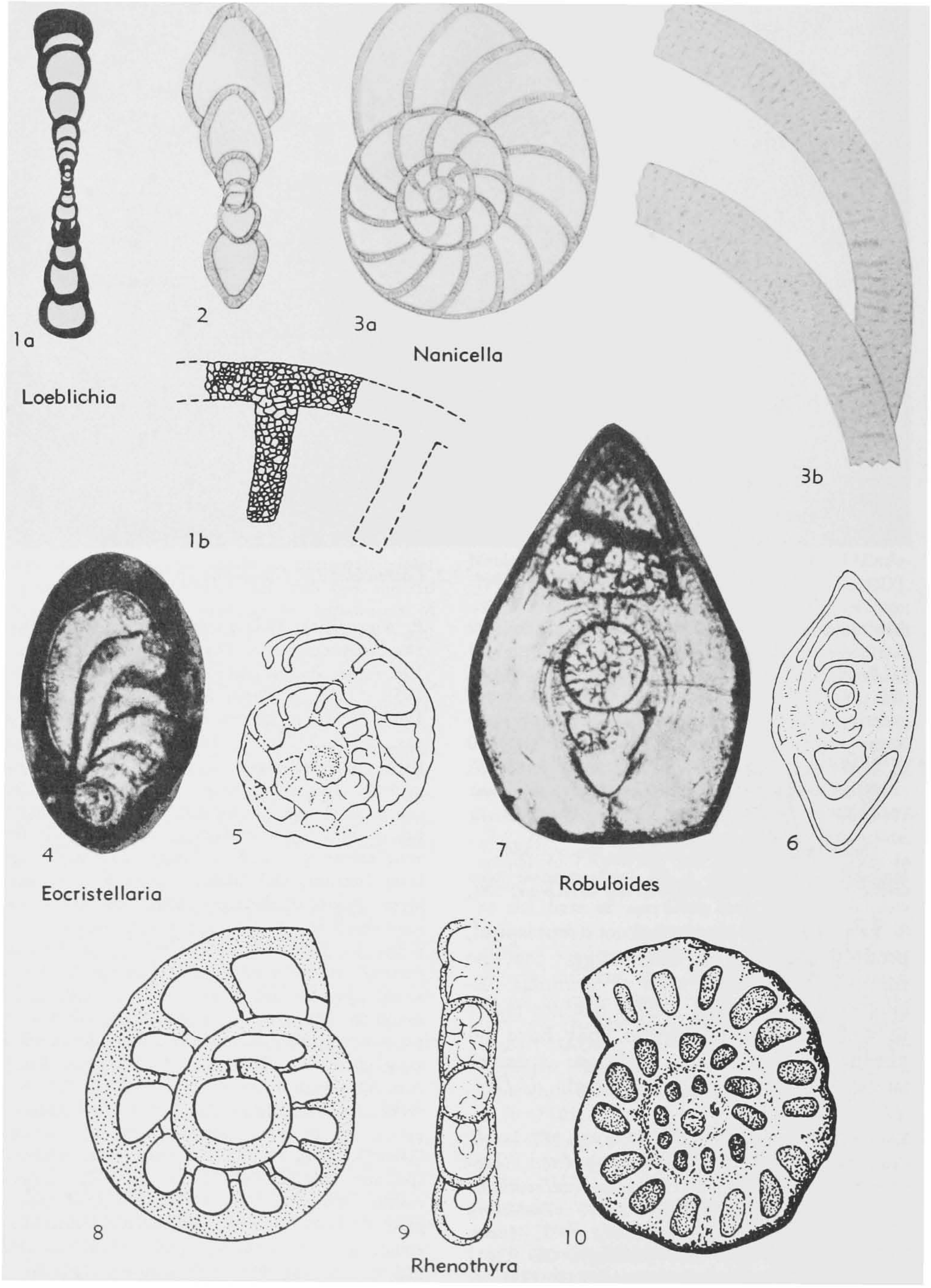


Fig. 261. Endothyridae (Loeblichiinae; *1, Loeblichia; 2,3, Nanicella; 4, Eocristellaria; 5-7, Robuloides; 8-10, Rhenothyra*) (p. *C342-C343*).

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*

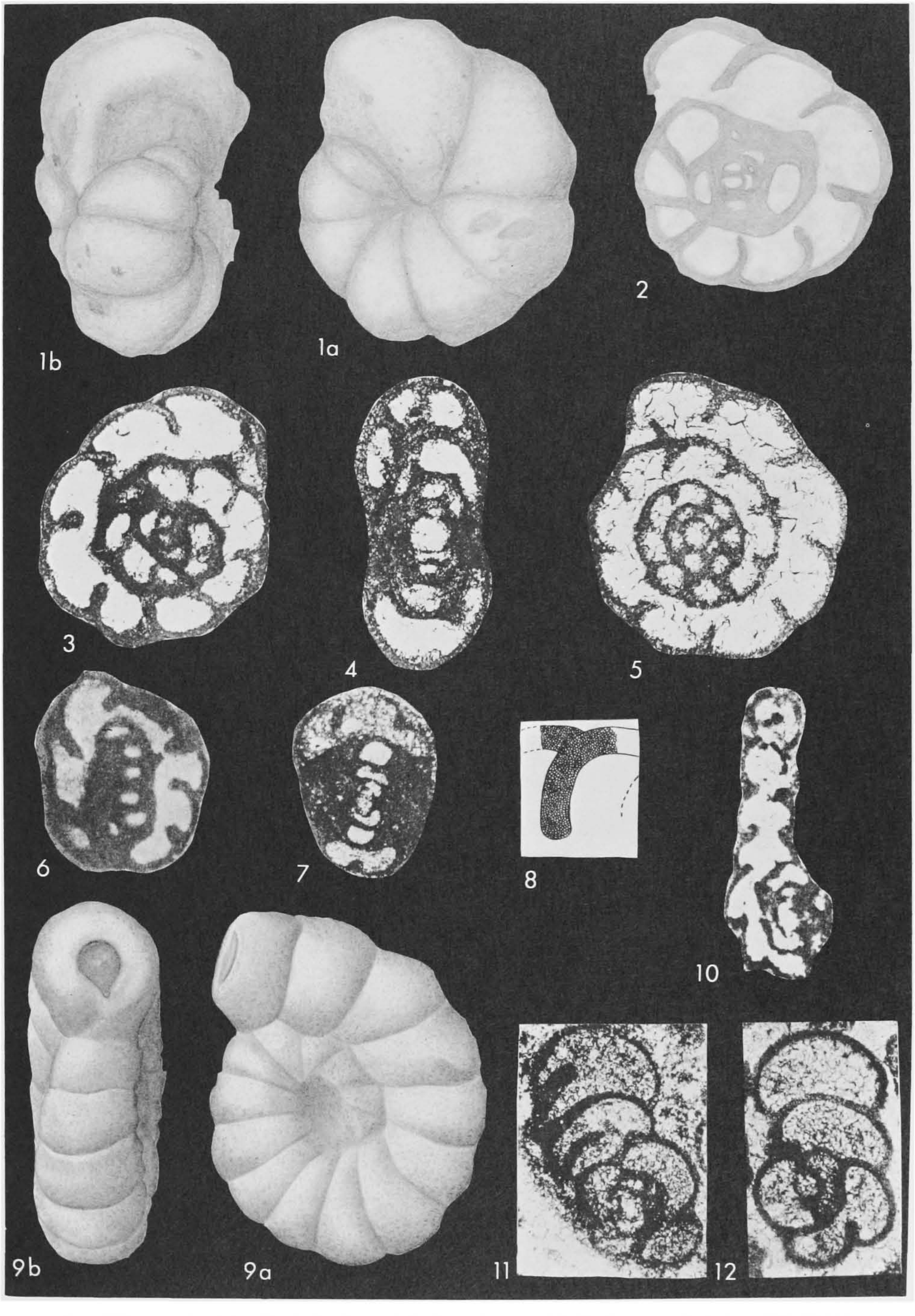


Fig. 262. Endothyridae (Endothyrinae; *1-8, Endothyra; 9-12, Endothyranella*) (p. C343-C346).

(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 Brazhnikova, 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, *Spiroplectammina 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.); *9a,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 & Ramovs, 1955, *1047A, p. 383, 412 [**K. pachytheca*; 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 Verbeekininae *1047A), but later it was transferred to the Staffellinae (*1509). It is here considered as simpler than the Fusulinacea and tentatively placed in the Endothyrinae.] *U.Perm.*, Yugoslav.-USSR. ——Fig. 262A,*1*. **K. pachytheca*, U.Perm., Yugoslav.; *1a*, axial sec. of microspheric form (holotype), ×40; *1b*, axial sec. of megalospheric form, ×20; *1c,d*, median secs. of microspheric forms, ×20 (*1047A).——Fig. 262A,*2*. *K. ussurica* (Sosnina), U.Perm., USSR; *2a,b*, axial and median secs., ×25; *2c*, 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 Endothyrinae, because of the undifferentiated wall, single aperture, and presence of chomata.] *U.Carb.(Namur.-Moscov.)*, USSR.——Fig. 262A,*3*. **N. evoluta, Moscov.*, Ural Mtns.; *3a,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*; *1a,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] [=*Cribroendothyra* 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

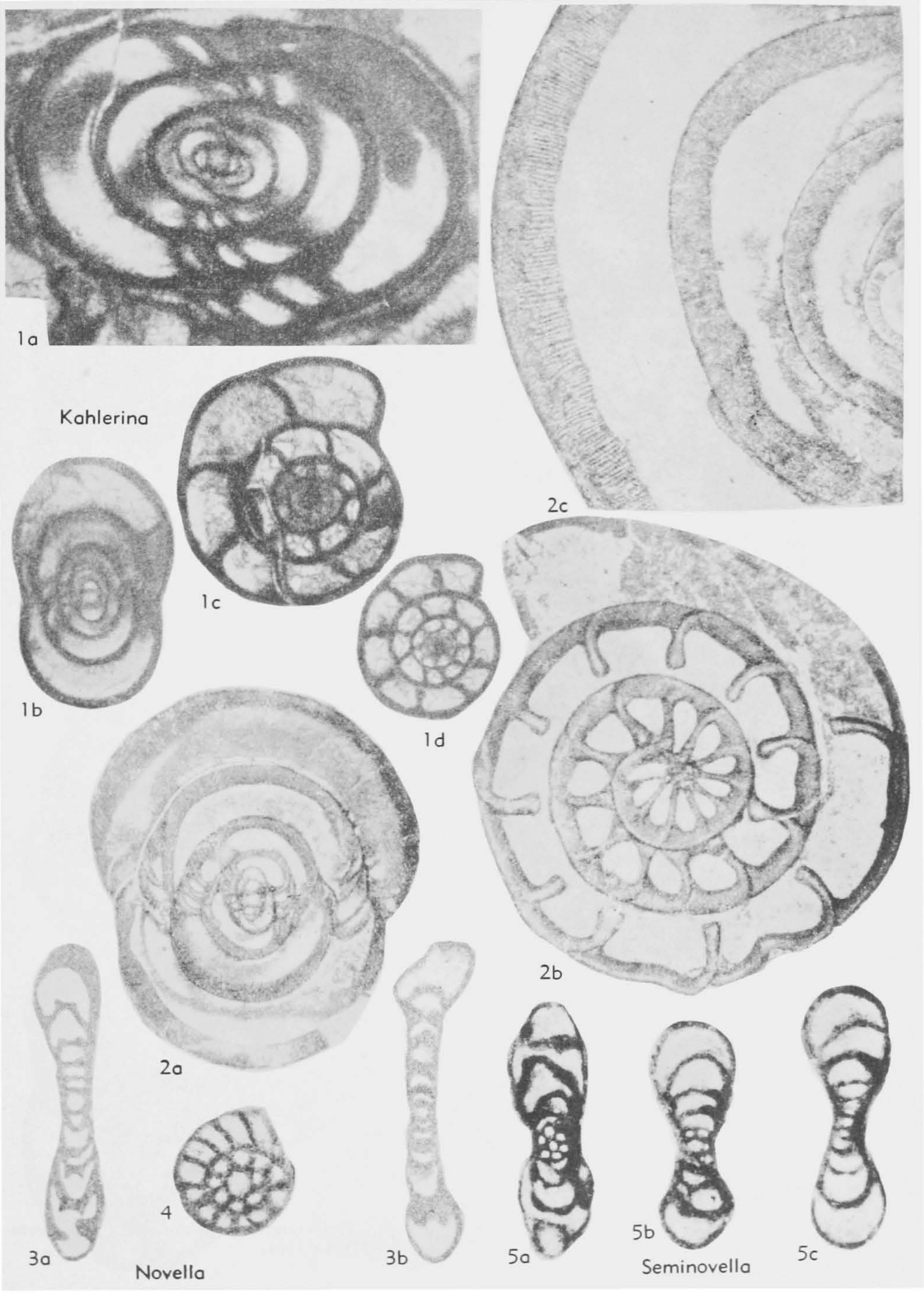


Fig. 262A. Endothyridae (Endothyrinae; *1,2, Kahlerina; 3,4, Novella; 5, Seminovella*) (p. C346, C350).

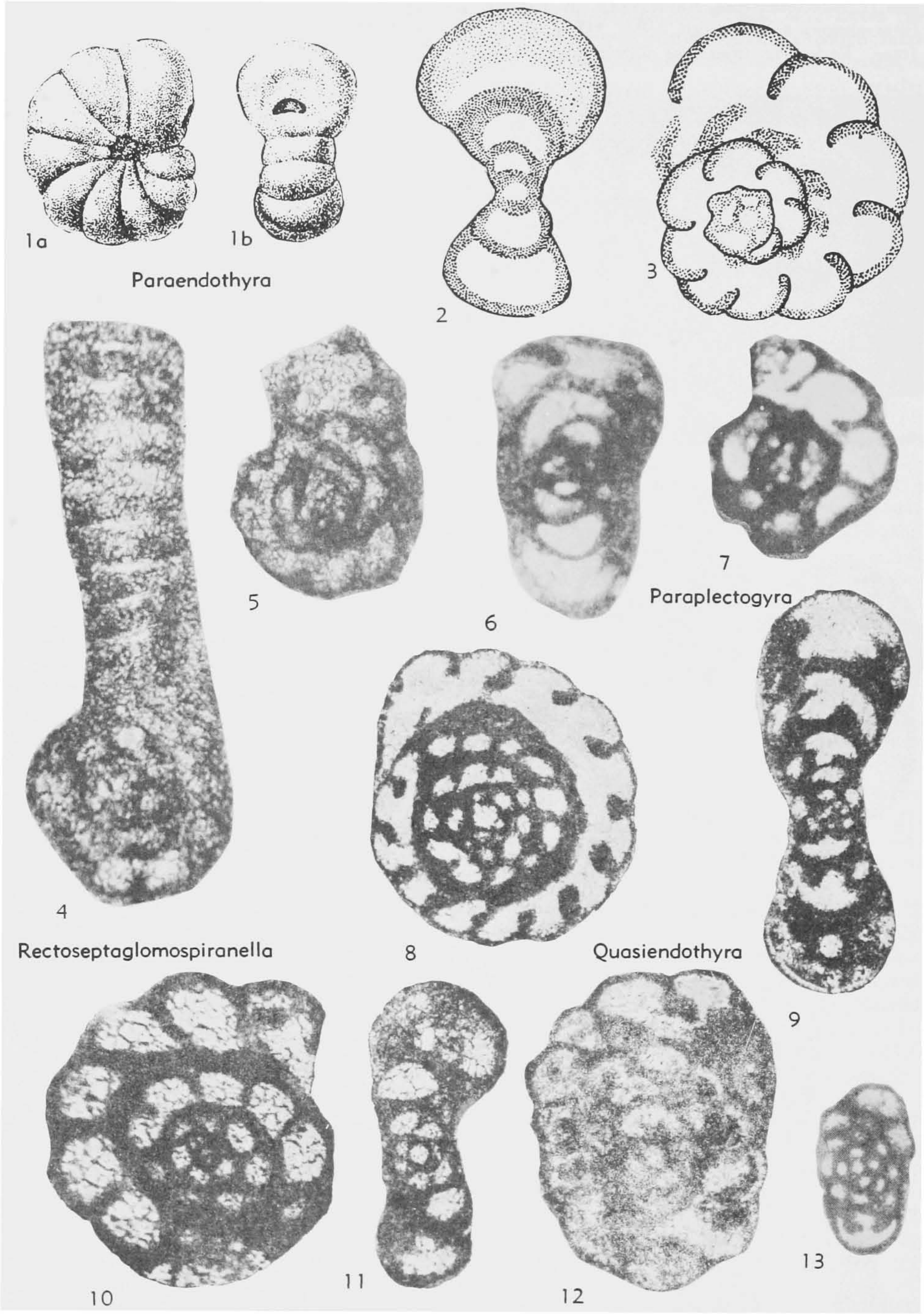


FIG. 263. Endothyridae (Endothyrinae; *1-3, Paraendothyra; 4,5, Rectoseptaglomospiranella; 6,7, Paraplectogyra; 8-13, Quasiendothyra*) (p. C346-C350).

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, ×75 (*1509).——Fig. 263,*10,11*. *Q. aljutovica* (Reytlinger), U.Carb.(Moscov.); equat. and axial secs.,

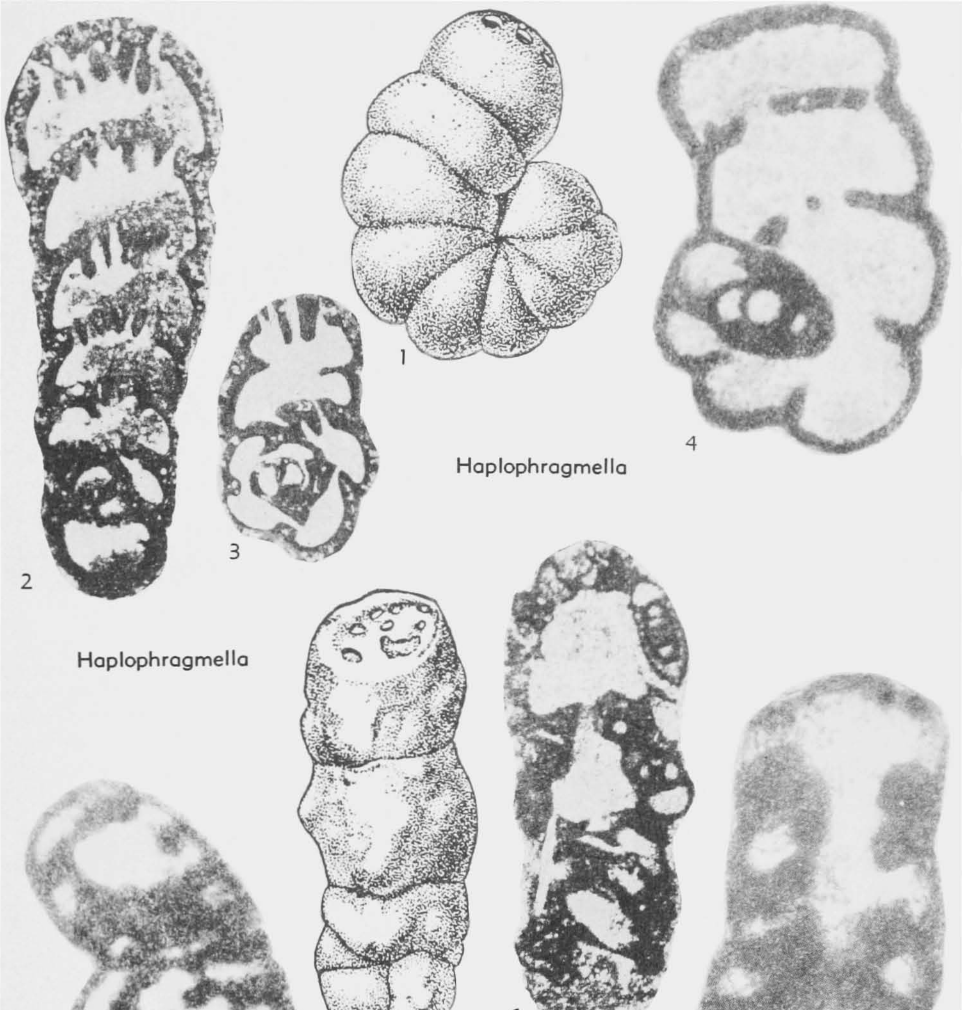


Fig. 264. Endothyridae (Haplophragmellinae; *1-6*, *Haplophragmella*; *7,8*, *Klubovella*) (p. C350-C352).

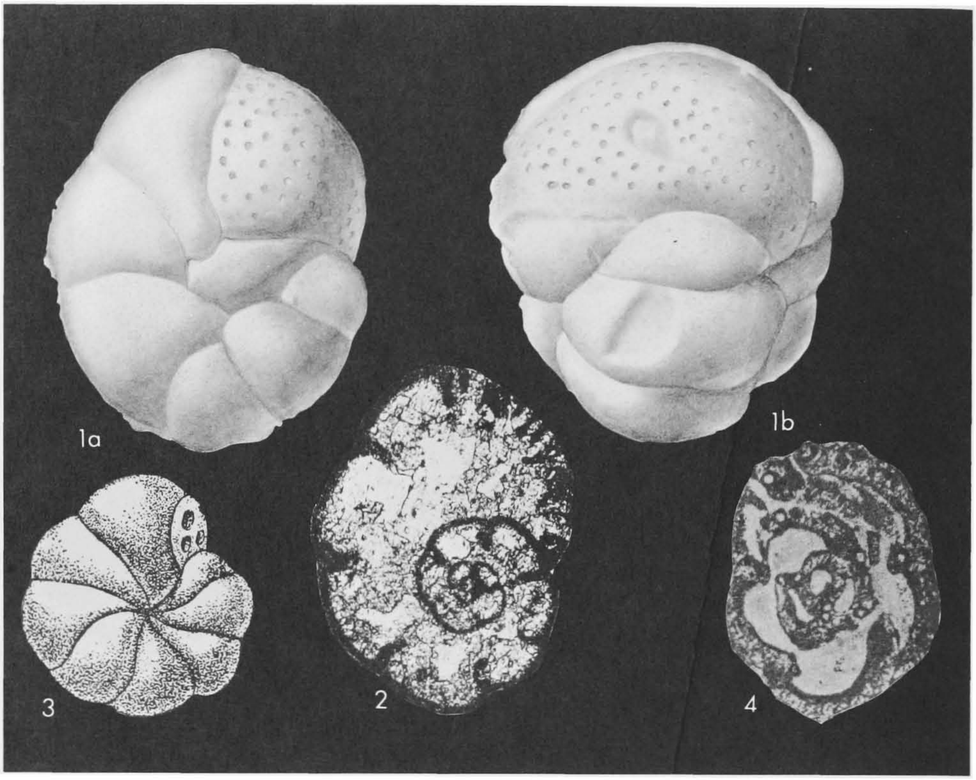


Fig. 265. Endothyridae (Haplophragmellinae; *1-4, Cribrospira*) (p. *C*352).

×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 *Septabrunsiina*), 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 Endothyrinae 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 Endothyrinae, 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] [=*Endothyrina* Mikhaylov, 1935, *1259,

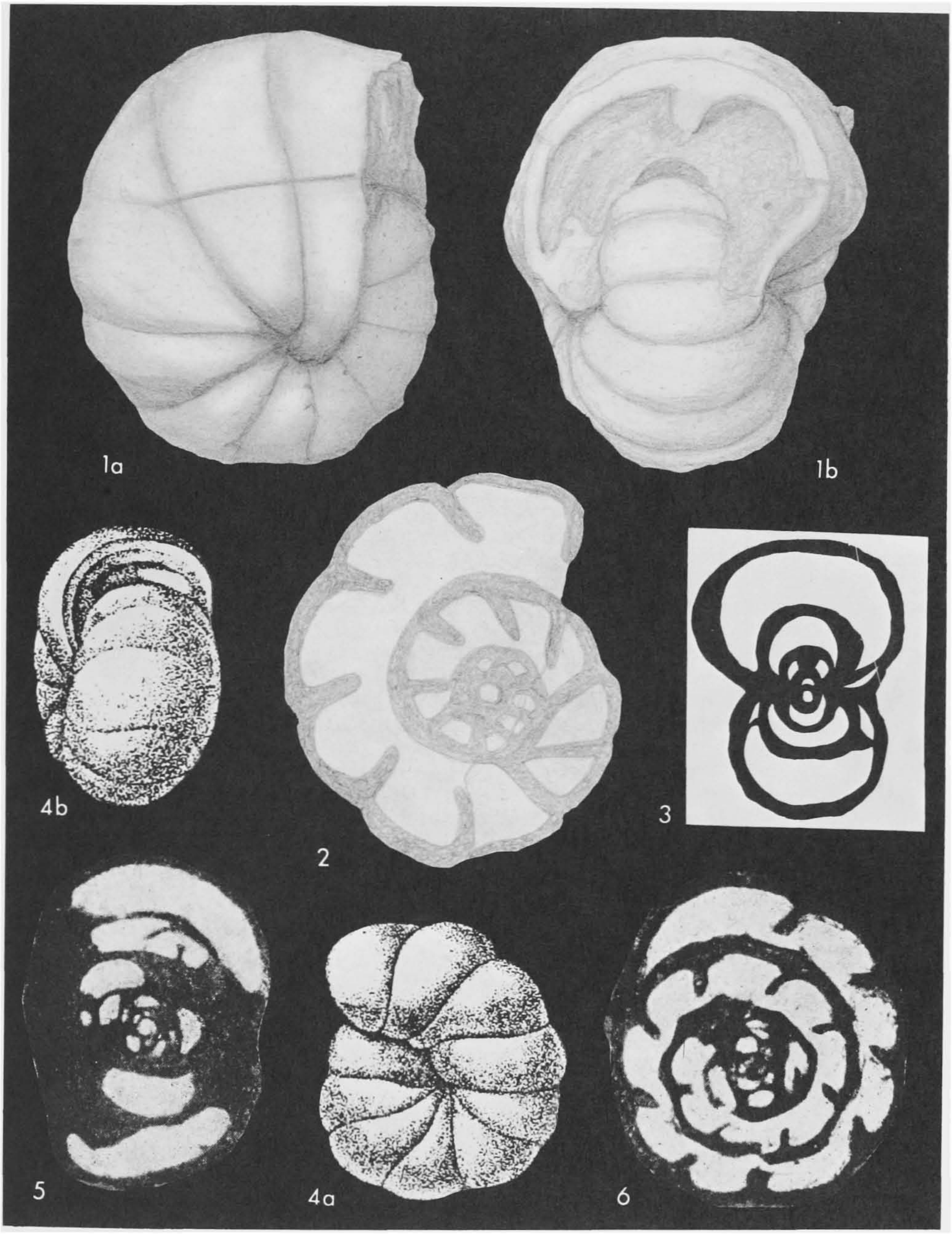


FIG. 266. Endothyridae (Endothyranopsinae; *1-6, Endothyranopsis*) (p. C352).

p. 40 (type, *E. typica, nom. nud.*); *Haplophragmina* REYTLINGER, 1950, *1560, p. 28 (type, *H. kashirica*); *Mikhailovella* GANELINA, 1956, *769, p. 100 (type, *Endothyrina? 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 simple 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), Visean; side view, ×44 (*1509).——FIG. 264,*2,3*. *E. irregularis* (RAUZER-CHERNOUSOVA), Visean, long. secs., ×20 (*1509).——FIG. 264,*4*. *E. gracilis* RAUZER-CHERNOUSOVA, L.Carb.; long. sec., ×72 (*769).

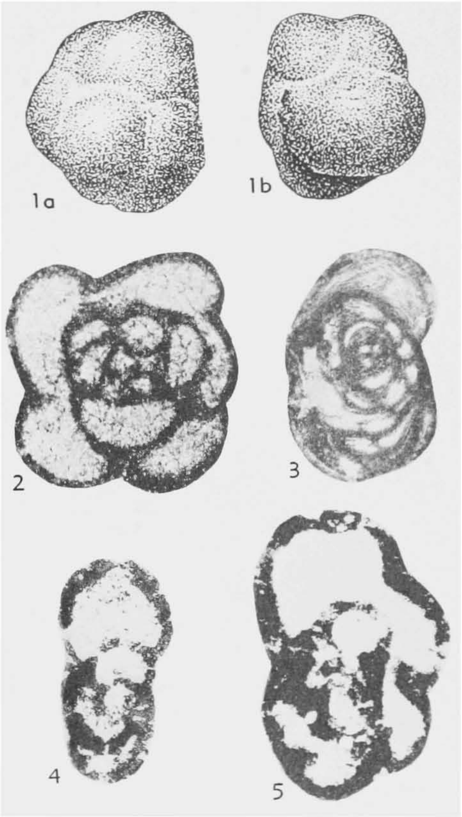


FIG. 267. Endothyridae (Endothyranopsinae; *1-5, Chernyshinella*) (p. C352-C353).

——FIG. 264,*5,6*. *E. kashirica* (REYTLINGER), Moscov.; *5*, side view, ×55; *6*, long. sec., ×46 (*1509).

