Rhynchonelliformea—Strophomenata

PRODUCTIDINA

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Suborder PRODUCTIDINA

Waagen, 1883


Productidines lacking interareas or with ginglymus only; toothed articulation absent after uppermost Devonian; cardinal process directed posteriorly or posteroventrally, not ventrally; brachial ridges commonly reniiform, confined. [This group comprises the more characteristic productidines that normally lived unattached on relatively soft substrates, stabilized by their straight or gently curved spines. There is a tendency within each superfamily for stratigraphically older representatives to have shallow corpus cavities that became deep in younger taxa. Trails may be long but lack elaboration, other than for rare anteromedian plication.] Lower Devonian (Pragian)—Upper Permian (Changhsingian), ?Lower Triassic.

Superfamily PRODUCTOIDEA

Gray, 1840

[Name transl. Maillieux, 1941, p. 7, ex Productidae Gray, 1840, p. 15]

Productidines with long trails, other than in early forms; ornamentation diverse, commonly ribbed, spines may be absent from near ventral hinge, otherwise widely to closely spaced; dorsal spines in some. Lower Devonian (Emian)—Upper Permian (Changhsingian), ?Lower Triassic.

Family PRODUCTELLIDAE

Schuchert, 1929


Shell small to medium sized; dorsal corpus concave, or rarely, only slightly concave; ribbing absent from beak or totally; spines varied, commonly on ventral valve only, commonly absent from hinge region; corpus cavity shallow, or rarely, deep in Carboniferous or Permian; teeth absent after uppermost Devonian; lateral ridges appearing in lower Tournaisian. Lower Devonian (Emian)—Upper Permian (Changhsingian), ?Lower Triassic.

Subfamily PRODUCTELLINAE

Schuchert, 1929

[Productellinae Schuchert in Schuchert & LeVene, 1929, p. 17]

Ribs rarely developed, then only anteriorly; spines evenly distributed over ventral valve only; corpus shallow; teeth present; lateral ridges, ear baffles lacking; cardinal process lobes divergent, V-shaped dorsally, with pit; dorsal adductor scars commonly nondendritic. Lower Devonian (Emian)—Upper Devonian (Famennian).

Productella Hall, 1867c, p. 153 [*Productus subaculeatus Murchison, 1840, p. 255; SD Oehlert, 1887b, p. 1279]. Width 10 to 20 mm; concavoconvex, with spines evenly distributed on ventral valve only, spine bases commonly not elongate; rugae weak posterolaterally, no ribbing. Middle Devonian (Givetian)—Upper Devonian (Frasnian), ?Famennian): Eura sia. Fig. 278,1a–e. *P. subaculeata (Murchison), upper Frasnian, France (Boullonais); a–d, shell viewed posteriorly, laterally, ventrally, dorsally, X2; e, dorsal valve interior, X3 (Muir-Wood & Cooper, 1960).

Chattertonia Johnson, 1976, p. 789 [*Spinulicosta campbelli Chatterton, 1973, p. 78; OD]. Similar to Spinulicosta, but with anderidia. Lower Devonian (Emian): Australia. —Fig. 278,2a–f. *C. campbelli (Chatterton), Emsian, New South Wales: a,b, holotype, viewed ventrally, dorsally, ANU 18950, X3 (new); c, ventral valve lateral view, X3; d, ventral valve exteriort, X2; e, ventral valve interior showing teeth, X3; f, dorsal valve interior showing andetria, X4 (Chatterton, 1973).

Helaspis Imbrie, 1959, p. 400 [*H. luna; OD]. Resembles Spinulicosta, but exaggerated elongate spine bases simulate ribs posteriorly, ribbed anteriorly. Middle Devonian (Givetian): North America. —Fig. 278,3a–c. *H. luna, Givetian, Michigan: a,b, ventral, dorsal exteriors of shell, X2; c, dorsal valve interior, X2 (Imbrie, 1959).

Sinoproductella Wang, 1955b, p. 349 [*Productella hemispherica Tien, 1938, p. 19; OD]. Poorly known; gently concavoconvex with short trail, shallow corpus; ?short interareas or ginglymus; spines long on ears, low angled on rest of ventral valve, rugae weak dorsally, plus dimples; ?teeth. Upper Devonian (Famennian): China. —Fig.
Fig. 278. Productellidae (p. 424–426).
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**Spinulicosta** NALLIKARI, 1937, p. 49 [*Productus spinulicostus* Hall, 1857, p. 173, OD]. Small; outline subrounded, strongly concavoconvex profile; weakly lamellose, spines as *Productus*, but with elongate spine ridges posterior to spines, ribbing anteriorly; dorsal valve dimpled. *Lower Devonian—Middle Devonian* (Eifelian): North America, Europe, Australia, Asia. ——Fig. 278, 5a–c. *S. spinulicostus* (Hall), Eifelian, New York; a, b, lectotype, ventral valve exterior, lateral views, AMNH 4377a, X2 (Muir-Wood & Cooper, 1960). ——Fig. 278, 5c. *S. sp. cf. S. spinulicostus* (Hall), Lower Devonian, Ohio; dorsal valve exterior, X2 (Muir-Wood & Cooper, 1960). ——Fig. 278, 5d–e. *S. sp. cf. S. navicella* (Hall), Middle Devonian, Nevada; d, silicified ventral valve exterior, X2; e, incomplete silicified dorsal valve interior, X3 (Muir-Wood & Cooper, 1960).

**Stelckia** CHICKAY, 1963, p. 21 [*S. galearius*; OD]. Poorly known; outline semicircular to subtriangular; highly arched medially; ears flat; radial ridges faint, possibly spine bases; rugae on ears, weak on venter, dorsal valve; spines at ears, medially, recumbent on venter. *Middle Devonian* (Givetian): Canada. ——Fig. 278, 6a–e. *S. galearius*, Givetian, Ramparts Formation, Northwest Territories; a, b, holotype, incomplete corpus viewed dorsally, posteriorly, showing paired dorsal ridges, PRI 27111, X1; c, d, ventral, lateral views of incomplete specimen, X1.5; e, dorsolateral view of posteroomedian region, X2 (new).

**Subfamily PRODUCTININAE**

Muir-Wood & Cooper, 1960

[Productininae Muir-Wood & Cooper, 1960, p. 181]

**Wide-hinged productellids commonly ribbed, especially ventrally; few spines on ventral valve only, absent from hinge region; corpus cavity shallow, except some Paramariniferini; brachial ridges, where present, with anterior lobe axes directed anteromedianly. *Upper Devonian (Famennian)—Upper Permian (Changhsingian).* **Lower Triassic.**

**Tribe PRODUCTININI**

Muir-Wood & Cooper, 1960


Ribbing on ventral valve, concentric lamellae prominent on dorsal valve; ventral profile an ideal spiral; no sulcus; brachial ridges unknown. *Upper Devonian (Famennian)—Lower Carboniferous (Asbian).*

**Productina** SUTTON, 1938, p. 551 [*Productus sampsoni* WELLER, 1909, p. 300; OD]. Small; subrounded outline with small ears, strongly concavoconvex with inflated umbos; ribbing regular, relatively fine, interrupted anteriorly by lamellae, especially dorsally. *Upper Devonian—Lower Carboniferous (lower Hastarian):* North America, Europe, Australia, southern Africa. ——Fig. 279, 1a–e. *P. sampsoni* (Weller), Hastarian; a, b, ventral valve viewed ventrally, laterally, Texas; c, ventral valve viewed posteriorly, Texas; d, e, dorsal view of shell, dorsal valve interior, Caballero Formation, New Mexico, X3 (Muir-Wood & Cooper, 1960).

**Argentinproductus** COOPER & MUIR-WOOD, 1951, p. 195, nom. nov. pro *Thomasia pauli*, 1942, p. 191, non FREDERICKS, 1928 [*Producta margaritacea* PHILLIPS, 1836, p. 215; OD] (= *Thomaxis Fredericks*, 1928, p. 783, nec POCHÉ, 1908, nec RITTER, 1910, nec WILSON, 1910, nec LAMBERT, 1918; *Thomasia Puckelmann*, 1931, p. 181, nec NEWSTEAD & CARTER, 1911). Transverse posteriorly; ribbing wide, flattened, branching, slightly lamellose, few ventral spines only. *Lower Carboniferous* (Viséan): Europe, northern Africa. ——Fig. 279, 2a–f. *A. margaritacea* (Philips), Asbian; a, neotype, ventral valve exterior, north Wales, BMNH BB 13616, selected by BRUNTON & MUNDY, 1993, X1; b, c, ventral, dorsal views of shell, silicified specimens, Fermanagh, British Isles, X1.5; d, ventral view of young valve with median spine, silicified specimen, Fermanagh, X1.5; e, ventral valve interior, silicified specimen, Fermanagh, X2.5; f, dorsal valve interior, silicified specimen, Fermanagh, X1.5 (new).

**Dorsirugatia** LAZAREV in LAZAREV & SUUR SUREN, 1992, p. 63 [*D. taogankholgensis*; OD]. Wide ears; weak ventral ribbing; row of three spines on each flank; dorsal lamellae plus weak anterior ribbing. *Upper Devonian* (upper Famennian): Mongolia. ——Fig. 279, 3a–d. *D. taogankholgensis*, uppermost Famennian, Gobi Altai; a, holotype, viewed ventrally, PIN 3385/1523, X3; b–d, ventral valve viewed anteroventrally, posteriorly, laterally, X3 (Brunton & Mundy, 1993).

**Productellina** REED, 1943, p. 99 [*Productus (Productellina) fremingtonensis*; OD]. Ears small; ventral valve only ribbed, dorsal valve lamellose; possibly only single pair of ventral flank spines. *Upper Devonian (Famennian)—Lower Carboniferous* (lower Tournaisian): southern Britain. ——Fig. 279, 4a–d. *P. fremingtonensis*, lower Tournaisian, Pilton Beds, Devon; a, holotype, dorsal valve external mold, latex replica, OUM E287, X2; c, d, ventral valve internal mold viewed ventrally, laterally, note spine base, arrowed, X2 (new).

**Tribe CHONETELLINI** Licharew, 1960


Outline subtriangular, may have ginglymus; lateral profile deeply concavoconvex
Fig. 279. Productellidae (p. 426).

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with shallow corpus cavity; ribbing weak or absent; commonly nasute, with spines only flanking umbo. Lower Permian (Artinskian)—Upper Permian (Changhsingian).

**Chonetella** WAAGEN, 1884, p. 613, 657, *non* Chonetella KROTOW, 1885, p. 274, «Chonetina KROTOW, 1888, p. 500 [*C. nasuta; OD*]. Subcircular to transverse chonetiform, strongly nasute outline; ventral ginglymus; ribbing absent or weak; spines extend posterolaterally from hinge line, ?absent from corpus; cardinal process long, but narrow; lateral ridges divergent from hinge, long brachial ridges bordered anteriorly by strong endospines. *lower Lower Permian (Kungurian)—Upper Permian (Capitanian):* Pakistan (Salt Range).——Fig. 280, 1a–d. *C. nasuta,* Permian, Kalabagh member, Khisor Range; *a,* ventral valve exterior, ×1; *b,* ventral valve interior, ×2; *c,* ventral valve exterior, ×2; *d,* dorsal valve interior, ×2 (Grant, 1976).

**Celebetes** GRANT, 1976, p. 137 [*C. gymnus; OD*]. Concavoconvex profile with weak geniculation; ribbing absent, concentric ornament weak or absent; spines few near hinge, few or absent elsewhere; anterior margin commonly not nasute; cardinal process narrow to trifid with short shaft; tubercles widespread, endospines at anterior margin of visceral disk. *Lower Permian (Artinskian):* Thailand.——Fig. 280, 2a–f. *C. gymnus,* Artinskian, Phangnga; *a,* holotype, viewed ventrally, ×1; *b,c,* holotype, viewed dorsally, laterally, USNM 212444, ×2; *d,* ventral valve interior, ×2; *e,* dorsal valve interior, ×2; *f,* dorsal valve interior, ×1 (Grant, 1976).

**Haydenella** REED, 1944, p. 78 [*Productus kiangiensis* KAYSER, 1885, p. 185; OD] [*Striatifera kayseri CHAO, 1927b, pl. 13, fig. 9; OD*]. Smaller medium-sized corpus with short simple trails, broad outline; short ginglymus common; ribbing weak, absent at umbos; rugae only on ears; spines separate corpus from posterior ear regions, thin spines scattered on ventral corpus; ventral diductor scars prominent; cardinal process dorsally trifid; lateral ridges weak, no marginal ridges. *upper Lower Permian (Roadian)—Upper Permian (Tatarian):* China, Asia, Transcaucasia.——Fig. 280, 3a–e. *H. kiangiensis* (KAYSER); *a,b,* ventral valve exterior, lateral view of shell showing flank spines, Permian, Jiangxi, ×1; *c–e,* ventral, dorsal, lateral views of shell, middle Productus Limestone, Salt Range, Pakistan, ×1 (Muir-Wood & Cooper, 1960).

**Ogbinia** SARYTCHYEVA in SARYTCHYEVA & SOKOLSKAYA, 1965, p. 229 [*O. dzhagrensis; OD*]. Small, around 10 mm wide, elongate outline; ginglymus; ribbing low, lacking rugae; spines in row near hinge only;
cardinal process unifid, supported by shell thickening anteriorly; median septum short. **Upper Permian** (Roadian): Transcaucusia.——Fig. 280, a–c. *O. zhongyinensis*, Uhman, Transcaucusia; holotype, viewed posteriorly, ventrally, laterally, PIN 207/65, X1 (Sarycheva & Sokolskaya, 1965).

**Parachonetella** Liao, 1980, p. 260 [*P. zhongyinensis*; OD]. Resembles *Chonetella*, but differs in having irregular ribs on trail, ventral cincture at corpus margin. **Upper Permian** (Changhsingian): China.——Fig. 280, a, b. *P. zhongyinensis*, Changhsingian, Guizhou; a, holotype, anteroventral view, NIGP 43650, X2; b, anteroventral view of another specimen, X2 (new).

**Planihaydenella** Chang, 1987, p. 757[*]764 [*P. anqingensis*; OD]. Poorly known, possible synonym of *Haydenella*, but ribbing reportedly well developed. **Upper Permian**: China.

**Tribe PARAMARGINIFERINI** Lazarev, 1986


Radial ribbing and, in some, posteriorly reticulate; ventral profile distorted, ventral trail (when present) commonly becoming anteriorly nasute; ventral marginal ridges commonly developed. **Lower Carboniferous** (Viséan)—**Upper Permian** (Changhsingian), ?**Lower Triassic**.

**Paramarginifera** Fredericks, 1916, p. 61 [*Marginifera clarkei* Cherynschey, 1902, p. 328; OD]. Medium size with pentagonal outline; profile concavoconvex, long trail with broadly nasute extension; median sulcus originates at umbo; ribbing coarse, rugae weak on disks; six spines symmetrically disposed on ears, flanks, venter; cincture bordering ventral corpus; interior unknown. **Lower Permian** (Assemblean—Artinskian): Ural Mountains, Inner Mongolia, northern China.—Fig. 281, 1a–d. *P. clarkei* (Tscherbinschew), Permian, Schwagerina Limestone, Ural Mountains; a, anterior view, X1; c, d, posteroventral view, lateral view, X1 (Muir-Wood & Cooper, 1960).

**Alitaria** Cooper & Muir-Wood, 1967, p. 808, nom. nov. pro *Alitfera* Muir-Wood & Cooper, 1960, p. 207 (type, Productus expansus de Koninck, 1842, p. 159, non Pandor, 1830) [*Alitfera konincki* Muir-Wood & Cooper, 1960, p. 208; OD]. Transverse outline with large strongly differentiated ears; disks reticulate, commonly two pairs of thick halaroid spines on flanks; strong ventral marginal ridges. **Lower Carboniferous** (Viséan); Europe, northern Africa, northern Asia.—Fig. 281, 2a–f. *A. konincki* (Muir-Wood & Cooper), Viséan, Visé, Belgium; a, oblique lateral view of internal mold showing marginal ridge, X2; b, c, ventral view of internal mold, replica of its dorsal valve interior, X2 (Muir-Wood & Cooper, 1960); d–f, anterior, posterior, lateral views of ventral valve exterior, X1.5 (new).

**Bibiatola** Grant, 1976, p. 156 [*B. costata*; OD]. Outline broadly triangular with nasute anterior margin; deeply concavoconvex; ribbing originates posteriorly on disks; spines few, two or three on each flank, up to six on venter; cardinal process trifid, sessile; lateral ridges extend weakly to separate ears; endospines short, few. **Lower Permian** (Artinskian): Thailand.—Fig. 281, 3a–c. *B. costata*, Artinskian, Ko Muk; a–c, holotype, viewed ventrally, dorsally, laterally, USNM 212423, X2; d, e, dorsal valve interior, viewed laterally, X2 (Grant, 1976).

**Bothrionia** Cooper & Grant, 1975, p. 984 [*B. nasuta*; OD]. Outline nasute; median ribs may be lacking at sulcus, on trail may branch anterior to spine bases; spines few, one large spine on each ear, others over ventral valve; posterior sulcus becoming nasute anteriorly at adult margin; ventral ear baffles continued anteriorly to form low ridge around corpus; cardinal process sessile, trifid; median septum short, thin; endospines numerous, long. **Permian** (Wordian): USA.—Fig. 281, 4a–c. *B. nasuta*, Permian, Word Formation, Texas; a–c, holotype, viewed ventrally, dorsally, laterally, USNM 149637a, X1; d, ventral valve interior, X2; e, dorsal valve interior, X3 (Cooper & Grant, 1975).

**Cathaysia** Ching in Wang, Ching, & Fang, 1966, p. 327 [*Productus chonetoides* Chao], 1927b, p. 62; OD). Small with transverse to quadrature outline, concavoconvex profile; ears distinct, sulcus shallow or absent; ribbing branched, rugae on ears, near hinge only; single large spine on each ear, one or two on each side of trail; ventral muscle scars smooth with slightly excavated adductor scars, prostrate endospines; dorsal interior with numerous endospines. **Permian** (Artinskian—Changhsingian), **Lower Triassic** (lower Scythian): southern China, Caucasus.—Fig. 282, 1a–d. *C. chonetoides* (Chao), Permian Coal Series, Jiangsu Province; a–d, ventral views of two incomplete specimens, Changhsingian, Zhejiang Province, X1 (now); c, replica of dorsal valve interior, Fujian Province, X2; d, ventral valve exterior, X2 (Xu & Grant, 1994).

**Cymopropodus** Xu, 1987, p. 227 [*C. callicostella*; OD]. Poorly known; medium size, transverse with hinge equal to maximum width; ventral disk weakly convex, genulate with short trail; ribbing fine, ears with irregular rugae only; spines strong, in rows separating ears; interiors unknown. **Upper Permian** (Changhsingian): China.—Fig. 282, 6a,b. *C. callicostella*, Changhsingian, China; a, ventral valve exterior, X1; b, incomplete dorsal valve exterior with dimples opposite ventral spine positions, X1 (Xu, 1987).

**Emomarginiferina** Brunton, 1966, p. 229 [*Emomarginiferina (E.) trispina*; OD]. Small, around 10 mm wide; ventral profile with tight spine, trail rarely slightly nasute; reticulate posteriorly, few (commonly three) thick symmetrical ventral spines; corpus relatively deep; no median sulcus; no anterior ventral.
marginal ridges. Carboniferous (Viséan; lower Moscovian): Europe, ?China.—FIG. 282,2a–h. *E. trispina (Brunton)., Asbian, Fermanagh, British Isles; silicified specimens; a, holotype viewed dorsally, showing position of ear baffles, BMNH BB 52890, ×4; b–d, ventral valve viewed ventrally, laterally, internally, showing median spine cavity, arrow, ×3; e, f, dorsal valve interior viewed ventrally, posteroventrally, ×4; g, juvenile ventral valve exterior with pedicle sheath, ×15 (Brunton, 1966).

Huatangia Liao & Meng, 1986, p. 78[91] [*H. sulcatifera; OD]. Small transverse shell with narrow anterior sulcus; ribbing irregular on corpus, fine on trail; rugae strong posterolaterally on ventral valve, reticulate posteriorly on dorsal disk; ventral marginal ridge; cardinal process narrow (?unifid). Upper Permian (Changhsingian): China.—FIG. 282,4a–d. *H. sulcatifera, Changhsingian, Hunan; a, holotype, lateral view, NIGP 74198, ×1; b, anteroventral view, NIGP 74198, ×2; c, ventral valve exterior, ×1; d, external mold of dorsal valve, ×1.5 (new).

Parryphella Liao in ZHao & others, 1981, p. 53[83] [*Cathaysia sulcatifera Liao, 1980, p. 261; OD] [=Spinoparyphella Liang, 1990, p. 11, nom. nud. (type, S. zhinanensis; OD)]. Small, widest at hinge with large flat ears; ginglymus short; dorsal disk weakly concave; ribbing simple, weak posteriorly; rugae strong on ears; two pairs of spines at hinge;
cardinal process narrow, elongate; low median septum extending to midlength of valve. upper Upper Permian (Changhsingian); Lower Triassic: southern China.—Fig. 282,7. *P. sulcatifera (LAMO), upper Upper Permian, Guizhou; ventral valve exterior, ×3 (new).

?Protoniella Bell, 1929, p. 110 [*P. beedii; OD].
Small; outline rounded, profile concavoconvex, slight median sulcus on ventral trail; ribbing starts near beak, bearing fine scattered spines ventrally; dorsal valve ribbed, weakly lamellate anterolaterally, no rugae; cardinal ridges, ear baffles. Lower Carboniferous (upper Viséan–lower Serpukhovian): central, eastern North America.—Fig. 282,3a–d. *P. beedii, Lower Carboniferous, upper Windsor, Nova Scotia; a–c, holotype, viewed ventrally, dorsally, laterally, GSC 7954d, ×1; d, posterior view of ventral valve, ×1 (Muir-Wood & Cooper, 1960).

Rugivestis Muir-Wood & Cooper, 1960, p. 235 [*R. proboscidea carinata Muir-Wood & Cooper in

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COPER, 1957, p. 36; OD]. Small, trigonal outline with trail folded into broad nasute extension; short flanges at start of trail continuous with ears; disks concavoconvex, reticulate; ribbing well developed on trails; spines few, symmetrically placed; marginal ridges in both valves. Lower Permian (Asselian–Artinskian, ?Kungurian): North America, Russia.

——Fig. 282, 5a–c. *R. carinata (MUIR-WOOD & COOPER), Permian, Coyote Butte Formation, Oregon; a, holotype, viewed ventrally, USNM 124156a, ×1; b,c, holotype, viewed anteriorly, laterally, USNM 124156a, ×2 (Muir-Wood & Cooper, 1960). ——Fig. 282, 5d. R. kutorgae (TSCHER-NYSCHEW), Lower Permian, Schwagerina Limestone, southern Ural Mountains; ventral view, ×1 (Muir-Wood & Cooper, 1960).

Subfamily OVERTONIINAE
Muir-Wood & Cooper, 1960

Ribs absent or rarely confined anteriorly on trails; spines scattered equally on both valves, but absent from ventral hinge; corpus depth varied. Upper Devonian (upper Famennian)—Upper Permian (Tatarian).

Tribe OVERTONIINI
Muir-Wood & Cooper, 1960

Strong rounded rugae bearing spines; corpus cavity deep; dorsal adductor scars raised. Lower Carboniferous (upper Viséan)—Lower Permian (Asselian).

Overtonia THOMAS, 1914, p. 259 [*Producta fimbriata J. de C. SOWERBY, 1824 in 1823–1825, p. 85; OD]. Small to medium; ventral spines associated with rugae from crests, short prostrate spines at lamellose anterior margins; dorsal spines erect in bands between series of short trails; dorsal adductor platforms raised. Lower Carboniferous (upper Viséan): Europe, ?Asia, ?northern Africa. ——Fig. 283, 1a–g. *O. fimbriata (J. de C. SOWERBY); a–d, ventral, dorsal, lateral, posterior views of shell, Asbian, York...
Fig. 284. Productellidae (p. 433–434).

**Tribe AVONIINI** Sarytcheva, 1960

Concentric ornament of broad irregular lamelllose bands; ventral lateral profile an ideal spiral; corpus cavity shallow to moderate. **Upper Devonian (upper Famennian)—Lower Carboniferous (lower Serpukhovian).**

**Avonia** Thomas, 1914, p. 259 [*Productus youngianus* Davidson, 1860, p. 180; OD]. Outline somewhat elongate; concentric ornament of weak irregular lamellae, ribbing weak, only anteriorly; lateral ridges to inner side of ears. **Lower Carboniferous (Viséan—lower Serpukhovian): Europe, Asia.** —Fig. 284,3a–d. *A. youngiana* (Davidson), Brigantian, Stirlingshire; a–d, lectotype, viewed ventrally, dorsally, posteroventrally, laterally, BMNH B 45680, ×1.5 (new).

**Barunkhuraya** Lazarev in Bruntont & Lazarey, 1997, p. 385 [*B. indrengynensis*; OD]. Small, slightly wider than long; nongeniculate; rugae on both valves, slightly lamelllose; spines ventral, with swollen bases, row near hinge; cardinal process pit; lateral ridges weak, very short, but strongly divergent. **Upper Devonian (upper Famennian): Mongolia.**
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(Indrengyn-Nuru Mountains).—Fig. 284,4a–c.
*B. indrengynensis*, upper Famennian, Indrengyn-Nuru Mountains; a,b, slab showing holotype, dorsal valve external mold (right), ventral valve external mold (left), PIN N 3385/1104, X2; c, dorsal valve internal mold, X2 (Brunton & Lazarev, 1997).

Onavia Lazarev in Brunton & Lazarev, 1997, p. 387 [*O. barunkhurensis; OD]. Small, nongeniculate; rugae, spines on both valves; lateral ridges very short, weak. Lower Carboniferous (Tournaissian): Mongolia.—Fig. 284,1a–d. *O. barunkhurensis*, Tournaissian, Khuren-Ula Mountains; a, holotype, viewed laterally, PIN N 3385/1358, X1; b, ventral view of specimen with most of ventral valve missing, X1; c, ventral valve internal mold, X2; d, dorsal valve external mold, X2 (Brunton & Lazarev, 1997).

Quasiavonia Brunton, 1966, p. 219 [*Productus aculeatus J. Sowerby, 1814 in 1812–1815, p. 156; OD]. Ventral umbo inflated; both valves irregularly lamellate, spines with slightly swollen bases ventrally, fine dorsally; corpus cavity moderate. Lower Carboniferous (Viséan): Europe, western Asia, northern Africa.—Fig. 284,2a–e. *Q. aculeata* (J. Sowerby); a–d, lectotype, viewed ventrally, dorsally, posteriorly, laterally, Viséan, Derbyshire, BMNH B 60992, X2; e, specimen viewed anteriorly, showing lamellae, Brigantian, Derbyshire, X2 (new).

Tribe COSTISPINIFERINI Muir-Wood & Cooper, 1960


Concentric ornament weak; ribbing may be present on trails; ventral profile geniculate, with shallow to deep corpus cavity.

Upper Carboniferous (Gzhelian)—Upper Permian (Tatarian).

Costispinera Muir-Wood & Cooper, 1960, p. 217 [*C. texana; OD; *Avenia wallottiana connata* R. E. King, 1931, p. 85]. Small, transverse corpus with geniculate profile, deep cavity, elongate trails; rugae irregular on posterior disks; ribbing developed on trails; spines evenly distributed over ventral valve, thinner on dorsal valve; cardinal process with short shaft; lateral ridges extend across ears; long endospines border brachial areas anteriorly and laterally, upper Lower Permian (Roadian)—lower Upper Permian (lower Kazanian).—Fig. 285,1a–f. *C. texana*, Kazanian, Word Limestone, Texas; a–d, holotype, viewed anteriorly, posteriorly, dorsally, laterally, USNM 124150a, X1; e, ventral valve partial interior, X2; f, dorsal valve interior, X2 (Muir-Wood & Cooper, 1960).

Comuquia Grant, 1976, p. 97 [*C. modestae; OD]. Small, elongate ovate; concavo-convex profile with shallow corpus; ribbing absent, some growth lines prominent; spines evenly distributed on ventral valve, dorsal spines fine; cardinal process bilobed, weakly quadriphd; median ridge weak, short; brachial ridges not developed. Lower Permian (Artinskian): Thailand, Himalaya, northern Tibet.—Fig. 285,2a–e. *C. modestae*, Artinskian, Ko Muk, Thailand; a–c, holotype, ventral valve viewed ventrally, internal, laterally, USNM 212136, X3; d, dorsal view of complete shell, X3; e, young dorsal valve interior, X3 (Grant, 1976).

Darlinunia Li & Gu, 1976, p. 245 [*D. liaoningensis; OD]. Small, subcircular corpus outline with small, well-differentiated ears; ventral profile weakly convex; dorsal valve concave; corpus cavity shallow; spines prostrate, small, in groups on ears, scattered on disk, concentrically in broad bands anteriorly; dorsal spines reportedly few; interiors poorly known. Upper Permian (Kazanian–Tatarian): northern Mongolia, China.—Fig. 285,3a–e. *D. liaoningensis*, Upper Permian, Liaoning Province; a,b, holotype, ventral, posterior views (with ventral valve uppermost), SIGM 7K20, X2.5; c, d, ventral, lateral views of specimen, X3; e, internal mold of ventral valve, X2 (new).

Dorashamia Sarytcheva in Sarytcheva & Sokolskaya, 1965, p. 217 [*D. abichi; OD]. Small chonetiform shell with thick-walled valves; ornament of weak rugae becoming lamellose anteriorly; spine row near hinge, rare thin spines over venter, three spines separate dorsal ears; cardinal process sessile, bilobed; lateral ridges separate ears, disappear anteriorly. Upper Permian (upper Capitanian): Transcaucasus, North Caucasus, Kazakhstan.—Fig. 285,5a–d. *D. abichi*, upper Capitanian, Transcaucasus; a,b, holotype viewed ventrally, dorsally, PIN 2072/42, X4; c, holotype viewed laterally, PIN 2072/42, X1; d, incomplete dorsal valve exterior, X4 (Sarytcheva & Sokolskaya, 1965).

Dyshcrestia Grant, 1976, p. 101 [*D. spodia; OD]. Broadly subovate, widest near midlength; beak inflated; spines equally and widely scattered on ventral disk, thicker in groups on flanks and on concentric lamellae on trail; dorsal spines slender; lateral ridges extend to separate ears weakly; endospines numerous in broad band around brachial ridges. Lower Permian (upper Artinskian): Thailand, Western Australia, Indonesia.—Fig. 286,1a–e. *D. spodia*, upper Artinskian, Ko Muk, Thailand; a–c, holotype viewed ventrally, dorsally, laterally, USNM 212164, X2; d, incomplete ventral valve interior, X4; e, dorsal valve interior, X2 (Grant, 1976).

Echiniaurilla Lazarev in Brunton & Lazarev, 1997, p. 387 [*Krotovia jisuensiformis* Sarytcheva in Sarytcheva & Sokolskaya, 1965, p. 216; OD]. Small, around 10 mm wide, strongly convex profile; spines fine posteriorly, densely distributed on both valves; plications incipient on trail; dorsal lateral ridges prominent, adductor scars narrow, elongate. upper Lower Permian (Roadian)—Upper Permian (Kazanian): Transcaucasus.—Fig. 285,4a–d. *E. jisuensiformis* (Sarytcheva), Roadian, River Vedi; a,b, holotype, viewed ventrally, laterally, PIN 2071/
Fig. 285. Productellidae (p. 434–436).
78, X1: c, ventral view of specimen, X1: d, dorsal valve interior, X3 (Sarytcheva & Sokolskaya, 1965).

Echinurus MUIR-WOOD & COOPER, 1960, p. 221 [*E. lateralis*; OD]. Small, subcircular outline, with small, well-differentiated ears; ventral corpus strongly inflated in transverse profile, cavity moderately deep; exterior smooth, but for erect spines covering both valves, clusters of thicker spines on flanks; ear baffle internally, dorsal lateral ridges separate ears, long endospines anteriorly; Lower Permian (Sakmarian)—lower Upper Permian (Wordian); USA, Tibet.——Fig. 286.2a–e. *E. lateralis*, Upper Permian, Word Limestone, Texas; a, holotype, ventral view, USNM 124052a, X1 (Muir-Wood & Cooper, 1960); b, dorsal view of specimen, X1: 1; c, lateral view of specimen, X1: 1; d, ventral view of shell with much of ventral valve missing, X1 (Cooper & Grant, 1975); e, dorsal valve interior, X1 (Muir-Wood & Cooper, 1960).

Lethamia WATERHOUSE, 1973, p. 38 [*L. liguritus*; OD]. Poorly defined; medium size, concavoconvex with shallow corpus cavity; spines seemingly erect on both valves; ribbing absent, rugae weak. If with geniculate profile, would be better accommodated in the Levipustulinae of the Plicatiforminae. Lower Permian—lower Upper Permian (Kazanian): New Zealand; Australia.

