

haueriana; SD DIENER, 1923, p. 118]. Sub-trigonal, only slightly inequilateral, with relatively short hinge margin and narrowly rounded, slightly protruding umbo; auricles small, well differentiated, anterior one acute at tip; inflation rather weak; gape of valves slight; cardinal area imperfectly known; surface with discontinuous subconcentric ribs, or smooth. *M.Trias.-U.Trias.*, Eu.(S.Alps).—FIG. C107,5. *T. cassiana* BITTNER, *M.Trias.*(Ladin.); RV, $\times 2$ (58).

Suborder OSTREINA Férussac, 1822

Because completion of systematic descriptions for taxa of this suborder was delayed too long for placement here, they are assigned out-of-sequence position (see Part N, Volume 3).

Subclass PALAEOHETERODONTA Newell, 1965

[Diagnosis by N. D. NEWELL]

Equivalve, with closed margins and, where preserved, prismaticnacreous shells; ligament amphidetic or opisthodontic, external and parivincular; dentition generally consisting of few teeth more or less radial and divergent from umbonal region, striated in some genera, rarely becoming taxodont in few genera (certain Unionoidea); where lateral teeth occur, they originate below beaks and are not separated from cardinals by edentulous interval, as in Heterodonta. [These forms include the actinodonts (earliest known Bivalvia), Trigonioidea and Unionoidea. They lead in various lines to the Pteriomorphia, Heterodonta, and possibly to the Mytiloidea early in the Paleozoic.] *M.Cam.-Rec.*

Order MODIOMORPHOIDA Newell, new order

[=Actinodonta DOUVILLÉ, 1912; Actinodontoidea NEWELL, 1965] [Diagnosis by N. D. NEWELL]

Extinct Paleozoic marine ovoid bivalves; shell microstructure unknown; generally unornamented, otherwise possessing characters of subclass. [This somewhat heterogeneous, poorly understood assemblage is grouped together for convenience. Clearly

it includes ancestral radicals of many major lines.] *M.Cam.-L.Perm.*, ?*U.Perm.*

Superfamily MODIOMORPHACEA Miller, 1877

[*nom. transl.* NEWELL, 1965 (ex Modiomorphidae S. A. MILLER, 1877)] [Materials for this superfamily prepared by AURÈLE LA ROCQUE & N. D. NEWELL]

Elongate, isomyarian or slightly anisomyarian, with anterior, but not terminal beaks; edentulous(?) or possessing a few posterior laterals and differentiated subumbonal cardinals. [This superfamily anticipates and strongly resembles certain Unionacea, Mytilacea and Carditacea, but differs especially in that the laterals originate below the beaks and essentially extend to the posterior extremity of the hinge under the ligament.] *L.Ord.-L.Perm.*, ?*U.Perm.*

Family MODIOMORPHIDAE S. A. Miller, 1877

[=Modiolopsidae FISCHER, 1887]

Shell subovate with or without radial ornamentation, opisthodontic, without extended posterior wing, more or less modioloid in form, commonly, but not invariably expanded posteriorly, with anterior lobe ahead of umbones and commonly with umbonal ridge or carina extending obliquely backward from umbones to posteroventral region; anterior adductor generally small, deeply impressed, in many shells reinforced by bordering buttress; posterior adductor relatively large, ovoid; anterior laterals absent, cardinals and posterior laterals may or may not be present. [It has been claimed but not satisfactorily demonstrated that some of these forms are edentulous. Some resemble Mytilacea and may represent ancestors of that group.] *L.Ord.-L.Perm.*, ?*U.Perm.*

Modiomorpha HALL & WHITFIELD, 1869, p. 72 [**Pterinea concentrica* CONRAD, 1838; SD HALL, 1885] [=Palanatina HALL & WHITFIELD, 1870 (type, *P. typa*; OD); *Dechenia* SPRIESTERSBACH, 1915, p. 70 (type, *D. rhenana*; SD LA ROCQUE & NEWELL, herein); *Spriestersbachia* MAILLIEUX, 1930, p. 62 (*nom. van. pro Dechenia* SPRIESTERSBACH, 1915)]. Mesial ventral sinus and oblique preumbonal sulcus distinct; LV with 1 large wedge-shaped tooth; RV with corresponding socket; without laterals (159). *M.Sil.-L.Perm.*,

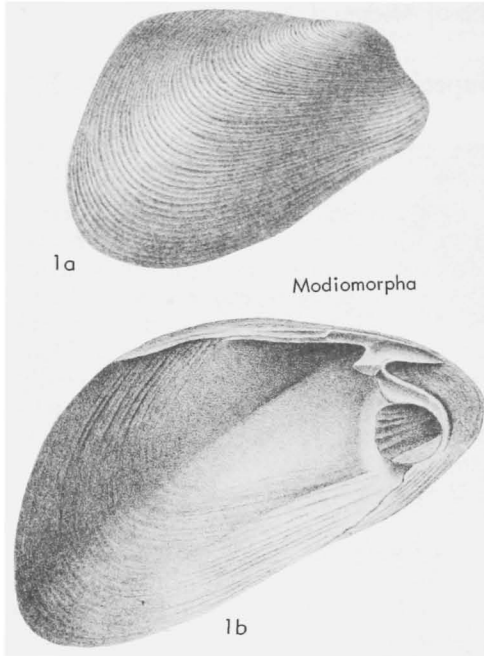


FIG. D1. Modiomorphae (p. N393-N394).

widely distributed.—FIG. D1,1. **M. concentrica* (CONRAD), M.Dev., USA(N.Y.); 1a,b, RV ext., LV int., $\times 1$ (Hall, 1884).

?*Aristarella* ULRICH, 1894, p. 524 [**A. nitidula*; OD]. Inequivalve, LV smaller; small, subovate, moderately convex; no lateral furrow; without radial costae; hinge thin and apparently without teeth; ligament parivincular?; otherwise similar to *Whiteavesia*. *M.Ord.(Blackriv.)-Miss.*, USA (Mo.).—FIG. D2,6. **A. nitidula*, Ord.(Trenton.), USA(Minn.); 6a, RV int. mold; 6b, dorsal view of molds showing inequality of valves; both $\times 4.5$ (930).

Byssodesma ISBERG, 1934, p. 199 [**B. ulrikae*; OD]. Similar to *Modiomorpha* but with lunule and ?without hinge teeth. *U.Ord.*, Sweden.—FIG. D2,5. **B. ulrikae*, Boda Ls., Dalarna; 5a, RV (holotype), $\times 2$; 5b, hinge of same, $\times 3$ (439).

Callodonta ISBERG, 1934, p. 212 [**C. monilifera*; OD]. Equivalve, higher posteriorly; beaks anterior, prosogyre; without radial ornamentation; hinge with 6 cardinal teeth, anterior one pointed, others blunt. *U.Ord.*, Sweden.—FIG. D2,4. **C. monilifera*, Boda Ls., Dalarna region, 4a, LV (holotype), $\times 3$; 4b, LV hinge, $\times 6$ (439).

Colpomya ULRICH, 1894, p. 522 [**C. constricta*; M]. Subrhomboidal, elongate, widest posteriorly; beaks anterior but not terminal; umbonal ridge

strongly convex; hinge plate straight, thick in front of beaks, thinner behind them; RV with 1 tubercle, LV with corresponding depression and strong process partly fitting into depression in front of tubercle of RV. *M.Ord.(Blackriv.)-Sil.(U. Medin.)*, E.N.Am.—FIG. D2,7. **C. constricta*, Ord.(Trenton.), USA(Ky.); 7a, LV int.; 7b, RV ext.; both $\times 1$ (930).

?*Cymatonota* ULRICH, 1893, p. 661 [**C. typicalis*; OD] [= *Chaenodomus* ULRICH, 1894, p. 477 (obj.); *Endodesma* ULRICH, 1894, p. 525 (type, *E. cuneatum*; OD); *Physetomya* ULRICH, 1893, p. 693 (type, *P. acuminata*; OD); *Psiloconcha* ULRICH, 1894, p. 530 (type, *P. grandis*; OD)]. Elongate, with subparallel dorsal and ventral margins; beaks about one-fourth distance from front end; ends rounded; umbonal ridge rounded; with broad lateral sulcus and commonly ventral sinus; surface essentially smooth, without radial ornamentation; posterior adductor larger than the anterior. *U.Ord.*, E.N.Am.—FIG. D3,8. **C. typicalis*, USA(Ohio); LV ext., $\times 1$ (929).

Dceruska BARRANDE, 1881, p. 77 **D. primula*; M]. Small, modioloid, without lunule, escutcheon or radial ornamentation; musculature and hinge unknown. [This genus requires restudy before it can be evaluated.] *Ord.(D3)*, Eu.(Boh.).

?*Dipleurodonta* ISBERG, 1934, p. 197 [**D. pulchella*; OD]. Externally similar to *Eurymya* and *Eurymyella*, but without posterior wing; cardinals unknown; 2 long and thin posterior lateral teeth parallel to shell margin. *U.Ord.(Richmond.)*, N. Am.-Sweden(Boda Ls.).—FIG. D2,3. **D. pulchella*, Sweden(Dalarna region); 3a, RV int. mold; 3b, LV ext.; both $\times 3$ (439).

Ectenocardiomorpha ISBERG, 1934, p. 188 [**E. elongata*; OD]. Similar to *Eurymyella* but without posterior wing and with strongly marked postumbonal ridge; differs from *Dipleurodonta* in lacking lamellar teeth. *U.Ord.*, Sweden.—FIG. D2,1. **E. elongata*, Boda Ls., Dalarna region; 1a, LV ext. (holotype); 1b, LV hinge, both $\times 3$ (439).

?*Eurymyella* WILLIAMS, 1912, p. 382 [**E. shaleri*; OD]. Subtriangular, narrow in front, subulate behind; umbonal ridge rounded and moderately elevated, without mesial depression; hinge plate very narrow at ends and without lamellar teeth, fairly strong under beaks where cardinal tooth occurs in each valve. *Sil.(Pembroke, Eastport)*, USA(Maine).—FIG. D2,2. **E. shaleri*; RV ext., $\times 1$ (984).

Goniophora PHILLIPS, 1848, p. 264 [**Cypricardia cymbaeformis* SOWERBY, 1839; OD] [= ?*Digonio-myia* WHIDBORNE, 1897, p. 116 (type, *D. elegans*; M); *Mytilomorpha* HIND, 1899 (obj.); ?*Naiadopsis* MENDES, 1952, p. 111 (type, *N. lamellosus*; OD)]. Equivalve, rhomboidal to trapezoidal; beaks anterior, curved inward and forward; strong umbonal carina from beaks to posterobasal angle;

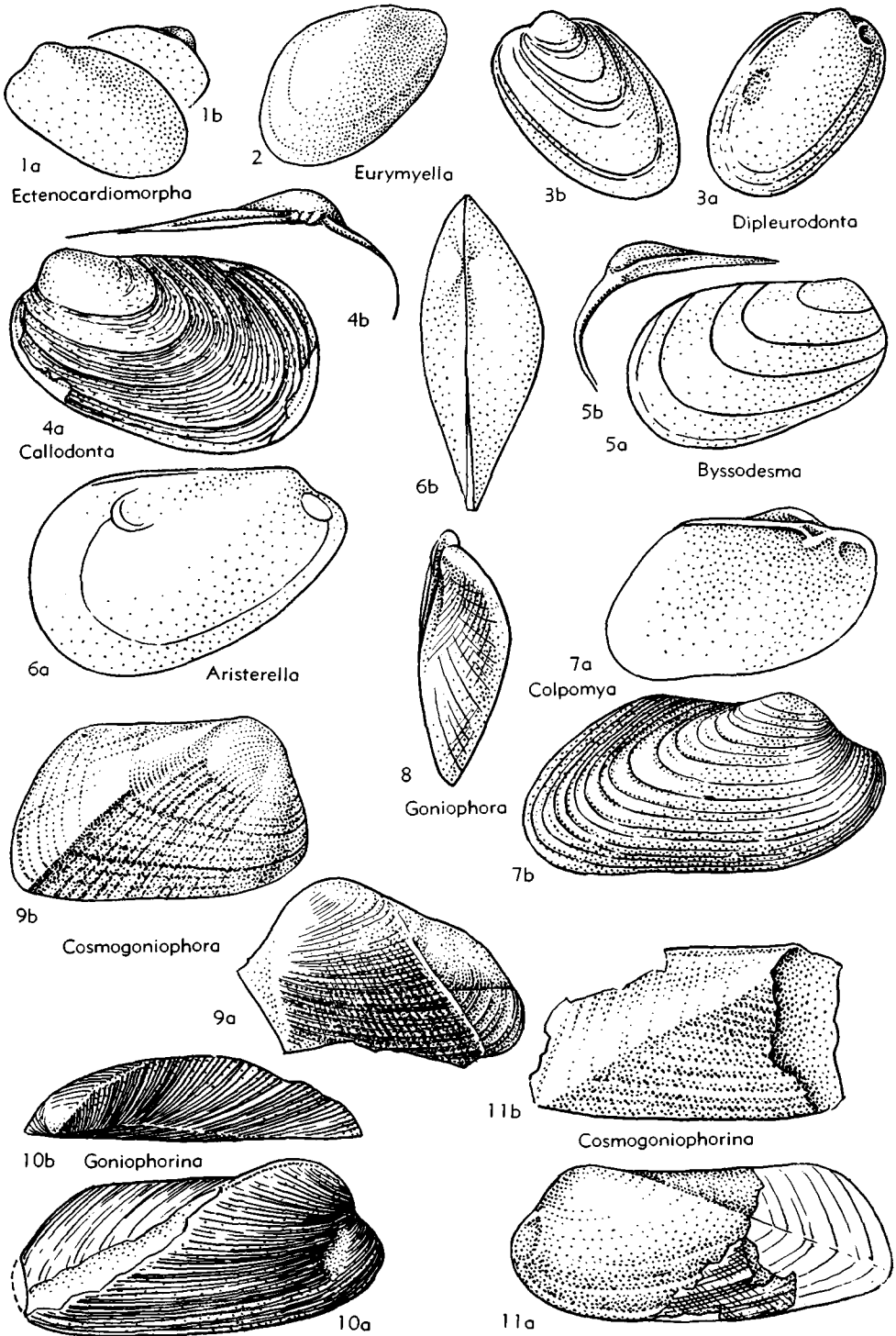


FIG. D2. Modiomorphidae (p. N394, N396-N397).

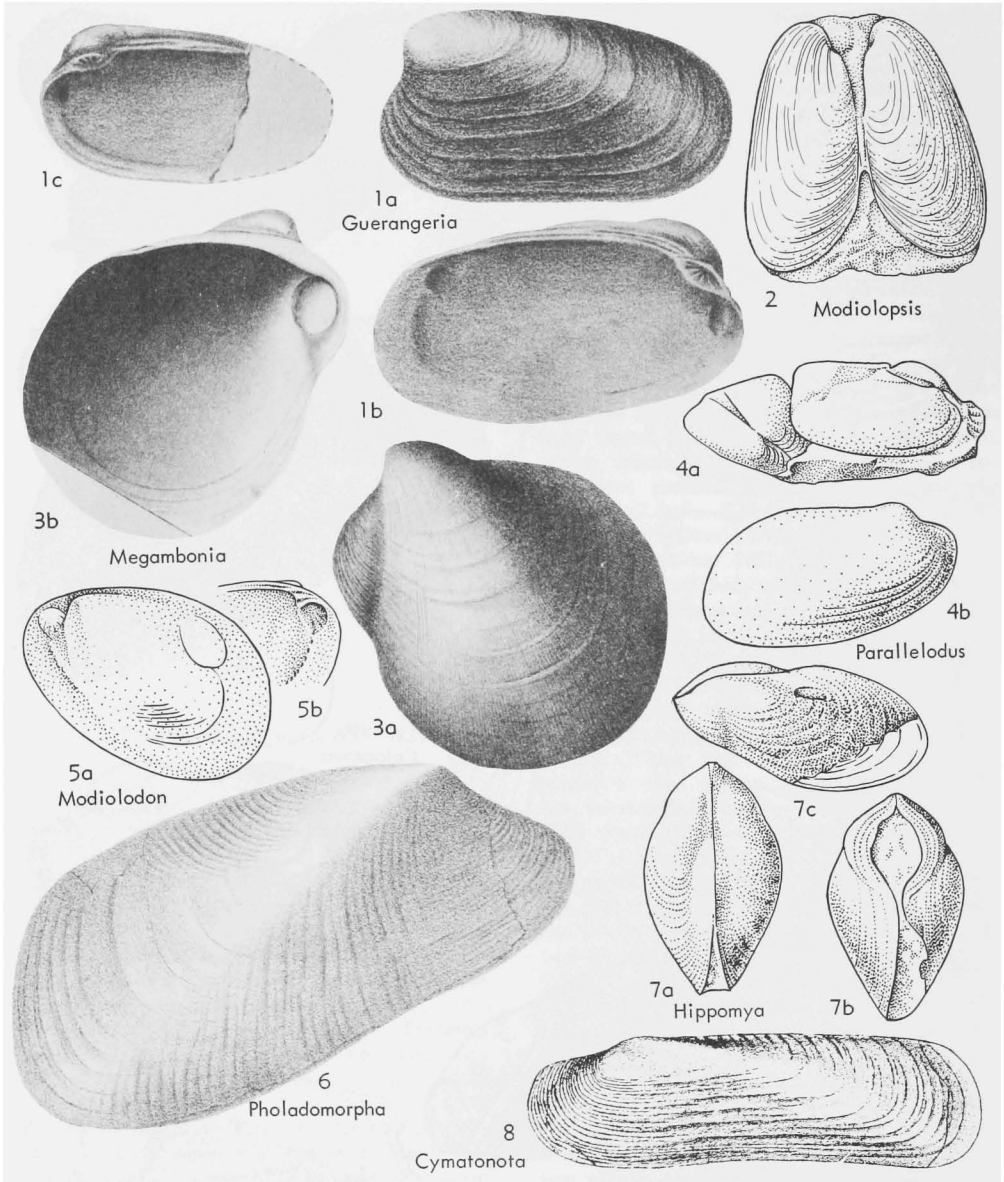


FIG. D3. Modiomorphidae (p. N397-N398).

dentition weak; LV in some species with 1 oblique tooth; anterior adductor deeply impressed and with a strong myophoric buttress behind it. *L. Ord.-L.Perm.*, cosmop.

G. (Goniophora). Without radial costae. *Ord. (Trenton.)-L.Perm.*, cosmop.—FIG. D2,8. **G. (G.) cymbaeformis* (SOWERBY), Sil.(U.Ludlow), Eng.; RV ant., $\times 1$ (Sowerby in Murchison, 1839).

G. (Cosmogoniophora) McLEARN, 1918 [**G. bellula* BILLINGS, 1874; OD]. With radial costae. *L.Ord.(Tremadoc.)*, Arg.-Dev., N.Am.—FIG. D2,9. **G. (C.) bellula* (BILLINGS), Sil.(Stonehouse F.), N.S.(Arisaig); 9a,b, LV ext., RV ext., both $\times 1.0$ (564).

Goniophorina ISBERG, 1934 [**G. volvens*; OD]. Similar to *Goniophora* but without teeth. *U.Ord.*, Sweden; *L.Perm.*, SW.USA.

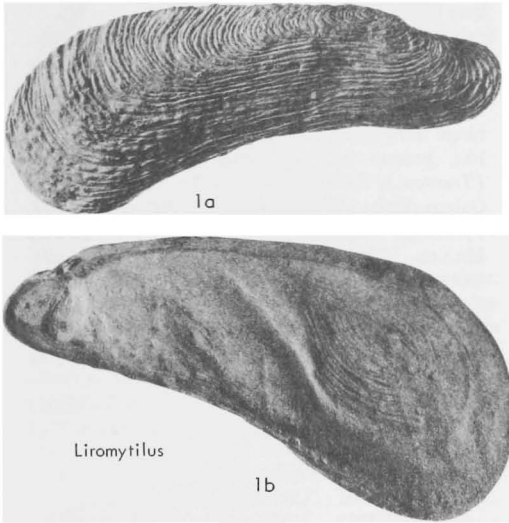


FIG. D3A. Modiomorphidae (p. N397).

G. (Goniophorina). Without radial costae. *U.Ord.-L.Perm.*—FIG. D2,10. **G. (G.) volvens*, *U.Ord.* (Boda Ls.), Sweden (Dalarna region); 10a,b, RV ext. and dorsal (holotype), $\times 2$ (439).

G. (Cosmogoniophorina) ISBERG, 1934 [**G. (C.) carinata*; OD]. With radial costae. *U.Ord.*, Sweden.—FIG. D2,11. **G. (C.) carinata*, Boda Ls., Dalarna region; 11a, LV ext. (holotype), $\times 3$; 11b, RV int. mold, $\times 2$ (439).

Guerangeria OEHLERT, 1880 (1881) [**G. davousti*; M]. Elongate, subquadrate, with anterior beaks; lacking escutcheon and lunule or radial ornamentation; somewhat superficially to *Cypricardinia*; single prominent cardinal tooth in RV marked by strong radial grooves, with corresponding socket in LV; well-defined posterior lateral tooth and socket in RV. *L.Dev.*, W.Fr.—FIG. D3,1. **G. davousti*, near Brulon; 1a,b, LV ext., int., $\times 3$; 1c, RV int., $\times 3$ (Oehlert, 1881).

?**Hippomya** SALTER, 1864, p. 299 [**H. ringens*; OD]. Modioliiform, without radial ornamentation or posterior wing; large byssal gape with thickened rim in front of byssal sulcus. *Ord.*, Eng.—FIG. D3,7. **H. ringens*, Budleigh Salterton, Eng.; 7a,b, dorsal and ventral view of both valves, $\times 0.7$; 7c, LV lat. view, $\times 0.7$ (823).

?**Liromytilus** LaRocque, 1950, p. 294 [**Modiomorpha attenuata* WHITEAVES; OD]. Surface with strong concentric ridges; umbones inconspicuous, not terminal, situated in anterior one-sixth of shell; anterior adductor small, posterior scar large, occupying more than one-half of posterior part of shell, bounded anteriorly by raised ridge; 2 small pyra-

midal cardinal teeth just in front of right umbo; lateral teeth and dentition of LV unobserved. *M.Dev.*, Can. (Manitoba).—FIG. D3A,1. **L. attenuata* (WHITEAVES); 1a,b, $\times 0.5$ (LaRocque). [LaRocque]

Megambonia HALL, 1859, p. 12 [**Pterinea cardii-formis* HALL, 1843; OD]. Ventricose, upright, with strongly defined anterior lobation; surface with fine radial costellae; hinge short, with distinct lateral tooth and groove near posterior cardinal angle of each valve. *Sil. (?Arisaig)*, Can. (N.S.); *M.Dev.*, USA (N.Y.).—FIG. D3,3. **M. cardii-formis* (HALL), *Dev.* (Onondaga), N.Y.; 3a,b, LV ext., LV int., both $\times 1$ (379).

Modiolodon ULRICH, 1894 (June 16), p. 521 [**Modiolopsis oviformis* ULRICH, 1890; OD] [*non ?Modiolodon* NECHAEV, 1894 (probably published late in year) (type, *Clidophorus pallasi oblongus* GOLOWKINSKY, 1868; OD)]. Similar to *Modiolopsis*, but with 1 to 3 oblique cardinal teeth in each valve. *M.Ord.-U.Ord.*, N.Am.; *Sil. (Llandov.)*, Scot.; ?*U.Perm.*, USSR (Krasnowidowo, Volga R.).—FIG. D3,5. **M. oviformis* (ULRICH), *Ord.* (Trenton), USA (Ky.); 5a,b, LV int. mold and cast, $\times 1$ (930).

Modiolopsis HALL, 1847, p. 157 [**Pterinea modiolaris* CONRAD, 1838; M] [= *Orthodesma* HALL & WHITFIELD, 1875, p. 93 (type, *O. rectum*; OD); *Orthonotella* MILLER, 1882, p. 117 (type, *O. jaberi*; M); ?*Sphenolium* S. A. MILLER, 1889, p. 513 (type, *S. cuneiforme*; OD); *Corallidomus* WHITFIELD, 1895, p. 493 (type, *C. concentricus*; M); *Lithobia* KOKEN, 1902, p. 132 (type, *L. atava*; M); *Modiodoesma* ULRICH, 1924 (obj.)]. Edentulous; without marked lateral sulcus or ventral

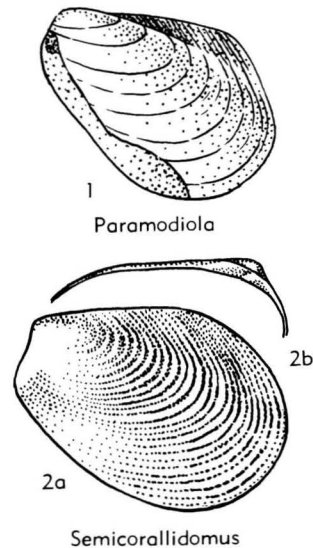


FIG. D4. Modiomorphidae (p. N398-N399).

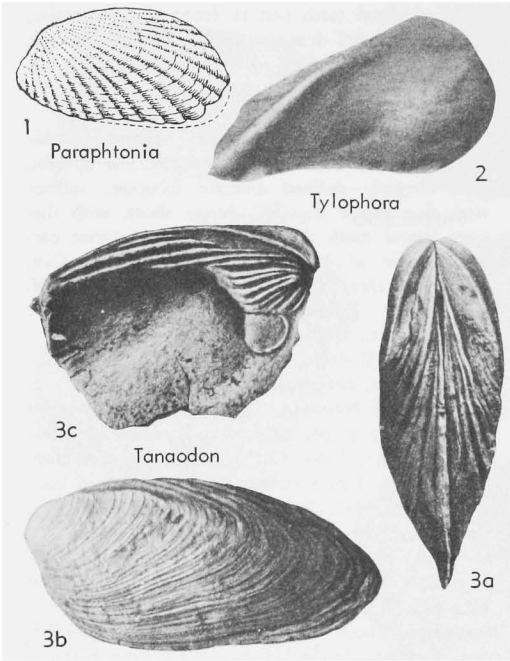


FIG. D5. Modiomorphae (p. N398-N399).

sinus; radial ornamentation lacking. *M.Ord.-U. Ord.*, cosmop.—FIG. D3,2. **M. modiolaris* (CONRAD), *U.Ord.*, USA (N.Y.); both valves ext., ca. $\times 0.8$ (931).

Parallelodus BRANSON, 1909 [**P. obliquus*; OD]. Similar to *Whiteavesia*, but RV with 1 anterior tooth and 1 posterior tooth, LV with 2 anterior teeth and 2 posterior teeth; teeth long and nearly parallel to hinge line. *M.Ord.*(Blackriv.), USA (Mo.).—FIG. D3,4. **P. obliquus*; 4a, 2 specimens showing dentition; 4b, RV ext.; all $\times 1$ (82).

Paramodiola ISBERG, 1934, p. 163 [**P. glabra*; OD]. Similar to *Modiomorpha* but with beaks low, anteriorly undifferentiated from front lobe of shell; edentulous. *M.Ord.*, Sweden.—FIG. D4,1. **P. glabra*, Kullsborg Ls., Dalarna region; lat. view of holotype, $\times 3$ (439).

Paraphontia KHALFIN, 1958, p. 182 [**P. imitabilis*; OD]. Externally similar to *Modiomorpha* but ornamented with coarse radial ribs. *M.Ord.*, USSR (Sib.).—FIG. D5,1. **P. imitabilis*; LV ext., $\times 1$ (Khalfin, 1958).

Pholadomorpha FOERSTE, 1914, p. 279 [**Modiolopsis pholadiformis* HALL, 1851; OD (= *Sedgwickia? divaricata* HALL & WHITFIELD, 1875)]. Similar to *Whiteavesia* except that costae are coarse and divaricate with respect to umbonal ridge. *U.Ord.*, USA (Ohio-N.Y.)-Can.(Quebec).

—FIG. D3,6. **P. pholadiformis* (HALL), Quebec; RV ext., $\times 1$ (381).

Prolobella ULRICH, 1894, p. 532 [**P. striatula*; OD]. Obliquely acuminate-ovate; beaks anterior but not terminal; anterior end of shell lobed; surface with concentric and radial ornamentation; hinge thin, apparently without teeth; short clavicle-like process just in front of beaks. *M.Ord.* (Trenton.), E.N.Am.—FIG. D6,1. **P. striatula*, Galena Dol., USA (Minn.); LV ext., $\times 1$ (930).

?Pyanomya MILLER, 1881, p. 318 [**P. gibbosa* MILLER, 1881; M]. Externally similar to *Modiomorpha*; interior unknown. *U.Ord.*, Ohio.

?Radiatodonta DAHMER, 1921, p. 245 [**R. goslaricensis*; OD]. Like *Modiomorpha* but with several short, steep-sided cardinal teeth, converging above in front of beak. *L.Dev.*, Eu.(Ger.).—FIG. D6,6. **R. goslaricensis*, Oberharzer Kahleberg Ss., near Drecksalkopf; LV int. mold, $\times 1$ (211b).

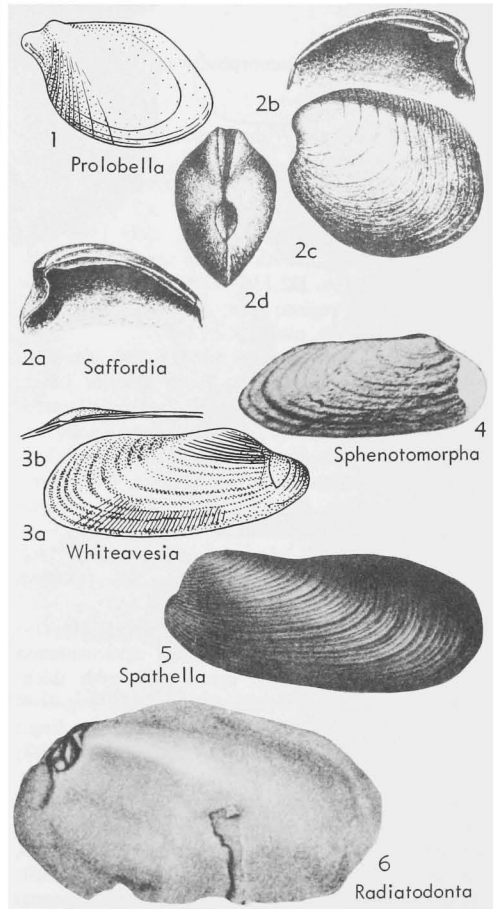


FIG. D6. Modiomorphae (p. N398-N399).

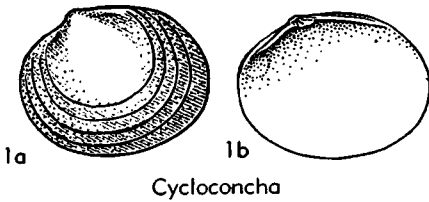


FIG. D7. Cycloconchidae (p. N399).

Redonia ROUAULT, 1851, p. 362 [**R. deshayesiana*; SD FISCHER, 1886]. Similar to *Modiomorpha* but attenuated posteriorly and with 2 posterior laterals in RV and 1 in LV. [Assigned also to Carditacea which it somewhat resembles excepting for fact that the posterior lateral teeth originate at beaks instead of behind the ligament. Placed in a separate family Redoniidae BABIN, 1966, but the distinction from Modiomorphidae appears to be insignificant.] *Ord. (Llandeil.)*, Eu. (France-Boh.-Spain)-N.Afr.—FIG. E44,4. **R. deshayesiana*, Brittany; 4a,b, LV int., RV int., $\times 1$; 4c,d, LV and RV hinges, enl. (Chavan, n).

?**Saffordia** ULRICH, 1894, p. 625 [**S. ventralis*; OD]. Subovate; beaks anterior; without radial ornamentation; lunule and escutcheon; hinge plate thin; LV with 1 horizontal wedge-shaped cardinal tooth and 1 slender lateral tooth extending from the beak; RV with cardinal socket and 1 lateral furrow. *M.Ord.-U.Ord.*, E.Can.-NE.USA.—FIG. D6,2. **S. ventralis*, U.Ord., USA (Minn.); 2a, RV hinge; 2b, LV hinge; 2c, LV; 2d, ant. view; all $\times 1$ (929).

Semicorallidomus ISBERG, 1934, p. 175 [**S. whitfieldi*; OD]. Similar to *Modiolopsis* but less elongate; LV with depression under umbo, probably to receive tooth in RV. *U.Ord.*, Sweden.—FIG. D4,2. **S. whitfieldi*, Boda Ls., Dalarna region; 2a, LV ext. (holotype), $\times 3$; 2b, LV hinge, $\times 5$ (439).

Spathella HALL, 1885, p. xxxiii [**S. typica*; OD]. Transversely subcylindrical, anterior end short, narrowly rounded; beaks subanterior, small; umbonal slope rounded or subangular; surface with concentric ornamentation only. Interior unknown. *U.Dev.-Miss.*, N.Am.-Eu.—FIG. D6,5. **S. typica*, U.Dev., USA (N.Y.); LV, $\times 1$ (379).

Sphenotomorpha WILLIAMS & BREGER, 1916, p. 233 [**S. rigidula*; OD]. Similar to *Modiomorpha* but with straight, horizontal or slightly declining hinge line; no mesial depression. *L.Dev.*, USA (Maine)-Brazil.—FIG. D6,4. **S. rigidula*, Chapman Ss.; RV ext., $\times 1$ (986).

?**Tanaodon** KIRK, 1927, p. 1 [**T. louderbacki*; M] [= *Neoactinodonta* HEIDECKER, 1959, p. 3 (type, *N. amygdalina*; M)]. Beaks terminal; lunule small, escutcheon large, well defined; ventral pro-

file convex; without radial ornamentation; hinge plate broad, traversed by many oblique teeth below the ligament, with or without cross striations, teeth becoming progressively longer and parallel with posterior margin of shell. *M.Dev.*, E.Australia-China.—FIG. D5,3. **T. louderbacki*, M.Dev., Tung Kou Distr., Szechuan, China; 3a-c, dorsal view both valves; LV ext., LV int., all $\times 0.7$ (473).

Tylophora DAHMER, 1936, p. 23 [**Goniophora convoluta* DREVERMANN; M]. Similar to *Goniophora* but ornamented with fine radial costellae; hinge unknown. *L.Dev.*, Eu. (Ger.).—FIG. D5,2. **T. convoluta* (DREVERMANN), L.Coblentz.; RV ext., $\times 1$ (213).

Whiteavesia ULRICH, 1893 (1895), expl. pl. 56 [nom. subst. pro *Actinomya* ULRICH, 1894 (non MAYER, 1870)] [**Modiolopsis cincinnatiensis* HALL & WHITFIELD, 1875; OD]. Lateral sulcus and ventral sinus absent, interior marked by fine radial ridges which may reflect fine external ornamentation; hinge edentulous(?). *M.Ord.-U.Ord.*, E.N. Am.-Arctic N. Am.—FIG. D6,3. **W. cincinnatiensis* (HALL & WHITFIELD), U.Ord., USA (Ky.); 3a, RV int. mold; 3b, RV hinge; both $\times 1$ (929).

Superfamily CYCLOCONCHACEA Ulrich, 1884

[nom. transl. NEWELL, herein (ex Cycloconchidae ULRICH, 1884)] [Diagnosis by N. D. NEWELL]

Ovoid, more or less isomyarian shells with submedian (never terminal) beaks; lacking radial ornamentation; dentition consisting of few elongate teeth below beaks increasing in length toward anterior and posterior margins of hinge. *M.Cam.-U.Dev.*

Family CYCLOCONCHIDAE Ulrich, 1884

[Materials for this family prepared by AURÈLE LAROCQUE & N. D. NEWELL]

Amphidetic, with median cardinals and laterals in front of and behind beaks; those of RV stronger than those of LV. *M.Ord.-U.Ord.*

Cycloconcha S. A. MILLER, 1874 [**C. mediocardinalis*; M]. Subcircular, with 2 or 3 cardinal teeth near middle of hinge and well-differentiated, long, lateral tooth in front and behind beaks. *M.Ord.-U.Ord.*, USA (Ohio).—FIG. D7,1. **C. mediocardinalis*, U.Ord.; 1a,b, LV ext., RV int., $\times 1.25$ (615).

Actinodonta PHILLIPS, 1848, p. 225 [**A. cuneata*; M]. Elongate-ovate, smooth, with somewhat extended posteroventral extremity; beaks located 0.25 to 0.3 behind anterior extremity; anterior

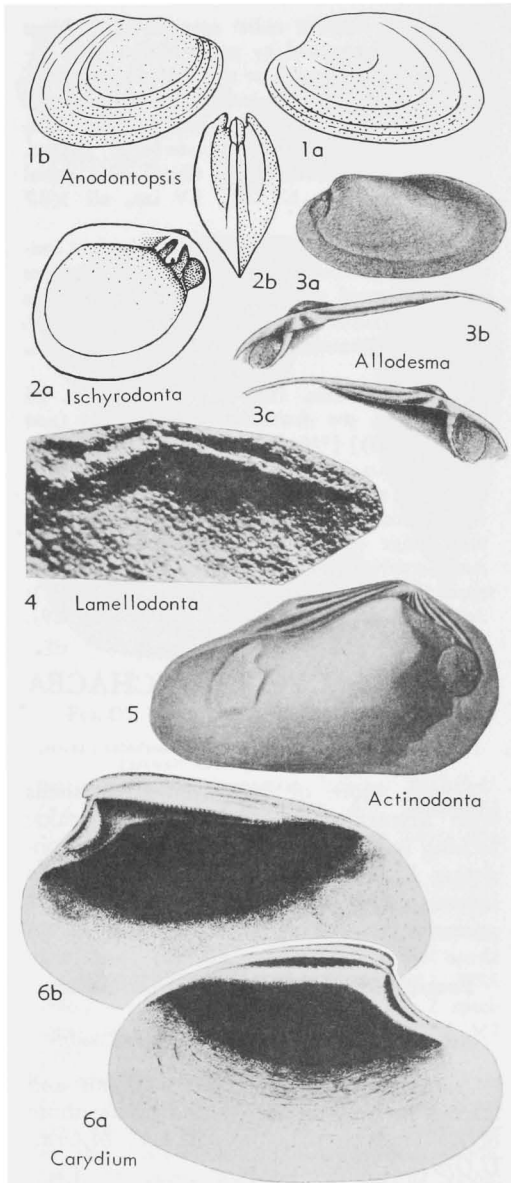


FIG. D8. Cycloconchidae (5); Lamellodontidae (4); Allodesmatidae (1-3); Carydiidae (6) (p.N399-N400).

adductor circular, somewhat smaller than posterior, reinforced posteriorly by buttress; dentition consisting of about 9 radial teeth on broad hinge plate, teeth short medially and longer marginally; anterior muscle scar strongly impressed, smaller than posterior scar. *M.Ord.*, G.Brit.—FIG. D8,5. **A. cuneata*, Llandeil., LV int., $\times 1$ (735).