Cribrospira 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 *Cribrospira* 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, ×44 (*2117); *2*, equat. sec., approx. ×28 (*1503).——FIG. 265,*3,4*. *C. bulloides* (MIKHAYLOV); *3*, side view; *4*, equat. sec., ×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., ×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 Reytlinger, 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., ×41 (*2117).——FIG. 266,*3*. *E.* sp.; axial sec., ×35 (*398).——FIG. 266,*4-6*. *E. pseudoglobulus* (REYTLINGER), Visean, USSR(Bashkiri); *4a,b,* side, apert. views, ×22 (*1509); *5,6,* axial equat. secs., approx. ×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

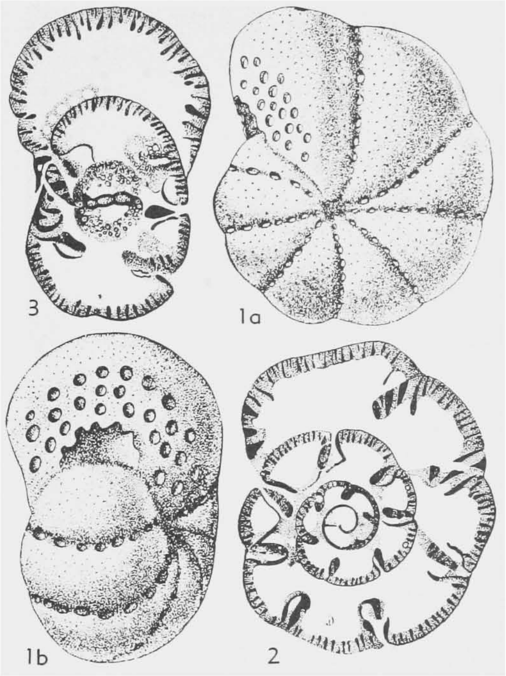


FIG. 268. Endothyridae (Bradyininae; *1-3, Bradyina*) (p. *C*353).

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, ×72 (*1509); *2*, equat. sec., ×70 (*1143); *3*, axial sec., ×35 (*649).——FIG. 267, *4,5*. *C. granulosa* (ZELLER), L.Miss., USA(Utah); axial and equat. secs., ×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., ×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] [=*Pseudobradyina* REYTLINGER, 1950, *1560, p. 45 (type, *P. pulchra*)]. Test planispiral, involute, few (usually 3) chambers to whorl, in-

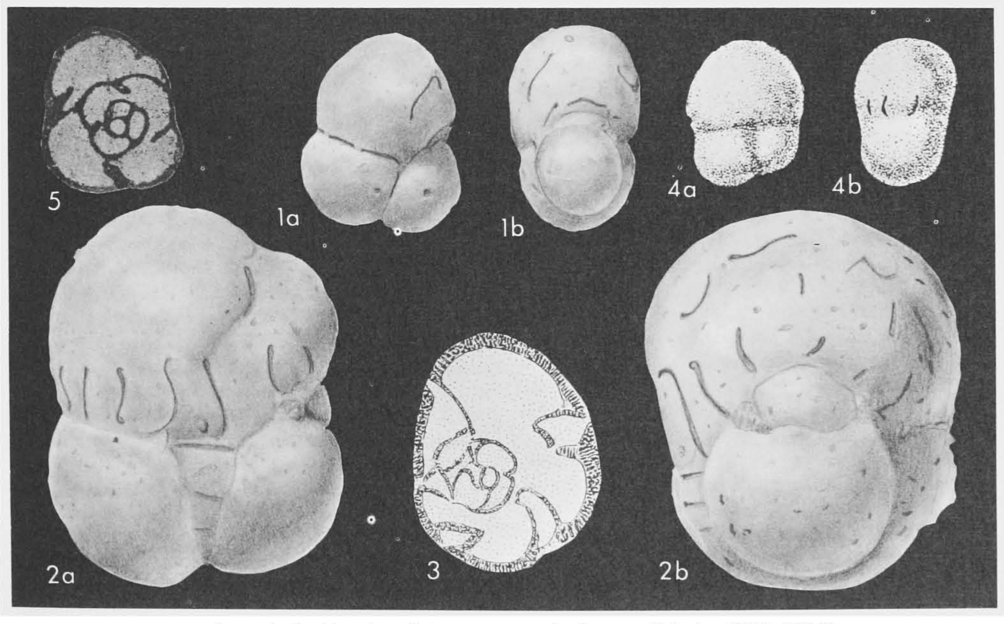


FIG. 269. Endothyridae (Bradyininae; *1-5, Glyphostomella*) (p. *C*353-*C*354).

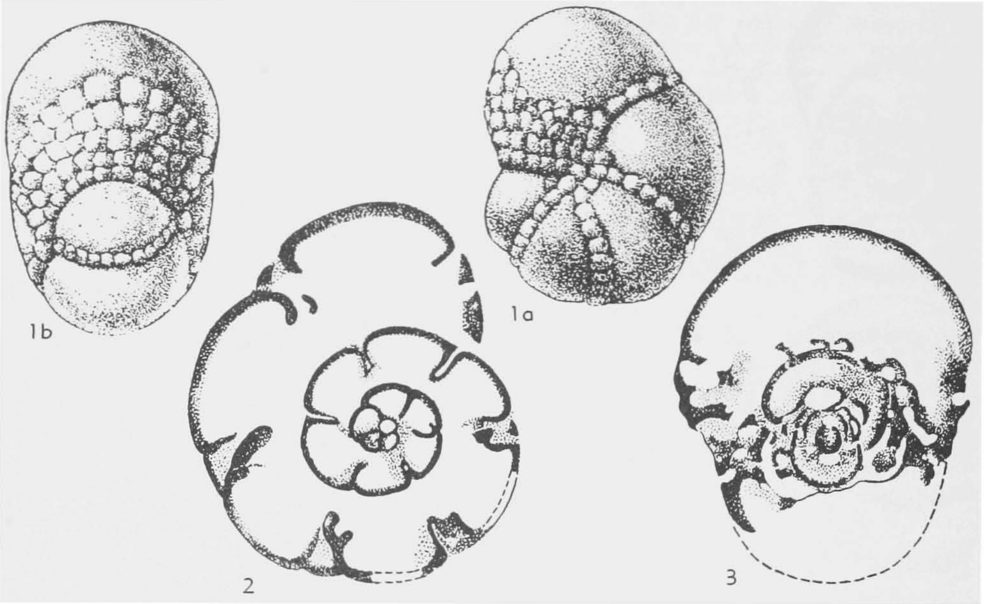


FIG. 270. Endothyridae (Bradyininae; *1-3, Janischewskina*) (p. *C*354).

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? triloculina* 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.); *1a,b*, side, apert. views of holotype of *Ammochilostoma? triloculina* CUSHMAN & WATERS, ×50; *2a,b*, large paratype of *A.? triloculina*, ×50 (*2117).——FIG. 269,*3*, *G.* sp., equat. sec., ×24 (*535).——FIG. 269,*4*,*5*. *G. pulchra* (REYTLINGER), U.Carb., USSR; *4a,b*, side, apert. views, ×28; *5*, equat. sec., ×36 (*1509).

Janischewskina MIKHAYLOV, 1935, *1259, p. 40 [**J. typica*; OD] [=*Yanischewskina* 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*; *1a,b*, side, apert. views, ×14; *2,3*, equat., axial secs., ×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. karreri*; 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 baschkiricus* KRESTOVNIKOV & TEODOROVITCH, 1936, *1055, p. 87); *Rugosoarchaediscus* A. D. MIKLUKHO-MAKLAY, 1957, *1266, p. 37 (type, *Archaediscus akchimensis* GROZDILOVA & LEBEDEVA, 1954, *831, p. 53)]. Test free, lenticular; proloculus followed by streptospirally coiled, long, undivided tubular second chamber, evolute, tending to become more

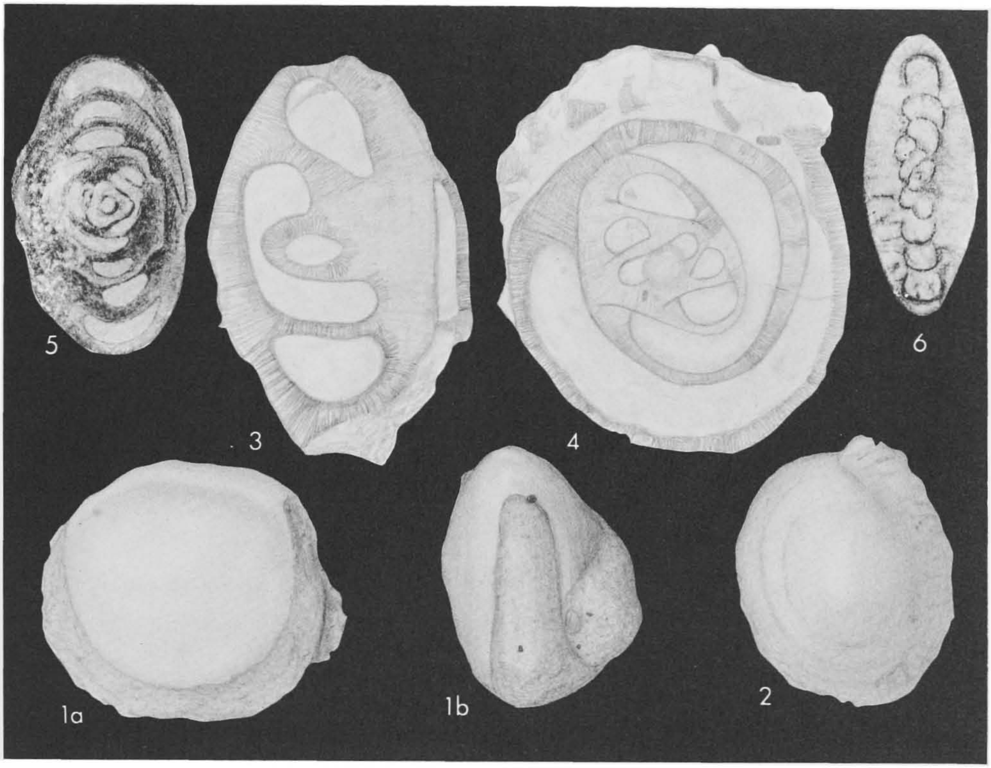


FIG. 271. Archaediscidae; _1-6, Archaediscus_ (p. C354-C355).

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. ḳarreri_, 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 ×64 (*2117).——FIG. 271,_5_. _A. milliloides_ (MIKLUKHO-MAKLAY), U.Perm., Caucasus; axial sec. of holotype, ×17 (*1262).——FIG. 271,_6_. _A. ulmeri_ (MIKHAYLOV), L.Carb. (Visean), USSR; ×80 (*1262).——FIG. 272,_1,2_. _A. dubitabilis_ (ORLOVA), U.Tournais., Saratov; _1_, ext., ×40; _2_, axial sec. of holotype, ×100 (*1399).——FIG. 272,_3_. _A. baschḳiricus_ KRESTOVNIKOV & TEODOROVITCH, M.Carb.(Bashkir.), USSR(Kolva); axial sec., ×100 (*1509).——FIG. 272,_4_. _A. aḳchimensis_ GROZDILOVA & LEBEDEVA, L.Carb.(L.Bashkir.), USSR; axial sec., ×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, ×100 (*1266).——FIG. 272,_6_. _B. incerta_ (GROZDILOVA & LEBEDEVA), Baskir region; holotype, ×100 (*1509).——FIG. 272,_7,8_. _B. pulchra_ MIKHAYLOV, Ukraine; equat. and axial secs., ×100 (*1509).——FIG. 272,_9_. *_B. irregularis_ (VON MÖLLER), holotype, ×135 (*700).——FIG. 272,_10,11_. _B. spirillinoides_ (RAUZER-CHERNOUSOVA), Kazakh.; _10_, axial sec. of holotype; _11_, equat. sec. of paratype, ×75 (*1505).——FIG. 272,_12_. _B. pamirensis_ (A. D. MIKLUKHO-MAKLAY), Visean, Pamir region; holotype, horiz. sec., ×180 (*1274).

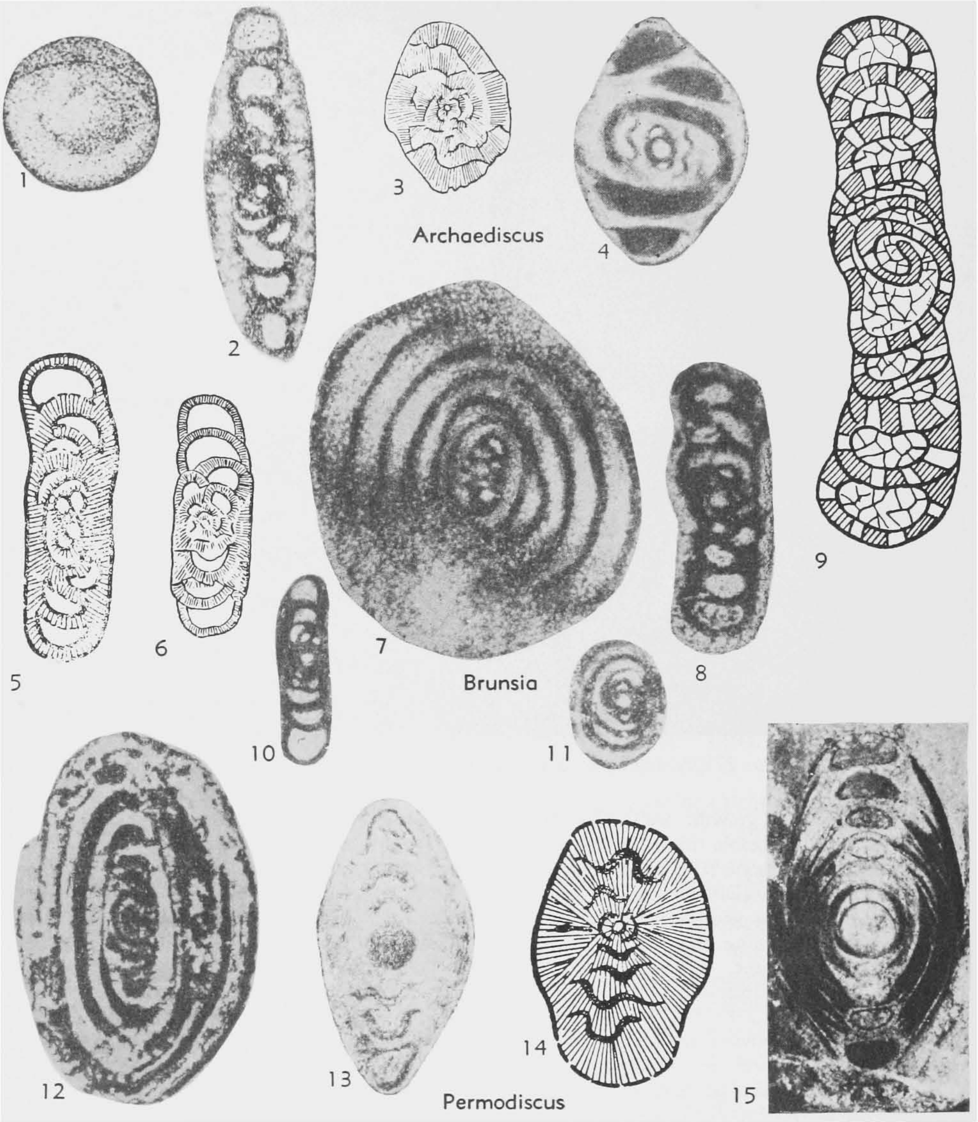


FIG. 272. Archaediscidae; *1-4, Archaediscus; 5-12, Brunsia; 13-15, Permodiscus* (p. C355-C358).

[*Brunsia* differs from *Archaediscus* 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 & LEBEDEVA (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 MÖLLER, 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 Endothyracea which are also characteristic of the Tournayellidae and Archaediscidae. 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, *Neoarchaediscus, Planoarchaediscus*, 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* PORCHNJAKOVA 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-

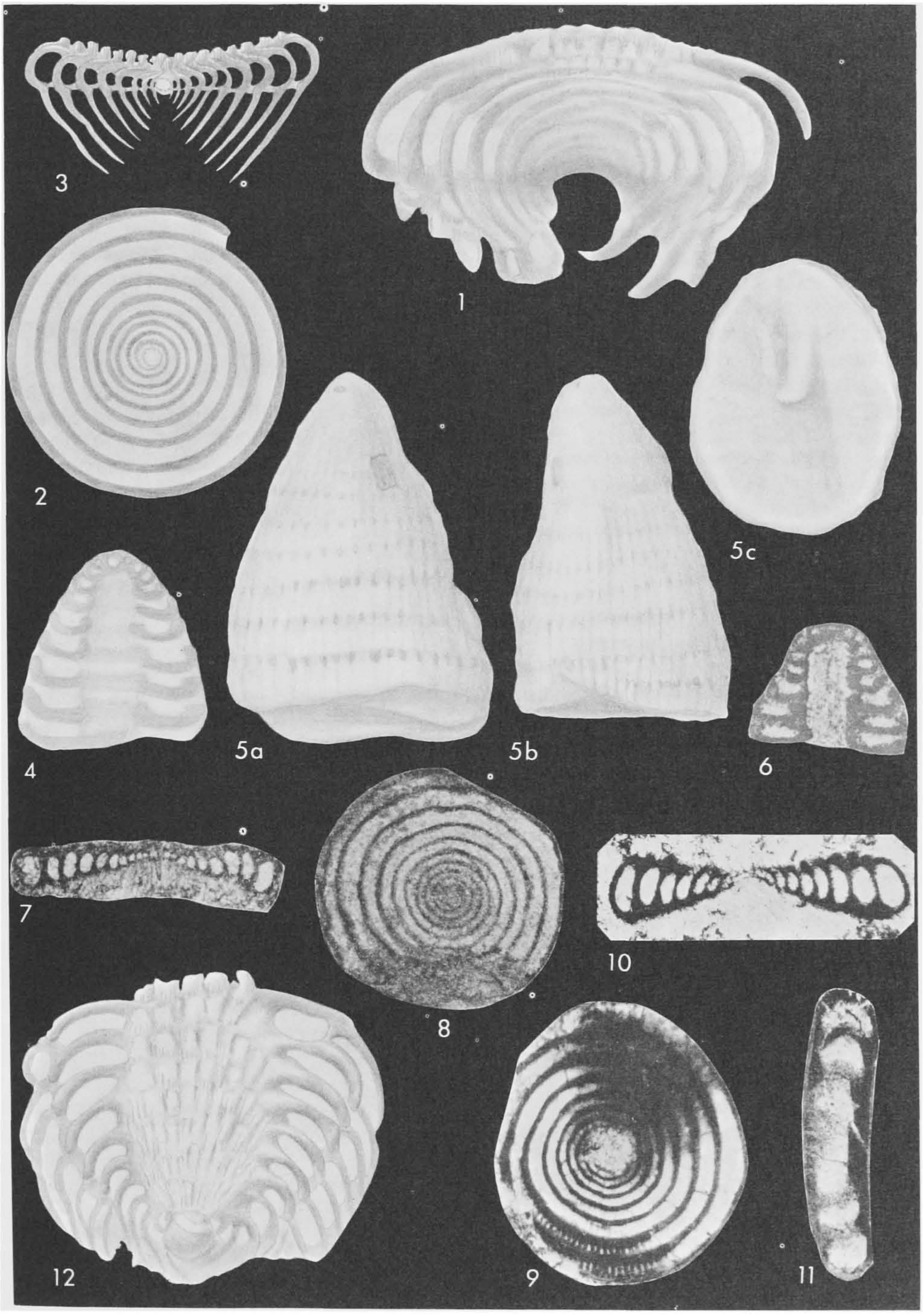


FIG. 273. Lasiodiscidae; *1-3, Lasiodiscus; 4-6, Howchinia; 7-11, Monotaxinoides; 12, Lasiotrochus* (p. C358).

Malay Arch.(Sumatra).——Fig. 272,*13*. **P. vetustus*, L.Carb.(Visean), USSR; ×100 (*1262).——Fig. 272,*14*. *P. ovalis* (Porchnjakova), U.Carb.(Namur.), USSR(Fergana); axial sec. of holotype, ×100 (*1266).——Fig. 272,*15*. *P. padangensis* (Lange), M.Perm., Sumatra; ×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, ×145; *2,3*, reconstr. equat. and axial secs., ×85 (*1517).

Howchinia Cushman, 1927, *431, p. 42 [**Patellina bradyana* Howchin, 1888, *965, p. 544; OD] [=*Monotaxis* Vissarionova, 1948, *2009, p. 190 (type, *Tetrataxis 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.(Visean)*, Eu.(Eng.-USSR).——Fig. 273,*4,5*. **H. bradyana* (Howchin), Eng.; *4*, sectioned hypotype, ×105; *5a-c*, side, edge and apert. views of neotype, ×105 (*2117).——Fig. 273,*6*. *H. gibba* (von Möller), USSR; ×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 (Azerbaidzhan).——Fig. 273,*12*. **L. tatoiensis*, U.Perm., Greece; long. sec. of holotype, ×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 ×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 ×174 (*1562).

FUSULINACEA

By M. L. Thompson

[Illinois State Geological Survey, Urbana]

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

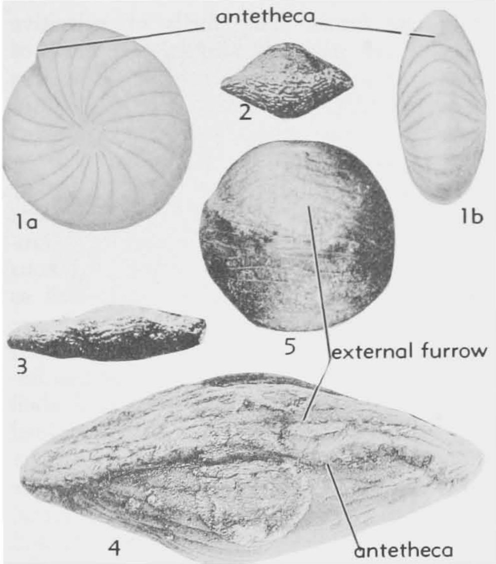


FIG. 274. Exterior views of fusulinaceans showing typical shapes of shells.——*1*. Discoid; **Nummulostegina velebitana* Schubert, Perm., Yugo., *1a,b*, side and edge views of holotype, ×20 (*2120B).——*2-4*. Fusiform: *2, Fusulina girtyi* (Dunbar & Condra), M.Penn., USA(Ill.), holotype, ×3.3 (*1922); *3,* **Waeringella spiveyi* Thompson, U. Penn., USA(Tex.), paratype, ×6.7 (*1922); *4, Triticites ventricosus* (Meek & Hayden), L.Perm., USA(Kans.), holotype, ×6.7 (*1926).——*5*. Spheroidal: **Verbeekina verbeeki* (Geinitz), U. Perm., Sumatra, topotype, ×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 midcontinent region and in Texas. In the midcontinent 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 Permian 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.

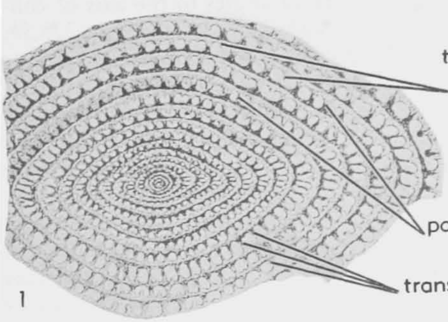
MORPHOLOGY

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 foraminiferal 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 foraminiferal 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, ×16.3 (*1922).——*2. Yangchienia tobleri* THOMPSON, U. Perm., Sicily; axial sec., ×16.3 (*1922).——*3. *Wedekindellina euthysepta* (HENBEST), M.Penn., USA(Ill.); *3a,* axial sec. of holotype; *3b,* sagittal sec. of paratype; both ×20 (*1922).——*4. Triticites ventricosus* (MEEK & HAYDEN), L.Perm., USA (Kans.); axial sec., topotype, ×8 (*1926).——*5. Lepidolina elongata* (GUBLER), U.Perm., Cambodia; axial sec. of submature specimen, ×8 (*838).——*6a. Parafusulina nosonensis* THOMPSON & WHEELER, L.Perm., USA(Calif.); parallel sec. of paratype showing cuniculi, ×8 (*1922).——*6b. Parafusulina wanneri* (SCHUBERT), Perm., Timor; axial sec. of holotype, ×8 (*1923).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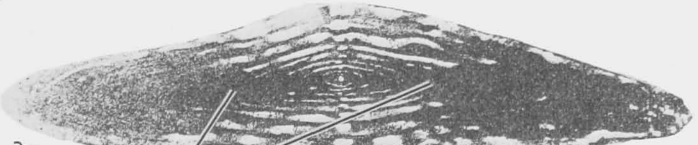
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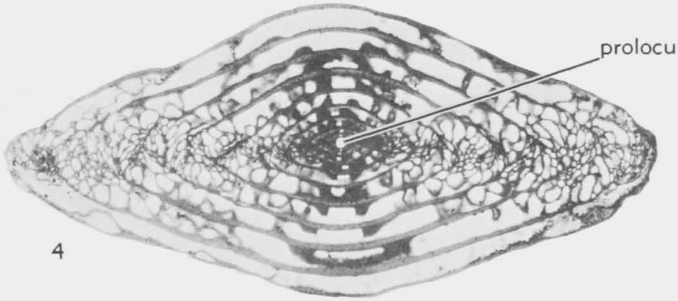
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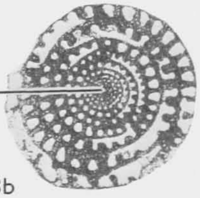
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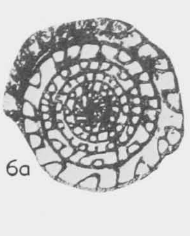
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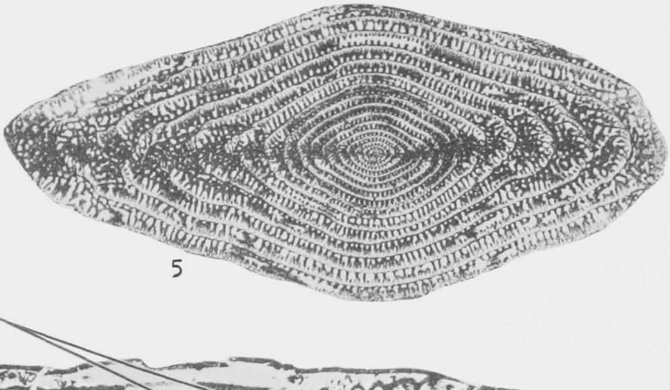
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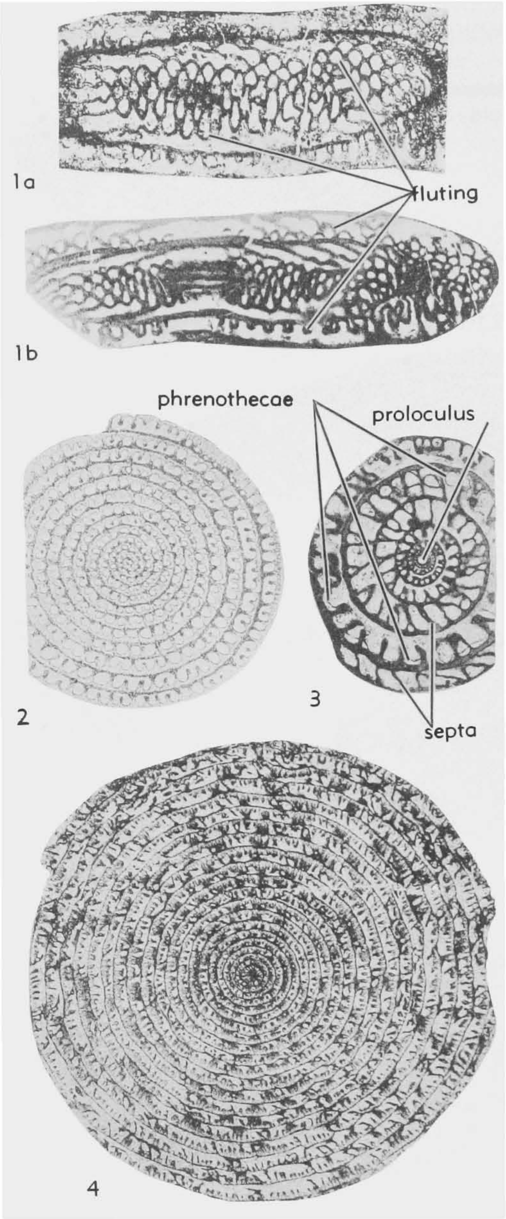

Fig. 276. Sagittal, tangential, and parallel sections of fusulinaceans.——_1a. Parafusulina nosonensis_ Thompson & Wheeler, L.Perm., USA (Calif.); tang. sec. of paratype showing septal fluting, ×8 (*1922); _1b. Parafusulina gracilis_ (Meek), L.Perm., USA (Calif.); tang. sec. showing septal fluting and cuniculi, ×8 (*1934).——_2. *Neoschwagerina craticulifera_ (Schwager), U.Perm., China; parallel sec. of paratype, ×16 (*1922).——_3. Schwagerina fax_ Thompson & Wheeler, L.Perm., USA (Calif.); sagittal sec. of syntype, ×8 (*1922).——_4. Lepidolina elongata_ (Gubler), U.Perm., Cambodia; parallel sec., ×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.