Neoplicatifera CHING, LIAM, & HOU, 1974, p. 309 [*Plicatifera huangi* USTRITSKY in USTRITSKY, HU, & CHAN, 1960, p. 26; OD]. Small to medium transverse corpus with long trail; ventral profile with weakly convex disk, weakly geniculate; flanks steep, nearly parallel; dorsal disk gently concave geniculate; corpus cavity moderately deep; rugae on both disks; weakly ribbed or smooth; spines fine, posteri orly on rugae, scattered anteriorly, curved row between umbonal slope and ears; dorsal valve with fine short spines; cardinal process bilobate; median septum long; lateral ridges, marginal ridges lost anteriorly. [Assigned to the Semicostellinae of the Plicatiforminae if with strong geniculation and ribbing on trail; USTRITSKY decided (1960) that the species described by HUANG (1932, p. 38–41) was not *Plicatifera minor* (SCHELLWEN) and renamed it *P. huangi*.] upper Lower Permian–Upper Permian (Kazanian): China, Salt Range.——Fig. 286.4a–d. *N. huangi* (USTRITSKY), Permian, China (Guizhou Province); a,–c, shell viewed posteriorly, anteriorly, laterally, X1; d, dorsal valve interior, X1 (HUANG, 1932).

Paraplicatifera ZHAO & TAN, 1984a, p. 26[30] [*P. regularis*; OD]. Resembles *Neoplicatifera*, but differs in its clearly defined anterior ribbing; dorsal valve unknown, but assumed spinose. Lower Permian (Artinskian)—lower Upper Permian (Wordian); China.——Fig. 286.3a–e. *P. regularis*, Permian, China; holotype, viewed posteriorly, anteriorly, laterally, HB 257, X2 (ZHAO & TAN, 1984a).

Pseudoavonia WANG in ZHANG, FU, & DING, 1983, p. 312 [*Avonia lopengensiformis* USTRITSKY in USTRITSKY, HU, & CHAN, 1960, p. 20; OD]. Poorly known, resembles *Costispinifera*, but lacks concentric ornament on ventral umbro, perhaps fewer dorsal spines; apparently has stronger marginal ridges at sides of dorsal disk. Lower Permian (Artinskian): China.——Fig. 286.6a,b. *P. lopengensiformis* (USTRITSKY), Chihsian, Xinjiang; ventral valve viewed anteriorly, posteriorly, X1 (ZHANG, FU, & DING, 1983).

Stictozoster GRANT, 1976, p. 96 [*S. leptus*; OD]. Small, shallow body outline, with concavoconvex profile; ribbing absent; ventral lateral ridges produce tubiform median trail; ribbing absent, concen tric ornament of weak lamellae; spines with swollen bases, densely spaced on both valves, concentrically arranged anteriorly; cardinal process bilobed, quadrifid; adductor scars indistinct; lateral ridges separate ears; disk interior strongly endospinose, upper Upper Carboniferous (Gzhelian)—Lower Permian (Artinskian): Canada, Russia.——Fig. 285.6a–e. *S. leptus*, Permian, Ko Muk, Thailand; a–c, holotype, viewed ventrally, anteriorly, laterally, X2; d, dorsally, USNM 212105; X1; e, dorsal valve interior, X2 (GRANT, 1976).

Tubersulculus WATERHOUSE in BAMBER & WATERHOUSE, 1971, p. 208 [*T. maximus*; OD]. Medium size, deeply concavoconvex profile; ventral sulcus and dorsal fold produce tubiform median trail; ribbing absent, concentric ornament of weak lamellae; spines with swollen bases, densely spaced on both valves, concentrically arranged anteriorly; cardinal process bilobed, quadrifid; adductor scars indistinct; lateral ridges separate ears; disk interior strongly endospinose, upper Upper Carboniferous (Gzhelian)—Lower Permian (Artinskian): New Zealand; Australia.

Zhuaconcha LIANG, 1990, p. 183[463] [*Z. hirsutispins*; OD]. Poorly preserved material. Small to medium size with weakly concavoconvex profile; hinge slightly less than maximum width; spines fine, closely covering both valves; ribbing, concentric ornament absent; dorsal marginal ridge, raised adductor scars; apart from marginal ridge genus similar to *Echiniauella*. Illustrations inadequate for publication. Upper Permian (Kazanian): China.

Tribe INSTITIFERINI

MUIR-WOOD & COOPER, 1960


Minute to small shells with relatively deep corpus cavity, bearing concentric ornament, coarse ribbing on trails strongly deflected as flanges or gutters; spines on ventral corpus only. Lower Carboniferous (Viséan).

Institifera MUIR-WOOD & COOPER, 1960, p. 203 [*Productus tessellatus de CONINCK, 1847b, p. 110;
OD]. Deep corpus, but slightly concave dorsal valve; ribbing variable, but clear anteriorly and especially on elaborate bordering structures that roll dorsally inward, ventrally outward; spines fine from concentric swollen bases. Lower Carboniferous (Viséan): western Europe.—Fig. 287,2a–e. *I. tessellata (DE KONINCK), Viséan, Ireland; a, shell viewed ventrally with section of recurved flange.

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Preserved, Cork, ×2; b,c, shell viewed dorsally, laterally with its inwardly turned dorsal flange, anteriorly recurved ventral flange, Cork, ×3; d, dorsal view of shell with complete dorsal, ventral flanges, Cork, ×3; e, dorsal view of corpus (flange missing) plus ventral flange, Kildare, ×2 (new).

**Thomasella** Friedericks, 1928, p. 778 [*Productus* *wrighti* Davidson, 1861, p. 162; OD]. Very small, corpus around 5 mm width; rugose visceral disk, ribbed flange; spines few from ventral rugae. Lower Carboniferous (Viséan): British Isles.—Fig. 287, a,b. *T. *wrighti (Davidson), Viséan, Cork, Ireland; a, drawing of ventral exterior, with flange, ×3 (Davidson, 1861); b, lectotype, same specimen, BMNH B 40097; ×4 (new).

**Krotovia** Friedericks, 1928, p. 779 [*Productus* *spinulosus* J. Sowerby, 1814 in 1812–1815, p. 155; OD]. Spine bases swollen (tuberculate); dense, quincuncially arranged; thin shelled; weakly developed marginal ridges; cardinal process quadrifid.

**Tribe Krotoviini**
Brunton, Lazarev, & Grant, 1995

[Krotoviini Brunton, Lazarev, & Grant, 1995, p. 926]
Concentric ornament weak or lacking; ventral profile an ideal spiral; shallow corpus cavity. Lower Carboniferous (Viséan)—Upper Carboniferous (Serpukhovian, ?Bashkirian).

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Lower Carboniferous (Viséan)—lower Upper Carboniferous (Serpukhovian, Bashkirian): Eurasia, northern Africa.—Fig., 287, 1a–e. *K. spirulosa* (J. Sowerby), silicified specimens, Asbian, Fermanagh, British Isles; *a–c*, shell viewed ventrally, dorsally, laterally, X2.3; *d, e*, incomplete dorsal valve viewed posterodorsally, internally, X3.6 (Brunton, 1966).

_Scoloconcha_ Gordon, 1966, p. 583 [*Productus indiansensis* Hall, 1858b, p. 13; OD]. Small, around 6 mm wide; spines less dense than _Krotovia_, may be roughly concentric; cardinal process trifid, strong marginal structures. _Lower Carboniferous_ (middle Viséan): USA.—Fig., 287, 4a–d. *S. indiansensis* (Hall), middle Viséan, Indiana; *a, b*, ventral, posterior views of shell, X3; *c*, internal view of dorsal valve, X3; *d*, posterior view of dorsal valve interior, X4 (Gordon, 1966).

**Subfamily MARGINIFERINAE Stehli, 1954**

[Marginiferae Stehli, 1954, p. 321, partim]

Ribbing normally dominates (may be reduced in _Permian_) concentric ornament; ventral profile commonly geniculate at start of trail growth; corpus cavity commonly shallow, becoming deep in _Permian_. *Lower Carboniferous_ (upper Tournaisian)—_Upper Permian_ (Changhsingian).

**Tribe MARGINIFERINI Stehli, 1954**


Ventral spines, rarely on both valves; always ribbed, but weak; commonly series of few dorsal trails, corpus cavity deep. _Lower Permian_ (Artinskian)—_Upper Permian_ (Changhsingian).

_Marginifera_ Waagen, 1884, p. 713 [*M. typica*; OD] [=Strigopina Liao, 1979, p. 535 (type, _S. lineata_; OD)]. Outline subquadrate with well-differentiated, wide ears; ventral profile strongly convex near geniculation, dorsal disk weakly concave with series of two to three trails; ribbing commonly weak, reticulate disks; spines in prominent rows along flanks plus others widely scattered on venter, none at hinge; ear baffles in both valves; dorsal lateral ridges strongly divergent, continue straight across ears, becoming marginal ridge; endospines in single row anterior to brachial ridges. _Lower Permian_ (upper Artinskian)—_Upper Permian_ (Kazanian): Himalayas, southeastern Asia, north, northeastern China.—Fig., 288, 1a–c. *M. typica*, Permian, Wargal Limestone, Pakistan, Khisor Range; *a, b*, posterior, anteroventral views of ventral valve, X1.5; *c*, dorsal view of shell, X2; *d*, lateral view of shell, X2; e, dorsal valve interior, X2 (Grant, 1968).

Entacanthus Grant, 1993b, p. 13 [*E. chioticus*; OD]. Small, moderately deep cavity resembling _Marginifera_ in shape, but lacking ribbing and with small ears; dorsal valve weakly concave, geniculate, with series of closely spaced trails; spines in row at flanks, widely scattered over ventral corpus; dorsal adductor scars slightly arched medially over start of short median septum. _Upper Lower Permian_ (Kungurian): Greece.—Fig., 288, 3a–c. *E. chioticus*, Kungurian, Khios Island; *a*, holotype, viewed ventrally, USNM 402157, X2; *b*, dorsal view of shell, X2; c, internal valve viewed laterally, internally, X2; e, dorsal valve interior, X2 (Grant, 1993b).

_Jipuproductus_ Sun, 1983, p. 123 [*J. jipuenensis*; OD]. Poorly known, seemingly similar to _Marginifera_, but condition of dorsal trails unknown, probably differing in its small ears, prominent rugae on flanks, dorsal cardinal ridges. _Upper Lower Permian_ (Artinskian): Xizang, Tibet.

**Oratius** Waterhouse, 1978, p. 30 [*Marginifera otaria* Grant, 1976, p. 115; OD]. Resembles _Marginifera_, but differs with trail overhanging dorsal disk, in lacking ribs, although there are elongate spinose bases on trail; widely extended concavoconvex ears with unusually deep auricular cavities, somewhat twisted appearance; dorsal valve seemingly with only one trail; spine row on flanks less prominent; dorsal interior with more numerous endospines. _Lower Permian_ (Artinskian–lower Kungurian): Thailand.—Fig., 288, 2a–e. *O. otaria* (Grant), Permian, Khao Chang; *a, b*, holotype viewed ventrally, laterally, USNM 212259, X2; c, holotype viewed dorsally, USNM 212259, X1; *d*, shell viewed anteroventrally, X2; e, dorsal valve interior, X2 (Grant, 1976).

**Probolonia** Cooper, 1957, p. 27 [*P. posteroventralis*; OD]. Small with well-differentiated ears forming widest part of shell; ventral profile with weakly convex disk, geniculation, convex trail; median sulcus from median disk; dorsal disk gently concave, geniculate, with several dorsal trails; ribbing originates near beak, with rugae forming reticulation; spines symmetrical on ears, venter, and row along flanks, no dorsal spines; lateral, marginal ridges complete. _Upper Lower Permian_ (Kungurian)—_Upper Permian_ (Kazanian): USA, Pamir.—Fig., 289, 2a–d. *P. posteroventralis*, Permian, Coyote Butte Formation, Oregon; *a–c*, holotype, viewed posteriorly; anteroventrally, laterally, USNM 125369, X2; *d*, drawing of longitudinal section showing dorsal trails, X2 (Muir-Wood & Cooper, 1960).

**Spimonarginifera** Huang, 1932, p. 16 [*S. kwangchouensis*; OD] [=Rugospimonarginifera Xu, 1987, p. 224 (type, _Marginifera jisuensis_ Chao, 1927b, p. 149; OD); _Haydenoides_ Chan in Yang De-ai & others, 1977, p. 352 (type, _H. orientalis_; OD)]. Small to medium, with wide hinge; weakly concavoconvex with long ventral trail anterior to geniculation, dorsal trail short; ribbing absent, but elongate spine bases; rugae irregular, narrow; spines commonly densely spaced, fine, but in some widely spaced...
Rhynchonelliformea—Strophomenata

anteriorly; dorsal valve with variably developed fine spines (the type species reported as lacking dorsal spines); marginal ridges strong in both valves, but ventrally incomplete anteriorly. upper Lower Permian (upper Roadian)—Upper Permian (Changhsingian): China, Japan, Afghanistan, Middle East.——

FIG. 289, 1a–f. *S. kueichowensis, Permian Coal Series, Guizhou, China: a–c, ventral, posterior, lateral views, ×1; d, ventral view with remnants of long spines, ×1; e, exfoliated dorsal valve interior, ×1; f, internal mold of dorsal valve, ×1 (Huang, 1932).

Tribe BREILEENIINI Brunton, 1997

[Breileeniiini BRUNTON in BRUNTON & LAZAREV, 1997, p. 389]

Spines on both valves, ribs commonly start anteriorly on corpus with elongate spine bases posteriorly. Lower Carboniferous (upper Tournaisian)—Upper Carboniferous (upper Moscovian).

OD]. Outline subrounded, corpus cavity moderately deep; spines distributed on both valves, ventrally with elongate bases or weak ribs originating at about half corpus length; growth lamellae weak, but may become prominent anteroventrally. Lower Carboniferous (upper Tournaissian)—Upper Carboniferous (Serpukhovian): western Europe, ?China, Canada. — Fig. 289, Fig. 289. 1a–e. *B. davidsoni* (JAROSZ); a,b, lectotype, viewed ventrally, laterally, Asbian, Derbyshire, British Isles, BGS 72461, ×1; c, external mold of dorsal valve, Asbian, Derbyshire, ×1; d, lateral view of shell, Asbian, Derbyshire, ×1; e, ventral view of shell with broken ventral trail, Staffordshire, ×1.5 (Brunton & Lazarev, 1997). — Fig. 290, Ifg. B. radiata BRUNTON, Brigantian, Derbyshire; corpus viewed ventrally, dorsally, showing lateral ridges, ×2 (Brunton & Lazarev, 1997).

Desmoinesia HOARE, 1960, p. 226 [*Productus muri- catus* NORWOOD & PRATTEN, 1855a, p. 14, non PHILLIPS, 1856; OD; *Marginifera muriacata* DUNBAR & CONDRA, 1932, p. 222] [=Rudinia MUIRWOOD & COOPER, 1960, p. 229, obj.]. Outline transverse, ventral umbo weakly inflated, irregularly rugose, weakly ribbed on corpus, trails; ventral spines on ribs, becoming concentric on anterior corpus and trail; dorsal spines sparse, reduced in later species; ventral ear baffles, subperipheral ridge.

Upper Carboniferous (upper Moscovian): North America.— Fig. 290,2a–f. *D. muriacata* (DUNBAR & CONDRA), Desmoinesian, Oklahoma; a, ventral view of shell, ×2; b,c, posterior, dorsal views of shell, ×2; d, lateral view of shell, ×1; e, ventral valve interior, ×2; f, dorsal valve interior, ×2 (Muir-Wood & Cooper, 1960).

Sandia SUTHERLAND & HARLOW, 1973, p. 41 [*S. brevis*; OD]. Radial ribbing relatively strong, posterior reticulation; dorsal spines thin plus few thick ones anteriorly. Upper Carboniferous (middle Moscovian): southern North America.— Fig. 290,3a–f. *S. brevis*, middle Moscovian, New Mexico; a,b, holotype viewed ventrally, laterally, OU 7688, ×1; c–e, holotype viewed anteriorly, posteriorly, dorsally, ×2; f, dorsal valve interior, ×2 (Sutherland & Harlow, 1973).

Tribe INCISINI Grant, 1976


Outline commonly anteriorly bilobate; ventral spines only, ribbing absent; hinge narrow; lateral profile not geniculate. Lower Permian (upper Artinskian)—Upper Permian (Changhsingian).
**Incisius** Grant, 1976, p. 103 [*I. concisus; OD*. Outline narrow, widening anteriorly forming weakly bilobed anterior margin; profile nongeniculate, with strongly incurved ventral umbo; halteroid spines in row on each flank, scattered over venter, absent from sulcus and from dorsal valve; cardinal process small, bilobed; brachial ridges enclose elongate lobes occupying most of dorsal disk. Lower Permian (upper Artinskian)—Upper Permian (Changhsingian): Thailand, southern China, Greece.——Fig. 291,3a—d. *I. concisus*, Permian, Ko Muk, Thailand; a, holotype viewed ventrally, USNM 212184, X4; b, holotype viewed dorsally, USNM 212184, X1.5; c, shell viewed laterally, X3; d, dorsal valve interior, X3 (Grant, 1976).

**Cyrtalosia** Termer & Termer, 1970, p. 455 [C. circinata; OD]. Poorly preserved and known, difficult to differentiate from *Incisius* other than by its reported lack of ventral spines. Upper Permian (Tatarian): Cambodia.——Fig. 291,1a,b. *C.
**Productida—Productoidea**

*Rhytisia* Cooper & Grant, 1975, p. 966 [*R. rugosa*; OD]. Small, around 8 mm wide, rounded, concavo-convex profile, no anterior sulcus; rugae on both valves, no ribbing; spines relatively strong, scattered on ventral valve only; cardinal process sessile, bilobed; lateral ridges strongly divergent, separating ears, disappear anterolaterally; median septum short, tuberculate anteromedianly. Lower Permian (Kungurian)–lower Upper Permian (Wordian): USA.——Fig. 291, 5a–d. *R. rugosa*, Permian, Road Canyon Formation, Texas; a, holotype, viewed dorsally, USNM 152703c, ×2; b, ventral valve exterior, ×3; c, dorsal valve exterior, ×2; d, dorsal valve interior, ×3 (Cooper & Grant, 1975).

**Scapharina** Cooper & Grant, 1975, p. 895 [*S. rugosa*; OD]. Small, elongate with rounded anterior margin; spines few, probably confined near posterior margin; shell commonly roughly lamellose; ear baffles in ventral valve; cardinal process small, supported by lateral ridges separating ears and continued as complete marginal ridge. Upper Permian (Capitanian): USA.——Fig. 291, 4a–e. *S. rugosa*, Permian, Bell Canyon Formation, Texas; a–e, holotype, viewed ventrally, dorsally, laterally, USNM 152657d, ×3; f, ventral valve interior, ×3; g, dorsal valve interior, ×3 (Cooper & Grant, 1975).

**Simplicarina** Cooper & Grant, 1975, p. 966 [*S. incompta*; OD]. Small, outline subquadrate with small ears, rounded anterior margin; hinge approximately equal to maximum width; exteriors smooth with variable median sulcus; spines few, one or two on lateral slopes, venter; cardinal process small, bilobate; median septum short; lateral ridges at high angle from hinge, extend as marginal ridge, weak anteriorly, but with endospines. Upper Permian (Roadian): USA.——Fig. 291, 2a–g. *S. incompta*, Permian, Road Canyon Formation, Texas; a–e, holotype viewed ventrally, posteriorly, anteriorly, dorsally, laterally, USNM 153927a, ×1; f, ventral valve viewed posteriorly, ×2; g, dorsal valve interior, ×2 (Cooper & Grant, 1975).

**Tribe PAUCISPINIFERINI**

Muir-Wood & Cooper, 1960

Commonly widest at hinge, with ventral median sulcus; always ribbed, ventral spines

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only; corpus cavity may be deep. *Upper Carboniferous* (Kasimovian)—*Upper Permian* (Tatarian).

**Paucisipinella** Muir-Wood & Cooper, 1960, p. 319 [*P. auriculata*; OD]. Medium size, transverse outline with large ears forming widest part of shell; ribbing most strongly developed in geniculation region, lost at trail margin; rugae absent; about six spines symmetrically placed on ears, flanks, venter, smaller spines in rows separating ears from corpus; cardinal process sessile, broad with zygidium; lateral ridges strong, continued as complete marginal ridge, *upper Lower Permian* (Roadian)—*lower Upper Permian* (Wordsian); southern USA.——Fig. 292, a–e. *P. auriculata*, Permian, Word Formation, Texas; a, holotype viewed anteriorly, posteroventrally, USNM 124054g, X1; c, dorsal valve interior, X1.5 (Muir-Wood & Cooper, 1960); d, e, shell viewed dorsally, laterally, X1 (Cooper & Grant, 1975).

**Anemonaria** Cooper & Grant, 1969, p. 8 [*A. inflata*; OD]; *Marginifera sublaevis* King, 1931, p. 89, *partim*). Subrectangular, ears extended; deeply concavoconvex; sulcus distinct; nearly smooth except for indistinct ribs on trail; spines few, in row on each flank, scattered over venter, visceral disk; ventral interior with small ear baffles; sessile cardinal process with zygidium. *Lower Permian* (Sakmarian—Roadian); USA, north and northeastern China.——Fig. 292, 2a–d. *A. inflata*, Permian, Cathedral Mountain Formation, Texas; a, ventral valve exterior; X1; b, dorsal view of complete specimen, X1; c, d, dorsal valve viewed internally, X2; posteriorly, X4 (Cooper & Grant, 1975).

**Azygidiun** Waterhouse, 1983c, p. 153 [*Horridenta miti Hill, 1950, p. 17; OD]. Similar to *Anemonaria*, but with longer trail, no zygidium, but similarly weak or no ribboning. *Lower Permian*; eastern Australia (Dresden Formation).

**Caricula** Grant, 1976, p. 128 [*C. salebroa*; OD]. Small, transverse, ears extended, geniculate; visceral disks strongly rugose, weakly ribbed, almost lost on trails; sulcus prominent; spines few, up to four across ears, six on venter; cardinal process internally V-shaped, on short shaft; median septum raised anteriorly; lateral ridges extend as low marginal ridges around corpus; brachial ridges prominent. *Lower Permian* (Artinskian); Thailand.——Fig. 293, 1a–e. *C. salebroa*, Artinskian, Ko Muk; a–c, holotype viewed ventrally, dorsally, laterally, USNM 212368, X3; d, e, ventral valve interior, dorsovalve interior, X3 (Grant, 1976).

**Costiferina** Costiferina (Kasimovian)—*Upper Permian* (Tatarian).

**Jiguliconcha** Lazarev, 1990, p. 81 [*Hystriculina gracilicosta Lazarev, 1984, p. 687; OD]. Same as *Hystriculina* but lateral ridges weak, close to hinge. *Upper Carboniferous* (Kasimovian)—*upper Lower Permian*; eastern Europe.——Fig. 293, 5a–d. *J. gracilicosta* (Lazarev). Kasimovian, Moscow basin; a, anteroventral view of ventral valve, X1; b, vental, lateral views of ventral valve, X1; d, dorsovalve interior, median septum broken, X3 (new).
Fig. 292. Productellidae (p. 444).
Lamnimargus Waterhouse, 1975, p. 10 [*Marginifera himalayensis Diener, 1899, p. 39; OD]. Transverse with large ears forming wide hinge line; median sulcus originates near beak; disk reticulate; spines in row near hinge, in row on flanks, plus about two on venter; ventral interior with striated adductor scars; dorsal lateral ridges become complete marginal ridge. upper Lower Permian (Kungurian): Himalayas.
Nepal, Pamirs.——Figs. 293, A–e. *L. himalayensis* (Diener), upper Lower Permian; a, b, lectotype (selected by Waterhouse, 1975) viewed ventrally, laterally, Kashmir, x1; c, ventral view of shell with exfoliated, partially missing ventral valve, Spirit, x1; d, e, external mold of dorsal valve, anteroventral view of shell, Spirit, x1 (Diener, 1899).

**Lampangella** Waterhouse, 1983a, p. 121 [*L. lata; OD*]. Transverse outline with large ears; short ginglymus; ribbing prominent anteriorly; spines in row near hinge, row at ears, sparse on ventral corpus; low ear baffles. Upper Permian (Tatarian); Thailand.—Fig. 294, A–c. *L. lata*, Upper Permian, Hualii Tak Formation, northwestern Thailand; a, holotype, incomplete ventral valve exterior, TBR 441, x2; b, ventral valve exterior, x3; c, dorsal valve external mold, x2 (5; Waterhouse, 1983a).

**Liosotella** Cooper, 1953, p. 36 [*L. rugosa; OD*]. Small to medium size with broad, shallow median sulcus; gently concavoconvex corpus, geniculate, long trails; steep flanks; ribbing strong only on trail; spines in curved rows at base of flanks, scattered variably on rest of valve; zygidium commonly present; dispositions of lateral ridges, extensions across ears variable; one or two rows of strong endospines anterior to well-marked brachial ridges, surfaces tuberculate. upper Lower Permian (Roadian)—lower Upper Permian (lower Kazanian); central, North America, northern and northeastern China.—Fig. 294, 2a–d. *L. rugosa*, Upper Permian, Monos Formation, Sonora, Mexico; holotype viewed posteriorly, anteriorly, dorsally, laterally, USNM 115458, x1 (Muir-Wood & Cooper, 1960).——Fig. 295, 1e–g. *R. perforata*, Permian, Bone Spring Formation, Texas; dorsal valve exterior, interior, x1 (Cooper & Grant, 1975).

**Nudauris** Stehli, 1954, p. 317 [*N. diaboloensis; OD*]. Medium size, weakly concavoconvex profile; ears well developed at widest part of shell; weak ventral sulcus, dorsal fold; ribbing weak to obscure; rugae on both disks; spines in row near hinge, scattered on ventral valve; lateral ridges short, close to hinge; cardinal process tridif, median septum long, thin. Lower Permian (Asioproductus); USA.—Fig. 294, 4a–e. *N. diaboloensis*, Permian, Bone Spring Formation, Texas; a–c, ventral valve viewed ventrally, anteriorly, laterally, x1; d, dorsal valve exterior, x1; e, dorsal valve interior, x1 (Cooper & Grant, 1975).

**Oncosarina** Cooper & Grant, 1969, p. 9 [*O. spinovestita; OD*]. Small, strongly concavoconvex profile with steep flanks; ventral sulcus weak or absent; disk smooth, ribbing originating anteriorly on disks, prominent on trail; spines thick in clusters on anterior ears, thinned on umbonal regions, lateral slopes, crests of costae; dorsal adductor scars on platforms overhanging medianly; cardinal process broad, variably bilobed, quadrifid; lateral ridges extend to separate ears. Lower Permian (Arteinochiria—lower Kangurian); USA.—Fig. 294, 3a–d. *O. spinovestita*, Permian, Skinner Ranch Formation, Texas; a, holotype viewed ventrally, USNM 149824, x2; b, holotype viewed laterally, USNM 149824, x1; c, shell viewed dorsally, x2; d, dorsal valve interior, x3 (Cooper & Grant, 1975).

**Retimarginifera** Waterhouse, 1970, p. 123 [*R. perforata; OD*]. Small, transverse, widest at hinge; profile deeply concavoconvex, deep ventral sulcus; visceral disk reticulate with clear ribbing commonly extending along trail; six major spines, in pairs on ears, venter; sessile, trifid cardinal process; lateral ridges extend as marginal ridge that may be lost anteriorly. Lower Permian (Arteinochiria—Kangurian); Western Australia, Thailand, Himalayas, northern China.—Fig. 295, 1a–d. *R. perforata*, Permian, Byro Group, Western Australia, Carnavon Basin; a, holotype viewed ventrally, U.W.A. 59282, x2; b, ventral valve exterior, x2 (Waterhouse, 1970); c, dorsal valve of shell, x1.5; d, dorsal valve interior, x1.5 (Archbold, 1984).——Fig. 295, 1e–g. *R. celestera* Grant, Permian, Ko Muk, Thailand; c, dorsal view of shell, x1; f, g, shell viewed ventrally, laterally, x1 (Grant, 1976).

**Shanxiproductus** Duan & Li, 1985, p. 232 [*S. shansienensis; OD*]. Resembling Hystriculina, but mediately sulcate, rugose on visceral disks, may form distal spine ridges on ventral trail; ventral internal marginal ridges. Upper Carboniferous (Gzelbian)—Lower Permian (Asioproductus); China.—Fig. 295, 2a–c. *S. shanxiensis*, Asselian, Shanxi; anterior, posterior, lateral views of ventral valve, x2 (Duan & Li, 1985).

**Spinarella** Cooper & Grant, 1975, p. 1058 [*S. perfecta; OD*]. Medium, outline rectangular, but with extended ears; deeply concavoconvex; ribbing low, variable over anterior disks, trails; rugae in posterior region producing varied degree of reticulation; spines in row across ears, scattered widely over ventral valve; ventral adductor scars sunk; cardinal process small, sessile, trifid to quadrifid; median ridge long; brachial ridges strong; inner surface strongly endospinous. upper Lower Permian (Roadian); USA.—Fig. 295, 3a–f. *S. perfecta*, Permian, Road Canyon Formation, Texas; a–c, holotype, viewed ventrally, dorsally, laterally, USNM 148844a, x1; d, ventral valve interior, x1; e, ventral valve viewed posteriorly, x1; f, dorsal valve interior, x1 (Cooper & Grant, 1975).

**Transennatia** Waterhouse, 1975, p. 10 [*Productus gratiosa* Wagner, 1884, p. 691; OD] [*G. gratiosa* Grant, 1976, p. 131, obj.; *Asioproductus chinensis* (Zhan) in Hou, Zhan, & Chen, 1979, p. 85 (type, *A. bellus*; OD); *Kurtomarginifera xu*, 1987, p. 225 (type, *K. spinata*; OD)]. Small, outline subquadrate with small ears; ribs strongly defined, commonly converging into sulcus; rugae strong, producing reticulation on both disks; spines in row separating ears, scattered on disk, trail; cardinal process sessile quadrifid. Lower Permian (Kangurian), upper Permian (Kazanian); Himalayas, Thailand, China, Timor, Western Australia, Greece, Sicily.—Fig. 295, 4a–e. *T. gratiosa* (Wagner), Upper Permian, Wargal Formation, Salt Range, Pakistan; a, b, ventral, dorsal views, x1; c, e, lateral, ventral interior, dorsal interior, x2 (Grant, 1976).——Fig.
Rhynchonelliformea—Strophomenata

Fig. 294. Productellidae (p. 447).
Productida—Productoidea

295, 4fg. *T. insculpta* (Grant) Permian, Ko Muk, Thailand; ventral, dorsal views of shell, ×2 (Grant, 1976).

*Xestosia* Cooper & Grant, 1975, p. 1063 [*X. obsolescens* OD]. Resembling Spinarella, but with clumps of spines on ears, internally with endospines.
Rhynchonelliformea—Strophomenata

Trabe valves, commonly including near hinge, spines sparsely or densely distributed on ventral disk; ornament normally strong, especially rugae; weak or only anteriorly on trails; concentric low to rarely deep anteriorly; ribbing lacking, gently convex; corpus cavity moderately shallow, trail long; ribbing absent or weak, only on trails; rugae or lamellae strongly developed on corpus; ear baffles in dorsal valve, rarely also in ventral valve. Carboniferous (middle Viséan–Bashkirian), ?Upper Carboniferous.

**Subfamily PLICATIFERINAE**

Muir-Wood & Cooper, 1960

Shell geniculated, with ventral disk only gently convex; corpus cavity moderately shallow to rarely deep anteriorly; ribbing lacking, weak or only anteriorly on trails; concentric ornament normally strong, especially rugae; spines sparsely or densely distributed on ventral valves, commonly including near hinge, rarely on both. Upper Devonian (upper Famennian)—Upper Permian (Kazanian).

**Tribe PLICATIFERINI**

Muir-Wood & Cooper, 1960

Corpus cavity moderately deep, trail long; ribbing absent or weak, only on trails; rugae or lamellae strongly developed on corpus; ear baffles in dorsal valve, rarely also in ventral valve. Carboniferous (middle Viséan–Bashkirian), ?Upper Carboniferous.

**Plicatfera** Chao, 1927b, p. 25 [*Productus plicatilis* J. de C. Sowerby, 1824 in 1823–1825, p. 85; OD]. Transverse outline: rugae strongly developed on corpus, ribbing absent or incipient, narrow, may extend over trail; stout spines near hinge, on flanks, few anteriorly, smaller ones scattered on rugae. Lower Carboniferous (middle Viséan–upper Viséan); Eurasia, northern Africa.—Fig. 297,1a–c. *P. plicatilis* (J. de C. Sowerby), Viséan, Derbyshire, British Isles; lectotype, viewed anteroventrally, dorsally, posteriorly, BMNH B 60960, ×2 (new).—Fig. 297,1d–f. *P. pseudoplicatilis* (Muir-Wood, 1928), Aditian, Fermanagh, silicified specimens; d, dorsal valve interior, ×1.5; e, interior of two incomplete articulated valves viewed anteriorly, ×1.5; f, incomplete juvenile ventral valve exterior showing pedicle sheath, arrow, clapping spines, ×10 (Brunton & Mundy, 1993).