Family LAMELLODONTIDAE Vogel, 1962

[Materials for this family prepared by N. D. NEWELL]

Subequilateral, amphidetic, with one or two subequal, nonrenulate lateral teeth in front of and behind beaks, in some shells joining medially in obtuse apex; cardinal teeth lacking. *M.Cam.*

Lamellodonta VOGEL, 1962, p. 216 [**L. simplex*; M]. Ovoid to subcircular, with centrally situated beaks. *M.Cam.*, Spain.—FIG. D8,4. **L. simplex*, Zaragoza; RV hinge, $\times 10$ (943).

Family ALLODESMATIDAE Dall, 1895

[Materials for this family prepared by AURÈLE LA ROCQUE & N. D. NEWELL]

Beaks near anterior end; surface without radial ornamentation; isomyarian; one or two posterior lateral teeth in each valve, or lacking; anterior laterals lacking or short; one or two cardinals in each valve; anterior adductor with strong posterior myophoric ridge. [Some genera of this family resemble certain Modiomorphidae and Carditidae.] *M.Ord.-U.Sil.*

Allodesma ULRICH, 1894, p. 617 [**Modiolopsis subelliptica* ULRICH, 1892; OD]. Elongate elliptical; hinge with 1 or 2 posterior lateral teeth in each valve; RV with 2 and LV with 1 cardinal tooth; anterior lateral teeth short or lacking; pallial line simple. *M.Ord.*, NE.USA-E.Can.—FIG. D8, 3. **A. subellipticum* (ULRICH), Galena Dol., USA (Minn.); 3a, LV int. mold, $\times 2$; 3b,c, RV and LV hinge, $\times 4$ (930).

Anodontopsis M'COY, 1851, p. 53 [**A. angustifrons*; OD] [=?*Orthodontiscus* MEEK, 1871, p. 298 (type, *Anodontopsis? milleri*; OD)]. Ovoid to subtrigonal; LV with 1 slender posterior lateral and 1 shorter anterior lateral tooth; RV with 2 posterior laterals and 1 shorter anterior lateral tooth. *Sil.(U.Ludlov.)*, G.Brit.—FIG. D8,1. **A. angustifrons*, Eng.(Kendal); 1a,b, LV ext., RV ext., $\times 1$ (Sedgwick & M'COY, 1854).

?**Ischyrodonata** ULRICH, 1890 [**I. truncata*; OD]. Short or elongate, thick-shelled; hinge straight or slightly arcuate, wide and strong; RV with 1 strong cardinal tooth; LV with 2 strong cardinals; no laterals. *U.Ord.*, E.N.Am.—FIG. D8,2. **I. truncata*, Cincinnati, USA(Ohio); 2a, LV int.; 2b, int. bivalved specimen; both $\times 1$ (926).

Family CARYDIIDAE Haffer, 1959

[Materials for this family prepared by N. D. NEWELL]

Shell isomyarian, strongly inequilateral, opisthodontic, with prosogyre beaks approximately 0.3 behind front margin; one pos-

terior lateral tooth in each valve below ligament; anterior dentition consisting of single curved, crenulated lateral tooth or single radially furrowed cardinal tooth; teeth of LV underlying those of RV. *L. Dev.-U.Dev.*

Carydium BEUSHAUSEN, 1895, p. 154 [**C. gregarium*; SD WOLF, 1930, p. 46]. Shell ovoid to sub-trigonal, tapering posteriorly; without radial ornamentation; anterior dentition variable, ranging from simple denticulate lateral tooth to radially furrowed tubercle. *L.Dev.-U.Dev.*, Eu. (Ger.-Belg.). —FIG. D8,6. **C. gregarium*, *L.Dev.* (Singhofen), Ger.; 6a,b, LV int., RV int., $\times 4$ (Haffer, 1959).

Order UNIONOIDA Stoliczka, 1871

[*nom. correct.* WEIR, herein (*pro* order Unionacea STOLICZKA, 1870)] [Diagnosis by JOHN WEIR]

Inequilateral, equivalved or subequivalved, flatly compressed to globular shells, varying in outline from nearly circular to elongate and rodlike (or with symmetry destroyed by attachment in one Recent family); but commonly ovate, elliptical, trigonal or trapeziform, ranging in length from 20 mm. to large forms of 300 mm. Beaks prosogyrous, relatively small, flat, and inconspicuous; or moderately large and prominent, with capacious cavities, giving good upstanding molds in fossils. Lunule and escutcheon absent, or only feebly defined. Periostacrum well developed, smooth and thin in Recent forms, but tough and resistant (in post-Pleistocene, and possibly older, fossils it is sometimes the only part preserved). Ornament of simple growth lines, supplemented (in some Unionacea only) by ribs or knobs, which may be spinose. Ligament external, opisthodontic. Internally shells are nacreous in Unionacea, and possibly also in some older taxa; integripalliate, isomyarian or subisomyarian, anterior retractor of foot commonly forming conspicuous circular or reniform scar above and behind anterior adductor. Dentition, when present, may consist only of one or two more or less subumbonal teeth situated transversely on hinge plate or forming groups of strong teeth (normally two in LV and one in RV) based on short dental fulcra situated in front of umbo, and supplemented (Unionacea only) by elongate, lamellar posterior teeth (commonly two in

LV and one in RV) below ligament and subparallel to hinge line. Anomalous dentition of pseudotaxodont character in Palaeomutelidae (Anthracosiacea). Mantle edges in living forms united only between branchial and anal orifices. *?M.Dev.*, *U.Dev.-Rec.*

This possibly heterogeneous order provides a convenient grouping of the Unionacea with certain older cryptogenic groups of *Unio*-like and *Anodonta*-like bivalves, which, except for some Pachycardiidae, shared with the Unionacea a preference for nonmarine environments. Despite the great variability of shell outline and dentition which makes concise diagnosis of genera and higher taxa exceedingly difficult, all have in common a certain combination of shell characters which, if not highly distinctive (hence their previous association with the Cardiniidae and other families), at least imparts a certain homogeneity of morphic character to the assemblage. In the Unionacea and Anthracosiacea shell form is greatly influenced by ecologic station (285), a factor which, added to the innate variability of the population at a given station or geologic horizon, contributes to the difficulty of classification.

No palaeontological evidence indicates that these superfamilies had a common origin. Those of the upper Paleozoic apparently lacked the nacreous condition that distinguishes the later Unionacea (or conditions of fossilization have destroyed all evidence of it), and while most Unionacea, like older forms, have simple growth lines as the only surface sculpture, others develop a more elaborate ornament of ribs, tubercles, or spinous excrescences that never are found in the Anthracosiacea and Archanodontacea.

Dentition is normally present, but certain taxa are characteristically edentulous (Anodontidae, ?Archanodontacea), and in others the anodont condition occurs in individuals as an aspect of variation in the hinge apparatus. The characteristic lamellar posterior "lateral" teeth that occur commonly in the Unionacea are not found in the Anthracosiacea. These teeth underlie the ligamental nymphs, at least proximally, and in this respect are not strictly homologous with the analogous teeth of Heterodonta.

The pseudotaxodont dentition of the Palaeomutelidae is unique. In the series of irregular teeth ranged along the hinge one or more below the umbo may acquire special prominence, and the whole series may be reduced to a few large, irregular teeth on a short and broadened hinge plate.

The very large bivalves of the Upper Devonian and Carboniferous that are now accorded superfamily rank as Archanodontacea have apparently no ancestral or other intimate relationship with the later-appearing but in part contemporaneous (or homotaxial) Anthracosiacea. A considerable gap in time separates their latest representative in the Pennsylvanian and the earliest *Unio* of the Triassic and a still greater interval before the appearance of unequivocal *Anodonta*, which the earliest (Devonian) archanodonts, especially, so much resemble in outline. The *Unio*-like *Neamnigenia* of the Permian of Siberia may represent a link. Unfortunately, as in *Archanodon*, its hinge is unknown. It occurs in a highly endemic fossil fauna whose other bivalve genera all became extinct before the end of the Permian; accordingly, *Neamnigenia* is unlikely to be the earliest recorded unionid, directly ancestral to species in the Triassic rocks of other regions (East Africa, North America, etc.) that are commonly referred to *Unio*. Its relations (if any) to the earlier and more *Anodonta*-like *Archanodon* are equally doubtful.

It is unknown whether any of these extinct genera possessed the glochidium or lasidium larvae of the Recent Unionacea.

Superfamily ARCHANODONTACEA Weir, new superfamily

[Materials for this superfamily prepared by JOHN WEIR]

Very large, sporadically thick shells (to 22 cm. in length), inequilateral, integripalliate, isomyarian, varying somewhat in outline and proportions, but in general transversely subelliptical, anodontiform, with inconspicuous depressed umbones situated at about 0.1 to 0.2 of length from anterior end. Straight hinge line extending posteriorly for half (or rather more) of postumbonal length, making obtuse angle with obliquely inclined posterior margin. Ventral margin

gently convex, straight, or slightly curved in wide but shallow sinus; hinge apparently edentulous; one or two lamellar ridges (claustra) radiating from umbo in posterior or posteroventral direction over inner dorsal surface of valves in at least one species, but lacking articular function. Posterior adductor scar unknown; anterior adductor situated close in front of umbo near dorsal margin, may unite with adjacent insertions of anterior retractor and anterior umbonal retentor muscles to form large composite scar of oval or reniform outline. *U.Dev.-L.Perm.*

The Archanodontacea are a cryptogenic group of very large *Anodonta*-like freshwater shells of the upper Paleozoic. Sporadic occurrences of them are known from the Upper Devonian (Up. Old Red Ss.) of Ireland (*Archanodon*, *s.s.*) and USA (*Amnigenia*), Lower Carboniferous of England (*Archanodon*, *s.l.*) and Pennsylvanian of Nova Scotia (*Asthenodonta*). Upper Devonian forms lived somewhat gregariously as communities of rather variable shells. At present it is possible to define neither the trends nor the limits of their variation, but differences between the Irish "*Anodonta*" *jukesi* FORBES and the American *Amnigenia catskillensis* HALL may be no more than specific or subspecific.

These considerations probably apply also to Carboniferous forms, of which altogether only four or five nearly complete specimens are known. The sparse material suggests that these were larger and more elongate than shells of the Upper Devonian belonging to the group, but again this difference may be no more than specific. The generic separation of the latest member of *Asthenodonta* was based on a misinterpretation of the anterior muscle complex. Excellent plaster casts of type material supplied by the Geological Survey of Canada show clearly that the structure called "ligamental fulcrum" by WHITEAVES, and misrepresented in his figure, is an integral dorsal part of the scar of a very large anterior muscle complex, and probably represents the combined insertions of the anterior retractor and anterior umbonal retentor muscles, situated adjacent to and coalescing with the scar of the adductor. A similar, if

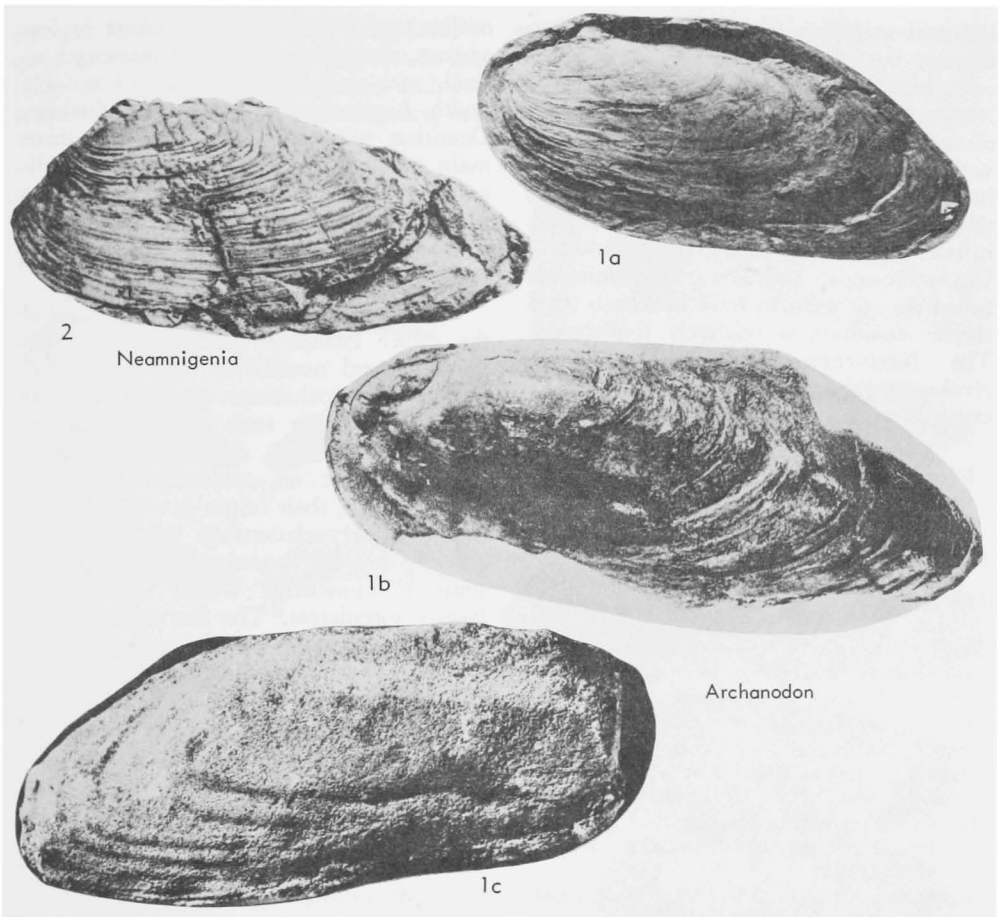


FIG. D9. Archanodontidae (p. N404).

less emphatic, division of the anterior muscle scar with smaller dorsal component, possibly representing only the anterior retractor, is shown in one of HALL's figures of the smaller Devonian species *Amnigenia catskillensis*. With the elimination of the "ligamental fulcrum" as a special structure, the justification of a separate genus *Asthenodonta* disappears.

Claustra have been figured only in the American forms referred to *Amnigenia*. It would be premature to say that they are absent in the others.

In view of the foregoing considerations there seems to be no alternative, in the present state of knowledge, to regarding *Amnigenia* and *Asthenodonta* as subjective synonyms of *Archanodonta*, a conclusion which does not rule out the possibility of

resurrecting these names for subgenera or genera if new material reveals unsuspected structural differences.

It is improbable that these *Anodonta*-like shells of the upper Paleozoic belong to the Unionacea. Apart from the gap in time that separates them from the earliest *Anodonta* (Eoc.) and *Unio* (Trias.), it is unlikely that they had evolved the elaborate mechanism of larval dispersal that characterizes Recent Unionacea. Otherwise it is difficult to explain the sporadic nature of their heterochronous occurrences. Had such an efficient mechanism of distribution been available, the thick-shelled *Archanodon westoni* of the Pennsylvanian of Nova Scotia might have been expected to yield fossils in the homotaxial deposits of the USA and in the much-explored Westphal-

ian coal measures of Britain and western Europe, but none has been found. It is not easy, however, to formulate a diagnosis of *Archanodon* that would emphasize morphic distinctions from *Anodonta*. The Pennsylvanian *Archanodon westoni* appears to have been thick-shelled (WHITEAVES records a thickness of 9 mm. anteriorly, and 12 mm. in one fragment). On the other hand, the Upper Devonian and Lower Carboniferous forms do not seem to have had such thick shells. *Anodonta* is relatively thin-shelled. The heterochronous homeomorphy of *Archanodon* and *Anodonta* must be accepted.

Family ARCHANODONTIDAE Weir, new family

Characters of superfamily. *U.Dev.-L. Perm.*

Archanodon HOWSE, 1878 [**Anodonta južesi* FORBES, 1853; OD] [= *Amnigenia* HALL, 1885 (type, *Cypricardites catskillensis* VANUXEM, 1842); *Asthenodonta* WHITEAVES, 1893 (type, *A. westoni*)]. Characters of superfamily. *Dev.(Up.Old Red Ss.)*, Ire.-Eng.; *U.Dev.*, USA; *L.Carb.*, Eng.; Penn., N.Scot.—FIG. D9,1a. **A. južesi* (FORBES), Up. Old Red Ss., Ire.; LV ext., $\times 0.4$ (Weir, n).—FIG. D9,1b. *A. westoni* (WHITEAVES), Penn., N.Scot.; LV ext., $\times 0.4$ (Weir, n).—FIG. D9,1c. *A. sp.*, L.Carb., Eng.; RV ext., $\times 0.4$ (Weir, n).

Neamnigenia KHALFIN, 1950 [**N. beljanini*; OD]. Large *Umo*-like shells; umbones obtuse, not prominent. Posterior end narrow, not expanded; posterior margin acutely rounded at its extremity, obliquely inclined above at very obtuse angle to straight hinge margin, which attains length of 0.5 to 0.8 length of shell. Ventral margin gently convex, without great subumbonal depth. Antero-dorsal margin rather long and straight. [Nonmarine.] *L.Perm.*, USSR (Sib.).—FIG. D9,2. *N. longa* (BETEKHTINA); LV ext., $\times 1$ (Ragozin, 1955).

Superfamily ANTHRACOSIACEA Amalitsky, 1892

[*nom. transl.* WEIR, herein (ex Anthracosiidae AMALITSKY, 1892)] [Materials for this superfamily prepared by JOHN WEIR except as recorded otherwise]

Upper Paleozoic nonmarine bivalves of moderate size (rarely attaining 90 mm. in length, and averaging less than half this), dimyarian (isomyarian or subisomyarian), integripalliate. Shells highly variable in

outline and inflation. Hinge more or less arcuate, according to the relative length of shell, with definite hinge plate of variable width. Ligament parivincular, opisthodontic. Dentition variable, but comprising three main categories, 1) with one or two cardinal teeth in one or both valves, rarely more; 2) irregularly pseudotaxodont; 3) teeth absent. ?*M.Dev.*, *Carb.-Perm.*, ?*Jur.* (especially *U.Carb.*).

The fresh-water or nonmarine bivalves of the upper Paleozoic (excluding Archanodontacea and nonmarine Myalinidae) fall into two heterochronous groups which are here given family rank as Anthracosiidae and Palaeomutelidae. Although much work has been done on constituent genera of these families, their origin is unknown and their mutual relationship uncertain. Discussion of these questions in the present state of knowledge would therefore be largely speculative. The few relevant facts and views are mentioned in discussion of each family, and possibility that the superfamily now proposed may be heterogeneous must be borne in mind. The nonmarine environments of the families were very different, typical Anthracosiidae having been essentially inhabitants of paralic marshes, and less fully continental than the Permian Palaeomutelidae. Nevertheless, in the absence of evidence from phylogeny, these families have in common a number of characters which make possible their provisional combination in the Anthracosiacea, thus conveniently maintaining the association of the Upper Carboniferous genera *Carbonicola* and *Anthracosia* with Permian *Palae-anodonta* and *Palaeomutela* favored by AMALITSKY (13), COX (1932, 1936) and ZITTEL's *Grundzüge* (1924), while facilitating future taxonomic redistribution by according separate family rank to the Carboniferous and Permian genera on the basis of distinctive dental patterns.

Palae-anodonta presents special difficulties. The name was proposed by AMALITSKY for certain forms of the Permian of the Oka-Volga basin, which he had previously assigned to "*Najadites*." The type species, by original designation, is *Unio castor* EICHWALD, whose sole figure, representing an

external view of an open shell (Fig. D10,3) gives no clue to hinge structure, nor is the hinge mentioned in the diagnosis and description. As interpreted by AMALITSKY, the

genus may be diphyletic, the Russian species falling naturally into two distinct groups of probably different origin: 1) small shells, some demonstrably edentulous, with opis-

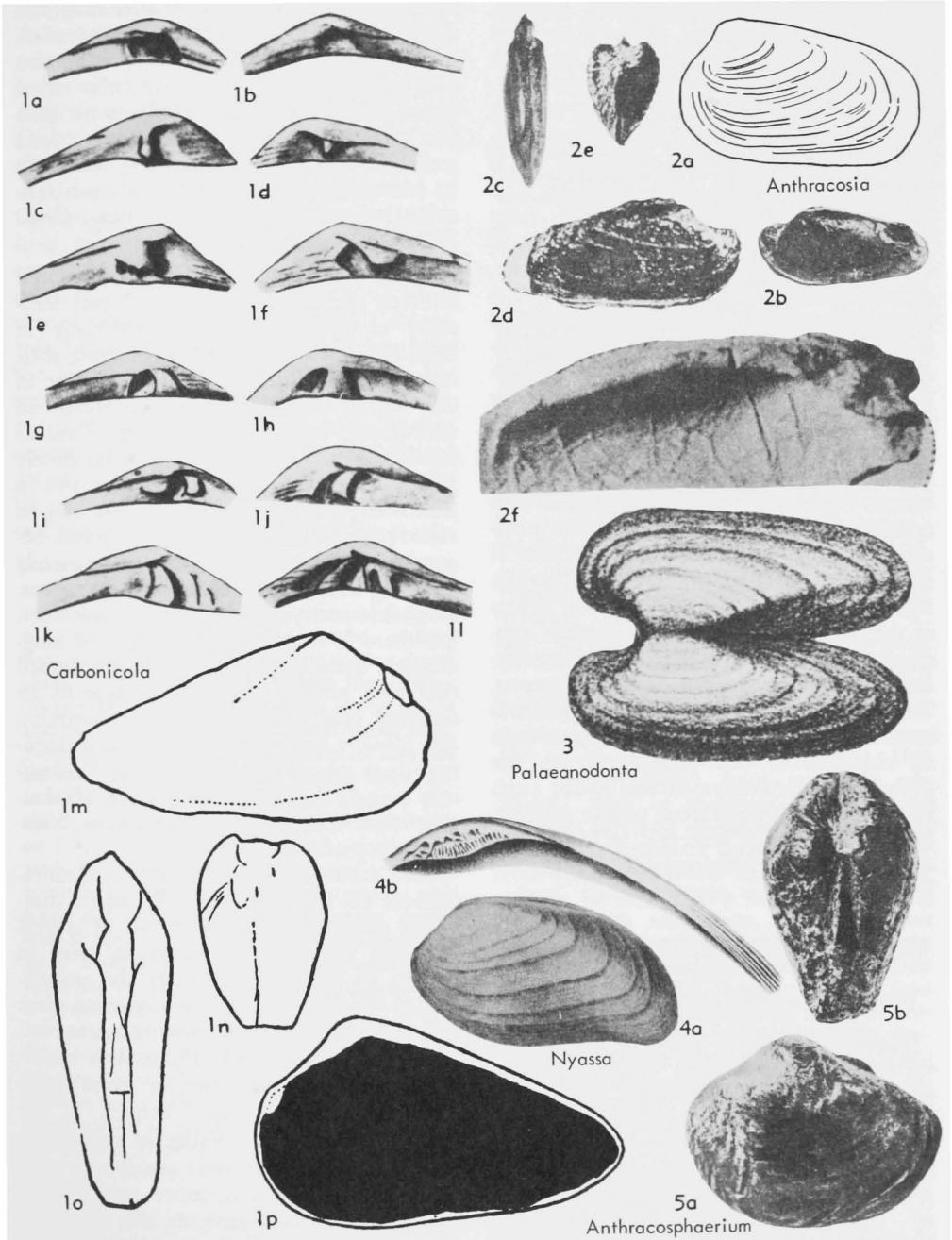


FIG. D10. Anthracosiidae (1-3,5); Family Uncertain (4) (p. N407, N411).

thodetic ligament, and externally like the type species (or plausible variants of it), and 2) relatively large, elongate edentulous forms like "*Najadites*" *verneuili*, which has, at least on the inner dorsal margin of the LV, two long, narrow parallel grooves, separated by a slender ridge. Doubtless these are opposed to but do not interlock with corresponding features in the other valve. A hinge margin of this kind may be interpreted as an extremely narrow ligamental area of duplivincular type. It is found also in certain early *Naiadites* (*N. obesus*), and also in *Anthraconaia*, from which the Permian "*Najadites*" *verneuili* may have evolved, through certain elongate, posteriorly narrowed forms that characterize the later stages of the Westphalian and the Stephanian in Europe. Group 2) is excluded from the present definition of *Palae-anodonta*. It is not known if *Unio castor* EICHWALD (type species of *Palae-anodonta*) possesses hinge features of this kind; more probably, like some plesiotypes, it is edentulous, with opisthodontic ligament. On this assumption I include *Palae-anodonta* provisionally in the Anthracosidae, by reason of its general external similarity to certain forms of the typical Carboniferous genera of the family and because the anodont condition occurs sporadically in the characteristically unstable hinges of these genera. The undoubtedly very different environment of *Palae-anodonta* may be regarded as an objection to this assignment, on the ground that derivation of this genus from forms of the Carboniferous paralic marches is unlikely. If this objection is valid, then the origin of *Palae-anodonta*, as of the Palaeomutelidae, is cryptic.

Family ANTHRACOSIIDAE Amalitsky, 1892

[*emend.* TRUEMAN & WEIR, 1946] [=Carbonicolidae Cox, 1932 (*partim*)]

Shells equivalve or subequivalve, highly variable, but commonly ovate, elliptical, subtriangular or suborbicular in outline; hinge line gently arcuate. Circular anterior adductor scar deeply impressed, slightly smaller in area than shallow oval posterior scar and situated near margin within angle of usually well-defined, subtriangular frontal lobe; anterior retractor muscle sit-

uated above and close to anterior adductor, its impression visible on internal molds as small single or double scar on crest of umbonal ridge. Dentition variable, usually consisting of one subumbonal tooth (in both valves, or in one only), which may not reach edge of hinge plate, but two teeth may occur in each valve, or in one valve only (single tooth, which may be in either valve, fitting between); rarely more than two teeth (maximum four, of low relief) present in each valve, and hinge plate may be edentulous. Lunule and escutcheon variable, but usually feebly defined. *Carb.*, ?*Perm.*

These inhabitants of Carboniferous forest swamps are common fossils in coal measures of Westphalian age, especially in Britain, which may well have been their center of dispersal. At many horizons in the British coal measures they occur in enormous numbers, forming "mussel bands" in which the shells may be closely packed in *lumachelles* of up to six feet in thickness. Individual mussel bands may be remarkably widespread and continuous, becoming stratal indices of more than merely local importance in coal-mining operations. Doubtless many cases are thanatocoenoses, but there is usually little evidence of long-distance transport, and it has been assumed that each affords a reliable sample of an adjacent, contemporaneous, living community. Usually one anthracosiid genus is dominant in a mussel band, commonly *Carbonicola* or *Anthracosia*, but locally *Anthracosphaerium*; nonmarine Myalinidae (*Naiadites*, etc.) may also occur.

Like nonmarine Myalinidae, the Anthracosidae are highly variable. Biometric studies of shells from mussel bands at several horizons have shown, however, that in respect of certain parameters the population of the genus studied in any given place is homogeneous, and represents a cross section of a chronospecies. From such homogeneous but highly variable populations morphospecies have been defined in the past, before detailed studies of association variation and ecology were possible, or considered necessary; and, more recently, for convenience in systematizing this taxonomically intractable family, thus rendering it

of stratigraphical value as the basis of the fruitful scheme of zonal subdivision now generally applied to the British coal measures.

Nothing definite is known of the origin of the family. The parivincular ligament and relatively small size of the anterior adductor may be consistent with derivation from some mytilacean, but not from the duplivincular Myalinidae. This would separate *Carbonicola* from *Anthraconaia* [*Anthracomya*], which were classified together as Unionidae by WHEELTON HIND and as Cardiniidae in the ZITTEL textbook (1913). It is true that elongate, so-called anthraconaioid forms occur in the lower coal measures of England, apparently as products of variation in populations of *Carbonicola*, but it is not known whether they have the hinge of true *Anthraconaia*; nor has such a variation relationship yet been detected between *Carbonicola* and *Anthraconaia s.s.* (the *adamsi-salteri-modiolaris* group). Provisionally it is better to refer the elongate "anthraconaioids" of the lower coal measures to *Carbonicola* with a query.

Anthracosia KING, 1856 [**A. beaniana*; OD]. Shell transversely subovate, elliptical, or elongate subtriangular, some with obliquely truncate posterior end; umbones low, strongly incurved, inclined forward and downward, giving in varying degree characteristic tilt to umbonal growth lines. Hinge plates beveled on their free edges, giving rise in internal molds to prominent median dorsal ridge. Postumbonal portion of each hinge plate long and narrow; anterior subumbonal portion short and broad, deflected ventrally at obtuse angle to posterior portion, and usually carrying single tooth on 1 or both valves. Dorsally and posteriorly to tooth (or dental cavity) and at anterior end of opisthodontic, parivincular ligament groove, each hinge plate bears conspicuous triangular groove with its apex contiguous to umbo. [In apposition these triangular grooves doubtless enclosed a ligamental structure, which may have grown from a persistent juvenile resilium.] Anterior lobe of internal mold compressed and strongly demarcated from rest of mold by vertical or inclined ridge descending ventrally from each umbo behind anterior adductor scar; sides of mold behind anterior lobe nearly parallel in dorsal view. *Carb. (Westphal. B)*, W.Eu.-USSR (Donetz).—FIG. D10,2a. **A. beaniana*, Eng., neotype (ICZN pend.); LV ext., $\times 1$ (915).—FIG. D10,2b-e. *A. aquilina* (J. DE C. SOWERBY); 2b,c, int. mold LV, both valves dorsal, $\times 1$; 2d,e, lectotype (ICZN pend.), RV, both

valves ant., $\times 1$ (915).—FIG. D10,2f. *A. sp. aff. A. atra* (TRUEMAN), Scot.; hinge, $\times 2$ (915).

Anthracosphacrium TRUEMAN & WEIR, 1946 [**Carbonicola exigua* DAVIES & TRUEMAN, 1927; OD] [= *Carbonicola* HIND, 1894 (*partim*); *Carbonicola* DAVIES & TRUEMAN, 1927 (*partim*)]. Suborbicular or subovate, inflated, equivalved, with gibbous, contiguous umbones. Internal characters unknown. *U.Carb. (Westphal. A, B)*, W.Eu.-USSR (Donetz).—FIG. D10,5. **A. exiguum* (DAVIES & TRUEMAN), Eng. (? Westphal. B), 5a,b, holotype LV lat., both valves dorsal, $\times 1$ (915).

Carbonicola M'COY, 1855 [**Unio acutus* J. SOWERBY, 1813; SD DAVIES & TRUEMAN, 1927] [= *Carbonicola* HIND, 1894 (*partim*); *Carbonicola* DAVIES & TRUEMAN, 1927 (*partim*) (non AMALITSKY, 1892)]. Like *Anthracosia*, but umbones erect, in most shells unequal in height, and umbonal growth lines usually not tilted. Hinge line curved, rarely straight behind umbo; hinge plates deep, forming continuous arc without marked division into anterior and posterior portions as in *Anthracosia*; 1 subumbonal tooth on one or both valves, or 2 in some, rarely more; or edentulous. Outline of internal mold in dorsal plan forming double wedge; beaks of mold prominent and divergent, its median dorsal ridge weak; anterior lobe not compressed and demarcated from rest of mold as in *Anthracosia. Carb.* (especially *U.Carb. (Namur. Westphal. A)*), W.Eu.-USSR (Donetz).—FIG. D10,1a-l. C. sp. aff. *C. pseudorobusta* (TRUEMAN), Scot.; 1a-l, hinges, LV's on left and unpaired, $\times 1$ (565).—FIG. D10,1m-p. **C. acuta* (J. SOWERBY), Eng.; 1m-o, lectotype (a mold; RV lat., both valves ant., dorsal), $\times 1$; 1p, same, LV, with shell restored, $\times 1$ (915a).

?**Palaeonodonta** AMALITSKY, 1895 [**Unio castor* EICHWALD, 1895] [= *Palaeonodonta* AMALITSKY, 1891 (*nom. nud.*); *Najadites* AMALITSKY, 1892 (*non* DAWSON, 1860)]. Small, transversely subelliptical, ovate or rhomboidal, elongated and somewhat attenuated posteriorly, posterior extremity narrower (measured dorsoventrally) than anterior lobe and regularly rounded, truncated or pointed. Umbones slightly inflated, distinct but not prominent, approximate, situated at about 0.25 of length from anterior end. Anterior lobe defined by well-marked lunular hollow; indefinite carina may be present, running obliquely from umbo to posteroventral extremity; hinge edentulous; hinge line gently curved or straight; ligament opisthodontic in narrow furrow. *Perm.*, USSR-S.Afr.-E.Afr.-Burma-Norway.—FIG. D10,3. **P. castor* (EICHWALD), USSR; both valves, $\times 2$ (Eichwald, 1855-61).

?Family MICRODONTIDAE Weir, new family

Small, equivalved, isomyarian, integripal-

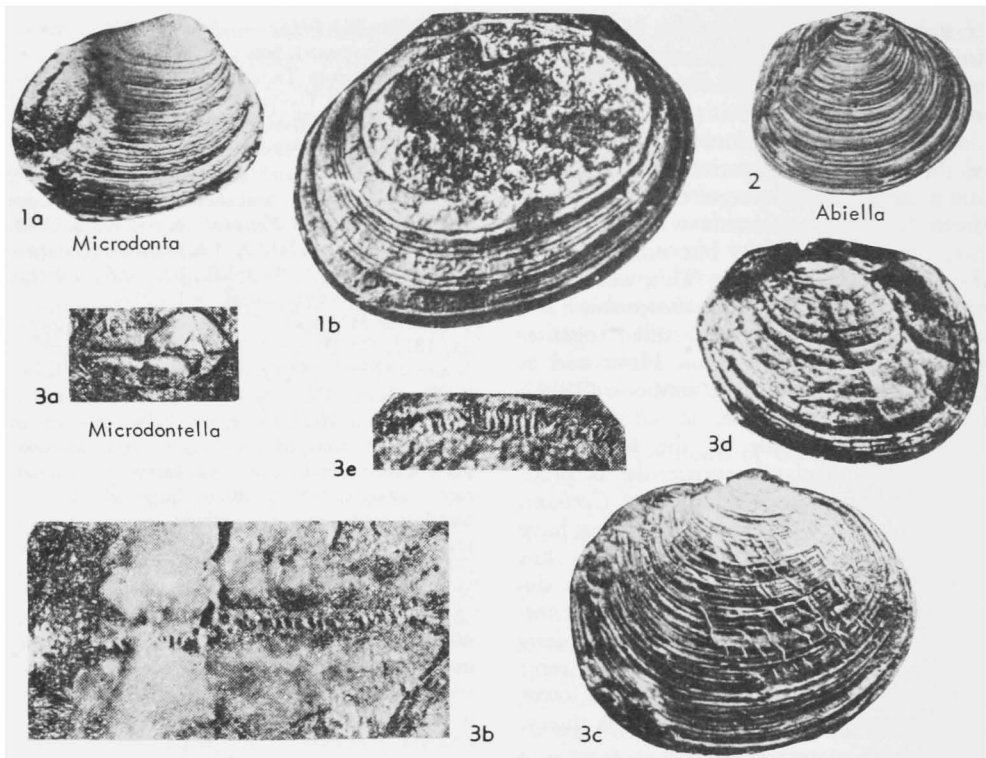


FIG. D11. Microdontidae (p. N408-N409).

liate shells with parataxodont (microdont) dentition, consisting of irregular denticles arranged in uninterrupted series along hinge, or edentulous. Suborbicular, transversely subelliptical in outline, with straight or nearly straight hinge line; or subnuculoid with slightly curved hinge line. Nonmarine. Perm.

In their usually crushed condition some of these shells have an external resemblance to *Posidonia* [*Posidonomya*], to which they were referred by their first describer, T. RUPERT JONES (1901), but from which they differ in all internal characters. They have been referred by Russian paleontologists to three genera, of which one, *Abiella*, is apparently edentulous, but the other two have in common a distinctive microdont dentition consisting of minute and somewhat irregular denticles arranged in taxodont fashion as an uninterrupted arc close to the dorsal margin, the teeth radiating from a point near the center of a valve.

In the commonly crushed condition of these fossils it is, according to Russian authors, not always easy to discriminate the genera, and different species have been assigned now to one genus, now to another. However few constituent taxa may ultimately be involved, these shells of distinctive dentition seem to constitute a homogeneous group which, isolated and endemic to the Kuznetsk Basin, may usefully be accorded family rank. Affinities are uncertain, but they may have originated, by degeneration of the hinge, from marine ctenodonts, which have taxodont teeth of normal size. *Abiella* is a homeomorph of the Lower Namurian *Edmondia punctatella* (JONES), recently re-investigated by R. B. WILSON, who sustains its reference to *Edmondia*. *Abiella* probably belongs to the same family as the associated microdont genera, in which the hinge precludes their inclusion in the Edmondiidae.