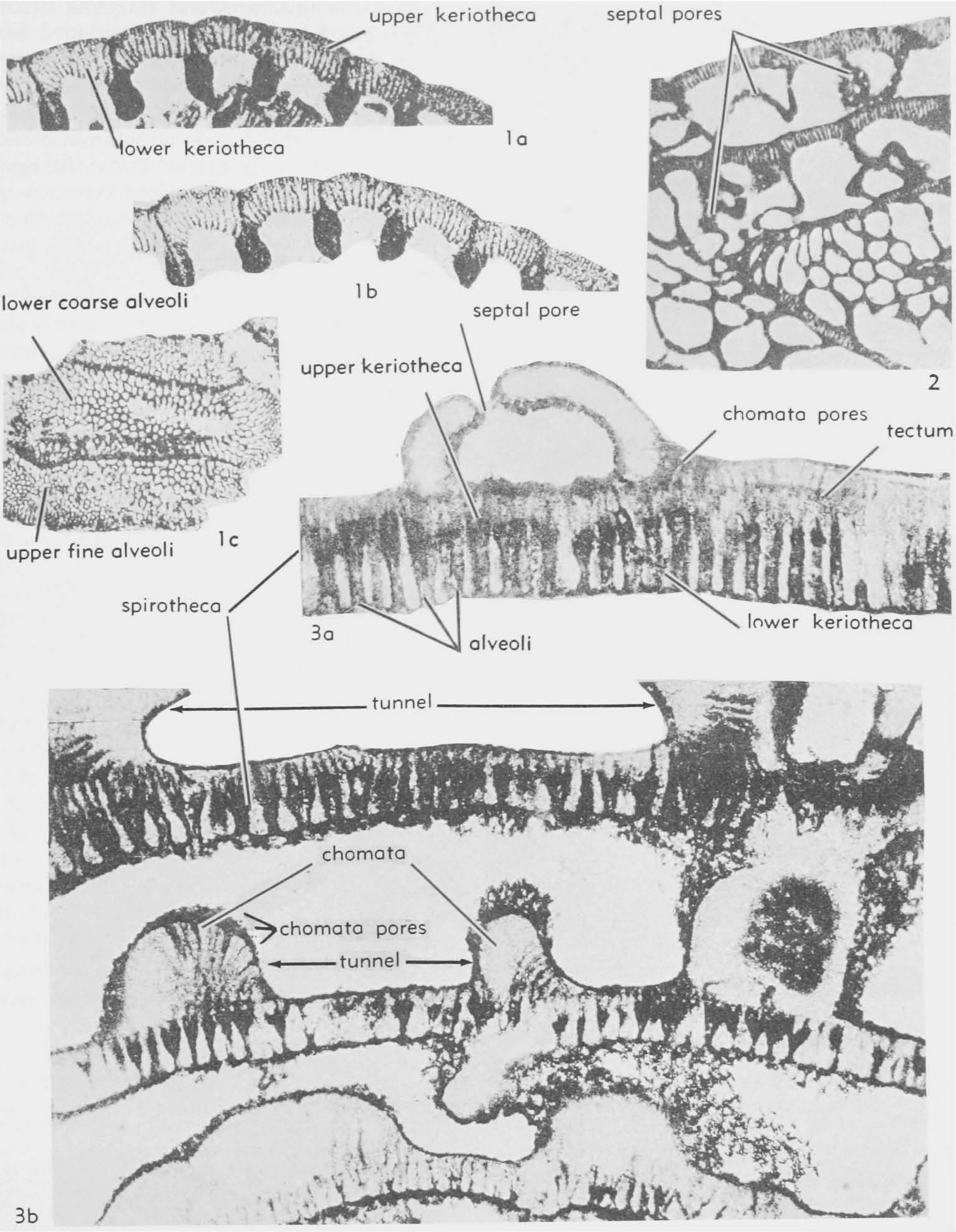

FIG. 277. Spirothecal and septal structures of fusulinaceans.——*1. Schwagerina rutschi* THOMPSON, L. Perm., Sumatra; *1a,* part of sagittal sec. showing lower and upper keriotheca of spirotheca; *1b,* part of sagittal sec. showing coarse and fine alveoli in lower and upper keriothecal layers of spirotheca;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

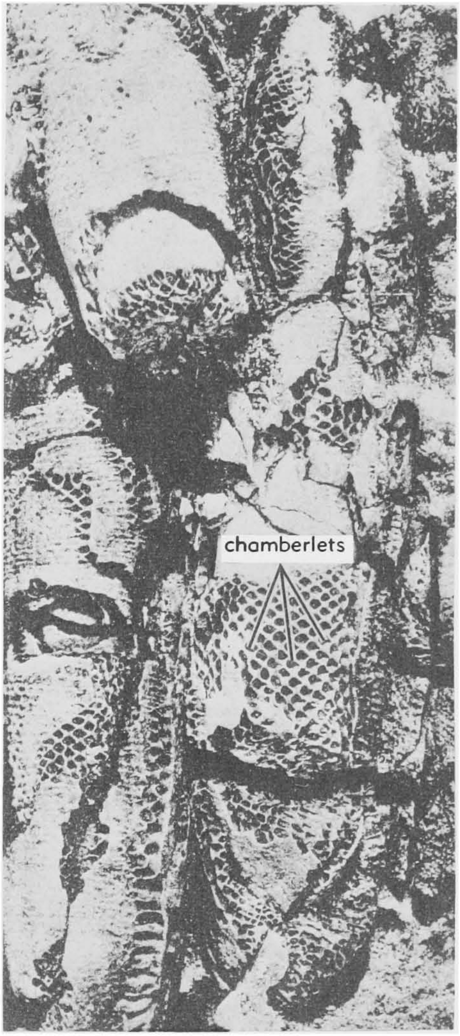

FIG. 278. **Parafusulina wordensis* DUNBAR & SKINNER, L.Perm.(Word F.), USA(Tex.); acid-etched silicified specimens showing prominent septal fluting which produces regularly arranged chamberlets, ×5 (*1922).

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 volution 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

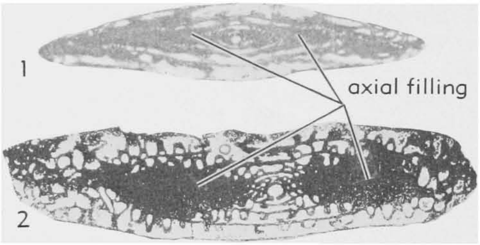

FIG. 279. Axial fillings in fusulinacean shells.——*1.* **Pseudowedekindellina prolixa* SHENG, M.Penn. (Penchi Ser.), China; axial sec. showing dense axial filling, ×14 (*1729).——*2.* **Quasifusulina longissima* (VON MÖLLER), U.Carb.(C_3), USSR(Tsarev Kurgan); axial sec. showing solid axial filling, ×10.5 (*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, 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.

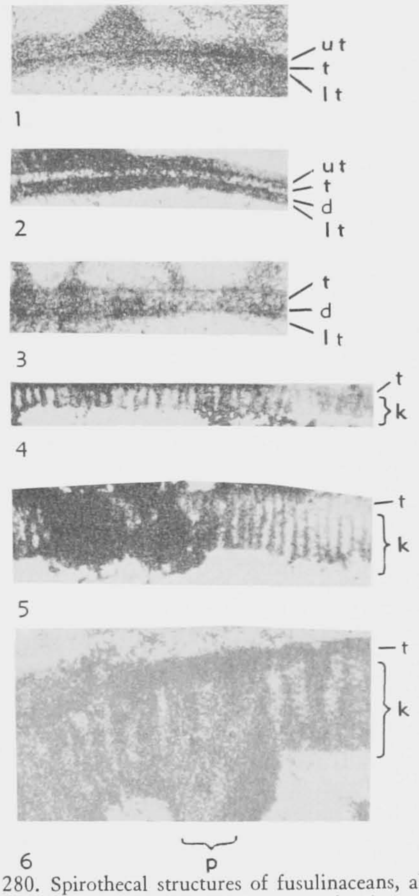

FIG. 280. Spirothecal structures of fusulinaceans, all ×100 (*1922).——*1. Profusulinella regia* THOMPSON, M.Penn., USA(Tex.); three-layered spirotheca.——*2. Fusulina* sp., M.Penn.(Garcia F.), USA(N. Mex.); four-layered spirotheca.——*3.* **Fusulina cylindrica* FISCHER DE WALDHEIM, Low.U.Carb.(Myatschkovo, 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.]

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*

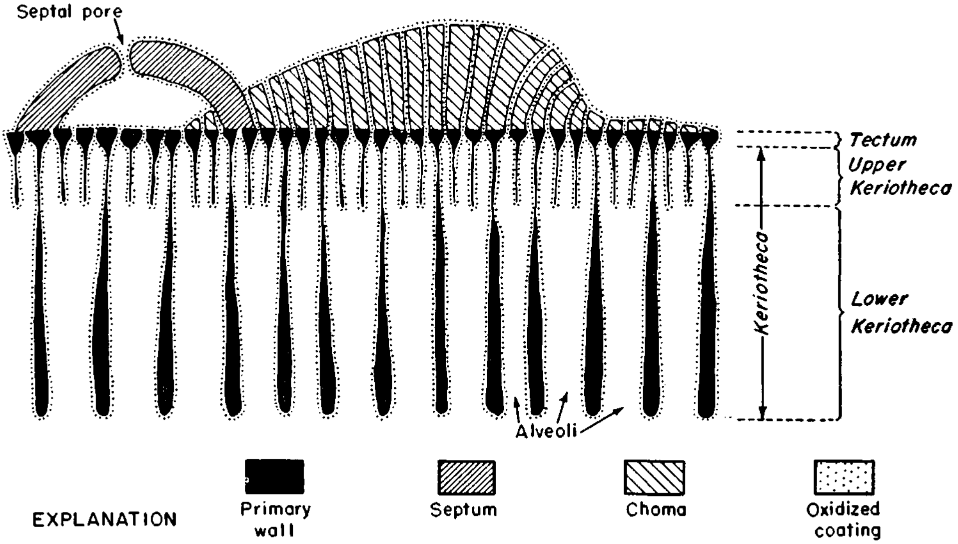

FIG. 281. Diagram of spirotheca showing pendant-like walls of alveoli, choma with chomatal pores, and septal pore, based on exceptionally well-preserved specimens of *Schwagerina campensis* THOMPSON, L.Perm. (Camp Cr. Sh.), USA(Tex.) (*1924).

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 constricted 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

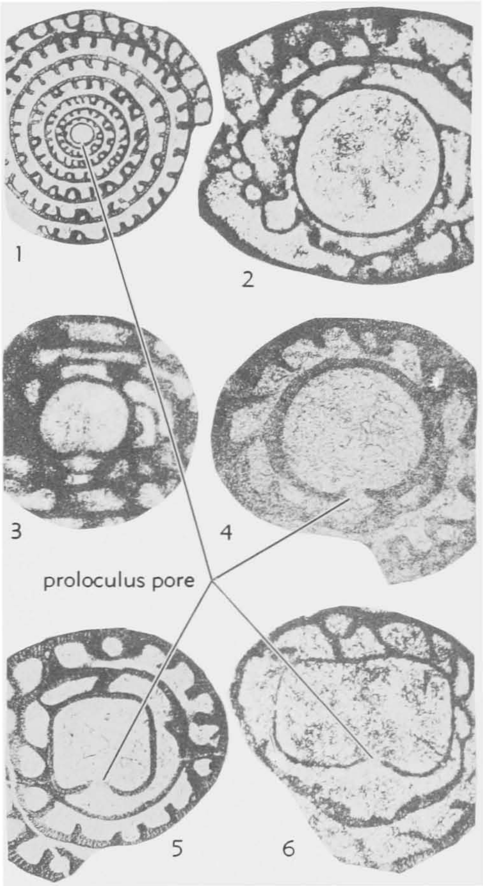

Fig. 282. Initial chambers (proloculi) of fusulinacean shells illustrated by species of *Parafusulina,* Permian, all "Fr. Indochina" except *5,* from Japan; proloculus pore, if present in section, directed downward.——*1. P. padangensis* (Lange); almost spherical proloculus with slightly thickened wall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

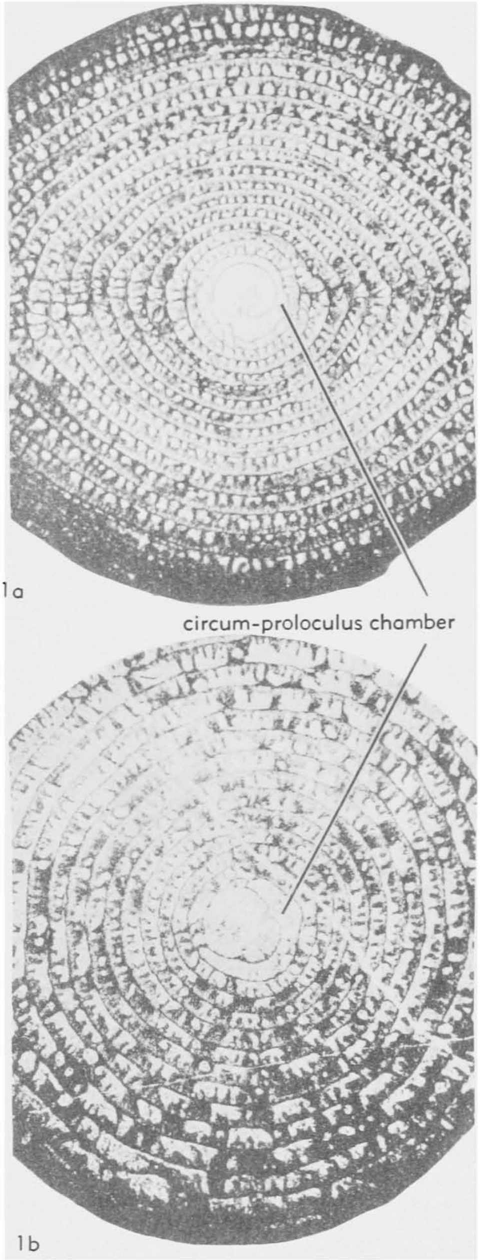

FIG. 283. Irregular circum-proloculus chamber observed in some fusulinaceans.——*1.* **Lepidolina multiseptata* (DEPRAT), U.Perm., Cambodia; *1a,b,* axial sec. of holotype, sagittal sec. of paratype, ×10 (*1922).

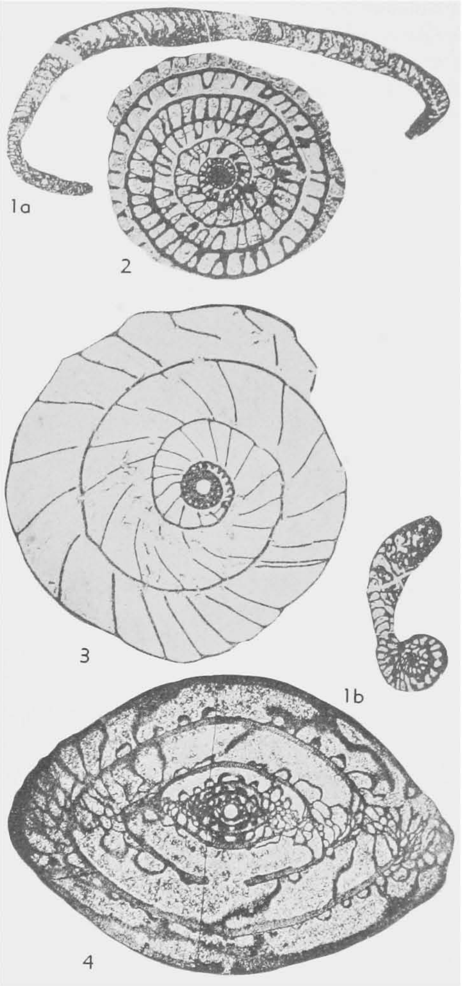

FIG. 284. Variation in chamber height and coiling in ontogeny of fusulinaceans.——*1. Nipponitella* HANZAWA, Perm.(Maiya Gr.), Japan; *1a, N. auricula* HANZAWA, axial sec. of syntype showing extreme uncoiling, ×6 (*1922); *1b, *N. explicata* HANZAWA, parallel sec. of paratype, ×6 (*1922).——*2. *Paraschwagerina gigantea* (WHITE), L. Perm.(Wolfcamp.), USA(Tex.), sagittal sec. of paratype showing contrast between juvenile and mature parts of shell, ×6 (*1922).——*3. *Robustoschwagerina tumida* (LIKHAREV), 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, ×6 (*1276).——*4. Pseudoschwagerina muongthensis* (DEPRAT), L. Perm., N.Vietnam(Tonkin); axial sec. showing abrupt increase in chamber height beginning in fourth whorl, ×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 reentrant 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 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.

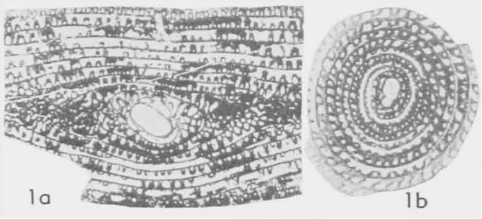

FIG. 285. Axial and sagittal sections of fusulinacean shells.——*1. Polydiexodina* DUNBAR & SKINNER, U. Perm.; *1a, P. afghanensis* THOMPSON, Bamian Ls., Afghan., axial sec. of holotype showing ellipsoidal proloculus and adjacent volutions, ×6.7 (*1922); *1b, *P. capitanensis* DUNBAR & SKINNER, Capitan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

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

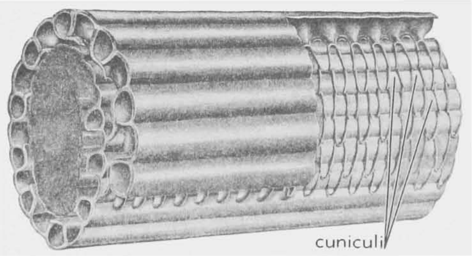

FIG. 286. Diagram illustrating inferred development of cuniculi in *Parafusulina* and *Polydiexodina* (*1922).

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 upturned 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

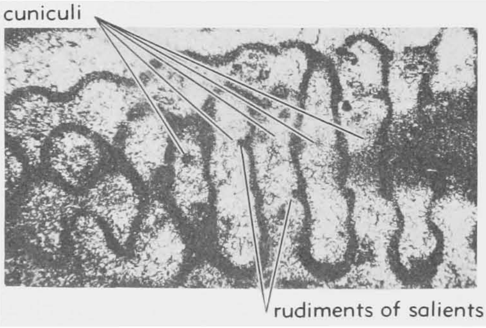

FIG. 287. Rudiments of salients of septa left after excavation of cuniculi in the test of *Parafusulina nosonensis* THOMPSON & WHEELER, L.Perm.(Nosoni F.), USA(Calif.), shown in part of tang. sec. of paratype, ×30 (*1922).

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.

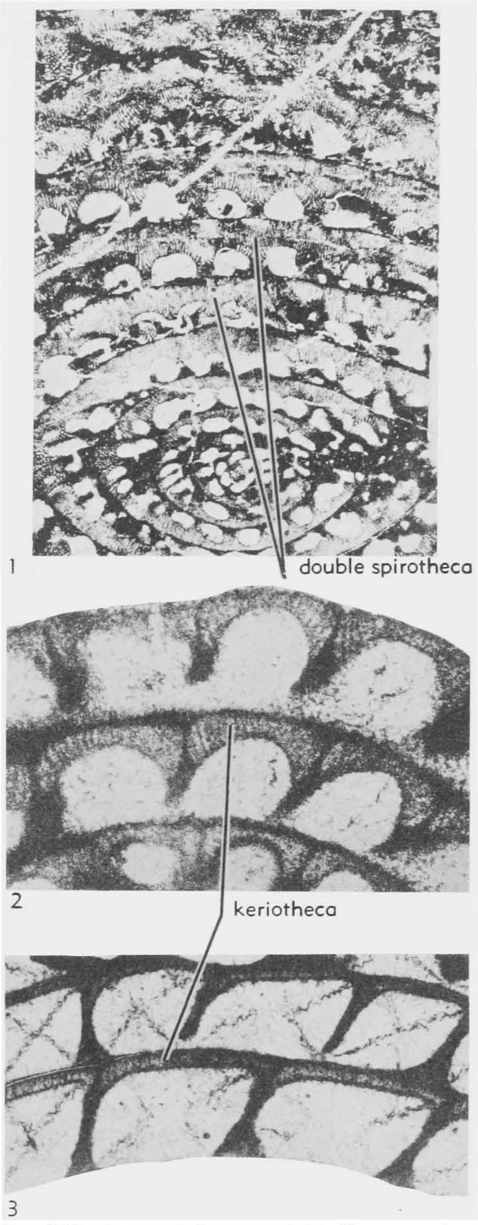

FIG. 288. Structural features of fusulinacean spirotheca and septa illustrated by *Neoschwagerina* YABE, U.Perm., and *Cancellina* HAYDEN, U.Perm., with thick spirotheca, and *Verbeekina* STAFF, U.Perm., with thin spirotheca.——*1*. *N. ovalis* (MINATO & HONJO), Akasaka Ls., Japan(Gifu Pref.); slightly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

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

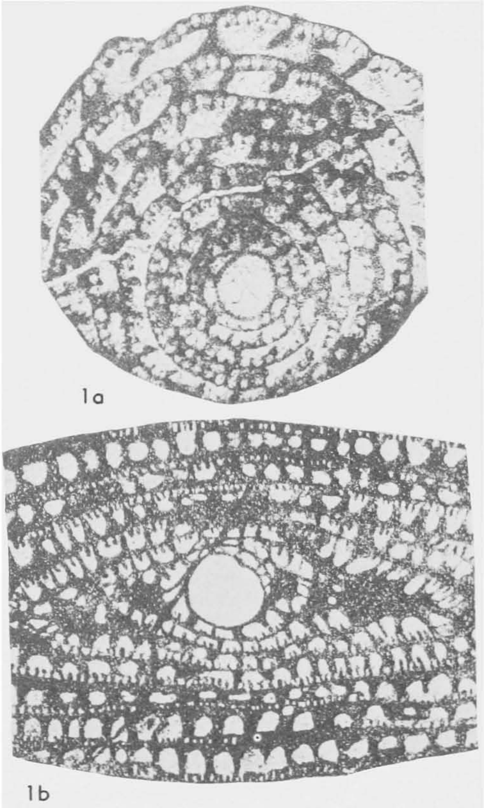

Fig. 289. Thin spirotheca of *Sumatrina* Volz, U. Perm., consisting of a single dense layer.——*1a. S. longissima* (Deprat), Cambodia (type-sp. of *Pseudolepidolina*), part of sagittal sec., ×45; *1b,* **S. annae* Volz, Sumatra, part of axial sec. of holotype, ×30 (*1922).

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

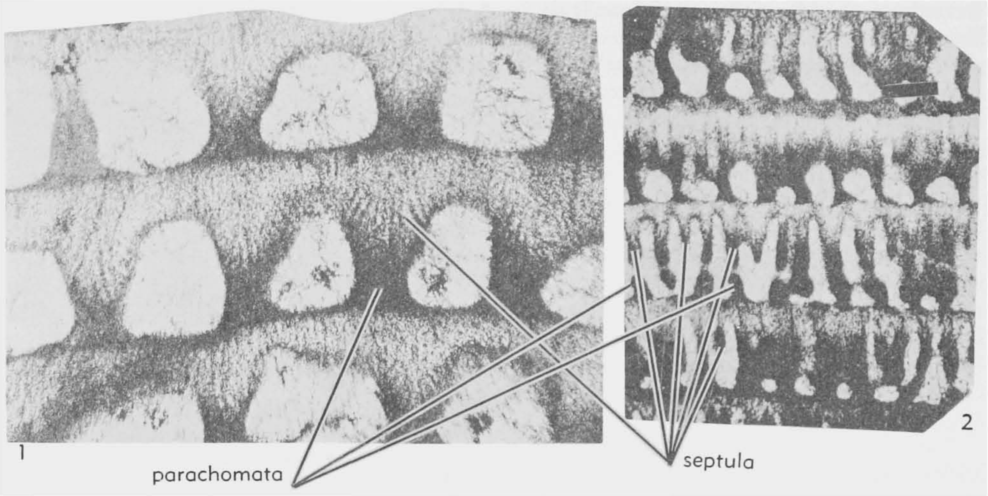

FIG. 290. Alveolar structure of spirotheca and septula in *Neoschwagerina* YABE, U.Perm., and *Yabeina* DEPRAT, U.Perm.——*1. N. haydeni* DUTKEVICH & KHABAKOV, Bamian Ls., Afghan.; part of axial sec. showing divergent alveoli extending through spirotheca into basal part of septula, ×100 (*1922).——2. **Y.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

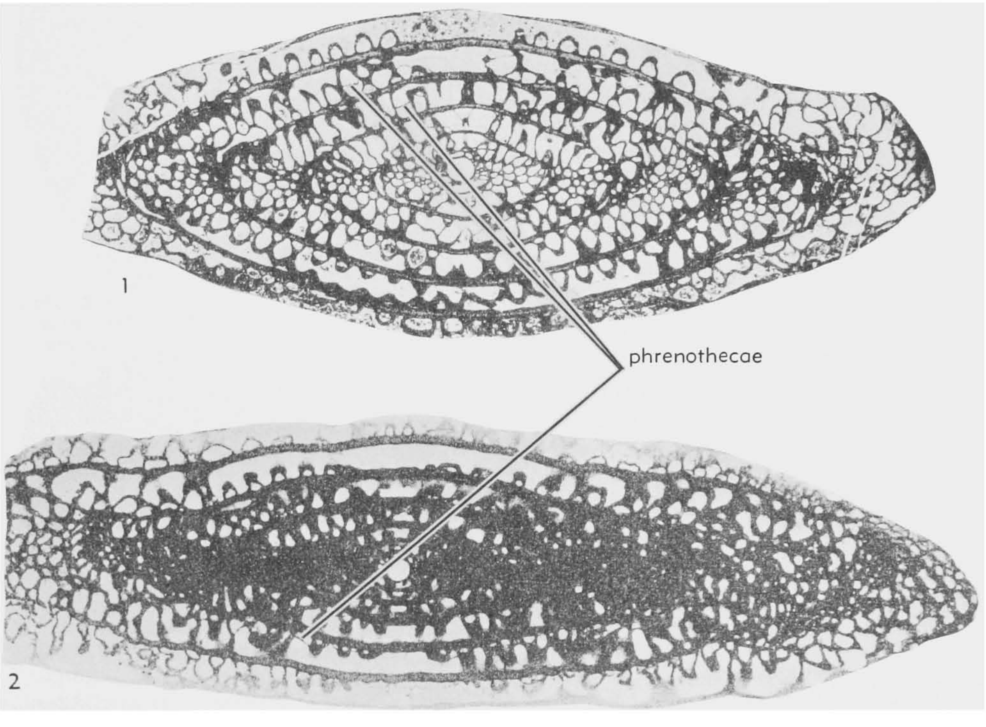

FIG. 291. Phrenothecae of fusulinaceans illustrated by *Pseudofusulina* DUNBAR & SKINNER, L.Perm.——*1. P. nelsoni* (DUNBAR & SKINNER), Hueco Ls., USA(Tex.); axial sec. with phrenothecae chiefly adjacent to tunnel, ×10 (*1922).——*2.* **P. huecoensis* DUNBAR & SKINNER, Hueco Ls., USA(Tex.); axial sec.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

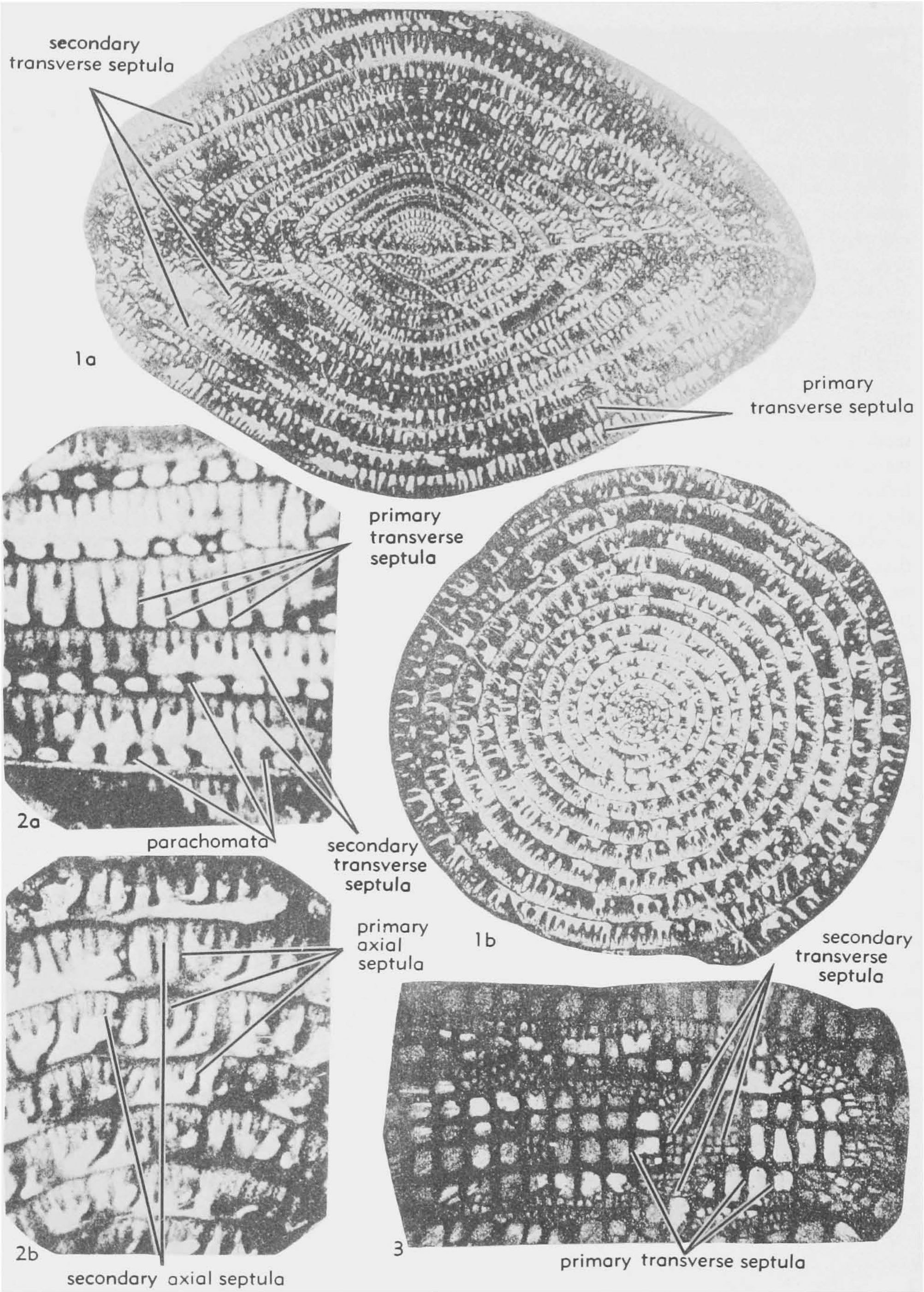

FIG. 292. Septula and parachomata of specialized fusulinaceans illustrated by *Yabeina* DEPRAT, U.Perm., *Lepidolina* LEE, U.Perm., and *Sumatrina* VOLZ, U.Perm.——*1.* **Y. inouyei* (DEPRAT), Akasaka Ls., Japan; *1a,* axial sec. of holotype showing primary and secondary transverse septula, especially in outer volutions, ×10; *1b,* sagittal sec. of paratype showing primary and secondary axial septula, ×10 (*1922).——*2.* **L. multiseptata* (DEPRAT), Cambodia *(2a)*, Akasaka Ls., Japan *(2b)*; *2a,* part of axial sec. showing transverse septula and parachomata, ×45; *2b,* part of sagittal sec. showing long primary septula with short secondary ones between them, ×45 (*1922).——*3.* **S. annae* VOLZ, Sumatra; tang. sec. showing transverse and axial septula, ×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,*1*). 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 developed Neoschwagerininae (e.g., *Lepidolina, Sumatrina*) are very thin and do not contain recognizable alveoli.