**Absenticosta** Lazarev, 1991, p. 58 [*A. uldzejtuensis* Stuur Suren & Lazarev in Lazarev, 1991, p. 58; OD]. Rugae thin, undulose, irregular; spines thin, densely arranged ventrally, dorsal spines few, thicker anteriorly; lateral ridges continue weakly to anterior margin. Lower Carboniferous (middle Viséan, upper Viséan); Transbaikalia, Mongolia.—Fig. 297,4a–d. *A. uldzejtuensis* (Stuur Suren & Lazarev), middle Viséan–upper Viséan, Mongolia; a, b, incomplete shell viewed anteroventrally, posteriorly, ×1.5 (new); c, external mold of dorsal valve, ×1; d, anteroventral view of external mold of dorsal valve, ×1 (Lazarev, 1991).

**Asceptella** Martínez Chacón & Winkler Prins, 1977, p. 18 [*A. asturica*; OD]. Small, up to 14 mm wide, transverse shell; rugae narrow but clear or lamellose, no ribs; ventral spines stout, in two radiating rows on each flank; dorsal interior with strong lateral ridges and ear baffles. Carboniferous (lower Serpukhovian–Bashkirian), Upper Carboniferous: Spain, Argentina, Thailand.—Fig. 297,2a–d. *A. asturica*, lower Bashkirian, Oviedo; a, external mold of ventral valve, ×8.5; b, internal mold of ventral valve, ×4; c, external mold of dorsal valve, ×4; d, internal mold of dorsal valve, ×7 (Martínez Chacón & Winkler Prins, 1977).

**Crossacanthia** Gordon, 1966, p. 580 [*C. perlamellosa*; OD]. Small; rounded shells, no ribbing, con-
centric lamellae on both valves bearing numerous spines, but only anteriorly on dorsal valve; dorsal complete subperipheral ridge. Lower Carboniferous (middle Viséan): USA.—Fig. 298, 2a–e. *C. perlamellosa, middle Viséan, Missouri; a, holotype viewed ventrally, USNM 120637, ×1; b, anteriorly, laterally, USNM 120637, ×2; d, dorsal valve exterior, ×2; e, dorsal valve interior, ×2 (Gordon, 1966).

**Ferganoprocess** Galitskaya, 1977, p. 33 [*Productus ferganensis* Janischewsky, 1918, p. 41; OD]. Rugae narrow, irregular posteriorly, forming some reticulation with spine bases; spines fine covering ventral valve, plus rows near hinge, at flanks, rarely and
thicker on dorsal valve. Carboniferous (upper Visian–Serpukhovian): eastern Europe, Asia.—Fig. 298.1a–d. *F. ferganensis* (JANISCHESKY), Serpukhovian, Kirghizia; a,b, ventral exterior viewed ventrally, posteriorly, ×1; c,d, external mold of dorsal valve viewed dorsally, posteriorly, ×1 (Galitskaya, 1977).

*Platyselma* GORDON, 1966, p. 575 [*P. echinatum*; OD]. Planoconvex with moderately deep corpus cavity; weak lamellae on both valves, spines in weak concentric bands confined to ventral valve (or perhaps fine ones on dorsal valves); strong subperipheral ridges. Lower Carboniferous (middle Visian): southern USA.—Fig. 297.3a–c. *P. echinatum*, middle Visian, Oklahoma; a, incomplete ventral valve exterior, ×2; b, dorsal valve exterior, ×1; c, dorsal valve interior, ×2 (Gordon, 1966).

*Rugoconcha* JIN & SUN, 1981, p. 132 [*Plicatifera chaoi* GRABAU, 1936, p. 171; OD]. Resembles *Plicatifera* but seemingly lacking trails, with rugae covering ventral valve; small cicatrix; ginglymus may be present. Upper Carboniferous (lower Bashkirian): southern China.—Fig. 298.3a–c. *R. chaoi* (GRABAU), lower Bashkirian, Guangxi; a, ventral valve exterior (holotype No. 5384 lost during WWII; neotype, NIGP 48674, held at Nanjing Institute of Geology & Paleontology), ×2; b,c, ventral valve exterior viewed ventrally, posteroventrally, ×1 (Grabau, 1936).

**Tribe LEVIPUSTULINI** Lazarev, 1985

[Dorsal valves with short trails, corpus cavity variable; rugae weak or lacking but spines numerous with pustulose bases, commonly...](https://www.jstor.org/stable/24935990)
Productida—Productoidea

on both valves, but lost dorsally in Permian; marginal structures, peripheral cavities reduced or absent. Lower Carboniferous (upper Viséan)—Lower Permian (Kungurian).

Levipustula Maxwells, 1951, p. 10 [*L. levius; OD]. Gently concavococonch profile, shallow to moderate corpus cavity; pustulose quincuncial spine bases covering ventral valve, spines long, slender, including on ears; lateral ridges short. Carboniferous (Serpukhovian, Bashkirian): Australia, South America.—Fig. 299, 3a–c. *L. levius, a, b, holotype, dorsal valve external mold, latex replica of ventral valve exterior, Moscow, Queensland, UQF 11900a,b, X1.5 (new); c, latex replica of dorsal valve interior, New South Wales, X2 (Muir-Wood & Cooper, 1960).

Bulahdelia Roberts in Roberts, Hunt, & Thompson, 1976, p. 213 [*B. myallensis; OD]. Ventral spine row near hinge, elongate spine bases posteriorly, lacking anteriorly where spines concentrically arranged; dorsal spines anteriorly only on lamellate bands; cardinal process pit present. Lower Carboniferous (upper Viséan): Australia.—Fig. 299, 1a–c. *B. myallensis, upper Viséan, New South Wales; a, holotype, latex replica of ventral valve exterior, AMF 57742, X1.5; b, internal mold of ventral valve interior, X1.5; c, latex replica of dorsal valve exterior, PIN 3979/1, X1; b, ventral valve internal cast, X2; c, dorsal valve external mold, X3; d, dorsal valve internal cast, X3 (Klets, 1983).

Onopordumaria Waterhouse in Bambr & Waterhouse, 1971, p. 205 [*O. punctata; OD]. Poorly known, resembles Levipustula, but has more, thinner ventral spines, swollen dorsal spine bases; dorsal interior with strong endospines anteriorly. Upper Carboniferous (middle Moscovian): Canada.—Fig. 300, 1a–c. *O. punctata, middle Moscovian, Yakutsk; a, holotype, incomplete ventral valve exterior, GSC 26396, X1; b, broken ventral valve internal casts, X1; c, dorsal valve internal cast, X1 (Bamber & Waterhouse, 1971).

Piatnitzkya Taboada, 1993, p. 591 [*P. borrellii; OD]. Small, resembles Jakutoproductus, but lacks concentric rugae, strong rounded spine bases on trail. [The presence of fine ribbing would place this genus in the Auriculipinacea]. Lower Permian (Asterian): Argentina.—Fig. 300, 4a–d. *P. borrellii, Permian, Rio Genoa Formation, Chubut Province; a, ventral valve exterior, X1.5; b, dorsal valve external mold, X2; c, latex replicas of dorsal valve interiors, X1.5 (Taboada, 1993).

Verchojania Abramov, 1970, p. 112 [*jakutoproductus chersakowii Kaschirtev, 1959, p. 30; OD]. Similar to Jakutoproductus but without dorsal spines, with weakly developed or lacking concentric rugae; ventral sulcus variable. Upper Carboniferous (Bashkirian–Moscovian): northern Asia.—Fig. 300, 3a–c. *V. chersakowii (Kaschirtev), Bashkirtian–Moscovian, Yakuts; a, b, internal mold of ventral valve viewed ventrally, anterolaterally, X1 (new); c, ventral shell, shell missing umbionally, viewed posteriorly, X1 (Abramov, 1970).

Tribe LEVITUSHNII
Muir-Wood & Cooper, 1960

Relatively large shells with long trails, moderate to deep corpus cavities; ribbing absent or weak fine radial striations; rugae, spines weak, sparsely developed; spine row anterior to ears, commonly a ventral median row on weak ridge; weak cardinal ridges, no marginal ridges. Lower Carboniferous (Tournaissian–upper Viséan).
Fig. 299. Productellidae (p. 453).
**Levitusia** Muir-Wood & Cooper, 1960, p. 295

[*Productus humerosus* J. Sowerby, 1822 in 1821–1822, p. 21; OD; *P. christiani* de Koninck, 1847a, p. 274]. Commonly large with thick walled ventral valve, trail long, spreading; fine radial ornament on some species, may also have median ridge with...
spines; corpus cavity shallow; ventral brachial pits in some species. Lower Carboniferous (Viséan): Europe, Ural Mountains, Middle Asia (Kirghizia).—Fig. 302a–f. *L. humerosa* (J. Sowerby); a, b, holotype, ventral valve internal mold viewed anteriorly, laterally, lower Viséan, Derbyshire, British Isles, BMNH B 60959; c, d, ventral valve exterior viewed anteriorly, laterally, Staffordshire, X0.75 (Brunton, 1979); e, dorsal valve interior, Staffordshire, X1; f, ventral valve exterior viewed posteroventrally, Visé, Belgium, X1 (Muir-Wood & Cooper, 1960).—Fig. 302g. Specimen called *P. christiani* by de Koninck; detail anteromedianly, showing median spines, fine radial ornament, Visé, Belgium, UPS D812, X2.5 (Brunton, 1979).

**Acanthoplecta** Muir-Wood & Cooper, 1960, p. 170 [*Producta mesoloba* Phillips, 1836, p. 215; OD]. Medium sized, around 30 mm wide; concavo-convex with long trails, may have gutter; commonly weak median fold bearing spines, dorsal sulcus; other spines scattered; body cavity shallow to deep. Lower Carboniferous (Viséan): Eurasia, northern Africa.—Fig. 303, a–f. *A. mesoloba* (Phillips); a, lectotype, ventral valve exterior viewed anteriorly, Ashian, Yorkshire, BMNH B427; X1.5; b, lectotype, ventral valve exterior viewed anterolaterally, Ashian, Yorkshire, X1; c, ventral valve exterior viewed posteriorly, Ashian, Yorkshire, X1 (new); d, complete shell viewed dorsally, Ashian, Yorkshire, X1 (Muir-Wood & Cooper, 1960); e, f, silicified dorsal valve with gutter viewed ventrally, laterally, Fermanagh, X1.25 (Brunton, 1966).

**Admodorus** Brunton & Mundy, 1993, p. 111 [*A. cracensis*; OD]. Small to medium sized; prominent rugae covering entire valves, no ribbing; larger spines in rows near hinge and medially. Lower Carboniferous (Ashian): western Europe.—Fig. 303, 2a–c. *A. cracensis*; a, b, holotype, shell with broken ventral valve, showing some of dorsal valve, viewed ventrally, posteriorly, Ashian, Yorkshire, BMNH BD 2447; X2; c, oblique view of shell with ventral trail missing, Staffordshire, X2; d, anterolateral view of complete ventral valve, Staffordshire, X2; e, anterior view of ventral valve showing median spines, Staffordshire, X2 (Brunton & Mundy, 1993).

**Geniculifera** Muir-Wood & Cooper, 1960, p. 187 [*Avonia boonensis* Branson, 1938, p. 40; OD]. Small, around 12 mm wide; planoconvex, deep corpus plus simple trails; rugae posteriorly on disks, trails smooth; spines few, scattered on ventral valve. Lower Carboniferous (Hastarian–Viséan): North America, Europe.—Fig. 304, 1a–d. *G. boonensis* (Branson), Hastarian, New Mexico; a–c, ventral valve exterior viewed ventrally, posteriorly, laterally, X2; d, dorsal valve interior, X3 (Muir-Wood & Cooper, 1960).—Fig. 304, 1e. *G. keyserlingiana* (de Koninck), Viséan, Visé, Belgium; latex replica of dorsal valve interior, X3.5 (Brunton & Mundy, 1993).

**Kadraliproductus** Galitskaya, 1977, p. 36 [*Productus (Plicatifer) kadralensis* Gladtczchenko, 1955, p. 15; OD]. Posterior nodose reticulation of persistent median ribbing with rugae; spines at hinge, scattered ventrally, corpus deep. Lower Carboniferous (upper Tournaisian): Kirghizia, western Europe.—Fig. 303, 3a–d. *K. kadralensis* (Gladtczchenko), upper Tournaisian, Kirghizia; a, b, holotype, ventral valve viewed posteroventrally, anteriorly, Inst. Geol. 8113; X1; c, complete ventral valve viewed laterally, X1; d, shell with part of ventral valve missing, viewed anteriorly showing deep corpus, X1 (Galitskaya, 1977).

**Spinorugifera** Roberts, 1976, p. 50 [*S. chichisterensis*; OD]. Small; gently concavoconvex profile without clear trails; entirely rugose, slightly lamellose ventrally, spines near hinge, scattered on ventral rugae, spines commonly lacking dorsally, lateral ridges short. Lower Carboniferous (upper Viséan): Australia.—Fig. 304, 2a–d. *S. chichisterensis*, upper Viséan, New South Wales; a, b, holotype, latex replicas of ventral valve exterior, dorsal valve exterior, AMF 37025a,b, X2; c, d, latex replicas of dorsal valve exterior, interior, X2 (Roberts, 1976).
Fig. 302. Productellidae (p. 455–456).
Fig. 303. Productellidae (p. 456).
Tribe RUGAURINI Lazev, 1990

Corpus cavity shallow; trail absent or very short; no ribbing, dense spines covering ventral valve, rarely on dorsal valves anteriorly; teeth in oldest taxa; no ear baffles or submarginal ridges. Upper Devonian (upper Famennian)—Lower Carboniferous (upper Viséan).

Rugauris Muir-Wood & Cooper, 1960, p. 193 [*R. paucispina; OD]. Medium size; semicircular outline, gently concave-convex profile; rugae numerous, narrow, covering disks; fine low-angled spines cover ventral valve; dorsal valve dimpled, few spines; lateral ridges subparallel to hinge. Lower Carboniferous (Hastarian): USA, Russia, eastern Australia, Canada, ?San Salvador.—Fig. 305, 1a–f. *R. paucispina, Hastarian, Iowa; a–d, holotype, ventral, anterior, posterior, lateral views of ventral valve, USNM 79477a, ×1; e, replica of dorsal valve exterior, ×1; f, dorsal valve interior, ×1 (Muir-Wood & Cooper, 1960).

Carringtonia Brunton & Mundy, 1986, p. 2 [*Productus carringtoniaw DAVISON, 1863, p. 274; OD]. Transverse, markedly but irregularly rugose, ventral spines only, at hinge, widely on rugae. Lower Carboniferous (upper Viséan): western Europe.—Fig. 305, 2a–d. *C. carringtoniana (DAVISON); a, lectotype, ventral valve exterior, Asbian, Staffordshire, BMNH B 5743, ×1; b, external mold of dorsal valve showing dimples of ventral hinge spines, Asbian, Staffordshire, ×1.5; c,d, posterolateral, dorsal views of shell, Yorkshire, ×1.5 (new).

Iniproductus Lazev, 1990, p. 88 [*Postula sinica SARUTCHEVA in BEZNOSSOVA & others, 1962, p. 151; OD]. Resembles Rugauris, but larger, rugae less regular, no dorsal spines; two or three rows of thicker spines near hinge, elongate quincuncial spine bases except on trails where spine bases small, concentric; cardinal ridges short. Upper Devonian (upper Famennian): Russia.—Fig. 306a–e. *I.
Fig. 305. Productellidae (p. 459–461).

Rhyynchonelliformea—Strophomenata

Jinicus (Sarytcheva), upper Famennian, Kuzbass;

a, b, ventral, lateral views of ventral valve, ×1; c, dorsal exterior of incomplete shell, ×1; d, spines extending from near lateral margin of ventral valve, ×2.5; e, incomplete dorsal valve interior, ×1 (Sarytcheva & others, 1963).

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Orbinaria Muir-Wood & Cooper, 1960, p. 149
[*Productella pyxidata Hall, 1858a, p. 498; OD].
Weakly concavoconvex profile; concentric ornament, especially on dorsal valve; dorsal spines sparse, fine; ventral spines with slight pustules; teeth minute; dorsal interior with strongly papillose subperipheral ridge. *Upper Devonian (Upper Famennian), Lower Carboniferous (?Hastarian): North America, Europe, Northern Africa.—Fig.: 305, 3a–e. *O. pyxidata (Hall), upper Famennian, possibly to lower Hastarian, Louisiana Limestone, Missouri; a, ventral valve exterior, ×2; b, c, lateral view, dorsal view of shell, ×2; d, e, ventral valve interior, dorsal valve interior, ×2 (Muir-Wood & Cooper, 1960).

Planoproductus Stainbrook, 1947, p. 310
[*Productella hillbornensis Kindle, 1909, p. 19; OD]. Medium sized; rugae weak ventrally, stronger dorsally; spines on ventral valve only; fine, numerous with short ridges; lateral ridges short, divergent. *Upper Devonian (Upper Famennian): southern USA, France, Japan.—Fig.: 305, 3a–c. *P. hillbornensis (Kindle), uppermost Famennian, New Mexico; a, b, ventral valve exterior viewed ventrally, laterally, ×1; c, detail of ornament, ×2; d, dorsal valve exterior, ×1; e, posterior region of dorsal valve interior, ×4 (Muir-Wood & Cooper, 1960).

Tribe SEMICOSTELLINI
Nalivkin, 1979
[nom. transl. Brunton, Lazarev, & Grant, 1995, p. 927, ex Semicostellinae Nalivkin, 1979, p. 67]
Corpus cavity deep; costae on long trails; lateral, marginal ridges commonly well developed in both valves. *Lower Carboniferous (Tournaissian)—Upper Permian (Kazanian).

Semicostella Muir-Wood & Cooper, 1960, p. 195
[*Avonia oklahomensis Snyder, 1915, p. 83; OD]. Rugae weak, with elongated spine bases on ventral disk, clear ribs anteriorly, spines in row on flanks; dorsal valve rugose, sparsely spinose, geniculate with clear ribs on trail; divergent lateral ridges, marginal structures. *Lower Carboniferous (Upper Viséan—lower Serpukhovian): southern USA, Ural Mountains, northern Asia.—Fig.: 307, 1a–c. *S. oklahomensis (Snyder), upper Viséan—lower Serpukhovian, Oklahoma; a–c, ventral valve viewed ventrally, posteriorly, laterally, ×1; d, shell viewed dorsally, ×1; e, dorsal valve interior, ×2 (Muir-Wood & Cooper, 1960).

Cinctifera Muir-Wood & Cooper, 1960, p. 165
[*Productus medusa de Koninck, 1842, p. 166;
OD]. Ventral valve disk flattened, ribbing complete, other than beaks; cinctures especially at margin of disk, spinose outgrowths from ventral valve margin. Lower Carboniferous (Viséan): Europe.——Fig. 307, 2a–g. *C. medusa (de Koninck); a–c, shell viewed ventrally, dorsally, ventral valve viewed later-
Fig. 308. Productellidae (p. 463–464).
ventral lateral and marginal ridges weak; dorsal cardinal ridges continue as ear baffles, weak submarginal ridges; adductor scars raised with medially curving crests. Upper Carboniferous: Arctic Russia.—Fig. 307.3a–c. *M. chaykensis*, upper Bashkirian–lower Kasimovian, Yugorsky Peninsula, Mongolia; a, holotype, viewed ventrally, PIN N2802/1168, ×1; b, ventral valve exterior, ×1; c, dorsal valve exterior, ×2 (Brunton & Lazarev, 1997).—Fig. 307.3d. *M. nana* Lazarev, upper Moscovian–lower Kasimovian; dorsal valve internal mold, ×2 (Brunton & Lazarev, 1997).

*Overtoniina* Grunt in Grunt & Dmitriev, 1973, p. 94 [*O. mamazairica*; OD]. Small, planoconvex corpus with geniculation to trails; ventral disk weakly but densely rugose, with rounded spine bases; trail with broad ribs; lateral ridges, median septum short; adductor platforms overhang anteromedianly. Lower Permian (Artinskian): Pamir, Afghanistan.—Fig. 308.1a–d. *O. mamazairica*, Artinskian, southeastern Pamir; a–b, holotype, internal mold viewed ventrally, dorsally, PIN 2228/590, ×1; c, d, specimen viewed ventrally, laterally, ×1 (Grunt & Dmitriev, 1973).

*Pharcidodiscus* Roberts, 1976, p. 46 [*P. boulderensis*; OD]. Rugae, ribbing weaker than *Semicostella*, ears prominent, corpus cavity moderately deep; spine rows just anterior to hinge; cardinal ridges, but ear baffles absent. Lower Carboniferous (upper Tournaisian): Australia.—Fig. 309a–c. *P. boulderensis*, upper Tournaisian, Queensland; a, holotype, latex replica of dorsal valve interior, GSQ F10269, ×1.5; b, latex replica of posterior region of ventral valve exterior, ×1.5; c, latex replica of anterior region of ventral valve exterior, ×1.5; d, latex replica of dorsal valve exterior, ×1.5; e, latex replica of dorsal valve interior, ×2 (Roberts, 1976).

*Rhytiophora* Muir-Wood & Cooper, 1960, p. 192 [*Productus blairi* Miller, 1891, p. 689; OD]. Subquadrate outline; rugae irregular, weak ventromedially, trail short, ribbed; spine ridges ventrally, especially anteriorly; spines numerous, dorsally only anteriorly; lateral ridges extend to separate ears from corpus. Lower Carboniferous (middle Hastarian): USA, Central America, northwestern Australia, central China.—Fig. 307.4a–d. *R. blairi* Miller, middle Hastarian, Missouri; a–c, ventral, dorsal, lateral views of shell, ×1; d, half of dorsal valve interior completed by mirror image, ×2 (Muir-Wood & Cooper, 1960).

*Spinosteges* Liang, 1990, p. 155[461] [*S. sinensis*; OD]. Small, outline subquadrate with hinge slightly less than maximum width; ventral disk flattened, trail sulcate; elongate spine bases on ventral disk, relatively fine ribbing on trail; dorsal valve interiors unknown. Upper Permian (Kazanian): China.—Fig. 308.2a,b. *S. sinensis*, Permian, Lengwu Formation, Zhejiang; anteroventral, lateral views, ×2 (Liang, 1990).

*Trib* YAKOVLEVIIIN* Waterhouse, 1975

Commonly medium sized with thick-shelled ventral valve, moderately deep corpus
cavity, becoming shallow in younger genera; ribbing on trails and all but posterior regions of corpus, commonly with four to six thick ventral spines; common trend to reduce ear cavities and extend anterior peripheral cavity. Lower Carboniferous (upper Viséan)—Upper Permian (Kazanian).

**Yakovlevia** Freidricks, 1925, p. 7 [*Y. kaluzinensis*; OD] [=Muirwoodia Licharew, 1947, p. 188, partim (type, *Productus mammatus* Keyserling, 1846, p. 206; OD)]. Medium to large, outline pentagonal to subquadrate; ventral profile with flattened disk, strong geniculation, long trail; corpus cavity shallow; commonly median sulcus, starting posteriorly on disk; ribbing fine, weak; spines in rows of increasing size near hinge, plus few others, commonly four symmetrically placed; muscle fields strongly impressed; cardinal process sessile, broad; lateral ridges close to hinge, strongly angled separating small ears; anterior disk thickened or with endospines. Lower Permian (Sakmarian)—Upper Permian (Kazanian); Siberia, Arctic regions, Mongolia, China, Japan, USA.—Fig. 310,1a. *Y. kaluzinensis*, upper Lower Permian, eastern Siberia; ventral valve internal mold, ×0.7 (Wiman, 1914).—Fig. 310,1b,c. *Y. mammata* (Keyserling), LowerPermian, northern Russia; ventral valve viewed ventrally, anteriorly, ×1 (Licharew, 1947).—Fig. 310,1d,e. *Y. multistriata* (Meeke), Lower Permian, Texas; d, ventral valve exterior, ×1; e, dorsal valve interior, ×2 (Licharew, 1947).

**Duartea** Mendes, 1959, p. 58 [*Productus batesianus* Derby, 1874, p. 54; OD] [=Muirwoodia Licharew, 1947, p. 188, partim; Paramuirwoodia Zhang in Zhang & others, 1983, p. 298]. Resembles

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Fig. 310. Productellidae (p. 465–467).
Rhynchonelliformea—Strophomenata

Yakovlevia externally, but moderately deep corpus; spines in weak row separating ears, slight posterior tecturation, ribs become weak anteriorly. Upper Carboniferous: South America, Eurasia.——Fig. 310,3a–d. *D. bateriana (Derby), lower part of Upper Carboniferous, Para Province, Brazil; a,b, shell viewed posteriorly, dorsally, ×1.5; c, ventral valve exterior, ×1; d, lateral view of ventral valve, ×1 (Mendes, 1959).

Inflatia Muir-Wood & Cooper, 1960, p. 226 [*Productus inflatus Mc Chesney, 1860, p. 40; OD] [=Adairia Gordón, Henry, & Trewoy, 1993, p. 20 (type, A. adairensis Drake, 1897, p. 402)]. Outline somewhat elongate with long trail, corpus deep; spines in row diverging from hinge, sparsely covering valve, especially anteriorly; dorsal valve strongly geniculate, no series of trails; ventral muscle fields strongly differentiated; dorsal interior thickened marginally. Lower Carboniferous (upper Viséan)—Upper Carboniferous (lower Bashkirian): North America, Asia, Australia.——Fig. 311,1a–g. *I. inflata (Mc Chesney), upper Viséan, Oklahoma; a–c, complete shell viewed ventrally, dorsally, laterally, ×1 (Gordon, Henry, & Trewoy, 1993); d, ventral valve exterior viewed posteriorly, ×2 (Muir-Wood & Cooper, 1960); e, ventral valve interior, ×1.5; f, dorsal valve interior, ×1.5; g, median section of shell showing corpus cavity, ×1 (Gordon, Henry, & Trewoy, 1993).

Sajakella Nasikanova in Sarytcheva, 1968, p. 141 [*S. formosa; OD]. Small to medium; closely resembling Inflatia, but ears more prominent, ribbing commonly finer, trail spines thicker, cardinal process supported by ridges connecting to adductor scars. Lower Carboniferous (upper Viséan)—Upper Carboniferous (Bashkirian): Boreal Asia.——Fig. 311,2a–d. *S. formosa, Bashkirian, Keregetassk Series, Kazakhstan; a, holotype, ventral valve exterior viewed anteriorly, PIN 1506/88, ×1; b, ventral valve viewed laterally, ×1; c, ventral valve internal cast, ×1; d, incomplete dorsal valve interior, ×1 (Sarytcheva, 1968).——Fig. 311,2e. *S. dehiscentu-
**Productida—Productoidea**

*Lioliimenna* Lazarev, upper Viséan, Gobi Altai, Mongolia; ventral valve exterior, X1 (Lazarev & Suur'suren, 1992).

*Tenaspinus* Brunt & Mund, 1994, p. 120 [*T. smarti* (OD)]. Small, rounded elliptical outline with well-differentiated ears; ribbing starts close to umbo, widens anteriorly, disks reticulate; clasping spines at hinge, anterior ear margins, sparsely scattered on ventral disk. Lower Carboniferous (upper Viséan): British Isles.——Fig. 310.2a–d. *T. smarti*; a,b, holotype, corpus plus part of one ear viewed ventrally, dorsally, Adryan, Yorkshire, BMNH BD 9544, X2; c, lateral view of a shell with part of ventral valve missing to show corpus depth (arrow), Derbyshire, X2; d, ventral view of shell clasping crinoid columnal (arrow), Derbyshire, X3 (Brunt & Mund, 1994).

**Subfamily UNCERTAIN**

*Lioliimenna* Li Li in Ding, 1989, p. 155[184] [*L. spanoptycha* (OD)]. Resembles small Rhytibulus, elongates oval outline with hinge less than maximum width; rugae fine, slightly increasingly separated anteriorly toward nonrugose margin; spines at hinge and scattered from rugae on ventral valve; dorsal valve and interiors unknown. Lower Permian: China.——Fig. 312a. *L. spanoptycha*, Lower Permian, Quinling; ventral valve, X3 (Ding & others, 1991).——Fig. 312b. *L. polypytcha*; ventral valve, X3 (Ding & others, 1991).

**Family PRODUCTIDAE** Gray, 1840

[Productidae Gray, 1840, p. 151]

Deep corpus cavity; spine row(s) near hinge; teeth only in oldest genera. **Upper Devonian (Famennian)—Upper Permian (Tatarian).**

**Subfamily PRODUCTINAE** Gray, 1840

[nom. nov. Brunt, 1989, p. 928, ex Productidae Gray, 1840, p. 151, partim]

Small to medium size; profile geniculate with trails long, may have bordering structures; ribbing entire, reticulate posteriorly; spines commonly only on ventral valve; marginal structures well developed, including ear baffles. Lower Carboniferous (lower Viséan)—Lower Permian.

**Tribe PRODUCTINI** Gray, 1840

[nom. nov. Brunt, 1989, p. 928, ex Productidae Gray, 1840, p. 151, partim]

Ribbing relatively fine; spines thin, numerous on ears; diaphragm associated with series of dorsal trails; dorsal adductor scars may be raised on platforms. Lower Carboniferous (Viséan)—Upper Carboniferous (Moscovian).

**Productus** J. Sowery, 1814 in 1812–1815, p. 153 [*Anomites productus* Martin, 1809, p. 9 (validated ICZN, 1956a, Opinion 419, p. 75); OD] [*Productus Convrel & Phillips, 1822, p. 357; Protonia Link, 1830, p. 449, non Rainesque, 1814, obj.; Pyxys von Chemnitz, 1784, p. 301, nonbinomial]; Hubeiproductus Yang Deli, 1984, p. 229[331] (type, H. guanyinyanensis; OD)]. Medium size; corpus deep, ventral trail long, spreading; dorsal valve geniculated, dorsal diaphragm restricted to one third anteriorly; dorsal cardinal ribs tend to diverge as lateral ribs, becoming subperipheral ridge, adductor scars slightly raised. Carboniferous (upper Viséan–Serpukhovian, ?Bashkirian): Eurasia, northern Africa, southern China, North America.——Fig. 313.1a–e. *P. productus* (Martin), upper Viséan, Derbyshire; a–d, complete holotype, ventral, lateral views, BMNH B 40952, dorsal, posterior views of detached corpus region, X1; e, anterior view of ventral valve, X1 (new).——Fig. 313.1f. P. carbonarius (de Koninck), lower Serpukhovian, Yorkshire; latex replica of dorsal valve interior, X2 (Muir-Wood & Cooper, 1960).

**Carlinia** Gordon, 1971, p. 258 [*Productus phillipsi* Norwood & Pratten, 1855a, p. 8; OD]. Resembles Diaphagnamus, but short trails, lacks strong reticulation posteriorly, ribbing commonly coarse; spines on ears, lacking clumps on flanks; wide zone of diaphragms. Lower Carboniferous (lower Serpukhovian): North America.——Fig. 313.3a–e. *C. phillipsi* (Norwood & Pratten), upper Chesterian, Utah; a,b, ventral, lateral views of specimens, X1; c, dorsal view of shell, X1; d, posterior view of ventral valve, X1.5; e, dorsal valve interior, X1 (Gordon, 1971).

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Fig. 313. Productidae (p. 467–469).
Companteris Lazarev, 1981, p. 79 [*C. aljutovensis; OD]. Small size; dorsal diaphragm with two trails; dorsal adductor scar platforms overhang laterally. Upper Carboniferous (upper Bashkirian–lower Moscovian): eastern Europe.—Fig. 313a–c. *C. aljutovensis, upper Bashkirian–lower Moscovian, Moscow Basin; a, b, ventral, lateral views of ventral valve, X1; c, ventral valve exterior with cardinal extremity, spine bases preserved, X2; d, dorsal valve exterior showing the ornament, microornament of diaphragm with traces of fragmented trails, X5; e, dorsal valve interior, X1 (Lazarev, 1981).

Diaphragmus Gryty, 1910, p. 217 [*Productus elegans Norwood & Pratten, 1855a, p. 13, non McCoy, 1884; OD; *=Productus cestriensis Worthen, 1860, p. 570]. Resembles Productus, but with series of dorsal diaphragms, trails leaving short flat external dorsal disk. Lower Carboniferous (upper Viséan–lower Serpukhovian): North America.—Fig. 314a–f. *P. elegans (Norwood & Pratten), upper Viséan–lower Serpukhovian; a, ventral view of ventral valve, Oklahoma, X1; b, c, dorsal, lateral views of complete specimen, Oklahoma, X1; d, spine bases on flank, Oklahoma, X2; e, longitudinal section of specimen showing two diaphragms, two successive dorsal trails, Oklahoma, X2; f, dorsal valve interior, Illinois, X4 (Muir-Wood & Cooper, 1960).