Microdonta KHALFIN, 1950 [**Palaeomutela microdonta* KHALFIN, 1939; OD]. Nuculoid; valves convex; hinge margin gently curved, microdont.

Perm., USSR (Sib.).—FIG. D11,1a. **M. microdonta* (KHALFIN); RV ext., $\times 2.5$.—FIG. D11,1b. *M. astartellaeformis* (FEDOTOV); RV int. showing part of microdont hinge, $\times 6$ (Ragozin, 1955).

Abiella RAGOZIN, 1933 [**Posidonomya concinna* JONES, 1901; SD RAGOZIN, 1955]. Like *Microdontella*, but apparently lacking microdont dentition; straight anterior and posterior parts of short hinge line meeting in wide angle at umbo. *Perm.*, USSR (Sib.).—FIG. D11,2. **A. concinna* (JONES); RV ext., $\times 3$ (Ragozin, 1955).

Microdontella LEBEDEV, 1944 [**M. problematica*; OD¹]. Like *Posidonia* in outline but microdont, with more tumid umbones in uncrushed shells and gently curved hinge line. *U.Perm.*, USSR (Sib.).—FIG. D11,3a,b. **M. problematica*; 3a, dorsal view showing tumid umbones, $\times 3$; 3b, same, showing microdont dentition, $\times 10$ (536).—FIG. D11,3c,d. *M. subovata* (JONES); 3c, LV (cast of ext.), $\times 4$; 3d, RV (impression), $\times 4$ (Ragozin, 1955).—FIG. D11,3e. *M. tomiensis* (RAGOZIN); microdont hinge “greatly enlarged” (536).

?Family PALAEOMUTELIDAE

Weir in Vokes, 1967

[=Anthracosidae (*sic*) AMALITSKY, 1892 (*partim*); Carbonicolidae Cox, 1932 (*partim*)]

Small shells of variable shape, mainly triangular-subovate or trapeziform, attaining maximum length of 35 to 40 mm., but usually less than 20 mm.; equivalved, inequilateral, integripalliate, subisomyarian; scar of posterior adductor suboval, anterior pyriform or lunate. Dorsally to anterior adductor scar and close to it small circular scar of anterior retractor muscle of foot; small semilunate scar close to and behind anterior adductor scar represents another pedal muscle (?anterior protractor). Umbones prominent and triangular in short triangular or subovate shells, inconspicuous in longer rhomboidal or trapezoidal forms. Hinge line arcuate in shorter shells but in longer ones may be subangulate below umbo and nearly straight posteriorly; ligament external, opisthodontic. Hinge plate of variable width bears transverse or obliquely inclined, higher irregular teeth of varying number, which may be prominent and even massive below umbo, or defined merely by numerous irregular grooves running more or less transversely, but in some shells anastomosing to form roughly reticulate

pattern over parts of hinge plate. Shell sculpture consisting of growth lines only. ?*U.Carb.*, *Perm.*

The distinctive dentition, comprising numerous highly variable and irregular teeth in both valves, is pseudotaxodont. Single teeth of series in either or both valves may acquire prominence (“cardinal teeth,” cf. *Carbonicola* AMALITSKY, 1892, *non* M’COY, and *Anthracosia* AMALITSKY, 1892, *non* KING), but only as an aspect of variation, associated with fewer teeth, that culminates in the hinge of *Oligodon*.

WÖHRMANN thought that *Palaeomutela* was derived from the marine genus *Palaeoneilo*, and, more recently, CHERNYSHEV assigned it to the Ctenodontidae. Both these views imply that dentition was primarily taxodont, which seems unlikely. AMALITSKY and Cox placed *Palaeomutela* in the Anthracosiidae (Carbonicolidae), but in view of distinctive hinge morphology and the cryptic origin of the genus it seems better to make it the type of a new family Palaeomutelidae, which I assign provisionally to the Anthracosiacea for convenience rather than from conviction of affinity, although it may well have been derived from more typical members of the superfamily.

Palaeomutela AMALITSKY, 1892 [**P. verneuilli*; SD WEIR, herein] [AMALITSKY invalidly designated both *P. verneuilli* and *P. keyserlingi* as type species of the genus. He also described and figured specimens of *Palaeomutela* (*s.l.*) as *Carbonicola* (*non* M’COY, 1855) and *Anthracosia* (*non* KING, 1856)] [=?*Palaeopleiodon* AMALITSKY, 1891; *Rectodontia* CHERNYSHEV, 1943]. Characters of family. Hinge plate with irregular, pseudotaxodont dentition extending over whole arc of dorsal margin, or with teeth reduced in number and restricted to shortened, subumbonal hinge plate. *Perm.*, Eu.(USSR)-S.Afr.-E.Afr.

P. (Palaeomutela). Pseudotaxodont dentition extending over whole arc of dorsal margin. *Perm.*, Eu.(USSR)-S.Afr.-E.Afr.—FIG. D12,2a-c. **P. (P.) verneuilli*, U.Perm., USSR; 2a,b, LV int. molds, $\times 1$; 2c, LV ext., $\times 1$.—FIG. D12,2d,e. *P. (P.) keyserlingi*, U.Perm., USSR; 2d, LV ext., $\times 1$; 2e, hinge, enl. (13).

P. (Oligodon) AMALITSKY, 1892 [**O. geinitzi*; SD WEIR, herein] [AMALITSKY invalidly designated both *O. geinitzi* and *O. zitteli* as type species of *Oligodon*]. Ovate-elliptical; teeth as in *P. (Palaeomutela)*, but fewer, massive and carried subumbonally on short, broad hinge plate

¹ RAGOZIN (1955) cited *Posidonomya subovata* JONES, 1901, as the “typical species,” doubtless regarding *M. problematica* subjectively as a junior synonym.

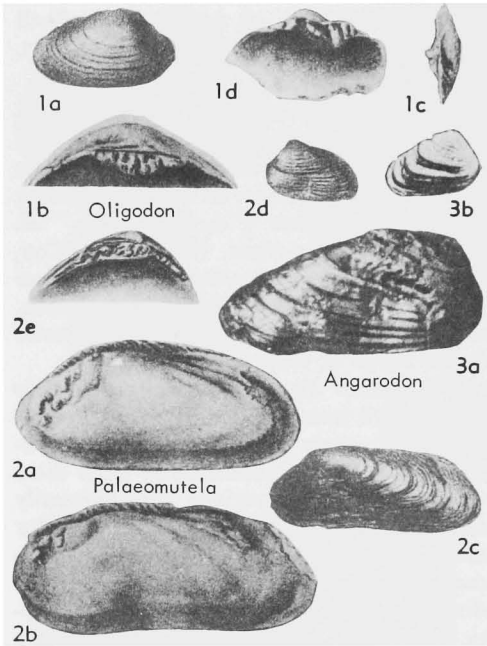


FIG. D12. Palaeomutelidae (p. N409-N410).

which may be projecting and linguiform. *U. Perm.*, Eu.(USSR).—FIG. D12,1a,b. **P. (O.) geinitzi*; 1a, RV ext., $\times 1$; 1b, hinge, enl.—FIG. D12,1c,d. *P. (O.) zitteli*; 1c, dorsal view of projecting hinge plate, $\times 1$; 1d, hinge, enl. (13).

?*Angarodon* RAGOZIN, 1935 [**A. kumsassiensis*; OD]. Trigonal, inequilateral, valves evenly swollen. Shallow median sulcus runs obliquely from umbones to ventral margin; umbones, rather massive and broad-based, form obtuse angle of triangle; other angles always rounded. Hinge line probably short. Internal characters unknown. Non-marine. *U.Carb.*, USSR(W.Sib.).—FIG. D12,3. **A. kumsassiensis*, 3a,b, 2 casts RV ext., $\times 1.5$ (Ragozin, 1955).

?Family **FERGANOCONCHIDAE**
Martinson, 1956

[Materials for this family prepared by L. R. Cox; its assignment to Anthracosiacea doubted by WEIR]

Shell small to small-medium in size, ovate or oblong, umbones at or anterior to mid-length; inflation weak to moderate; dentition, where known, consisting of very weak, scarcely perceptible, lamelliform anterior and posterior lateral teeth, about two in each valve; no cardinal teeth; muscle scars, pallial line, and position of ligament not observed; surface unornamented except

for growth lines and rugae; ostracum thin. [Fresh-water.] *Jur.*

Ferganoconcha CHERNYSHYEV, 1937, p. 18 [**F. sibirica*; SD LUMKEVICH *et al.*, 1960, p. 99]. Shell 12 to 30 mm. long when full-grown, ovate, subequilateral, inflation very weak; umbones broadly rounded, not at all or very little protruding; hinge line slightly arcuate; hinge structure as defined for family; growth rugae relatively coarse. *L. Jur.-U. Jur.*, USSR(Sib.)-C.Asia-E.Asia.—FIG. D13,1. **F. sibirica*, M.Jur., E.Sib.; RV ext., $\times 1$ (Martinson, 1956).

?Family **PSEUDOCARDINIIDAE**
Martinson, 1961

[Materials for this family prepared by L. R. Cox]

Shell small to medium-sized, ovate or oblong, obliquely truncated posteriorly, inequilateral, with umbones anterior to mid-length, moderately inflated; most species with posterior diagonal ridge; dentition consisting of anterior and posterior series of elongated lateral teeth, respectively more or less parallel to adjacent dorsal margin, and without any intervening transverse or "cardinal" teeth; muscle scars, pallial line, and position of ligament unobserved; surface unornamented except for growth rugae. [Freshwater.] *Jur.*

Pseudocardinia MARTINSON, 1959, p. 33 [**P. submagna*; OD]. Shell small to medium-sized, known species not exceeding 42 mm. in length, oblong, short to moderately elongate, with posterior end slightly truncated obliquely; umbones broadly rounded, moderately protruding; posterior diagonal ridge usually present; RV with 2 anterior and 2 posterior lateral teeth, separated by sockets each receiving single corresponding tooth of LV;

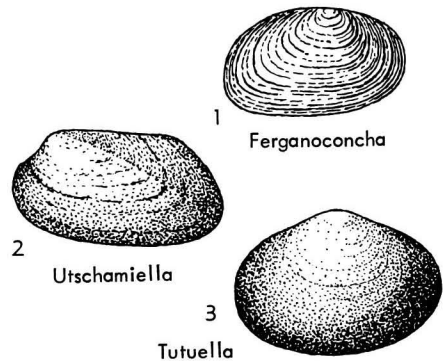


FIG. D13. Ferganoconchidae (1); Pseudocardiiniidae (2,3) (p. N410-N411).

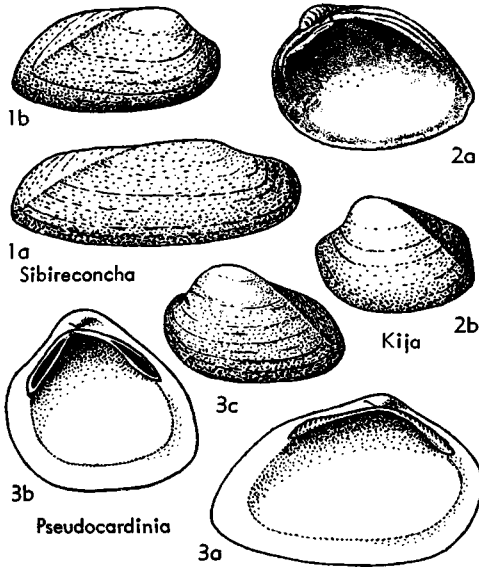


FIG. D14. Pseudocardiniidae (p. N410-N411).

RV teeth have rounded transverse ridges, to which grooves in dental sockets of LV correspond; anterior laterals not extending beyond beaks. *M.Jur.* (*Aalen.-Bathon.*), C.Asia-E.Asia.—FIG. D14, 3a. **P. submagna*, Bajoc., E.Tien-Shan; LV int., $\times 1$ (Martinson, 1959).—FIG. D14,3b. *P. carinata* (MARTINSON), Bajoc., E.Tien-Shan; RV int., $\times 0.9$ (Martinson, 1959).—FIG. D14,3c. *P. jeni-seica* MARTINSON, Bajoc., Chulimo-Yenisei basin, C.Asia; LV ext., $\times 1$ (Martinson, 1961).

Kija LEBEDEV, 1958, p. 73 [**K. tjazhinensis*; OD]. Shell small, known species not exceeding 17 mm. in length, ovate, short to well elongated, obliquely truncated posteriorly; umbones protruding slightly; most species with posterior diagonal ridge; RV with 2 or 3 anterior and 2 or 3 posterior, transversely grooved lateral teeth, separated by sockets which receive corresponding teeth of LV; anterior laterals extending posteriorly well beyond beaks, posterior laterals distant from latter, occupying posterodorsal angle. *M.Jur.-U.Jur.*, C.Asia.—FIG. D14,2a. **K. tjazhinensis*, U.Jur., Chulimo-Yenisei basin; RV int., $\times 3.3$ (Lebedev, 1958).—FIG. D14,2b. *K. kibitenensis* LEBEDEV, U.Jur., same region; LV ext., $\times 3.3$ (Lebedev, 1958).

Okribella KAKHADZÉ, 1942, p. 77 [**O. elliptica*; OD]. Shell to 24 mm. long, ovate, length nearly twice height, inequilateral, inflation moderate; umbones broadly rounded, not protruding, at about anterior third of length; hinge edentulous; growth lines irregular, moderately coarse; adductor scars very dorsally placed, narrow, anterior one deep, posterior shallow. *M.Jur.*(*Bathon.*), USSR (Georgia).

?**Sibireconcha** LEBEDEV, 1958, p. 69 [**S. lanqovien-*

sis; OD]. Shell small, known species not exceeding 22 mm. in length, oblong, much elongated, strongly inequilateral, obliquely truncated posteriorly; umbones broad, not protruding; weak posterior diagonal ridge present; dentition unknown. *M.Jur.*, USSR (W.Sib.-E.Sib.-Transbaikal)-China.—FIG. D14,1a. **S. lanqoviensis*, C.Asia (Chulimo-Yenisei basin); RV ext., $\times 1.4$ (Lebedev, 1958).—FIG. D14,1b. *S. anodontoides* (CHERNYSHEV), same region; RV ext., $\times 1.2$ (Lebedev, 1958).

?**Tutuella** RAGOZIN, 1938, p. 106 [**T. chachlovi*; SD LUMKEVICH *et al.*, 1960, p. 99]. Shell about 10 to 20 mm. long when full-grown, ovate, sub-equilateral, more strongly convex than *Ferganconcha* and with more protruding umbones; hinge line straight; dentition unknown; growth lines inconspicuous. *L.Jur.-M.Jur.*, USSR (Sib.)-C.Asia-E.Asia.—FIG. D13,3. **T. crassa* RAGOZIN, *M.Jur.*, Chulimo-Yenisei basin, C.Asia; LV ext., $\times 1$ (Lebedev, 1958).

?**Utschamiella** RAGOZIN, 1938, p. 138 [**U. tungusica*; SD LUMKEVICH *et al.*, 1960, p. 99]. Shell about 10-20 mm. long when full-grown, oblong, strongly inequilateral, with unprotruding, prosogyrous umbones placed near anterior end; inflation moderate; obtuse angulation commonly runs from umbo to posteroventral angle of shell; dentition unknown. *L.Jur.-M.Jur.*(mainly *Lias.*), USSR (Sib.)-C.Asia-E.Asia.—FIG. D13,2. **U. tungusica*, *L.Jur.*(*Lias.*), Sib.(Tunguska basin); LV ext., $\times 1.5$ (Ragozin, 1938).

Family UNCERTAIN

?**Nyassa** HALL & WHITFIELD, 1869 [**N. arguta*; OD] [= *Modioconcha* HALL & WHITFIELD, 1869; *nom. oblit.* (obj.)]. Equivalve, beaks anterior, transversely elongate or subelliptical. Beaks small, appressed; hinge long, arcuate, with numerous irregular cardinal teeth under the beak and 1 to 4 elongate lamellar teeth; ligament external. Surface with concentric growth lines and in some species obscure radii and a weak sulcus. *M.Dev.*, N.Am.-Eu.(Ger.).—FIG. D10,4. **N. arguta*, USA (N.Y.); 4a, ext. LV, showing ornamentation, $\times 1$; 4b, hinge RV, showing dentition, greatly enl. (Hall, 1885). [LaRocque]

Superfamily UNIONACEA

Fleming, 1828

[*nom. transl.* THIELE, 1934 (ex Unionidae FLEMING, 1828)] [*pro* Naiadacea AUCT. (invalid family-group lacking type genus)] [Materials for this superfamily prepared by FRITZ HAAS, except as otherwise recorded]

Shell mostly equivalent and isomyarian except where modified by attachment, mainly nacreous, with prismatic layer and heavy periostracum; beaks commonly with ornamentation; dentition, wherever present,

usually consisting of somewhat rugose cardinal and posterior lamellar teeth. [Exclusively fresh-water habitat with larval stage parasitic in fish.] ?*Perm., Trias.-Rec.*

The fresh-water bivalves classed together in the Unionacea are distinguished by the porcelain-white to bluish or purple-tinted pearly layer of their shells, rather variable nature of dentition or lack of hinge teeth, various structures of the soft parts, and characters of larval development. Variability of the shells due to ecologic modifications gives rise to many problems in classification.

SHELL CHARACTERS

Unionacean shells range in outline from nearly circular to elongate rodlike shapes and in thickness from flatly compressed forms to subglobular. Some shells are less than one inch (25 mm.) in length and others more than one foot (300 mm.). The shell is composed of three layers: a horny organic external covering of conchiolin, the **periostracum**, which is smooth, yellow-brown or black-brown, and commonly marked by color bands that radiate from the beak; a **prismatic calcareous layer**; and forming the hinge teeth and interior, a **nacreous layer** of calcium carbonate with lamellar structure consisting chiefly of aragonite. These layers together range from paper-thin to a thickness of about 15 mm. Names commonly applied to parts of unionacean shells, and not corresponding to those used by other clams, are indicated in Fig. D15. Although the surface of some shells is smooth or merely shows growth lines, that of others is partly or entirely wrinkled or ribbed, and there may be knobs, tubercles, or even spinose projections; commonly these surface features of the shell form a pattern that is fairly definite and constant within limits of an individual genus or species.

The **hinge** varies greatly in the Unionacea. Shells having well-defined dentition are characterized by prominent cardinals beneath and somewhat in front of the beaks accompanied by less conspicuous long, lamellar ridges (regarded by many investigators as modified cardinal teeth not homologous with the laterals of heterodonts) behind the beaks. This dentition

normally consists of two cardinals and two posterior lamellar teeth on the left valve matching sockets between the teeth of the opposed valve, but there is much deviation from this. The teeth project from a widened portion of the dorsal shell margin (**hinge plate**), which persists in the toothless space between cardinals and lamellar teeth. The cardinal teeth are relatively persistent; those which are very slender commonly are supported by a strengthening deposit (**fulcrum**). The posterior lamellar teeth tend to be reduced and in many forms to disappear. Some shells have very imperfect dentition (Alasmidontinae) or none at all (Anodontinae) other than lamellar ridges close to the dorsal margin; such ridges (termed **claustra**) are not homologous with the teeth of other Unionacea. A type of hinge found in a few genera (e.g., *Pseudodon*, *Leguminaia*) tentatively classed among Unionacea is distinguished by several short rounded projections along the dorsal margin of the shell near the beaks, but no hinge plate or fulcrum is present. Still another type, which is observed in the generally edentulous Mutelidae, is marked by crenulations along the hinge line, superficially resembling taxodont dentition.

Inside the shell, the **beak cavities** may be capacious and deep or small and shallow. Muscle impressions (anterior and posterior adductors) lack special importance, but that of the pallial muscle is marked by an entire **pallial line** in most shells or by one with a slight sinus in some mutelid (Fig. D15,C).

Shells belonging to genera of the Margaritiferidae, Unionidae, and Mutelidae are bilaterally symmetrical, owing to the upright (orthothetic) position in which they are held, partly embedded in bottom sediment. Among the Etheriidae, however, a free-moving early life is followed by attachment of one of the valves lying on its side (pleurothetic) like an oyster, and because the lower valve becomes larger and deeper, symmetry of the shell vanishes. Exceptionally, as in *Arconaia* and *Arcidopsis* of the Unionidae, the youthful symmetrical stage is followed by sideward bending of the valves or twisting of the shell around its axis in such manner that it can no longer stand upright but comes to rest on its side with one valve larger than the other.

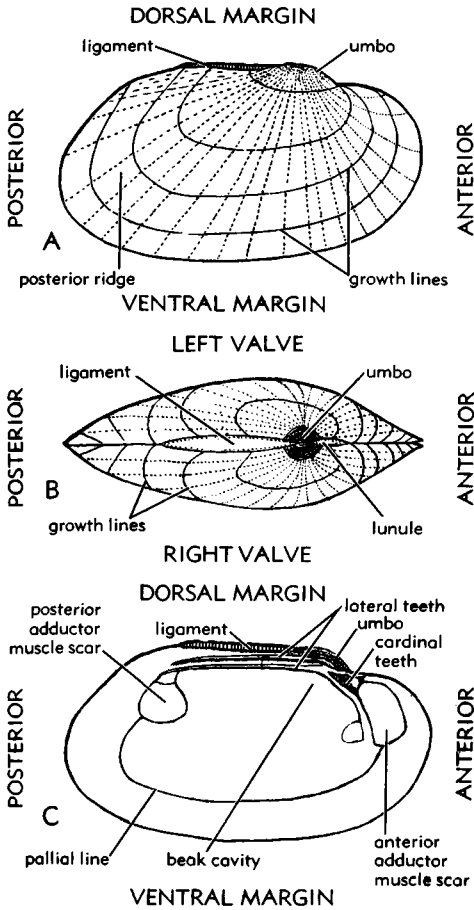


FIG. D15. Morphological features of unionacean shells (A-C, exterior, dorsal, interior) (after Baker).

LARVAL STAGE

All known Unionacea, after hatching from fertilized eggs, pass through a larval stage (generally termed glochidium, but in the Mutelidae called lasidium). First development of the larva occurs in a brood pouch (marsupium) of the parent, consisting of space between pairs of gills. The glochidia develop within their egg membranes and feed almost exclusively on the egg yolk. After a time, the larvae are expelled and further growth then becomes dependent on chance contact with a fish, to which the glochidium fixes itself by a sticky thread and by hooks on its valves. As a cyst-inclosed parasite in the flesh of

the fish, it draws nourishment from its host until it grows into a minute complete clam, when it pierces the skin of the fish and drops to the bottom of whatever stream, pond, or lake is being traversed by its free-swimming carrier. Obviously, this curious adaptation in larval development, which distinguishes the Unionacea from other pelecypods, is extremely important as means of dispersal.

ECOLOGIC INFLUENCE ON SHELL CHARACTERS

Study of unionacean assemblages living in different environments serves to demonstrate the existence of variations in shell characters that may be correlated with the nature of physical surroundings. Size, shape, and color of the surficial conchiolin layer all may be affected. The shells of members of this group living on a hard bottom generally are shorter and rounder than those found in mud or soft sand. Individuals collected from lake-bottom sediment show a tendency to have shortened and thickened anterior areas associated with produced and somewhat compressed posterior regions. Shells of Unionacea from small streams are less swollen generally than corresponding shells in rivers. Also, the same species may be represented by smooth shells in small streams and by populations with more or less strongly sculptured shells in large streams and lakes. Prevalingly, shell surfaces marked by tubercles and ridges characterize river and lake environments.

Variations that reflect ecological factors must not be overlooked in study of the classification of Unionacea, for otherwise erroneous conclusions as to the taxonomic significance of divergent or convergent shell characters are invited. Owing to the ecological plasticity and the rapidity and wide range of dispersal of these fresh-water clams by fish-borne larvae, a single generation may produce offspring that on reaching maturity differ notably from parent forms. This is strikingly illustrated by comparing the completely sculptured shells of some unionids in large eastern African lakes with taxo-

nomically equivalent smooth shells in streams that empty into these lakes.

CLASSIFICATION

Arrangement of the varied hosts of Unionacea, distributed throughout the world and having a range from ?Triassic or Jurassic to Recent, offers great difficulty to the taxonomist who aspires to recognize and define phylogenetically significant assemblages of varying magnitude. Characters of the soft parts, such as union of mantle lobes, completeness of siphons, adaptation of gill spaces as marsupia, nature of the foot and musculature all aid in recognizing relationships among living forms but mostly have little value for work on fossils. Chief shell characters judged to be useful for classification include general form (with attention given to effects of sessile existence), features of the beak region (denoting nature of the immature shell), ligament, dentition, muscle scars, and pallial markings. Evidence of the high degree of developmental plasticity of the unionacean shell and the certainty that many gaps in knowledge limit the understanding of modern forms, not to mention fossils, indicate the difficulty of formulating a satisfactory natural classification not yet achieved in this group. The only all-inclusive study of fossil Unionacea so far published is by SANDBERGER (1870-75) long before most of the genera were established. Later workers have been concerned with Recent forms alone or with assemblages of various regions. The ZITTEL (1913) textbook on invertebrate fossils mentions only 13 unionacean genera, mostly without characterizations: these are divided among three families (Unionidae, Mutelidae, Etheriidae). Only very recently a system of the Unionacea for both Recent and fossil forms has been published by MODELL (1942); it lists practically all the genera and subgenera of the superfamily known at that time.

The following section of the *Treatise* on Unionacea recognizes 150 genera and 112 subgenera (223 units excluding nomotypical subgenera); these are grouped in four families, one of which (Unionidae) is divided into six subfamilies.

LITERATURE ON UNIONACEA

As well may be expected, a vast literature pertains to Recent and fossil unionacean bivalves. Only a selected fraction can be cited in the general reference list. Here it may be useful to make note of more important works in a few classical groups, as follows.

Comprehensive general works on Recent Unionacea. Here may be included nos. 140, 354, 496, 497, 535, 538, 845, 846, 862-869 of the reference list.

Regional monographs on Recent Unionacea. For North America, nos. 144, 147, 328; Central America, nos. 306, 359, 588; South America, nos. 359, 694, 702; Europe, nos. 798, 969; India, nos. 389, 756; China, no. 405; Africa, nos. 142, 362, 538, 589; Australia, nos. 168, 434.

Comprehensive monograph on fossil Unionacea. No. 824.

Regional works on fossil Unionacea. For North America, no. 401; Europe, nos. 86, 87, 411, 881, 968; China, no. 686.

Family MARGARITIFERIDAE Haas, 1940

[Validated family-group name, ICZN, 1957 (Opinion 495, p. 293)] [=Margaritaninae ORTMANN, 1910 (suppressed by ICZN, 1957, Opinion 495, p. 290)]

Shell equiavalve, mostly compressed; umbonal sculpture (if present) comprising two angular unjoined hooks; beak cavities shallow, posterior lamellar teeth tending to be reduced. Gills without water tubes, partly free posteriorly, with incomplete diaphragm, marsupium occupying all four gills. *U.Cret.-Rec.*

Margaritifera SCHUMACHER, 1816, p. 7 [valid emendation of *Margaritifera* SCHUMACHER, 1816 (ICZN, 1957, Opinion 495, p. 289)] [**Mya margaritifera* LINNÉ, 1758, p. 671; M] [=*Margaritana* SCHUMACHER, 1817, p. 123 (obj.); *Margaritifera* SCHUMACHER, 1823, p. 6 (*nom. van. pro Margaritifera*); *Damalis* LEACH, 1847, p. 272]. Characters of family. *U.Cret.-Rec.*, Eu.-N.Am.-Asia.

M. (Margaritifera). Shell heavy, thick, compressed, without posterior lamellar teeth. *U.Cret.-Rec.*, Eu.-N.Am.-E.Asia.—FIG. D16.3. **M. (M.) margaritifera* (LINNÉ), Rec., Eu.; 3a,b, LV ext., RV int., ×0.5 (after 497).

M. (Cumberlandia) ORTMANN, 1912 [**Unionia monodonta* SAY, 1829; OD]. Elongate-arcuate,

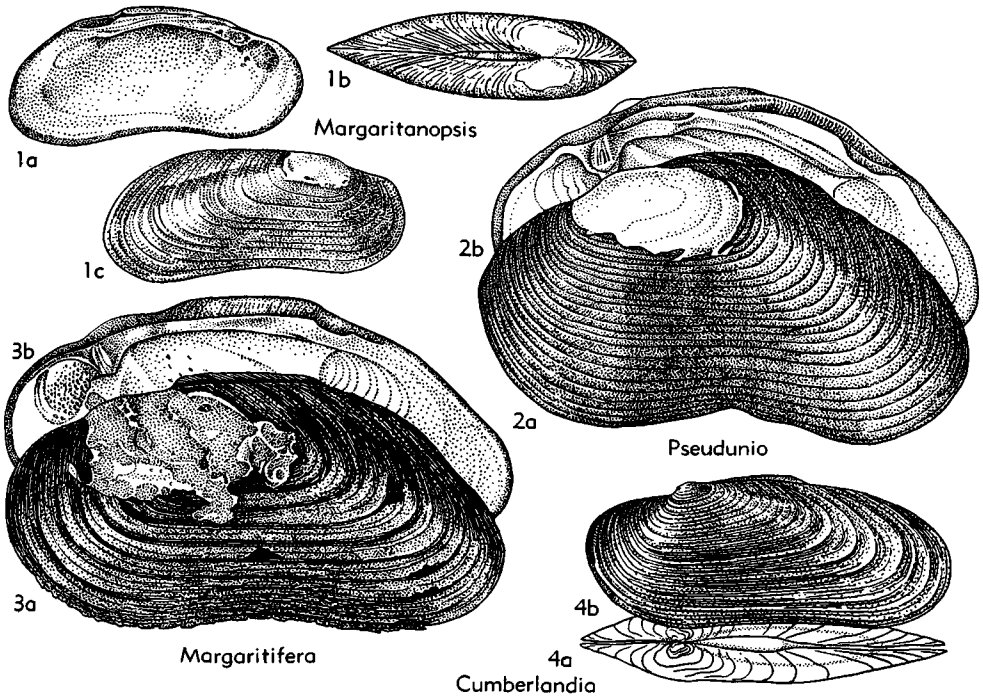


FIG. D16. Margaritiferidae (p. N414-N415).

thin; lamellar teeth weak, poorly defined. Continuous laminar septa between gills, running obliquely forward. *Rec.*, N.Am.—FIG. D16,4. **M. (C.) monodonta* (SAY); 4a,b, both valves dorsal, LV ext., $\times 0.5$ (after 497).

M. (Margaritanopsis) HAAS, 1910 [**Unio laosensis* LEA, 1863; OD]. Elongate, compressed, kidney-shaped; cardinals and posterior lamellar teeth with long interdental area. *Rec.*, SE.Asia.—FIG. D16,1. **M. (M.) laosensis* (LEA); 1a-c, LV int., both valves dorsal, RV ext., $\times 0.5$ (after 534).

M. (Pseudunio) HAAS, 1910 [*pro Potodoma* HERRMANNSEN, 1947 (*non* MEIGEN, 1800)] [**Unio sinuata* LAMARCK, 1819 (= **Unio auricularius* SPENGLER, 1793); OD]. Shell ear-shaped, heavy, thick; with cardinals and posterior lamellar teeth. *Eoc.-Rec.*, Eu.-N.Am.—FIG. D16,2. **M. (P.) auricularia* (SPENGLER), *Rec.*, Eu.; 2a,b, LV ext., RV int., $\times 0.5$ (after 497).

Family UNIONIDAE Fleming, 1828

Equivalve (nacreous, with thick periostracum), beaks generally sculptured and commonly with remnant of larval shell; beak cavities deep, hinge mostly with two cardinals and two posterior lamellar teeth

in LV and single cardinal and lamellar tooth in RV. Gills with water tubes, marsupium occupying all four gills or outer pairs only, diaphragm complete. *Trias.-Rec.*

Subfamily UNIONINAE Fleming, 1828

[*nom. transl.* THIELE, 1934 (*ex* Unionidae FLEMING, 1828)]

Umbonal sculpture mostly concentric. Marsupium occupying all four gills or outer pairs only. *Trias.-Rec.*

Unio PHILIPSSON, 1788 [**Mya pictorum* LINNÉ, 1758; SD TURTON, 1831 (ICZN, 1957, Opinion 495, p. 289)] [= *Limnaea* POLI, 1791 (obj.); *Limnaeoderma* POLI, 1795; *Uniigenus* RENIER, 1807; *Lymnium* OKEN, 1815 (rejected, ICZN, Opinion 417); *Unionea* RAFINESQUE, 1815; *Mysca* TURTON, 1822; ?*Margarita* LEA, 1836 (*non* LEACH, 1819); *Myisca* L. AGASSIZ, 1846; *Chondrostea* GISTEL, 1848; ?*Margaron* LEA, 1852; *Nodularia* CONRAD, 1853; *Nodularidia* COCKERELL, 1901]. Posterior slope generally distinct, coarse ridges on umbo looped or broken, remainder of shell smooth, periostracum with or without rays. Marsupium occupying whole length of outer gill pairs. [Fossil species of *Unio* described from North America are generally forms with complete hinge

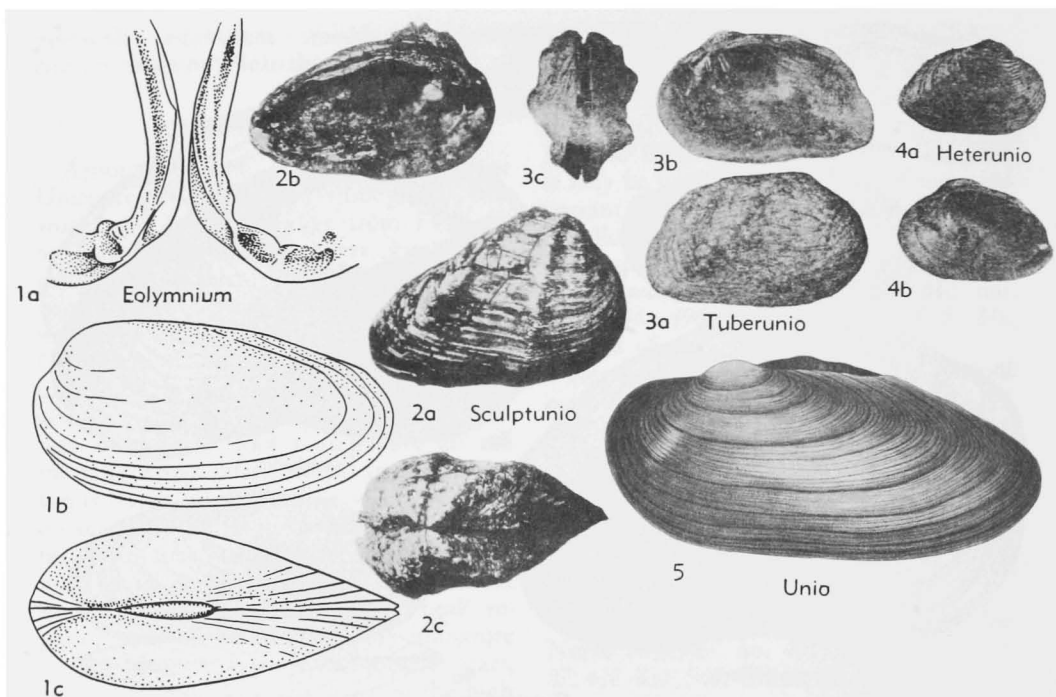


FIG. D17. Unionidae (Unioninae) (p. N415-N416).

and are distinct from the palearctic *Unio* defined here.] *Trias.-Rec.*, Eu.-Asia-Afr.-USSR.

U. (Unio). Gills subequal, foot fairly well developed. *Trias.-Rec.*, Eu.-Asia-Afr.—FIG. D17, 5. **U. (U.) pictorum* (LINNÉ), *Rec.*, Eu.; LV ext., $\times 0.7$ (after 497).

U. (Eolymnium) PRASHAD, 1919 [**Unio terminalis* BOURGUIGNAT, 1852; OD]. Inner gills broader than outer pair, branchial aperture high, foot poorly developed. *Rec.*, Eu.(E.Medit.).—FIG. D17,1. **U. (E.) terminalis* BOURGUIGNAT; 1a-c, hinges, LV ext., both valves dorsal, $\times 1$ (after Bourguignat).

The three following subgenera are known to me only through LINDHOLM's short description; it seems appropriate, hence, to retain them at this place, where their author had them.

U. (Heterunio) LINDHOLM, 1932 [**U. exquisitus*; OD]. Shell with apical sculpture consisting of concentrically arranged, short or interrupted ridges which may cover half of disc; inflated and mostly so in the middle of well-defined posterior ridge. *M.Plio.*, USSR(SW.Sib.).—FIG. D17,4. **U. (H.) exquisitus*; 4a,b, RV ext., int., $\times 0.7$ (after 543).

U. (Sculptunio) LINDHOLM, 1932 [**U. bituberculatus* MARTENS, 1874; OD]. Shell characterized by 2 rows of knobs which radiate from beaks.

M.Plio., USSR(SW.Sib.).—FIG. D17,2. *U. (S.) bituberculatus trigonoides* LINDHOLM; 2a-c, RV ext., int., both valves dorsal, $\times 0.7$ (after 543).

U. (Tuberunio) LINDHOLM, 1932 [**U. uniserialis*; OD]. Upper half of disc rather strongly granulate, wrinkled; row of 4 to 5 larger knobs on posterior slope. *M.Plio.*, USSR(SW.Sib.).—FIG. D17,3. **U. (T.) uniserialis*; 3a-c, RV ext., int., both valves ant., $\times 0.7$ (after 543).

Acuticosta SIMPSON, 1900 [**Unio sinensis* LEA, 1868; OD]. Solid, inflated, pointed behind, produced at center of base, in one species with distinct, nodulated posterior ridge; beaks full, their radial sculpture strong, zigzag; cardinals rather low, ragged, lamellar teeth obliquely ridged and granular. *Rec.*, China.—FIG. D18,3. **A. sinensis* (LEA); 3a-d, LV ext., RV int., LV int., both valves dorsal, $\times 0.8$ (Haas).