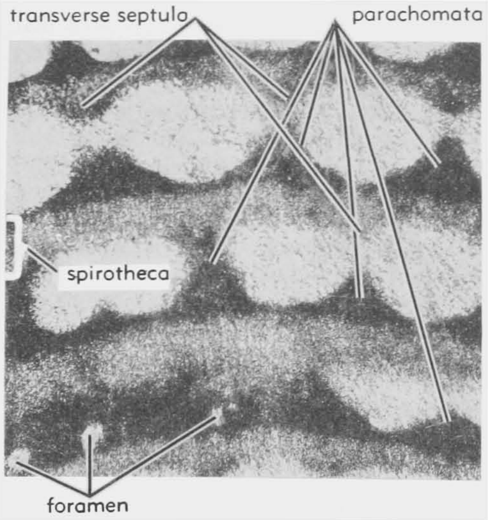

FIG. 293. Spirotheca, rudimentary transverse septula, and parachomata shown in axial sec. of **Cancellina primigena* (HAYDEN), U.Perm., Iran; septula comprise pendant extensions of keriotheca from roofs of chambers opposite parachomata (dark) on floors of chambers, ×100 (*1922)

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

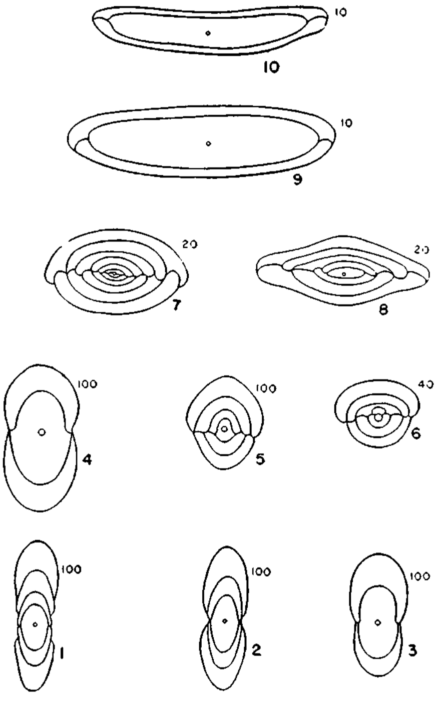

FIG. 294. Development of shell shape and size of fusulinaceans belonging to the Ozawainellidae and Fusulinidae (Fusulininae), numbers at upper right of each figure denoting relative (not actual) magnifications.——*1. *Millerella marblensis,* M.Penn. (Marble Falls Ls.), USA(Tex.).——*2. M. pressa,* L.Penn.(Kearny 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).

(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, Quasifusulina*). Out of fusiform shells of primitive *Triticites,* the Schwagerininae produced 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

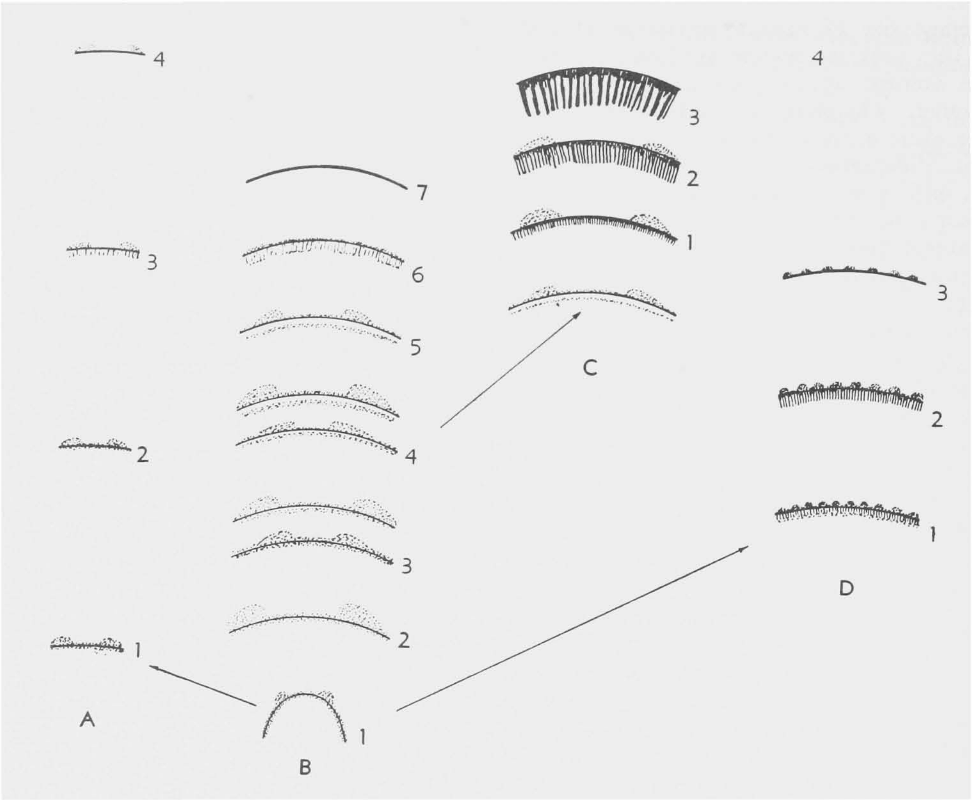

FIG. 295. Evolution of the spirotheca in the Fusulinidae.——*A1-4*. Schubertellinae; *1*, primitive *Eoschubertella; 2,* highly developed *Eoschubertella*; *3,* typical *Schubertella*; *4,* highly developed *Schubertella.*——*B1-7*. Fusulininae; *1, Pseudostaffella*; *2, Profusulinella regia*; *3, Fusulinella? 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,* Verbeekininae; *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 *Millerella.* 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,B*1,2*) developed into the four-layered spirotheca of *Fusulinella* (Fig. 295, B*4*). 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, Polydiexodina*) 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 become 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 volutions 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 volutions of *Eoverbeekina* and occur only adjacent to the septa of inner volutions of *Verbeekina* but extend across the chambers of outer volutions. 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 considerable 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 Verbeekininae, lacks a recognized closely similar ancestor and its relationship to other members of the Verbeekininae 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 cyclothems, 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 interregional 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 Pensylvanian 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

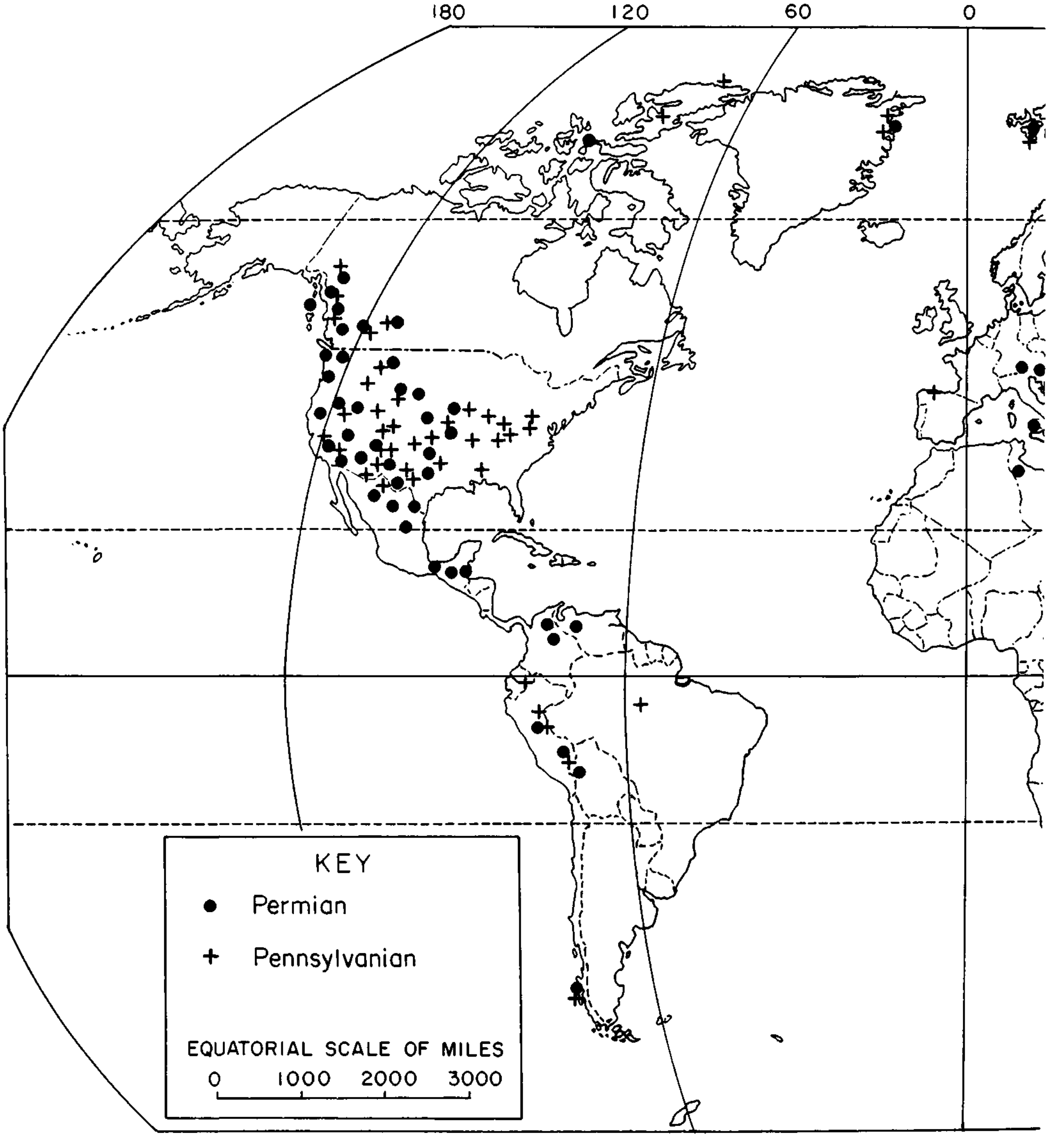

FIG. 296. Distribution of Pennsylvanian (Upper Carboniferous) and Permian fusulinaceans indicated by general localities from which they have been described or reported (*2120B).

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

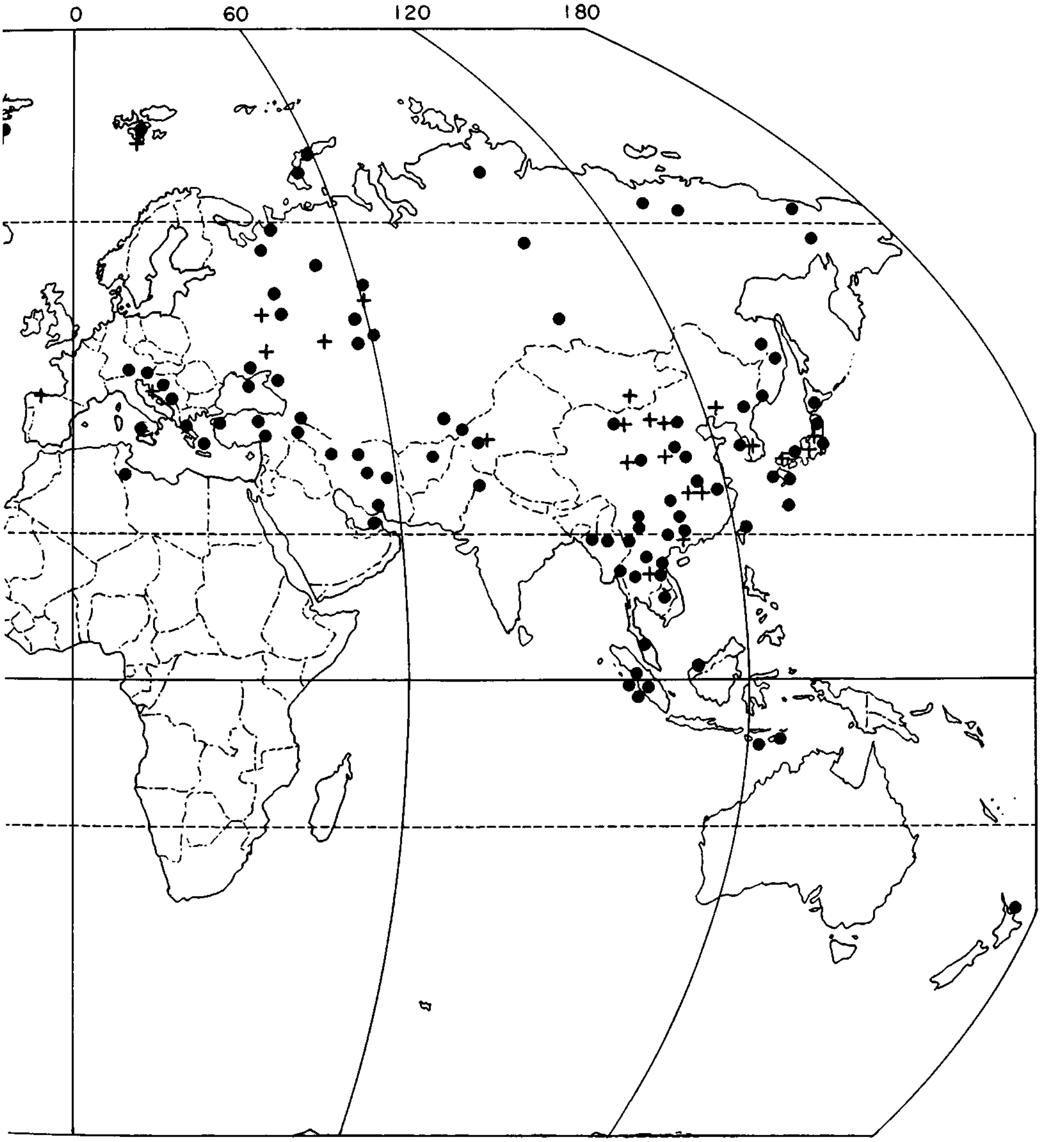

FIG. 296. *(continued from facing page).*

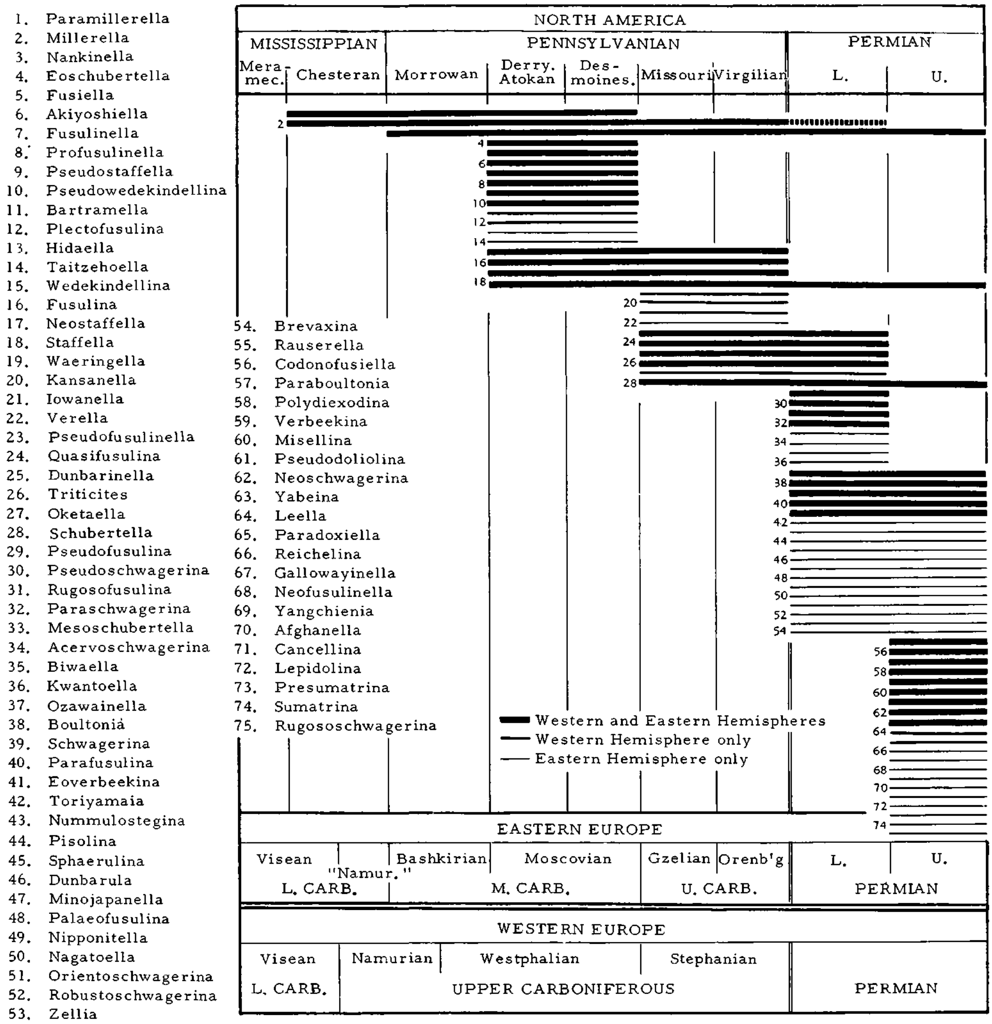

FIG. 297. Stratigraphic distribution of fusulinacean genera as recorded in *Treatise* text devoted to systematic descriptions. Attention is drawn to the fact that many ranges are plotted as spanning all of one or more stratigraphic divisions, whereas the actual ranges, if precisely known, may be appreciably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

Acervoschwagerina—34
Afghanella—70
Akiyoshiella—6
Bartramella—11
Biwaella—35
Boultonia—38
Brevaxina—54
Cancellina—71
Codonofusiella—56
Dunbarinella—25
Dunbarula—46
Eoschubertella—4
Eoverbeekina—41
Fusiella—5
Fusulina—16
Fusulinella—7
Gallowayinella—67
Hidaella—13
Iowanella—21
Kansanella—20
Kwantoella—36
Leella—64
Lepidolina—72
Mesoschubertella—33
Millerella—2
Minojapanella—47
Misellina—60
Nagatoella—50
Nankinella—3
Neofusulinella—68
Neoschwagerina—62
Neostaffella—17
Nipponitella—49
Nummulostegina—43
Oketaella—27
Orientoschwagerina—51
Ozawainella—37
Palaeofusulina—48
Paraboultonia—57
Paradoxiella—65
Parafusulina—40
Paramillerella—1
Paraschwagerina—32
Pisolina—44
Plectofusulina—12
Polydiexodina—58
Presumatrina—73
Profusulinella—8
Pseudodoliolina—61
Pseudofusulina—29
Pseudofusulinella—23
Pseudoschwagerina—30
Pseudostaffella—9
Pseudowedekindellina—10
Quasifusulina—24
Rauserella—55
Reichelina—66
Robustoschwagerina—52
Rugosofusulina—31
Rugososchwagerina—75
Schubertella—28
Schwagerina—39
Sphaerulina—45
Staffella—18
Sumatrina—74
Taitzehoella—14
Toriyamaia—42
Triticites—26
Verbeekina—59
Verella—22
Waeringella—19
Wedekindellina—15
Yabeina—63
Yangchienia—69
Zellia—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 POLYDIEXODINA

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 (^{1}superfamily, ^{2}family group); dagger(†) indicates *partim*]——[^{1}=Orthoklinostegia† EIMER & FICKERT, 1899, p. 685 (*nom. nud.*); =^{2}Rotaliaridia† RHUMBLER in KÜKENTHAL & KRUMBACH, 1923, p. 88; =^{1}Fusulinaceae MIKLUKHO-MAKLAY, 1957, p. 96; =^{1}Neoschwagerinaceae MIKLUKHO-MAKLAY, 1957, p. 109; =^{1}Fusulinidea POKORNÝ, 1958, p. 220; =^{1}Verbeekinacea MIKLUKHO-MAKLAY, 1958, p. 7; =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)] [=Reichelininae 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-

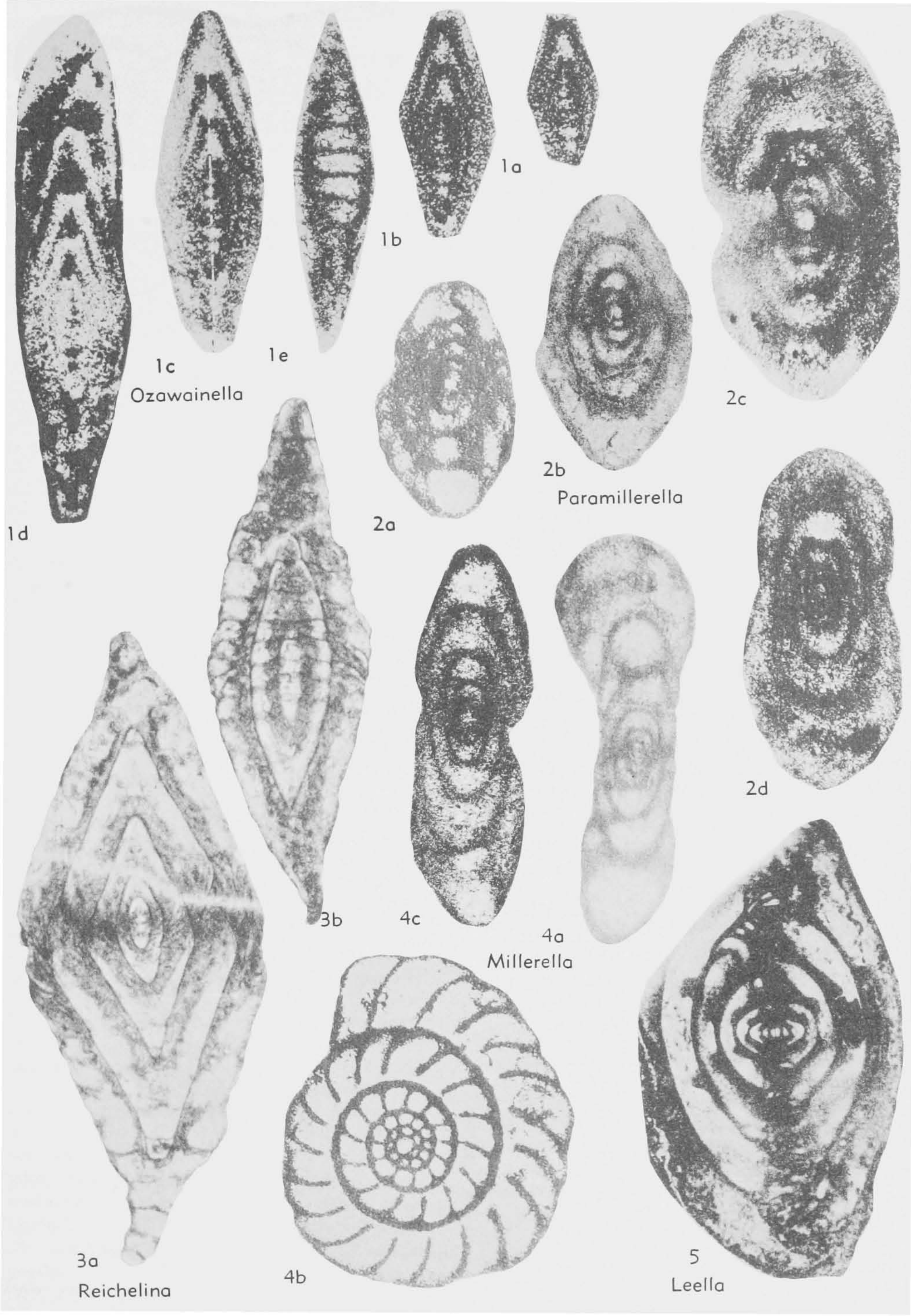

FIG. 298. Ozawainellidae; *1, Ozawainella; 2, Paramillerella; 3, Reichelina; 4, Millerella; 5, Leella* (p. C396-C397).

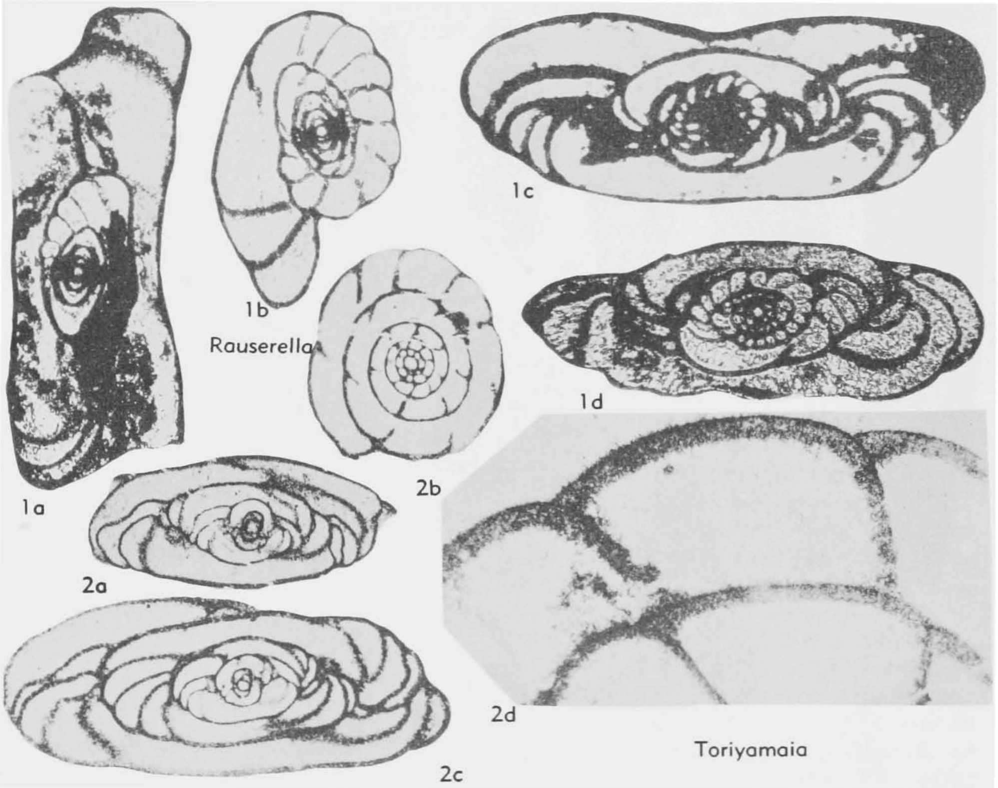

FIG. 299. Ozawainellidae; *1, Rauserella; 2, Toriyamaia* (p. C397).

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, ×45; *1d*, axial sec. of paratype, ×45; *1e*, tang. sec. of paratype, ×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, ×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, ×100 (*1922); *4b*, sagittal sec., ×100 (*1926).——FIG. 298,*4c*. *M. pressa* THOMPSON, L.Penn. (Kearny F.), USA (Kans.); axial sec. of holotype, ×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 mediocris* 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, ×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. cribroseptata*; 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. cribroseptata*, Turkey; *3a*, axial sec. of holotype, ×70 (*1926); *3b*, tang. sec. of paratype, ×70 (*1926).