Dowhatania Waterhouse in Waterhouse & Gupta, 1979, p. 127 [*Productus doubatensis Diener, 1915, p. 27; OD] [=Pentactonita Yang & Zhang, 1982, p. 304 (type, P. kongjigenensis; OD); Shishapangmaella Yang in Yang & Fan, 1983, p. 273 (type, S. shishapangmensis; OD); obj.]. Poorly known; medium size; numerous fine spines, especially on ventral ears, flanks, absent dorsally; possibly with dorsal diaphragms; cardinal ridges. Lower Carboniferous (Viséan), Upper Carboniferous (Moscovian): Himalayas, ?China.—Fig. 314a–c. *D. doubatensis (Diener), ?Bashkirian, Kashmir; a, ventral valve exterior with fringing spines, X1; b, dorsal valve exterior, X1; c, incomplete dorsal valve interior, X1 (Diener, 1915).

Lopasnia Ilkhypsky in Lazarev, 1990, p. 103 [*Thomasina (?) adhaerescens Ivanov in Ivanov, 1935, p. 112; OD]. Small to medium size; outline rather transverse; ribbing strong, coarse anteriorly; two dorsal trails, short diaphragm; cardinal process supported by adductor ridges. Upper Carboniferous (Moscovian): Russia.—Fig. 314a,b.c. *L. adhaerescens (Ivanov), Moscovian, Moscow basin; a, ventral view of ventral valve, X2 (Ivanov, 1935); b, exfoliated dorsal valve exterior showing adductor ridges, X3 (new).

?Marginirina Sutton, 1938, p. 559 [*Productus magnus Meek & Worthen, 1862, p. 142; OD]. Large; weakly plano- to concavoconvex lateral profile with short trails, moderate to deep corpus; fine ribbing entire, rugae posterolaterally, no reticulation; spines only ventrally, thick row close to hinge, posteriorly directed, fine spines sparse on corpus; cardinal process trifid, lateral ridges continue as weak subterminal rim. Lower Carboniferous (lower Viséan): central North America.—Fig. 315a–f. *M. magnus (Meek & Worthen), lower Viséan; a, b, posterior, lateral views of ventral valve, Illinois, X1; c, posterior view of dorsal valve showing cardinal process, Illinois, X1; d, posteroventral view of ventral valve interior, Illinois, X1; e, f, dorsal valve interior, ventral view of ventral valve, Oklahoma, X1 (Muir-Wood & Cooper, 1960).

Spines variable, but may include few thick halteroid spines; zygidium may be present; marginal ridges associated with series of many dorsal trails. Lower Carboniferous (Viséan–lower Permian) (?Bashkirian–lower Sakmarian).

Kozlowska Fredericks, 1933, p. 29 [*Productus capaci d’Orbigny, 1842, p. 50; OD]. Small, outline transverse with well-developed ears forming widest part of shell; planoconvex corpus, commonly with reticulate disks; ribbing may disappear anteriorly; spines variable from few, thick, and symmetrically arranged to more numerous scattered spines; zygidium present; endospines in single row at anterior margin of disk. Upper Carboniferous (Bashkirian–lower Permian) (?Sakmarian): cosmopolitan.—Fig. 316a–f. *K. capaci (d’Orbigny), lower Permian, Capinota, Bolivia; a, b, ventral valve posteriorly, laterally, X2; c, ventral valve interior, X2 (Muir-Wood & Cooper, 1960).—Fig. 316g–i. *K. splendens (Norwood & Pratten), Upper Carboniferous, Magdalena Formation, New Mexico; d, dorsal view, X1; e, anteroventral view, X2; f, dorsal valve interior, X2 (Muir-Wood & Cooper, 1960).

Eomarginifera Muir-Wood, 1930, p. 103 [*Productus longispina J. Sowerby, 1814 in 1812–1815, p. 154; OD] [=Lisomarginifera Lane, 1962, p. 901 (type, L. nuda; OD)]. Small, around 15 mm wide; ears small, zygidium absent; six symmetrical, stout spines; commonly weak median sulcus; dorsal submarginal ridges weak anteriorly, absent ventrally. Lower Carboniferous (Viséan–lower Serpukhovian); ?Upper Carboniferous (lower Moscovian): Eurasia, northern Africa, ?North America.—Fig. 316a–d. *E. longispina (J. Sowerby), upper Viséan, Ayrshire, Scotland; ventral, dorsal, lateral, posterior views of complete specimen, X2 (new).—Fig. 316e,f. *E. lobata (J. Sowerby); c, internal mold of ventral valve, Pendleian, Northumberland, British Isles, X2; f, dorsal valve interior, Brigantian, X2 (new).

Minispina Waterhouse, 1982a, p. 45 [*M. alata; OD]. Similar to Kozlowska, possibly differing by

Tribe KOZLOWSKIINI
Brunton, Lazarev, & Grant, 1995

[Kozlowskini Brunton, Lazarev, & Grant, 1995, p. 928]
having no dorsal trails. *Upper Carboniferous* (Kasimovian–Gzhelian): southeastern Asia.—Fig. 316, 1a–c. *M. alata*, upper Upper Carboniferous, northeastern Thailand; a, ventral valve exterior, ×2.2; b, ventral valve internal mold, ×3.5; c, dorsal valve internal mold, ×3 (Waterhouse, 1982a).
Fig. 315. Productidae (p. 469).
Trail nonlamellose, may be tubiform; row of thick spines at base of ventral flank, sparse or absent from dorsal valves; dorsal adductor scars commonly positioned relatively anteriorly, with pitted, tuberculate surface ornamentation in ventral umbo. Lower Carboniferous (lower Viséan)–Lower Permian.

Kutorginella Ivanova, 1951, p. 329 [*K. mosquensis; OD] [=Retaria Muir-Wood & Cooper, 1960, p. 230 (type, R. umbonata; OD); Neoproboscidiella Ivanova, 1949, nom. nud.; Calliomarginatia Cheng in Zhang & Cheng, 1976, p. 181 (type, C. hima- layensis; OD); Aspinosella Waterhouse, 1982a, p. 47 (type, Kutorginella uddeni Cooper & Grant, 1975, p. 1029; OD)]. Ventral median sulcus prominent, may form extended (nasute) trail medianly; ears large, almost flat; cardinal or lateral ridges continuous with ear baffles, extending as endospinous marginal ridge. [A Retaria group of species with widely divergent lateral ridges, poorly differentiated from ear baffles, may be separable from the mosquensis group of species with cardinal or lateral ridges close to the hinge line]. Upper Carboniferous (Kasimovian)–Lower Permian: eastern Europe, middle Asia, North America, China.——Fig. 317, 1a–d. *K. mosquensis, Kasimovian–Gzhelian, Moscow Basin; a, anterior view of specimen lacking nasute trail, \( \times 1 \); b, ventroanterior view of specimen showing nasute trail, \( \times 1 \) (Muir-Wood & Cooper, 1960); c, posterior view of ventral valve, \( \times 1.2 \); d, dorsal valve interior, \( \times 1.5 \) (Sarytcheva, 1971).——Fig. 317, 1e,f. K. umbonata (Muir-Wood & Cooper), Leonardian, Texas; e, lateral view of shell, \( \times 1 \); f, dorsal valve interior, \( \times 1.5 \) (Muir-Wood & Cooper, 1960).

Antiquatonia Miloradovich, 1945, p. 496 [*Productus antiquatus J. Sowerby, 1821 in 1821–1822, p. 15; OD]. Ventral spine ridge flanking ears with internal complimentary lateral ridges; ventral spines thick, halteroid. Carboniferous (Viséan–Serpukhovian); cosmopolitan.——Fig. 317, 2a,b. *A. antiquata (J. Sowerby), Viséan, Derbyshire; lectotype selected by Muir-Wood, 1928, anterior, lateral views of specimen lacking ears, BMNH B 60956, \( \times 1 \) (new).——Fig. 317, 2c–f. A. hindii (Muir-Wood), lower Brigantian, Derbyshire; c,d, holotype, posterior, lateral views, BMNH B 47860, \( \times 1 \) (Muir-Wood, 1928); e,f, posterior view, showing part of internal mold, oblique lateral view of ventral valve, \( \times 1 \) (new).

Kelamelia Zhang Zixin in Zhang & others, 1983, p. 305 [*K. typica; OD]. Poorly known; ventral spines
at hinge, flank to ear junction; lateral ridges short, slightly divergent, not extended as ear baffles. Upper Carboniferous (Moscovian): northern China.

Fig. 317. Productidae (p. 472–475).

—Fig. 318. 1a–d. *K. typica*, Moscovian, Xinjiang; anterior, dorsal, lateral, posterior views of complete specimen, ×1 (Zhang & others, 1983).
Keokukia CARTER, 1990, p. 229 [*K. sulcata; OD].
Medium size; ears small, pointed; spine row diverges slightly from ventral hinge, others on flanks, trail, no dorsal spines; lateral ridges close to hinge, no marginal ridges. Lower Carboniferous (lower Viséan): central North America.——Fig. 318, 3a–e. *K. sulcata, lower Viséan, Illinois; a–d, holotype, ventral, anterior, posterior, lateral views, CMNH 34891. 3b; e, dorsal valve interior, ×1.5 (Carter, 1990).

Marginoproductus TAN ZHEN-XIU, 1986, p. 435[443] [*M. hunanensis; OD]. Small to medium sized, around 20 mm wide; deep corpus with long trail; dorsal spines reportedly absent, but if present should be assigned to the Tolmatchoffitae; closely resembles Marginatia. Lower Carboniferous (lower
Tuaria.—Fig. 317, 3a–e. *M. huanensis,* lower Viséan, Hunan; a, holotype, posterior view, HB 318, X1; b, c, anterior, lateral views of ventral valve, X1; d, dorsal valve exterior, X1; e, dorsal valve interior, X1 (Tan, 1986).

Promarginifera SHELLS, 1966, p. 428 [*P. tvearnensis* (OD)]. Small; corpus deep, eyes well differentiated, trail simple; spines numerous, covering ventral valve, few and fine dorsally; lateral ridges close to hinge. Lower Carboniferous (upper Viséan); British Isles.—Fig. 318, 2a–e. *P. tvearnensis,* Abadian, Ayrshire; a–c, holotype, ventral, dorsal, lateral views, HM 16202, X2; d, ventral valve interior, X2; e, dorsal valve interior, X2.5 (Shells, 1966).

Svalbardproductus USHTRITSKY, 1962b, p. 82 [*S. strataauritus* (OD)]. Similar to Thamsnesia, but said to differ by lacking spine clusters on ears; ribbing weak, indistinct anteriorly. Upper Permian (Kungurian); Spitzbergen.

Tesquea SUTHERLAND & HARLOW, 1973, p. 53 [*T. formosa* (OD)]. Small to medium size; corpus deep; spines only ventrally, small over reticulate disk, single or double rows prominent on flanks, continued onto trail; cardinal process small, sessile, cardinal ridges angle sharply at ears, continue as ear baffles. Lower Upper Carboniferous (Bashkirian); southern North America.—Fig. 319, 2a–e. *T. formosa,* Bashkirian, New Mexico; a, holotype, ventral view, OU 7659, X1; b, c, posterior, lateral views, X2; d, dorsal valve exterior, X2; e, dorsal valve interior, X2 (Sutherland & Harlow, 1973).

Thamsnesia COOPER & GRANT, 1969, p. 10 [*T. anteropinosa* (OD); [=Neopugilis Li in Dunn & others, 1991, p. 159 (186) (type, *N. typicus* (OD)); Thuleproductus SARYTCHeva & WATERHOUSE, 1972, p. 67 (type, *T. tvearnensis* (OD))]. Medium, widest at hinge; ventral disk gently convex, genulate with long trail, medianly sulcate; spines on both valves, ventral valve with clusters of thicker spines on lateral slopes and anterior trail, dorsals small, thin; ear baffles in both valves, dorsally as extensions of cardinal ridges that diverge from hinge; marginal ridge becoming overgrown by row of endospines anteriorly. [The inclusion of *Neopugilis* from the Lower Permian of Shaanxi, China, may extend the range from the uppermost Carboniferous; interiors are poorly known.]. Upper Upper Carboniferous (*Gzhelian*), upper Lower Permian (Roadian); USA, Arctic Canada, eastern Greenland, Arctic Eurasia, ?China.—Fig. 319, 1a–e. *T. anteropinosa,* Lower Permian, Cathedral Mountain Formation, Texas; a–c, holotype, viewed ventrally, dorsally, laterally, USNM 149852, X1; d, ventral valve interior, X1; e, dorsal valve interior, X1 (Cooper & Grant, 1975).


Tribe SPIRIDIOPHORINI

Muir-Wood & Cooper, 1960


Ribbing coarse, homogeneous anteriorly; spine row on each arched ear; no diaphragm or series of dorsal trails; dorsal adductor platforms well developed (spiridium). Upper Carboniferous (Moscovian–Lower Permian (Sakmarian, ?Artinskian).

Spiridiophora COOPER & SHELLS, 1955, p. 471 [*S. distintica* (OD); [=Spiridiophora SARYTCHeva in SARYTCHeva, LICHAREV, & SOKOLSKAJA, 1960, p. 234]. Medium size with transverse outline, ears large; ventral sulcus originating on umbo; dorsal disk almost flat, genulate; spines include ear clusters, none dorsally; ear baffles in both valves strong; cardinal process sessile, bilobed, quadridril; dorsal adductor scars raised, laterally directed platforms or true spiridium. Lower Permian (Asselian–Sakmarian, ?Artinskian); USA, southeastern Asia. ——Fig. 320, 2a–e. *S. distintica,* Lower Permian, Wolfcamp Formation, Texas; a–c, shell viewed ventrally, anteriorly, dorsally, X1; d, dorsal valve viewed posteriorly showing spiridium, X3 (Muir-Wood & Cooper, 1960); e, holotype, dorsal valve interior, USNM 124117, X2 (Cooper & Grant, 1975).

Alexenia IVANOVA in IVANOVA, 1935, p. 89 [*A. reticulata* (OD)]. Externally similar to *Spiridiophora* but internal dorsal adductor platforms separated medially, and less elevated. Upper Carboniferous (Moscovian–Kazanian): Eurasia.—Fig. 320, 1a–c. *A. reticulata,* Moscow basin; a, ventral valve exterior, Moscovian, X2; b, ventral valve exterior, Moscovian, X1 (Ivanova, 1935); c, dorsal valve interior, Kazimovian, X1 (Lazarev, 1990).

Subfamily LEIOPRODUCTINAE

Muir-Wood & Cooper, 1960

[Leioproductinae Muir-Wood & Cooper, 1960, p. 168]

Ribbing commonly absent or weak, never at beak; dorsal spines commonly absent; teeth absent in all but oldest genera. Upper Devonian (Famennian)–Upper Permian (Capitanian).

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Tribe LEIOPRODUCTINI
Muir-Wood & Cooper, 1960

Small to medium sized; ribbing absent, but commonly with ventral median weak fold; ventral spines sparse, dorsal spines absent; teeth in early genera. Upper Devonian (Famennian)—Lower Carboniferous (lower Visian).

Leioproductus STAINBROOK, 1947, p. 307 [*Productella coloradoensis var. plicatus KINDLE, 1909, p. 18; OD].

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Spines sparse, evenly distributed roughly radially, commonly including ventral median row on low ridge; weak lateral ridges extend toward lateral margins, short accessory ridges posterior to adductor scars; cardinal process pit. *Upper Devonian (upper Famennian): North America, Asia.*—Fig. 321,1a–f. *L. plicatus* (Kindle), uppermost Famennian, New Mexico; a, posterior view, X1; b, anteroventral view, X2; c, dorsal view, X1; d, lateral view, X2; e, dorsal valve interior, X2; f, conjoined valves showing dorsal, ventral interiors, X3 (Muir-Wood & Cooper, 1960).

**Ardiviscus** Lazarev in Lazarev & Pushkin, 1986, p. 42[35] [*A. naidovense* Pushkin in Lazarev & Pushkin, 1986, p. 43[38]; OD]. Similar to *Leinoproductus*, but with thinner spines, occurring more densely posterolaterally; teeth present, but no cardinal process pit. *Upper Devonian (lower Famennian): Europe, North America.*—Fig. 321,5a–e. *A. naidovense* Pushkin, lower Famennian, Belorussia, Gomel’ region; a,b, holotype, ventral, lateral views, PIN N 4067/113, X1; c, oblique lateral view of ventral valve exterior, X1; d, dorsal view of shell, X1; e, partial ventral valve internal mold showing muscle scars, X3 (Lazarev & Pushkin, 1986).

**Bispinoproductus** Stainbrook, 1947, p. 311 [*B. varispinosus* OD]. Resembles *Leinoproductus*, but with numerous ventral small spines, anteriorly on elongate bases, separated by slightly lamelliform bands. *Upper Devonian (upper Famennian): southern North America.*—Fig. 321,4a–d. *B. varispinosus*, Famennian, New Mexico; a, dorsal view of complete specimen, X1; b, ventral view of ventral valve, X1; c, lateral view of ventral valve, note spines, X1; d, dorsal valve interior, X2 (Muir-Wood & Cooper, 1960).

**Galeatella** Muir-Wood & Cooper, 1960, p. 173 [*G. galeata*; OD]. Small; relatively shallow corpus; ventral disk weakly convex, gentle median sulcus; spines thin, at hinge, on indistinct rugae and anteriorly; cardinal process pit, accessory ridges posterior to adductor scars, no cardinal ridges. *Upper Devonian (upper Famennian): North America.*—Fig. 321,2a–c. *G. galeata*, uppermost Famennian, New Mexico; a–c, ventral, anterior, lateral views of ventral valve, X1; d, dorsal view of nearly complete specimen, X1; e, dorsal valve interior, X2 (Muir-Wood & Cooper, 1960).

**Grandiproductella** Lazarev in Lazarev & Simakov, 1987, p. 121[134] [*G. omolonensis* Simakov in Lazarev & Simakov, 1987, p. 121[135]; OD]. Medium sized, around 30 mm wide; spines thin, in line at hinge, elsewhere rare; no ventromedian sulcus; teeth strong. *Upper Devonian (Famennian): northeastern Asia.*—Fig. 322,1a–c. *G. omolonensis* Simakov, Famennian, Omolon Massif; a, holotype, ventral view, PIN N 4112/101, X1; b, posterior view of ventral valve, X1; c, posteroventral view of exfoliated ventral valve showing muscle scars, X1 (Lazarev & Simakov, 1987).

**Hunanoproductus** Hou Hong-xin, 1965, p. 117 [*H. hunanensis*; OD]. Smaller medium size, outline subrounded; profile geniculate with flared trail; spines at hinge and rare, thin anteriorly; posterior rugae slight, corpus relatively shallow. *Lower Carboniferous (lower Tournaisian): southern China.*—Fig. 321,3a–d. *H. hunanensis*, lowermost Tournaisian, southern China; a,b, holotype, lateral, posterior views of ventral valve, IV 530, X1; c,d, ventral, dorsal views of complete specimen, X1 (Hou, 1965).

Resembles *Grandiproductella*, but dorsal visceral disk more flat; teeth absent; no cardinal process pit. Upper Upper Devonian, Lower Carboniferous (lower Tournaisian): northeastern Asia.—Fig. 322.a–d. *K. intrastriata* Simakov, uppermost Famennian–lower Tournaisian, Omolon Massif; a, holotype, dorsal view, showing cardinal process, PIN N 4112/104.
Productida—Productoidea

×1: 6, internal cast of ventral valve, ×1; c, incomplete dorsal valve interior, ×3 (Lazarev & Simakov, 1987); d, anterolateral view of largely exfoliated valve, ×1 (new). *Magnumbonella* CARTER, 1968, p. 1145 [*M. macrura* OD]. Lateral profile strongly curved with deep corpus; rugae confined posteriorly, strong on flanks; spines rare, fine on dorsal valve, occasional elongate.
spine bases distal to spines; no cardinal process pit; lateral ridges diverge slightly from hinge, reaching ears. Lower Carboniferous (Tournaissian–Lower Viséan): central North America.—Fig. 322,2a–d. *M. macrura, lower Viséan, Missouri; a,b, ventral, lateral views of ventral valve, X1,5; c, anterior view of ventral valve, X1,5; d, dorsal valve interior, X2 (Carter, 1968).

Mesopica REED, 1943, p. 97 [*Leptaena praetonga J. DE C. SOWERRY, 1840, pl. 55, fig. 29; OD]. Medium size; distinct ventral median fold bearing thicker spines in some; ribbing incipient anteriorly on corpus; teeth absent; cardinal ridges short. Upper Devonian (upper Famennian): Europe, northern Africa, Asia.—Fig. 322,3a–d. *M. praelonga (J. DE C. SOWERRY), uppermost Famennian, Devonshire; a,b, lateral, anterior views of ventral valve internal mold, X1 (type); c,d, portion of interior anterior of posterior part of dorsal valve, X2 (Muir-Wood & Cooper, 1960).—Fig. 322,5e. *M. simplicior (NĂLÎVIN), Famennian, Kirghizia; posterior view of ventral valve, X1 (Muir-Wood & Cooper, 1960).

Productelloides O. KOTEKAR, 1985, p. 112[97] [*P. gorobtsovensis; OD]. Resembles Leoproductus, but without ventromedian fold, spines fine, widely scattered; teeth small. Upper Devonian (upper Famennian): Ukraine.—Fig. 322,3a–d. *P. gorobtsoven- sis, upper Famennian, Poltava District; a,b, holotype, anteroventral, lateral views, IGN 2078/110, X1; c, view of ventral valve surface at anterior margin, X3; d, part of dorsal valve interior, ventral umbo showing teeth, X5 (Kotylar, 1985).

Tribe HORRIDONIINI
Muir-Wood & Cooper, 1960


Medium or commonly large, thick-walled valves; ribs weak or absent, one to three rows of halteroid spines commonly on ventral ears and, rarely, one row near dorsal hinge; rarely other dorsal spines; marginal structures commonly absent. Lower Carboniferous (Serpukhovian)–Upper Permian.

Horridonia CHAO, 1927b, p. 24 [*Productus horridus J. SOWERRY, 1822 in 1821–1822, p. 17; OD] [*Sowerbina FREDERICKS, 1928, p. 778 (type, Productus timanicus STUCKENBERG, 1905, p. 86; OD); Pleurohorridonia DUNBAR, 1955, p. 89 (type, P. scoreshyensis; OD)]. Medium size, outline pentagonal with wide hinge; weak median sulcus and dorsal fold; ribbing, rugae absent; spines in one to three rows on ears, few scattered on ventral valve, single row near dorsal hinge; dorsal lateral ridges extend to ears; dorsal muscle field rhombic; endospines around anterior margins of disk. Upper Permian: Europe, Arctic regions, ?Pakistan (Salt Range).—Fig. 323,1a–f. *H. horrida (J. SOWERRY); a–e, shell viewed ventrally, posteriorly, anteriorly, laterally, dorsally, Zechezin, Thuringia, Germany; X1; f, dorsal valve interior, Magnesian Limestone, Durham, X1 (Muir-Wood & Cooper, 1960).

Bailliena NELSON & JOHNSON, 1968, p. 723 [*B. yukonensis; OD]. Resembles Horridonia, but lacks dorsal spines near hinge, but with spines at dorsal geniculation zone; lamellose, especially dorsally; ribbed anteriorly on trail, anterior to thick spine bases. Upper Carboniferous (Gzhelian)–Lower Permian (Asselian): northern Canada.—Fig. 323,2a–d. *B. yukonensis, Gzhelian–Asselian, Yukon Territory; a, holotype, viewed laterally, UCF 1088, X1; b, holotype, close up of ventral hinge region, UCF 1088, X2; c,d, ventral, dorsal views of specimen, X1 (Nelson & Johnson, 1968).

Burovia USHTIKSY, 1980, p. 25 [*B. selandensis; OD]. Medium to large with variable outline, ears well differentiated; median sulcus originating on disk; prominent growth lines may form bands anteriorly; spines lacking at hinge, arranged in well-spaced rows on ventral valve and row at dorsal hinge with thick cluster on ears; cardinal process sessile, quadrifid; cardinal ridges weak or absent, marginal ridges strong laterally, continued anteriorly; shell substance thick, giving strong morphology with wide adductor scars. Upper Permian: Arctic regions.—Fig. 324a–c. *B. selandensis, Selander Formation, Selander Bay, Spitzbergen; a, holotype, ventral valve exterior, repository and number unknown, X1; b, incomplete ventral valve with spine cluster, X1; c, dorsal valve interior, X1 (Ustritsky, 1980).—Fig. 324d. B. maynei (DUNBAR); anteroventral view of specimen, X1 (Ustritsky, 1980).

Prachorridonia USHTIKSY, 1962a, p. 57 [*P. drosoplicata; OD]. Shape similar to Horridonia, but with thin spines scattered over ventral valve and anteriorly only on dorsal valve; incipient radial ribbing; lateral ridges thick, extended to separate ears. Carboniferous (Serpukhovian–Bashkirian): Arctic regions, Siberia, Canada.—Fig. 325,1a–d. *P. drosoplicata, lowermost Bashkirian, Khodolinn Formation, Taymyr; a,b, holotype, lateral, ventral views, VSEGEI 8363/176, X1; c, ventral view showing incipient ribbing, VSEGEI 8363/176, X2; d, dorsal valve interior, X1 (Ustritsky, 1962a).

Rugoclostus EASTON, 1962, p. 59 [*R. nivalis; OD]. Similar to Prachorridonia but possibly differs in having ventral ginglymus and spines more densely covering dorsal ears. Lower Carboniferous (lower Bashkirian): central North America.—Fig. 325,2a–c. *R. nivalis, lower Bashkirian, Cameron Creek Formation, Mororan, Montana; holotype, dorsal, posterior, anteroventral views, USNM 118789, X1 (Easton, 1962).

FIG. 323. Productidae (p. 480–483).
Rhynchonelliformea—Strophomenata

Fig. 324. Productidae (p. 480).

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on ventral flange and trail, and in having only rare or absent dorsal spines. Lower Permian: Canada.

—— Fig. 323,3a–c. *T. nelsoni, Lower Permian, basal Tahkandit Formation, Yukon Territory; a,b, holotype, viewed ventrally, dorsally, GSC 26417, X1; c, anterobrrial view of internal cast, X1 (Bamber & Waterhouse, 1971).

Tribe SEMIPRODUCTINI
McKellar, 1970


Medium size with deep corpus cavity, long trails; elongate spine bases arranged quincuncially on ventral disk, spines extending onto trail; ribs originate anteriorly on disks and always occur on trails; lateral ridges commonly short, no marginal structures; teeth in early genera. Upper Devonian (Famennian)—Lower Carboniferous (lower Visian).

Semiproductus BURLICHENKO, 1956, p. 99 [*S. minax OD]. Size medium, around 35 mm; outline subquadrato to elongate with broad sulcus anteriorly, ventral profile strongly convex; rugae weak or incomplete on disks with elongate spine bases; spines on weak ribs on ventral trail; lateral ridges prominent, but short. upper Upper Devonian (upper Famennian)—lower Carboniferous (lower Tournaisian); Ural Mountains, Asia, northern Australia.
**Acanthoproductus** Martynova, 1970, p. 59[49] [*A. bogdanovi; OD]. Smaller medium size, 25 mm wide; rugae narrow on corpus, elongate spine bases become weak ridges only; dorsal valve with fine radial striations, median fold, sulcus; teeth. Upper Devonian (Famennian): Kazakhstan. —— Fig. 326, 2a–e. *A. bogdanovi*, Famennian, Kazakhstan; a–c, holotype, anterodorsal, dorsal, lateral views, MGU 137/42, ×1; d, exfoliated dorsal valve inte-

Fig. 326. Productidae (p. 483–485).
ripar, \(X\) (Martynova, 1970); \(e\), dorsal valve exterior, \(X\) (Lazarev, 1990).

**Lomatiphora** ROBERTS, 1971, p. 84 [*L. aquila*; OD]. Ribbing complete, other than at beak, weaker on trail ranges of both valves; spines fine, scattered ventrally; sessile quadrifid cardinal process supported by adductor ridges; weak lateral marginals. Lower Carboniferous (Tourneian): Australia.—Fig. 327.1a–c. *L. aquila*, lower Tourneian, Bonaparte Gulf basin; \(a\), latex replica of ventral valve exterior, \(X\); \(b\), anteroventral view of ventral valve exterior, \(X\); \(c\), dorsal valve exterior, \(X\); \(d\), ventral valve internal mold, \(X\); \(e\), holotype, latex replica, dorsal valve interior, CPC 8261a, \(X\) (Roberts, 1971).

**Margaritiproductus** LAZAREV, 1986a, p. 67 [*Productus (Oxertontus) celak Nalivkin, 1937; p. 61; OD]. Small to medium size; moderately deep corpus, resembling *Semipectus*, but ribbing confined to trails; teeth small. Upper Devonian (upper Famennian): central Asia.—Fig. 328.3a–e. *M. celak* (Nalivkin), upper Famennian, Kazakhstan; \(a\), dorsal valve interior with fragment of ventral valve, small teeth, \(X\); \(b\), dorsal valve exterior, \(X\) (Lazarev, 1986a).—Fig. 328.3c. *Margaritiproductus* sp.; part of dorsal valve interior showing socket, muscle scar, \(X\) (new).

**Nigerinoplica** LAZAREV, 1986a, p. 66/45 [*Plicatiforma nigerina MARTYNOVA, 1961; p. 87; OD]. Ribbing coarse, commonly confined anteriorly on trail; resembles *Spinocarinifera*, but with teeth. Upper Devonian (Famennian): Eurasia, *North America*.—Fig. 327.3a–e. *N. nigerina* (Martynova), upper Famennian, Kazakhstan; \(a\), dorsal view of shell, \(X\); \(b\), partly exfoliated dorsal valve interior showing greatly reduced tooth, \(X\) (Lazarev, 1986a); \(c\), oblique view of dorsal interior, \(X\) (Lazarev, 1990).

**Seminicella** CARTER, 1987, p. 26 [*Spinocarinifera (Seminicella) parus*; OD]. Small, around 10 mm wide; resembles *Spinocarinifera*, but subparallel flanks, less even ribbing anteriorly; without peglike median lobe of cardinal process, perhaps larger cardinal process pit. Lower Carboniferous (Tourneian-Upper Viséan): northern North America.—Fig. 327.2a–f. *S. parus*, Tourneian, western Alberta; \(a\)–\(d\), holotype, viewed ventrally, anteriorly, posteriorly, laterally, GSC 63207, \(X\); \(e\), dorsal valve exterior, \(X\); \(f\), dorsal valve interior, \(X\) (Carter, 1987).

**Spinocarinifera** ROBERTS, 1971, p. 100 [*S. adounata; OD*] [*Nigerinoplica Nalivkin, 1975, p. 160 (type, Productus niger Gosselet, 1888, p. 632); *Productus flemingii* de Koninck, 1847a, p. 196, non Sowerby, 1812, p. 155, sens Gosselet, 1880, pl. 6, fig. 16]. Small size; outline subquadrate with small but well-differentiated ears, profile strongly convex; dorsal valve weakly concave, geniculate with no spines; ribbing well formed anteriorly; cardinal process trifid with pit small, variable; cardinal ridges diverge from hinge close to ears. Lower Carboniferous (lower Tourneian): Australia, Eurasia, northern Africa, North America.—Fig. 328.1a–e. *S. adounata*, Hastarian, Bonaparte Gulf, Australia; \(a\)–\(d\), holotype viewed ventrally, dorsally, posteriorly, laterally, CPC 8564; \(e\), dorsal valve interior, \(X\) (Roberts, 1971).

**Yanguania** YANG SHI-PU, 1978, p. 107 [*Spinocarinifera dushanensis* YANG SHI-PU, 1964; p. 87; OD]. Similar to *Spinocarinifera*, possibly differing by weak rugae posteriorly, weakly developed ribbing anteriorly. Lower Carboniferous (Tourneian): southern China.—Fig. 328.2a–d. *Y. dushanensis*, lower Tourneian, Yangan, Guizhou; \(a\), shell viewed anteroventrally, \(X\); \(b\), shell viewed dorsally, \(X\); \(c\)–\(d\), shell viewed anteriorly, laterally, \(X\) (Yang Shi-pu, 1978).

**Tribes TYLOPLECTINI**

**Termier & Termier, 1970**

[Lazarev, 1990].

Ribbed, other than at beak; additional striae dorsally; ventral spines large near hinge and on flanks, probably absent dorsally. Lower Permian (Artinskian—Upper Permian (Capitanian).

**Tylopecta** MUIR-WOOD & COOPER, 1960, p. 290 [*Productus scabriculus mut. nankinensis FRECH, 1911, p. 163; OD*] [*Nankinoproductus HUANG & TSENG, 1948, p. 254, nom. nud.]. Medium size, planoconvex with short adult trail; hinge equal to maximum width; elongate spine bases posteriorly, becoming ribs at midlength of corpus; rugae present posteralaterally on both valves; spines near hinge, scattered on venter; cardinal process with wide shaft; weak lateral ridges, ear baffles; shell substance thick. Lower Permian (Artinskian—Kungurian): China, southern Europe, Indonesia.—Fig. 329.a–g. *T. nankinensis*, Lower Permian, Chihlian Formation, Sichuan; \(a\)–\(c\), specimen viewed ventrally, posteriorly, laterally, \(X\); \(d\), shell viewed dorsally, \(X\); \(e\), ventral valve interior, \(X\); \(f\), dorsal valve interior, \(X\); \(g\), detail of dorsal valve external ornament, \(X\) (Muir-Wood & Cooper, 1960).