Afroparreyisia HAAS, 1936 [**Parreyisia lobensis* FRIERSON, 1913; OD]. Ovoid, lenticular; beaks very far forward, with deep internal cavities; sculpture narrowly zigzag, extending over entire disc, commonly reduced to wavy folds; hinge with long interdental interval, cardinals nearly normal to lamellar teeth. *Rec.*, W.Afr.(Cameroons).—FIG. D18,1. **A. lobensis* (FRIERSON); 1a,b, LV ext., RV int., $\times 1$ (Frierson).

Arcidopsis SIMPSON, 1900 [**Unio footei* THEOBALD, 1876; OD]. Elongate, with dorsal and ventral

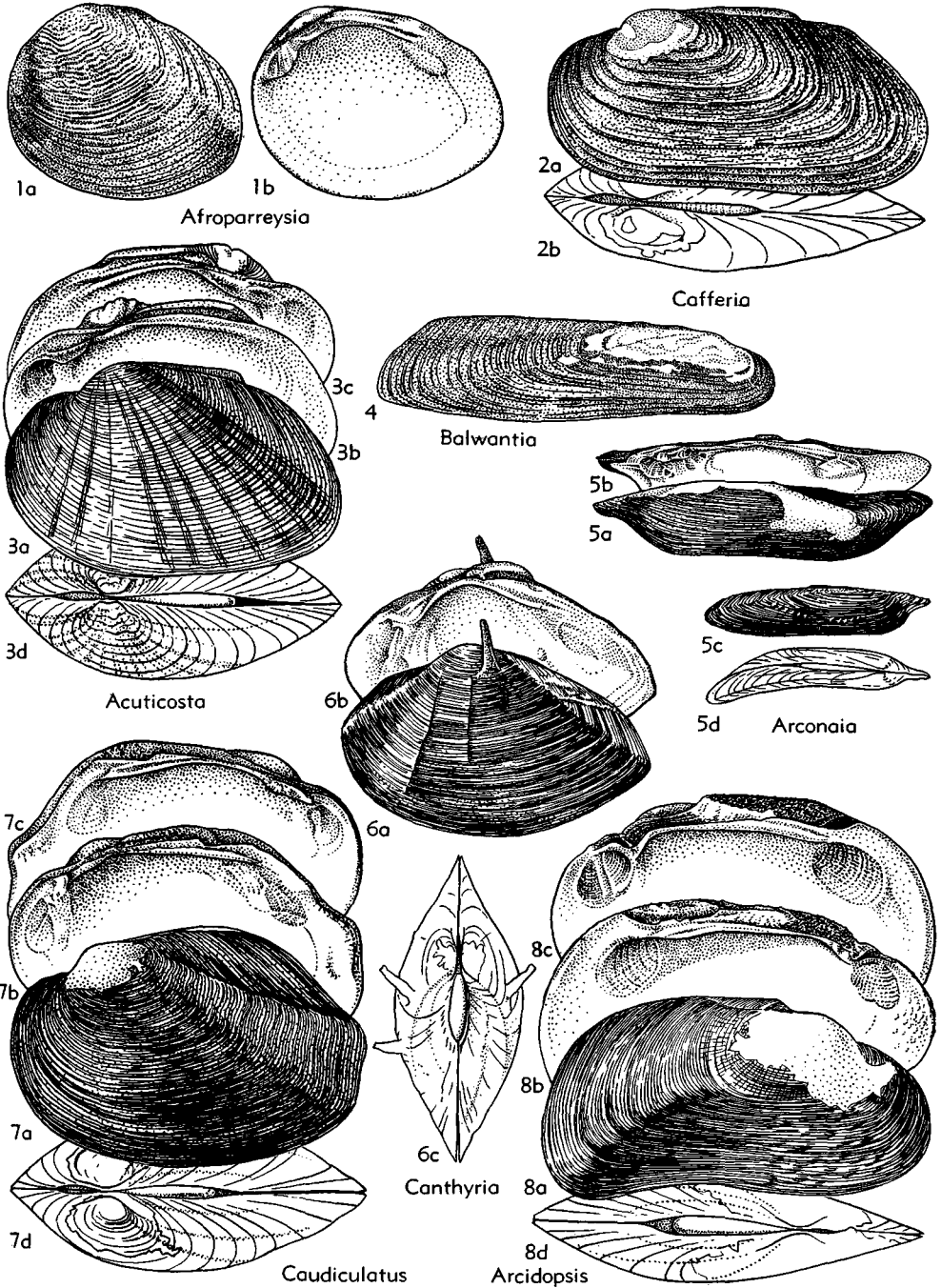


FIG. D18. Unionidae (Unioninae) (p. N416, N418, N420).

margins nearly straight and parallel, short, low, rather compressed and rounded in front, high, long, obliquely and roundedly truncate and inflated behind; posterior slope ill-defined, full; periostracum black, disc with fine concentric and radial ridges; cardinals strong, short, supported by strong, riblike fulcrum, lamellar teeth very remote, short. *Rec.*, India.—FIG. D18,8. **A. footei* (THEOBALD); *8a-d*, RV ext., LV int., RV int., both valves dorsal, $\times 0.75$ (Haas).

Arconaia CONRAD, 1865 [**Unio lanceolata* LEA, 1856; OD]. Elongated into pointed projections at both ends, thick-shelled, twisted on axis or almost straight but generally having posterior end curved to right or left; posterior slope distinct, beaks low, with shallow cavities; hinge with strong, triangular and serrated cardinals and rather thick, long, almost straight lamellar teeth. *Tert.-Rec.*, E.Asia.—FIG. D18,5. **A. lanceolata* (LEA), *Rec.*; *5a-d*, LV ext., RV int., RV ext., both valves dorsal, $\times 0.3$ (Haas).

Balwantia PRASHAD, 1919 [**Anodonta soleniformis* BENSON, 1836; OD]. Elongate, soleniform, thin, narrower in front, gaping at anterior base and behind; posterior slope low, not well defined; beaks low; hinge line narrow, toothless but for vestiges of marginal lamellae. Foot large, muscular, adapted for burrowing. *Rec.*, E.India.—FIG. D18,4. **B. soleniformis* (BENSON); RV ext., $\times 0.3$ (384).

Caelatura CONRAD, 1853 [**Unio aegyptiaca* CAILLIAUD, 1826; OD] [= *Pharaonia* BOURGUIGNAT, 1880; ?*Reneus* ROCHEBRUNE, 1888; ?*Renatus* ROCHEBRUNE, 1904; *Horusia*, *Jaronia* PALLARY, 1924]. Elliptical, generally thin, short and rounded in front, long and high behind, pointed or rounded, mostly somewhat produced at posteroventral margin; beaks not prominent, with sculpture consisting of zigzag generally pustulate ridges, commonly extending to disc which may bear rays; cardinals long, thin, bladelike, lamellar teeth normal. *U. Plio.-Rec.*, Afr.

C. (Caelatura). Short, mostly elliptical or ovate, inflated; anterodorsal margin not steeply descending; beaks inflated, full, with sculpture of W-shaped bluntly pustulate folds. *U. Plio.-Rec.*, Afr.—FIG. D19,7. **C. (C.) aegyptiaca* (CAILLIAUD), *Rec.*; *7a-c*, LV ext., both valves dorsal, hinges, $\times 0.8$ (497).

C. (Brazzaea) BOURGUIGNAT, 1885 [**B. anceyi*; OD] [= *Bruzzaea* PAETEL, 1890; *Brazzaea* GERMAIN, 1909]. Thin, translucent, wine-colored, elliptical, greatly inflated, with small postero-dorsal wing and high double posterior ridge; beaks apparently smooth, compressed, but umbones full; anterodorsal margin of RV projecting slightly above LV; hinge edentulous, ending abruptly in front at deep lunule. *Rec.*, Afr.—FIG. D19,8. **C. (B.) anceyi* (BOURGUIGNAT); LV ext., $\times 0.7$ (74).

C. (Grandidieria) BOURGUIGNAT, 1885 [**Unio burtoni* WOODWARD, 1859; OD] [= *Ruellania* BOURGUIGNAT, 1885]. Small, oval, rounded or rhomboidal, heavy, much inflated; beaks high with zigzag wrinkles which become finely nodulose and sulcate on disc, especially in front and behind; hinge line curved; cardinals short, deeply cleft, lamellar teeth short, somewhat curved. *Pleist.-Rec.*, E.C.Afr.—FIG. D19,1. **C. (G.) burtoni* (WOODWARD), *Rec.*; *1a-c*, RV ext., int., LV int., $\times 1$ (Pilsbry & Bequaert).

C. (Kalliphenga) HAAS, 1936 [**Unio ruellani* BOURGUIGNAT, 1883; OD]. Small, obliquely rhomboidal; beaks prominent; dorsal margin straight; all teeth of hinge heavy; periostracum black to green, as if coated with lacquer, densely rayed; nacre rosy, with metallic iridescence. *Rec.*, E.Afr. (L.Victoria)—C.Afr.—FIG. D19,3. **C. (K.) ruellani* (BOURGUIGNAT); *3a-c*, RV ext., int., LV int., $\times 1$ (Haas).

C. (Kistinaia) HAAS, 1936 [**C. shoutedeni*; OD]. Quadrangular, inflated and truncate, short in front, long, submedianly produced and truncate behind; beaks prominent, with W-shaped ridges; posterior ridge distinct; cardinals strong, lamellar teeth thin. *Rec.*, C.Afr.—FIG. D19,2. **C. (K.) shoutedeni*; *2a-d*, LV ext., RV int., LV int., both valves dorsal, $\times 1$ (Haas).

C. (Laevirostris) SIMPSON, 1900 [**Unio stagnorum* DAUTZENBERG, 1890 (= *Pharaonia bourguignati* ROCHEBRUNE, 1886); OD]. Rounded lens-shaped or irregularly quadrangular, thin, compressed; anterodorsal margin descending steeply, posterior margin long and high; beaks not prominent, with sculpture reduced to few isolated tubercles; cardinals long, bladelike, lamellar teeth slightly curved, at angle with cardinals; areola and posterior slope commonly corrugated. *Rec.*, C.Afr.—FIG. D19,4. **C. (L.) bourguignati* (ROCHEBRUNE); *4a-c*, RV ext., int., LV int., $\times 1$ (Pilsbry & Bequaert).

C. (Mweruella) HAAS, 1936 [**Unio mweruensis* E. A. SMITH, 1908; OD]. Anteriorly short, rounded truncate, posteriorly long and pointed, much compressed, with greatest depth near dorsal margin; disc sculptured with folds zigzag near beaks becoming gradually wavy toward center; posterior slope covered with fan-shaped folds radiating from posterior ridge; cardinals long, bladelike when young, thicker and somewhat ragged when old. *Rec.*, C.Afr.—FIG. D19,6. **C. (M.) mweruensis* (SMITH); *6a-d*, LV ext., int., RV int., both valves dorsal, $\times 1$ (Haas).

C. (Rhytidoniaia) HAAS, 1936 [**C. graueri* HAAS, 1927; OD]. Elongate, irregularly quadrangular, thick, ventral margin almost straight, postero-dorsal margin high; beaks not prominent; entire disc sculptured with ridges which are W-shaped near beaks and wavy over mature shell; cardinals thickened throughout ontogeny. *Rec.*, C.Afr.—FIG. D19,5. **C. (R.) graueri* HAAS; *5a-d*, LV

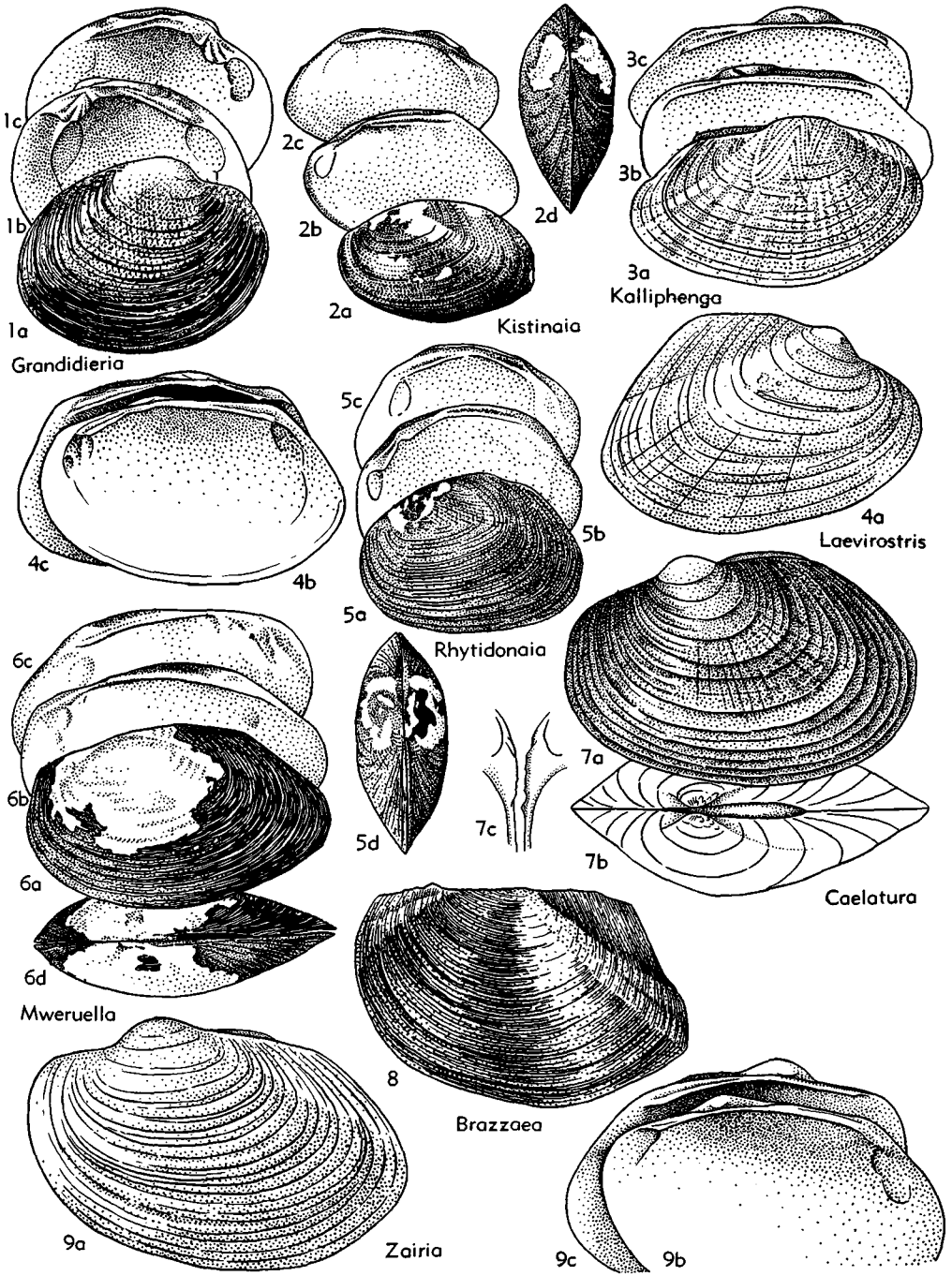


FIG. D19. Unionidae (Unioninae) (p. N418, N420).

- ext., RV int., LV int., both valves dorsal, $\times 1$ (Haas).
- C. (Zairia) ROCHEBRUNE, 1886** [**Zairia elegans*; SD PILSBRY & BEQUAERT, 1927] [= *Zaira* SIMPSON, 1900]. Elongate-ovate or elliptical, thin, with dorsal margin rather straight; beaks prominent, sculptured only on extreme tips with weak, W-shaped tuberculate; cardinals long, bladelike, lamellar teeth almost straight, meeting cardinals under beaks at very low angle. *Rec.*, W.Afr.—FIG. D19,9. **C. (Z.) elegans* (ROCHEBRUNE); *9a,b*, LV ext., RV int., LV int., $\times 1$ (Pilsbry & Bequaert).
- Cafferia SIMPSON, 1900** [**Unio caffer* KRAUSS, 1848; OD]. Elongated, elliptical, or rhomboid, rather solid; beaks full, ornamented with corrugated zigzag ridges, corrugations commonly extending over entire disc; periostracum yellowish to black, rayless; hinge typical, its elements rather strong. *Pleist.-Rec.*, S.Afr.—FIG. D18,2. **C. caffer* (KRAUSS), *Rec.*; *2a,b*, LV ext., both valves dorsal, $\times 0.75$ (497).
- Canthyrina SWAINSON, 1840** [**Unio spinosus* LEA, 1836; OD]. Spinose, inflated, suboval, with high, rather sharp posterior ridge; disc smooth; hinge typical of family, sharply curved at center. *Rec.*, N.Am.—FIG. D18,6. **C. spinosa* (LEA); *6a-c*, LV ext., RV int., both valves dorsal, $\times 0.5$ (497).
- Caudiculatus SIMPSON, 1900** [**Unio caudiculatus* MARTENS, 1866; OD]. Oval, inflated, slightly winged posteriorly, with deep furrow above posterior margin; cardinals short, low, widely separated from lamellar teeth. *Rec.*, W.Pac.(Borneo).—FIG. D18,7. **C. caudiculatus* (MARTENS); *7a-d*, LV ext., RV int., LV int., both valves dorsal, $\times 0.8$ (Haas).
- Chamberlainia SIMPSON, 1900** [**Unio hainesianus* LEA, 1856; OD] [= *Simpsonia* ROCHEBRUNE, 1904]. Large, very massive in front, less so behind, round obovate, with low posterior slope winged in young shells; beaks low but full; periostracum yellowish green in young, blackish brown in old shells, rayed; ligament hidden by symphy-noty of dorsal wing; cardinals blunt, low, breaking into denticles in old shell, lamellar teeth very short, thick, remote; interdental interval very long, partly covered by periostracum; umbonal cavities moderately deep, nacre purplish, highly iridescent. *Rec.*, SE.Asia.—FIG. D20,5. **C. hainesiana* (LEA); *5a-d*, LV ext., RV int., LV int., both valves dorsal, $\times 0.3$ (Haas).
- Contradens HAAS, 1913** [**Unio contradens* LEA, 1838; OD] [= *Schizocleithrum* HAAS, 1913]. Oval, elongate, short and rounded in front, longer behind; beaks not prominent, mostly inflated, sculptured with wavy wrinkles which may extend over disc; hinge normal, cardinals compressed or blade-like; auxiliary tooth above cardinal of RV; posterior cardinal of LV small to obsolete; lamellar teeth long, somewhat curved; interdental interval narrow, smooth. *Pleist.-Rec.*, SE.Asia-Indon.
- C. (Contradens).** Sculpture restricted to tips of beaks. *Pleist.-Rec.*, SE.Asia.—FIG. D20,4. **C. (C.) contradens* (LEA), *Rec.*; *4a-c*, LV ext., RV int., both valves dorsal, $\times 0.7$ (Haas).
- C. (Sprickia) MODEL, 1942** [**Unio verbeekei* MARTENS, 1897; OD]. Sculpture extending over most or all of disc. *Rec.*, SE.Asia-Indon.—FIG. D20,6. **C. (S.) verbeekei* (MARTENS); *6a-c*, LV ext., RV int., LV int., $\times 1$ (Haas).
- Ctenodesma SIMPSON, 1900** [**Unio borneensis* ISSEL, 1874; OD] [= *Cristadens*, *Christadens* SIMPSON, 1914]. Subtrapezoid to subelliptical, rather thin, compressed; posterior slope poorly defined; beaks low, ornamented by densely zigzag ridges which become finely corrugated or nodulose over disc; cardinals of varying shape, showing tendency to break up into denticles. *Rec.*, W.Pac.(Borneo).—FIG. D20,1. **C. borneense* (ISSEL); *1a-d*, LV ext., RV int., LV int., both valves dorsal, $\times 0.8$ (Haas).
- Cucumerunio IREDALE, 1934** [**Unio novae-hollandia* GRAY, 1834; OD] [= *Cucumaria* CONRAD, 1853 (*non* DE BLAINVILLE, 1830; *nec* LESSON, 1831); *Cucumeria* SIMPSON, 1900 (*nom. null.*); ?*Aparcthyria*, ?*Quaesithyria* IREDALE, 1943]. Elongate, trapezoid, widest behind, thickest in front; disc covered posteriorly with irregular nodules which radiate somewhat from posterior ridge; cardinals not well developed, small, with tendency to break into denticles; lamellar teeth feeble. *Rec.*, Australia.—FIG. D20,3. **C. novae-hollandiae* (GRAY); *3a,b*, RV ext., both valves dorsal, $\times 0.3$ (497).
- Cuncopsis SIMPSON, 1900** [**Unio celtiformis* HEUDE, 1874; OD]. Heavy, elongate, wide in front, tapering to a point behind, commonly twisted on axis; beaks high, anterior, ornamented by radiating lines of nodules; cardinals immediately under beaks, short, lamellar teeth granularly striated, very long. *U.Mio.-Rec.*, E.Asia.—FIG. D20,2. **C. celtiformis* (HEUDE), *Rec.*; *2a-d*, RV ext., LV int., RV int., both valves dorsal, $\times 0.6$ (Haas).
- Diaurora COCKERELL, 1903** [*pro Aurora* SIMPSON, 1900 (*non* RAGONOT, 1887; *nec* SOLLAS, 1888)] [**Unio aureus* HEUDE, 1883; OD]. Small, ovate, subinflated, rather solid, with high, small beaks and strong, corrugated sculpture which extends over half of disc; periostracum fulvous, with green rays; cardinals conical, truncate, lamellar teeth normal; nacre orange. *Rec.*, China.—FIG. D21,8. **D. aurea* (HEUDE); *8a,b*, LV ext., int., $\times 1$ (Zilch).
- Elliptio RAFINESQUE, 1819** [**Unio nigra*; OD] [= *Euryntia* RAFINESQUE, 1820; *Cunicula* SWAINSON, 1840; *Curricula* GRAY, 1847; *Eurymia* CONRAD, 1853; *Rurynea* PAETEL, 1875; *Euryntia* FRIERSON, 1927]. More or less elongate; beaks placed well back of anterior end, not prominent,

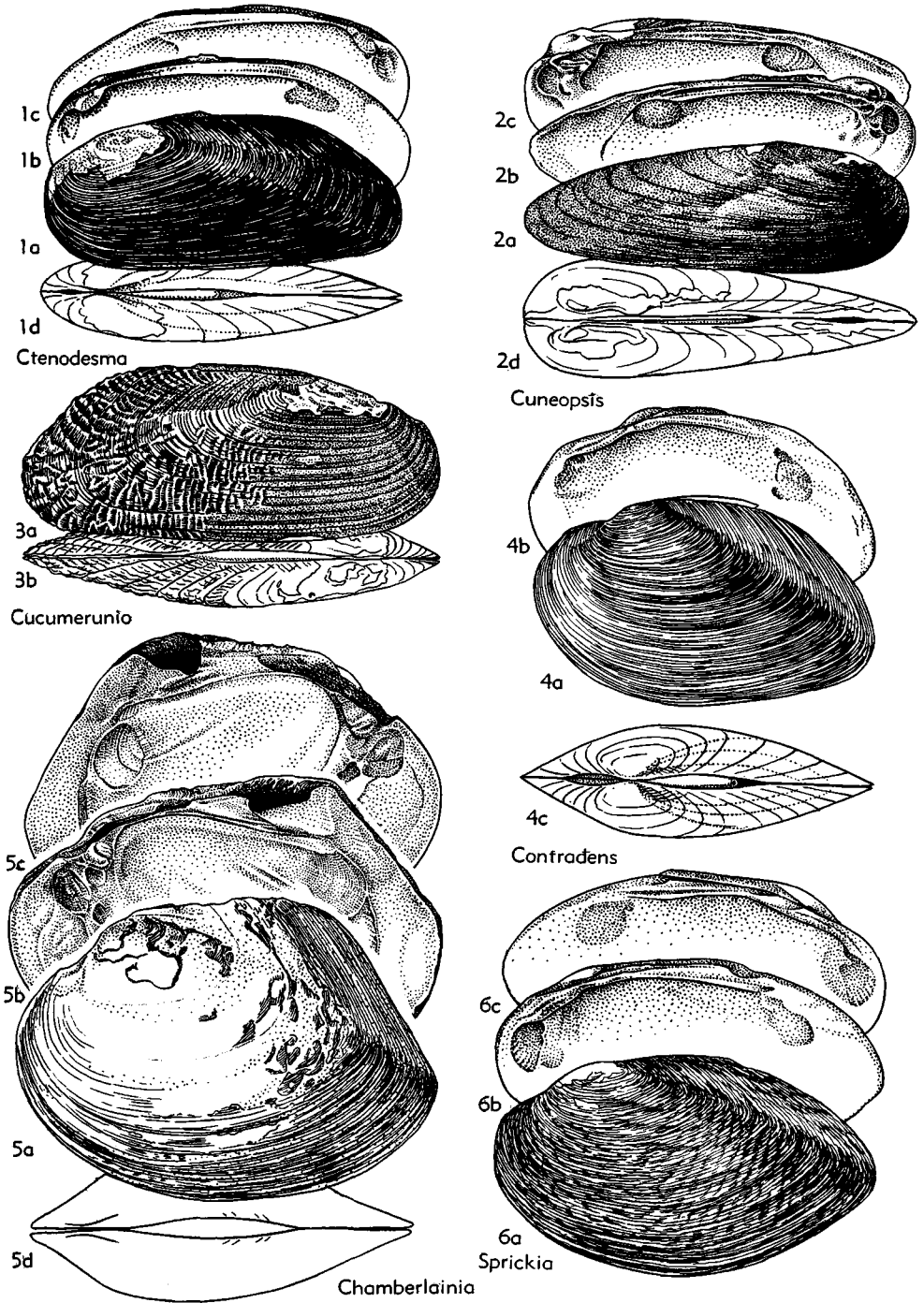


FIG. D20. Unionidae (Unioninae) (p. N420).

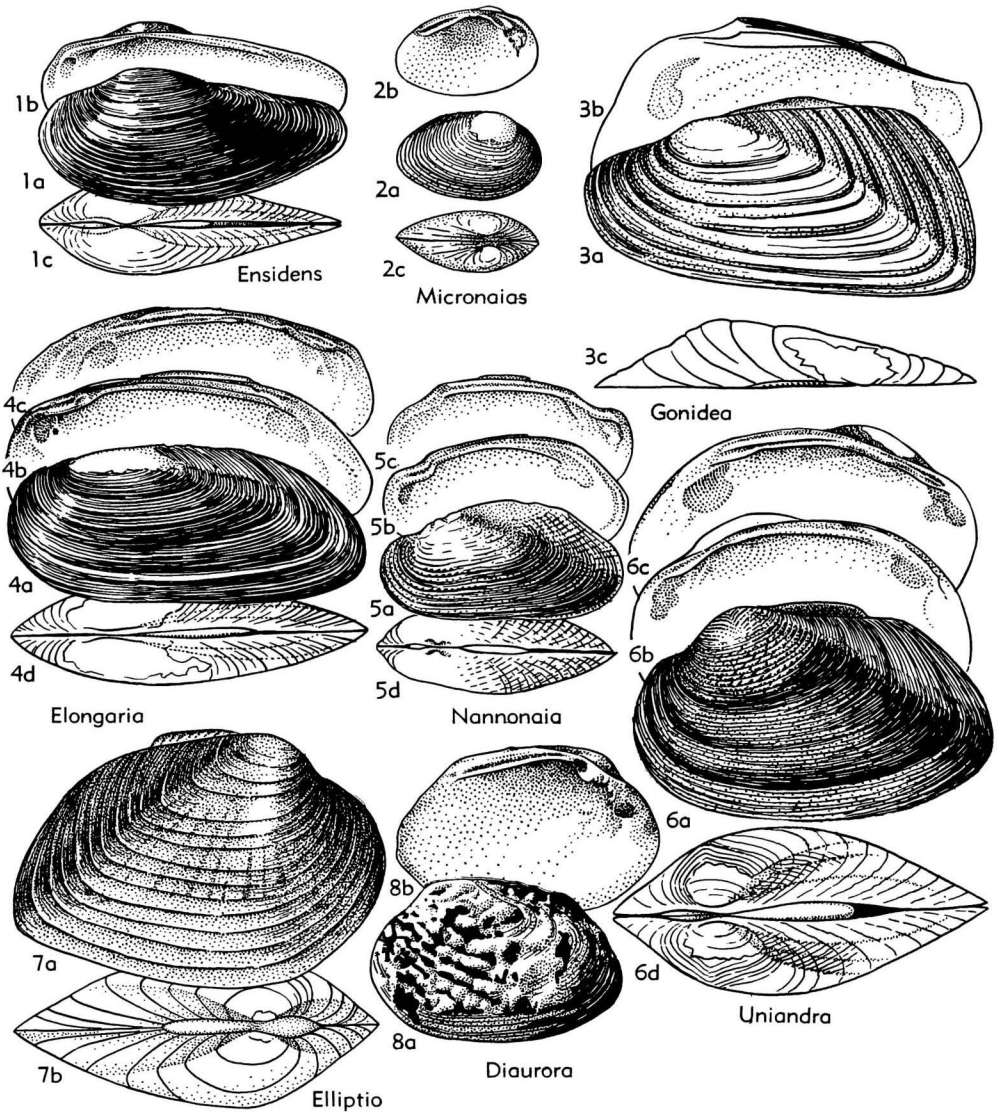


FIG. D21. Unionidae (Unioninae) (p. N420, N422-N423).

covered by few rather strong ridges parallel to growth lines or forming double loops; hinge typical of family. [Cretaceous species referred to *Elliptio* may belong to *Protelliptio* RUSSELL.] ?*U.Cret.*, *Rec.*, N.Am.-?Eu.

E. (Elliptio). Rhomboid or oval, usually more or less biangulate behind; disc without sculpture. ?*U.Cret.*, *Rec.*, N.Am.—FIG. D21,7. *E. (E.) crassidens* (LAMARCK), *Rec.*; 7a,b, RV ext., both valves dorsal, $\times 0.5$ (497).

E. (Micronaias) SIMPSON, 1900 [**Unio aratus* LEA,

1843; OD]. Small, oval; whole disc strongly and closely ridged concentrically; beaks rather prominent; hinge typical of family, all teeth curved. *Rec.*, C.Am.—FIG. D21,2. **E. (M.) aratus* (LEA); 2a-c, RV ext., LV int., both valves dorsal, $\times 1$ (535).

Elongaria HAAS, 1913 [**Unio orientalis* LEA, 1840; OD]. Elongate, narrow, rather solid; beaks not prominent; posterior slope low, indistinctly defined; periostracum smooth or with low wrinkles which radiate from umbonal region; preumbonal

region somewhat impressed as seen dorsally; hinge normal, cardinals long, lamelliform; without fulcrum; interdental interval long and narrow, lamellar teeth long, almost straight, beak cavities shallow. *Pleist.-Rec.*, W.Pac. (Java-Borneo).

E. (Elongaria). Long, narrow, thick, somewhat inflated; beaks low, not prominent; disc smooth; cardinals broadly lamelliform. *Pleist.-Rec.*, Java. —FIG. D21,4. **E. (E.) orientalis* (LEA), *Rec.*; 4a-d, LV ext., RV int., LV int., both valves dorsal, $\times 0.7$ (Haas).

E. (Nannonaia) HAAS, 1913 [**Unio trompi* DROUËT & CHAPER, 1892; OD]. Small, long, narrow, thin, rather inflated; beaks lower than posterior dorsal margin, projecting above anterior one; disc with fine wrinkles on rear end; cardinals thin, bladlike. *Rec.*, W.Pac. (Borneo). —FIG. D21,5. **E. (N.) trompi* (DROUËT & CHAPER); 5a-c, LV ext., RV int., LV int., both valves dorsal, $\times 1$ (Haas).

Ensidents FRIERSON, 1911 [**Unio ingallsianus* LEA, 1852; OD]. Ovate or elongate, pointed behind, thin obese; beaks prominent, smooth or sculptured with faint, concentric zigzag ridges; posterior slope low, ill-defined; hinge with thin, bladlike cardinals and long, almost straight, thin lamellar teeth; without buttress-supporting cardinals. *Rec.*, SE. Asia.

E. (Ensidents). Elongate, pointed behind, beaks without sculpture. *Rec.*, SE. Asia. —FIG. D21,1. **E. (E.) ingallsianus* (LEA); 1a-c, LV ext., RV int., both valves dorsal, $\times 0.7$ (Haas).

E. (Uniandra) HAAS, 1912 [**Unio inaequalis* ROCHEBRUNE, 1882; OD]. Ovate, hardly pointed behind; beaks prominent, sculptured by concentric zigzag ridges; posterior slope compressed. *Rec.*, SE. Asia. —FIG. D21,6. **E. (U.) inaequalis* (ROCHEBRUNE); 6a-d, LV ext., RV int., LV int., both valves dorsal, $\times 1$ (Haas).

Gonidea CONRAD, 1857 [**Anodonta randalli* TRASK, 1855 (**Anodonta angulata* LEA, 1838); OD] [= *Limnobasilissa* HANNIBAL, 1912]. Elongate subtriangular, much narrowed in front, wide behind, inflated, usually with high posterior ridge; beaks sharp but not high, sculptured with few, strong, concentric ridges; hinge with or without rudimentary cardinal and lamellar tooth in each valve. *Mio.-Rec.*, N. Am. —FIG. D21,3. **G. angulata* (LEA), *Rec.*; 3a-c, LV ext., int., dorsal, $\times 0.8$ (140).

Haasodonta McMICHAEL, 1956 [**Hyridella fannyae* JOHNSON, 1948; OD]. Subquadrate, much inflated, shell thin, compressed in front, swollen behind, particularly along greatly expanded posterior ridge; posterior dorsal margin winged; periostracum brown; hinge line straight, long; cardinals and laterals elongate, lamellar. *Rec.*, N. Guinea. —FIG. D22,1. **H. fannyae* (JOHNSON); 1a-c, RV int., LV ext., both valves dorsal, $\times 0.7$ (McMichael).

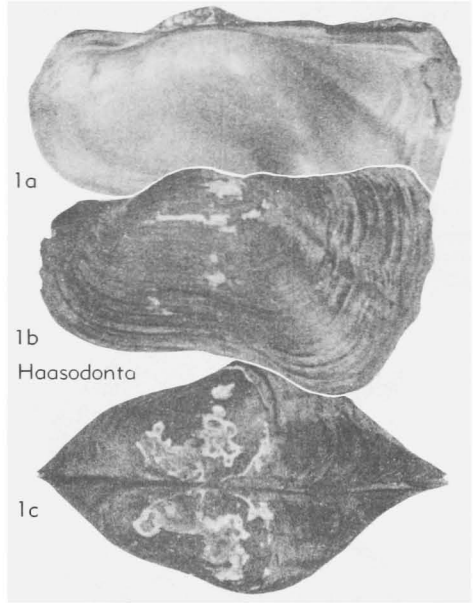


FIG. D22. Unionidae (Unioninae) (p. N423).

Heudeana FRIERSON, 1922 [**Unio murinus* HEUDE, 1883; OD]. Elliptical, somewhat moderately solid; beaks little prominent, sculptured with widely undulating ridges; cardinals thin, bladlike, lamellar teeth short, straight, almost touching cardinals; fulcrum very narrow. *Rec.*, China. —FIG. D23,3. **H. murina* (HEUDE); 3a,b, LV ext., RV int., $\times 0.5$ (Haas).

Hyriopsis CONRAD, 1853 [**Unio delphinus* GRUNER, 1841 (*non* SPENGLER, 1793) (= **Hyriopsis bialata* SIMPSON, 1900); OD] [= *Limnoscapha* LINDHOLM, 1932]. Large, compressed, heavy, rhomboid-elliptical, low in front, high behind, commonly produced posteroventrally, winged dorsally; beaks low, compressed, sculpture consisting of numerous wavy ridges nearly parallel with growth lines, some extending over part of disc; periostracum greenish or brownish, with few rays; cardinals oblique to interdental interval, separating into denticles in old shell, with auxiliary cardinals; lamellar teeth long, somewhat curved, vertically striated in old shell, with lower auxiliary in some RV's; interdental interval long, narrow, curved. *Oligo.-Rec.*, Eu.-E. Asia-SE. Asia. —FIG. D23,2. **H. bialata* SIMPSON, *Rec.*, Eu.; LV ext., $\times 0.5$ (Haas).