Toriyamaia Kanmera, 1956, *1013, p. 251 [**T. laxiseptata*; 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. laxiseptata*, 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; =Staffelininae 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 Canyon); outline drawing, ×40 (*1922).——FIG. 300,*1b,c*. *N. plummeri* THOMPSON, M.Penn. (Marble Falls Ls.), USA(Tex.); *1b,* axial sec. of holotype, ×50 (*1922); *1c,* tang. sec. of paratype, ×50 (*1922).——FIG. 300,*1d*. **N. discoides* (LEE), Perm.(Chihsia Ls.), China(Nan-

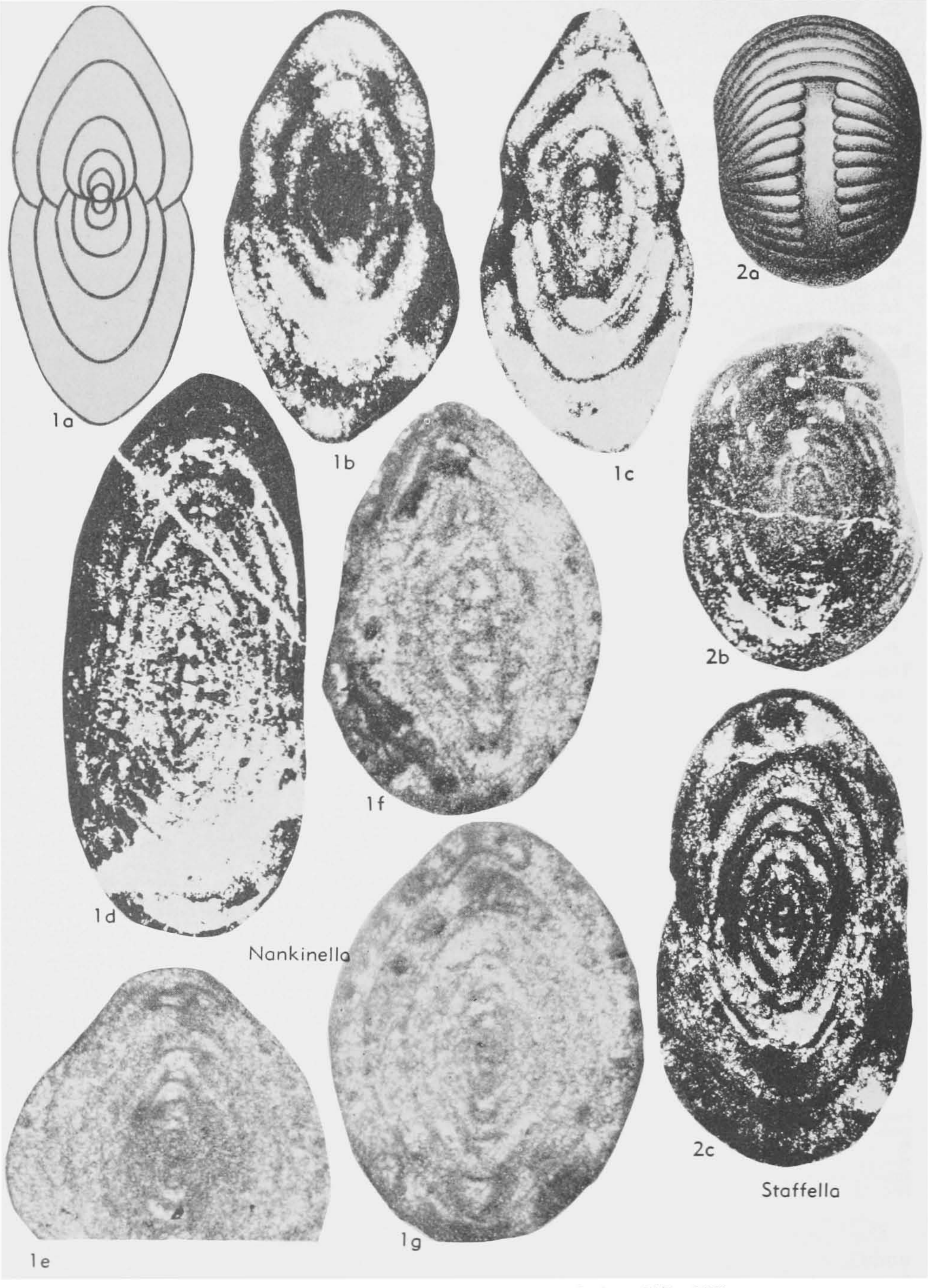

FIG. 300. Staffellidae; *1, Nankinella; 2, Staffella* (p. C397-C399).

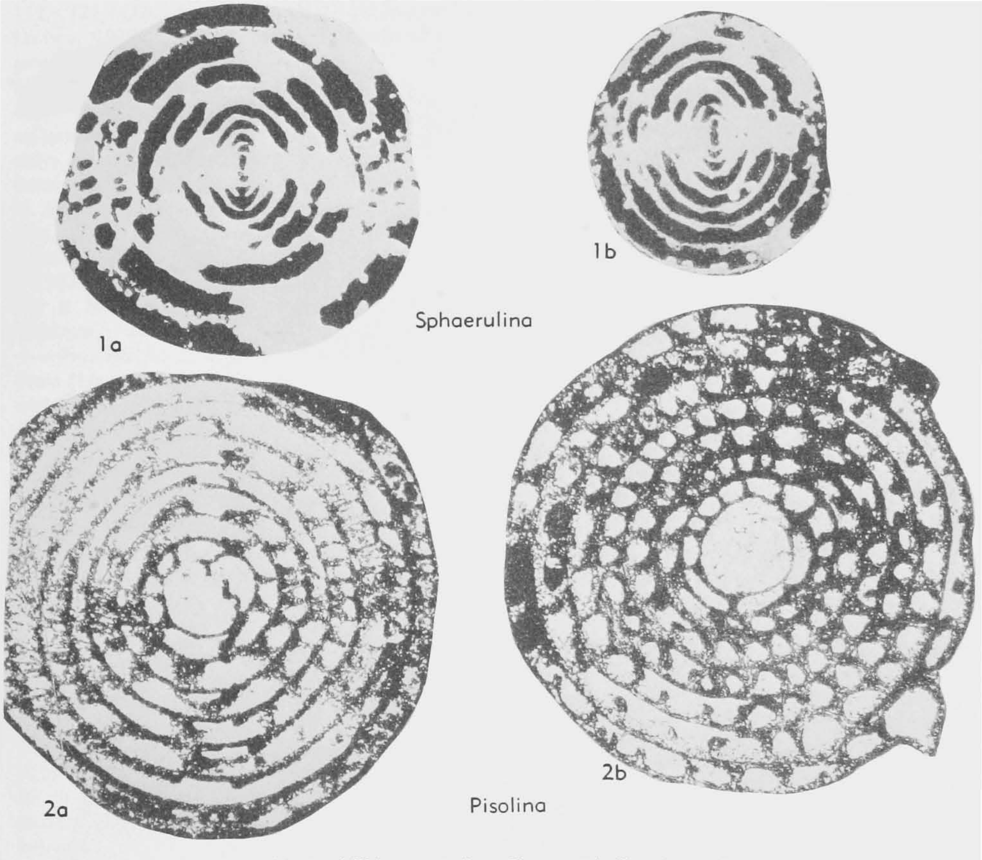

Fig. 301. Staffellidae; *1, Sphaerulina; 2, Pisolina* (p. *C*399).

king); tang. sec. of holotype, ×15 (*1922).——Fig. 300,*1e-g*. *N. kotakiensis* (Fujimoto & Kawada), L.Perm.(Omi Ls.), Japan(Niigata Pref.); *1e,* near-centered axial sec., ×40; *1f,* eccentric axial sec., ×40; *1g,* axial sec., ×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, ×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, ×15; *2b,* sagittal sec. of paratype, ×15 (*1922).

Sphaerulina Lee, 1933[1934], *1120, p. 16 [**S. crassispira*; OD]. Minute, mature shell spherical and slightly umbilicate, composed of about 10 volutions, planispiral throughout, first 3 or 4 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, ×30; *1b,* axial sec. of paratype, ×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; =Fusilinidae 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-

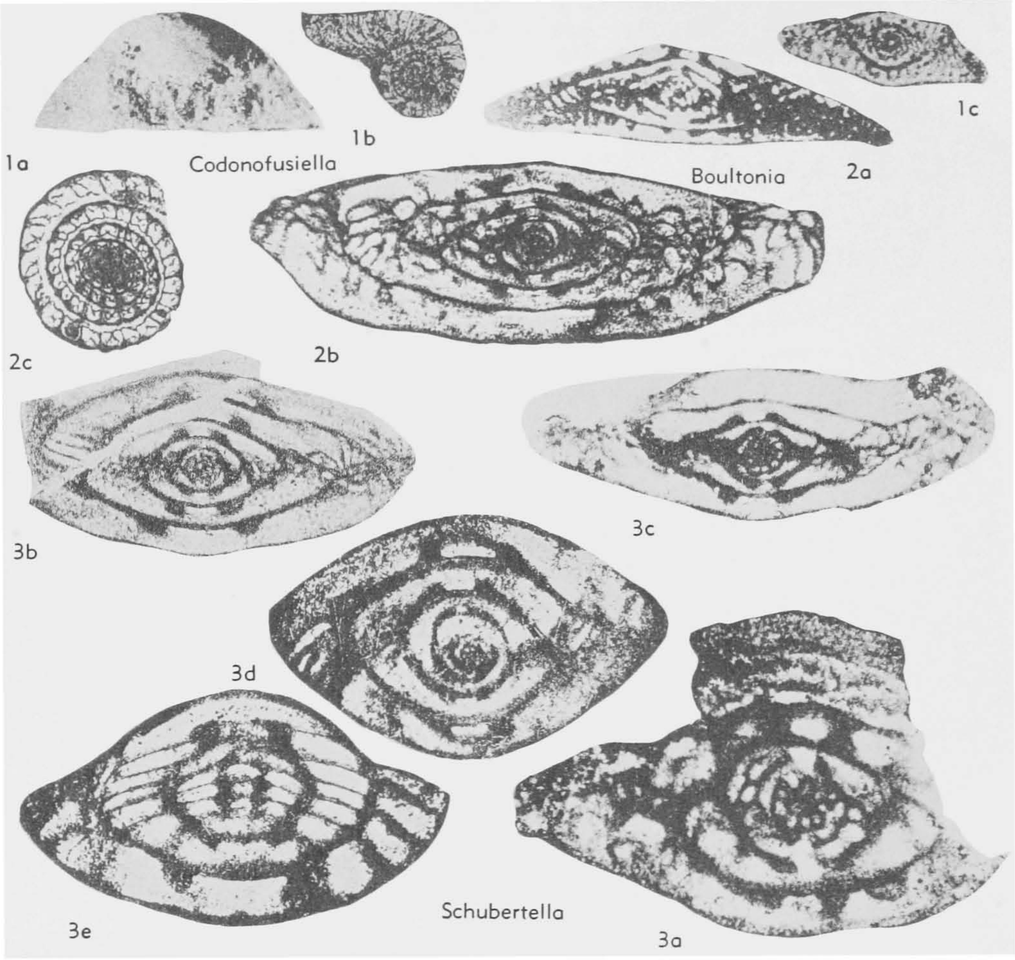

FIG. 302. Fusulinidae (Schubertellinae; *1, Codonofusiella; 2, Boultonia; 3, Schubertella*) (p. C400-C401).

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; =Schubertellininae 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 topotype, ×83 (*1922).——Fig. 302,*3b*. *S. mulleriedi* Thompson & Miller, L.Perm.(Paso Hondo F.), Mex. (Chiapas); axial sec. of syntype, ×20 (*1922). ——Fig. 302,*3c*. *S. kingi* Dunbar & Skinner, L. Perm.(Hueco Ls.), USA(Tex.); axial sec. of syntype, ×50 (*1922).——Fig. 302,*3d,e*. *S. giraudi* (Deprat), L.Perm., Laos(Cammon); *3d*, axial sec. of holotype, ×45 (*1922); *3e*, tang. sec. of paratype showing lack of septal fluting, ×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, ×53 (*1922).——Fig. 302,*2b,c*. *B. guadalupensis* Skinner & Wilde, L.Perm.(Parafusulina Z., Bone Spring Ls.), USA(Tex.); *2b*, axial sec. of holotype, ×40; *2c*, sagittal sec. of paratype, ×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 ×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 topotype showing diagonal arrangement of septal pores, ×40; *3b*, part of sagittal sec. showing structure of spirotheca, ×150; *3c*, part of axial sec. of *3a* showing diagonal arrangement of septal pores, ×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, ×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, ×30; *1b*, sagittal sec. of paratype, ×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, ×30; *2c*, tang. sec. of paratype, ×30; *2d*, part of axial sec. of holotype showing structure of spirotheca, ×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 topotype, ×30, ×40; *2b*, sagittal sec. of topotype, ×40; *2d*, tang. sec. of paratype showing septal fluting, ×150 (*1926).

Paraboultonia Skinner & Wilde, 1954, *1795, p.

441 [**P. splendens*; OD] [=?*Tavajzites* TUMANSKAYA, 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 volutions 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

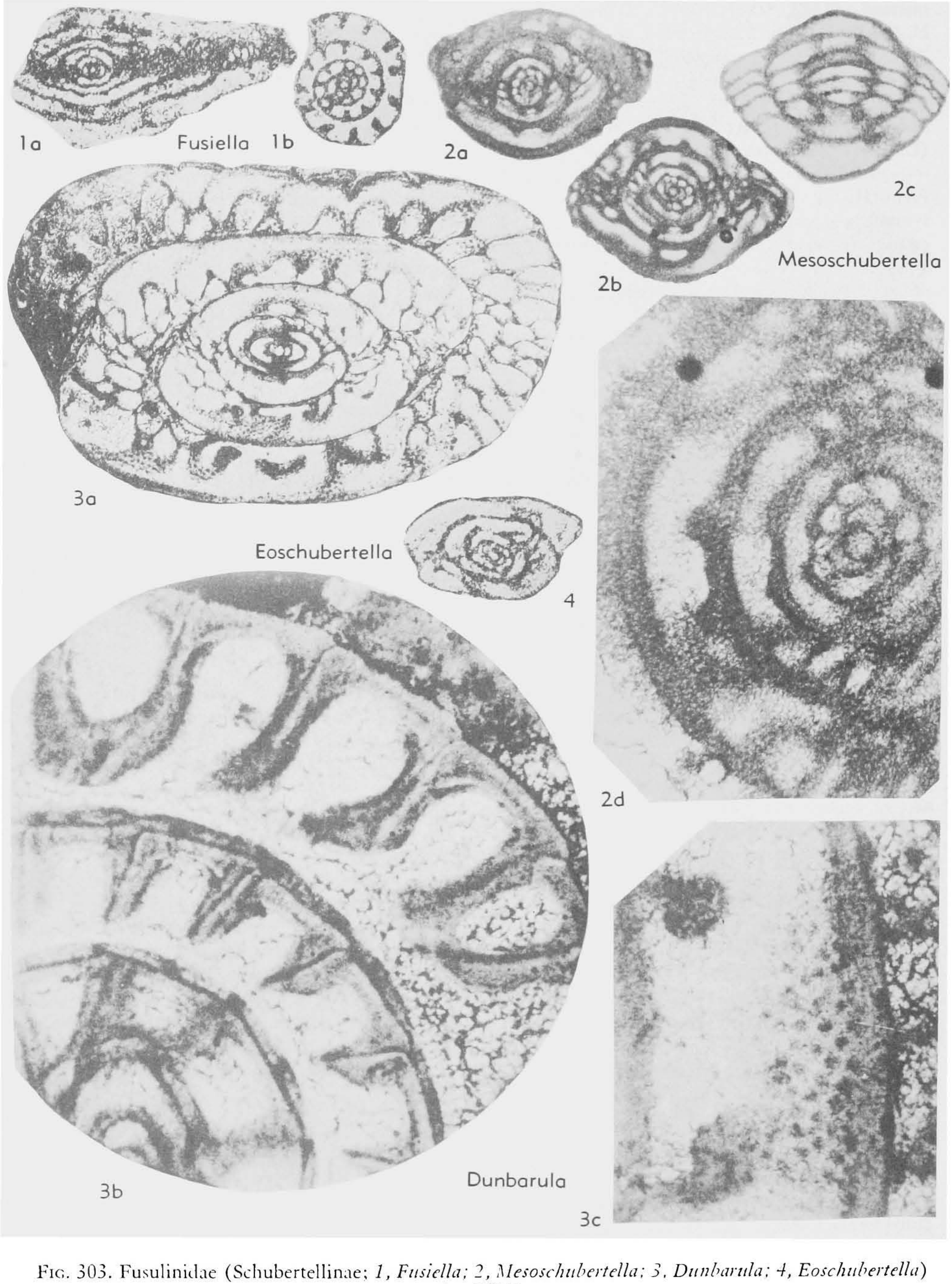

FIG. 303. Fusulinidae (Schubertellinae; *1, Fusiella; 2, Mesoschubertella; 3, Dunbarula; 4, Eoschubertella*) (p. *C*401).

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, ×40; *1b,* axial sec. of holotype, ×40; *1c,* tang. sec. of paratype showing cuniculi, ×100 (*1795).——Fig. 304,*1d*. *P. delicata* (Colani), type-sp. of *Tavajzites,* China(Yunnan); slightly oblique axial sec., ×100 (*354).

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

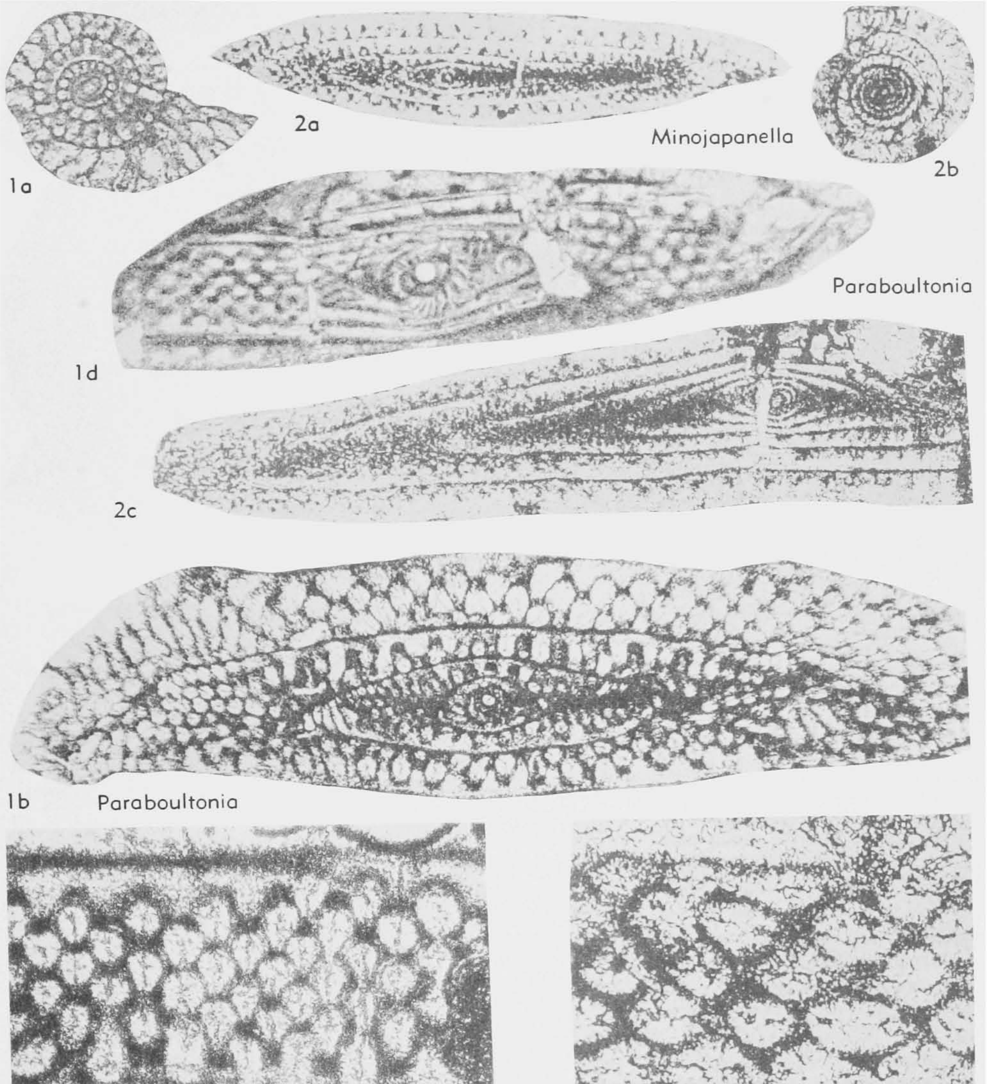

Fig. 304. Fusulinidae (Schubertellinae; *1, Paraboultonia; 2, Minojapanella*) (p. C401-C403).

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 epithecal layer on anterior and posterior surfaces near center of shell, septa intensely fluted throughout, developing what seem to be cuniculi, 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, ×30; *1c,d,* horiz. axial secs. of paratype and holotype, ×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 volutions coiled 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,

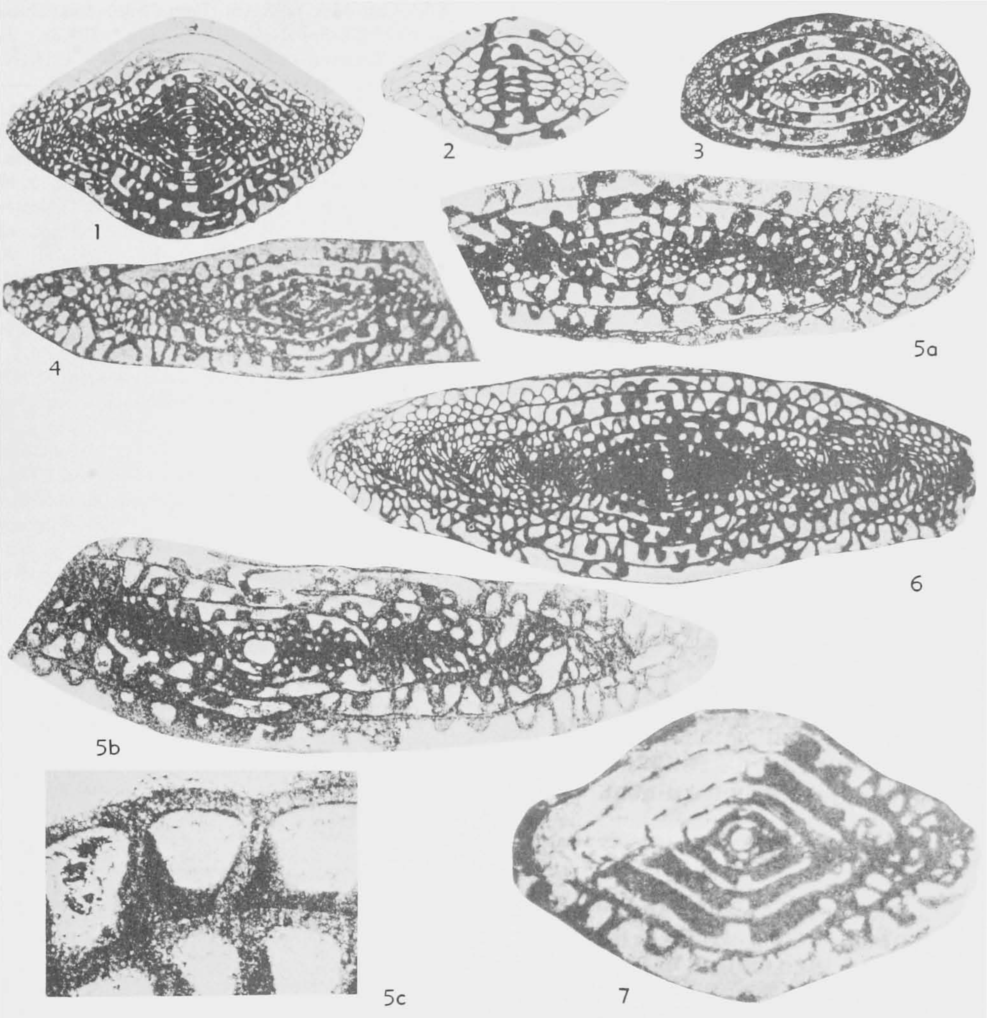

FIG. 306. Fusulinidae (Fusulininae; *1-7, Fusulina*) (p. C404-C406).

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 volutions; 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., ×10 (*1922).——FIG. 306,*2*. *F.* sp., M. Penn.(Garcia F.), USA(N.Mex.); tang. sec., ×10 (*1922).——FIG. 306,*3*. *F. minima* SCHELLWIEN (=*Hemifusulina bocki* VON MÖLLER, 1878), Moscov., USSR(Tver); axial sec. of holotype, ×15 (*1922).——FIG. 306,*4*. *F. donbassica* (PUTRYA),

Moscov., USSR(Donets Basin); axial sec. of syntype, ×12 (*1491).——Fig. 306,*5*. **F.* *cylindrica* Fischer de Waldheim, Moscov.(Myachkovo Ls.), USSR(Myachkovo Quarry); *5a,b,* axial secs. of topotypes, ×15, ×20; *5c,* part of sagittal sec. of topotype, ×100 (*1922) (see also Fig. 280,*3*).——Fig. 306,*6*. *F. mysticensis* Thompson, M.Penn.(Worland Ls.), USA(Iowa); axial sec. of syntype, ×10 (*1922) (see also Fig. 294, 9).——Fig. 306,*7*. *F. prima* (Solovieva), Moscov. (Kachir Horizon), USSR (Noura-Taou); axial sec. of holotype, ×35 (*1812).——Fig. 328A,*2*. *F. triangula* Rauzer-Chernousova & Belyaev, Moscov. (Podolsk Horizon), USSR(Skar-Yu River, Sib.); axial sec. of holotype, ×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, *1941, 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, ×20; *3b,* tang. sec. of paratype showing asymmetry of outer volutions, ×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, ×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. imamurai*; 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, ×20 (*1922).——Fig. 307,*2b*. *F. imamurai* (Okimura), Atetu Ls., Japan(Okayama Pref.); part of axial sec., ×250 (*1386).——Fig. 307,*2c*. **F. bocki* von Möller, USSR(Tver, Kresty); axial sec. of topotype, ×40 (*1922).——Fig. 307,*2d*. *F. iowensis* Thompson, Cherokee equiv., USA(Iowa); axial sec. of holotype, ×20 (*1910).——Fig. 307,*2e*. *F. famula* Thompson, Cuchillo Negro F., USA(N. Mex.); part of sagittal sec. of paratype showing 4-layered spirotheca, ×100 (*1922). [See also Fig. 294,*8*.]

Gallowayinella Chen in Dunbar & Skinner, 1937, *333, p. 571 [*nom. correct.* Thompson, herein (*pro Gallowaiinella* Chen, 1937, *nom. subst. pro Gallowaiina* Chen, 1934, *331, p. 237, =*Gallowayina* Chen, 1934, *nom. correct., non Gallowayina* Ellis, 1932, *699, p. 1)] [**Gallowaiina 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, ×15, ×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 *Gallowaiina,* 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 *Gallowaiina* 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. *Gallowaiinella* Chen in Dunbar & Skinner, 1937, is such a name, but it is defective in the same ways as *Gallowaiina,* 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 *Gallowaiina,* 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 ×20 (*754).

Neofusulinella Deprat, 1912, *585, p. 1549 [**N.*

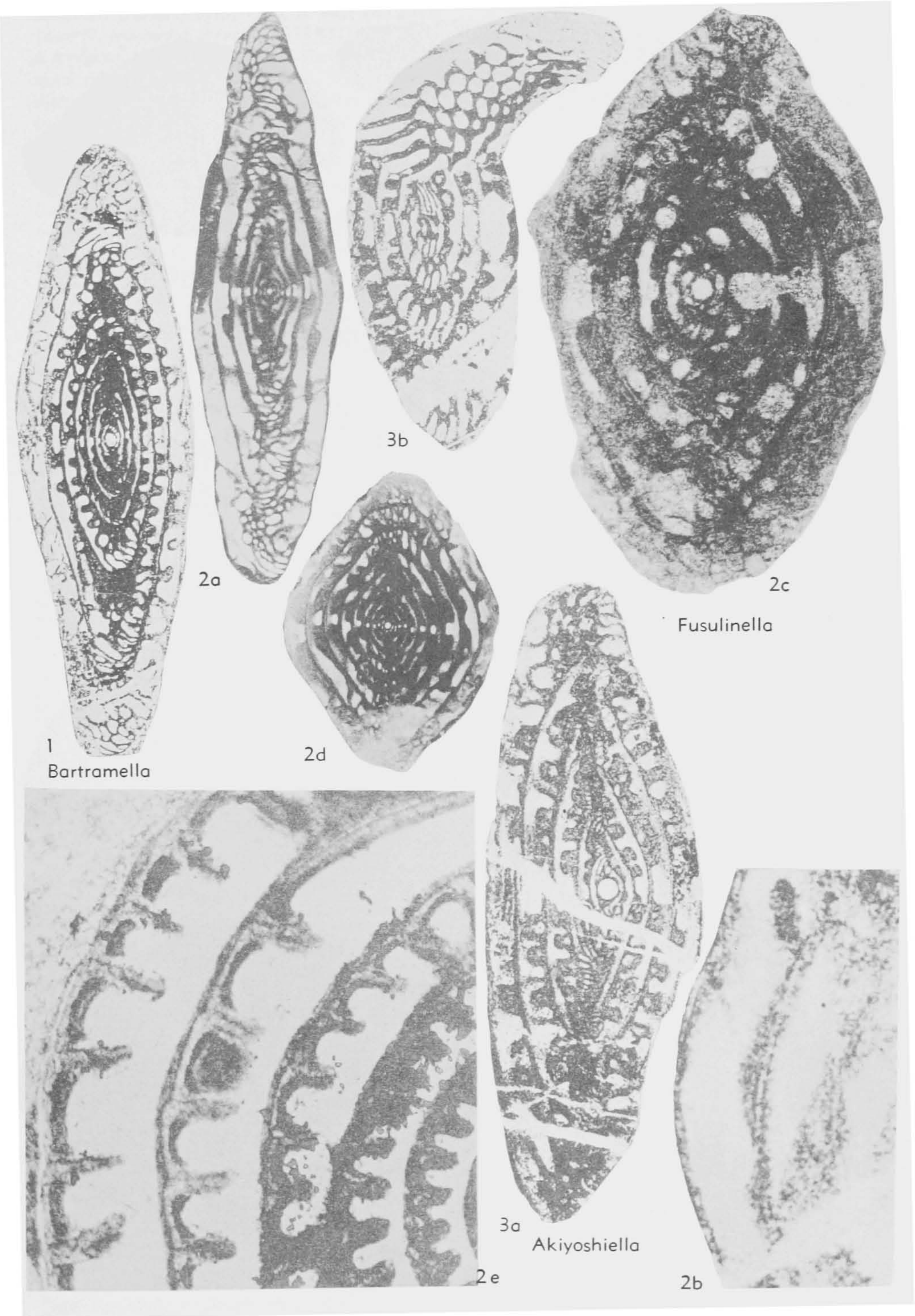

FIG. 307. Fusulinidae (Fusulininae; *1, Bartramella; 2, Fusulinella; 3, Akiyoshiella*) (p. C406).