**Araxisilevis** SARYTCHEVA in SARYTCHEVA & SOKOLSKAYA, 1965, p. 221 [*Productus intermedius ARYTCHEVA, 1878, p. 27; OD]. Medium to large, ventral profile strongly convex with weak geniculation, anterior trail lamellose; median sulcus weak; ribbing absent, rugae weak on disks, ears; spine bases swollen, rounded posteriorly, elongate on ventral trail; dorsal valve weakly concave with short trail; cardinal process large, trifid; lateral ridges diverge slightly from hinge, continue weakly separating ears and to lateral margins; valves thick shelled, finely striate on exfoliated surfaces. Upper Permian (upper Capitanian): Transcaucasia.—Fig. 330.1a–e. *A. intermedius* (Arytcheva), upper Capitanian, Transcaucasia; \(a\)–\(b\), lectotype, viewed laterally, dorsally, LGE 24/99, \(X\); \(c\), anterior view, \(X\); \(d\), ventral view, \(X\); \(e\), dorsal valve interior, \(X\) (Sarytcheva & Sokolskaya, 1965).
Fig. 327. Productidae (p. 485).
Fig. 328. Productidae (p. 485).

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Pseudoantiquatonia Zhan & Wu, 1982, p. 98 [*P. mutabilis; OD]. Medium size, planoconvex corpus with trails; spine distribution, ribbing as in Tyloplecta, but finer. lower Upper Permian (Kazanian): China (Xizang, Tibet). ——Fig. 350.2a–d. *P. mutabilis, Upper Permian, Xiali Formation, Xainza, Tibet; a,b, anterior, lateral views, ×1; c,d, deeply exfoliated dorsal valve interior, anterior, ×1 (Zhan & Wu, 1982).

Subfamily DICTYOCLOSTINAE Stehli, 1954

[Dictyclostinae Stehli, 1954, p. 316]

Medium to large size; trails long, simple; ribbing complete with reticulation posteriorly; ventral spines commonly stout halteroid, dorsal spines absent; dorsal adductor scars positioned close to hinge line; marginal structures absent or weak. lower Carboniferous (Viséan)—Upper Permian (Tatarian).

Dictyoclostus Muir-Wood, 1930, p. 103 [*Anomites semireticulatus Martin, 1809, p. 7; OD]. Medium to commonly large; ribbing entire, ginglymus absent; spines clustered at ears, otherwise weak; cardinal ridges weak, not extended as ear baffles. Lower Carboniferous (Viséan): Europe; Asia, ?northern Africa. ——Fig. 351a–d. *D. semireticulatus (Martin), upper Viséan, Yorkshire; neotype, ventral, dorsal, posterior, lateral views, BMNH B45691, ×1 (new). ——Fig. 331e. D. pinguis (Muir-Wood), upper Viséan, Yorkshire; wax replica of dorsal valve interior, ×1 (Muir-Wood & Cooper, 1960).

Auloprotonia Muir-Wood & Cooper, 1960, p. 273 [*A. aulacophora; OD]. Somewhat resembling Dictyoclostus in ornament, but less strongly rugose, spines weaker, but with pair of strong spines on ears; trail with gutter; cardinal ridges extending to weak ear baffles. Lower Carboniferous (middle Viséan): North America. ——Fig. 332.1a–f. *A. aulacophora.
middle Viséan, Oklahoma; a–c, holotype, ventral, lateral, lateral oblique views, USNM 123976e, ×1; d, dorsal valve exterior, ×1; e, latex replica of dorsal valve interior, ×1; f, posterior view of ventral valve internal mold, ×1 (Muir-Wood & Cooper, 1960).

Callytharrella Archbold, 1985, p. 19 [*Dictyoclostus callytharrensis Prendergast, 1943, p. 13; OD]. Resembling Stereochia, but less strongly geniculate, weaker ear baffles, and with ribs on adult ears. Lower Permian (Sakmarian): Western Australia, Himalayas.—Fig. 333, 2a–c. *C. callytharrensis Prendergast, Lower Permian; a, b, ventral valve exterior, ventral valve viewed laterally, Jimba Jimba Calcarenite, Carnarvon Basin, Western Australia, ×1; c–e, ventral view, dorsal view, incomplete dorsal valve interior, Callytharra Formation, ×1 (Archbold, 1985).

Chaoiella Fredericks, 1933, p. 27 [*Productus semireticularis var. gruenewaldti Krotow, 1888, p. 546; OD]. Ears large; strong ventromedian sulcus,
Rhynchonelliformea—Strophomenata

Fig. 331. Productidae (p. 488).
ribbing weak or absent on trails, reticulation relatively weak; strong cardinal ridges, dorsal adductor scars dendritic, placed relatively anteriorly. Lower Permian (Artinskian): Eurasia.——F. 332, 2a–e. *C. gruenewaldti (Krotov), Artinskian, Russia; a–c, ventral, lateral, dorsal views of large specimen, X1; d, posterior view of ventral exterior, X1; e, posterodorsal view of specimen showing cardinal process, X1 (Muir-Wood & Cooper, 1960).

Dasysaria Cooper & Grant, 1969, p. 9 [*D. undulata; OD]. Resembles Reticulatia, but with more densely scattered ventral spines and clusters on ears. Lower Permian (Sakmarian): USA.——Fig. 333, 1a–f. *D. undulata, Lower Permian, Hueco Formation, Texas;
Rhynchonelliformea—Strophomenata

Fig. 333. Productidae (p. 489–492).

Kunlunia Wang Zhi, 1983, p. 308 [*K. aspera; OD].

Resembles Liraplecta, but differs in having large extended ears on which are clusters of spines. Lower
Permian (Asselian–Kungurian): China.—Fig. 334.1a–c. *K. aspera, lower Chihsian, Kunlun Mountains, Xinjiang; a,b, holotype, ventral, lateral views, XBRB 355, repository unknown, ×1; c, incomplete dorsal valve interior showing part of external mold, ×1 (new).

Liraplecta Jin & Sun, 1981, p. 136 [*Productus richthofeni CHAO, 1927b, p. 60; OD]. Resembles Stereochia, but has dorsal capillae plus normal ribbing. Lower Permian (Asselian–Sakmarian): China.—Fig. 334.1a–e. *L. richthofeni (Chao), Sakmarian, Lizha Formation, Tibet; a,b, anterior,
Rhynchonelliformea—Strophomena

lateral views of specimen, ×1; c,d, ventral, dorsal views of shell, ×1; e, detail of dorsal external ornament, ×10 (Jin & Sun, 1981).

*?Niutoushania Liao, 1984, p. 281 [*N. niutoushanensis; OD]. Medium size, elongate with hinge wider than corpus width; profile strongly, evenly convex; median sulcus weak; dorsal valve with flattened posterior disk, geniculate, with trail; ribbing fine, somewhat irregular posteriorly, widening anteriorly; rugae seemingly absent; spines reported at hinge only; dorsal cardinal ridges extend as weak marginal ridge. Possibly a dictyoclostid but seemingly no reticulation. Upper Permian (Tatarian): China.—Fig. 335.1a–d. *N. niutoushanensis, Longtian Formation, Anhui Province; a,b, holotype, viewed posteriorly, laterally, NIGP 71140, ×1; c, anterior view of shell, ×1; d, incomplete dorsal valve interior, ×1 (new).

Niutoushania

Ozora Carter, 1990, p. 226 [*O. genevievensis; OD]. Spines ventral, near hinge, on flanks, rare on disk, but in concentric bands on trail with widened ribs; reticulation prominent posteriorly; adult dorsal disk with marginal ridges. Lower Carboniferous (lower Viséan): central North America.—Fig. 336.1a–e.

FIG. 335. Productidae (p. 494–496).
*O. genevievensis*, lower Viséan, Missouri; *a*, holotype, dorsal valve exterior, CMNH 34893, ×1; *b,c*, ventral valve exterior viewed ventrally, posteriorly, ×1; *d*, ventral valve viewed laterally, ×1; *e*, incomplete dorsal valve interior, ×1 (Carter, 1990).

**Fig. 336. Productidae (p. 494–496).**

*Pugilis* SABYTCHEVA, 1949, p. 104 [*Producta pugilis* PHILLIPS, 1836, p. 215; OD] [=*Pugilus* SABYTCHEVA in SABYTCHEVA & SOLOSKAYA, 1952, p. 77, obj.].

Medium size; deep corpus; ribs regular posteriorly, but irregular and commonly weak on trails.
enlarged or branched distal to spine bases; dorsal valve commonly lamellose on trail; trail ridges strong, near hinge, continue as ear baffles and subperipheral ridge laterally. Lower Carboniferous (upper Viséan–lower Serpukhovian): Europe, northern Africa. ——Fig. 336, 2a–f. *P. pugilis (Phillips); a–d, anterior, ventral, posterior, lateral views of shell, upper Viséan, north Wales; X1; e, dorsal valve interior. Northumberland, X1 (new); f, dorsal view of shell exterior showing series of dorsal trails, Serpukhovian, Renfrewshire, Scotland; X1 (Muir-Wood & Cooper, 1960).

**Reticulatia** Muir-Wood & Cooper, 1960, p. 284 [*Productus huecoensis* King, 1931, p. 68; OD]. Resembles *Dizyclostus*, but differs in having ginglymus, lateral ridges near the hinge that may continue weakly as marginal ridges with endospines anteriorly. Upper Carboniferous (Baasbergenian)–Lower Permian (lower Artinskian): North America, Europe, Asia. ——Fig. 335, 2a–e. *R. huecoensis* (King), Lower Permian, Hughes Creek Shale, Nebraska; a–d, shell viewed ventrally, posteriorly, laterally, dorsally; X1; e, dorsal valve interior; X1 (Muir-Wood & Cooper, 1960).

**Rugatia** Muir-Wood & Cooper, 1960, p. 285 [*Productus paradoxicus* McKee, 1938, p. 241; OD]. Medium size, transverse with large, well-differentiated ears; median sulcus shallow, extending to valve margins; rugae weak on ears, some on dorsal disk; ribbing variable, originates anteriorly on disks, weak, irregular, coarse to strong anteriorly on corpus; spines thick, in lines separating umbo from ears, in clusters on ears, widely scattered on corpus, also with small spines; ventral adductor platform high; cardinal ridges lost at ears. Lower Permian (Artinskian): southern USA. ——Fig. 337, 2a–e. *P. paradoxicus* (McKee), Lower Permian, Leonard Formation, Texas; a–b, anterior, lateral views; X1; c, dorsal view; X1; d, dorsal valve interior; X1; e, disarticulated dorsal, ventral valves; X1 (Muir-Wood & Cooper, 1960).

**Stereochia** Grant, 1976, p. 150 [*S. litostyla*; OD]. Medium size, widest at hinge; disks of both valves reticulate, trails costate; spines thick, but few, single on one valve, venter; ventral adductor platforms raised, dendritic; diductor scars strongly striated; cardinal process trifid, shaft short, continuous with median septum; lateral ridges, ear baffles, latter strong in ventral valve. Lower Permian (upper Artinskian): Thailand, Indonesia, (northeastern Asia). ——Fig. 337, 2a–e. *S. litostyla*, upper Artinskian, Ko Muk, Thailand; a,b, holotype, viewed laterally, dorsally, USNM 212592, X0.75; c,d, ventral valve exterior, interior, X1; e, dorsal valve interior, X1 (Grant, 1976).

**Subfamily BUXTONIINAE**

**Muir-Wood & Cooper, 1960**

[Subfamily Buxtoniinae Muir-Wood & Cooper, 1960, p. 255]

Size varied, but with corpus cavity deep; ribbing on trails, commonly on corpus; spines dense on both valves, but may be restricted anteriorly on dorsal valve; elongate cardinal process pit seldom absent; dorsal muscle scars separated from hinge region. Lower Carboniferous (Tournaisian)–upper Lower Permian (Roadian).

**Tribe BUXTONIINI**

**Muir-Wood & Cooper, 1960**

[Dorsal trail commonly short, bordering structures (flanges) sporadic; ribs cover both valves, other than in Tournaisian, when smooth posteriorly; rugae irregular, may dominate ribs; spines on ventral valve uniformly distributed, commonly from swollen bases; buttress plates and pit present, but variable. Lower Carboniferous (Tournaisian)–Upper Permian (Asselian, Sakmarian).]

**Buxtonia** Thomas, 1914, p. 259 [*Anominitis scabriculus* Martin, 1809, p. 8; OD, species declared invalid, ICZN, 1956a; *Productus scabriculus* J. Sowerry, 1814 in 1812–1815, p. 157; SD, ICZN, Opinion 420, 1956b, p. 143]. Medium size; ventral posterior ribbing characterized by swollen elongate spine bases; cardinal ridges to ears, cardinal process narrow, dorsally reflexed. Carboniferous (Viséan–Serpukhovian): Europe, America, Australia, ?Far East. ——Fig. 338, 2a–e. *B. scabriculus* (J. Sowerry), upper Viséan, Derbyshire; a–c, lectotype, ventral, dorsal, lateral views, BMNH B 60954; X1 (new). ——Fig. 338, 3de. *Buxtonia* sp., Lower Carboniferous, Pendleian, Northumberland; d, dorsal view of internal mold, X1; e, latex replica of dorsal valve interior, X1.5 (new).

**Bellacalathus** Winters, 1963, p. 26 [*B. spinosus*; OD]. Medium size, corpus outline subquadrate; corpus profile almost planoconvex with strong dorsal geniculation; trails short; ventral sulcus weak; disks reticulate; spines fine on both valves plus rows of thick spines at ventral ears; cardinal process trifid with short shaft internally; lateral ridges reach ears, median septum divided posteriorly. Lower Permian: USA. ——Fig. 338, 1a–f. *B. spinosus*, Lower Permian, Fort Apache Limestone, Arizona; a–c, holotype, viewed ventrally, dorsally, laterally, AMNH 27995/3:1; X1; d, ventral view; X1; e, part of dorsal valve interior; X2; f, exterior showing cardinal process, X3 (Winters, 1963).

**Buxtonioides** Mendes, 1959, p. 43 [*Productus amazonicus* Katzler, 1903, p. 264; OD] [*Gemmuconites* Waterhouse in Bamber & Waterhouse, 1971, p. 210 (type, *G. gemma*; OD)]. Similar to Kochiproductus, but apparently lacking bordering flange, internal ventral postmedian ridges, and without adult buttress plates. *Upper Carboniferous*

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(Bashkirian–Gzelian): South America, Canada, Russia.—Fig. 339a–c. *B. amazonicus* (KATZER), Morrowan–Desmoinesian, Brazil; a, k, ventral, dorsal views of complete specimen, X1; c, details of ventral valve exterior, X5 (Mendes, 1959).—Fig. 339d. *B. gemma* WATERHOUSE, Moscovian, western
Rhynchonelliformea—Strophomenata

Alberta; ventral view of ventral valve, ×1 (Bamber & Waterhouse, 1971).—Fig. 339c. B. gielensis (Ivanov), Gzhelian, Gzel, near Moscow; dorsal valve exterior plus interior of ventral umbo showing cardinal process, lack of ventral ridge, ×1 (Lazarev, 1990).

Flexaria Muir-Wood & Cooper, 1960, p. 258
[*Productus arkansanus Girty, 1910, p. 216; OD].

Fig. 338. Productidae (p. 496–500).

Fig. 339. Productidae (p. 496–498).
Medium to large, with large ears, commonly with anterolateral flange; ribbing weak on ventral valve, accentuated by closely spaced elongate spine bases; rugae more prominent on dorsal valve; spines re-cumbent from swollen bases, semierect on ears and ventral trail, cover dorsal valve; low ventral median ridge from umbo to anterior of muscle field; cardi-nal ridges long, buttress plates with pit in adults. Lower Permian (Asselian, ?lower Sakmarian): Arctic regions, Mongolia, North and South America.——

Fig. 338, 2a–e. *K. peruvianus* (d’Orbigny), Lower Permian, Hueco Formation, Texas; a–d, shell viewed ventrally, posteriorly, laterally, dorsally, ×0.75; e, dorsal valve interior, ×1 (Muir-Wood & Cooper, 1960).


Smaller than *Buxtonia*, but with stronger ribs, small bordering flange, no ventromedian sulcation. Lower Carboniferous (upper Tournaisian–Viséan): central North America.——

Fig. 341, 1a–e. *L. wortheni* (Hall), upper Tournai- sian, Missouri; a–d, ventral, lateral, anterior, poste- rior views of specimen, ×2; e, latex replica of dorsal valve interior, ×2 (Muir-Wood & Cooper, 1960).


Fig. 341, 1a–e. *L. wortheni* (Hall), upper Tournais- ian, Missouri; a–d, ventral, lateral, anterior, poste- rior views of specimen, ×2; e, latex replica of dorsal valve interior, ×2 (Muir-Wood & Cooper, 1960).

**Marginicinctus** Sutton, 1938, p. 561 [*Productus marginicinctus* Proult, 1857, p. 43; OD]. Resembles *Buxtonia*, but smaller, with bordering reflexed flange, internal marginal ridges in both valves. Lower Carboniferous (middle Viséan): North
**Productida—Productoidea**

America, Europe.—Fig. 340, 1a–d. *M. marginicinctus* (Prout), middle Viséan; **a**, ventral valve exterior, Missouri, ×1; **b,c**, oblique lateral, anterior views of specimen, Iowa, ×2; **d**, latex replica of dorsal valve interior, Tennessee, ×2 (Muir Wood & Cooper, 1960).—Fig. 340, 1e,f. *M. projectus* (Muir-Wood), Viséan, Cork; **e**, dorsal valve exterior, ×1; **f**, ventral view of shell with flange, ×1 (Muir-Wood & Cooper, 1960).

**Setigerites** Girty, 1939, p. 141, nom. nov. pro *Setigera* Girty, 1938b, p. 434, non Ehrenberg, 1872 [*Productus setigerus* Hall, 1858a, p. 638; = *P. setiger*, nom. correct. Muir-Wood & Cooper, 1960, p. 197; OD]. Size medium; trail commonly with gutter, rugae at umbonal flanks weak; ribbing fine, entire, associated with slightly swollen spine bases; spine groups posteriorly and on ears; cardinal process pit small, lateral ridges only slightly divergent from hinge, no marginal ridges. Lower Carboniferous (upper Tournaisian–lower Serpukhovian): North America, Eurasia, ?northern Africa.—Fig. 341, 2a–e. *S. setiger* (Hall), upper Tournaisian; **a**, ventral, posterior, lateral views of ventral valve, Indiana, ×1; **b**, posterolateral region showing spine bases on ears, Indiana, ×2; **c**, latex replica of dorsal valve interior, Missouri, ×2 (Muir-Wood & Cooper, 1960).

**Tribe TOLMATCHOFFIINI**

Sarytcheva, 1963


Dorsal trail of varied length; ribbing covering both valves, other than in lower
Rhynchonelliformea—Strophonemata

Tournaisian, when umbos smooth; rugae commonly absent, spines on ventral valve not uniformly distributed; commonly with elongate cardinal process pit. Lower Carboniferous (Tournaisian)—upper Lower Permian (Roadian).

Tolmatchoffia Freierdicks, 1935, p. 28 [*Productus robustus Tolmatchoff, 1924, p. 230; OD]. Medium size; almost planoconvex, deep corpus, gently spreading trail; ribbing entire, becoming wider, indistinct on ventral valve; rugae more distinct dorsally, reticulate; spines scattered on both valves, commonly concentric on ventral trail; cardinal process large, normally with pit, cardinal ridges may reach ears, no marginal ridges. Lower Carboniferous (upper Tournaisian): Europe, northern Africa; North America, Europe, northern Africa; central China.—Fig. 344.3a–d. *M. feruglenesi* (Weller), lower Viséan, Missouri; a–c, posterior, anterior, lateral views of ventral valve, X1; d, dorsal valve interior, X1 (Muir-Wood & Cooper, 1960).

Peniculaurs Muir-Wood & Cooper, 1960, p. 278 [*P. mckeei; OD; nom. nov. pro Productus iviesi King, 1931, p. 69, non Newberry, 1861]. Medium to large, widest at hinge, with large ears; ginglymus incipient; ventral profile somewhat flattened posteriorly; geniculate and long trail; ribbing strong, swollen at densely positioned lateral ridges; weakly reticulate; spines in rows near hinge, clusters on ears and scattered over ventral valve, fine on dorsal valve; cardinal process thin; with large median sector; lateral ridges extend across ears; adductor scars wide; long median septum. Lower Permian (Sakmarian–Roadian): USA.—Fig. 345.1a–e. *P. mckeei*, Lower Permian, Leonard Formation, Texas; a–d, holotype, viewed ventrally, anteriorly, laterally, dorsally, USNM 123445, X1; e, dorsal valve interior, X1 (Muir-Wood & Cooper, 1960).

Piloricilla Carter, 1987, p. 33 [*P. desmetensis; OD]. Resembles Acanthocosta, but with flared lateral margins and some thicker ventral spines anteriorly; cardinal ridges widening laterally and uniting with obscure marginal rim. Lower Carboniferous (lower Viséan): Canada.—Fig. 345.2a–g. *P. desmetensis*, lower Viséan, western Alberta; a–e, holotype, ventral, anterior, lateral, posterior, dorsal views, GSC 63246, X1; f, dorsal valve interior, X2; g, posterior view of preceding specimen, X3 (Carter, 1987).

Scissicosta Lazarev in Lazarev & Suur’suren, 1992, p. 65 [*S. gobieni; OD]. Remakes Tolmatchoffia, but smaller, more concave dorsal valve, ribbing absent at beaks, well defined on trails; dorsal spines rare, confined to zone of geniculation, lower Lower Carboniferous (lower Tournaisian): Mongolia.—Fig. 346.1a–d. *S. gobieni*, Hastarian, Mongolia; a–b, holotype, ventral, lateral views, PIN N 3385/1080, X1; c, ventral valve exterior, X1; d, incomplete dorsal valve interior, X1 (Lazarev & Suur’suren, 1992).—Fig. 346.1e. *S. basalensis* Suur’suren; exterior mold of dorsal valve, X1 (Lazarev & Suur’suren, 1992).

Spinifrons Stehli, 1954, p. 318 [*S. quadratus; OD]. Medium size, resembling Peniculaurs, but with clusters of thicker spines on ears and rarely anteriorly; cardinal process small; weakly developed lateral ridges close to hinge, and other internal morphology weak. Lower Permian (upper Sakmarian–Artinskian); southern USA.—Fig. 346.3a–e. *S. quadratus*, Lower Permian, Bone Spring Formation, Texas; a–b, shell viewed ventrally, posteriorly, X1; c, lateral view, X1; d, e, dorsal valve exterior, interior, X1 (Muir-Wood & Cooper, 1960).

Marginitia Muir-Wood & Cooper, 1960, p. 262 [*Productus ferglenesi* Weller, 1909, p. 299; OD] [Pranamarginata Yang Shi-fu, 1978, p. 111 (type, *P. weingerinensis*; OD)]. Small to medium size; reticulate posteriorly; dorsal spines rare, small; dorsal valve with variably positioned lateral ridges, commonly extending to lateral margins and commonly subperipheral rim. Lower Carboniferous (lower Viséan): North America, Europe, northern Africa; central China.—Fig. 344.3a–d. *M. feruglenesi* (Weller), lower Viséan, Missouri; a–c, posterior, anterior, lateral views of ventral valve, X1; d, dorsal valve interior, X1 (Muir-Wood & Cooper, 1960).

Peniculauris Muir-Wood & Cooper, 1960, p. 278 [*P. mckeei; OD; nom. nov. pro Productus iviesi King, 1931, p. 69, non Newberry, 1861]. Medium to large, widest at hinge, with large ears; ginglymus incipient; ventral profile somewhat flattened posteriorly; geniculate and long trail; ribbing strong, swollen at densely positioned lateral ridges; weakly reticulate; spines in rows near hinge, clusters on ears and scattered over ventral valve, fine on dorsal valve; cardinal process thin; with large median sector; lateral ridges extend across ears; adductor scars wide; long median septum. Lower Permian (Sakmarian–Roadian): USA.—Fig. 345.1a–e. *P. mckeei*, Lower Permian, Leonard Formation, Texas; a–d, holotype, viewed ventrally, anteriorly, laterally, dorsally, USNM 123445, X1; e, dorsal valve interior, X1 (Muir-Wood & Cooper, 1960).

Piloricilla Carter, 1987, p. 33 [*P. desmetensis; OD]. Resembles Acanthocosta, but with flared lateral margins and some thicker ventral spines anteriorly; cardinal ridges widening laterally and uniting with obscure marginal rim. Lower Carboniferous (lower Viséan): Canada.—Fig. 345.2a–g. *P. desmetensis*, lower Viséan, western Alberta; a–e, holotype, ventral, anterior, lateral, posterior, dorsal views, GSC 63246, X1; f, dorsal valve interior, X2; g, posterior view of preceding specimen, X3 (Carter, 1987).

Scissicosta Lazarev in Lazarev & Suur’suren, 1992, p. 65 [*S. gobieni; OD]. Remakes Tolmatchoffia, but smaller, more concave dorsal valve, ribbing absent at beaks, well defined on trails; dorsal spines rare, confined to zone of geniculation, lower Lower Carboniferous (lower Tournaisian): Mongolia.—Fig. 346.1a–d. *S. gobieni*, Hastarian, Mongolia; a–b, holotype, ventral, lateral views, PIN N 3385/1080, X1; c, ventral valve exterior, X1; d, incomplete dorsal valve interior, X1 (Lazarev & Suur’suren, 1992).—Fig. 346.1e. *S. basalensis* Suur’suren; exterior mold of dorsal valve, X1 (Lazarev & Suur’suren, 1992).

Spinifrons Stehli, 1954, p. 318 [*S. quadratus; OD]. Medium size, resembling Peniculaurs, but with clusters of thicker spines on ears and rarely anteriorly; cardinal process small; weakly developed lateral ridges close to hinge, and other internal morphology weak. Lower Permian (upper Sakmarian–Artinskian); southern USA.—Fig. 346.3a–e. *S. quadratus*, Lower Permian, Bone Spring Formation, Texas; a–b, shell viewed ventrally, posteriorly, X1; c, lateral view, X1; d, e, dorsal valve exterior, interior, X1 (Muir-Wood & Cooper, 1960).

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Fig. 342. Productidae (p. 502).

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Squamaria Muir-Wood & Cooper, 1960, p. 287 [*S. moorei; OD]. Medium size with wide hinge; ventral trail lamellose marginally; disks reticulate, but ribbing weak, irregular on trails; spines in prominent thick clusters on ears of both valves, widely scattered ventrally on accentuated ribs, sparse, fine dorsally; lateral, marginal ridges weak; shell substance thick. Lower Permian: USA.—Fig. 347.1a–f. *S. moorei, Lower Permian, Talpa Formation, Texas; a, b, holotype, viewed anteriorly, dorsally, USNM 123987, ×1; c, d, posterior, lateral views of shell, ×1; e, incomplete ventral valve interior, ×1; f, dorsal valve interior, ×1 (Muir-Wood & Cooper, 1960).

Tomilia Sarycheva in Sarycheva & others, 1963, p. 220 [*T. khalafni; OD]. Resembles Tolmatchoffia, but smaller, ribbing less well developed, sulcate, with thick-walled valves; cardinal process massive, protruding, supported by thick, short, divergent lat-
eral ridges. *Lower Carboniferous* (lower Viséan): Siberia. —— Fig. 346. 2a–e. *T. khalfini*, Viséan, Kuzbass, central Asia; a,b, ventral, posterior views of ventral valve, ×1; c, posterior view of ventral valve internal mold, ×1; d,e, holotype, lateral, dorsal views of internal mold, PIN N 1493/134, ×1 (Sarytcheva & others, 1963).

**Tomiproductus** SARYTCHENAA in SARYTCHENAA & others, 1963, p. 201 [*Productus elegantulus* TOLMATCHOFF, 1924, p. 244; OD]. Small; thin shelled, deep corpus, elongate ventral trail; ribbing entire, fine, weak reticulation on disks; spines sparsely scattered, thicker, somewhat concentric on ventral trail; paired ridges posterior to dorsal adductor scars, lateral.
Ridges reach ears. Lower Carboniferous (lower Tournaissian): Eurasia, North America, ?northern Africa.—Fig. 348, 2a–e. *T. elegantulus* (Tolmatchoff), Tournaissian, Kuzbass, central Asia; a–c, neotype, dorsal, lateral, anterior views, PIN N 1493/238, ×1; d, posterior view of ventral valve.

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Fig. 346. Productidae (p. 502–505).
Umboanctus Waterhouse in Bamber & Waterhouse, 1971, p. 212 [*U. spinosus; OD]. Size medium; thick shelled with geniculated dorsal valve; ventral trail medianly sulcate, ribbing strong, clearly reticulate disks; spines numerous on both valves, concentric on ventral trail; cardinal ridges prominent, endospines large anteriorly; prominent ventral adductor scar platform. Upper Carboniferous (lower Moscovian): Canada.—Fig. 347.2a–e. *U. spinosus, Moscovian, Yukon; a, ventral view of ventral valve, ×1; b,c, holotype, anterior, dorsal views, GSC 26411, ×1; d,e, ventral, dorsal views of internal cast, ×1 (Bamber & Waterhouse, 1971).

Xinshaoproductus Tan Zhen-xiu, 1986, p. 433[442] [*X. xinshaoensis; OD] [=Neoyanguania Shi Xiao-yeng, 1988, p. 348[352] (type, N. quadrata)]. Simi-

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lar to *Marginatia*, but with less well-defined ribbing, reticulation posteriorly; spines numerous from ventral elongate bases, not known dorsally; weak cardinal ridges plus ridges posterolaterally to adductor scars. Lower Carboniferous (upper Tournaisian); southern China.—Fig. 348, 1a–d. *X. xinshaensis*, Tournaisian, Hunan; a–c, holotype, lateral, anterior, posterior views, HB 302, ×1; d, dorsal valve interior, ×1 (Tan, 1986).

Superfamily

**ECHINOCONCHOIDEA**

Stehli, 1954


Productidines widest anterior to hinge, with corpus cavity deep in most families; trail commonly very short; spines covering both valves, including at hinge, commonly arranged in concentric bands, recumbent, forming dense mats; ribbing absent. Middle Devonian (Givetian)–Upper Permian (Changhsingian).

Family **ECHINOCONCHIDAE**

Stehli, 1954

[Echinoconchidae Stehli, 1954, p. 326]

Corpus with planoconvex profile, cavity deep; dorsal trail commonly short; spines thin, commonly in concentric bands, recumbent. Lower Carboniferous (Tournaisian)–Upper Permian (Kazanian).

Subfamily **ECHINOCONCHINAE**

Stehli, 1954


Concentric bands well developed on both valves bearing spines differentiated in size; buttress plates, cardinal process pit absent. Lower Carboniferous (upper Viséan)–Upper Permian (Kazanian).

Tribe **ECHINOCONCHINI**

Stehli, 1954


Medium to large; concentric bands cuesta-like in profile, posterior part smooth, narrower than anteriorly where spines differentiated by size; one or two rows of thicker spines posteriorly, thinner rows anteriorly; dorsal adductor scars tend to become raised, crests curve laterally. Lower Carboniferous (upper Viséan)–Lower Permian (Sakmarian).

**Echinoconchus** Weller, 1914, p. 138 [*Anomites punctatus* Martin, 1809, pl. 37, fig. 6–8, declared invalid from 1948, ICZN, 1950; *Productus punctatus* J. Sowerby, 1822 in 1821–1822, p. 22; SD Chao, 1927b, p. 63]. Outline transversely subcircular, dorsal valve weakly concave, minimal trails; cardinal process narrow, supported by cardinal ridges; adductor scars elongate, slightly raised.
Rhynchonelliformea—Strophomenata

anteriorly. Lower Carboniferous (upper Viséan): cosmopolitan.——Fig. 349a–e. *E. punctatus* (J. Sowerby), Asbian; a, lectotype, viewed ventrally, Derbyshire, British Isles, BMNH B 60966, ×1 (new); b–d, shell viewed dorsally, laterally, ventrally, Yorkshire, ×1; e, anterolateral detail of ventral exte-

rior, Yorkshire, ×2 (Muir-Wood & Cooper, 1960).

——Fig. 349f. *E. alternatus* (Norwood & Pratten), dorsal valve interior, Chesterian, Oklahoma, ×1 (Muir-Wood & Cooper, 1960).

Echinaria Muir-Wood & Cooper, 1960, p. 248 [*Pro-
ductus semipectatus* Shepard, 1838, p. 153; OD].

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Medium to large; elongate outline widening anteriorly; cardinal ridges, strong median septum support narrow, trifid, cardinal process; ear baffles weak. 

**Upper Carboniferous** (Gzhelian)–**Lower Permian**: North America, northern South America, Eurasia. — Fig. 350, 2a–d. *E. semipunctata* (Shepard), Virgilian; 1a, ventral valve exterior, Texas, ×1; 2a, incomplete dorsal valve exterior, Texas, ×2; 2b, c, shell viewed laterally, Kansas, ×1; 2c, d, dorsal valve interior, Illinois, ×1 (Muir-Wood & Cooper, 1960).