Inversidents HAAS, 1911 [**Unio brandti* KOBELT, 1879; OD]. Rounded elliptical; 2 cardinals and 1 posterior lamellar teeth on LV, 1 cardinal and 2 posterior lamellar teeth on RV. *Rec.*, Japan. —FIG. D23,4. **I. brandti* (KOBELT); 4a-d, LV ext.,

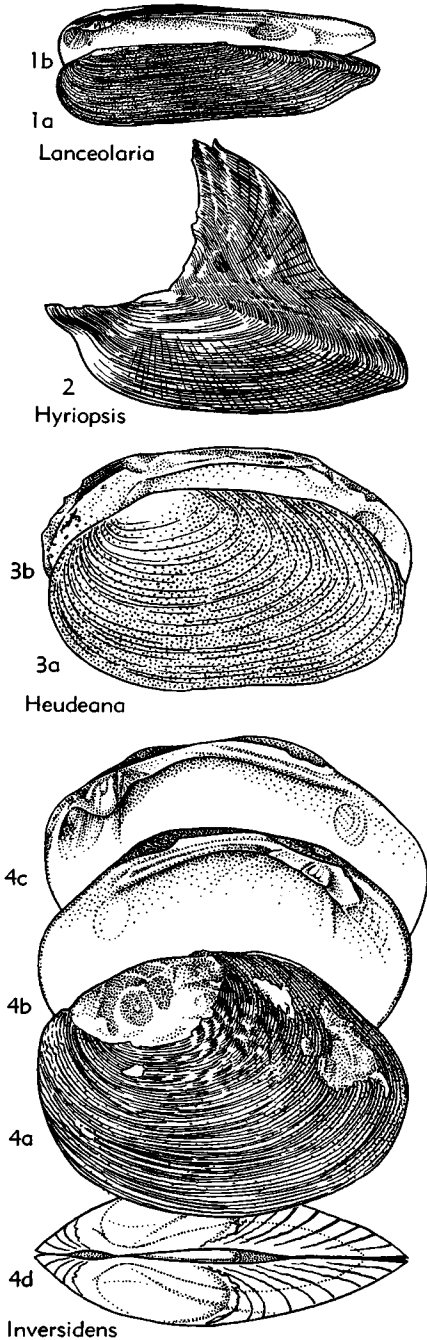


FIG. D23. Unionidae (Unioninae) (p. N423-N424).

int., RV int., both valves dorsal, $\times 1$ (after Haas). **Lamellidens** SIMPSON, 1900 [**Unio marginalis* LAMARCK, 1819; OD]. Elongate, elliptical, pointed behind; beaks with curved radiating ridges which may be zigzag-shaped and concentric, reaching about halfway from beaks, and fading out gradually; periostracum smooth, shiny, dark, almost rayless; cardinals compressed, elongated; lamellar teeth long. *Mio.-Rec.*, E.Indies.—FIG. D24,4. **L. marginalis* (LAMARCK), Rec.; 4a,b, LV ext., both valves dorsal, $\times 0.8$ (497).

Lanceolaria CONRAD, 1853 [**Unio grayanus* LEA, 1834; OD] [= *Cylindrica* SIMPSON, 1900; *Pericylindrica* TOMLIN, 1930]. Very inequilateral sword-shaped, extended and pointed behind, bent to right or left in some, posterior slope well defined, beaks low, periostracum rayed in immature forms; cardinals short, lamellar teeth very long. *Plio.-Rec.*, E.Asia.—FIG. D23,1. **L. grayana* (LEA), Rec.; 1a,b, LV ext., RV int., $\times 0.3$ (after Haas).

Lastena RAFINESQUE, 1820 [**Anodonta lata* RAFINESQUE, 1820; OD] [= *Hemistena* RAFINESQUE, 1820; ?*Flexiptis* RAFINESQUE, 1831; *Odatelia* RAFINESQUE, 1832; *Lostena* GRAY, 1847; *Stenelasma* HERRMANNSEN, 1849; *Hemilastena* L. AGASSIZ, 1852; *Lastenes* DESMAREST, 1859; ?*Sayunio* DE GREGORIO, 1914]. Elongate, very inequilateral, wide and rounded-truncate in front, pointed behind; posterior slope low, with 2 or 3 posterior ridges; beaks low, sculptured with few coarse, irregular, longitudinal folds; periostracum shining, commonly rayed; hinge consisting of imperfect cardinal in each valve and in some forms vestiges of lamellar teeth. *Rec.*, N.Am.—FIG. D24,2. **L. lata* (RAFINESQUE); 2a,b, LV ext., both valves dorsal, $\times 0.7$ (497).

Leguminaia CONRAD, 1865 [**Monocondylaea mardinensis* LEA, 1864; OD] [= *Legumenaia* TRYON, 1884; *Seguminaia* PAETEL, 1890]. Rhomboid to elliptical, slightly biangulate behind, posterior ridge faint, double; beaks anterior, sculptured with fine, concentric ridges which tend to form 2 rounded loops; periostracum almost or completely without rays; hinge without fulcrum, teeth arising immediately from dorsal margin of shell, single cardinal in each valve, that of LV under beak, in RV in front of beak; dorsal side of teeth commonly covered with periostracum; beak cavities shallow. *Rec.*, SE.Eu.-SC.Eu.-SW.Asia (Iraq-Syria).

L. (Leguminaia). Rather solid, beaks rather full; cardinals strong, with slight 2nd cardinal in LV of some forms. *Rec.*, SW.Asia (Iraq).—FIG. D25,4. **L. (L.) mardinensis* (LEA); 4a-c, RV ext., LV int., both valves dorsal, $\times 0.6$ (535).

L. (Microcondylaea) VEST, 1866 [**Anodonta uniopsis* LAMARCK, 1819; OD] [= *Microcondylus* DROUËT, 1879]. Decidedly inequilateral, elongate, subrhomboid to elliptical, compressed, rather

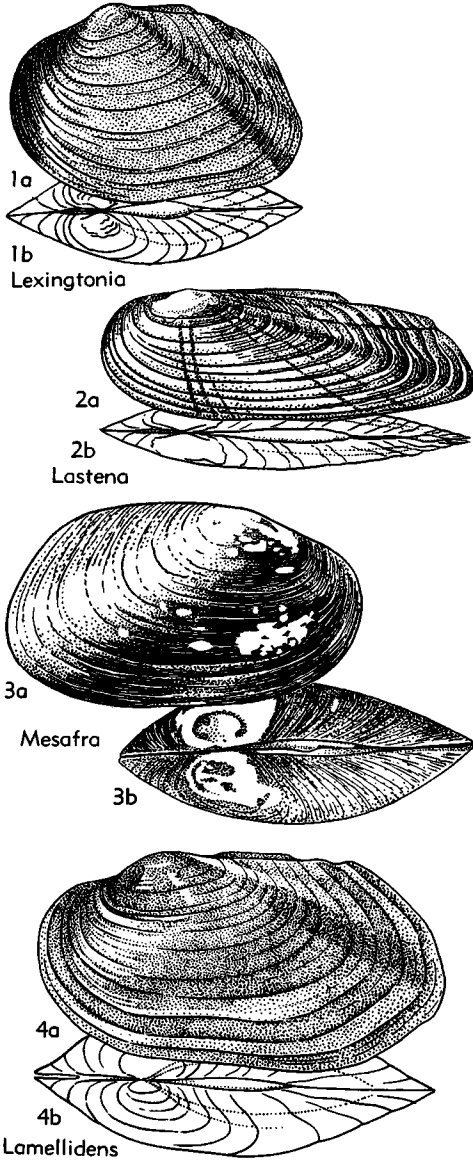


FIG. D24. Unionidae (Unioninae) (p. N424-N425).

thin, with low beaks; 1 cardinal in each valve, very compressed. *Rec.*, SE.Eu.-SC.Eu.—FIG. D25,2. **L. (M.) uniopsis* (LAMARCK); 2a-c, LV ext., RV int., both valves dorsal, $\times 0.7$ (497).

L. (Pseudodontopsis) KOBELT, 1913 [**Unio euphraticus* BOURGUIGNAT, 1853; OD]. Thin, broadly elliptical or rhomboid, rather compressed; beaks subcentral with tendency to shift forward

during growth; 1 cardinal in each valve, very compressed. *Rec.*, SW.Asia (Iraq).—FIG. D25,3. **L. (P.) euphratica* (BOURGUIGNAT); 3a-c, LV ext., RV and LV hinges, both valves dorsal, $\times 0.7$ (481).

L. (Pseudoleguminaia) GERMAIN, 1911 [**Pseudodon chantrei* LOCARD, 1883; OD]. Subelliptical, somewhat inflated, rather thin, almost transparent; beaks near center, rather full, sculptured with irregular undulations; periostracum bright, yellowish-brown; cardinals very obtuse, rather prominent and thick. *Rec.*, SW.Asia (Syria).—FIG. D25,1. **L. (P.) chantrei* (LOCARD); 1a-c, LV int., RV int., LV ext., $\times 0.7$ (Locard).

Lexingtonia ORTMANN, 1914 [**Unio subplanus* CONRAD, 1837; OD] Subquadrate or subtrapezoidal, beaks slightly elevated, well behind anterior extremity; beak sculpture consisting of 6 to 8 rather crowded subconcentric ridges, which form indistinct rounded angle on posterior ridge; periostracum brownish, with rather indistinct continuous rays; hinge teeth well developed, nacre white to pink. *Rec.*, N.Am.—FIG. D24,1. **L. subplana* (CONRAD); 1a,b, LV ext., both valves dorsal, $\times 1$ (497).

Mesafra HAAS, 1936 [**Caelatura mesaficana* PILSBRY & BEQUAERT, 1927; OD]. Ventricose, elongate-ovoid, thin; beaks full, not prominent, with sculpture consisting of crowded ribs that radiate from tips; hinge teeth thin, bladelike, cardinals short; periostracum lusterless, silky, olive green. *Rec.*, C.Afr.—FIG. D24,3. **M. mesaficana* (PILSBRY & BEQUAERT); 3a,b, RV ext., both valves dorsal, $\times 1$ (Haas).

Nephronaias FISCHER & CROSSE, 1893 [**Unio plicatulus* CHARPENTIER, 1856; OD] [= *Leptonaias*, *Simonaias*, *Caenonaias*, *Graptionaias* FISCHER & CROSSE, 1893]. Oblong to elliptical, that of male showing tendency to become kidney-shaped with age, female usually having posterior inflation; surface concentrically sculptured, beaks low, ornamented with faint broken ridges tending to fall into 2 rounded loops; umbonal cavities rather deep; hinge with generally somewhat compressed ragged cardinals and with obliquely ridged posterior lamellar teeth. *Rec.*, C.Am.-N.Am.

N. (Nephronaias). Elliptical. *Rec.*, C.Am.—FIG. D26,4. **N. (N.) plicatula* (CHARPENTIER); 4a-c, RV ext., LV int., both valves dorsal, $\times 2$ (497).

N. (Elliptoideus) FRIERSON, 1927 [**Unio sloati-anus* LEA, 1840; OD]. Marsupium occupying all 4 gills. *Rec.*, N.Am.—FIG. D26,2. **N. (E.) sloati-anus* (LEA); RV ext., $\times 1$ (497).

N. (Martensnaias) FRIERSON, 1927 [**Unio rubicundus* MARTENS, 1900; OD]. Oblong, solid, with well-developed posterior slope; beaks high, anteriorly placed (2.5 of length); disc marked by strong concentric sulci, and posterior slope with radial plications; cardinals strong, crenu-

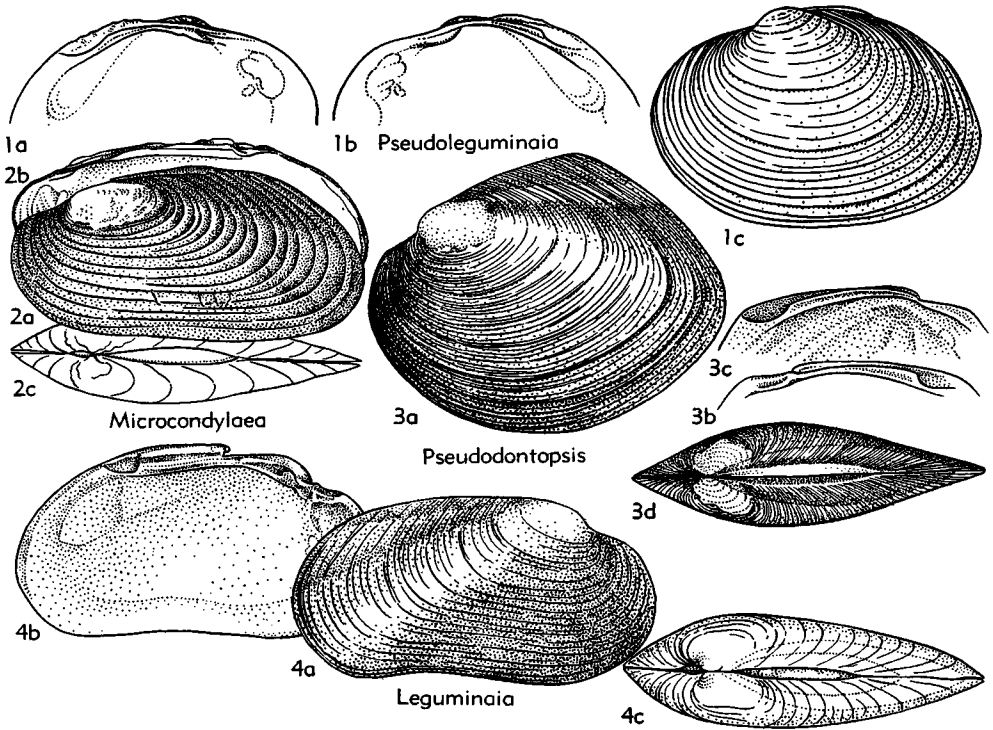


FIG. D25. Unionidae (Unioninae) (p. N424-N425).

lated, lamellar teeth strongly curved; nacre purple. *Rec.*, C.Am.—FIG. D26,1. *N. (*M.*) *rubicunda* (MARTENS); 1a,b, LV ext., int., $\times 0.5$ (588).

N. (*Nephritica*) FRIERSON, 1927 [**Unio poeyanus* LEA, 1857; OD]. Very similar to *Popenaias* but more cylindrical, having greatest diameter behind middle, scarcely diminishing anteriorly. *Rec.*, C.Am.—FIG. D26,5. *N. (*N.*) *poeyana* (LEA); 5a-c, RV ext., LV int., both valves dorsal, $\times 0.8$ (535).

N. (*Popenaias*) FRIERSON, 1927 [**Unio popeii* LEA, 1857; OD]. Elongate, especially in front; teeth compressed, sharp. *Rec.*, N.Am.—FIG. D26,3. *N. (*P.*) *popeii* (LEA); 3a-c, RV ext., LV int., both valves dorsal, $\times 0.8$ (535).

N. (*Reticulatus*) FRIERSON, 1927 [**Unio reticulatus* SIMPSON, 1900; OD]. Elliptical, solid, inflated; surface covered with fine, concentric ridges and having delicate, radiating furrows which cut sulcations and form them into loops. *Rec.*, C.Am.—FIG. D26,6. *N. (*R.*) *reticulata* (SIMPSON); RV ext., $\times 1$ (845).

N. (*Sphenonaias*) FISCHER & CROSSE, 1893 [**Unio liebmanni* PHILIPPI, 1847; OD] [= *Barynaias*

FISCHER & CROSSE, 1893]. Solid, somewhat trapezoid in shape; cardinal teeth heavy. *Rec.*, C.Am.—FIG. D26,7. *N. (*S.*) *liebmanni* (PHILIPPI); 1a,b, LV ext., RV int., both valves dorsal, $\times 0.5$ (497).

Nippononaias SUZUKI, 1941 [**Unio ryosekiana*; OD]. Subelliptical, medium-sized, with many acute V-shaped ridges centering on line from beak to middle of ventral margin which is finely crenulate. *L.Cret.*, Japan.—FIG. D27,3. *N. *ryosekiana* (SUZUKI); LV ext., $\times 1$ (after 896).

Nitia PALLARY, 1924 [**Unio teretiusculus* PHILIPPI, 1847; OD]. Heavy, inflated, elongate, slender, with almost straight and parallel dorsal and ventral margins; beaks slightly prominent; periostracum thick, grayish, feltlike; beaks with zigzag ridges which become wavy wherever they extend over part of disc; cardinals short, heavy; lamellar teeth long, slender. *Rec.*, C.Afr.-NE.Afr.—FIG. D27,1. *N. *teretiuscula* (PHILIPPI); 1a-c, LV ext., both valves dorsal, hinges, $\times 1$ (497).

Oxynaia HAAS, 1913 [**Unio jourdyi* MORLET, 1886; OD]. Elongate, rounded in front, pointed behind, beaks prominent, with zigzag ridges on oldest part, posterior slope low; cardinals stout, lamellar

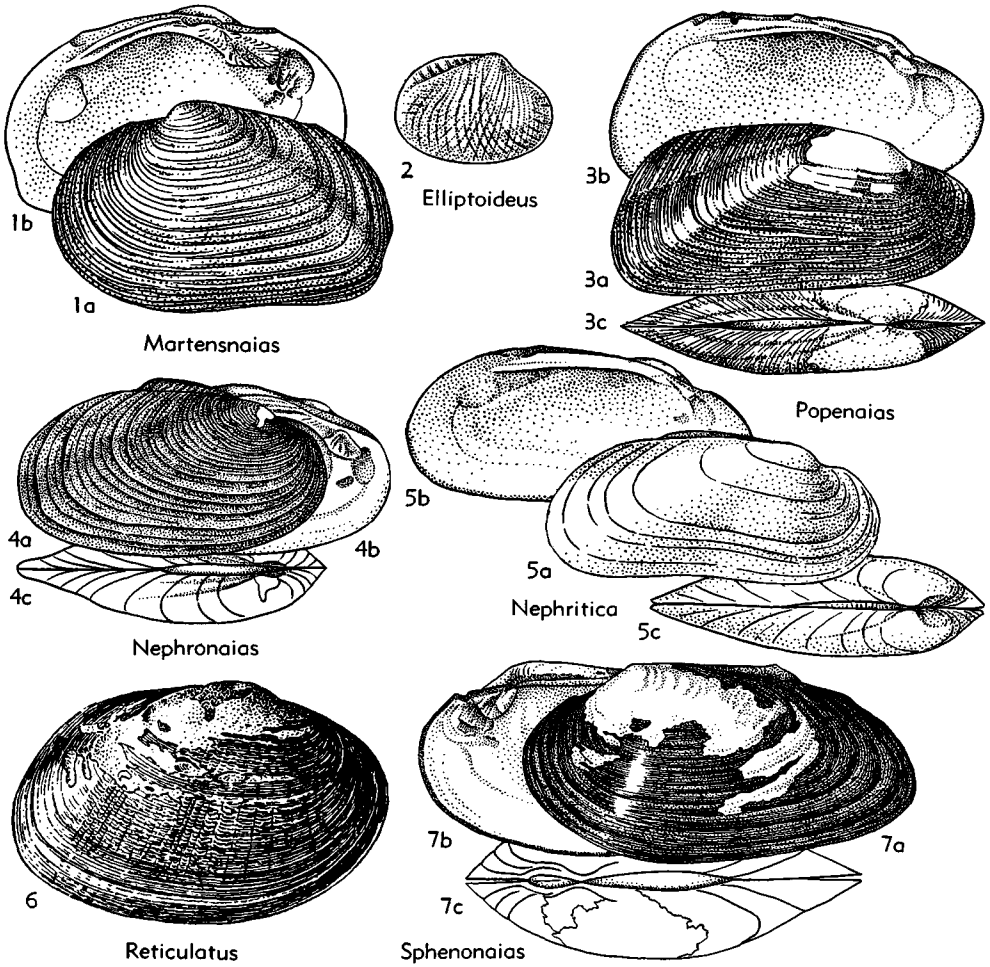


FIG. D26. Unionidae (Unioninae) (p. N425-N426).

teeth, slender. *Rec.*, SE.Asia.—FIG. D27,4. **O. jourdyi* (MORLET); 4a-c, LV ext., RV int., both valves dorsal, $\times 1$ (after Haas).

Palindonaia MODELL, 1950 [**Unio solandri* J. DE C. SOWERBY, 1826; OD]. Small, elongate, oval or rectangular, rather compressed; beaks low, posterior ridge faint, indistinct sculpture on beaks and posterior slope; cardinals small, flat. *Cret. (Gosau)-Eoc.*, Eu.—FIG. D27,2. *P. solandri emszti* MODELL, *Cret.*, Eu.; RV ext., $\times 1$ (632).

Paranodonta KOBAYASHI & SUZUKI, 1936 [**P. otai*; OD]. Elliptical to subovate, very thick, highly convex; beaks near center; disc smooth except for growth lines; cardinals almost rudimentary, laterals absent. *U.Jur.* (*Naklong Wakino Ser.*), Japan.—FIG. D27,5. **P. otai*; RV ext., $\times 1$ (479).

Parreysia CONRAD, 1853 [**Unio multidentatus*

PHILIPPI, 1847; OD]. Heavy, inflated, rounded to subrhomboid, with full, high, radially zigzag ribs on beaks, sculpture commonly extending over disc; periostracum smooth, bright, rayed; hinge normal, cardinals heavy, ragged or vertically striate, lamellar teeth short, in some shells duplicated in RV; cavity of beaks rather deep. *Mio.-Rec.*, S.Asia-C.Afr.

P. (Parreysia). Shell with center of ventral region swollen; beak sculpture strong, with central ridges generally united at their lower points to form chevron-shaped markings. *Mio.-Rec.*, S. Asia.—FIG. D28,2. *P. (P.) corrugata* (MUELLER), *Rec.*; 2a,b, RV ext., LV int., $\times 1$ (497).

P. (Nyassunio) HAAS, 1936 [**Unio nyassaensis* LEA, 1864; OD]. Rounded triangular to quadrangular, old specimens elongate and descending

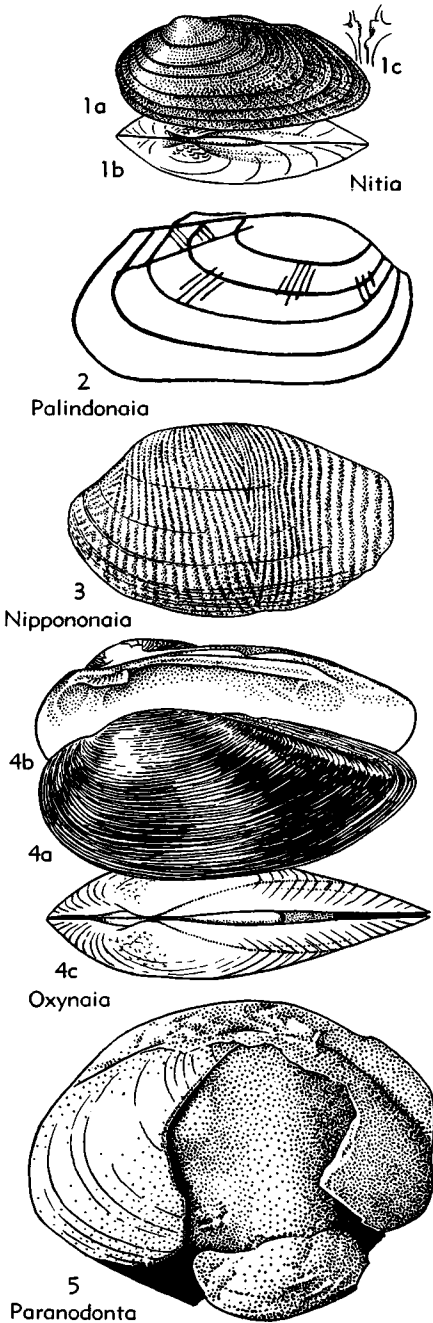


FIG. D27. Unionidae (Unioninae) (p. N426-N427).

behind, solid; beaks very prominent, sculpture consisting of sharply bent zigzag wrinkles reduced to isolated waves in old specimens; posterior slope concave, posterior ridge distinct, showing as furrow within; hinge heavy, cardinals serrate, compressed, standing at angle with short lamellar teeth. *Rec.*, C.Afr.—FIG. D28,1. **P. (N.) nyassaensis* (LEA); 1a-d, LV ext., RV int., LV int., both valves dorsal, $\times 0.5$ (Haas).

P. (Radiatula) SIMPSON, 1900 [**Unio crispisulcatus* BENSON, 1862; OD] [= *Indonaia* PRASHAD, 1918]. Triangularly oval, beaks little inflated, entire surface of disc covered with radiating or zigzag-shaped or divaricate ridges separated into nodules by concentric sulcations. *Mio.-Rec.*, S. Asia.—FIG. D28,6. **P. (R.) crispisulcata* (BENSON), *Rec.*; LV ext., $\times 0.8$ (384).

Physunio SIMPSON, 1900 [**Unio gravidus* LEA, 1856; OD]. Irregularly obovate, thin, narrowed in front, produced at posterior base; posterior slope high, winged, excavated, posterior ridge distinct; beaks inflated, with deep cavities, tips sculptured with zigzag folds; disc smooth, periostracum yellowish or brownish green; hinge normal, cardinals elongate, compressed, lamellar teeth short, somewhat curved, auxiliary tooth added in each valve in old specimens. *Rec.*, SE.Asia-Java.

P. (Physunio). Generally very ventricose, not symphyonote; beak cavities deep. *Rec.*, SE.Asia-Indon.(Java).—FIG. D28,5. **P. (P.) gravidus* (LEA); 5a-d, RV ext., LV int., RV int., both valves dorsal, $\times 0.5$ (Haas).

P. (Lens) SIMPSON, 1900 [**Unio eximius* LEA, 1860; OD]. Sublenticular, not symphyonote; umbonal cavities compressed. *Rec.*, SE.Asia.—FIG. D28,8. **P. (L.) eximius* (LEA); 8a-c, RV ext., int., both valves dorsal, $\times 0.8$ (Haas).

P. (Velunio) HAAS, 1914 [**Unio velaris* SOWERBY, 1868; OD]. Compressed, symphyonote; beaks incurved forward. *Rec.*, SE.Asia.—FIG. D28,7. **P. (V.) velaris* (SOWERBY); LV ext., $\times 1$ (Haas).

Plethobasus SIMPSON, 1900 [**Unio aesopus* GREEN, 1827 (= **Obliquaria cyphya* RAFINESQUE, 1820); OD]. Large, irregularly oval, inflated, abruptly swollen at posterior base; beaks subanterior, rather high, having few strong ridges which curve upward behind and row of tubercles extending from beaks to postbasal area; hinge normal, cardinals rough, triangular; cavities of beaks not deep; front part of shell heavy, rear part much thinner. *Pleist.-Rec.*, N.Am.—FIG. D28,3. **P. cyphus* (RAFINESQUE), *Rec.*; 3a,b, LV ext., both valves dorsal, $\times 0.7$ (497).

Pleurobema RAFINESQUE, 1820 [**Unio mytiloides* RAFINESQUE, 1820; SD HERRMANNSEN, 1846]. Heavy, triangular to rhomboid, umbonal region prominent; beaks subanterior or anterior, incurved, pointing forward; beak sculpture coarse, consist-

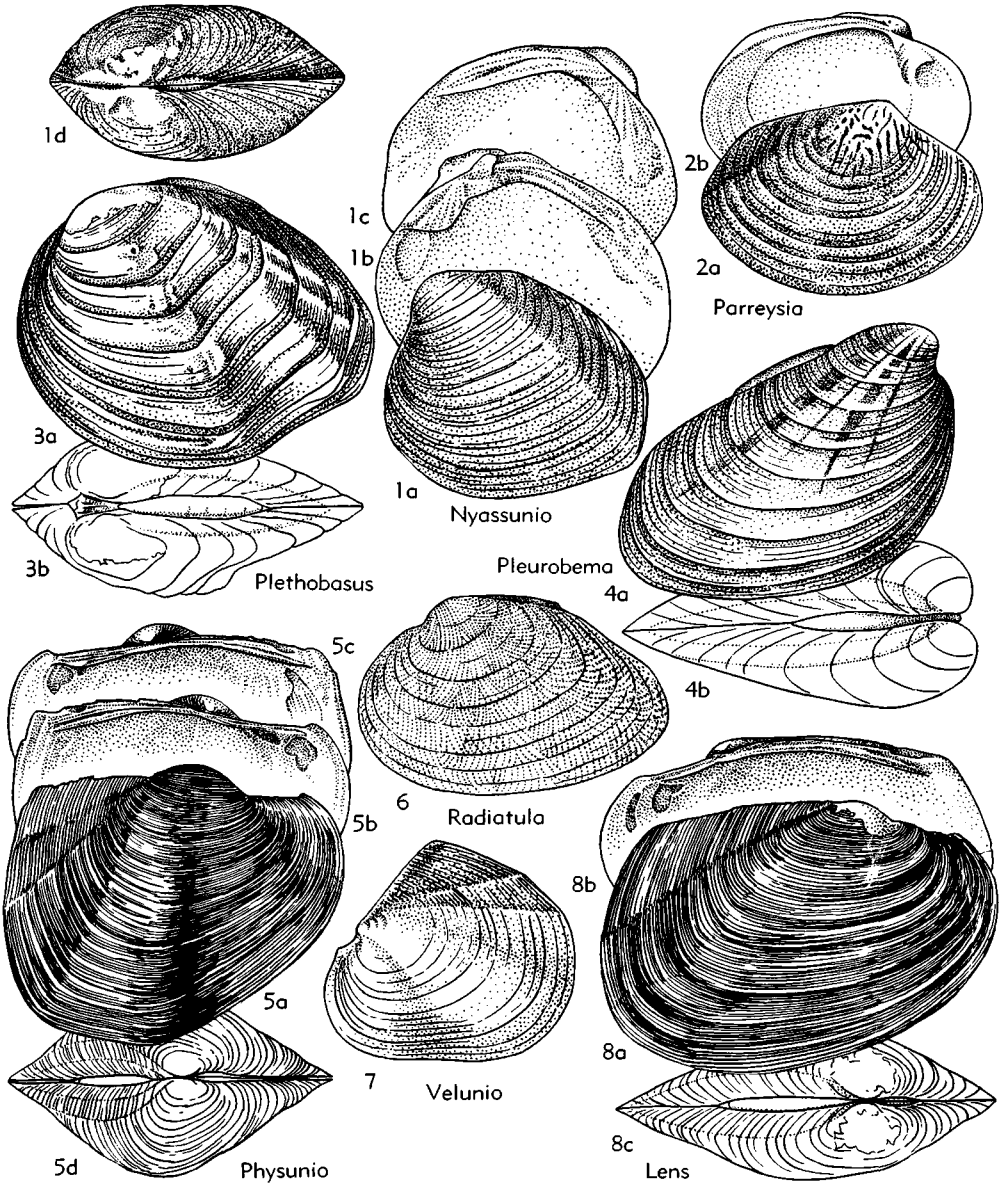


FIG. D28. Unionidae (Unioninae) (p. N427-N429).

ing of few irregular, commonly discontinuous ridges which curve upward posteriorly; posterior slope low, posterior ridge low and rounded; periostracum commonly with rays which show tendency to break into square spots; hinge rather strong, cardinals triangular, ragged, lamellar teeth almost reaching cardinals, auxiliary lateral below that of RV. *U.Cret.-Rec.*, N.Am.—FIG. D28, 4.

**P. mytiloides* (RAFINESQUE), Rec.; 4a,b, RV ext., both valves dorsal, $\times 0.75$ (497).
Plicatunio KOBAYASHI & SUZUKI, 1936 [**P. nak-tongensis*; OD]. Moderately convex, subelliptical to subtriangular; umbones large, located at or slightly ahead of middle; several strong subrenate plications radiate from umbonal region to postero-ventral margin; anterior cardinal tooth relatively

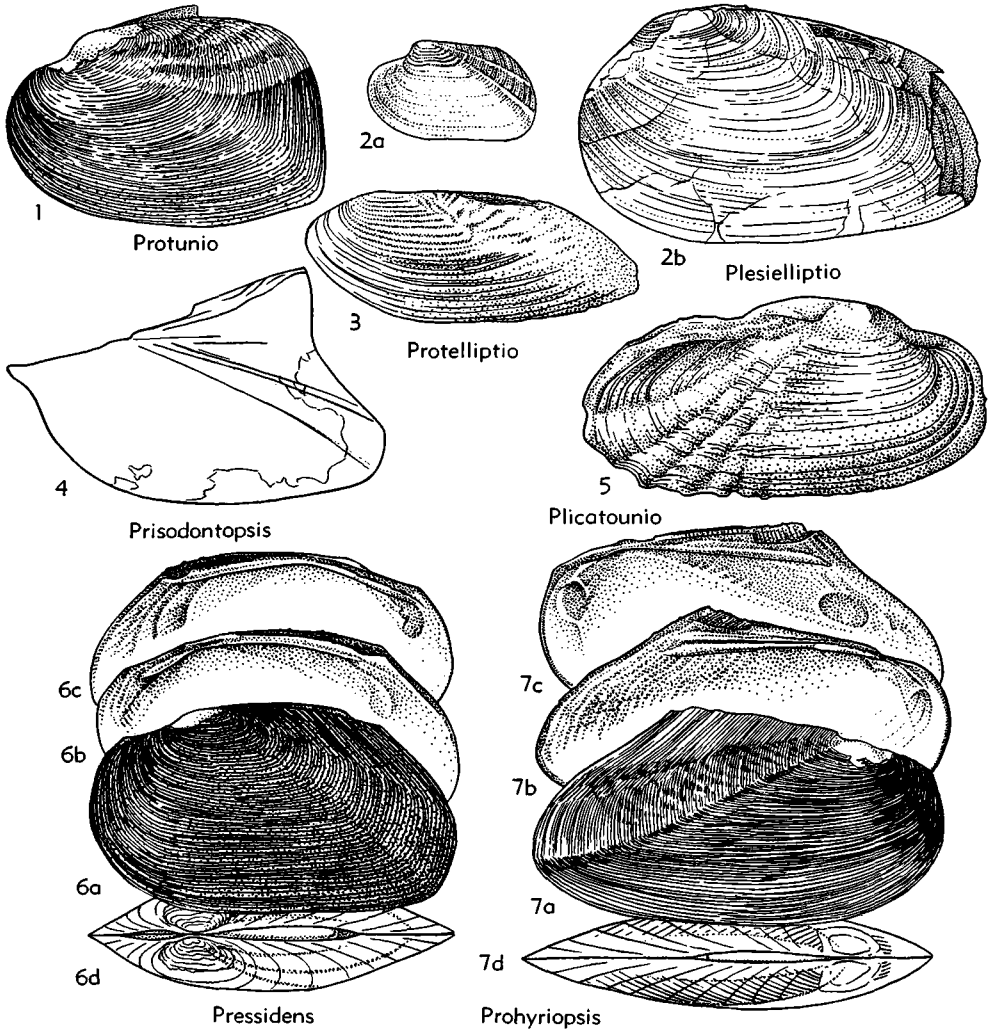


FIG. D29. Unionidae (Unioninae) (p. N429-N431).

long and regularly crenulate; posterior cardinal prominent, noncrenulate; anterior adductor scar more strongly impressed than posterior. *U.Jur.*, Manchuria-Japan; *U.Cret.*, N.Afr. (Fr.Sudan).—FIG. D29,5. **P. nakdongensis*, *U.Jur.*, Japan; RV ext., $\times 0.75$ (479).

Pressidens HAAS, 1900 [**P. moellendorffi*; OD]. Oval, thin, somewhat compressed; beaks low, their sculpture consisting of concentric undulating wrinkles, or entirely absent; posterior slope high; hinge consisting of one long compressed cardinal and of one long low lateral in each valve. *Rec.*, W.Pac. (Borneo).—FIG. D29,6. **P. moellendorffi*; 6a-d, LV ext., RV int., LV int., both valves dorsal, $\times 0.75$ (Haas).

Prisodontopsis TOMLIN, 1928 [*pro Pseudavicula* SIMPSON, 1900 (non ETHERIDGE, 1892)] [**Unio (Metaptera) johnstoni* E. A. SMITH, 1893; OD]. With well-developed anterior and posterior dorsal wings; posterior margin of posterior wing deeply incurved; beaks low, full; cardinals elongate, slightly corrugated, 1 in LV, 2 in RV; lamellar teeth long, straight, thin and prominent, 2 in LV, 1 in RV. *Rec.*, C.Afr.—FIG. D29,4. **P. johnstoni* (SMITH); LV ext., $\times 1$ (Pilsbry & Bequaert).

Prohyriopsis HAAS, 1914 [**Unio stolatus* MARTENS, 1900; OD]. Elongate, very inequilateral, somewhat symphyonote, produced and slightly truncate behind, thin, compressed; posterior slope high, compressed in middle, with distinct posterior ridge

close to which slope shows slightly wavy folds; ligament hidden; cardinals compressed, at angle with dorsal margin, lamellar teeth long and straight. *Rec.*, W.Indon.(Sumatra).—FIG. D29, 7. **P. stolata* (MARTENS); 7a-d, RV ext., LV int., RV int., both valves dorsal, $\times 0.75$ (Haas).

Protelliptio RUSSELL, 1934 [**Unio biornatus* RUSSELL, 1932; OD]. Medium-sized, elongate-ovoid; beaks low, sculptured with numerous regular concentric or double-looped plications; 2 somewhat divergent lines directed posteroventrally. *L.Cret.-Paleoc.*, N.Am.

P. (Protelliptio). Concentric plications on beak extending on to disc and posterior loop weakly developed; 2 narrowly divergent, posterodorsal lines may be present; posterodorsal surface usually marked by radiating, upcurved plications similar to those of *Lasmigona*; umbonal ridge poorly developed. *L.Cret.*, N.Am.—FIG. D29,3. **P. (P.) biornatus* (RUSSELL); LV ext., $\times 0.8$ (807).

P. (Plesielliptio) RUSSELL, 1934 [**Unio priscus* MEEK & HAYDEN, 1867; OD]. Narrowly to broadly ovoid; beaks sculptured with a few fine, close-set plications, concentric or double-looped, and having 2 slightly divergent, straight or gently curved lines directed posteroventrally, without posterior radiating ornamentation; other shell characters as in *Elliptio*. *U.Cret.-Paleoc.*, N.Am.—FIG. D29,2. **P. (P.) priscus* (MEEK & HAYDEN), Paleoc. (Ft. Union F.); 2a, LV ext., $\times 0.75$; 2b, LV ext., $\times 1$ (604).

Protunio HAAS, 1913 [**Unio messageri* BAVAY & DAUTZENBERG, 1901; OD]. Ovate rhombic, solid, rounded in front, truncate behind; beaks prominent, ornamented by undulating ridges which extend over upper half of disc; cardinal of RV low, sulcate above, posterior cardinal of LV identical, anterior narrow; compressed, lamellar teeth long, slightly curved, thicker behind; interdental interval rather long, wide, smooth. *Rec.*, SE.Asia.—FIG. D29,1. **P. messageri* (BAVAY & DAUTZENBERG); LV ext., $\times 1$ (Haas).