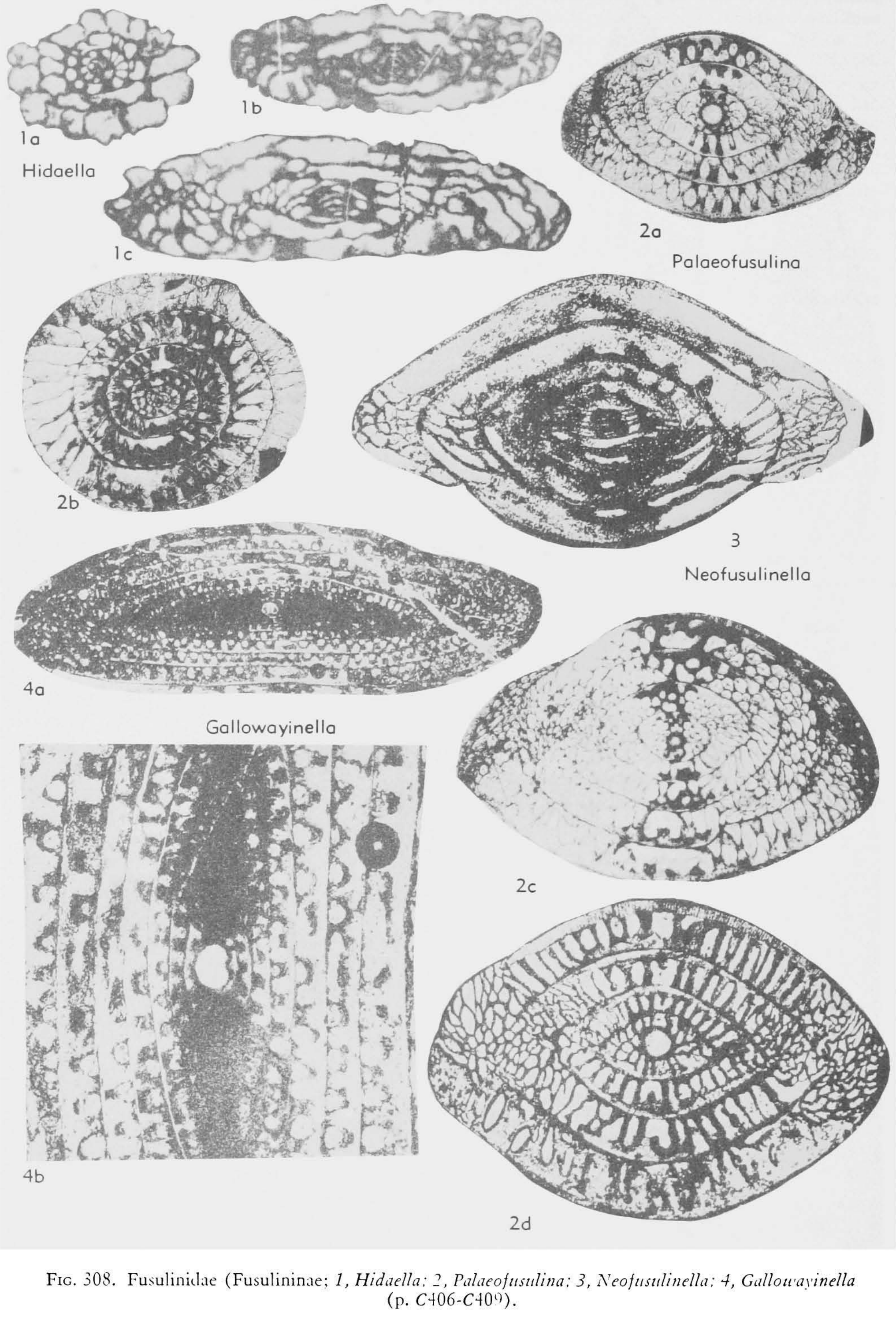

Fig. 308. Fusulinidae (Fusulininae; *1, Hidaella; 2, Palaeofusulina; 3, Neofusulinella; 4, Gallowayinella* (p. *C*406-*C*409).

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, ×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 Bam-Na-Mat, between Sam-Neua and Luang-Prabang, writing as follows: "*Neofusulinella*. J"ai trouvé dans les calcaires rapportés de Bam-Na-Mat (entre Sam-Neua et Luang-Prabang), par M. Mansuy, un autre Fusulinidé constituant indiscutablement un genre nouveau. . . . Malgré le grande 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. schwagerinoides*. Deprat's 1913 paper contains the following: "*Neofusulinella* nov. gen. J'ai signalé il y a quelque temps un nouveau genre de Fusulinidée 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 schwagerinoides* 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,I of these Rules reads: "Cases in which the generic type is accepted *solely* upon the basis of the original publication." Case c, Article 30,I 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. schwagerinoides* 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.] *U.Carb.(M.Penn.-U.Penn.)*, Eu.-Asia-N. Am.——Fig. 311,*2a*. *N. paradoxa* (Dutkevitch), Myachkovo Horizon, USSR(Polazna); axial sec., ×20 (*1509A).——Fig. 311,*2b*. *N. ozawai compacta* (Manukalova), Podolsk Horizon, USSR (Nytva); axial sec., ×20 (*1509A).——Fig. 311,*2c*. **N. sphaeroidea* (Ehrenberg), Podolsk Horizon, USSR(Andreyev Gorge); axial sec., ×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., ×20; *2b,* sagittal sec., ×20; *2c,* axial sec. tangent to proloculus, ×20 (*354); *2d,* axial sec. of holotype of *P. pseudo-prisca* (Colani), seemingly retouched, ×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, ×70; *1b,* sagittal sec. of paratype, ×70; *1c,* part of sagittal sec. showing structure of spirotheca, ×600 (*1839).

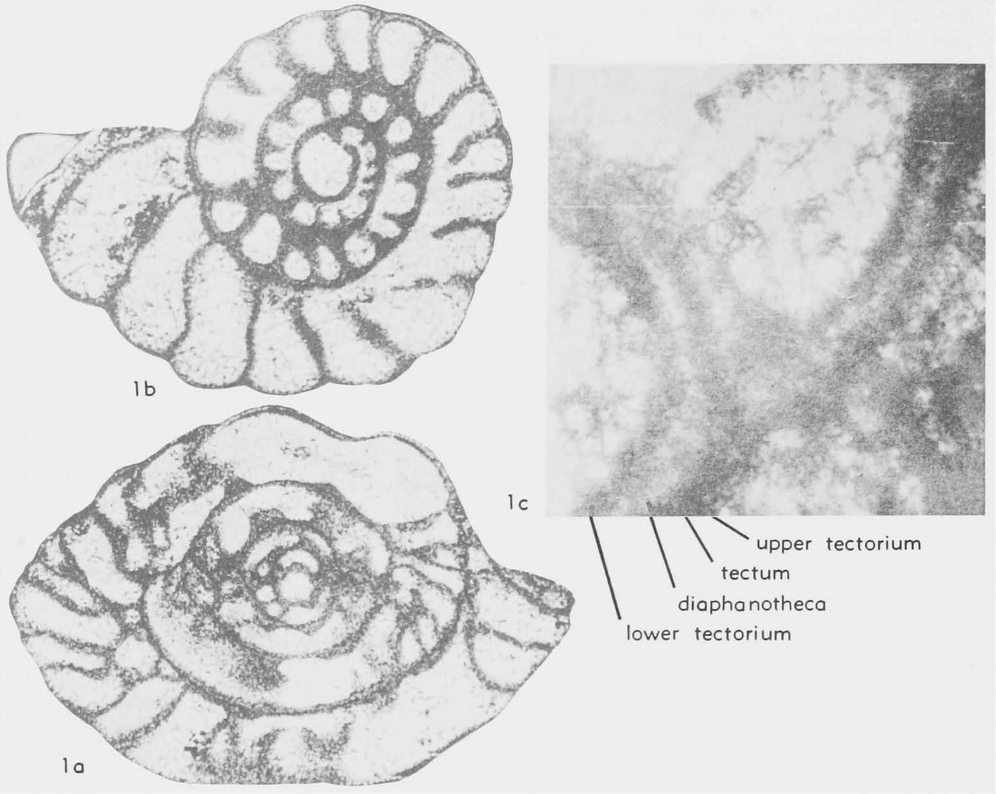

Fig. 309. Fusulinidae (Fusulininae; *1, Plectofusulina*) (p. C409).

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, ×30 (*1501); *1c,* part of axial sec. showing structure of spirotheca, ×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, ×20 (*1922).—Fig. 310,*2*. **P. pararhomboides,* Moscov., USSR(N. Urals); axial sec. of holotype, ×50 (*1922).——Fig. 310,*3*. *P. regia* Thompson, USA(W.Tex., Powwow Canyon); part of sagittal sec. of paratype showing spirothecal structure, ×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, ×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, ×20; *4b,* sagittal sec. of paratype, ×20; *4c,* tang. sec. of paratype with fluted septa in polar regions, ×20 (*1926).——Fig. 311,*4d*. *P. utahensis* Thompson & Bissell, L.Perm.(Oquirrh F.), USA(Utah); axial sec. of holotype, ×20 (*1926).

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

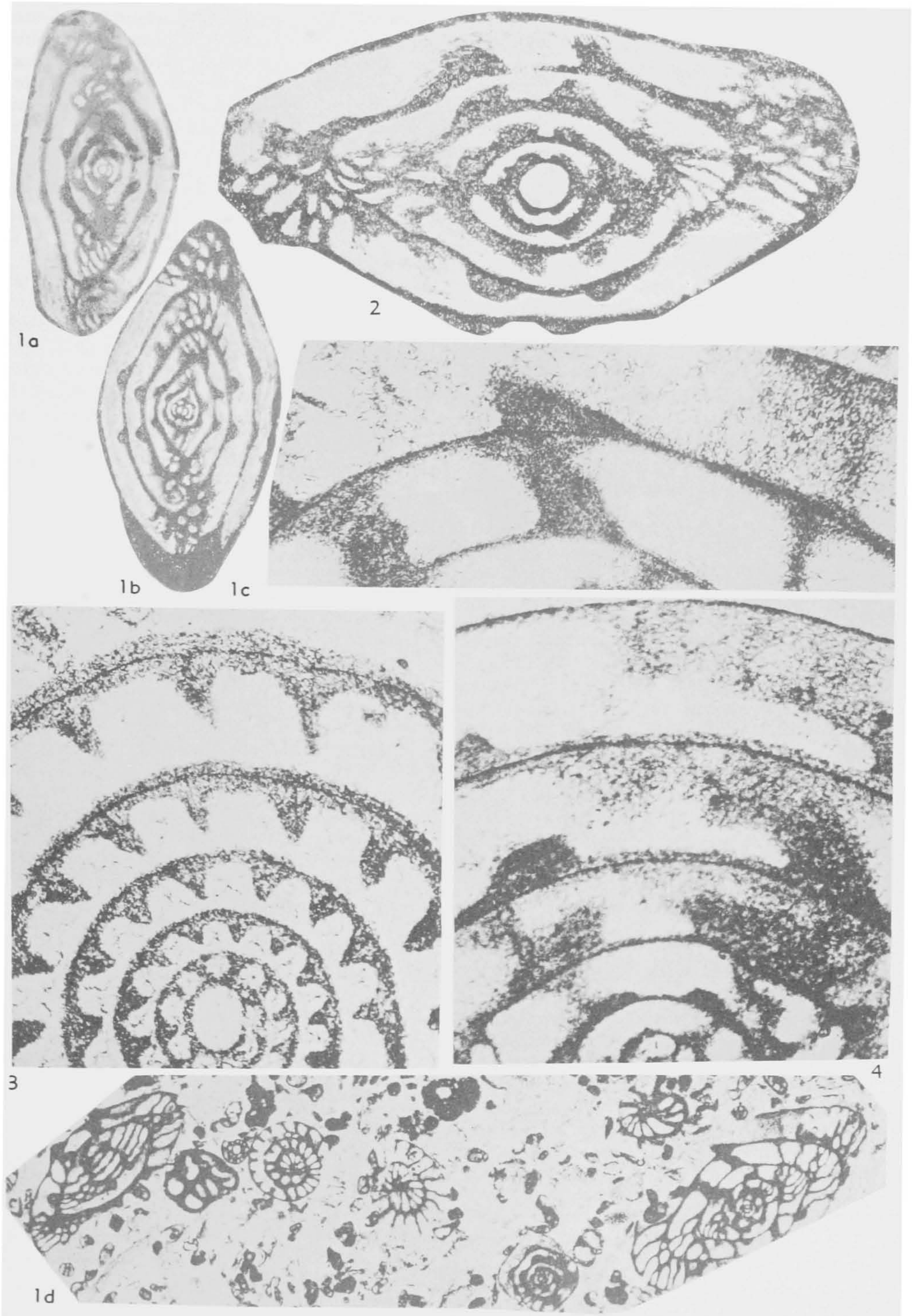

FIG. 310. Fusulinidae (Fusulininae; *1-4, Profusulinella*) (p. C409-C410).

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, ×50; _3c,_ axial sec. of holotype, ×50 (*1922).

Pseudowedekindellina SHENG, 1958, *1729, p. 87 [*_P. prolixa_; OD] [=_Frumentella_ 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, ×70 (*1839).——FIG. 311,_1c,d_. *_P. prolixa,_ Penchi Ser.(Hsiaoshih Ls.), China; _1c,d,_ axial sec. of holotype and enlarged part, ×20, ×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 (_fide_ 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_3), USSR(Tsarev Kurgan); axial sec. of holotype, ×10.5 (*1922).

Taitzehoella SHENG, 1951, *1727, p. 79 [*_T. taitzehoensis_; 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. taitzehoensis,_ Penchi Ser.; _3a,_ axial sec. of holotype, ×25; _3b,_ oblique sec. of paratype, ×35 (*1727).

Verella 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, ×30 (*551).——FIG. 312,_4b_. _V. spicata_ DALMATSKAYA, Kaial Stage, Penza Oblast(Kikina); axial sec. of holotype, ×30 (*551).

Waeringella 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, ×10; _1b,_ sagittal sec. of paratype, ×20; _1c,d,_ axial sec. of holotype and part enlarged to show 3 layers of spirotheca, ×20, ×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, ×20; _2b,_ typical specimen from Myachkovo beds at Levshino, ×20 (*1509A).——FIG. 312,_2c_. _W. matura_ THOMPSON, M.Penn. Youghall F.), USA(Utah); axial sec. of holotype, ×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,_ ×40, ×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-

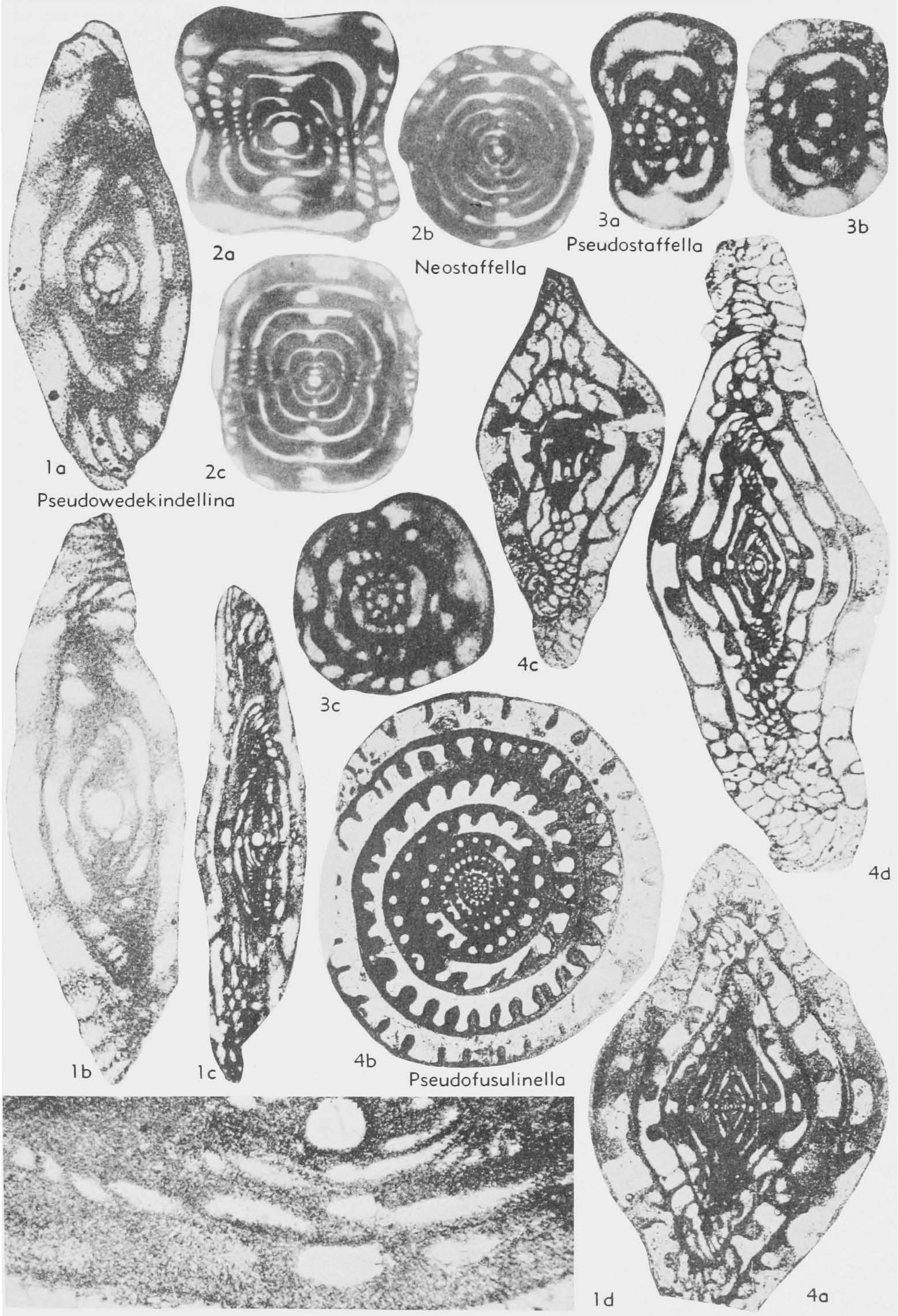

Fig. 311. Fusulinidae (Fusulininae; *1, Pseudowedekindellina, 2, Neostaffella, 3, Pseudostaffella; 4, Pseudofusulinella*) (p. C409-C412).

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. iniqua*, Chihsia Ls., China(E. of Chusanshan); *1a,* axial sec. of holotype, ×40; *1b,* tang. sec. of paratype, ×40 (*1922).— FIG. 313,*2* *Y. haydeni* THOMPSON, U.Perm.(Bamian Ls.), Afghan.; *2a,* axial sec. of holotype, ×20; *2b,* enlargement of *2a* showing chomata structure, ×100 (*1922).

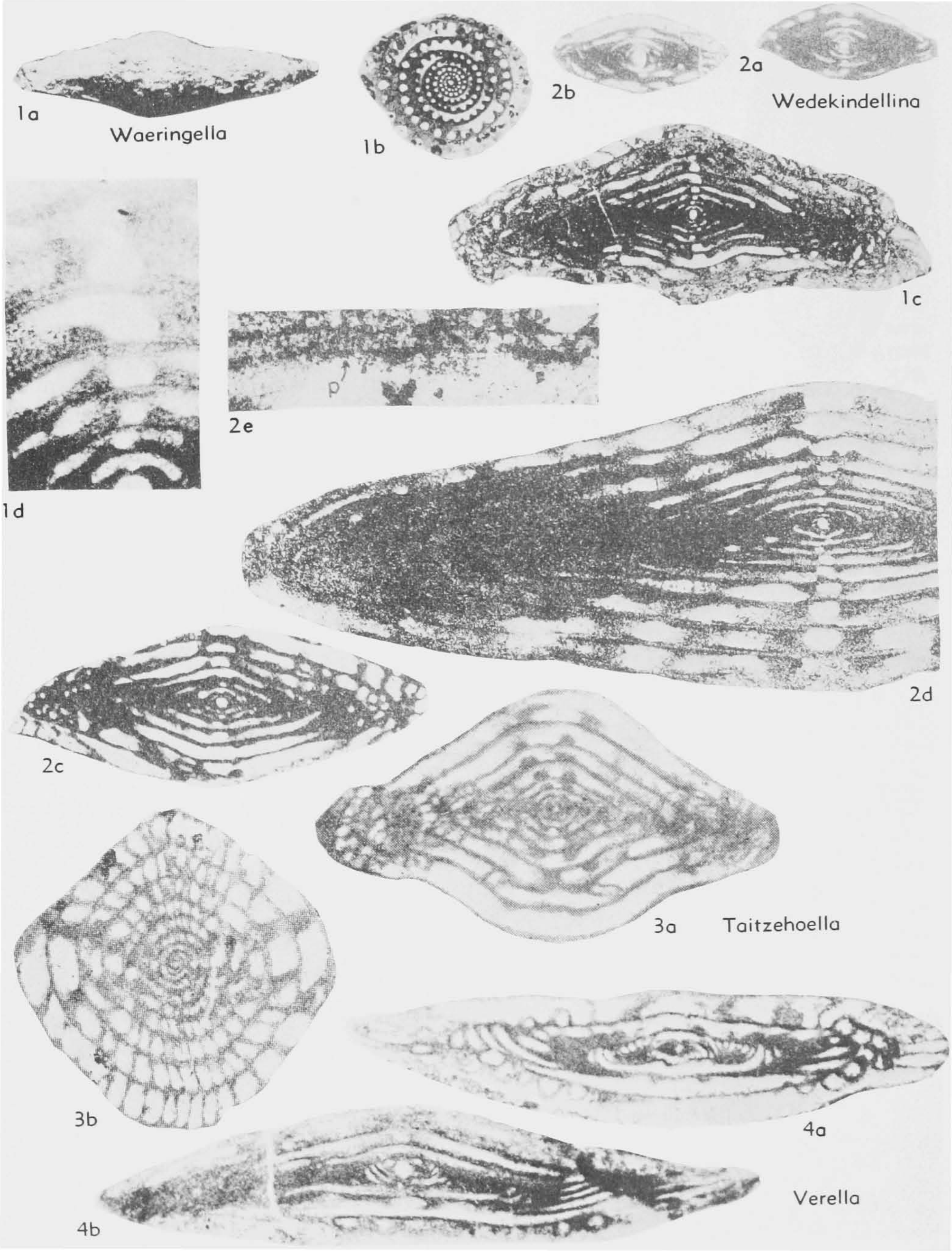

FIG. 312. Fusulinidae (Fusulininae; *1, Waeringella; 2, Wedekindellina; 3, Taitzehoella; 4, Verella*) (p. C412).

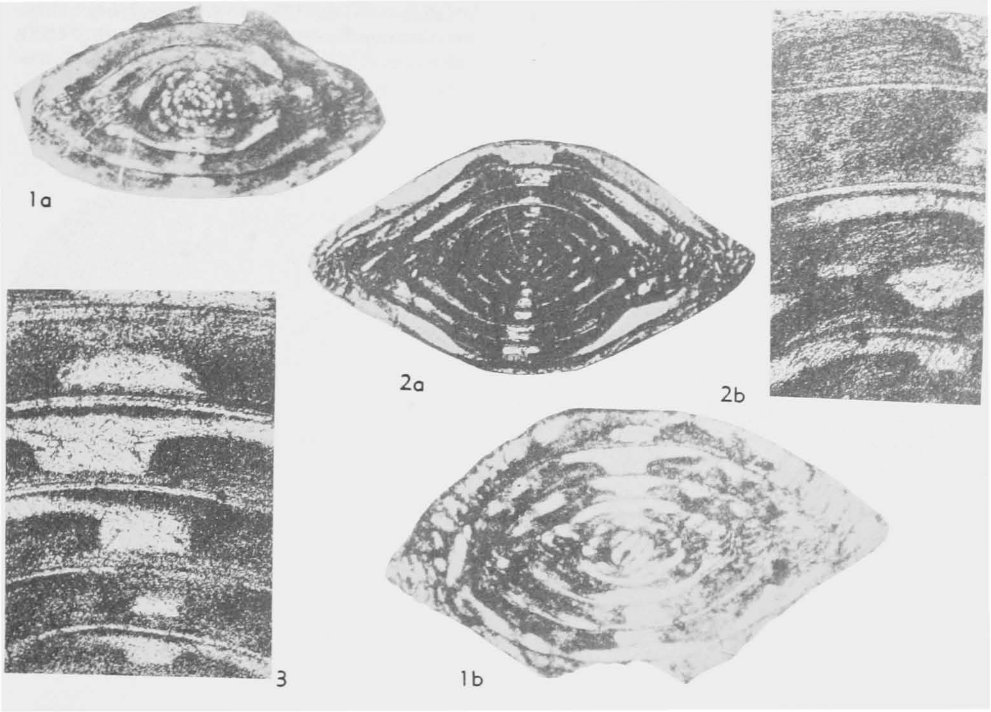

Fig. 313. Fusulinidae (Fusulininae; *1-3, Yangchienia*) (p. C412-C414).

——Fig. 313,*3*. *Y. tobleri* Thompson, U.Perm. (Sosio Beds), Sicily(Castellamare del Golpo); part of axial sec. showing structure of spirotheca, ×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* Viên, 1959, *2005A, p. 111 (type, *C. thuanae*; OD)]. Shell fusiform to subcylindrical; 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, ×10; *1b*, centered axial sec. of syntype, ×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, ×10; *2b*, axial sec. of holotype, ×10; *2c*, etched surface of paratype showing fluting of septa across specimen, ×10 (*1922).——Fig. 314,*3*. *S. jigulensis* (Rauzer-Chernousova), L.Perm., USSR(Samara Bend); axial sec. of holotype, ×15 (*1926).——Fig. 314, *4*. *S. ruzhencevi* (Rozovskaya), C_3^{1-c} Horizon, USSR(Ural River); axial sec. of holotype, ×9 (*1926).——Fig. 314,*5*. *S. gruperaensis* Thompson & Miller, L.Perm.(Grupera F.), Mex. (Chiapas); axial sec. of syntype, ×10 (*1922).——Fig. 314,6. *S. ishanensis* (Hsu), Chungkuh Ls., China(Kuangsi); axial sec. of holotype, ×10 (*1922).——Fig. 328A,*3*. *S. stuckenbergi* (Rauzer-Chernousova), Horizon I_1, U.Carb., USSR (Shiryayevo, Samara Bend) (type-sp. of *Rauserites*); axial sec. of holotype, ×15 (*1501).——

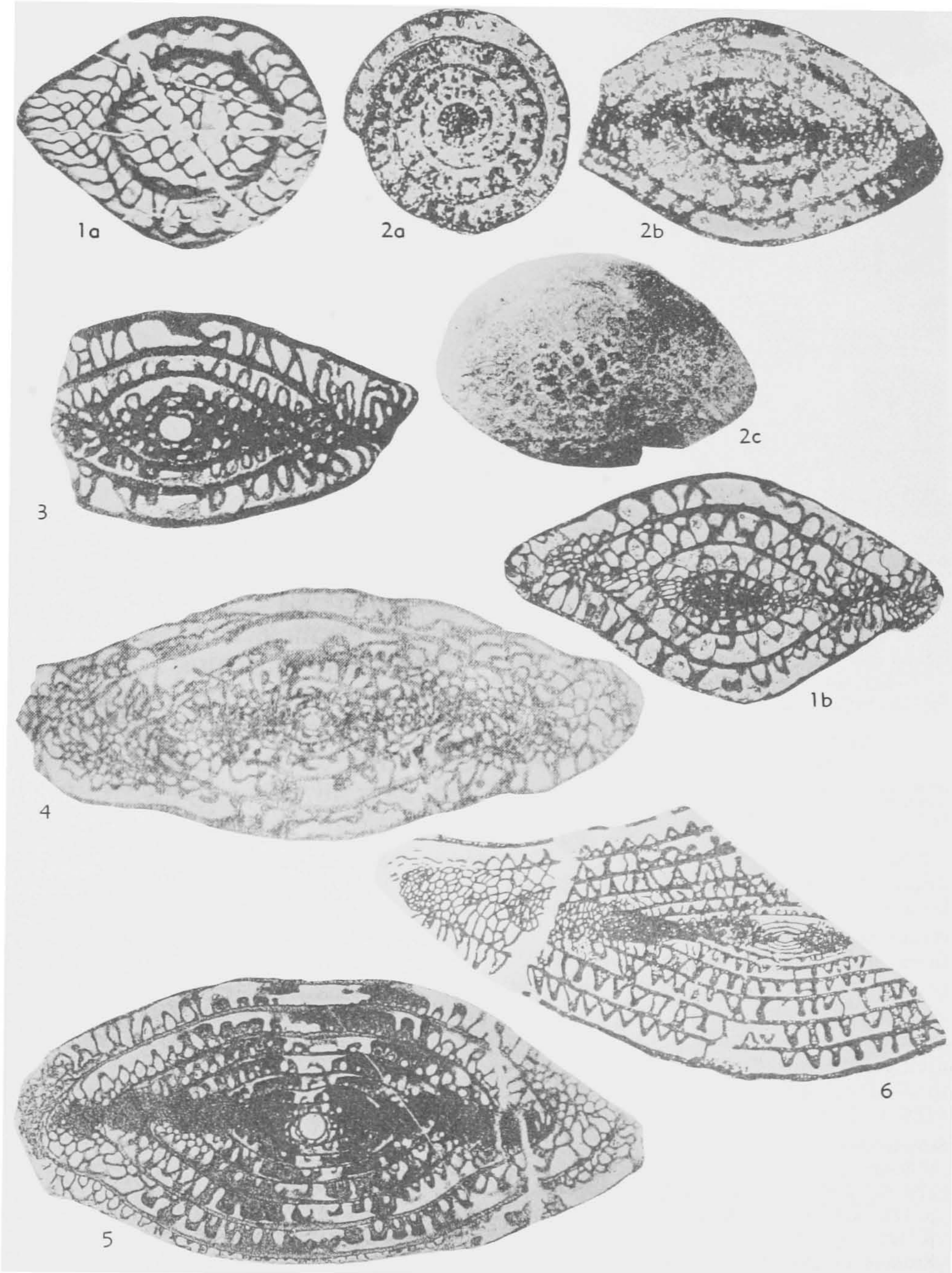

Fig. 314. Fusulinidae (Schwagerininae; *1-6, Schwagerina*) (p. C415-C416).