**Stepanoconchus** Lazarev, 1985, p. 69[68] [*Echinoconchidae* postpunctatus Stepanov in Volgin, 1960, p. 62; OD]. Externally resembles *Echinoconchus*, but differs internally by having dorsal adductor scars on laterally curving muscle platforms. **Upper Carboniferous** (upper Gzhelian)–**Lower Permian** (Sakmarian): Ural Mountains. — Fig. 350, 1a,b. *S. postpunctatus* (Stepanov), Lower Permian, Ural Mountains; 1a, dorsal view of incomplete shell fractured at adductor platform, ×0.75; b, transverse section of dorsal adductor platform, valve internal surface to bottom, ×5 (Lazarev, 1990).

**Tribe CALLIPROTONIINAE** Lazarev, 1985  

Medium size; concentric ornamentation of low, anteriorly, somewhat lamellose bands covered by evenly distributed recumbent spines on each band, grading from large to small anteriorly; lateral ridges strongly developed, extending as submarginal ridges. **Upper Carboniferous** (Gzhelian)–**Lower Permian** (Sakmarian).
Calliprotonia Muir-Wood & Cooper, 1960, p. 246
[*C. renfrarum; OD]. Small to medium size; plano-convex with short trails, commonly weak ventromedian sulcation; cardinal process trifid, strongly supported by lateral ridges. Upper Carboniferous (Gzhelian)—Lower Permian (Sakmarian): North America, South America, eastern Europe (Moscow basin, Ural Mountains), Asia, Spitzbergen.——Fig. 351,2a–g. *C. renfrarum, Virgilian, Texas; a–e, shell viewed ventrally, posteriorly, anteriorly, laterally, dorsally, ×1; f–g, dorsal valve exterior, interior, ×2 (Muir-Wood & Cooper, 1960).

Karavankina Ramovš, 1969, p. 261 [*K. typica; OD] [=Karavankina Ramovš, 1966, p. 120, nom. nud.]. Small to medium size; outline commonly transversely subcircular; concentric bands with wide, spine-free regions; cardinal ridges weak, paired dorsal adductor platforms undercut anteromedianly. Upper Carboniferous—Upper Permian (Kazanian): Eurasia.——Fig. 351,1a–d. *K. typica, Kazanian, northern Yugoslavia; a–c, holotype, viewed ventrally, dorsally, laterally, UL 3714/160, ×1; d, detail of ventral ornament, ×5 (Ramovš, 1969).

Echinoconchella Lazarev, 1985, p. 70[68] [*Productus elegans M'Coy, 1844, p. 108; OD]. Resembles Karavankina, but without dorsal muscle platforms. Lower Carboniferous (Brigantian—lower Serpukhovian): Eurasia.——Fig. 351,3a–c. *E. elegans (M'Coy), Brigantian, Scotland; a,b, shell viewed ventrally, laterally, ×2; c, dorsal valve interior, ×3 (new).——Fig. 351,3d. E. venusta (Thomas), lower Brigantian, Derbyshire; dorsal view of shell showing spine bases, ×2 (new).

Tribe KARAVANKININI Ramovš, 1969

Small to medium size; high relief concentric bands, symmetrical in profile, tops bearing concentric rows of spines, distributed by size, separated by wider smooth bands; dorsal adductor scars raised, crests curved medially after Serpukhovian. Lower Carboniferous (Brigantian)—Upper Permian (Kazanian).
Subfamily JURESANIINAE
Muir-Wood & Cooper, 1960

[Juresaniinae Muir-Wood & Cooper, 1960, p. 266]

Concentric bands absent or confined anteriorly; spines may be differentiated by size anteriorly; cardinal process pit, buttress plates present in Carboniferous juveniles only. Lower Carboniferous (Tournaisian)–Upper Permian (Kazanian).

Tribe JURESANIINI
Muir-Wood & Cooper, 1960


Quincuncial pustules posteriorly, reducing in area through upper Permian; concentric bands of spines commonly on rest of valves; anteriorly rugose or lamellose. Lower Carboniferous (upper Asbian)–upper Lower Permian (Roadian).

Juresania FREDERICKS, 1928, p. 786 [*Productus juresanensis CHERNYSHEV, 1902, p. 276; OD*]. Smaller medium size, subquadrate outline with hinge forming widest part; ventral profile weakly geniculate; median sulcation weak; ventral disk with elongate spine bases arranged quincuncially, anterior to disk (trail) nonrugose bands with differentiated spines, elongate thicker spines posteriorly, thinner to disk (trail) nonrugose bands with differentiated spines; anteriorly; buttress plates converging anteriorly to median septum, upper Upper Carboniferous (Kasimovian)–Lower Permian (Aselian): Arctic Eurasia, western Himalayas.—Fig. 352,2a–e. *J. juresanensis* (TSCHERNYSHEV), Schwangerine Limestone, Jurean River, Russia; a,b, syntype, specimen viewed posteriorly, laterally, X1 (Muir-Wood & Cooper, 1960); c, anteroventral view of ventral valve, X1; d, detail of ventral trail, X3 (Lazarev, 1990); e, dorsoposterior view of shell with dorsal valve removed, showing short convergent buttress plates (arrows), X3 (new).

Ametoria COOPER & GRANT, 1975, p. 1055 [*A. residua*; OD]. Medium, hinge wide; spines of two sizes covering venter, clusters on ears and flanks, finer covering dorsal valve; buttress plates absent. upper Lower Permian (Roadian): USA.—Fig. 352,1a–e. *A. residua*, Road Canyon Formation, Texas; a–c, holotype, viewed ventrally, anteriorly, laterally, USNM 153476; X1; d, incomplete dorsal valve exterior, X1; e, incomplete dorsal valve interior, X1.5 (Cooper & Grant, 1975).

Bathymynia Muir-Wood & Cooper, 1960, p. 244 [*Productus nevadensis MEEEK, 1877, p. 64; OD*]. Medium, subquadrate in dorsal outline; dorsal disk plane to gently concave with short trail; medium sulcation slight; spines mixed in size, varied inclinations; ventral disk with elongate swollen bases, anteriorly spines arranged in bands of several rows; cardinal process large, with shaft, buttress plates absent; cardinal ridges strong; ventral valve thick shelled posteriorly. Lower Permian (Artinskian, Kangurian): USA, eastern China, Japan.—Fig. 353,1a–g. *B. nevadensis* (MEEK), Lower Permian, phosphoria Formation; a–d, lectotype, viewed ventrally, posteriorly, anteriorly, laterally, Nevada, USNM 668a, X1; e, dorsal valve exterior, Nevada, X1; f, ventral valve internal mold, Nevada, X1; g, dorsal valve interior, Wyoming, X1 (Muir-Wood & Cooper, 1960).

Biloina REED, 1944, p. 109 [*Strophalosia (Biloina) subsecta*; OD] [=Septasteges WATERHOUSE & PYTASIN, 1970, p. 120 (type, S. acanthus; OD)]. Smaller medium size with subquadrate corpus outline, deep planoconvex profile with geniculate trails; small cistitcs may be present; ventral ginglymus; elongate spine ridges may simulate persistent ribbing; spines strong, evenly scattered on ventral valve, thin on dorsal valve; cardinal process strong, supported by paired elevated adductor platforms; cardinal, marginal ridges strong. Lower Permian (Artinskian): western Pakistan, Thailand.—Fig. 352,2a–e. *B. subsecta*, Amb Formation, Khisor Range; a,b, ventral valve exterior viewed ventrally, laterally, X1; c, incomplete dorsal valve interior, X1 (Grant, 1976).—Fig. 352,2d–g. *B. acantha* (WATERHOUSE & PYTASIN), Rat Bui Limestone, southern Thailand; d,e, ventral valve viewed ventrally, posteriorly; X2; f, dorsal valve exterior, X1; g, dorsal valve interior, X2 (Grant, 1976).

Buntoxia LAZAREV, 1986b, p. 94 [*Buxtonia cabriclella var. mosquensis IVANOVA, 1935, p. 102; OD*]. Dorsal valve almost flat; ventral spine bases swollen umbonally, rugae anteriorly with bands of differentiated spines; median septum grooved posteriorly, upper Upper Carboniferous (upper Asbian)–Upper Carboniferous (Gzhelian): Russia.—Fig. 354a–d. *B. mosquensis* (IVANOVA), Moscovian, Myachkivian, Moscow basin; a–c, ventral valve exterior viewed anteroventrally, laterally, posteroventrally, X1; d, dorsal valve interior, X1 (new).—Fig. 354e,f. B. sp. aff. *B. mosquensis* (IVANOVA), Kasimovian; detail of ventral ornament anteriorly, X3 (Lazarev, 1990).—Fig. 354f. B. sp., Serpukhovian; detail of ventral valve posteroventrally, X3 (Lazarev, 1990).

Cubacula LAZAREV, 1984, p. 73 (70) [*Productus subunguiculatus NIKITIN, 1890, p. 58; OD*]. Small to medium sized; slightly emarginate outline; resembles Parajuresania, but between every four or five recurrent spines erect spines project from middle of bands, each widely separated by narrow rugae originating at about half corpus length, commonly symmetrical in profile. Upper Carboniferous (Kasimovian–lower Gzhelian): eastern Europe.—Fig. 355,1a–f. *C. subunguiculatus* (NIKITIN), Kasimovian, Moscow basin; a–c, shell viewed ventrally, laterally, dorsally, X1; d, detail of cardinal process dorsally, X4; e, detail of ventral valve ornament, X3; f, dorsal valve interior, X1 (new).


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as in *Juresania* posteriorly, but lacks concentric bands anteriorly. *Upper Carboniferous (upper Bashkirian–lower Moscovian): Russia.*—Fig. 356,1a–d. *D. russiensis* (Semenova), lower Moscovian, Moscow basin; *a*, ventral valve viewed anteriorly, ×3; *b*, dorsal valve exterior, ×1; *c*, detail of dorsal valve exterior, ×4; *d*, incomplete juvenile dorsal valve interior showing buttress plates, ×3 (Lazarev, 1982).

*Parajuresania* Lazarev, 1982, p. 70 [*Productus nebrascensis* Owen, 1852, p. 584; OD]. Resembles *Juresania* but differs in having small, uncommon ventral cicatrix; concentric bands with differentiated spines only anteriorly, anterior spines thin, recum-
bent, posterior spines thicker, suberect; buttress plates subparallel as juvenile. *Upper Carboniferous (upper Kasimovian–Lower Permian (Asselian); North America, northern Europe—Fig. 353,2a–f. *P. nebrascensis* (Owen). Asselian, Kansas; a–e, shell viewed ventrally, posteriorly, anteriorly, laterally, dorsally, ×1; f, dorsal valve interior, ×1 (Muir-Wood & Cooper, 1960).

**Pulchratia** Muir-Wood & Cooper, 1960, p. 249 [*Productus symmetricus* McChesney, 1860, p. 35; OD]. Resembles *Parajuresania*, but spines more uniform in size, lacking strong spine bases; lateral ridges diverge slightly from hinge, buttress plates weak, convergent, or lost in adults. *Upper Carboniferous (Kasimovian–Gzhelian); North America—Fig. 353,2a–e. *P. symmetrica* (McChesney), Virgilian, Texas; a–d, shell viewed anteroventrally, laterally, dorsally, dorsolaterally, ×1 (new); e, dorsal valve interior, ×1 (Muir-Wood & Cooper, 1960).

**Vediproductus** Sarytcheva in Sarytcheva & Sokolskaya, 1965, p. 219 [*V. vediensis*; OD]. Medium size, resembles *Juresania*, but differs by having spine bands of strong relief covering ventral valve; cardinal ridges bend sharply across ears, *Upper Lower Permian (Roadian); Transcaucasus, China—Fig. 356,2a–e. *V. vediensis*, Ufimian, Avush,
Transcaucasia: a–c, holotype, viewed ventrally, posteriorly, laterally, PIN 207/32, ×1; d, detail of ventral valve exterior, ×3; e, incomplete dorsal valve interior, ×1 (Sarytcheva & Sokolskaya, 1965).

**Tribe WAAGENOCONCHIN**
Muir-Wood & Cooper, 1960

Corpus with small quincuncially arranged spines, dense mat of long peripheral spines; weak banding anteriorly; trails may be long. Lower Carboniferous (Tournaissian)—Upper Permian.

**Waagenoconcha** Chao, 1927b, p. 24, 85 [*Productus humboldti* d’Orbigny, 1842, p. 54; OD]

Productida—Echinoconchoidea

p. 125 (type, Waagenoconcha wimani FREEDERIKS, 1934, p. 28). Medium to large shells; outline subrounded with hinge slightly less than maximum width; corpus planeconvex, with short trails; corpus covered by pustulose, slightly elongate spine bases arranged quincunxially; dorsal interior with no buttress plates. Wimanoconcha was reported as differing in having anteriorly thickened dorsal valve (but see ARCHBOLD, 1993, upper Capitanian of Australia). Biplatyconcha was reported as lacking dorsal spines. upper Upper Carboniferous–Upper Permian: cosmopolitan.

W. (Waagenochocha) CHAO, 1927b, p. 85 [*Productus humboldti d’OBERGNY, 1842, p. 54; OD]. Waagenoconcha with spreading flanks; ventral trail with smaller spines than corpus and with small rounded bases. upper Upper Carboniferous–upper Lower Permian: cosmopolitan.——Fig. 357,1a–c. *W. humboldti (d’OBERGNY), Lower Permian, Bolivia; shell viewed ventrally, dorsally, posteriorly, ×1 (Muir-Wood & Cooper, 1960).——Fig. 357,1d. W. propheticus (COOPER & GRANT), upper Finnis Shale, Gzhelian, Texas; detail of ventral valve exterior, ×2 (Muir-Wood & Cooper, 1960).——Fig. 357,1e,f. W. magnifica COOPER & GRANT, upper Lower Permian, Texas; dorsal valve exterior, part of interior, ×1 (Muir-Wood & Cooper, 1960).

W. (Gruntoconcha) ANGIOLINI, 1995, p. 206 [*W. (G.) macrotuberculata; OD]. Differs from Waagenoconcha in having coarse, less elongate spine bases, weak differentiation of anterior nonswollen spine bases; weak rugae near start of ventral trail, steep lateral margins giving more strongly convex transverse profile. [Septo-productus FREC, 1911, p. 132 (type, Productus abichi WAAGEN, 1884, p. 697) might be considered a senior synonym, but the type species was misidentified by FRECH and his genus belongs with Tschernyschewia STOVANOVA, 1910; BRUNTON, 1997 (ICZN Case 3034)]. upper Lower Permian (Roadian)–lower Upper Permian (Kazanian); western Himalayas (Karakorum).——Fig. 357,2a. *W. (G.) macrotuberculata, Ufimian, Karakorum; ventral valve exterior, ×1 (new).——Fig. 357,2b–f. W. (G.) abichi...
Rhynchonelliformea—Strophomenata

(WAAGEN), Kazanian, mid-Productus Limestone, Khisor Range; *k*, shell viewed ventrally, anteriorly, ×1 (Muir-Wood & Cooper, 1960); *d*, anteroventral view of shell, ×1.5; *e*, dorsal view of shell, ×1.25; *f*, dorsal valve interior, ×1.5 (Grant, 1966).

**Balkhasheconcha** Lazarev, 1985, p. 68[66] [*Waagenoconcha balkhashensis* NASIKANOVA in Sarytcheva, 1968, p. 106; OD]. Similar to *Waagenoconcha* in ornament, but with buttress plates. **Upper Carboniferous** (Bashkirian–Moscovian): northeastern Arctic Russia.—Fig. 358,2a–c. *B. balkhashensis* (NASIKANOVA), Upper Carboniferous, Keregetask Formation, Kazakhstan; *a*, holotype, ventral valve exterior, PIN 1506/1163, ×1; *b*, incomplete dorsal valve interior, ×1; *c*, detail of ventral external ornament, ×3 (Sarytcheva, 1968).

**Buxtoniella** Abramov & Grigorjeva, 1986, p. 94 [*B. longipina*; OD]. Similar to *Balkhasheconcha* but no anterior band of thinner spines on ventral valve. **Lower Carboniferous** (middle Viséan): Russia.—Fig. 358,1a–d. *B. longipina*, middle Viséan, Sokolsk Beds, Verkhoyanski; *a*, holotype, anteroventral view of ventral valve, PIN 4002/858, ×1; *b*, ventral view of ventral exterior, ×1; *c*, dorsal view of incomplete specimen, ×1; *d*, incomplete dorsal valve interior, ×1 (Abramov & Grigorjeva, 1986).

**Spinauris** Roberts, 1971, p. 107 [*S. cristata*; OD]. Resembles *Waagenoconcha*, but lacks well-differentiated finer spines anteriorly; cardinal process shaft weak or lacking, pit variably present; cardinal ridges weak, short, may extend as weak ear baffles, submarginal ridge. **Lower Carboniferous** (Tournaisian): Western Australia.—Fig. 358,3a–e. *S. cristata*, lower Tournaisian, Bonaparte Gulf; *a–d*, shell viewed ventrally, posteriorly, laterally, dorsally, ×1; *e*, holotype, dorsal valve interior, CPC 8543, ×1 (Roberts, 1971).

Subfamily PUSTULINAE

Waterhouse, 1981

Medium to large size; low rugae; spine base pustules may not be arranged in bands; buttress plates, cardinal process pit absent. **Lower Carboniferous** (upper Tournaisian–Viséan).
**Pustula** THOMAS, 1914, p. 259 [*Producta pustulosa* PHILLIPS, 1836, p. 216; OD]. Outline subrectangular with weak ventral sulcus, dorsal median fold, almost planoconvex, trails minimal; spine bases elongate, in irregular concentric bands with weak spine differentiation; cardinal process narrow, dorsal face trifid; cardinal ridges diminish toward ears, no marginal ridges. Lower Carboniferous (Viséan): Eurasia, northern Africa, North America.—Fig. 359, 1a–f. *P. pustulosa* (PHILLIPS), Asbian–Brigantian; a, holotype, viewed anterolaterally, Lancashire, British Isles, BMNH B419, X1; b–e, specimen viewed ventrally, posteriorly, laterally, dorsally, Staffordshire, X1 (new); f.

?Etheridgina OEHLERT, 1887b, p. 1278 [*Productus complectens Etheridge, 1876, p. 462; OD]. Poorly known, possibly representing the young of more than one taxon; ventral valves around 3 mm wide, attached by clasping spines, rugae bearing scattered spines; associated dorsal valves, similarly rugose, spinose; quadrifid cardinal process supported by cardinal ridges, may also be buttress plates. Lower
Productida—Echinoconchoidea

Carboniferous (Viséan): British Isles.——Fig. 359,2a–d. *E. complicate* (Etheridge), Brigantian, East Lothian; a, ventral valve exterior, ×5; b, ventral valve clasping crinoid stem, ×7; c,d, incomplete dorsal valve exterior, interior, ×5 (Muir-Wood & Cooper, 1960).

**Scutepustula** Sarytcheva in Sarytcheva & others, 1963, p. 165 [*Productus (Wagenhoconcha) scutelatus* Balashova, 1955, p. 146; OD]. Size medium; outline subcircular, closely spaced rugae bearing well-differentiated bands of elongate spine bases; otherwise resembles *Pustula*. Lower Carboniferous (upper Tournaisian): Eurasia, North America.——Fig. 360,1a–e. *S. scutelata* (Balashova), upper Tournaisian, southeastern Ural Mountains; a,b, shell viewed ventrally and with corpus removed, exposing part of dorsal valve external mold, ×1; c, ventral ornament viewed posterolaterally, ×3; d, ventral ornament viewed anteromedianly showing spine bases, ×5; e, ventral valve in lateral profile, ×1 (Sarytcheva & others, 1963).

**Septarinia** Muir-Wood & Cooper, 1960, p. 251 [*Productus leuchtenbergensis* de Koninck, 1847a, p. 226; OD]. Ornamentation resembles *Pustula* on disks, but spines in concentric bands anteriorly, with more prominent dorsal median fold; ventral umbo interior with low median septum. Lower Carboniferous (Asbian): western Europe.——Fig. 360,2a–f. *S. leuchtenbergensis* (de Koninck), Asbian; a,b, lectotype, internal mold, viewed

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Echinococonchoids having shallow corpus cavity; concentric bands, spine differentiation commonly absent. *Middle Devonian* (Givetian)–*Upper Permian* (Changhsingian).

**Subfamily SENTOSINAE** McKellar, 1970


Sentosiids without teeth; spines thin, may have elongate bases. *Upper Devonian* (Famennian)–*Upper Permian* (Changhsingian).

**Tribe SENTOSININI** McKellar, 1970


Concentric rugae or lamellae may be as bands anteriorly. *Upper Devonian* (Famennian)–*Upper Permian* (Changhsingian).

**Sentosia** Muir-Wood & Cooper, 1960, p. 196 [*Krotovia praecursor* Stanbrook, 1947, p. 315; OD]. Size small to medium; outline transversely elliptical, ventral umbo small; rugae delicate, irregular, associated with fine prostrate spines from small rounded bases; cardinal process bilobed, quadrifid, lateral ridges short, only slightly divergent from hinge. *Upper Devonian* (Famennian): North America; *Northern Africa, Europe.*—Fig. 361,1a–e. *S. praecursor* (Stanbrook), Famennian, New Mexico; a–c, shell viewed ventrally, posteriorly, laterally, X1; d, shell viewed dorsally, X2; e, part of dorsal valve interior, X2 (Muir-Wood & Cooper, 1960).

**Alatoproduxus** Jing & Zhu in Jing & Hu, 1978, p. 120 [*A. truncatus*; OD] [=Chenianoproduxus Liao & Meng, 1986, p. 79 (type, *C. nitens*; OD); *Chonostegoidella* Li & Yang in Li, Yang, & Feng, 1986, p. 219 (type, *C. longinensis*; OD)]. Small to medium size, subtrigonal in outline with hinge less than maximum width; small cinctirix present in some; ventral median sulcus shallow; dorsal disk gently concave, trail short; short elongate spine bases with suberect fine spines becoming weakly arranged concentrically anteriorly; interiors poorly known, but with lateral ridges curving to lateral margins. *Lower Permian, Upper Permian* (Kazanian–Changhsingian): China.—Fig. 361,2a,b. *A. truncatus*, Kunlung Formation, Jungtai; dorsal valve external mold, interior, X1.5 (Jin & Hu, 1978).—Fig. 361,2c,d. *A. nitens* Liao & Meng, Upper Permian, Hunan; c, holotype, ventral valve exterior, NIGP 74181, X1.5; d, external mold of dorsal valve, X2 (new).

**Jakutella** Abramov, 1970, p. 119 [*J. sarychevae*; OD]. Medium; ventral profile strongly convex; concentric ornament anteriorly lamellose, somewhat resembling *Stegacanthia*; no differentiation of spines, arranged quincunxally posteriorly; interiors unknown. *Upper Carboniferous* (Moscovian–Kasimovian): northern Asia.—Fig. 361,4a–d. *J. sarychevae*, Moscovian, Yakutsk; a, anterior view of ventral valve exterior, X1 (Abramov, 1970); b,c, posteroventral, lateral views of ventral valve, X1; d, external mold of dorsal valve, X1 (new).

**Laminatia** Muir-Wood & Cooper, 1960, p. 189 [*Prodectella laminata* Kindle, 1909, p. 18; OD]. Small; gently concavoconvex; concentric ornament strong, lamellose; spines differentiated into bands and by size; lateral ridges short, divergent. *Upper Devonian* (Famennian): southern North America, Australia; *Kazakhstan.*—Fig. 362,1a–f. *L. laminata* (Kindle), uppermost Famennian, New Mexico; a, ventral valve exterior, X2; b–e, shell viewed anteriorly, laterally, posteriorly, dorsally, X2; f, dorsal valve interior, X2 (Muir-Wood & Cooper, 1960).

**Mallopredus** Tachibana, 1981, p. 62, nom. nov. pro *Nodella* Tachibana, 1964, p. 38 [*M. pexus*; OD]. Size medium; similar to *Sentosia*, but possibly with longer fine spines, extending almost radially; cardinal process elongate, median septum short, narrow. *Upper Devonian* (Famennian): Japan.—Fig. 362,3a–c. *M. pexus*, Famennian, northeastern Japan; a, ventral valve exterior with corona of spines, squashed, X1; b, replica of dorsal valve exterior, including cardinal process, X1.5; c, replica of dorsal valve interior, X1 (new).

**Markamia** Jin Yungan & Shi Quan in Jin & others, 1985, p. 192 [*M. transversa*; OD] [=Tubercella Li in Li, Yang, & Feng, 1986, p. 222 (type, *T. typica*; OD); *Uralonchus* Lazarev, 1990, p. 112 (type, *Productus jakovlevi* Chernyshev, 1902, p. 300; OD)]. Size small to medium; outline transverse, weakly concavoconvex; spines prostrate, coarse posteriorly on narrow lamellose bands separated by narrower bands of smooth shell; dorsal spines fine; interiors unknown. *Upper Carboniferous* (Gzhelian)–*Lower Permian* (Artinskian): China, Tibet, western Ural Mountains.—Fig. 362,4a,b. *M. transversa*, Gzhelian–Asselian, Xizang: a, ventral valve exterior, NIGP 60757, X1; b, dorsal valve exterior, X1 (Jin & others, 1985).

**Productellana** Stanbrook, 1950, p. 373 [*P. bifaria*; OD]. Small; outline subcircular, reportedly with short interarea, open delthyrium; rugae weak, irregular, slightly lamellose; spines widely spaced, weakly concentric. *Upper Devonian* (Famennian): North America, *China.*—Fig. 362,2a–e. *P. bifaria*, Famennian, Aplington, Iowa; a–e, holotype,
viewed ventrally, laterally, anteriorly, SUI 21656A, ×1; d, shell viewed dorsally, ×1.5; e, shell viewed dorsally, ×3 (new).

**Sentosioides** Lazarev in Lazarev & Suur'suren, 1992, p. 69 [*S. tsagankhalginensis*; OD]. Ventral umbo moderately inflated; elongate spine-base pustules on both valves, ventral spines thicker than *Sentosia*; weak concentric ornament. **Upper Devonian** (upper Famennian): Russia, Asia.——Fig. 362, a–d. *S. tsagankhalginensis*, uppermost Famennian, Gobi Altai, Mongolia; a, incomplete ventral valve exterior, ×2 (new); b, replica of incomplete dorsal valve exterior, ×1.5; c, part of dorsal valve interior plus external mold, ×1.6 (new); d, holotype, incomplete dorsal valve interior, PIN 3385/1050, ×1 (Lazarev & Suur’suren, 1992).

**Stegacanthia** Muir-Wood & Cooper, 1960, p. 198 [*S. bowsherii*; OD]. Size medium; concavoconvex with short trails, ornament lamellose, each band with elongate spine bases, spines prostrate; lateral ridges diverge toward ears. **Lower Carboniferous** (upper Tournaisian–lower Viséan): southern North America, ?northern Africa, Europe.——Fig. 361, a–e. *S. bowsherii*, Ivorian, New Mexico; a–d, holotype, viewed ventrally, anteriorly, laterally, dorsally, USNM 123963, ×1; e, dorsal valve interior, ×1 (Muir-Wood & Cooper, 1960).

**Tribe BAGRASINI** Nalivkin, 1979

[nom. transl. Brunton, Lazarev, & Grant, 1995, p. 929, ex Bagrasiinae Nalivkin, 1979, p. 189]

Elongate spine bases simulate ribs on both valves. **Lower Carboniferous** (upper Tournaisian–lower Viséan).
Erictatia Muir-Wood & Cooper, 1960, p. 172
[*Productus newberryi Hall, 1857, p. 180; OD; =Productella newberryi Hall, 1883, pl. 49, fig. 1–3]
[*Bagrusia Nalivkin in Sarytcheva, Licharew, & Sokolskaja, 1960, p. 251 (type, Productus chonetiformis Krestovnikov & Karpenchev, 1948, p. 48)].
Size small to medium; outline subcircular to transverse, elongate spine bases simulate ribbing over
Productida—Echinoconchoidea

complete shell; cardinal process weakly supported by short lateral ridges. Lower Carboniferous (upper Tournaisian–lower Viséan): western Ural Mountains, North America.—Fig. 363.a–d. *E. newberryi* (Hall), upper Kinderhookian–lower Osagean, Ohio; a, ventral valve exterior, X1; b, lateral profile

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of ventral valve, X1; c, replica of dorsal valve exterior, X1; d, replica of incomplete dorsal valve interior, X1.5 (Muir-Wood & Cooper, 1960).

Subfamily CAUCASIPRODUCTINAE Lazarev, 1987

[Caucasiproductinae Lazarev, 1987, p. 49]

Sentosiids with teeth, sockets; ventral spines relatively thick, suberect; lateral ridges short, divergent anteriorly. Middle Devonian (Givetian)–Upper Devonian (Famennian).

Caucasiproductus Lazarev, 1987, p. 50[47] [*C. gretchishnikovae, OD]. Size small; narrow ginglymus; thick-walled with up to 0.5 mm thick ventral spines; short ventral median septum; cardinal process strongly V-shaped. Middle Devonian (Givetian): Transcaucasia.——Fig. 364,2a. *C. gretchishnikovae, Givetian, Transcaucasia; holotype, ventral valve exterior, PIN 4127/103, X3 (Lazarev, 1987).——Fig. 364,2b–c. Caucasiproductus sp.; b, c, dorsal, posterior views of shell, X3 (Lazarev, 1987); d, ventral valve internal mold plus shell anterolaterally, X3; e, dorsal valve interior, X3 (Lazarev, 1990).

Praewaagenoconcha Sokolskaya, 1948, p. 132 [*Productus orielanus von Möller, 1871, p. 389; OD]. Small; thinner shelled than Caucasiproductus, spines relatively fine in roughly concentric arrangement, commonly with spine bearing median ridge; no ventral median septum. Upper Devonian (Famennian): eastern Europe.——Fig. 364,3a–d. *P. orielana (von Möller), Famennian, Moscow basin; a, b, ventral valve exterior viewed ventrally, laterally, X2; c, shell viewed posteriorly, X2; d, shell viewed dorsally showing spines, X2 (new).

Strophoproductus Nalivkin, 1937, p. 46 [*Productella hystricula Hall, 1867c, p. 178; OD]. Small; undulose concentric ornament; weak elongate spine bases, spines probably recumbent; cardinal process strongly bilobed internally, with pit and short socket ridges. Upper Devonian (Frasnian): North America, Eurasia.——Fig. 364,1a–c. *S. hystriculus (Hall), Frasnian, New York; a, ventral valve exterior, X2; b, dorsal valve exterior, X2; c, dorsal valve interior on left, X2 (Muir-Wood & Cooper, 1960).

Family UNCERTAIN

Septiconcha Termier & others, 1974, p. 125 [*S. taeniina; OD]. Insufficient morphology to assign, but if deep corpus cavity, then assigned to Juraseaniinae. Upper Permian (Kazanian): Afghanistan.

Superfamily LINOPRODUCTOIDEA Stehli, 1954


Trail commonly long but simple; ribbing regular, entire, relatively fine, commonly delicately sinuose; ventral spines at hinge, diverse on rest of valve, never few, thick and symmetrical; dorsal valve without spines except grandaurispinins and some giganto-productins. Lower Devonian (Pragian)–Upper Permian (upper Tatarian).

Family LINOPRODUCTIDAE Stehli, 1954


Linoproductoids with deep corpus cavity, distinct trails; commonly no dorsal spines.


**Lower Carboniferous (middle Viséan)–Upper Permian (Tatarian).**

**Subfamily LINOPRODUCTINAE**

Stehli, 1954

[Linoproductinae STEHLI, 1954, p. 319] [=Fluctuariinae NALIVKIN, 1979, p. 107; Stepanoviellinae WATERHOUSE, 1975, p. 12]

Linoproductids without marginal structures or dorsal spines. **Lower Carboniferous (middle Viséan)–Upper Permian (Kazanian).**

**Linoproductus** CHAO, 1927b, p. 128 ["Productus cora d’ORBIGNY, 1842, p. 55; OD] [=Epiproductus WHITEHOUSE, 1928, p. 281, obj.; Cora FREDDERICKS, 1928, p. 781, 790, obj; Leviapicus TONG in TONG & others, 1990, p. 66[100] (type, L. giganteus)]. Medium to large, outline elongate subcircular; ventral profile inflated posteriorly, dorsal corpus gently concave; hinge commonly widest part of shell; ribbing complete, tends to be distorted at spine bases, which are widely scattered ventrally; spines also closely set in one or two rows along hinge; rugae on ventral ears, flanks, dorsal corpus; cardinal process sessile, trifid, supported by lateral ridges; adductor scars, brachial ridges weakly marked. [Leviapicus, Zhigou Formation (Sakmarian) of Sichuan, is reported as having a group of spines on ears.] upper Upper Carboniferous–Upper Permian (Kazanian); cosmopolitan.—**Fig. 365.**

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**Fig. 364.** Sentosiidae (p. 526).
ventrally, ×1; f. incomplete dorsal valve interior, ×1 (Kozlowski, 1914).