Pseudodon GOULD, 1844 [**Anodon inoscularis* GOULD, 1844; OD] [= *Pseudodus* MORGAN, 1885]. Ovate to elliptical, very inequilateral; beaks low, ornamented by W-shaped wrinkles which gradually become undulate with age; posterior slope mostly high, well defined, ornamented in some; periostracum dark brown or black, rayless in mature specimens; teeth unsupported by buttress arising immediately from margin of shell; 1 blunt, mostly blade-shaped cardinal in each valve, in some species with vestiges of another cardinal or of lamellar teeth; umbonal cavities shallow. *Phio-Rec.*, E.Asia-SE.Asia.

P. (Pseudodon). Ellipsoid, rather thick, ventricose, with distinct posterior slope which may be alate and may be crossed by wrinkles; cardinals heavy, rounded above. *Rec.*, China-SE.Asia.—FIG.

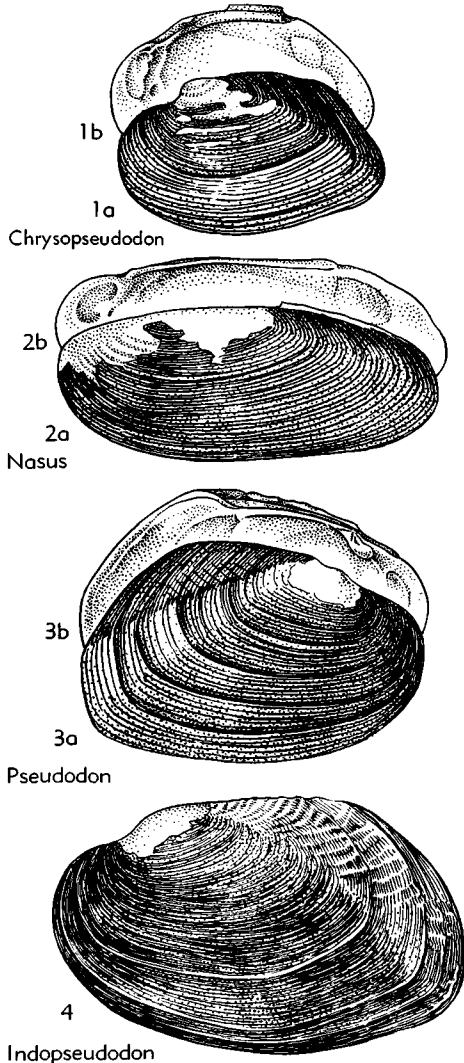


FIG. D30. Unionidae (Unioninae) (p. N431-N432, N434).

D30,3. **P. (P.) inoscularis* (GOULD); 3a,b, RV ext., LV int., $\times 0.75$ (Haas).

P. (Bineurus) SIMPSON, 1900 [**Unio mouhoti* LEA, 1863; OD]. Elongate, rhomboid, thin, rounded in front, widely and indistinctly biangulate behind; with 2 or more raised ridges on posterior slope which may be transversely wrinkled; disc ornamented by fine irregular concentric grooves; cardinals smooth, compressed. *Rec.*, SE.Asia.—FIG. D31,2. **P. (B.) mouhoti* (LEA); 2a-c, LV ext., RV int., both valves dorsal, $\times 0.7$ (Haas).

P. (Cosmopseudodon) HAAS, 1920 [**P. resupina-*

tus MARTENS, 1902; OD]. Elongate, rather thick, with well-defined triangular posterior slope; beaks low, sculptured with V-shaped folds which gradually smooth distally into undulating wrinkles; disc of juvenile shells sculptured with curved

folds; cardinals thick, low. *Rec.*, SE.Asia.—FIG. D31,4. **P. (C.) resupinatus* MARTENS; 4a-c, LV ext., RV int., both valves dorsal, $\times 0.7$ (Haas). *P. (Chrysopseudodon)* HAAS, 1920 [**P. aureus* HEUDE, 1885; OD]. Small, rhomboid, solid, in-

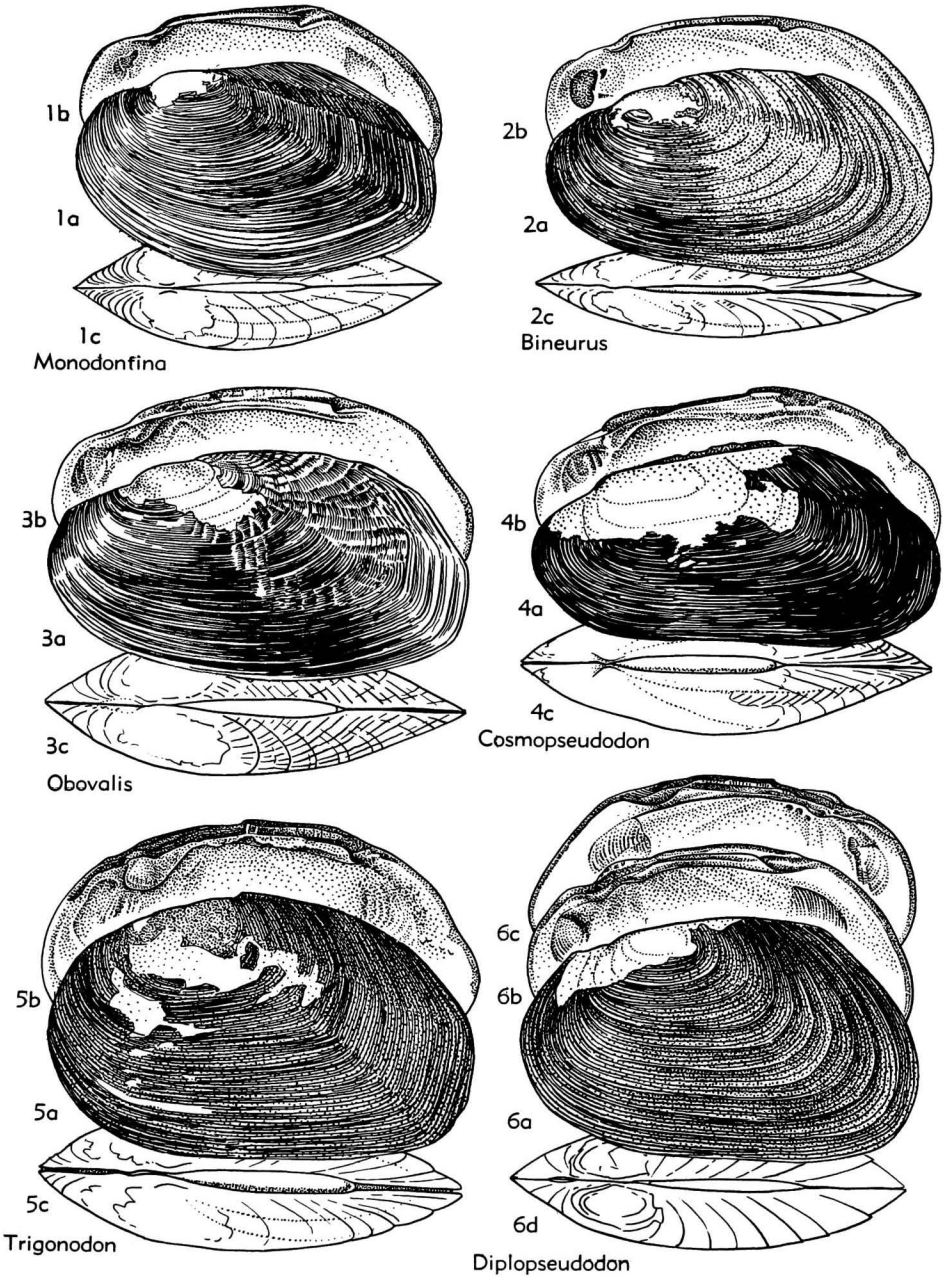


FIG. D31. Unionidae (Unioninae) (p.N431-N432, N434).

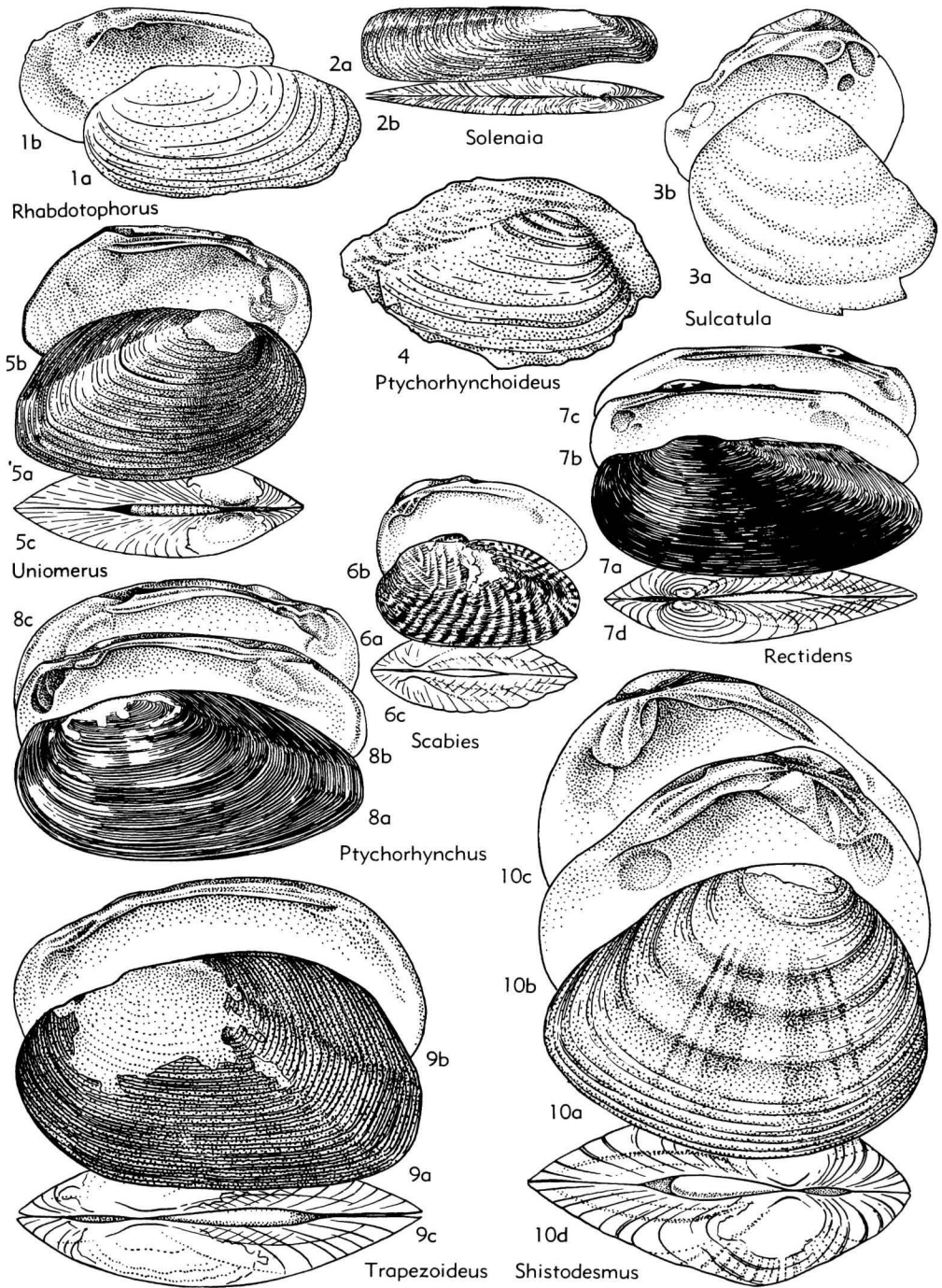


FIG. D32. Unionidae (Unioninae) (p. N434-N435).

- flated; beaks rather central, prominent, with concentric wrinkles; posterior slope wide, concave, with folds over upper half; 1 cardinal in each valve. *Rec.*, China.—FIG. D30,1. **P. (C.) aureus* HEUDE; 1*a,b*, LV ext., RV int., $\times 1$ (Haas).
- P. (Diploseudodon)** HAAS, 1920 [**P. crassus* DROUËT, 1892; OD]. Elongate rhomboid, comparatively high, thick, inflated; anterior end short and low, posterior long and high with distinct posterior slope; 2 cardinals in RV and 1 in LV. *Rec.*, W.Pac. (Borneo).—FIG. D31,6. **P. (D.) crassus* DROUËT; 6*a-d*, LV ext., RV int., LV int., both valves dorsal, $\times 0.7$ (Haas).
- P. (Indopseudodon)** PRASHAD, 1922 [**Anodon salweenianus* GOULD, 1884; OD]. Characterized by considerable length and strong, plicate sculpture on alate posterior slope. *Rec.*, SE.Asia. (Burma).—FIG. D30,4. **P. (I.) salweenianus* (GOULD); LV ext., $\times 0.75$ (Haas).
- P. (Monodontina)** CONRAD, 1853 [**Margaritana vondembuschiana* LEA, 1840; OD] [= *Suborbiculus* SIMPSON, 1900]. Rounded, compressed, anterior slope low, posterior high, alate, symphinite when young; 1 smooth tooth parallel to dorsal margin in each valve. *Rec.*, SE.Asia.—FIG. D31,1. **P. (M.) vondembuschiana* (LEA); 1*a-c*, LV ext., RV int., both valves dorsal, $\times 0.5$ (Haas).
- P. (Nasus)** SIMPSON, 1900 [**Monocondylaea nankingensis* HEUDE, 1874; OD]. Very elongate, low, moderately thick, somewhat inflated; posterior very low, rounded or roundly truncate; beaks not prominent, of unknown sculpture; cardinals compressed, high, blunt. *Rec.*, China.—FIG. D30,2. **P. (N.) nankingensis* (HEUDE); 2*a,b*, LV ext., RV int., $\times 0.8$ (Haas).
- P. (Obovalis)** SIMPSON, 1900 [**Pseudodon loomisi* SIMPSON, 1900; OD]. Elongate-ovate, thin, moderately inflated, with low posterior slope; V-shaped folds branching out from posterior ridge, crossing posterior slope and neighboring portion of disc; periostracum dark; with 1 high, triangular cardinal and vestiges of 1 lamellar tooth in each valve. *Rec.*, Japan.—FIG. D31,3. **P. (O.) loomisi* SIMPSON; 3*a-c*, LV ext., RV int., both valves dorsal, $\times 0.75$ (Haas).
- P. (Trigonodon)** CONRAD, 1865 [**Monocondylaea crebristriata* ANTHONY, 1863; OD]. Solid, compressed, rhomboid; disc irregularly and finely concentrically wrinkled; cardinals triangular, heavy, showing auxiliary tooth in each valve. *Plio.-Rec.*, SE. Asia (Burma)-Indon. (Java).—FIG. D31,5. **P. (T.) crebristriatus* (ANTHONY), *Rec.*; 5*a-c*, LV ext., RV int., both valves dorsal, $\times 0.75$ (Haas).
- Ptychorhynchoides** MODELL, 1931 [**P. gümbeli*; OD]. Small or medium-sized, elongate-ovate; beaks not prominent, their sculpture concentric with distinct angles posteriorly, less distinctly angulate anteriorly, central part mostly elevated; hinge imperfectly known, cardinals short, flat, lamellar teeth rather short; disc smooth except for folds crossing posterior slope. *U.Oligo.*, Eu.—FIG. D32,4. **P. gümbeli*; RV ext., $\times 1$ (629).
- Ptychorhynchus** SIMPSON, 1900 [**Unio pfisteri* HEUDE, 1874; OD]. Elongate elliptical, round in front, pointed behind, heavy, slightly inflated, with low posterior slope which is crossed by slightly curved, parallel folds above; beaks low, ornamented by zigzag wrinkles; cardinals low, more or less elongate, lamellar teeth moderately long, wide, commonly granulose; umbonal cavities shallow. *Rec.*, China.—FIG. D32,8. **P. pfisteri* (HEUDE); 8*a-c*, LV ext., RV int., LV int., $\times 0.75$ (Haas).
- Rectidens** SIMPSON, 1900 [**Unio prolongatus* DROUËT, 1893; OD]. Very elongate, inequilateral; beaks full, displaying sculpture of concentric undulating ridges; posterior slope distinct, almost carinate, posterior ridge mostly high, with fine, parallel folds; periostracum indistinctly rayed; cardinals thin, elongate. *Pleist.-Rec.*, SE.Asia.—FIG. D32,7. **R. prolongatus* (DROUËT), *Rec.*; 7*a-d*, LV ext., RV int., LV int., both valves dorsal, $\times 0.5$ (Haas).
- Rhabdotophorus** RUSSELL, 1935 [**R. gracilis*; OD]. Ovoid, elongate; beaks well in advance of mid-length, unornamented except by fine, curved costae on postumbonal slope which sweeps backward and upward, commonly interrupted by heavier growth lines; hinge plate narrow; 2 wedge-shaped cardinals on LV, 1 peglike tooth on RV; lamellar teeth slender and posteriorly placed, probably 2 on LV and 1 on RV; anterior adductor scar with dendritic pattern. *U.Cret.*, N.Am.—FIG. D32,1. **R. gracilis*; 1*a,b*, LV ext., RV int., $\times 1$ (Russell).
- Scabies** HAAS, 1911 [**Unio scobinatus* LEA, 1856; OD]. Elongate elliptical, V-shaped tuberculate ridges on most of shell; right posterior lamellar tooth with auxiliary tooth beneath posterior extremity. *Rec.*, E.Asia.—FIG. D32,6. **S. scobinata* (LEA); 6*a-c*, LV ext., RV int., both valves dorsal, $\times 1$ (after Haas).
- Shistodesmus** SIMPSON, 1900 [**Unio lampreyanus* BAIRD & ADAMS, 1867; OD] [= *Shistodesma* SIMPSON, 1900; *Schistodesmus* HAAS, 1914]. Heavy, triangular, inflated, beaks high; surface of disc marked by strong broad, concentric ridges; periostracum lustrous, greenish-yellow, commonly with discontinuous green rays; posterior ridge tending to be spinose, especially in young specimens; RV with high, triangular, vertically furrowed cardinal of LV narrow, posterior cardinal high, thick, situated under beak, upper lamellar tooth straight and low, lower tooth curved and high; fulcrum very strong and wide; umbonal cavities deep, compressed, right one opened by gap in the interdental interval. *Rec.*, China.—FIG. D32,10. **S. lampreyanus* (BAIRD & ADAMS); 10*a-d*, RV ext.,

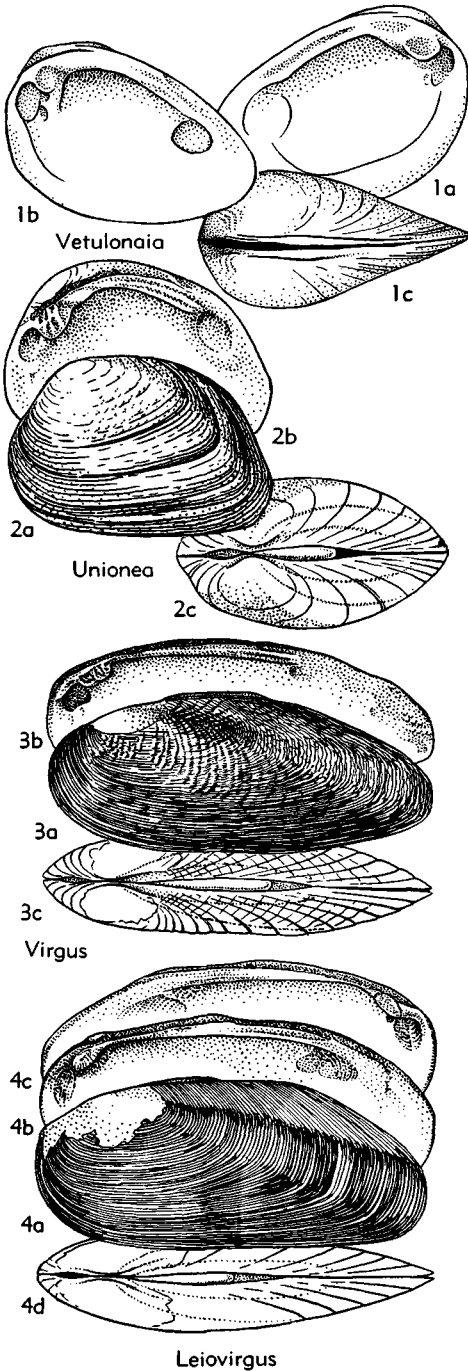


FIG. D33. Unionidae (Unioninae) (p. N435-N436).

LV int., RV int., both valves dorsal, $\times 1$ (Haas). **Solenia** CONRAD, 1869 [**Mycetopus emarginatus* LEA, 1860; OD]. Very elongate, soleniform, falcate, rather thin, narrower and rounded in front with upper anterior portion strongly sulcate, gaping at anterior base and behind, with strong posterior ridge which ends below posterior extremity; beaks low, sculptured by looped concentric ridges; periostracum rayless; dentition consists of vestiges of 1 or more lamellar teeth in each valve; pallial line with distinct posterior sinus. ?*Cret., Rec., China-SE.Asia.*—FIG. D32,2. **S. emarginata* (LEA), *Rec.*; 2a,b, RV ext., both valves dorsal, $\times 0.3$ (535).

Sulcatula LEROY, 1940 [**S. tungurensis*; OD]. Externally like *Shistodesmus*; general outline oblong, not pointed at the posterior extremity; cardinal tooth of RV strong, rounded below, bordered above by small socket and behind, close to lamellar tooth, by large one; lamellar tooth long and bevelled; cardinal of LV gently tapering posteriorly and joining long bifid lamellar tooth, limited anteriorly by rounded and thin cardinal. *U.Mio., China.*—FIG. D32,3. **S. tungurensis*; 3a,b, LV ext., int., $\times 0.75$ (539).

Trapezoideus SIMPSON, 1900 [**Unio foliaceus* GOULD, 1843; OD]. Trapezoid, compressed, with low posterior slope and low beaks which are concentrically sculptured by zigzag ridges; disc somewhat concentrically sulcate; hinge with elongate cardinals. *Rec., S.Asia-SE.Asia.*—FIG. D32,9. **T. foliaceus* (GOULD); 9a-c, LV ext., RV int., both valves dorsal, $\times 1$ (Haas).

Unio CONRAD, 1853 [**Unio tetralasmus* SAY, 1830; SD HAAS, herein (all of 8 species included by CONRAD in *Unio*, none designated as type species, are synonyms or varieties of *Unio tetralasmus* SAY)] [= *Unio* UTTERBACK, 1915 (*nom. null.*)]. Shell trapezoid, with almost parallel dorsal and ventral margins; beaks sculptured with 10 to 15 curved, rather strong concentric ridges sweeping upward posteriorly and drawing close together; hinge typical, teeth compressed. *Rec., N.Am.*—FIG. D32,5. **U. tetralasmus* (SAY); 5a-c, RV ext., LV int., both valves dorsal, $\times 0.5$ (Lea).

Unionea HAAS, 1955 [**Unio fabagina* DESHAYES & JULLIEN, 1874; OD] [= *Unionella* HAAS, 1913 (*non* ETHERIDGE, 1888)]. Small, ovate-rhomboidal, very short in front, obliquely truncate behind, solid, heavy; beaks prominent, inflated, bearing very pointed zigzag wrinkles which may extend over entire disc; posterior ridge distinct, prominent; cardinals low, triangular or compressed, lamellar teeth short, strong, straight, including strong auxiliary lamellar tooth under that of RV; interdental interval long, smooth, ascending posteriorly. *Rec., SE.Asia.*—FIG. D33,2. **U. fabagina* (DESHAYES & JULLIEN); 2a-c, LV ext., RV int., both valves dorsal, $\times 1$ (Haas).

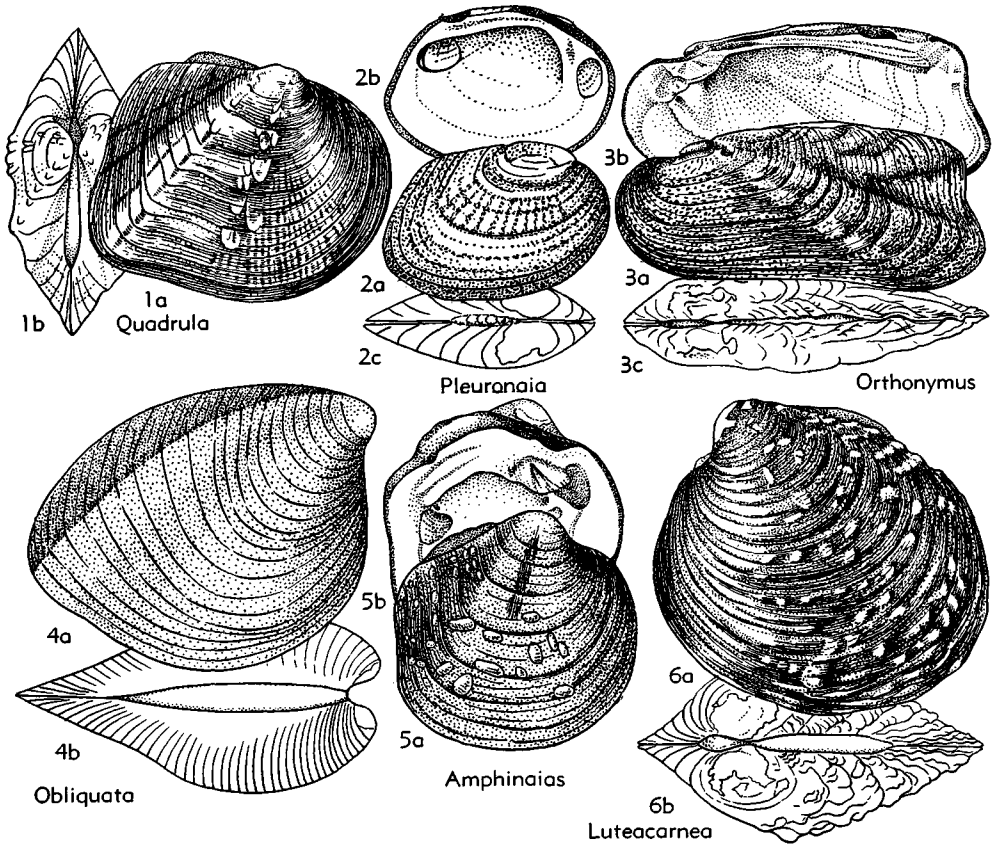


FIG. D34. Unionidae (Quadrulinae) (p. N436).

Vetuloniaia BRANSON, 1935 [**V. whitei*; OD] [= *Vetuloniaea* HOLT, 1942]. Beaks nearly terminal, LV with 2 lamellar teeth, cuneiform cardinal tooth above triangular socket; RV with single lamellar tooth below triangular socket; umbonal region marked by concentric wrinkles, ventral area posterior to beaks marked by radial undulations. ?*Jur.*, N.Am.—FIG. D33,1. **V. whitei*; 1a-c, LV int., RV int., both valves dorsal, $\times 0.7$ (79).

Virgus SIMPSON, 1900 [**Unio beccarianus* TAPPERONE CANEFRI, 1883; OD]. Rather solid, elongate, compressed, rounded in front, nearly straight below; posterior slope low, smooth or sculptured; cardinals small, solid, generally 2 in each valve; interdental interval long and narrow, lamellar teeth rather long, straight. *Rec.*, N.Guinea.

V. (Virgus). Solid, sculptured with parallel folds which begin at posterior ridge and branch out over posterior slope and adjacent region of disc. *Rec.*, N.Guinea.—FIG. D33,3. **V. (V.) beccarianus* (TAPPERONE CANEFRI); 3a-c, LV ext., RV int., both valves dorsal, $\times 0.7$ (Haas).

V. (Leiovirgus) HAAS, 1912 [**Unio misoolensis* SCHEPMAN, 1896; OD] [= *Nesonaia* HAAS, 1912]. Elongate, very short in front, long behind; beaks low, sculptured with radial folds; disc smooth. *Rec.*, N.Guinea (Misool I.).—FIG. D33,4. **V. (L.) misoolensis* (SCHEPMAN); 4a-d, LV ext., RV int., LV int., both valves dorsal, $\times 0.8$ (Haas).

Subfamily QUADRULINAE Haas, 1929

Shell mostly heavy, high, squarish to triangular; beaks full, ornamented with V- or W-shaped folds which commonly extend over entire disc, degenerating in some into rows of tubercles; hinge heavy, angular; shell shape commonly subject to sexual dimorphism. Marsupium occupying all four gills. *L.Cret.-Rec.*

Quadrula RAFINESQUE, 1820 [**Obliquaria quadrula* RAFINESQUE, 1820; SD HERRMANNSEN, 1847] [= *Theliderma* SWAINSON, 1840; *Telederma*

PAETEL, 1875]. Triangular, quadrangular or rhomboid, inflated; beaks rather prominent, sculptured generally with few coarse, irregular, subparallel ridges which form knobs or tubercles where they cross posterior ridge; disc smooth or sculptured; periostracum usually dull, rayless or only feebly rayed; hinge normal, hinge plate flat, wide; cardinals heavy, ragged, lamellar teeth rather short, lower auxiliary one in some RV's. *Pleist.-Rec.*, N.Am.

Q. (Quadrula). Rounded to rhomboid, solid, pustulose, equal in both sexes; beaks sculptured with few coarse, subparallel ridges; anterior end rounded or subtruncate, base commonly arcuate, posterior end truncate, high, angled above; beak cavities rather deep. *Pleist.-Rec.*, N.Am.—FIG. D34,1. **Q. (Q.) quadrula* (RAFINESQUE), *Rec.*; *1a,b*, RV ext., both valves dorsal, $\times 0.75$ (497).

Q. (Amphinaias) CROSSE & FISCHER, 1894 [**Unio couchianus* LEA, 1860; OD] [= *Bullata* FRIERSON, 1927 (non JOUSSEAUME, 1875); *Pustulosa* FRIERSON, 1927]. Round quadrate, truncate behind, full, angled back of ligament; beaks high with few coarse ridges swollen at posterior ridge; disc mostly pustulose, but may be smooth or corrugated; periostracum commonly with broad and faint green ray; hinge massive. *Rec.*, N.Am.—FIG. D34,5. **Q. (A.) couchianus* (LEA); *5a,b*, RV ext., LV int., $\times 0.7$ (497).

Q. (Lutecarnea) FRIERSON, 1927 [**Quadrula striata* RAFINESQUE, 1820; OD] [= *Striata* FRIERSON, 1927 (non O. BOETTGER, 1878)]. Oboval, thick inflated, concentrically ridged, ridges being pustulose in places. Soft parts yellow. *Rec.*, N.Am.—FIG. D34,6. **Q. (L.) striata* RAFINESQUE; *6a,b*, LV ext., both valves dorsal, $\times 0.7$ (497).

Q. (Obliquata) FRIERSON, 1927 [**Obliquaria (Scalenaria) obliquata* RAFINESQUE, 1820; OD] [= ?*Scalenaria* RAFINESQUE, 1820]. Subtriangular, rather inflated, heavy; beaks very anterior, high, full, turned forward over conspicuous lunule; truncate in front, more or less pointed behind; with radial depression behind and parallel to posterior ridge; hinge massive, cardinals radial; beak cavities deep, compressed. *Rec.*, N.Am.—FIG. D34,4. **Q. (O.) obliquata* (RAFINESQUE); *4a,b*, RV ext., both valves dorsal, $\times 0.7$ (497).

Q. (Orthonymus) L. AGASSIZ, 1852 [**Unio cylindricus* SAY, 1816; OD]. Quadrate rhomboid, with radial furrow on posterior slope; whole surface except anterior end generally pustulose, that of posterior slope commonly wrinkled; umbonal region high; periostracum lustrous, with pattern of triangular spots or chevron-shaped lines; hinge strong, in some with auxiliary 3rd lamellar tooth in RV; umbonal cavities deep, compressed, *Rec.*, N.Am.—FIG. D34,3. **Q. (O.) cylindrica*

(SAY); *3a-c*, LV ext., RV int., both valves dorsal, $\times 0.5$ (497).

Q. (Pleuronaia) FRIERSON, 1927 [**Unio barnesianus* LEA, 1838; OD]. Subtriangular to almost elliptical, solid; beaks high, full; posterior ridge strong; curved or subangular; cardinals small, including auxiliaries, also with auxiliary lamellar teeth; beak cavities shallow. *Rec.*, N.Am.—FIG. D34,2. **Q. (P.) barnesiana* (LEA); *2a-c*, RV ext., LV int., both valves dorsal, $\times 1$ (535).

Amblema RAFINESQUE, 1819 [**A. costata* RAFINESQUE, 1832; SD RAFINESQUE, 1832] [= *Bariosta* RAFINESQUE, 1832; *Crenodonta* SCHLUETER, 1838; *Baryosta* L. AGASSIZ, 1846]. Heavy, with prominent beaks; surface usually sculptured with oblique folds, posterior slope generally having smaller radial plications which curve up behind; periostracum brown to black. *L.Cret.-Rec.*, N.Am.-C.Am.

A. (Amblema). Rounded to subrhomboid; radial plications usually strong, oblique, though in some discs may be almost unornamented or slightly sculptured concentrically. *L.Cret.-Rec.*, N.Am.-C.Am.—FIG. D35,5. **A. (A.) plicata costata* RAFINESQUE, *Rec.*; *5a,b*, LV ext., both valves dorsal, $\times 0.5$ (497).

A. (Plectomerus) CONRAD, 1853 [**Unio dombeyana* VALENCIENNES, 1827; SD FRIERSON, 1927] [= ?*Gonambulus* RAFINESQUE, 1831]. Rhomboidal, inflated with high posterior ridge; beak sculpture coarse, irregular corrugations swollen to nodules on posterior ridge; disc sculptured on posterior half with oblique ridges, which may be corrugated, and with strong corrugations on posterior slope; beak cavities moderately deep, nacre purple. *Rec.*, N.Am.—FIG. D35,3. **A. (P.) dombeyana* (VALENCIENNES); *3a,b*, LV ext., both valves dorsal, $\times 0.7$ (497).

A. (Psorula) HAAS, 1930 [**Quadrula rudis* SIMPSON, 1900; OD]. Round to rounded quadrangular, ventricose to quite compressed; beaks prominent, with deep, commonly quite compressed cavities; umbonal sculpture of many crowded, wavy, concentric wrinkles gradually passing into concentric pustulose or granular sculpture of disc on which very conspicuous, cord-like zones of growth are visible; nacre white to violet. *Rec.*, C.Am.—FIG. D35,2. *A. (P.) salinarum* HAAS; *2a-c*, LV ext., RV int., LV int., $\times 0.4$ (Haas).

Cokeria MARSHALL, 1916 [**C. southalli*; OD]. Subquadrangular, rather thin, ventricose, gaping in front; rounded and narrow in front, perpendicularly truncate and high behind; beaks high, incurved, sculptured with 4 concentric ridges, which become elevated posteriorly; pronounced furrow extending from beak to lower 3rd of posterior margin; in RV with 2 thin cardinals and 1 thin high lamellar tooth; 2 lamellar teeth in LV. [Based

on a unique individual, hence doubtful; perhaps an abnormality of *Quadrula (Quadrula) undulata* (BARNES).] *Rec.*, N.Am.—FIG. D35,9. **C. southalli*; 9a,b, RV ext., int., $\times 0.75$ (580).

Costanaia MACNEIL, 1935 [**C. arciformis*; OD]. Subquadrate, much inflated, posterior margin perpendicularly truncated, nearly straight, ventral margin arcuate; beaks high, anterior, with fine

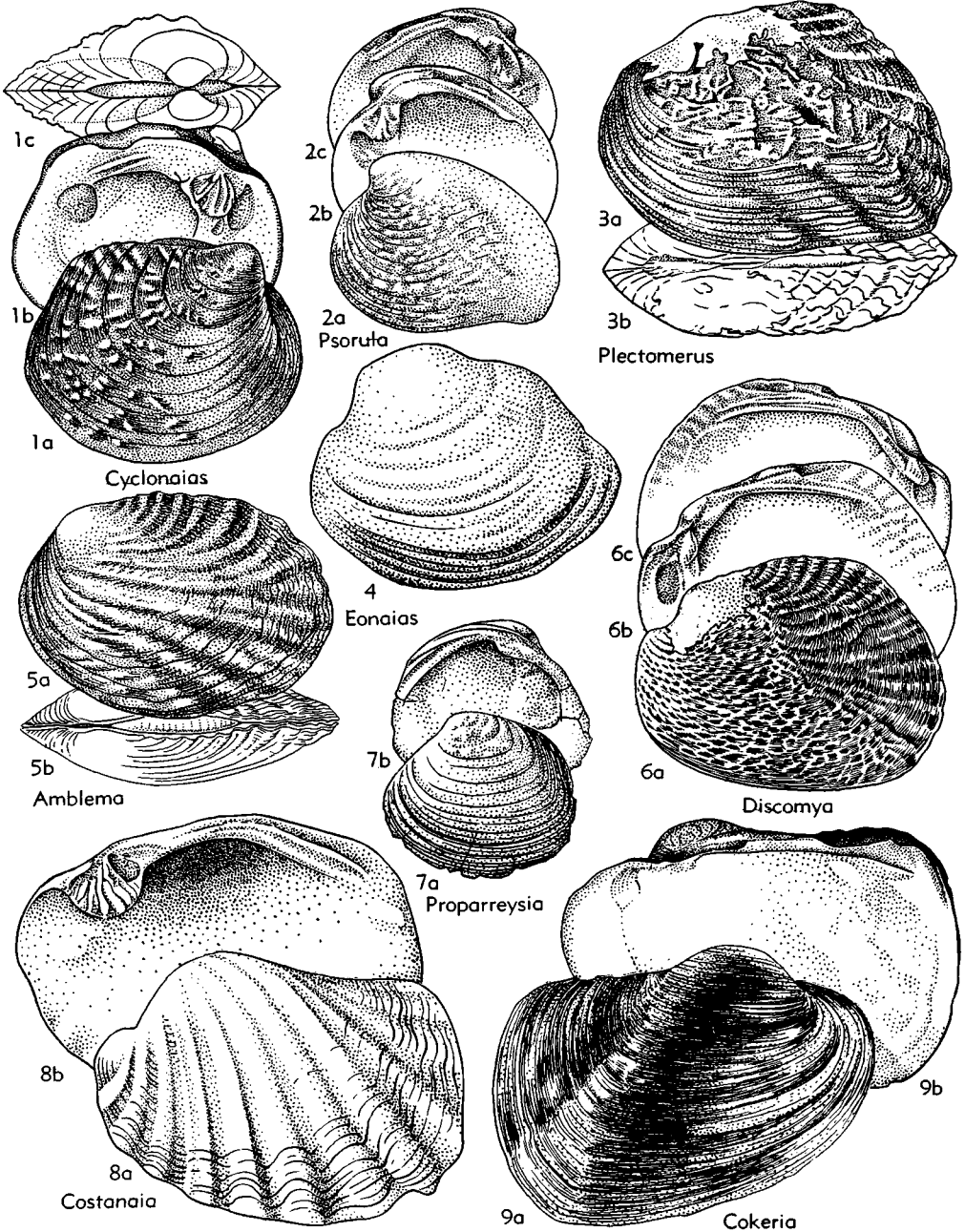


FIG. D35. Unionidae (Quadrulinae) (p. N437-N439, N441-N442).

concentric undulations, pointing down umbonal ridge as raised chevrons; surface sculptured with 12 to 15 radial ribs which intersect shell margin at deep crenulations; hinge margin long, arcuate; cardinals deeply furrowed, lamellar teeth short and feeble. *Mio.*, N.Am.—FIG. D35,8. **C. arciformis*; 8a,b, LV ext., RV int., $\times 0.75$ (568).