FIG. 328A,4. *S. thuanae* (VIÊN), Perm., Asia(S. Vietnam) (type-sp. of *Codonoschwagerina*); sec. cut through proloculus, ×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-

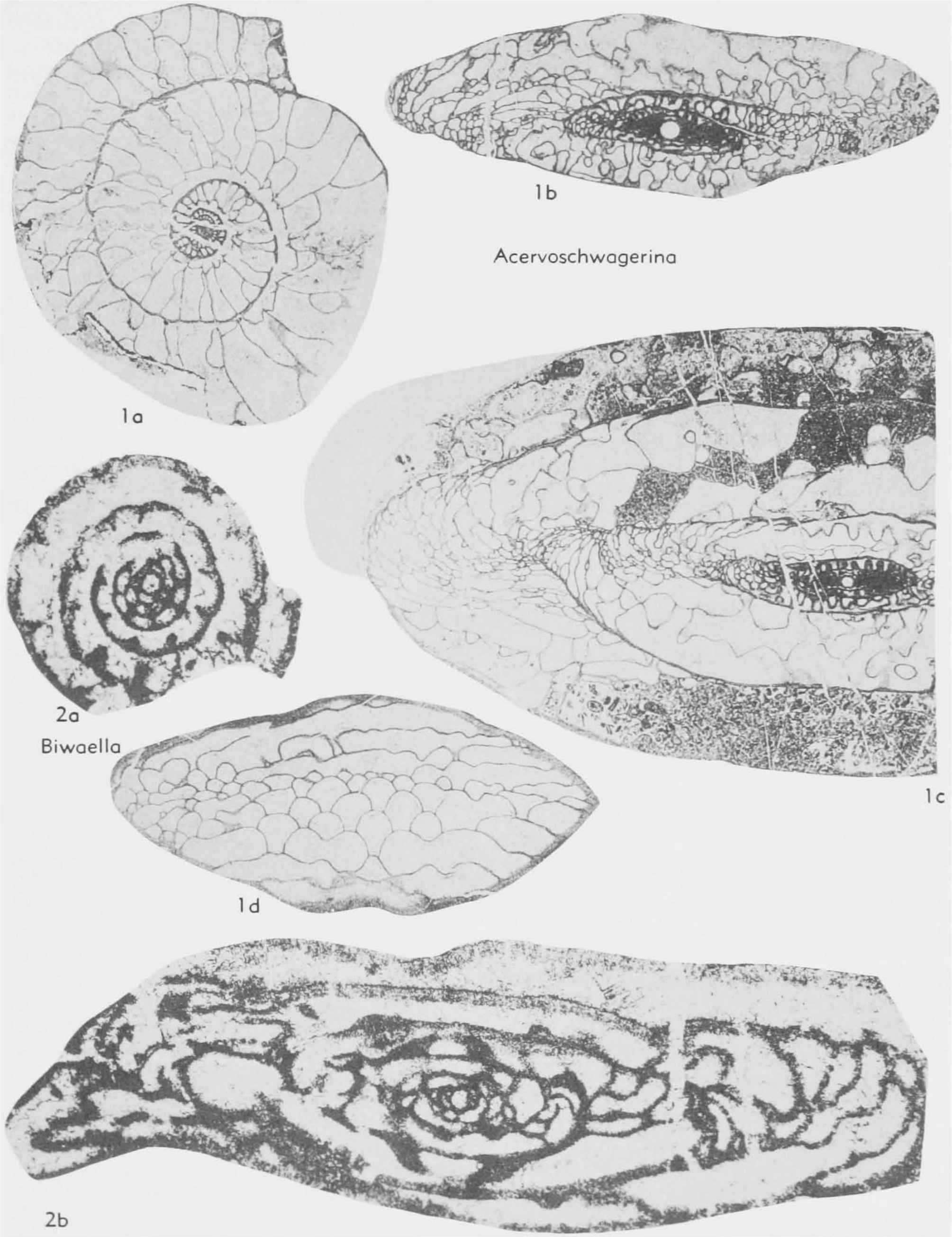

FIG. 315. Fusulinidae (Schwagerininae; *1, Acervoschwagerina; 2, Biwaella*) (p. C417-C418).

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,*1*. **A. endoi* (Hanzawa), Gombo Ls., Gifu Pref.; *1a,* sagittal sec. of topotype showing phrenotheca over tunnel, ×10; *1b,* axial sec. of submature topotype, ×10; *1c,* axial sec. of mature topotype, ×10; *1d,* tang. sec. of topotype showing irregular fluting of septa, ×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 secs. of paratype and holotype, ×50 (*1313).

Dunbarinella Thompson, 1942, *1919, p. 416 [**D. ervinensis*; 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. ervinensis*, U.Penn.(Ervine Creek Sh.), USA (Okla.); *3a,* external view of paratype; *3b,* sagittal sec. of paratype; *3c,* axial sec. of holotype; all ×10 (*1922).——Fig. 316,*3d*. *D. eoextenta* Thompson, L.Perm.(Waldrip No. 1 Ls.), USA (Tex.); axial sec. of paratype, ×10 (*1926).——Fig. 316,*3e,f*. *D. tumida* (Skinner), L.Perm. (Neva Ls.), USA(Kans.); *3e,f,* axial and sagittal secs., ×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, ×10; *1b,* axial sec. of holotype, ×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, ×10; *2b,* axial sec. of holotype, ×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, ×30, ×100; *4b,* sagittal sec. of paratype, ×30 (*1621).

Nagatoella Thompson, 1936, *1916, p. 196 [**Fusulina (Schellwienia) 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, ×10 (*1922).——Fig. 317,*3b,c*. *N. kobayashii* Thompson, Akiyoshi Ls., Yamaguchi Pref.; *3b,* tang. sec. of holotype, ×10 (*1916); *3c,* axial sec., ×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 ×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, ×50; *2b,* sagittal sec. of topotype, ×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?,

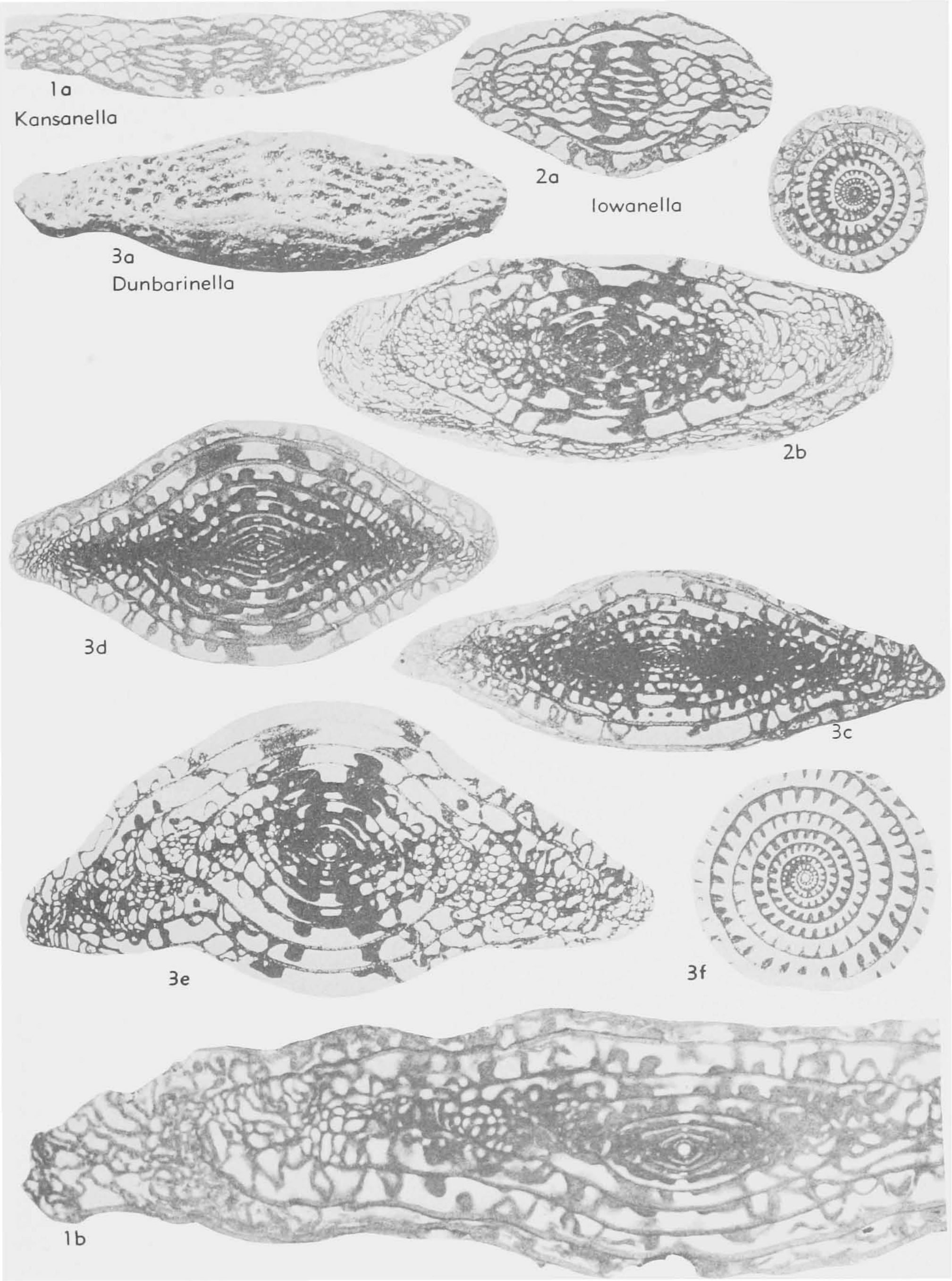

Fig. 316. Fusulinidae [Schwagerininae; *1, Kansanella (Kansanella); 2, K. (Iowanella); 3, Dunbarinella*] (p. *C*418).

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, ×15, ×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. ×6.8 (*1816).——Fig. 318,_1b. P. gracilis_ (Meek), L.Perm.(McCloud Ls.), USA(Calif.); axial sec., ×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 ×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, ×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, ×10 (*1922); _2b,_ tang. sec., ×10 (*1926) (see also Fig. 284,_2_).

Polydiexodina Dunbar & Skinner, 1931, *644, p. 263 [_*P. capitanensis_; 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, ×10; _2b,_ enlarged part of axial sec. showing structure of spirotheca, ×100 (*1922) (see also Fig. 285,_1a_).——Fig. 319,_2c. *P. capitanensis,_ Capitan Ls., USA(Tex.); axial sec. of holotype, ×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. ×10 (*1922) (see also Fig. 291,2, holotype).——Fig. 319,_1b. P.? disca_ (Lee), Taiyuan Ser., China; axial sec. of holotype, ×30 (*1922).——Fig. 319,_1c. P. vulgaris fusiformis_ (Schellwien), USSR(Darvaz Ser.); axial sec. of holotype, ×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. roeseleri_ Thompson & Hazzard, Bird Spring F., USA (Calif.); axial sec. of holotype, ×8.3 (*1922).——Fig. 320,_1b. P. fusulinoides_ (Schellwien), Uggowitzer Breccie, Aus.(Carnic Alps); polished axial sec., ×8.3 (*1644).——Fig. 320,_1c. *P. uddeni_ (Beede & Kniker), Hueco Ls., USA (Tex.); axial sec. of holotype, ×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-

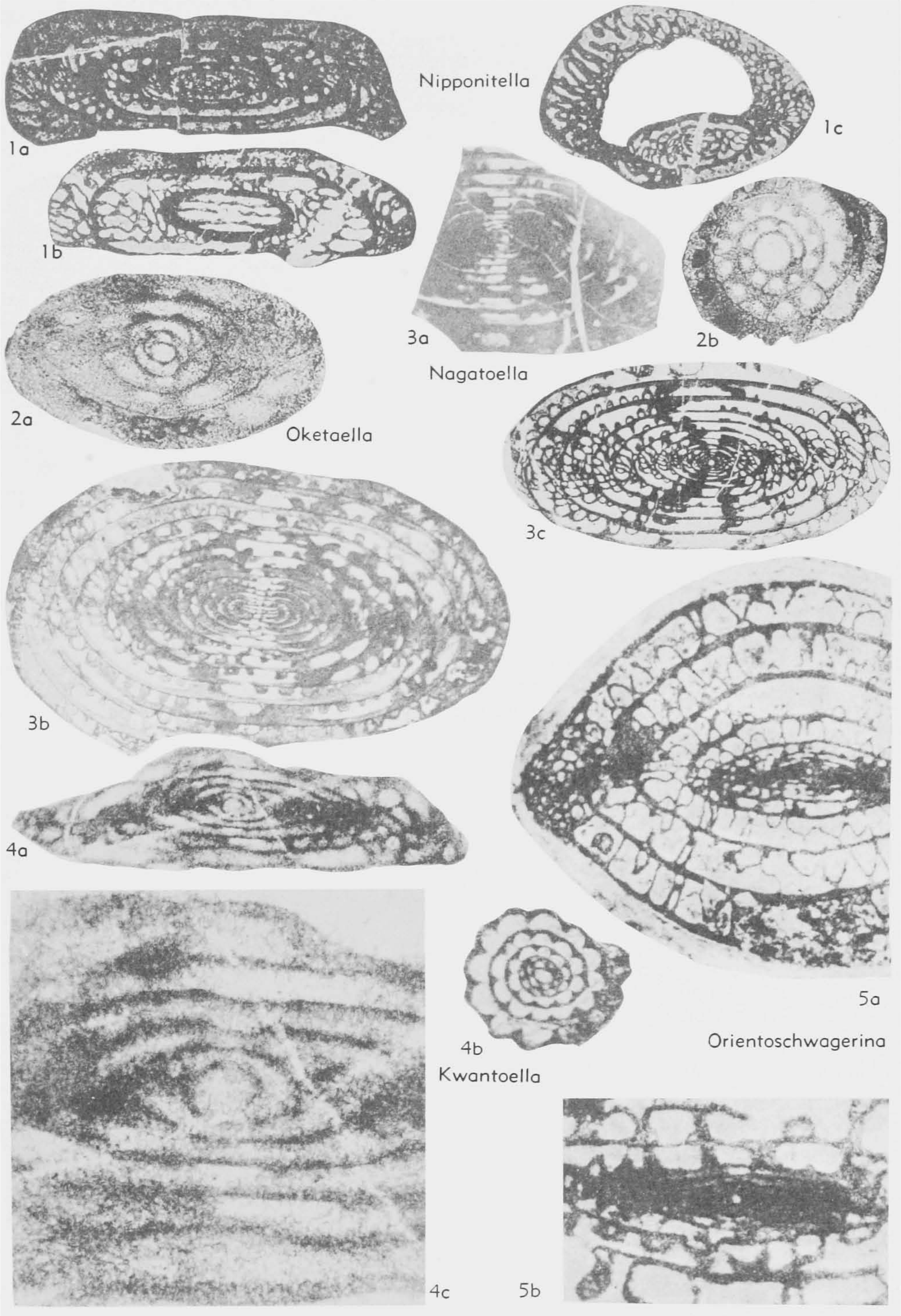

FIG. 317. Fusulinidae (Schwagerininae; *1, Nipponitella; 2, Oketaella; 3, Nagatoella; 4, Kwantoella; 5, Orientoschwagerina*) (p. C418-C420).

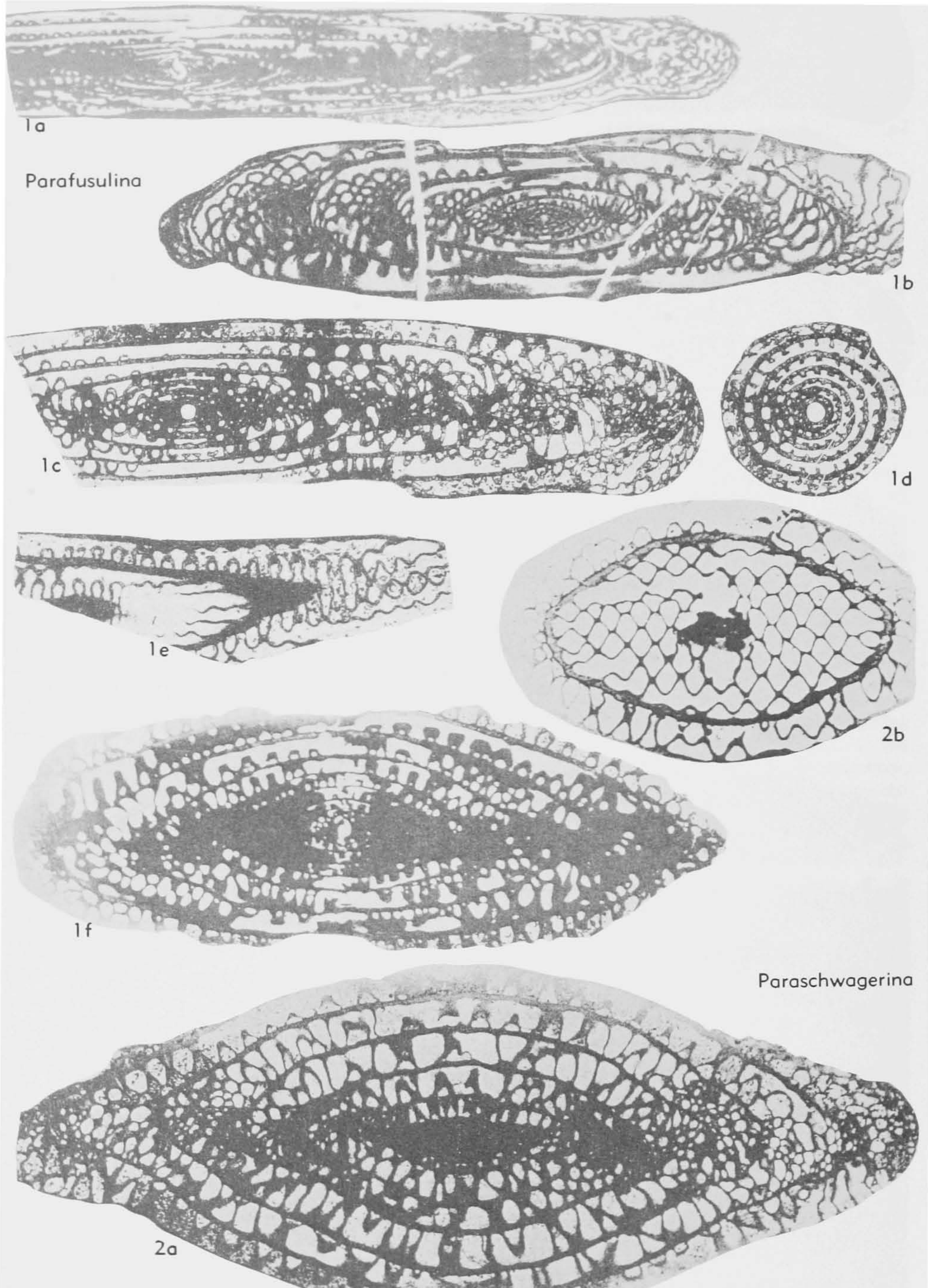

FIG. 318. Fusulinidae (Schwagerininae; *1, Parafusulina; 2, Paraschwagerina*) (p. C420).

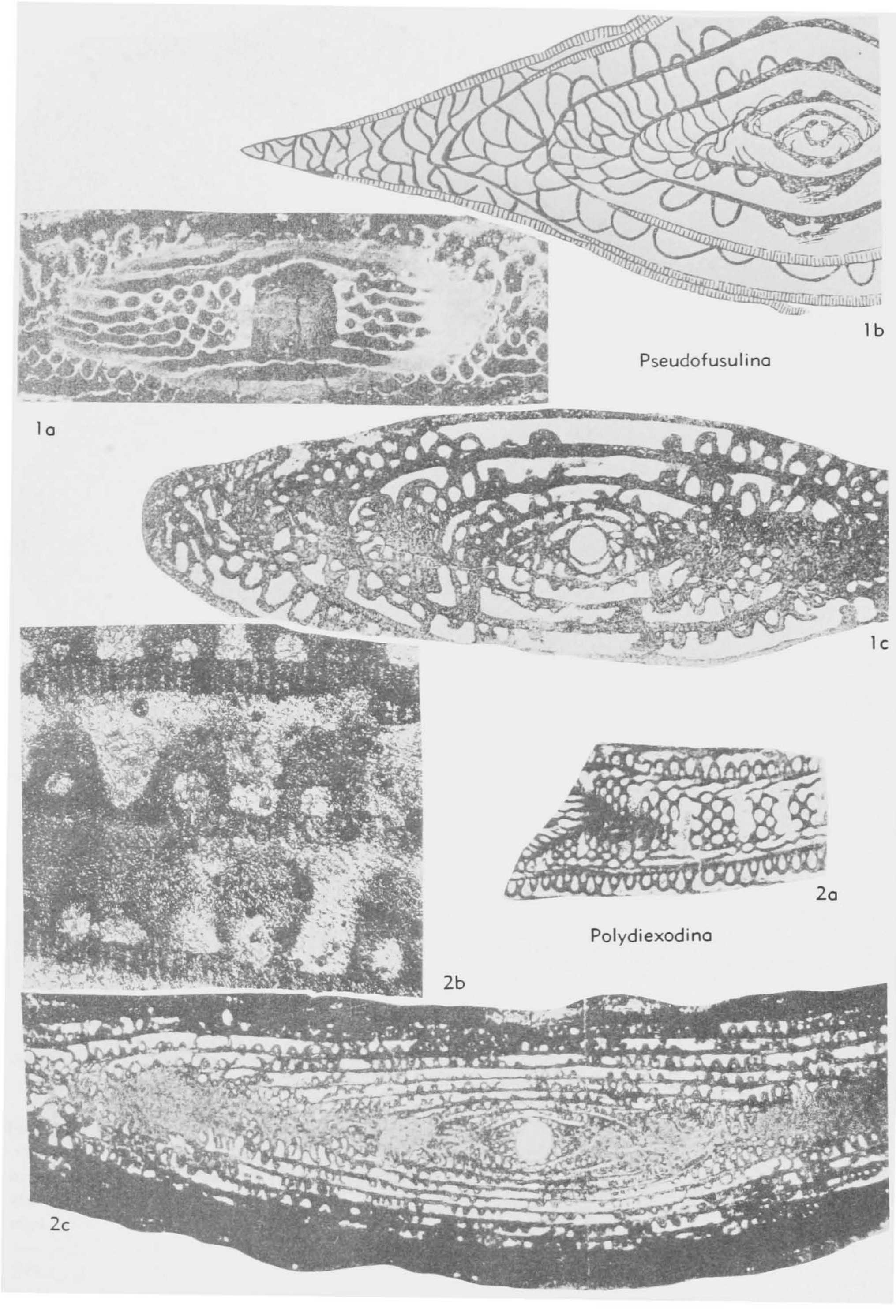

FIG. 319. Fusulinidae (Schwagerininae; *1, Pseudofusulina; 2, Polydiexodina*) (p. C420).

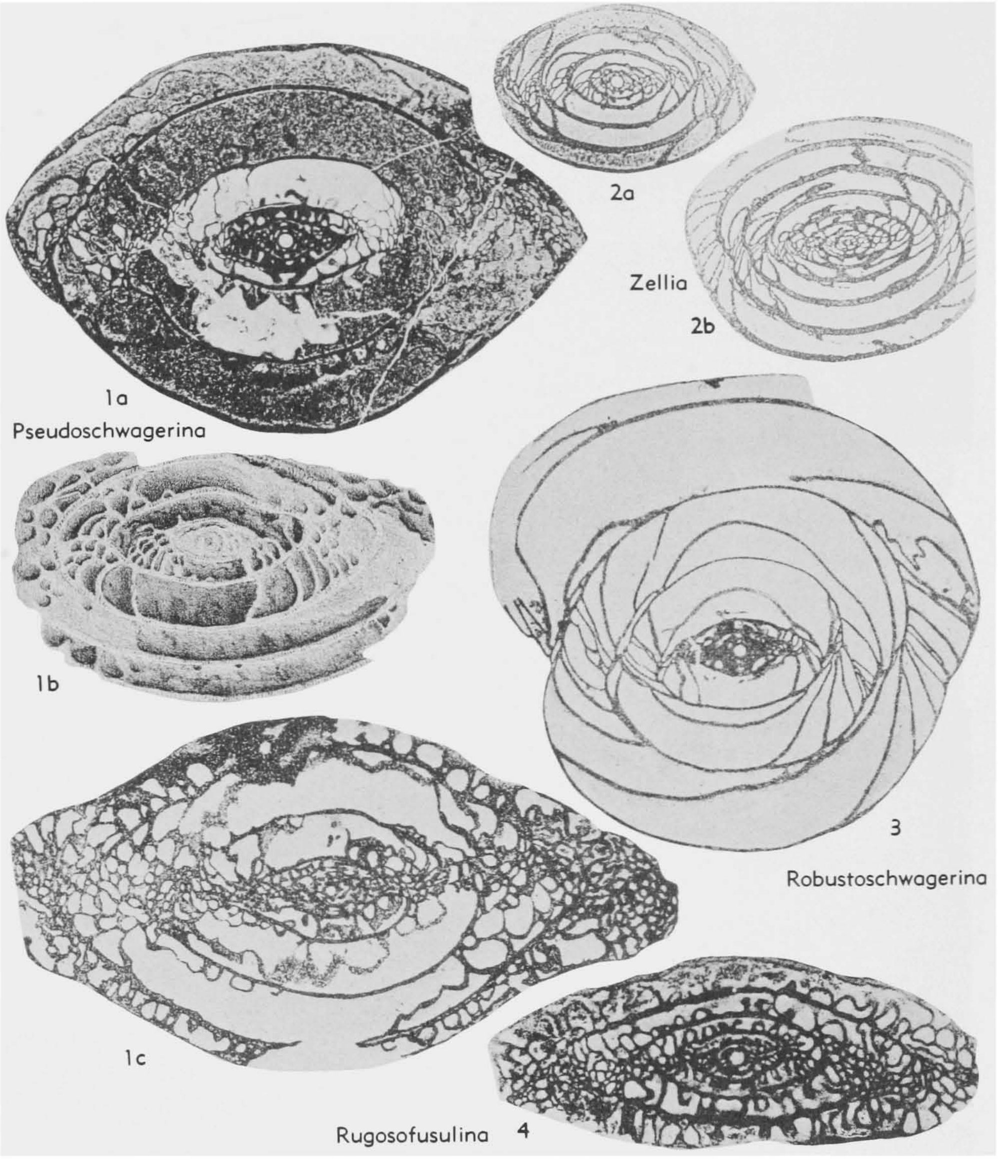

Fig. 320. Fusulinidae (Schwagerininae; *1, Pseudoschwagerina; 2, Zellia; 3, Robustoschwagerina; 4, Rugosofusulina*) (p. *C*420-*C*424, *C*426).

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, ×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, ×12.5 (*1922).

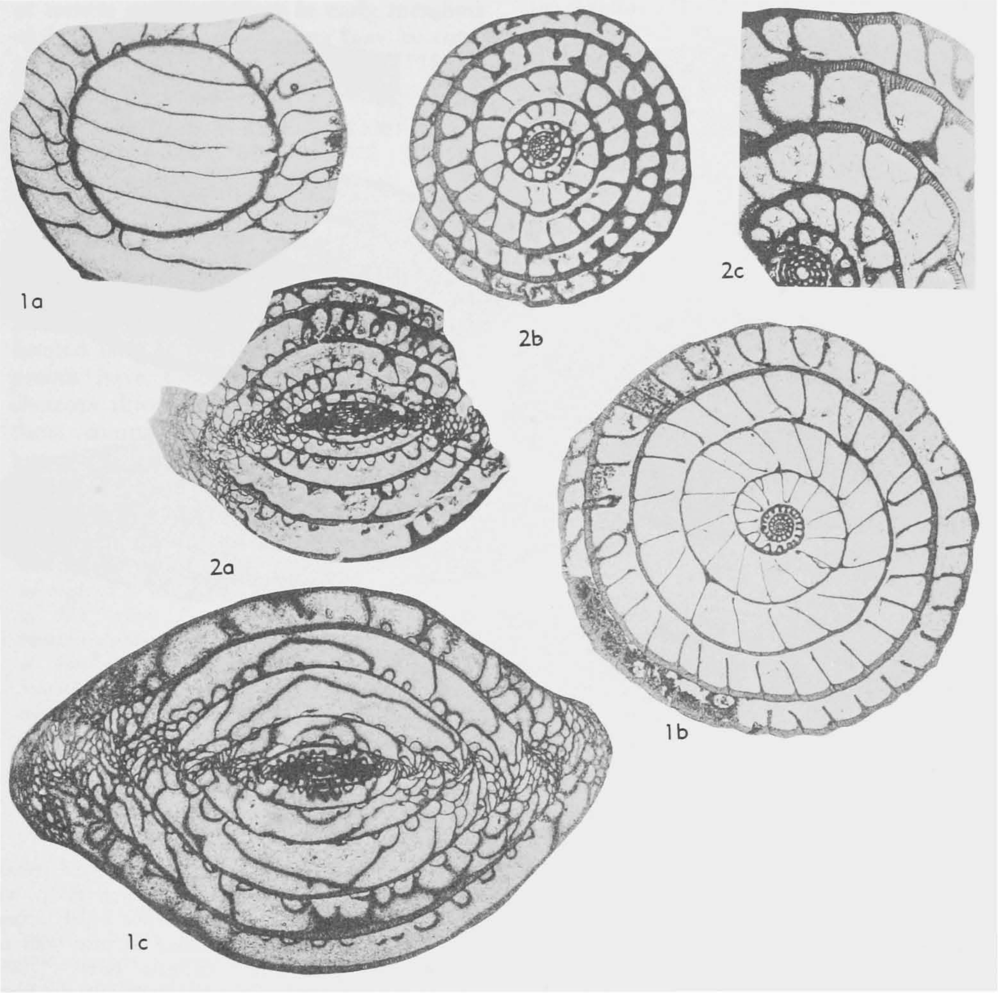

Fig. 321. Fusulinidae (Schwagerininae; *1,2, Rugososchwagerina*) (p. *C*425).