**Balakhonia** Sarytcheva in Sarytcheva & others, 1963, p. 231 [*B. ostrogensis*, OD]. Medium size; ventral profile convex with long trail, ears prominent, flanks gently sloping; spines at hinge, rarely on ventral corpus where finer than ribs; cardinal process sessile with well-separated lobes; dorsal adductor scars di-
vided, bordered posterolaterally by ridges. **Upper Lower Carboniferous (upper Viséan–lower Serpukhovian),** ?*Upper Carboniferous (Bashkirian)*: Eurasia, ?northern Africa.—**Fig. 365.2a–d.** *B. astrogenis,* upper Viséan–Serpukhovian, Ostrog Formation, Kuzbass; a–c, holotype, internal mold of ventral valve, dorsal valve external, internal molds, PIN 1493/278, ×1; d, incomplete dorsal valve interior, ×2 (Sarytcheva & others, 1963).

**Bandoproductus** JIN & SUN, 1981, p. 138 [*B. hemiglobica; OD]*. Medium size, resembling *Linoproductus,* but with fine ventral spines no wider than ribs on corpus, single row of hinge spines; trails short; thin shelled. **Upper Carboniferous (Gzhelian)–Lower Permian (Sakmarian):** Tibet (Xizang).—**Fig. 366.4a,b.** *B. hemiglobica,* Lower Permian, Bando Group, Tibet; a, ventral valve exterior, ×1; b, external mold of incomplete dorsal valve, ×1 (Jin & Sun, 1981).

**Coolkilella** ARCHBOLD, 1993, p. 14 [*Cancrinella coolkilyaensis* ARCHBOLD, 1983b, p. 241; OD]. Resembles *Cancrinella,* but with planoconvex corpus, strongly geniculate dorsal valve, long trails; rugae at ears, weak on disks; spines in two rows on ears, sparse on venter from weakly developed, elongate bases. **Upper Lower Permian (upper Artinskian–lower Kungurian):** Western Australia.—**Fig. 366.1a–e.** *C. coolkilyaensis* (ARCHBOLD), upper Lower...
Rhynchonelliformea—Strophomenata

Fluctuaria Muir-Wood & Cooper, 1960, p. 303
[*Productus undatus D'Orbigny, 1826, p. 354; OD]. Small; elongate, nongeniculate profile; rugae prominent, entire, increasing in size anteriorly; spines at hinge, ears, otherwise rare; cardinal process small, sessile; cardinal ridges weak. Lower Carboniferous (upper Viséan)—Upper Carboniferous (lower Moscovian): Eurasia, ?North America. ——Fig. 366.2a–d.

Kasetia Waterhouse, 1981, p. 89 [*K. kaseti; OD]. Resembles Coolkilella, but small with irregular discontinuous rugae; spines in clusters on ear, weakly developed spine bases. Lower Permian (Artinskian): southern Thailand. ——Fig. 367.2a–e. *K. kaseti, Lower Permian, Ko Yao Noi Formation, Thailand; a,b, holotype, incomplete internal mold of ventral, dorsal valves, TBR 287, ×3; c, ventral valve internal mold, ×3; d, replica of ventral valve exterior, ×3; e, exfoliated dorsal valve interior, ×3 (Waterhouse, 1981).

Marginovatia Gordon & Henry, 1990, p. 533 [*Productus ovatus var. minor Snider, 1915, p. 79; OD]. Small, less than 20 mm wide; spines in one or two rows near ventral hinge, others sparsely scattered; rugae at ears, less commonly complete on ventral disk; marginal ridges in both valves at start of trails. Lower Carboniferous (middle Viséan)—Upper Carboniferous (Bashkirian): USA, Arctic Canada. ——Fig. 365.3a–f. *M. minor (Snider), Chesterian, Oklahoma; a–d, ventral, dorsal, posterior, lateral views of shell, ×2; e, posterolateral view of shell, ×2; f, dorsal valve interior, ×3 (Gordon & Henry, 1990).

?Mistproductus Yang De-li, 1991, p. 81[90] [*M. eucallusus; OD]. Poorly known, similar to Linoproductis, but may be folded anteriorly, possibly resulting from shell damage, and reportedly with cinctirix surrounded by rhizoid spines on ear, flanks; corpus cavity deep. Lower Permian (Artinskian–Kungurian): southern China.——Fig. 366.3a–c. *M. eucallusus, Lower Permian, Guangxi; a,b, ventral valve exterior, lateral view, ×1; c, dorsal valve interior, ×1.5 (Yang De-li, 1991).

Subfamily ANIDANTHINAE

Waterhouse, 1968

[Anidanthinae Waterhouse, 1968a, p. 1172]

Linoproductids with well-developed ears, marginal structures; concentric lamellae (series of trails) commonly on dorsal valve; corpus cavity commonly deep. Upper Carboniferous (Bashkirian)—Upper Permian (Capitanian).
**Anidanthus** Hill, 1950, p. 9 [*Linoproductus springsurensis* Booker, 1932, p. 67; OD] [≡*Anidanthus Whitehouse, 1928, p. 282, nom. nud.; *Pseudomarginifera* Stepánov, 1934, p. 56 (type, *Productus ussuricus* Fredericks, 1924, p. 8)]. Medium size, transverse shells with large, well-differentiated ears forming maximum width; ribbing on both valves, except ears; rugae lamellose dorsally; spines in row near hinge, widely scattered on corpus, trail; dorsal interior with thickened shell posteromedianly, median septum about half disk length. *Upper Lower Permian*–*Lower* *Upper Permian*: Australia, northern and central Asia, central America.——*Fig. 368,1a–d.* *A. springsurensis* (Booker), New South Wales; *a*, ventral valve exterior; *b*, dorsal valve exterior; *c*, ventral valve interior; *d*, replica of dorsal valve interior (Muir-Wood & Cooper, 1960).

**Akatchania** Kleits in Abramov & Grigorjeva, 1988, p. 135 [*A. plana*; OD]. Medium size, hinge width approximately equal to corpus width; cavity shallow; rugae on ventral flanks and ears, dorsal valve with widely separated lamellae; spines near hinge only, extending posterolaterally; median septum short; lateral, marginal ridges complete in both valves. *Lower Permian* (Asselian): central Siberia.——*Fig. 368,4a–d.* *A. plana*, Lower Permian, Katchan Formation, southern Verkhoyan; *a,b*, holotype, internal mold viewed ventrally, dorsally.
Fusiproductus Waterhouse, 1975, p. 12 [*Linoproductus fusiformis Huang, 1932, p. 45; OD]. Poorly known small shells with highly enroled ventral valve; outline wide with subtubular ventral ears; ribbing fine; spines single on ears, lacking on venter. Upper Permian (Capitanian): China (Guizhou), ?Urals, ?Siberia.—Fig. 368,2. *F. fusiformis (Huang), Capitanian, Guizhou; ventral valve exterior, X1 (Huang, 1932).

Kuvelousia Waterhouse, 1968a, p. 1175 [*K. sphiva; OD] [=Nothokuvelousia Waterhouse in Waterhouse & Briggs, 1986, p. 62 (type, N. aurifera)]. Resembles Megousia, but larger with dorsal valve heavily thickened; median septum may reach marginal ridge. Upper Permian (Kazanian): Arctic Canada, USA, eastern Australia.—Fig. 369,1a-f. *K. sphiva, Kazanian, Degerbols Formation, Arctic Canada; a–c, holotype, ventral valve exterior, interior, dorsal valve exterior, GSC 22910, X1; d,e, ventral valve exterior, viewed laterally, ×1; f, dorsal valve interior, X1 (Waterhouse, 1968a).

Megousia Muir-Wood & Cooper, 1960, p. 309 [*M. auriculata; OD]. Resembles Anidanthus, but ribbing on extended ears curving anterodorsally. Lower Upper Permian: North America, eastern Australia, Tasmania.—Fig. 369,3a–c. *M. auriculata, Upper Permian, Word Limestone, Texas; a, holotype,
viewed dorsally, USNM 124108b, \( \times 2 \); b, ventral valve exterior, \( \times 2 \); c, dorsal valve interior, \( \times 3 \) (Muir-Wood & Cooper, 1960).—Fig. 369, 3d. M. alata (COOPER), Monos Formation, Sonora, Mexico; ventral valve exterior, \( \times 2 \) (Muir-Wood & Cooper, 1960).

**Protanidanthus** Liao, 1979, p. 536[544] [*P. elegans*; OD]. Similar to **Aidanthus**, but lacks dorsal lamellae. Lower Permian: China.—Fig. 368, a–c. *P. elegans*, Asselian, Guizhou; a, ventral valve exterior, \( \times 1 \); b, dorsal valve exterior, \( \times 1 \); c, lateral view of shell, \( \times 1 \) (Liao, 1979).

**Zia** Sutherland & Harlow, 1973, p. 59 [*Z. novamexicana; OD*] [=**Semilunataproductus** HAN TONG-XIANG in HAN & others, 1987, p. 317 (type, S. semilunatus; OD)] Medium size, around 30 mm wide; outline subcircular, profile geniculate with flattened ventral disk; disks reticulate, trails ribbed; spines scattered on ventral valve, but larger on trail; dorsal disk weakly concave with maximum width; dorsal disk tinct, rugae weak on dorsal disk; spines thick, in short trail; ribbing fine (capillae) commonly indiscernible. Resembles **Linoproductus** with thin spines also on dorsal corpus; ribbing may be reduced; marginal structures, series of trails absent. [Upper Carboniferous (Gzhelian)—Upper Permian (Tatarian)].

**Subfamily GRANDAURISPININAE**

**Lazarev**, 1986

[Grandaurispininae Lazarev, 1986c, p. 32] [=**Paucispininae Waterhouse in Waterhouse & Briggs, 1986, p. 2**]

Linoproductids with thin spines also on dorsal corpus; ribbing may be reduced; marginal structures, series of trails absent. [Upper Carboniferous (Gzhelian)—Upper Permian (Tatarian)].

**Grandaurispina** Muir-Wood & Cooper, 1960, p. 305 [*C. kingorum; OD*]. Medium size with hinge at maximum width; dorsal disk weakly concave with short trail; ribbing fine (capillae) commonly indistinct, rugae weak on dorsal disk; spines thick, in clusters on ears and flanks, thin with slightly elongated bases quincuncially arranged ventrally; dorsal valve with dimples, thin suberect spines; cardinal process sessile, trifid, lacking pit; lateral ridges short, medium septum long. [Upper Permian (Kazanian): Upper Permian, Word Formation, Texas; a, holotype, viewed dorsally, USNM 123454, \( \times 1.5 \); b, ventral valve exterior, \( \times 1 \); c, d, dorsal valve viewed externally showing capillae, internally, \( \times 2 \) (Muir-Wood & Cooper, 1960).]

**Cancrinella** Fredericks, 1928, p. 784 [*Productus cancrinellifer de VERNEUIL, 1845, p. 245; OD*] [=**Platyacancrinella** Waterhouse, 1983b, p. 126 (type, *P. grandarius*).] Small to medium size, corpus almost planoconvex, deep cavity; spines with elongate swollen bases on ribs, evenly distributed, clusters on ears, spines fine on dorsal valves; rugae weak on both valves; cardinal process sessile; lateral ridges close to hinge; median septum commonly divided posteriorly. [**Platyacancrinella**, from Upper Permian of Nepal, said to differ by having less crowded spines on ears and flanks.] [Upper Carboniferous (Gzhelian)—Upper Permian (Wordian): cosmopolitan. —Fig. 370, 2a–d. *C. cancricrini de VERNEUIL*, Lower Permian, Arctic Russia; a–c, shell viewed ventrally, dorsally, laterally, \( \times 1 \); d, part of dorsal valve interior, \( \times 4 \) (Sarytcheva, 1977). —Fig. 370, 2e,f. *C. subquadrate Cooper & Grant*, Upper Permian, Word Formation, Texas; a, dorsal valve exterior, \( \times 2 \); f, dorsal valve interior, \( \times 1 \) (Cooper & Grant, 1975). —Fig. 370, 2g,h. *C. subquadrata* (R. H. King), Guizhian, Wayland Shale, Texas; shell viewed ventrally, dorsally, \( \times 1 \) (Muir-Wood & Cooper, 1960).

**Holotricharina** Cooper & Grant, 1975, p. 1173 [*H. hirvata; OD*]. Resembles **Grandaurispina** with ventral spines of two sizes, but lacks ventral ribbing. Lower Permian—Lower Upper Permian: USA.—Fig. 371, 1a,e. *H. hirvata*, Lower Permian, Road Canyon Formation, Texas; a, holotype, ventral valve exterior, USNM 149866a, \( \times 1 \); b, c, ventral valve exterior viewed ventrally, laterally, \( \times 1 \); d, shell viewed dorsally, \( \times 2 \); e, dorsal valve interior, \( \times 2 \) (Cooper & Grant, 1975).

**Lyonia** Archbold, 1983b, p. 244 [*Linoproductus cancricformis var. lyoni Prendergast, 1943, p. 24; OD*]. Resembles **Cancrinella**, but with strong hinge spines, no ear clusters, dorsal spines developed anteriorly; cardinal process small, unusually sessile, not supported by ridges, lacking clear lateral ridges. Lower Permian (Sakmarian): Western Australia, Himalayas.—Fig. 372, 1a–e. *L. lyoni* (Prendergast), Sakmarian, Lyons Group, Carnarvon basin; a, holotype, ventral valve exterior, AMF 36530, \( \times 1 \); b, ventral valve exterior, \( \times 1 \); c, dorsal valve external mold, \( \times 1 \); d, dorsal valve internal mold, \( \times 1 \); e, replica of dorsal cardinalia, \( \times 4.5 \) (Archbold, 1983b).

**Paucispininaria** Waterhouse, 1983b, p. 130 [*Terekea concava Waterhouse, 1964, p. 67; OD*]. Similar to **Terekea**, but possibly differing in its coarser ventral spines and band of coarse spines at base of dorsal trail. [Upper Permian—Lower Upper Permian: southern New Zealand, Australia. —Fig. 371, 2a–e. *P. concava* (Waterhouse), low Upper Permian, *Productus Creek* Limestone, Southland, New Zealand; a, b, holotype, ventral valve internal mold viewed posteriorly, replica of dorsal external valve, NZGS BR 200, \( \times 2 \); c, d, ventral valve exterior viewed anteriorly, posteroventrally, \( \times 2 \); e, replica of dorsal valve interior, \( \times 2 \) (Waterhouse, 1964).]

**Stepanoviella** Zavodovsky, 1960, p. 336 [*S. paracurvata; OD*]. Resembles **Globiella**, but with planoconvex deep corpus profile; outline more transverse, with recumbent, suberect spines on ventral valve, suberect spines on dorsal trail. [Upper Permian (Kazanian–Tatarian): northeastern Russia. —Fig. 370, 3a–e. *S. paracurvata*, Kazanian,
Rhynchonelliformea—Strophomenata

Khivatch Horizon, Kolymo-Omolon; a–d, holotype, viewed ventrally, anteriorly, posteriorly, laterally; TsNIGRA 30/9081, X1; e, dorsal valve interior, X1 (Zavodowsky, 1960).

Terrakea BOOKER, 1930, p. 66 [*Productus brachythaerus MORRIS in DE STREZLECKI, 1845, p. 284, non G. B. SOWERBY, 1844, p. 158; SD MAXWELL, 1956, p. 335] [=Saetolina WATERHOUSE in WATERHOUSE & BRIGGS, 1986, p. 54 (type, Terrakea multispinosa DEAR, 1971, p. 18)]. Medium size, gently concavoconvex profile, moderate to deep corpus; ribbing on both valves, ventrally with swollen elongate spine bases with semirecumbent spines; spines on dorsal valve mainly anteriorly; dorsal lateral ridges slightly divergent from hinge; median ridge commonly weakly divided posteriorly. Lower Permian—lower Upper Permian: eastern Australia, New Zealand, Russian Arctic.——Fig. 372,2a–d. *T. brachythaerus (MORRIS), upper Marine Series, New South Wales; a, ventral valve internal mold viewed

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laterally, ×1; b, exfoliated dorsal valve exterior, ×1; c, replica of shell viewed dorsally, ×1; d, replica of dorsal valve interior, ×1 (Muir-Wood & Cooper, 1960).——Fig. 372.2e,f. T. fragile (Dana); ventral valve internal mold, ventral valve exterior, ×1 (Muir-Wood & Cooper, 1960).

Subfamily SIPHONOSIINAE Lazarev, 1986

[Siphonosiinae LAZAREV, 1986c, p. 32]

Linoproductids with elongate outline, short tubiform ventral trail; hinge narrower than maximum width; spines rhizoid, on ventral valve only; marginal structures at borders of both valves. upper Lower Permian (Artinskian–Kungurian).

Siphonosia COOPER & GRANT, 1975, p. 1188 [*S. alleni; OD]. Small siphonate shells; beak with small cicatrix; weakly reticulate disks; spines posterolaterally on ventral valve; ventral diductor scars widely triangular; cardinal process sessile, narrow quadrifid; lateral ridges strongly divergent; brachial ridges elongate, reaching disk borders. upper Lower Permian (Artinskian–Kungurian): USA.——Fig. 373a–f. *S. alleni, Cathedral Mountain Formation, Texas; a–c, holotype, ventral valve viewed ventrally, posteriorly, laterally, USNM 152789a, ×1.5; d, holotype, ventral valve viewed internally, USNM 152789a, ×1.5; e, dorsal valve exterior, ×2; f, dorsal valve interior, ×3 (Cooper & Grant, 1975).
Subfamily UNCERTAIN


Family MONTICULIFERIDAE
Muir-Wood & Cooper, 1960


Linoproductoids with moderately shallow corpus cavity, rarely very shallow; rugae posterolaterally or irregularly widespread; spines on ventral valve, rarely restricted to hinge region; marginal structures normally absent. Lower Devonian (Pragian)—Upper Permian (upper Tatarian).

Subfamily MONTICULIFERINAE
Muir-Wood & Cooper, 1960

[Monticuliferinae Muir-Wood & Cooper, 1960, p. 327]

Medium to large with weakly convex transverse profile; lateral shell profile flattened over disks, convex geniculation, trails; spines at hinge, scattered on venter; commonly with tubercles or monticules, capillae may be present. Lower Permian (Artinskian)—Upper Permian (Kazanian).

Monticulifera Muir-Wood & Cooper, 1960, p. 327 [*Productus intermedius var. sinensis Frech, 1911, p. 176; OD] [=Sinoproductus Chan & Li, 1962, p. 477, obj.]. Medium size; monticules dense posteriorly, decreasing anteriorly, interrupted by irregular capillae; ill-defined ribs on trail; spines near hinge line, scattered on ventral valve; dorsal median septum narrow, almost reaching anterior edge of disk.
Lower Permian (Artinskian–Kungurian), Upper Permian (Kazanian); central China, Indonesia.—Fig. 374,2a–d. *M. sinensis* (Frech), Chihisian–Maokouan, Sichuan; a,b, ventral valve exterior, lateral views, ×1; c, detail of external ornament, ×3; d, incomplete dorsal valve interior, ×2 (Muir-Wood & Cooper, 1960).

Chilianshania Yang & Ting in Yang & others, 1962, p. 85 [*C. chinlanbananensis* Ting in Yang & others, 1962, p. 86; OD] [*Capillifera* Jin & Ye in Jin & others, 1979, p. 86, invalid; *Pseudomonticulifera* Zha & Tan, 1984b, p. 26 (type, *C. bananensis* Zhao & Tan in Liu, Tan, & Ding, 1982, p. 189)]. Resembles *Monticulifera*, but lacks capillae ventrally and monticles; small spine tubercules present posteriorly. (*Capillifera* erected in incorrect belief that *Chilianshania* was junior homonym of a trilobite, however, spelling is different: *Qilianshania* Chu, 1960, p. 62.) upper Lower Permian (Artinskian)–lower Upper Permian (Kazanian); west central China.—Fig. 374,1a–d. *C. chinlanbananensis* (Ding), Chihisian–Maokouan, Qinghai; a,b, holotype, viewed posteriorly, anteriorly, IGAS 00178, ×1; c, ventral valve viewed posteriorly, ×1; d, incomplete dorsal valve interior, ×1 (Yang & others, 1962).

?Paramonticulifera Tong, 1978, p. 234 [*P. incusta*; OD] [*Tonghuella* Liang, 1990, p. 202[466] (type, *T. basilica*). Medium to large transverse shells, around 50 mm, resembling *Monticulifera*, but lacking capillae and having tuberculate ornament, possibly not true monticles; no anterior ribbing. lower Upper Permian: China.—Fig. 375,1a–d. *P. incusta*, Upper Permian, Maokouan Formation, Sichuan; a–c, holotype, viewed ventrally, posteriorly, laterally, SB 4075, repository unknown, ×1; d, posterior view of ventral valve, ×1 (Yang & others, 1962).

Zhenania Ding in Zhang, Fu, & Ding, 1983, p. 293 [*Z. zhenanensis*; OD]. Poorly known; similar to *Monticulifera*, but with smaller tubercules or monticles; capillate, but with no anterior ribs. upper Lower Permian (Roadian)–lower Upper Permian (Wordian); China.—Fig. 375,2a–c. *Z. zhenanensis*, Upper Permian, Shuxiaokou Formation, Shanxi; posterior, anterior, lateral views, ×1 (Zhang, Fu, & Ding, 1983).

Subfamily AURICULISPININAE

Waterhouse, 1986


Medium size with rounded to elongate outline; spines normally on ventral valve only, with clusters on ears; teeth, sockets absent; marginal structures commonly absent. Lower Carboniferous (Tournaisian)–Upper Permian (Capitanian).

Auriculispina Waterhouse, 1975, p. 13 [*Cancrinella levis* Maxwell, 1964, p. 34; OD]. Medium size with narrow ventral umbo; both valves finely ribbed, moderately rugose; spines ventral only, dense along hinge, ears, quinconically on venter; dorsal valve dimpled; ventral adductor scars smooth to striate. Lower Permian: eastern Australia.—Fig. 376,1a–d. *A. levis* (Maxwell), Lower Permian, Burnett Formation, Yaral basin; a, holotype, ventral valve internal mold, UQF 187056, ×1.5; b, incomplete ventral valve external mold, ×1.5 (Waterhouse & Briggs, 1986); c, dorsal valve internal mold, ×1.2; d, part of ventral valve exterior, ×1.2 (Maxwell, 1964).

Asperlinus Waterhouse & Pivskin, 1970, p. 132 [*Productus asperulus* Waagen, 1884, p. 693; OD]. Small size with relatively strong ribbing; spines evenly distributed over ventral valve, producing dorsal dimples; weak lateral ridges in dorsal valve. upper Lower Permian–Upper Permian (Capitanian); western Pakistan, Thailand, Timor.—Fig. 376,4a–d. *A. asperulus* (Waagen), upper Productus Limestone, Capitanian, Salt Range, Pakistan; a–c, lectotype, viewed ventrally, dorsally, anteriorly, GSI F3732, ×1; d, incomplete dorsal valve interior, ×1 (Waagen, 1884).

Cancrinelloides Ustritsky in Ustritsky & Tschernjak, 1963, p. 85 [*Productus obrutschewi* Licharew,
1934c, p. 24; OD]. Medium to large, transverse shell; profile gently convex with weak geniculation, short trail; corpus cavity becoming moderate in depth by adulthood; spine bases elongate except at hinge, anterior margin; spines evenly distributed, recumbent posteriorly, erect, more dense anteriorly; lateral ridges diverge from hinge, rather short; short ridges posterolaterally to dorsal adductor scars. Upper Lower Permian (Roadian): Arctic, Transbaikalia, Mongolia.—Fig. 376, 3a–c. *C. obrutschewi* (Licharew), Roadian, Omolonskya; a, holotype, incomplete ventral valve exterior, TsNIGRA 16/10901, ×1; b, lateral view of ventral valve, ×1; c, ventral valve exterior, ×1 (Sarytcheva, 1977).

*Chianella* Waterhouse, 1975, p. 13 [*Avonia? chianensis* Chao, 1927b, p. 126; OD] [=Longyanta Zhu, 1990, p. 71 (type, *L. magna*)]. Small to medium shells with wide hinge, well-defined ears; ventral disk flattish, curving into simple trail; ribbing strong; spines along ventral hinge, sparsely scattered; rugae on dorsal flanks. *Longyanta* is very poorly known, appearing to be somewhat larger, coming from lower Upper Permian of China (Maokouan); upper Lower Permian (Kungurian)—lower Upper Permian (Kazanian): China.—Fig. 377, 1a–c. *C. chianensis* (Chao), Hsiaokiang Limestone, Jiangxi; a, b, holotype, viewed ventrally, laterally, NIGP 904, ×1; c, median longitudinal section of specimen, ×1 (Chao, 1927b).

*Costatumulus* Waterhouse in Waterhouse & Briggs, 1986, p. 58 [*Auriculospina tumidus* Waterhouse, Briggs, & Parfrey, 1983, p. 133; OD]. Similar to *Cancrinelloides* with double row of spines close to ventral hinge, but possibly with less regular rugae, elongate spine bases continuing to ventral valve margin. Lower Permian (Artinskian): Australia, central and eastern Himalayas.—Fig. 376, 2a–d. *C. tumidus* (Waterhouse, Briggs, & Parfrey), Lower Permian, Elvinita Formation, Bowen basin, Australia; a, replica of ventral valve exterior, ×1.5; b, replica of incomplete ventral valve exterior, ×1.5; c, dorsal valve external mold, ×1.5; d, replica of dorsal valve interior, ×1.5 (Waterhouse & Briggs, 1986).

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Filiconcha Dear, 1969, p. 299 [*F. hillae; OD]. Similar to Cancrinelloides, but with more abundant spines posteriorly, spines on dorsal valve also. Upper Lower Permian: eastern Australia.——Fig. 377, 3a–e. *F. hillae, Flat Top Formation, Lower Permian, Bowen basin, Australia; a, holotype, viewed ventrally, GSQ F10996a, ×1; b, replica of ventral valve exterior, ×1; c, dorsal valve internal mold, ×1.5; d, replica of part of dorsal interior, ×3; e, dorsal valve external mold, ×2 (Dear, 1969).

Globiella Muir-Wood & Cooper, 1960, p. 304 [*Productus hemisphaericum Kutorga, 1844, p. 99; OD]. Smaller medium size shell, globose, anteriorly elongate; small, poorly differentiated ears at maximum width; anterior flanks steep, corpus cavity moderately shallow; ribbing fine, regular, covering shell; spines only at ventral hinge; ventral muscle field deeply impressed; ventral lateral ridges separate ears, fit with weak dorsal ridges; paired median ridges separate dorsal adductor fields. Upper Permian (Kazanian): Russia, Himalayan chain.—Fig. 377, 2a–g. *G. hemisphaericum (Kutorga), Kazanian, Kama River, Russia; a–c, ventral valve viewed ventrally, laterally, internally, ×1; d, dorsal valve interior, ×2 (Muir-Wood & Cooper, 1960); e, f, shell viewed ventrally, dorsally, ×1; g, posterior view of shell, ×1 (Grigorjewa, 1962).

Linoprotonia Ferguson, 1971, p. 551 [*Productus hemisphaericus J. Sowerby, 1822 in 1821–1822, p. 31; OD] [=Connectoproductus Donakova, 1974, p. 173 (type, Productus probus Rotal, 1931, p. 53]. Size medium to large; gently concavoconvex profile,
umbo weakly differentiated; rugae weakly developed; low cardinal process, commonly with pit; brachial cones low. Lower Carboniferous (upper Tournaisian–Viséan): Eurasia, northern Africa.—Fig. 378,1a–e. *L. hemisphaericus* (J. Sowerby), Asbian; a, lectotype, viewed ventrally, southern Wales, BMNH B 44114, selected by PRENTICE, 1949, p. 265, X1; b, dorsal valve exterior, southern Wales, X1; c, ventral valve internal mold, Somerset, X1; d, incomplete dorsal valve interior, northern Wales, X1; e, details of posterolateral spines on ventral valve, Lancashire, X3 (new).

**Liraria** COOPER & GRANT, 1975, p. 1156 [*L. lirata*; OD]. Resembles *Globiella*, but wider than long;
spines near hinge; few on venter; dorsal median septum more prominent; dorsal lateral ridges short, strong, divergent; adductor scars with raised median edges. Lower Permian (Artinskian–Kungurian): USA.——Fig. 376.3a–f. *L. lirata, Bone Spring Formation, Texas; a–d, holotype, viewed ventrally, posteriorly, laterally, internally, USNM 152782a, ×1; e, dorsal valve exterior, ×2; f, dorsal valve interior, ×3 (Cooper & Grant, 1975).

*Magadanial* Ganelin in Grigorev, Ganelin, & Kotlyar, 1977, p. 153 [*Cancrinella bajurica* Ustritsky in Ustritsky & Tschernjak, 1963, p. 65; OD]. Outline elongate, strongly concavoconvex with shallow corpus cavity; ribbing narrow, rugae on dorsal disk; spines only ventrally, elongate, slightly swollen bases, recumbent, becoming erect anteriorly; dorsal lateral ridges strongly divergent from hinge; median septum divided posteriorly; shell
Rhynchonelliformea—Strophomenata

walls thick. Upper Permian (?Kazanian): Taymyr, ?northeastern Mongolia.—Fig. 379, 1a–d. *M. bajkurica (USTRITSKY), Upper Permian, upper Baykur Formation, River Sokolinaya, Russia; a,b, holotype, viewed ventrally, dorsally, TsNIGRA 126/8263, ×2; c, ventral valve internal mold, ×1

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Productida—Linoprotoidea

(Grigorjeva, Ganelin, & Kotlyar, 1977); d, ventral valve viewed laterally, ×1 (new).

Magniplicatina Waterhouse, 1983b, p. 130

[*Cancrinella magniplica* Campbell, 1953, p. 7; Od] [=Helenaeproductus Lazarev in Pavlova & others, 1991, p. 117 (type, *H. khubsugulensis*)]. Resembles *Cancrinella*, but with shallow corpus, strong rugae on ventral valve and relatively thick, widely
Papiliolinus

Ovatia

544

Rhynochonelliformea—Strophomenata

Fig. 380. Monticuliferidae (p. 544).

spaced ventral spines. upper Lower Permian (Kungurian)—Upper Permian (Kazanian): Australia, New Zealand, USA, Mongolia, Russian Arctic, ?China.— Fig. 378,2a–c. M. halli (WATERHOUSE), Mangarewa Formation, New Zealand; a,b, holotype, ventral, lateral views of incomplete internal mold, NZGS BR950, X1; c, oblique view of ventral valve internal mold, X1 (Waterhouse, 1982c).—

Fig. 378,2d,e. M. sparsispinosus (COOPER & GRANT), Bone Spring Formation, Texas; d, holotype, ventral valve interior, USNM 152780a, X2; e, dorsal valve interior, X2 (COOPER & GRANT, 1975).

Ovatia

MUIR-WOOD & COOPER, 1960, p. 311 [*O. elongata; OD]. Small to medium sized; ventral profile close to ideal spiral with no geniculation, trail narrow, elongate; umbo narrow, but highly arched, strongly differentiated from ears where rugae are strong; one to two rows of spines near hinge, sparsely scattered on ventral valve where they commonly interrupt ribs; lateral ridges short. Lower Carboniferous (Tournaisian)—Upper Carboniferous (Serpukhovian): North America, Eurasia, northern Africa.—Fig. 379,4a–e. *O. elongata, Chesterian, Oklahoma; a–c, holotype, viewed anteroventrally, laterally, posteriorly, USNM 124101a, X1; d, dorsal view of small shell, X1; e, dorsal valve interior, X1 (Muir-Wood & Cooper, 1960).

Papiliolinus

WATERHOUSE & GUPTA, 1977, p. 160 [*P. eichmakami; OD, nom. nov. pro Productus undatus DIENER, 1899, p. 23, non DUFRANCE, 1826]. Poorly known; large; subsemicircular outline, profile curvature weak; ribbing fine for family, rugae fine and possibly covering valves; cardinal process seemingly trifid with broad median ridge. upper Lower Carboniferous (upper Viséan): northern India.—Fig. 380,2a–h. *P. eichmakami, upper Viséan, Kashmir; two external casts of dorsal valves, X1 (Diener, 1899).

Pseudohaydenella

LIANG, 1990, p. 174[462] [*P. huadongensis; OD] [=Lamiproductus liang, 1990, p. 205[467] (type, L. typicus)]. Poorly known, possible synonym of Chianella. Medium to large, subtriangular, somewhat nasute outline; no sulcus; rugae confined to ears; spines sparsely scattered on ribs; dorsal lateral ridges low, thick. upper Permian (upper Chesterian): eastern China.—Fig. 380,1. *P. huadongensis, upper Capitanian, Lengwu Formation, Zhejiang; ventral valve exterior, X1.5 (Liang, 1990).