Cyclonaias PILSBRY, 1922 [**Obliquaria tuberculata* RAFINESQUE, 1820; OD] [=Rotundaria AGASSIZ, 1852 (non RAFINESQUE, 1820)]. Rounded or quadrate; beaks prominent, curved inward and forward over strongly marked lunule, their sculpture consisting of 20 to 30 fine, irregular, broken, somewhat concentric corrugations which gradually blend with regular sculpture; posterior 0.6 of shell tuberculate; beak cavities deep, compressed, nacre violet. *Pleist.-Rec.*, N.Am.—FIG. D35,1. **C. tuberculata* (RAFINESQUE), *Rec.*; 1a-c, RV ext., LV int., both valves dorsal, $\times 0.5$ (497).

Discomya SIMPSON, 1900 [**Unio radulosus* DROUËT & CHAPER, 1892; OD]. Round or rhomboidal, compressed, almost lens-shaped, heavy, short and narrowly rounded in front, wide and roundly truncate behind; beaks low, their sculpture unknown; posterior slope very low and compressed; shell sculpture covering entire disc, consisting on anterior half of 2 intersecting systems of elongated knobs which meet nearly at right angles to form meshwork, while on posterior half are cord-like folds which curve upward, some with bifurcation; massive hinge plate, cardinals short, heavy, lamellar teeth short, almost at right angles with cardinals from which they are separated by wide, smooth, ascending intercardinal interval; beak cavities deep, compressed. *Rec.*, W.Pac. (Borneo).—FIG. D35,6. **D. radulosa* (DROUËT & CHAPER); 6a-c, LV ext., RV int., LV int., $\times 0.75$ (Haas).

Eonaias MARSHALL, 1929 [**E. reynosenica*; OD]. Beaks with numerous V-shaped loops, which are nearly regularly spaced and nested into each other, V's pointing toward ventral margin; posterior areas with fine ribs running from posterior ridge to margin. *Plio.*, N.Am.—FIG. D35,4. **E. reynosenica*; LV ext., $\times 1$ (Marshall).

Fusconaias SIMPSON, 1900 [**Unio trigonus* LEA, 1831 (=subsp. of *U. undatus* BARNES, 1823); OD] [=?Lintonia RAFINESQUE, 1820; ?Lyntoxia L. AGASSIZ, 1846, *Fusconia* FRIERSON, 1927]. Rounded, elliptical, rhomboid, or triangular with beaks high and full, curved inward and forward, sculptured with few coarse, parallel ridges which curve upward behind; periostracum dark, disc not sculptured; hinge plate of moderate width, cardinals strong, nacre white, salmon or purple. *Pleist.-Rec.*, N.Am.-C.Am.—FIG. D36,2. **F. undata trigona* (LEA), *Rec.*; 2a-c, RV ext., LV int., both valves dorsal, $\times 0.4$ (497).

Lamprotula SIMPSON, 1900 [**Chama plumbea*

CHEMNITZ, 1795; OD] [=Gibbosula SIMPSON, 1900]. Rounded, subquadrangular, or triangular, heavy, inflated, with high beaks; beak with few coarse, concentric ridges which form double loops; disc generally covered with coarse nodules or knobs; periostracum gray to black, lustrous; hinge massive, all teeth vertically striated, lower auxiliary lamellar tooth in RV; cavity of beaks deep, compressed. *Oligo.-Rec.*, E.Asia-Japan.

L. (Lamprotula). Rounded or subquadrangular, with beaks near anterior end. *Oligo.-Rec.*, E.Asia-Japan.—FIG. D37,5. **L. (L.) plumbea* (CHEMNITZ); 5a,b, LV ext., int., $\times 0.5$ (497).

L. (Parunio) PING, 1931 [**Parunio crassus*; OD]. Rounded ovoid with anterior beaks, ventrally curved; surface commonly with ridges or rows of nodules parallel to growth lines; hinge massive, lamellar teeth above and parallel to cardinals. *Plio.-Rec.*, E.Asia.—FIG. D37,2. **L. (P.) crassa* (PING), *Plio.*; 2a,b, LV ext., int., $\times 0.5$ (738).

Loxopleurus MEEK, 1871 [**Unio bellicatus*; OD]. Subquadrangular, very inflated, with almost central high beaks; surface sculptured with about 6 broad, subparallel folds originating at or near beaks and corresponding to crenulations of the ventral and posterior margins. *U.Cret.*, N.Am.—FIG. D36,5. **L. bellicatus* (MEEK); LV ext., $\times 0.75$ (569).

Megalonaias UTTERBACK, 1915 [**Unio heros* SAY, 1829 (=U. giganteus BARNES, 1823); OD] [=Magnonaias UTTERBACK, 1915]. Large, heavy, subrhomboid, moderately inflated; posterior slope rather high ribbed with coarse, regular undulations originating in umbonal region; beaks low, sculptured with coarse double-looped corrugations which extend as nodules to posterior ridge and as zigzag ridges over umbonal region to upper portion of disc; periostracum black; cardinals heavy, lamellar teeth long and straight, extending near to cardinals. *Rec.*, N.Am.-C.Am.—FIG. D36,9. **M. gigantea* (BARNES), *Rec.*; LV ext., $\times 0.3$ (Conrad).

Megalonoidea MACNEIL, 1935 [**M. porcata*; OD]. Large, subquadrate, inflated; beak sculpture of semiconcentric, doubly looped undulations in youngest stage, but in adult of heavy diagonal posterior plications originating at anterior side of umbonal chevrons and smaller plications set at conspicuous angle with large ones; cardinals fairly heavy, lamellar teeth long and arcuate; ventral border of shell slightly scalloped by external ribs. *Mio.*, N.Am.—FIG. D37,1. **M. porcata*; RV ext., $\times 0.5$ (568).

Pliconaias MARSHALL, 1929 [**P. popenoi*; OD]. Subquadrate; beaks with wavy concentric undulations, each posteriorly completed by fine straight threadlike rib running across posterodorsal area

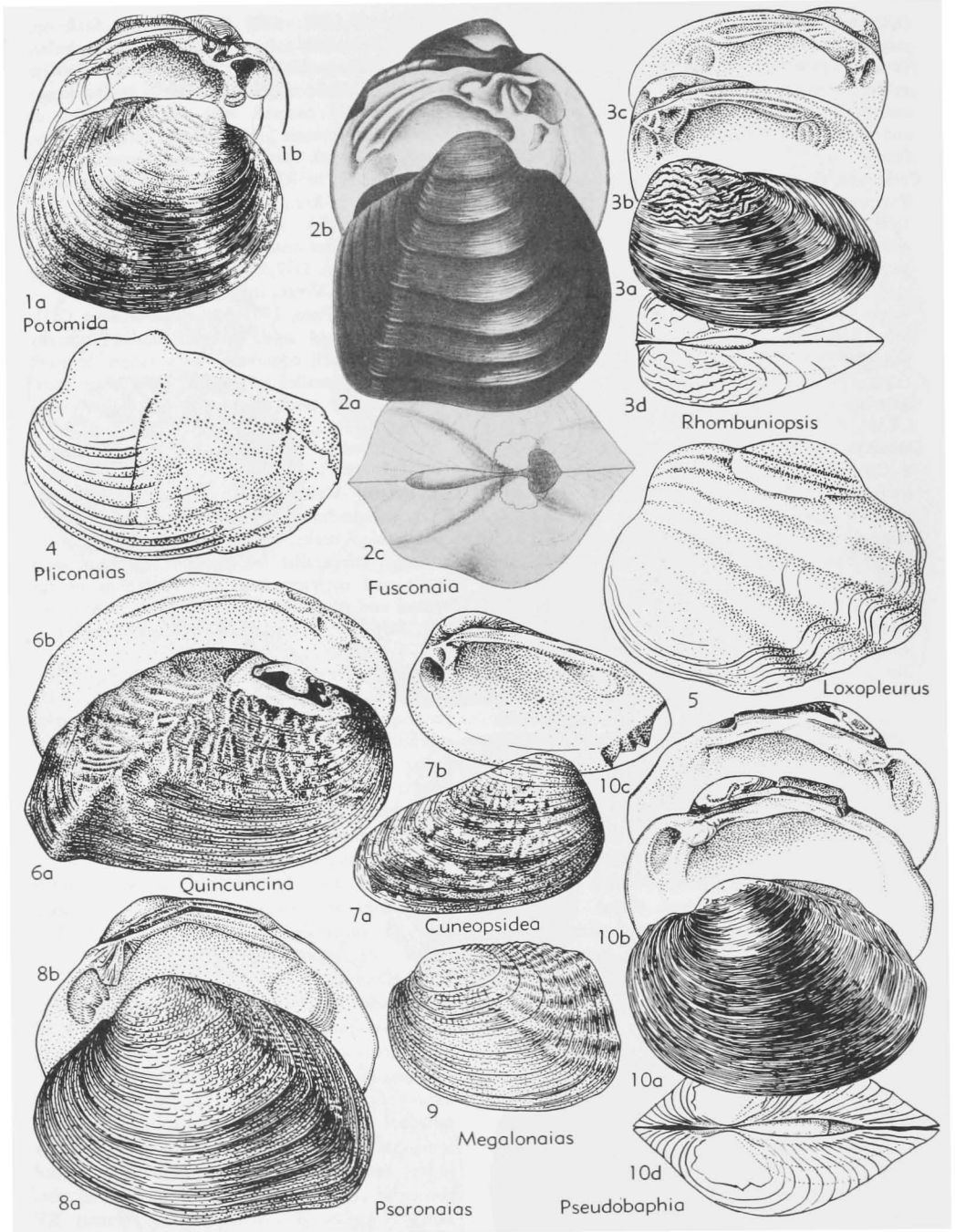


FIG. D36. Unionidae (Quadrulinae) (p. N439, N441-N442).

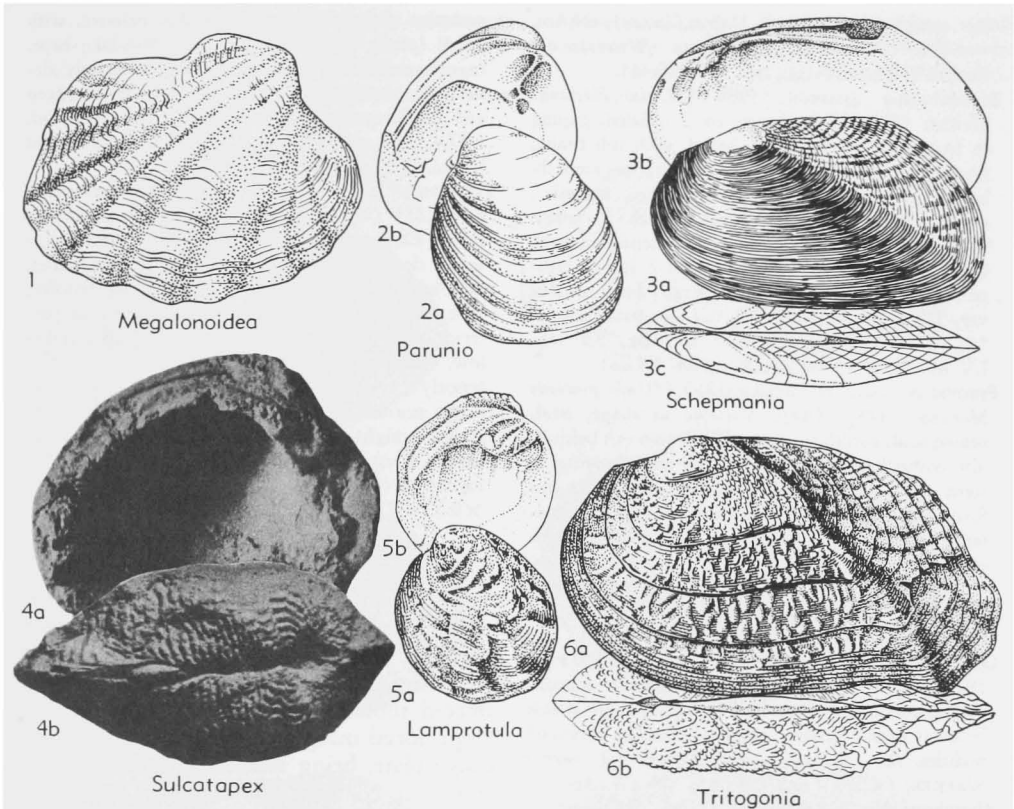


FIG. D37. Unionidae (Quadrulinae) (p. N439, N442).

toward beak; anteriorly undulations nearly fade out but are indistinctly completed by faint ribs curving toward beak; posterior portion of shell with several rude plications running obliquely across surface with pattern found in plicate North American naiads. *Plio.*, N.Am.—FIG. D36,4. **P. popenoi*; LV ext., $\times 0.7$ (584).

Potomida SWAINSON, 1840 [**Unio corrugata* (= **Unio semirugatus* LAMARCK, 1819); OD] [= *Potamida* L. AGASSIZ, 1846; *Psilunio*, *Rytia* STEFANESCU, 1896; *Sabbaia* COSSMANN, 1897; *Rhombunio* GERMAIN, 1911; *Migranaia* HANNIBAL, 1912]. Rounded rhomboid, moderately heavy, subinflated, round and short in front, wide and roundly truncate behind; beaks high, full with numerous, fine subparallel wavy ridges which may extend well over disc as rows of knobs or nodules; cardinals moderately massive, lamellar teeth commonly curved slightly; beak cavity rather deep. [Under lacustrine conditions (e.g., Hungarian and Rumanian *Pliocene*) the shells are more elongate wedge-shaped and the beaks anterior; the cardinals and lamellar teeth may be parallel to each other, strongly remindful of American and of

East Asiatic quadruline.] *Oligo.* (*John Day*)-*Rec.*, Eu.-?E.Asia.

P. (Potomida). Rounded, narrow in front, wide behind; beaks submedian, covered by numerous subparallel wavy ridges, mostly not extending to disc; hinge moderately heavy. *Oligo.* (*John Day*)-*Rec.*, Eu.-?E.Asia.—FIG. D36,1. **P. (P.) littoralis semirugata* (LAMARCK), *Rec.*, Eu.; 1a,b, RV ext., LV int., $\times 1$ (Ellis).

P. (Cuncopsidea) WENZ, 1928 [*pro Iridea* STEFANESCU, 1896 (*non* SWAINSON, 1840)] [**Unio sculptus* BRUSINA, 1874; OD]. Elongate to wedge-shaped, beaks placed well forward, anterior end steeply descending; sculpture of subparallel wavy ridges and on greater portion of disc, of knobs and nodules; hinge massive, cardinals and lamellar teeth parallel. *Pleist.*, E.Eu.—FIG. D36,7. **P. (C.) sculpta* (BRUSINA); 7a,b, RV ext., int., $\times 0.5$ (967).

Proparresya PILSBRY, 1921 [**Unio percorrugata* WHITFIELD, 1903; OD]. Small, quadrate; surface in younger specimens with very strong corrugation extending over half of disc, front half of shell unsculptured; hinge strong, cardinals high, lamel-

- lar teeth strongly bent. *U.Cret.(Lance)*, N.Am.—FIG. D35,7. **P. percorrugata* (WHITFIELD); 7a,b, RV ext., LV int., $\times 1$ (Whitfield).
- Pseudobaphia** SIMPSON, 1900 [**Unio biesianus* HEUDE, 1877; OD]. Large, oval, inflated, gaping in front and behind, rather heavy, with full beaks; posterior extremity biangular; periostracum smooth, brownish, rayed; cardinal of RV large, irregular, situated behind pit and in front of beak; 2 remote lamellar teeth, poorly defined, interdental interval with numerous denticles; LV with 2 large cardinals and 2 remote, indistinct laterals; beak cavities very large and deep. *Rec.*, E.Asia.—FIG. D36,10. **P. biesiana* (HEUDE); 10a-d, LV ext., RV int., LV int., both valves dorsal, $\times 0.5$ (Haas).
- Psononias** CROSSE & FISCHER, 1893 [**Unio psonicus* MORELET, 1851; OD]. Variable in shape, oval, subtriangular, cordiform, or rather drawn out behind; disc covered with small tubercles and showing in some folds posteriorly; cardinal of RV thick and furrowed, behind thin, compressed auxiliary; lamellar teeth rather short, forming obtuse angle with cardinals and separated from them by narrow, straight interdental interval. *Rec.*, C.Am.—FIG. D36,8. **P. psonica* (MORELET); 8a,b, LV ext., RV int., $\times 0.6$ (306).
- Quincuncina** ORTMANN, 1922 [**Q. burkei* WALKER, 1922; OD]. Sculptured, beak sculpture subconcentric and followed on disc by zigzag ridge which becomes locally broken into quincuncially arranged nodules. *Rec.*, N.Am.—FIG. D36,6. **Q. burkei* WALKER; 6a,b, RV ext., LV int., $\times 1$ (Walker).
- Rhombuniopsis** HAAS, 1920 [**Unio (Cuneopsis) tauriformis* FULTON, 1906; OD]. Oval to subtriangular, heavy; beaks nearly anterior, inflated, their sculpture consisting of undulate folds; beak cavities deep; hinge consisting of heavy, low cardinals and short, strong lamellar teeth with distinct angle between these elements. *Pleist.-Rec.*, E.Asia.—FIG. D36,3. **R. tauriformis* (FULTON), *Rec.*; 3a-d, LV ext., RV int., LV int., both valves dorsal, $\times 1$ (Haas).
- Schepmania** HAAS, 1912 [**Unio nieuwenhuisi* SCHEPMAN, 1892; OD]. Elongate, rounded in front and behind, rather high and heavy, beaks not prominent; posterior slope crossed by parallel folds originating at posterior ridge and curving up toward dorsal margin; hinge normal for family, cardinals low and stout, lamellar teeth low and short; interdental interval long and smooth. *Rec.*, W.Pac.(Borneo).—FIG. D37,3. **S. nieuwenhuisi* (SCHEPMAN); 3a-c, LV ext., RV int., both valves dorsal, $\times 0.75$ (Haas).
- Sulcatapex** YEN, 1945 [**S. cretaceus*; OD]. Trapezoidal to subtriangular in outline, inflated, heavy, with prominent umbones and strong ligament trace; beaks near anterior end, slightly incurved and sculptured with broad, radiating wrinkles together with coarse, subregularly concentric ridges; posterior slope well marked; hinge massive, with broad plate; cardinals of subrhomboidal shape, ragged and heavy; lamellar teeth moderately developed, more or less impressed; muscle scar deep and of irregular shape. *L.Cret.*, N.Am.—FIG. D37,4. **S. cretaceus*; 4a,b, LV int., both valves dorsal, $\times 1$ (1011).
- Tritogonia** L. AGASSIZ, 1852 [**Unio verrucosus* SAY, 1834 (= **Unio tuberculatus* BARNES, 1823); OD]. Elongate rhomboid, heavy with strong posterior slope, obliquely truncated behind in males, somewhat compressed and rounded in females; base incurved, whole disc of female, except posterior wing, covered with pustules; beaks rather low, bearing irregular, subparallel ridges posteriorly curved upward; periostracum dark olive; hinge normal, hinge plate narrow, lamellar teeth long, straight, near cardinals; cavity of beaks rather deep. *Rec.*, N.Am.—FIG. D37,6. **T. verrucosa* (SAY); 6a,b, LV ext., both valves dorsal, $\times 0.5$ (497).

Subfamily ANODONTINAE Ortmann, 1910

Shell thin to medium thick, of variable shape; hinge either toothless or with short posterior lamellar elements which cannot be homologized with those of previously treated subfamilies since they arise directly from dorsal margin of shell and not from a hinge plate, being sometimes termed "claustra," in contrast to "lamellar teeth" or "laterals." Beak sculpture consists of concentric, wavy ridges. Marsupium pad-shaped, occupying entire outer gills; fully developed glochidia kept within marsupium over winter; a special device for oxygen supply of glochidia within the gills has been developed, the so-called lateral (or Ortmann's) water tubes. *U.Cret.-Rec.*

Anodonta LAMARCK, 1799 [**Mytilus cygneus* LINNÉ, 1758, *nom. conserv.*] [= *Glochidium* RATHKE, 1797; *Anodontigenus* RENIER, 1807; *Cista* HUEBNER, 1810; *Anodon* OKEN, 1815; *Anodontes* CUVIER, 1817; *Edentula*, *Lipodonta* NITZSCH, 1820; *Anodonte* FISCHER VON WALDHEIM, 1823; *Onodon* PARTINGTON, 1836-37; *Anodontina* SCHLUETER, 1853; *Collopterum* BOURGUIGNAT, 1881; *Pteranodon* L. FISCHER, 1886; *Euanodonta* WESTERLUND, 1890; *Nayadina* DE GREGORIO, 1914; *Anodota* PETRBOK, 1930; *Collopterum* BÉDÉ, 1932; *Euphrata* PALLARY, 1933]. Irregularly elliptical, thin, flattened to inflated, uncommonly winged slightly behind; beak sculpture consisting of parallel ridges, usually doubly looped, becoming slightly nodulose on loops; surface smooth, periostracum lustrous; hinge reduced to thin margins of shell, curved, but some in lacustrine habitats

with traces of claustra; accompanied by symphyoty of posterior wing (*Colletopterum* phase). *U.Cret.-Rec.*, worldwide in northern hemisphere.
A. (Anodonta). Beak subcentral, moderately strong

posterior ridge and dorsal wing, surface smooth except for growth lines. *U.Cret.-Rec.*, holarctic.
 —FIG. D38.3. **A. (A.) cygnea* (LINNÉ), *Rec.*; LV ext., $\times 0.25$ (497).

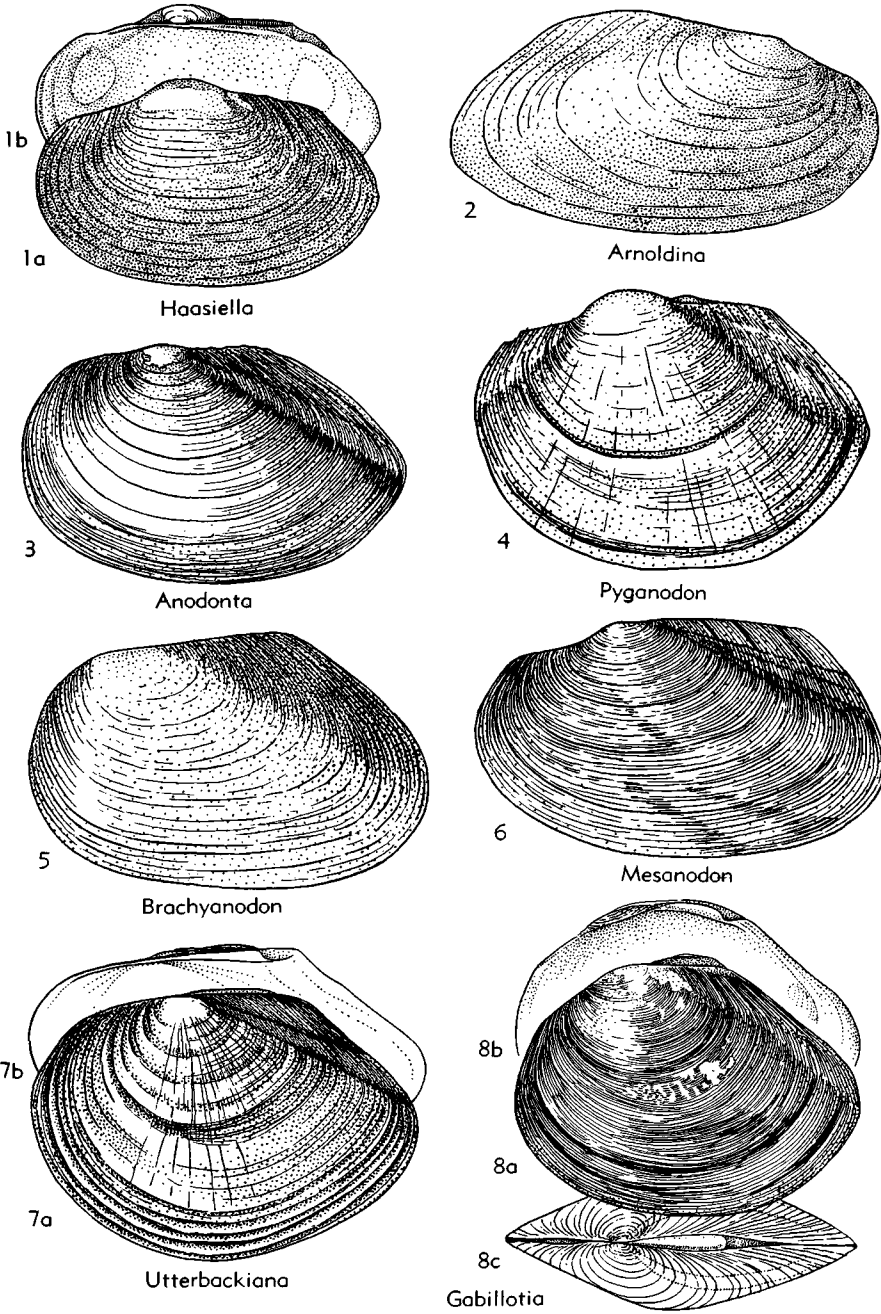


FIG. D38. Unionidae (Anodontinae) (p. N442-N444).

A. (Arnoldina) HANNIBAL, 1912 [**A. dejecta* LEWIS, 1875; OD]. Elongate-elliptical, broader behind; beaks not prominent, their sculpture consisting of numerous irregular ridges which tend to become doubly looped and nodulose. *Pleist.-Rec.*, USA (Calif.).—FIG. D38,2. **A. (A.) dejecta* LEWIS, Pleist.; RV ext., $\times 0.7$ (386).

A. (Brachyanodon) CROSSE & FISCHER, 1893 [**A. chapalensis* CROSSE & FISCHER, 1892 (= **A. coarctata* ANTON, 1839); SD THIELE, 1934]. Short, beaks anteriorly situated, not prominent, dorsal margin ascending behind beaks. *Rec.*, C.Am.—FIG. D38,5. **A. (B.) coarctata* ANTON; LV ext., $\times 1$ (497).

A. (Gabilotia) SERVAIN, 1890 [**A. pseudodopsis* LOCARD, 1883; SD SIMPSON, 1900]. Large, moderately thick, slightly compressed, subrhomboid, gaping behind; beaks low, with fine, broken, concentric sculpture; hinge line very short, edentulous, invaded by periostracum. *L.Plio.(U. Maecot.)-Rec.*, SE. Eu.-SW. Asia (Syria).—FIG. D38,8. **A. (G.) pseudodopsis* LOCARD, Rec.; 8a-c, LV ext., RV int., both valves dorsal, $\times 0.4$ (481).

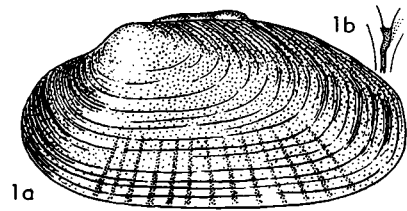
A. (Haasiella) LINDHOLM, 1925 [**A. arcaeformis* HEUDE, 1877; OD]. Very inflated, with beaks almost central. Glochidium without hook or filament. *Rec.*, E.Asia.—FIG. D38,1. **A. (H.) arcaeformis* HEUDE; 1a,b, LV ext., RV int., $\times 0.5$ (405).

A. (Liouvillea) BÉDÉ, 1932 [**A. pallaryi*; OD]. Hinge with feeble "cardinals" and 2 claustra in RV, and with single claustrum in LV [Doubtful subgenus; good figure unavailable.] *Rec.*, N.Afr.

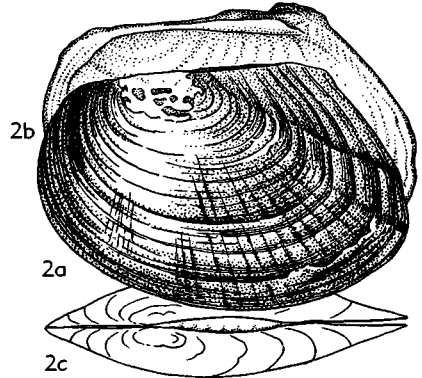
A. (Mesanodon) CROSSE & FISCHER, 1893 [**A. lurulenta* MORELET, 1849; SD THIELE, 1934]. Subrhomboid or ovoid, thin, inflated, with well-developed low dorsal wing; beaks low, sharp, their sculpture unknown; periostracum green or olive. *Rec.*, C.Am.—FIG. D38,6. **A. (M.) lurulenta* MORELET; LV ext., $\times 1$ (306).

A. (Pyganodon) CROSSE & FISCHER, 1893 [**A. globosa* LEA, 1841; SD FRIERSON, 1927]. Large, oval, thin, inflated; beaks submedian, full and rather high, with looped and nodulose sculpture; periostracum lustrous bluish-green. *Rec.*, C.Am.—FIG. D38,4. **A. (P.) globosa* LEA; LV ext., $\times 0.4$ (306).

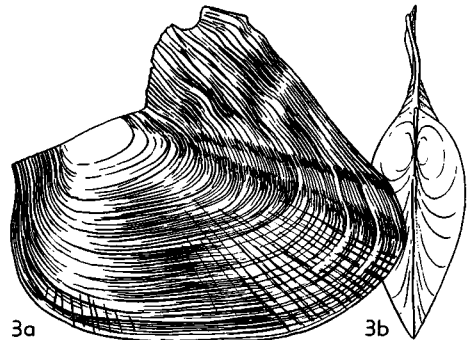
A. (Utterbackiana) FRIERSON, 1927 [**A. suborbiculata* SAY, 1831; OD] [= *Utterbachia*, *Utterbachia*, F. C. BAKER, 1927]. Large compressed, suborbicular, somewhat produced near middle of base, rounded in front, bluntly pointed behind; beaks flattened, bearing few irregular ridges, generally broken into nodules, or only corrugated; posterior ridge distinct; disc smooth, periostracum delicately rayed near beaks. *Rec.*, N.Am.—FIG. D38,7. **A. (U.) suborbiculata* SAY; 7a,b, LV ext., RV int., $\times 0.3$ (140).



Anodontoides



Pletholophus



Cristaria

FIG. D39. Unionidae (Anodontinae) (p N444-N446).

Anodontoides SIMPSON, 1898 [pro *Anodontopsis* SIMPSON, 1898 (non M'Coy, 1851)] [**Anodonta ferussaciana* LEA, 1834; OD]. Elliptical, inflated, thin, some constricted at center of base; beaks rather full, with few coarse, subparallel, concentric ridges, curved up abruptly toward rear, superimposed on fine radiating ridges; periostracum smooth, shining, commonly rayed; hinge line slightly curved in front of beaks, edentulous or with rudimentary claustra. *Pleist.-Rec.*, N.Am.—FIG. D39,1. **A. ferussacianus* (LEA), Rec.; 1a,b, LV ext., hinges, $\times 0.75$ (497).

Cristaria SCHUMACHER, 1817 [pro *Dipsas* LEACH,

1814 (non LAURENTI, 1768)] [**Dipsas plicatus* LEACH, 1815; OD] [=*Barbala* Museum Callonianum, 1797, *nom. nud.*; *Appius* MENKE, 1830; *Dianisotis* RAFINESQUE, 1831; *Dipsada* CUVIER,

1834; *Dipsax* VOIGT, 1834; *Dipsus* GRAY, 1835; *Dionisotis* FÉRUSSAC, 1835; *Barbata* SOWERBY, 1839; ?*Craspedodonta* KUESTER, 1842; *Cleone* GISTEL, 1848; *Dypsas* KOBELT, 1880; *Crassitesta*,

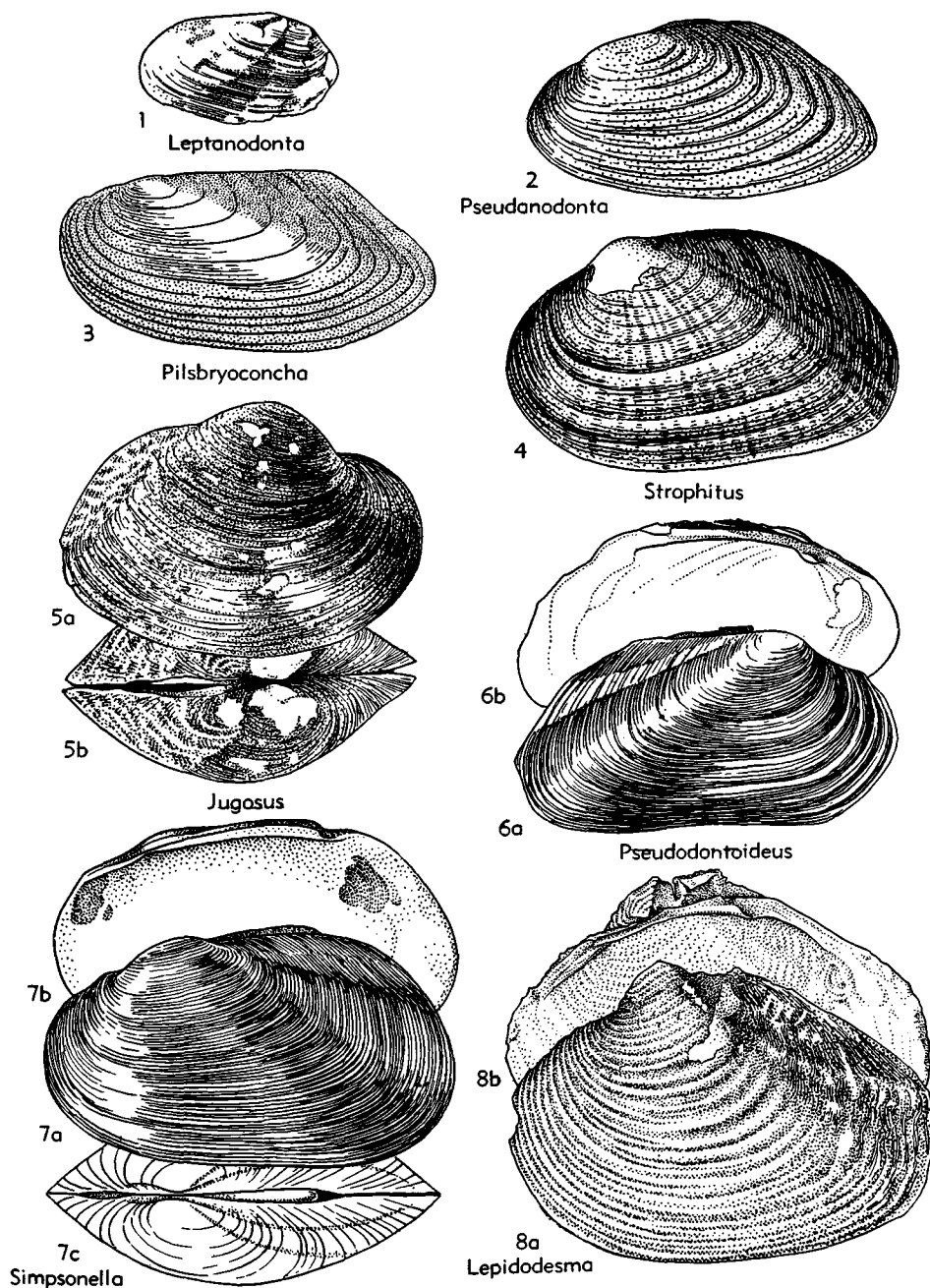


FIG. D40. Unionidae (Anodontinae) (p. N446).

Clione SIMPSON, 1900]. Mostly thin, elliptical, winged posteriorly and symphyntote; beaks rather low, sculptured with fine, somewhat doubly looped ridges at first, and later with coarse, low concentric ridges, nearly parallel with growth lines; periostracum smooth, commonly rayed; hinge with anterior claustrum wanting or vestigial and with elongate remote posterior claustrum in each valve. *Tert.*(*Mieken Ser.*)-*Rec.*, E.Asia-Japan.

C. (Cristaria). Large, thin, thicker in front, strongly winged posteriorly, with 2 rows of plications on posterior slope. *Tert.*-*Rec.*, E.Asia-Japan.—FIG. D39,3. *C. (*C.*) *plicata* (LEACH), *Rec.*; *3a,b*, LV ext., both valves dorsal, $\times 0.3$ (140).