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-fusiform, first 3 or 4 volutions tightly coiled, elongate-fusiform, 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., ×8 (*1922).——Fig. 321,2. *R. fosteri* (Thompson & Miller), Yanghsin Ls., W.China; *2a,* axial sec. of lectotype, ×8; *2b,c,* sagittal sec. of paratype, ×8, ×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,

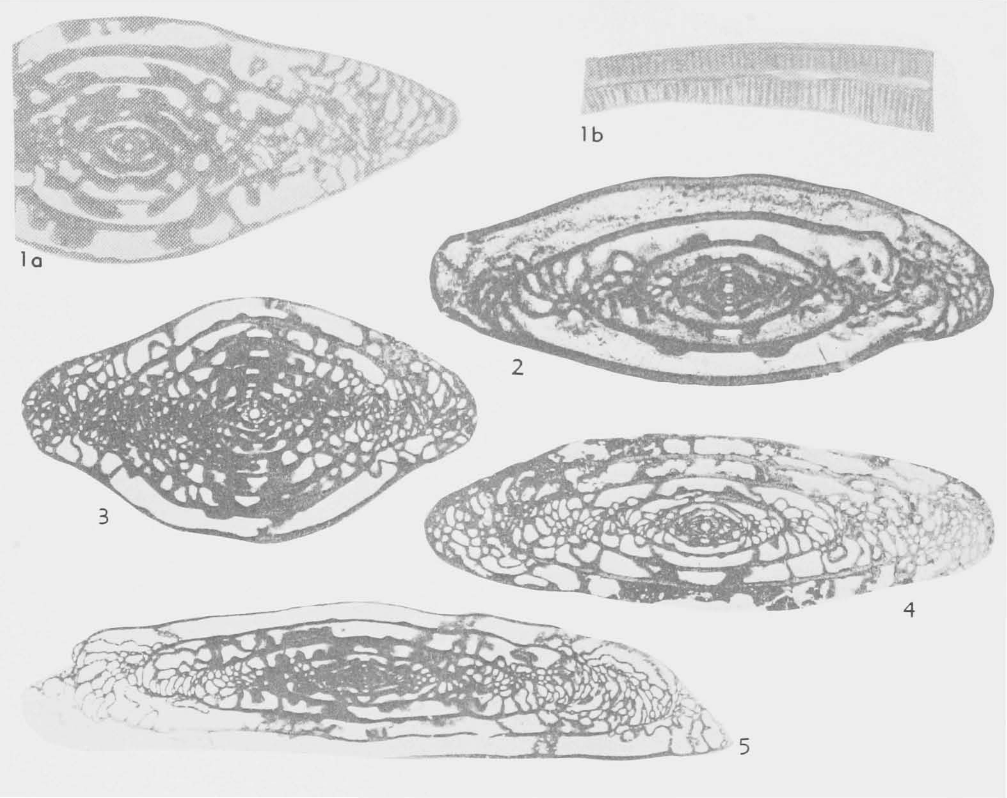

Fig. 322. Fusulinidae (Schwagerininae; *1-5, Triticites*) (p. C425-C426).

*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_3^nF., USSR(European); *1a,* axial sec. of holotype, ×15; *1b,* apparent double wall of *"Protriticites" globulus,* approx. ×80 (*1492).——Fig. 322,*2*. *T. milleri* Thompson, U.Penn.(Hartville Ls.), USA(Wyo.); axial sec. of syntype, ×20 (*1922).——Fig. 322, *3*. *T. beedei* Dunbar & Condra, U.Penn.(Ervine Creek Ls.), USA(Kans.); axial sec. of syntype, ×10 (*1922).——Fig. 322,*4*. **T. secalicus* (Say), U.Penn.(Plattsmouth Ls.), USA(Neb.); axial sec., ×10 (*1922).——Fig. 322,*5*. *T. ohioensis* Thompson, U.Penn.(Cambridge Ls.), USA(Ohio); axial sec. of syntype, ×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-subspherical, 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, ×8.3; *2b,* tang. sec. of holotype, ×7.5 (*1922).

Family VERBEEKINIDAE
Staff & Wedekind, 1910

[*nom. transl.* A. D. Miklukho-Maklay, 1957, p. 110 (*ex* subfamily Verbeekininae 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

[Verbeekininae 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, ×8; *1b*, etched surface of the same topotype (*1a*) showing development of parachomata in outer volution, ×8; *1c*, central part of axial sec. of topotype, ×32; *1d*, axial sec. of topotype, ×8 (*1922) (see also Fig. 274,*5*, 288,*3*).——FIG. 323,*1e*. *V. grabaui* THOMPSON & FOSTER, Yanghsin Ls., China (Szechuan); axial sec. of syntype, ×8 (*1922).——FIG. 323,*1f*. *V. karinae* (A. D. MIKLUKHO-MAKLAY), USSR(Transcaucasia); axial sec., ×12 (*1264).——FIG. 323,*1g*. *V. pontica* (A. D. MIKLUKHO-MAKLAY), USSR(Crimea); axial sec. of holotype, ×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, ×12; *2b*, axial sec. of holotype, ×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, ×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, ×15; *1c*, axial sec. of holotype, ×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., ×10 (*1922).——FIG. 324,*2c,d*. **P. ozawai*, Akasaka Ls., Japan(Mino Prov.); *2c,d*, axial and sagittal secs. of topotypes, ×20 (*1922).

Subfamily NEOSCHWAGERININAE
Dunbar & Condra, 1928

[Neoschwagerininae DUNBAR & CONDRA, 1927[1928], p. 74] [=Sumatrininae KAHLER & KAHLER, 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-

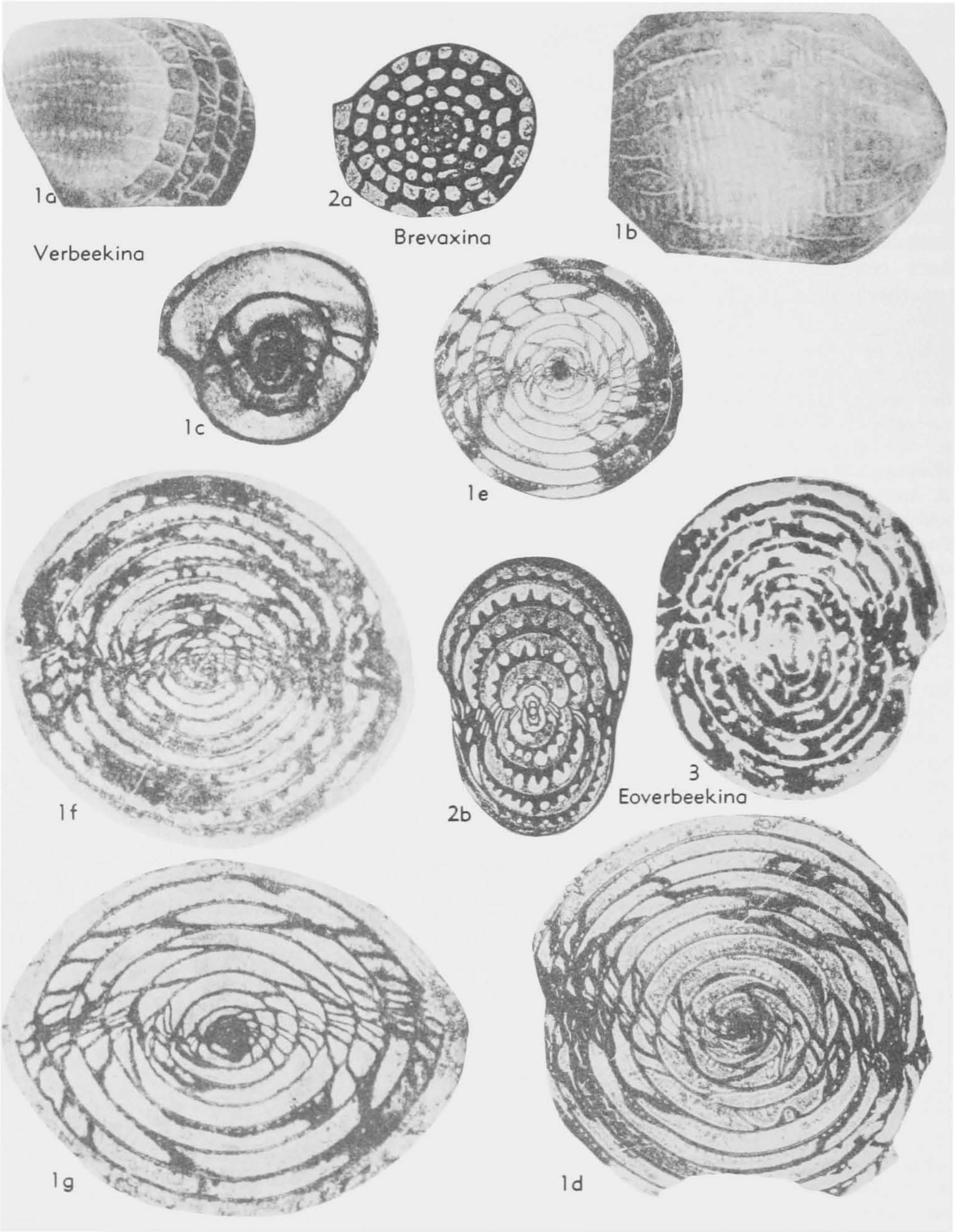

FIG. 323. Verbeekinidae (Verbeekininae: *1, Verbeekina; 2, Brevaxina; 3, Eoverbeekina*) (p. C427).

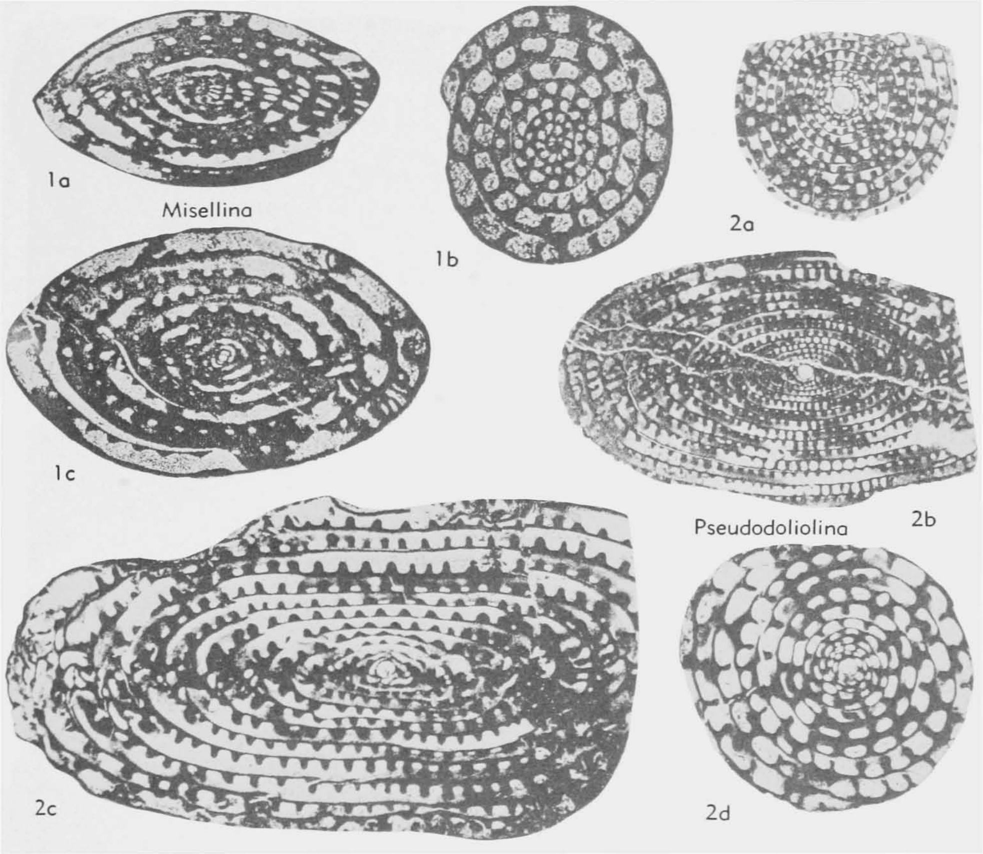

FIG. 324. Verbeekinidae (Verbeekininae; *1, Misellina; 2, Pseudodoliolina*) (p. *C*427).

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, ×10; *1b*, oblique sec. of holotype, ×10 (*1401B).——FIG. 325,*1c,d*. *N. gifuensis* (HONJO), Akasaka Ls., Japan, Gifu Pref.; *1c*, axial sec. of holotype, ×15; *1d*, sagittal sec. of paratype, ×15 (*954).——FIG. 325,*1e*. *N. haydeni* DUTKEVICH & KHABAKOV, Bamian Ls., Afghan.; axial sec. of holotype, ×20 (*1922) (see also Fig. 290,*1*).——FIG. 325,*1f*. *N. verae* (TUMANSKAYA), USSR (Crimea); axial sec. of holotype, ×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-

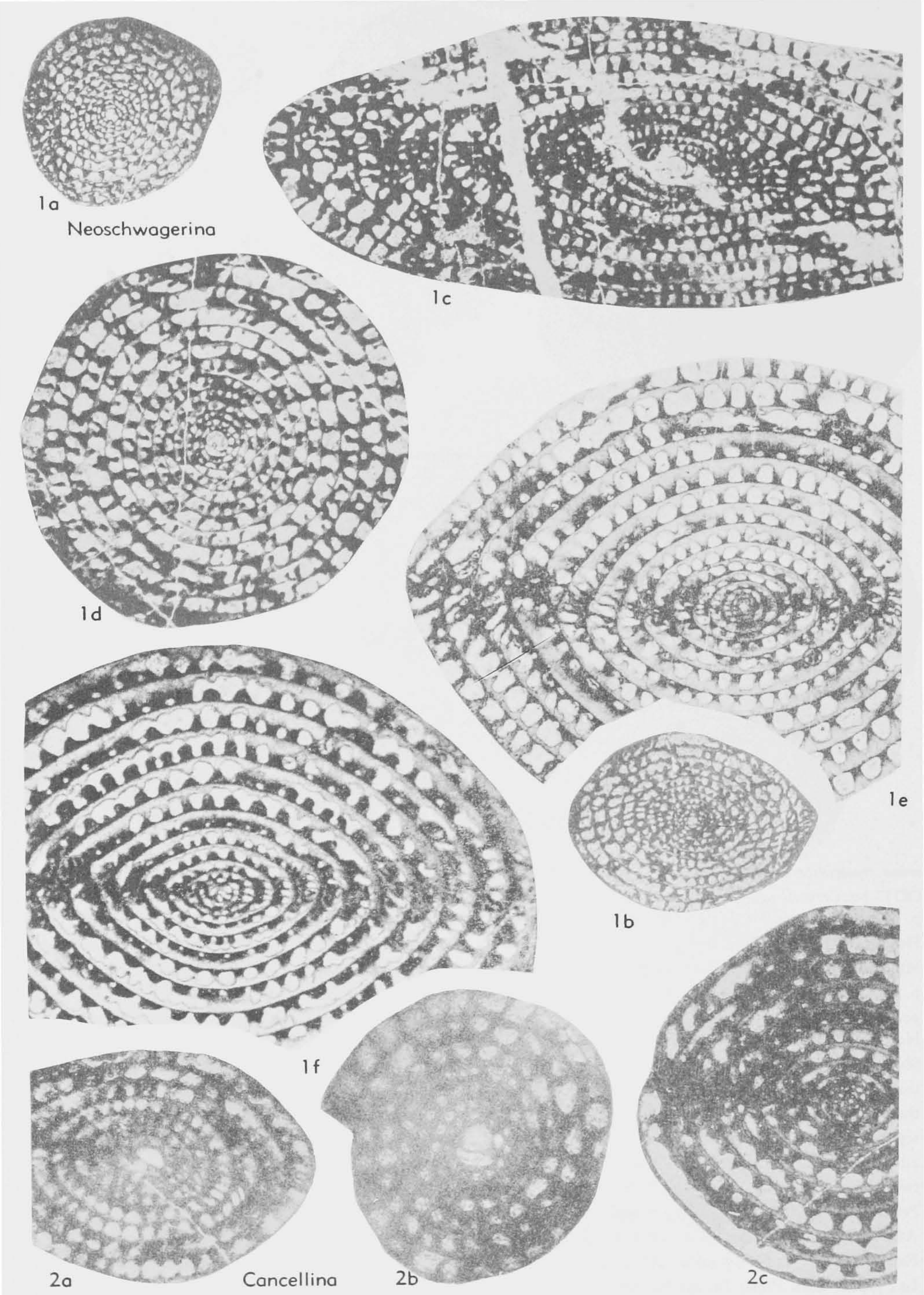

FIG. 325. Verbeekinidae (Neoschwagerininae; *1, Neoschwagerina; 2, Cancellina*) (p. *C*428-*C*431).

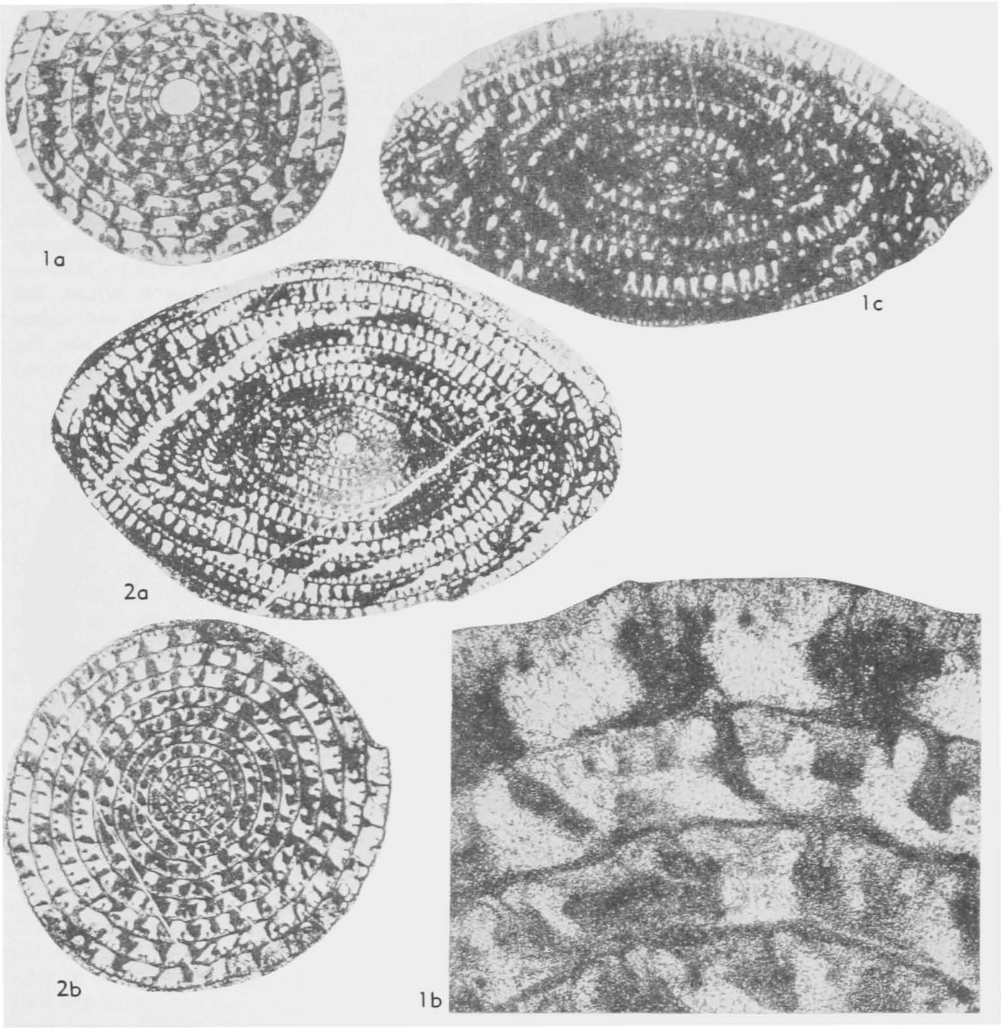

Fig. 326. Verbeekinidae (Neoschwagerininae; *1,2, Afghanella*) (p. *C*429-*C*431).

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, ×20, ×100; *1c,* axial sec. of holotype, ×20 (*1922).——Fig. 326,*2*. *A. sumatrinaeformis* (Gubler), Laos(Pong Oua); *2a,b,* axial and sagittal secs., ×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, ×17; *2b,* sagittal sec. of paratype, ×20; *2c,* axial sec., ×20 (*1922) (see also Fig. 288,2, 293).

Lepidolina Lee, 1933[1934], *1120, p. 21 [**Neoschwagerina (Sumatrina) 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. kwangsiana* (Lee), China(Chien-kiang, Kwangsi); axial sec. of holotype, ×15 (*1922).——Fig. 327,*2*. **L. multiseptata* (Deprat), Akasaka Ls., Japan, Gifu Pref. *(2a,b),* Cambodia *(2c)*; *2a,* sagittal sec. of paratype, ×15; *2b,* axial sec., ×15; *2c,* tang. sec., ×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., ×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., ×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, ×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 kueichihensis* 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.) maslennikovi*; 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

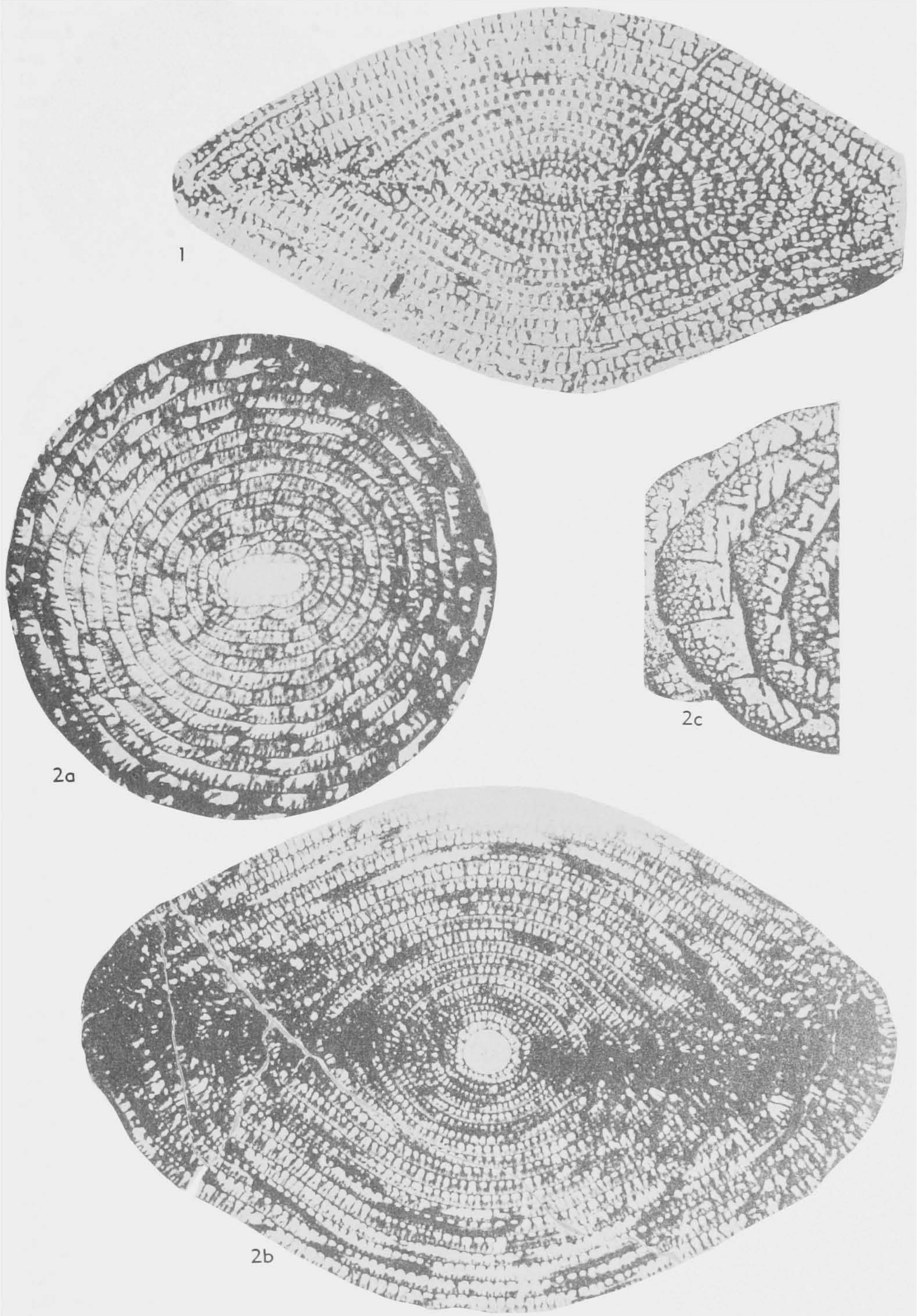

FIG. 327. Verbeekinidae (Neoschwagerininae; *1,2, Lepidolina*) (p. C431-C432).

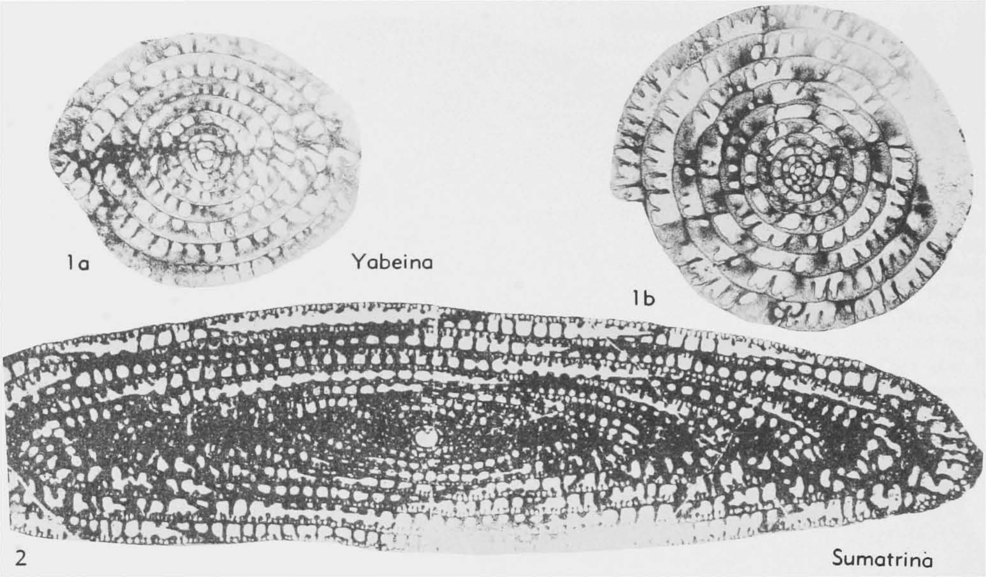

FIG. 328. Verbeekinidae (Neoschwagerininae; *1, Yabeina; 2, Sumatrina*) (p. *C*432).

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.)*]. *Paraeichelina* 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).

Praeparafusulina 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-

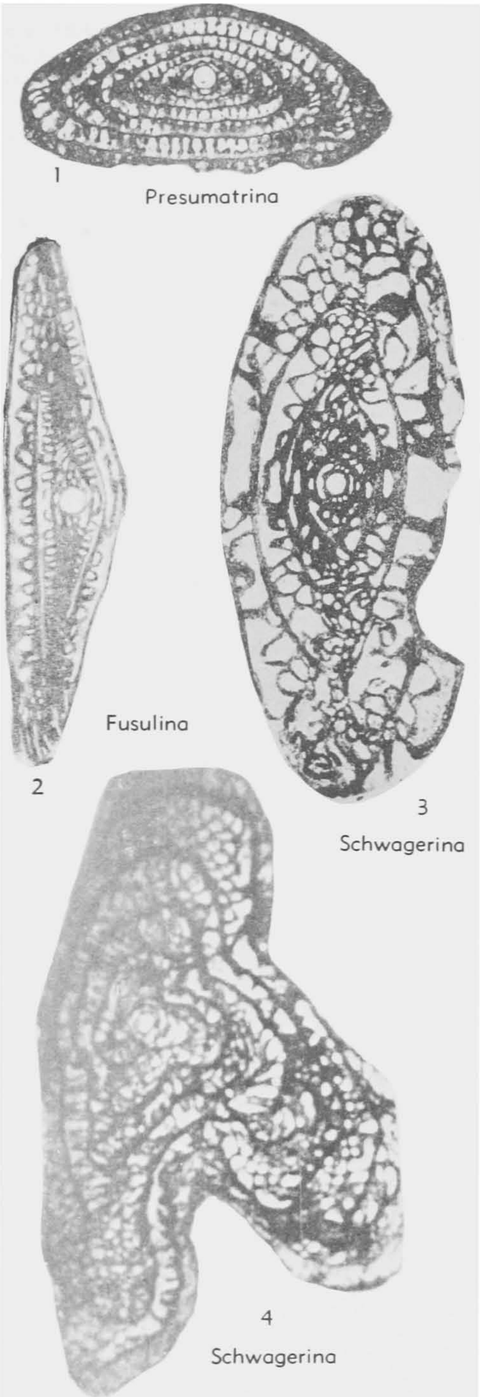

FIG. 328A. Verbeekinidae (Neoschwagerininae; *1, Presumatrina*); Fusulinidae (Fusulininae; *2, Fusulina*); Fusulinidae (Schwagerininae; *3,4, Schwagerina*) (p. C404, C415, C432).