Spitzbergenia

G. KOTLYAR in GRIGORJEWA, GANELIN, & KOTLYAR, 1977, p. 155 [*Productus loveni WIMAN, 1914, p. 72; OD]. Medium, subquadrate outline; prominent elongate spine bases on ventral disk resemble Magniplicatina, but lacks prominent rugae; spines recurved, thin, concentric arrangement anteriorly, erect spines on ears, flanks, trail; ventral diductor scars enclose adductor scars anteriorly; cardinal process small, supported by medianly grooved median septum, strongly diverging short lateral ridges. Lower Upper Permian (Kazanian): Spitzbergen, Novaya Zemlaya, Canada, Alaska, northern and northeastern Europe Russia.—Fig. 379,2a–c. *S. loveni, Kazanian, Selander Formation, Spitzbergen; a, ventral valve exterior, X1; b, ventral valve internal mold, X1; c, dorsal valve interior, X1 (Grigorjewa, Ganelin, & Kotlyar, 1977).

Teleoproduc tus

Li Li in LI LI, YANG DE-LI, & FENG RU-LIN, 1986, p. 230 [*T. typicus; OD]. Small to medium size, hinge widest part of shell, anterior margin strongly nasute, but not forming tube with dorsal trail; rugae strong on flanks, ears, dorsal disk; spines at hinge and few on ventral flanks; interiors unknown. Lower Permian (Sakmarian)—lower Upper Permian (Würdian): China.—Fig. 381,3a–c. *T. typicus, Longyin Formation, Guanshi; holotype,
viewed anteroventrally, posteriorly, laterally, NGM 562176 (repository unknown), ×1.5 (new).

Undaria Munr-Wood & Cooper, 1960, p. 317 [*U. manxensis; OD]. Small; trails elongate, tubiform; ribbing entire, prominent at rugae that cover corpus, trails posteriorly; spines at and close to hinge, widely scattered on ventral corpus; cardinal process bilobed, quadrifid; lateral ridges and short ear baffles, median septum long, but thin. **Upper Lower Carboniferous (Upper Viséan); western Europe.**

Fig. 381. Monticuliferidae (p. 544–546).
mold of dorsal valve viewed laterally, X2; c. replica of dorsal valve interior, X3 (Muir-Wood & Cooper, 1960).—Fig. 379, 3d. U. erminea (de Koninck), Viséan, Belgium; external mold of dorsal valve viewed laterally, X1 (Muir-Wood & Cooper, 1960).

Undellaria Cooper & Grant, 1975, p. 1157 [*U. magnifica; OD]. Medium size with hinge slightly narrower than midwidth; transverse profile evenly convex; rugae weak on both valves; spines numerous, thin, short, less abundant on anterior venter; ventral muscle field relatively small; cardinal process small, sessile, bilobed, quadrifid; lateral ridges weak, short in both valves; adductor scars raised anteriorly.

Upper Lower Permian (Artinskian–Kungurian): USA.—Fig. 381, 1a–f. *U. magnifica, Bone Spring Formation, Texas; a–d, holotype, viewed ventrally, posteriorly, anteriorly, laterally, USNM 1927833; X1; e, f, dorsal valve exterior, interior, X1.5 (Cooper & Grant, 1975).

Vitiliproductus CHING YU-GAN & LIAO ZHAO-TING, 1974, p. 278 [*Productus groeberi Krenkel, 1913, p. 42; OD]. Medium to large; intersecting oblique rugae forming tetrahedral elevations over corpus, rugae commonly strong at flanks; interiors unknown. Lower Carboniferous (upper Viséan): China, western Europe, Asia, Australia.—Fig. 381.2a–c. *V. groeberi (Krenkel); a, b, ventral, lateral views of shell, as figured by Krenkel (1913). ?Asbian, Tien Shan, X1; c, ventral valve exterior, upper Viséan, Guizhou, X1 (Brunton & Mundy, 1988a).—Fig. 381.2d. V. weakerenisi Brunton & Mundy, X1; a, b, ventral valve exterior, interior, X1 (Brunton & Mundy, 1988a).

Subfamily COMPRESSOPRODUCTINAE Jing & Hu, 1978

[Compressoproductinae Jing & Hu, 1978, p. 115]

Small or medium size, elongate outline, hinge narrow; corpus cavity moderately shallow; valves thin shelled with complete ribbing, rugae; spines rare, rhizoid; cardinal process single median ridge (unifid), lateral ridges weak. Lower Permian–Upper Permian (upper Tatarian).

Compressoproductus SYRTCHYEVA in SYRTCHYEVA, LICHAREW, & SOKOLSKAJA, 1960, p. 231 [*Productus compressus WAAGEN, 1884, p. 710; OD] [*Substratissera Kotlyar, 1964, p. 123 (type, Productus (mytiloides) elastioswienensis FREDERICKS, 1925, p. 171)]. Medium size, elongate trigonal outline resembling Stratisfera, but commonly with narrow hinge, deeper corpus cavity, and rugae persisting over both valves; ventral lateral ridges weak; shell substance thin. Lower Permian (Kazanian–upper Tatarian): Pakistan, northern Caucasus, Transcaucasus, southeastern Asia.—Fig. 382, 1a–c. *C. compressus (WAAGEN), Productus Limestone, Salt Range, Pakistan; ventral valve exterior viewed ventrally and from both sides, X0.8 (Waagen, 1884).

Fallaxoproductus LI, GU, & LI, 1982, p. 115 [128] [*F. sutunagensis; OD]. Resembles Compressoproductus, but lacks ears and rugae confined to dorsal valve. Lower Permian: Inner Mongolia.—Fig. 382, 2a. *F. sutunagensis, Lower Permian, Inner Mongolia; ventral valve exterior, X1 (Li, Gu, & Li, 1982).—Fig. 382, 2b–d. F. dedorus, Lower Permian, Inner Mongolia; b, dorsal valve exterior, X1; c, d, internal molds of ventral, dorsal valves, X1 (Li, Gu, & Li, 1982).

Sarychevinella WATERHOUSE, 1983a, p. 126 [*Productus djuiferensis STOYANOW, 1915, p. 84; OD]. Resembles Compressoproductus, having somewhat wider hinge line, in having spines on the venter, and weak or no rugae anteriorly. Upper Permian (upper Capitanian): Armenia, Caucasus, southern China, northern Thailand.—Fig. 382, 3a–c. *S. djuiferensis (STOYANOW), upper Capitanian, Armenia; a, b, exterior viewed ventrally, laterally, X1; c, posterior part of shell viewed dorsally, X2 (Stoyanow, 1915).

Subfamily DEVONOPRODUCTINAE

Muir-Wood & Cooper, 1960

[Devonoproductinae Muir-Wood & Cooper, 1960, p. 177]

Moderately shallow corpus cavity; fine ribbing especially on ventral valve; dorsal valves with concentric lamellae as traces of series of trails; cardinal process pit absent; ear baffles in ventral valve, weak dorsal lateral ridges; weak submarginal ridge in dorsal valve with papillae. Middle Devonian (Eifelian)—Upper Devonian (Frasnian).

Devonoproductus STAINBROOK, 1943, p. 55 [*Produstella walcotti FENTON & FENTON, 1924, p. 119; OD, nom. nov. pro Productus dissimilis HALL, 1858a, p. 497, non DE KONINCK, 1847a, p. 225; =P. (Productella) balliana WALCOTT, 1884, p. 130, partim] [*Stratisoprocessus NALVEZEN, 1947, p. 75 (type, Orbus sericea von BUCH, 1838, p. 68)]. Small; outline subcircular, cicatrux small, rare; spines subrect at hinge, widely scattered ventrally from bases wider than ribs; dorsal lamellae prominent; lateral ridges may continue anteriorly; median septum long, not supporting cardinal process. Upper Devonian (Frasnian): North America, Europe, central Asia.—Fig. 383, 1a–f. *D. walcotti (FENTON & FENTON), Frasnian, Iowa; a, b, shell viewed posteriorly, laterally, X2; c, ventral valve exterior, X2; d, ventral valve interior, X2; e, f, dorsal valve exterior, interior, X3 (Muir-Wood & Cooper, 1960).
Chonopectoides CRICKMAY, 1963, p. 23 [*C. catamorphus; OD]. Poorly known; small, around 4.5 mm wide, chonetiform shells with ventral ginglymus; ribs fine, obscure, on ventral valve only; dorsal valve lamellose; spines project posterolaterally from hinge only; teeth strong; socket ridges continue as weak ear baffles. Upper Middle Devonian: Canada (Northwest Territories).——F 383.2a–d. *C. catamorphus; a, holotype, viewed ventrally, PRI 27124, X10; b, ventral valve interior, X10; c, dorsal valve exterior, X10; d, dorsal valve interior, X10 (new).

Polonioproductus BIERNAT & LAZAREV, 1988, p. 66 [*Productella varians BIERNAT, 1966, p. 66; OD]. Resembles Devonoproductus, but with suberect spines from slightly elongate bases and weak concentric lamellae on both valves; no ribbing; teeth small; brachial impressions wide on disk. Middle Devonian (Eifelian): eastern Europe.——F. 383.3a–f. *P. varians (BIERNAT), Eifelian, Holy Cross Mountains; a–c, shell viewed ventrally, posteriorly, laterally, X2 (new); d, shell viewed dorsally, X2 (Lazarev, 1990); e, ventral valve interior, X2 (new); f, dorsal valve interior, X2.5 (BIERNAT, 1966).
Fig. 383. Monticuliferidae (p. 546–547).
Subfamily EOPRODUCTELLINAE
Lazarev, 1987

[Eoproductellinae Lazarev, 1987, p. 49]

Small or medium size; both valves or dorsal valve only with fine ribbing, spines on ventral valve only; teeth, sockets present. Lower Devonian (Pragian)–Middle Devonian (upper Givetian).

Eoproductella Zhonsnitskaya, 1980, p. 59 [*E. menakovae; OD]. Small; hinge widest part of shell; profile strongly concavoconvex; ribbing weak on both valves, spines widespread from thick bases; andéridia present. Lower Devonian (Pragian–Emsian): middle Asia. —— Fig. 384, 1a–c. *E. menakovae, Pragian, Tadzjikistan; a, oblique lateral view of ventral valve, ×1; b, ventral valve viewed dorsally showing teeth, ×1.5; c, dorsal valve interior, one lobe of cardinal process missing, ×1.5 (Lazarev, 1990).

Plicoproductus Liaschenko, 1969, p. 14 [*Productella mosolovica Liaschenko, 1958a, p. 93; OD]. Small; relatively coarsely costellate with additional fine striae especially dorsally; spines ventral, relatively coarse with irregular concentric arrangement. Middle Devonian (Eifelian): Russia. —— Fig. 384, 2a–d. *P. mosolovica (Liaschenko), Middle Devonian, Russia; a, ventral, dorsal views of shell, ×2; c, d, dorsal valve external mold, lateral view of shell with two spines, ×2 (new).

Striatoproductella Krivlova, 1962, p. 54 [*Striato-productus tunguensis Nalivkin, 1960, p. 319; OD] [=Hanaeproductus Ficner & Havlicek, 1978, p. 65 (type, Productus ritterbergensis Quenstedt, 1871, p. 613)]. Small with subcircular corpus; spine bases fine, elongate, only ventrally; dorsal valve with low
Rhynchonelliformea—Strophomenata

Dichotomizing ribs; teeth small. Middle Devonian (upper Givetian): northern Eurasia. — Fig. 384, 3a–d. *S. tunguensis* (NALIVKIN), upper Givetian, Siberia: a, ventral valve exterior viewed ventrally, ×1; b, ventral valve exterior viewed posteriory, ×1.5; c, dorsal valve external mold, ×1; d, partly exfoliated dorsal valve interior, ×2 (new).

**Fig. 385. Monticuliferidae (p. 551).**

Subfamily GIGANTOPRODUCTINAE

Muir-Wood & Cooper, 1960

Gigantic, large or medium size, hinge at greatest width; corpus cavity very shallow;
fully ribbed, spines on ventral valve, rarely also on dorsal valves; marginal structures commonly absent; cardinal process pit commonly present. *Lower Carboniferous (Viséan)—Upper Carboniferous (Serpukhovian).*

Tribe GIGANTOPRODUCTINI
Muir-Wood & Cooper, 1960


Large or gigantic, thick-walled ventral valves; ventral umbo not strongly incurved; commonly ribbed; spines commonly on ventral valve; cardinal process trifid with median ridge well developed or sole element; brachial cones commonly distinct. *Lower Carboniferous (Viséan)—Upper Carboniferous (Serpukhovian).*


Commonly gigantic, transverse; ribbing entire, but commonly irregular and weakened at trail plications; spines rare; ventral valve thick-shelled with pits accommodating dorsal brachial cones; cardinal process trifid, sessile. *Lower Carboniferous (upper Viséan):* Eurasia, northern Africa.—FIG. 385a–c. *G. giganteus* (J. Sowerby), upper Viséan: a, ventral valve exterior, England, ×0.6 (Muir-Wood, 1965b); b, c, incomplete dorsal valve interior, internal mold, northern Wales, ×1 (new).—FIG. 386a–c. *G. giganteus* (J. Sowerby), upper Viséan: a, ventral valve internal mold, northern Wales, ×0.6; b, c, ventral valve viewed posteriorly, showing damaged shell, and dorsally showing short ginglymus (arrow), Scotland, ×0.5 (new).

Beleutella Litvinovich, 1967, p. 55 [*B. rara; OD*]. Outline subrounded; ventral profile flattened umbonally; ginglymus strongly developed; ribbing narrow; spines thin, sparse; valve walls thick; cardinal process prominent, trifid with fused median ridges dominant; brachial cones present. *Lower Carboniferous (lower Serpukhovian):* Kazakhstan.—FIG. 387a–c. *B. rara*, Serpukhovian, Kazakhstan, Zhuzgazgan district; a, b, holotype, viewed ventrally, laterally, MGU 31/342, ×1 (Litvinovich, 1967); c, incomplete ventral valve internal mold, ×1 (Litvinovich & Vorontsova, 1991).

Globosoproductus Litvinovich & Vorontsova, 1983, p. 88 [*Gigantella magnifica Schimansky, 1940, p. 106; OD]. Poorly known; large, somewhat ventrally inflated corpus; ribs fine posteriorly, where also reticulate, becoming coarser anteriorly; ventral spines sparse with thinner row near hinge, dorsal spines thin, rarely present; cardinal process narrow, bilobed; thin shelled, no brachial pits. Lower Carboniferous (middle Viséan): Russia.—Fig. 388.1a–c. *G. magnifica (Schimansky), Lower Carboniferous, Tulsky, northern Urals; ventral valve viewed anteriorly, posteriorly, laterally, ×0.75 (Litvinovich & Vorontsova, 1991).

Kansuella Chao, 1928, p. 67 [*Striatifera kansuensis Chao, 1927b, p. 108; OD] [=Parakanussella Tan Zhen-xiu, 1987, p. 123 (type, P. xinhsuensis; OD)]. Transverse outline; weakly concavoconvex with weakly inflated ventral umbo and prominent ginglymus in both valves; rugae posteriorly, but weak anteromedianly; interiors as in Gigantoproductus but
Fig. 388. Monticuliferidae (p. 552–555).
with bilobed cardinal process. [Parakansuella may differ in lacking rugae and more inflated ventral umbo.]

Lower Carboniferous (Viséan): Eurasia.——Fig. 389a,b. *K. kansuensis*, Viséan, Kansu, China; a, incomplete dorsal valve internal mold, ×0.75; b, posterior view of shell with short ginglymus, ×0.75 (Muir-Wood & Cooper, 1960).——Fig. 389c–e. Kansuella sp., upper Viséan, Scotland; incomplete shell viewed ventrally, dorsally, posteriorly, ×0.75 (new).

*Kueichowella* Yang Shi-pu in Feng & Jiang, 1978, p. 267 [*K. kueichowensis*; OD] [=Guizhouella* Yang Shi-pu, 1978, p. 125, obj.]}; Externally resembles *Kueichowella*, but more strongly concavoconvex, no ginglymus; rugae cover valves fully; valves relatively thin shelled; cardinal process large, unifid. Carboniferous (lower Serpukhovian): China.——Fig. 390a–c. *K. kueichowensis*, lower Serpukhovian, Guizhou, originally figured as *G. guizhouensis*; a,b, holotype, viewed ventrally, posteriorly, MCMB F3-2297, ×0.5; c, ventral valve exterior viewed posteroventrally; ×1 (Yang Shi-pu, 1978).

*Serbarinia* Morozov, 1985, p. 115 [*Productus kalugensis* Sarytcheva, 1928, p. 61; OD]. Resembles *Gigantoproductus*, but thin shelled; cardinal process trifid with strong median ridge; posterolateral internal surfaces strongly pustulose. Lower Carboniferous (lower upper Viséan): Russia.——Fig. 391a–d. *S. kalugensis* (Sarytcheva), lower Alexin, Moscow basin; a,b, replica of holotype, viewed ventrally, posteriorly, MGRI 30/27, ×0.5 (new); c, ventral valve interior, ×1; d, dorsal valve interior, ×1 (Sarytcheva, 1928).

*Titanaria* Muir-Wood & Cooper, 1960, p. 334 [*T. costellata*; OD]. Gigantic or large, transverse, resem-
bling *Gigantoproductus*, but lacking rugae, anterior plications; ginglymus short; spines fine, widely distributed on both valves; ventral adductor scars between diductors; cardinal process trifid with strongly projecting median portion, brachial cones absent. Lower Carboniferous (Viséan–lower Serpukhovian): North America, North Africa.—Fig. 388,2a–d. *T. costellata*, Chesterian, California; a,b, holotype, internal mold, viewed ventrally, posteriorly, USNM 8040a, ×0.8; c,d, replica of external mold, viewed posterodorsally and replica of incomplete dorsal valve interior, USNM 8040a, ×0.8 (Muir-Wood & Cooper, 1960).

*Xinjiangiproductus* YAO & FU, 1987, p. 96[101] [*X. yamansuensis*; OD]. Medium size; resembling *Datangia*, but with thick-shelled ventral valve and brachial cones; dorsal valve thin shelled. Lower Carboniferous (Viséan–lower Serpukhovian): China.—Fig. 390,1a–c. *X. yamansuensis*, Lower Carboniferous, Xinjiang; a,b, holotype, partly exfoliated

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Rhynchonelliformea—Strophomenata

ventral valve viewed ventrally, laterally, ×1; c, exfoliated dorsal valve interior viewed anterolaterally, ×1 (Yao & Fu, 1987).

Tribe SEMIPLANINI Sarytcheva, 1960


Medium size to large, with very thin shell substance; ventral umbo strongly incurved; ribs of various widths; spines on both valves, some on ventral only; cardinal process bilobed or trifid, with median ridges poorly developed; no brachial cones. Lower Carboniferous (middle Viséan–lower Serpukhovian).

Semiplanus Sarytcheva in Sarytcheva & Sokolskaya, 1952, p. 119 [*Productus semiplanus Schwetsov,
Fig. 392. Monticuliferidae (p. 556–559).
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1922, p. 10; OD]. Medium to large; outline strongly transverse with poorly defined ears; ribbing distinct, entire; spines fine, numerous on both valves, less wide than ribs; cardinal process bilobed, becoming weakly trifid, supported by thick median septum; brachial ridges indistinct. Lower Carboniferous (upper Viséan): Eurasia.—Fig. 392, la–d. *S. semiplanus (Schwetsov), Asbian, Isle of Anglesey, north Wales; a, dorsal valve interior viewed posteriorly, X1.5 (Sarycheva & Legrand-Blain, 1977); b,c, ventral valve exterior viewed anteroventrally, posterovertrally, X1; d, detail of ear showing ornament, spine bases, X3 (new).—Fig. 392, le. Semiplanus sp., Derbyshire; ventral valve exterior showing spine bases, X1 (new).

Latiproductus Sarycheva & Legrand-Blain, 1977, p. 75 [*Productus latissimus J. Sowerby, 1822 in 1821–1822, pl. 330, fig. 2–3; OD]. Resembles Semiplanus, but lacking dorsal spines and with somewhat thicker ventral spines, ribbing; cardinal process trifid with short middle lobe. Lower Carboniferous (Brigantian–lower Serpukhovian): Eurasia, northern

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Africa.—Fig. 392, a–e. *L. latisimus (J. Sowerby), Brigantian, Isle of Anglesey; a, b, external mold of dorsal valve viewed ventrally, posteriorly, ×1; c, external ornament with spine bases, ×2; d, median longitudinal section showing ventral profile, ×1 (new); e, dorsal valve interior, ×1 (Sarytcheva & Legrand-Blain, 1977).

Semiplanella Sarytcheva & Legrand-Blain, 1977, p. 79 [*S. carinthica Sarytcheva in Sarytcheva & Legrand-Blain, 1977, p. 81; OD]. Resembles Semiplanus, but with thick-shelled valves and sessile cardinal process with strong but short median lobe; cardinal ridges obscure; spines fine, more common ventrally; brachial ridges well defined. Lower Carboniferous (upper Viséan); western Europe, ?central Asia, ?northern Africa.—Fig. 393, a–e. *S. carinthica (Sarytcheva), Brigantian, Carnic Alps, Austria; a, b, holotype, viewed ventrally, in section, PIN 3704/2, ×1; c, dorsal valve interior viewed posteriorly, ×3 (Sarytcheva & Legrand-Blain, 1977); d, anterior view of ventral valve exterior, ×1; e, segment of dorsal valve trail external mold with few spine bases, ×5 (new).

Talasoproductus Lityvinovich & Vorontsova, 1983, p. 92 [*T. turlanensis; OD]. Shell large but thin walled, lateral profile unusually gently convex;
Subfamily STRIATIFERINAE
Muir-Wood & Cooper, 1960

[Striatiferinae Muir-Wood & Cooper, 1960, p. 328]

Shell large to medium; outline elongate or with tubiform trail, hinge narrow; spines on ventral valve only. Carboniferous (upper Viséan–Serpukhovian).

Tribe STRIATIFERINI
Muir-Wood & Cooper, 1960


Large, with very shallow corpus; trails simple; cardinal process of single ridge continuous with median septum. Carboniferous (upper Viséan–Serpukhovian).

Striatifera Chao, 1927b, p. 94 [*Mylitus striatus Fischer de Waldheim, 1837, p. 181; OD; non Pileopsis striatus Phillips, 1836, p. 224]. Elongate, tapering posteriorly, flattened shell; spines ventral, clustered at ears and scattered on costellae; cardinal process commonly unifid, supported by long median septum. Lower Carboniferous (upper Viséan–lower Serpukhovian). Eurasia, northern Africa, North America.—Fig. 394a–e. *S. striata (Fischer de Waldheim): a, dorsal valve interior, Asbian–Brigantian, Russia, ×1 (Muir-Wood & Cooper, 1960); b–d, corpus of specimen viewed ventrally, dorsally, laterally, upper Asbian, Belgium, ×0.75; e, lateral view of ventral umbo with spine bases marginally, British Isles, Yorkshire, ×3 (new).—Fig. 394f,g. Striatifera sp., Meramecian–Chesterian, Oregon; f, dorsal valve interior, ×1; g, partly exfoliated ventral valve viewed posteriorly, ×1 (Muir-Wood & Cooper, 1960).

Tribe PROBOSCIDELLINI
Muir-Wood & Cooper, 1960


Corpus cavity shallow; hinge narrower than maximum width; ventral trail long and forming tube, irregularly rugose; cardinal process bilobed, lateral, and submarginal ridges present. Lower Carboniferous (upper Viséan).

Proboscidella Oehlert, 1887b, p. 1277 [*Productus proboscidens de Verneuil, 1840, p. 259; OD]. Corpus with weak rugae that may extend on ventral trail, forming long tube; spines strong at posterior margin, sparse or absent elsewhere. Lower Carboniferous (upper Viséan). Eurasia.—Fig. 395a–e. *P. proboscidia de Verneuil), upper Viséan, Belgium;
Productida—Linoproctioidea

Fig. 396. Monticuliferidae (p. 562–563).
Subfamily SCHRENKEILLINAE

Lazarev, 1986

Medium size to large, with flattened ventral disk; spines in row near hinge margin only, ribs separated by wider interspaces, commonly with fine capillation; rugae may be present. Lower Permian (Sakmarian)—Upper Permian (upper Capitanian).

Schrenkiella Barchatova, 1973, p. 97 [*Productus schrenki Stuckenbg, 1875, p. 88; OD] [*Dictyoclostoidea Striatospica Barchatova, 1973, p. 100 (type, I. ilibeica)]. Medium to large, somewhat trapezoid to broadly trigonal with median ventral fold; visceral disks weakly curved; ribs fine, narrower than interspaces, tend to fluctuate in width; spines only recorded at ventral hinge. Lower Permian (Sakmarian): northern Russia, ?Australia. — Fig. 396,1a,b. *S. schrenki (Stuckenbg), Sakmarian, Timan; partly exfoliated ventral valve exterior viewed ventrally, laterally, ×1 (new). — Fig. 396,1c,d. S. timanica Barchatova; specimen viewed posteriorly, laterally, ×1 (Barchatova, 1973). — Fig. 396,1e. S. triangulata (Barchatova); exfoliated dorsal valve interior, ×1.5 (Barchatova, 1973).

Productida—Linoproductoidea

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sal valve, rare spines on ventral valve; short ginglymus may be present. upper Lower Permian (Artinskian)–lower Upper Permian (Kazanian); eastcentral China.——Fig. 397, 2a–d. *D. kiaiensis* WANG & CHING, Xiaojiangbian Limestone, Jiangxi; a–c, specimen viewed ventrally, dorsally, laterally, ×1.5; d, detail of dorsal valve ornament, ×5 (new).——Fig. 397, 2e,f. D. changxingensis (LIANG), Chihsian Formation, Anhui; holotype, internal mold of ventral valve viewed ventrally, laterally, ZI 52803, ×1.6 (new).

Permundaria Nakamura, Kato, & Choi, 1970, p. 295 [*P. asiatica*; OD]. Poorly understood genus; medium to large with very weakly concavoconvex profile; rugae, fine ribbing cover shell, but no spines reported. Upper Permian: Japan, Cambodia, southern China, Kashmir, Iran.——Fig. 396, 2a. *P. asiatica*, Upper Permian, Sisophon Limestone, Kitakami Mountains; holotype, ventral valve external mold, UHR 19015, ×1.4 (Nakamura, Kato, & Choi, 1970).——Fig. 396, 2b,c. *P. sisophonensis* Nakamura, Kato, & Choi; b, holotype, incomplete ventral valve exterior, UHR 19017, ×1.4; c, detail of ribbing. UHR 19017, ×10 (Nakamura, Kato, & Choi, 1970).

Striastospera Waterhouse, 1975, p. 11 [*Striastiffera? kayseri* CHAO, 1927b, p. 115; OD]. Medium size with hinge forming widest part of shell; trail forming flange anteriorly, laterally; rugae fine on both disks; capillae on both valves, no costation; strong spine rows on ears, close to hinge only; interiors unknown. Upper Permian (upper Capitanian); China.——Fig. 397, 1a–c. *S. kayseri* (Chao), Loping Formation, Jiangxi; a, holotype, ventral valve exterior, NIGP 1104, ×1; b, ventral valve exterior, ×1; c, external mold of part of dorsal valve, ventral umbo, ×1 (Chao, 1927b).

Subfamily UNCERTAIN

Lercarella Mascle & Termier, 1970, p. 188 [*L. sicana*; OD]. Poorly known, large, transverse, widest at hinge with ginglymus or interarea; weakly concavoconvex with shallow corpus; spines near ventral hinge, on ears and rarely on venter; interiors poorly known, cardinal process possibly ventrally

Fig. 398. Monticuliferidae (p. 563–564).
Rhynchonelliformea—Strophomenata

Directed, indicating relationship with the Strophalosiinae, otherwise possibly in Monticuliferidae.

**Lower Permian**: Sicily.—Fig. 398,1a,b. *L. sicana*, Lower Permian, Lercara Friddi; a, reconstruction of ventral valve, ×1; b, reconstruction of dorsal valve, ×1 (Mascle & Termier, 1970).

**Zhejiangoproductus** LIANG WEN-PING, 1990, p. 196 [*Z. zhejiangensis*; OD]. Poorly known, large with hinge equal to maximum width; ventral disk flattened, with convex trail; sulcus originating on ventral disk; spines at hinge line and ears, reportedly absent elsewhere; exteriors reportedly smooth other than rugae on ears. **Upper Permian** (Kazanian): China.—Fig. 398,2a,b. *Z. zhejiangensis*, Kazanian, Lengwu Formation, Zhejiang; shell viewed ventrally and laterally, ×1.5 (Liang, 1990).

**Superfamily UNCERTAIN**

**Gosaukammerella** SENOWBARI-DARYAN & FLÜGEL, 1996, p. 92 [*G. eomesozoica*; OD; =Pycnoporidae eomesozicum FLÜGEL, 1972, p. 968, possibly alga]. Minute, 2 to 3 mm wide, planoconvex corpus, thin valve walls, but ventrally with outgrowths of thick, symmetrical mass of tubules attaching to substrate; shell substance reportedly pseudopunctate, laminar; interiors unknown. [If a productide it is a long holdover that lived in a cryptic reef environment].

**Upper Triassic** (?Norian, ?Rhaetian): alpine Mediter-
ranean region.—Fig. 399a,b. *G. comezozoica, Dachstein Reef Limestone, Norian, Austria: a, oblique longitudinal section of both valves, ×15; b, transverse section of ventral valve and tubular attachment structure, ×15 (Senowbari-Daryan & Flügel, 1996).

Suborder STROPHALOSIIDINA Schuchert, 1913

Productides with interareas in ventral valve only or both valves; commonly ventrally attached; profile includes conical shape; spines on ventral or both valves, rarely absent; toothed articulation retained or lost; cardinal process directed ventrally or posterolaterally attached; profile includes conical shape; attachment is by direct cementation of part of the ventral valve or by creeping, irregularly shaped spines. Carboniferous and Permian taxa tend to be adapted to live on hard substrates, commonly reef environments, and the various elaborations of trails appear to have been in response to these habitats. Lower Devonian (Emsian)–Upper Permian (Changhsingian).

Superfamily STROPHALOSIOIDEA Schuchert, 1913

Cicatrix commonly developed; corpus cavity shallow; teeth retained; brachial ridges commonly extending to disk margins. Lower Devonian (Emsian)–Upper Permian (Changhsingian).

Family STROPHALOSIIDAE Schuchert, 1913
([nom. transl. Stiell, 1954, p. 328, ex Strophalosiacea Schuchert, 1913a, p. 391]

Outline rounded; strong rhizoid spines over ventral or both valves, may be bidirec-
tional; planoconvex profile, but corpus cavity rather shallow; trails short. Lower Carboniferous (Hastarian)–Upper Permian (Changhsingian).

Subfamily STROPHALOSIINAE Schuchert, 1913

Spines on ventral valve only; plano- to weakly concavoconvex profile. Lower Carboniferous (Hastarian)–Upper Permian (Changhsingian).

Strophalosia W. King, 1844, p. 313 [*S. gerardi W. King, 1846, p. 92; SD Muir-Wood & Cooper, 1960, p. 74] [=Leptaenalosia W. King, 1850, p. 93, nom. nud.]. Medium, slightly transverse subrounded outline with ill-defined small ears; hinge less than maximum width; ventral interarea wide but short; weak concavoconvex profile; concentric ornament weak ventrally, lamelllose dorsally; weak capillation may be present on dorsal valve; spines cover ventral valve, suberect, semicircular; lateral ridges ventrally, separating ears; medium septum connected to cardinal process, interrupted at adductor scars, reaching two-thirds disk length. Lower Permian (Sakmarian)–Upper Permian (Kazanian): Himalayas, Australia ?Arctic Russia, China, Salt Range. —Fig. 400,1a–c. *S. gerardi W. King, Ladakh, Himalayas; a,b, lectotype, viewed ventrally, dorsally. FC D 267, ×1.5; c, incomplete dorsal valve interior, ×1.5 (Brunton, 1966).——Fig. 400,1d–f. S. irwinensis COLEMAN, Callytharra Formation, Carnarvon basin, Australia; d, ventral valve exterior, ×1.2; e, ventral valve internal mold, ×1.6; f, dorsal valve interior, ×2 (Archbold, 1986).

Coronalosia WATERHOUSE & GUPTA, 1978, p. 415 [*Coronalosia bljniensis; OD]. Similar to Strophalosia, but with fine ventral spines, other than at hinge line; relatively smooth dorsal valve exterior. Published figures inadequate for illustration. Lower Permian (Sakmarian): India.

Craspedalosia Muir-Wood & Cooper, 1960, p. 82 [*Orthothrix lamellosa GEINITZ, 1848, p. 86; OD]. Resembles Dasyalosia ventrally, but with dorsal valve strongly lamelllose, lacking spines. upper Lower Permian (Roadian): Europe.—Fig. 401,1a–d. *C. lamellosa (GEINITZ), lower Zechstein, Gera, Germany; a–c, shell viewed ventrally, dorsally, laterally, ×2; d, dorsal valve interior, ×2 (Muir-Wood & Cooper, 1960).

Etherilosia Archbold, 1993, p. 11 [*Etherilosia etheridgei PRENDERGAST, 1943, p. 43; OD]. Small, subcircular with hinge less than maximum width; resembling Heterolosia, but differing in its relatively larger cicatrix, distinct rhizoid spines, in having only ventral uniform, suberect spines. Lower Permian