C. (Pletholophus) SIMPSON, 1900 [**Symphynota discoidea* LEA, 1834; OD]. Short, elliptical, lenticular, with compressed beaks sculptured with low, wide, concentric ridges; weakly winged, pointed posteriorly; claustra very weak or wanting. *Rec.*, E.Asia-SE.Asia.—FIG. D39,2. *C. (*P.*) *discoidea* (LEA); *3a-c*, LV ext., RV int., both valves dorsal, $\times 1$ (497).

Lepidodesma SIMPSON, 1900 [**Unio languilata* HEUDE, 1874; OD]. Large, thin, inflated, with 2 high and sharp posterior ridges; beaks very high and full, with sculpture of cordlike ridges following growth lines and extending over whole shell; with row of radiating nodules on middle of disc and another stronger one on posterior ridge; ligament very large, covered with concentric scales; 2 anterior claustra in LV; 1st elongate, and with 2 long, posterior claustra, higher having edge reflexed upward; an anterior and posterior claustrum in RV; periostracum scaly, folded into hinge. *U.Plio.*-*Rec.*, E.Asia.—FIG. D40,8. **L. languilatum* (HEUDE), *Rec.*; *8a,b*, LV ext., RV int., $\times 0.4$ (405).

Leptanodonta WENZ, 1927 [**Dreissenomya unionides* WENZ, 1927 (non FUCHS, 1870) (= **Leptanodonta rumana* WENZ, 1941); OD]. Small, thin, rounded trapezoidal, compressed with small, low beaks; dorsal margin straight, sloping anteriorly, anterior margin subangular, ventral and dorsal margins straight, almost parallel, posterior margin somewhat produced; hinge edentulous. *L.Plio.* (*U.Maeot.*), Eu.(Rumania).—FIG. D40,1. **L. rumana*; WENZ; RV ext., $\times 1$ (966).

Pilsbryconcha SIMPSON, 1900 [**Unio exilis* LEA, 1839; OD]. Elongate, elliptical, thin, compressed, with low posterior wing, narrow and rounded in front, pointed behind, with almost parallel dorsal and ventral margins, latter expanded posteriorly; beaks low, compressed, sculptured with coarse, irregularly concentric and doubly looped undulations; periostracum smooth, yellowish to brown, faintly rayed in some; hinge edentulous, but commonly with vestiges of faint, compressed claustrum in front of beaks. *Rec.*, SE.Asia-Indon.—FIG. D40,3. **P. exilis* (LEA); LV ext., $\times 0.6$ (Haas).

Pseudanodonta BOURGUIGNAT, 1877 [**Anodonta complanata* ROSSMAESSLER, 1835; SD WESTERLUND, 1902] [= *Pseudoanodonta* PICAGLIA, 1893; *Pseuanodonta* KENNARD & WOODWARD, 1926]. Elongate, compressed, thin, short and rounded in front, long and bluntly pointed behind, with ventral margin gently curved, expanded posteriorly, and dorsal margin almost straight, ascending posteriorly; incipient posterior wing; beaks low, sculptured with 3 to 5 tuberculate ridges; surface smooth, green, hinge edentulous. *Rec.*, Eu.—FIG. D40,2. **P. complanata* (ROSSMAESSLER); LV ext., $\times 0.7$ (798).

Simpsonella COCKERELL, 1903 [*pro Daliella* SIMPSON, 1900 (non COSSMANN, 1895)] [**Anodonta purpurea* VALENCIENNES, 1833; OD]. Subtrapezoidal, thin, inflated, with low posterior slope and full beaks bearing sculpture of zigzag ridges which develop into angular protracted ridges on posterior slope; surface smooth; hinge generally toothless, but in some with single vestigial cardinal and equally vestigial, short, low, thin claustrum in each valve; beak cavities moderately deep. *Rec.*, Philip.—FIG. D40,7. **S. purpurea* (VALENCIENNES); *7a-c*, LV ext., RV int., both valves dorsal, $\times 1$ (Haas).

Strophitus RAFINESQUE, 1820 [**Anodonta undulata* SAY, 1816; OD] [= *Strophites* DESHAYES, 1832; *Strophilus* GRAY, 1847; *Strophites* DESMAREST, 1859]. Elliptical to rhomboid, inflated, moderately heavy, pointed or biangular behind, with low posterior slope; beaks full, sculpture consisting of few strong, concentric ridges, which curve sharply upward behind; surface smooth or plicate on posterior slope; periostracum lustrous, rayed in some; hinge line incurved in front of beaks, hinge nearly edentulous except for vestigial compressed anterior claustrum in each valve; posterior claustra rarely present. *Rec.*, N.Am.

S. (Strophitus). Smooth. *Rec.*, N.Am.—FIG. D40,4. **S. (S.) undulatus* (SAY); LV ext., $\times 1$ (Sowerby).

S. (Jugosus) SIMPSON, 1914 [**S. wrightianus* WALKER, 1901; OD]. Dorsal slope strongly plicate subradially; claustra unusually strong. *Rec.*, N.Am.—FIG. D40,5. **S. (J.) wrightianus* WALKER; *5a,b*, RV ext., both valves dorsal, $\times 0.9$ (Walker).

S. (Pseudodontoides) FRIERSON, 1927 [**Margaritana alabamensis* LEA, 1861; OD] [= *Pseudodontoides* THIELE, 1934]. Beak sculpture consisting of few strong ridges parallel with growth lines; general surface with irregular, concentric sculpture; anterior claustra feeble, low, smooth; posterior claustra obsolescent or absent. *Rec.*, N.Am.—FIG. D40,6. **S. (P.) alabamensis* (LEA); *6a,b*, RV ext., LV int., $\times 0.5$ (140).

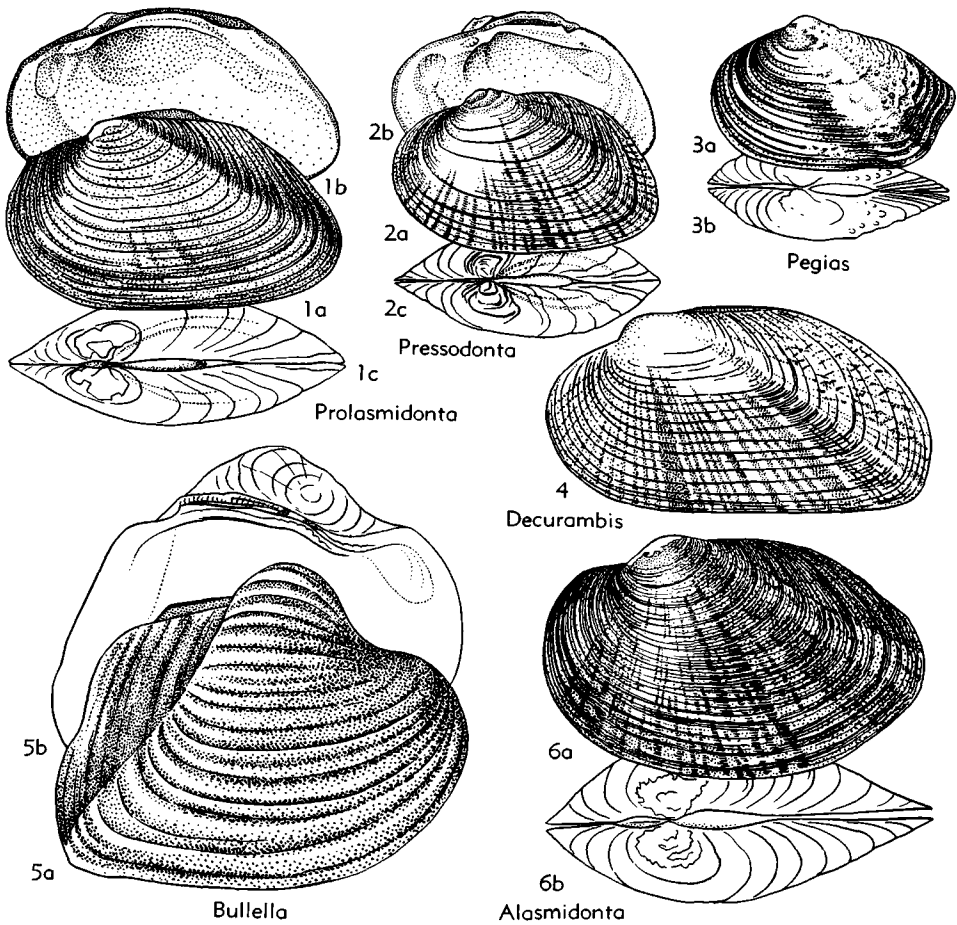


FIG. D41. Unionidae (Alasmidontinae) (p N447-N448).

Subfamily ALASMIDONTINAE Frierson, 1927

Oval to subrhomboid, compressed to inflated, thin to thick, with low to high posterior slope; beaks with tuberculate double-looped sculpture of strong ridges; disc smooth or with radiating tubercles originating at beaks; hinge incomplete, with anterior obsolescent posterior claustra. Marsupium filling entire outer gills. *U.Oligo-Rec.*

Alasmodonta SAY, 1818 [*pro Monodonta* SAY, 1816 (non LAMARCK, 1801)] [**Monodonta undulata* SAY, 1816; OD] [= *Alasmodonta* SAY, 1819; *Alasmodon* THOMSON, 1820; *Alasmodonta* DE BLAINVILLE, 1825; *Ambblasmodon* RAFINESQUE, 1831; ?*Anadontina* SCHLUETER, 1838; *Uniopsis*, *Hemidon*, *Hemidon* SWAINSON, 1840; *Anelasma-*

don L. AGASSIZ, 1846; *Anelasmadonta* HERRMANNSEN, 1846; *Alasmesodonta* GRAY, 1847; *Alasmodonta* GRAY, 1847; *Unionopsis* MEEK, 1876]. Ovate-rhomboid, solid, inflated, with high posterior slope, beaks high, full, with strong, concentric or double-looped sculpture; periostracum lustrous, rayed; 2 anterior claustra in LV and 1 in RV, posterior claustra wanting or imperfect; cavity of beaks deep. *Pleist.-Rec.*, N.Am.

A. (Alasmidonta). Ovate-rhomboid, heavy, inflated, shining, with very strong, generally concentric beak sculpture; anterior claustra solid, low, somewhat radially ridged, posterior claustra short, imperfect or wanting; beak cavities deep, compressed. *Pleist.-Rec.*, N.Am.—FIG. D41,6.

***A. (A.) undulata** (SAY), *Rec.*; 6a,b, LV ext., both valves dorsal, $\times 0.8$ (Haas, n).

A. (Bullella) SIMPSON, 1900 [**Margarita (Margaritana) arcua* LEA, 1836; OD]. Thin, greatly

- inflated, somewhat triangular, with high, sharp posterior slope; beaks very full, with very strong concentric sculpture, extending well on to disc; anterior claustra reflexed, compressed. *Rec.*, N. Am.—FIG. D41,5. **A. (B.) arcuata* (LEA); 5a,b, RV ext., LV int., $\times 1$ (140).
- A. (Decurambis)** RAFINESQUE, 1831 [**Alasmodonta scriptum* RAFINESQUE, 1831 (= **Alasmodonta marginata* SAY, 1818); OD] [= *Decurambis* PAETEL, 1875; *Rugifera* SIMPSON, 1900]. Elongate rhomboid, inflated, surface with brilliant rays which commonly break into a dappled or splashed color pattern; posterior slope slightly corrugated; hinge imperfect, posterior claustra wanting. *Rec.*, N. Am.—FIG. D41,4. **A. (D.) marginata* SAY; LV ext., $\times 0.8$ (343).
- A. (Pegias)** SIMPSON, 1900 [**Margarita (Margaritana) fabula* LEA, 1836; OD] [= *Pegias* ORTMANN, 1921]. Irregularly subovate, with posterior end greatly elevated above base line, and obliquely truncated below; posterior ridge present; shells of females with posterior ridge better developed and posterobasal truncation more oblique; anterior claustra rather heavy, posterior claustra lacking. *Rec.*, N. Am.—FIG. D41,3. **A. (P.) fabula* (LEA); 3a,b, LV ext., both valves dorsal, $\times 1$ (497).
- A. (Pressodonta)** SIMPSON, 1900 [*pro Calceola* SWAINSON, 1840 (*non* LAMARCK, 1799)] [**Unio calceolus* LEA, 1830; OD]. Rhomboid, with posterior slope low and rounded; periostracum generally with unbroken rays; beak sculpture slightly corrugated; teeth compressed. *Rec.*, N. Am.—FIG. D41,2. **A. (P.) calceola* (LEA); 2a-c, LV ext., RV int., both valves dorsal, $\times 1$ (Walker).
- A. (Prolasmodonta)** ORTMANN, 1914 [**Unio heterodon* LEA, 1830; OD]. Posterior claustra in reversed position, 2 in RV and 1 in LV; beak sculpture moderately heavy, ridges forming angle on posterior ridge, and slight sinus in front of it; shells of females slightly swollen in region of posterior ridge. *Rec.*, N. Am.—FIG. D41,1. **A. (P.) heterodon* (LEA); 1a-c, LV ext., RV int., both valves dorsal, $\times 1$ (497).
- Arcidens** SIMPSON, 1900 [**Alasmodonta confragosa* SAY, 1829; OD]. Moderately thick, inflated, subrhomboidal, with high, full beaks with strong sculpture of irregular corrugations which fall into 2 loops, ridges at base swollen into knobs that continue out in 2 radiating rows on disc; in front and behind beaks are many fine, radial plications, posterior of which follow zigzag course; periostracum dark olive, lustrous; anterior claustra elongate, compressed, 2 in LV and 1 in RV, posterior claustra reduced to numerous indistinct uneven vestiges; beak cavities deep. *Pleist.-Rec.*, N. Am.—FIG. D42,3. **A. confragosus* (SAY), *Rec.*; RV ext., $\times 0.8$ (Walker).
- Arkansia** ORTMANN & WALKER, 1912 [**A. wheeleri*; OD]. Moderately thick, subtrund to subovate, or subrhomboidal, inflated; disc sculptured with irregular, oblique folds, which may be indistinct; beak sculpture poorly developed, consisting of 2 or 3 double-looped ridges with loops slightly swollen or tuberculose, disappearing toward disc and not merging with its sculpture; hinge well developed, with strong anterior claustra, very strong projection on intercardal interval of LV, and with well developed, strong but rather short posterior claustra. *Rec.*, N. Am.—FIG. D42,4. **A. wheeleri*; RV ext., $\times 0.8$ (Walker).
- Lasmigona** RAFINESQUE, 1831 [**Alasmodonta rugosa* BARNES, 1823 (= **Alasmodonta costata* RAFINESQUE, 1820); OD] [= *Elasmogona* L. AGASSIZ, 1846; *Elasmogena* HERRMANNSEN, 1852]. Rhomboid, compressed or inflated posteriorly; beaks low, compressed, bearing sculpture of double-looped ridges, and commonly with radiating ridges in front and behind; anterior claustra heavy or reduced, posterior claustra obsolescent. *Pleist.-Rec.*, N. Am.
- L. (Lasmigona)**. Subrhomboid, compressed, corrugated behind; periostracum lustrous; posterior claustra weakly developed, sloping diagonally downward and backward; cavities of beaks shallow. *Pleist.-Rec.*, N. Am.—FIG. D42,5. **L. (L.) costata* (RAFINESQUE); 5a-c, LV ext., RV int., both valves dorsal, $\times 0.4$ (497).
- L. (Platynaias)** WALKER, 1918 [**Symphinota compressa* LEA, 1829 (= **Unio viridis* RAFINESQUE, 1820); OD]. Shell smooth subsolid, shining, rayed; beak sculpture sharply double-looped; claustra delicate, posterior ones compressed, moderately developed. *?Rec.*, N. Am.—FIG. D42,2. **L. (P.) viridis* (RAFINESQUE); 2a-c, LV ext., RV int., both valves dorsal, $\times 0.3$ (497).
- L. (Pterosyna)** RAFINESQUE, 1831 [**Alasmodonta complanata* BARNES, 1823; OD] [= *Complanaria*, *?Megadomus* SWAINSON, 1840; *Pterosyna* SIMPSON, 1900]. Large, ovate-rhomboid, inflated in postbasal region; beaks compressed, with sculpture of sharp strong double loops; periostracum dark, obscurely rayed; claustra heavy. *Rec.*, N. Am.—FIG. D42,6. **L. (P.) complanata* (BARNES); 6a-c, LV ext., RV int., both valves dorsal, $\times 0.3$ (497).
- L. (Sulcularia)** RAFINESQUE, 1831 [**Alasmodonta badia* RAFINESQUE, 1820; OD] [= *Alasminota* ORTMANN, 1914]. Moderately thick, beak sculpture rather strong, doubly looped; periostracum brownish, somewhat rayed; anterior claustra delicate, posterior claustra nearly or entirely wanting. *Rec.*, N. Am.—FIG. D42,1. **L. (S.) badia* (RAFINESQUE); 1a,b, LV ext., both valves dorsal, $\times 1$ (497).
- Simpsonia** FRIERSON, 1914 [**Alasmodonta ambigua* SAY, 1825; OD] [= *Simpsoniconcha* FRIERSON, 1914]. Small, elongate elliptical, rounded in front and behind, slightly incurved ventrally; beaks

rather sharp but not full, ornamented by fine parallel ridges which are looped in middle and open behind; periostracum brownish, rayless; hinge imperfect, with simple irregular anterior claustrum in each valve, posterior claustra obsolescent or lacking; anterior end of shell thickened. *Rec.*, N.Am.—FIG. D43,1. **S. ambigua* (SAY); RV ext., ×1 (Walker).

Vanderschliea MODELL, 1943 [**Unio kolasii*

MODELL, 1931; OD]. Elongate, with nearly parallel dorsal and ventral margins; beak sculpture an anterior shallow loop which curves up and ends in rounded loop; hinge rather strong, complete, 2 anterior and 1 posterior claustra in LV, those of RV being narrow; beak cavities shallow. *U. Oligo.* (*Cyrenen.-Mergel.*), C.Eu.—FIG. D43,2. **V. kolasii* (MODELL); 2a,b, LV ext., RV int., ×1 (631).

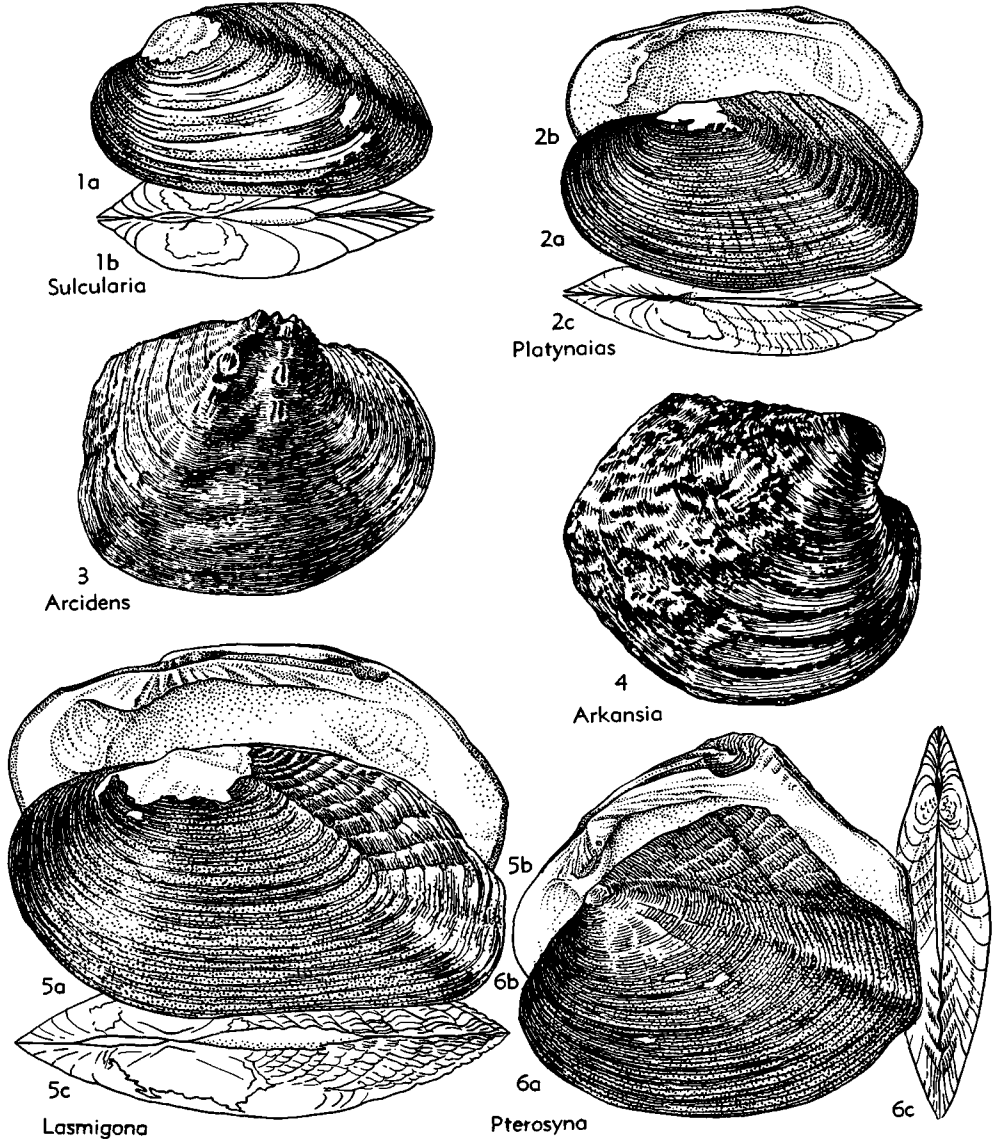


FIG. D42. Unionidae (Alasmidontinae) (p. N448).

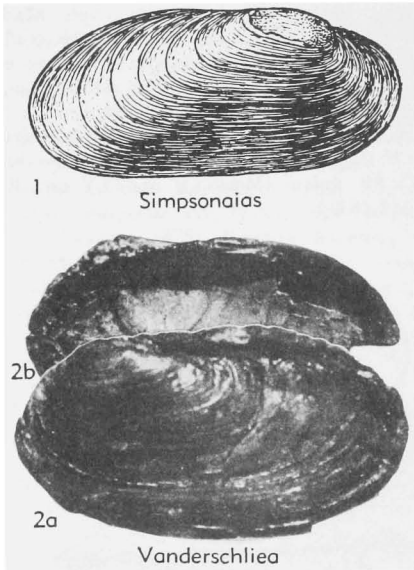


FIG. D43. Unionidae (Alasmidontinae) (p. N448-N449).

Subfamily LAMPSILINAE Ortmann, 1912

Shell generally thin and without sculpture on disc; periostracum generally lustrous and rayed; hinge complete, interdental interval never flat, but smooth and rounded. [Most Lampsilinae show sexual dimorphism of the shell to a greater or lesser extent. The marsupium occupies only the posterior part of the outer gills, the marsupial portion being differentiated even when not occupied.] ?*Trias.*, *L.Oligo.-Rec.*

Lampsilis RAFINESQUE, 1820 [**Unio ovatus* SAY, 1823; SD HERRMANNSEN, 1846] [= *Aeglia* SWAINSON, 1840]. Oval to elliptical, generally smooth, usually without posterior ridge; periostracum mostly smooth, lustrous, commonly rayed; sculpture obsolete or with double-looped parallel ridges, posterior loop open behind; hinge normal, but auxiliary cardinal may occur in RV; female shell with strong inflation and dilatation in postbasal region, producing posterior truncation of shell. ?*Trias.*, *L.Oligo.-Rec.*, N.Am.-C.Am.

L. (Lampsilis). Weak posterior ridge, beak raised above straight dorsum, narrow rays. ?*Trias.*, *L.Oligo.-Rec.*, N.Am.-C.Am.—FIG. D44,5. **L. (L.) ovata* (SAY), *Rec.*; 5a,b, RV ext., both valves dorsal, $\times 0.6$ (497).

L. (Cyrtonaias) CROSSE & FISCHER, 1893 [**Unio berlandieri* LEA, 1857; OD] [= *Cyrtonais* FRIERSON, 1927]. Oval or subtetragonal, heavy; beaks

generally full; disc smooth or concentrically striated. *Rec.*, N.Am.-C.Am.—FIG. D44,3. **L. (C.) berlandieri* (LEA); RV ext., $\times 0.5$ (535). **L. (Delphinoniaias)** CROSSE & FISCHER, 1893 [**Unio delphinulus* MORELET, 1849; OD]. Very compressed, posterodorsal margin raised into high wing; cardinals compressed. *Rec.*, C.Am.—FIG. D44,9. **L. (D.) delphinulus* (MORELET); RV ext., $\times 0.7$ (306).

L. (Disconaias) CROSSE & FISCHER, 1893 [**Unio discus* LEA, 1838; OD]. Large, oval or sub-trigonal, very much compressed, concentrically striated; cardinals strong, lamellar teeth very long and furrowed. *Rec.*, N.Am.(Mex.).—FIG. D44,4. **L. (D.) discus* (LEA); 4a,b, LV ext., both valves dorsal, $\times 0.3$ (497).

L. (Mesonaias) CROSSE & FISCHER, 1893 [**Unio explicatus* MORELET, 1849; OD]. Transverse oval, high, beaks not prominent; disc smooth or concentrically striated; cardinals oblique, compressed. *Rec.*, C.Am.—FIG. D44,2. **L. (M.) explicata* (MORELET); 2a,b, LV ext., RV int., $\times 0.4$ (306).

L. (Ortmanniana) FRIERSON, 1927 [**Unio carinatus* BARNES, 1823; OD]. Heavy, very elliptical, moderately inflated; periostracum yellowish-green, broadly rayed; beaks not prominent, sculpture fine, restricted to tips; cardinals rather small, stumpy; female shell not greatly swollen in postbasal region. *Rec.*, N.Am.—FIG. D44,7. **L. (O.) carinata* (BARNES); 7a-c, RV ext., LV int., both valves dorsal, $\times 0.5$ (497).

L. (Phyllonaias) CROSSE & FISCHER, 1893 [**Unio paludosus* MORELET, 1849; OD]. Flat, posterodorsal margin high, forming rudimentary wing; cardinals mostly compressed. *Rec.*, C.Am.—FIG. D44,8. **L. (P.) paludosa* (MORELET); 8a,b, LV ext., RV int., $\times 0.7$ (306).

L. (Venustaconcha) FRIERSON, 1927 [**Unio venustus* LEA, 1838; OD] [= *Venusta* FRIERSON, 1927 (non O. BOETTGER, 1877, nec BARRANDE, 1881)]. Elliptical, slightly inflated, pointed behind; beak sculpture doubly looped, rear loop open behind in some; periostracum dull, rayed, with wavy lines, generally arranged in bands; female shell only slightly swollen at posterior base, behind which is slight sinus. *Rec.*, N.Am.—FIG. D44,6. **L. (V.) venusta* (LEA); RV ext., $\times 1$ (535).

L. (Villosa) FRIERSON, 1927 [**Lampsilis villosus* WRIGHT, 1898; OD]. Small, obovate, inflated; beaks rather high, sculptured with fine, parallel ridges arranged in double loop, that in front being large and rounded, that behind small and rather pointed below; periostracum varying from smooth to somewhat clothlike, always showing green tints when seen through transmitted light, indistinctly rayed; greatest height of shell just behind center, greatest diameter just in front of center or behind beaks; hinge teeth compressed.

Rec., N.Am.—FIG. D44,1. **L. (V.) villosa* WRIGHT; RV ext., $\times 1$ (SIMPSON).

Actinonaias CROSSE & FISCHER, 1893 [**Unio sapotalensis* LEA, 1841; OD]. Elliptical to rhomboid, heavy, somewhat inflated; beaks low, their sculpture not known; surface smooth; periostracum lustrous, with divided rays; cardinals short, heavy.

Pleist.-Rec., N.Am.(Mex.).—FIG. D45,2. **A. sapotalensis* (LEA), Rec.; RV ext., $\times 0.8$ (535).

Carunculina SIMPSON, 1900 [**Unio texasensis* LEA, 1857; OD] [= ?*Toxolasma* RAFINESQUE, 1831; ?*Toxelasma* L. AGASSIZ, 1847]. Small, inflated, obovate, rather solid; periostracum thick, lusterless, almost rayless, clothlike; beak sculpture consisting

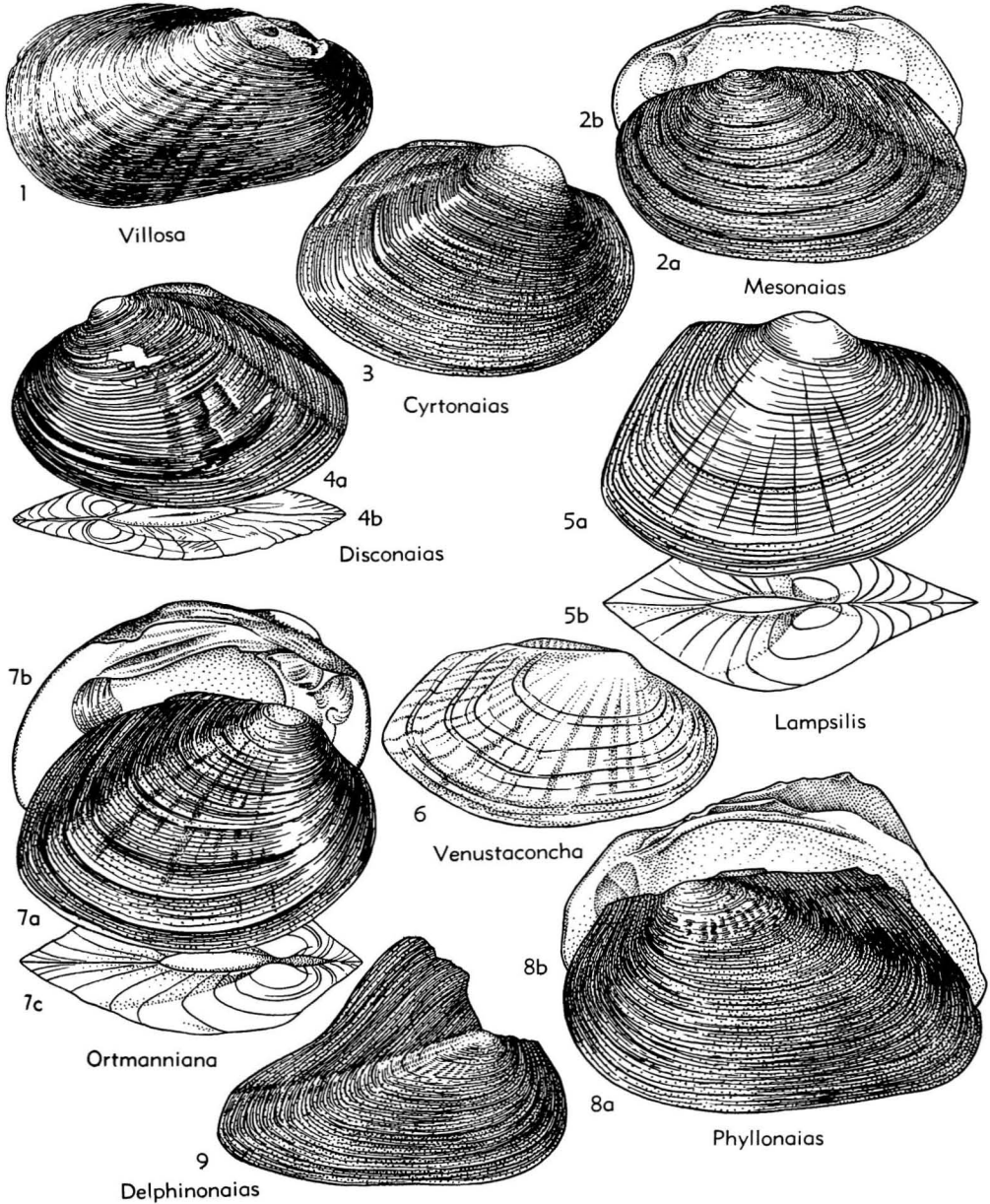


FIG. D44. Unionidae (Lampsilinae) (p. N450-N451).

of rather strong, concentric ridges which usually form 1 single rounded loop in front and are strongly curved upward behind; cardinals compressed, mostly reflexed upward; male shell some-

what pointed behind, female shell truncated obliquely on posterior base. *Rec.*, N.Am.—FIG. D45,1. **C. parva texasensis* (LEA); 1a,b, RV ext., LV int., $\times 1$ (535).

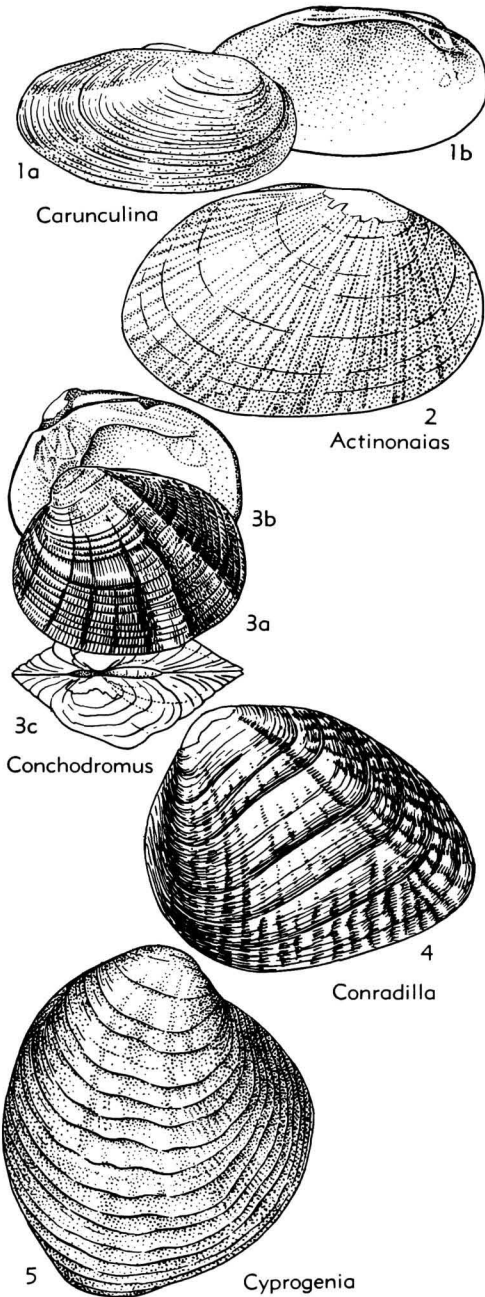


FIG. D45. Unionidae (Lampsilinae) (p. N451- N452).

Conchodromus HAAS, 1930 [*pro Dromus* SIMPSON, 1900 (*non* SELBY, 1840)] [**Unio dromus* LEA, 1834; OD]. Heavy, rounded-triangular; beaks very anterior, rather high, with sculpture of fine ridges running parallel with growth lines, furrows between ridges interrupted at distinct posterior ridge, row of humps running down from beaks to center of ventral margin, otherwise shell sculptured by irregular concentric ridges; periostracum marked by wavy, radial fine lines or maculations; hinge plate wide, cardinals triangular, small, low, lamellar teeth short, low; cavity of beaks deep and compressed. *Rec.*, N.Am.—FIG. D45,3. **C. dromus* (LEA); 3a-c, LV ext., RV int., both valves dorsal, $\times 0.5$ (497).

Conradilla ORTMANN, 1921 [**Unio caelatus* CONRAD, 1834; OD] [=?*Lemiox* RAFINESQUE, 1831]. Subtriangular to ovate, solid; beaks sculpture almost absent, consisting of few feeble double-looped ridges; periostracum dark, feebly rayed with undulating lines; hinge teeth heavy, lamellar teeth club-shaped, truncate behind; female shell swollen in posterobasal region, swelling irregularly ridged in some. *Rec.*, N.Am.—FIG. D45,4. **C. caelata* (CONRAD); LV ext., $\times 1$ (Reeve).

Cyrogenia L. AGASSIZ, 1852 [**Unio irroratus* LEA, 1830 (= **Obovaria stegaria* RAFINESQUE, 1820); OD] [=*Crypogenia* FISCHER, 1886]. Heavy, inflated, rounded triangular, mostly biangular behind; umbonal region flattened, beaks curved inward and forward, sculptured faintly with double-looped ridges; sculpture of disc nodular, radially wrinkled or lachrymose; periostracum shining, with delicate dark mottling on light background; hinge plate wide, flat, cardinals long, triangular, lamellar teeth short, obliquely striated; cavity of beaks not deep. *Rec.*, N.Am.—FIG. D45,5. **C. stegaria* (RAFINESQUE); RV ext., $\times 1$ (535).

Dysnomia L. AGASSIZ, 1852 [**Obliquaria flexuosa* RAFINESQUE, 1820; OD] [=*Epioblasma* RAFINESQUE, 1831; *Disnomia* BIELZ, 1869; *Dysonomia* PAETEL, 1890; *Epilobasma* SIMPSON, 1900]. Shell of males with posterior and central radiating ridge, that of females with great produced inflation which is continuation of central ridge. *Rec.*, N.Am.

D. (**Dysnomia**). Shell of males with wide, flattened space between central and posterior ridges, that of females with produced inflation but little behind center of base. *Rec.*, N.Am.—FIG. D46, 4. **D.* (*D.*) *flexuosa* (RAFINESQUE); 4a,b, ♂ RV ext., ♀ RV ext., $\times 0.5$ (Walker).

D. (**Capsaeformis**) FRIERSON, 1927 [**Unio capsaeformis* LEA, 1834; OD]. Male shells but little inflated or compressed, rounded into postbasal flap. *Rec.*, N.Am.—FIG. D46,5. **D.* (*C.*) *cap-*

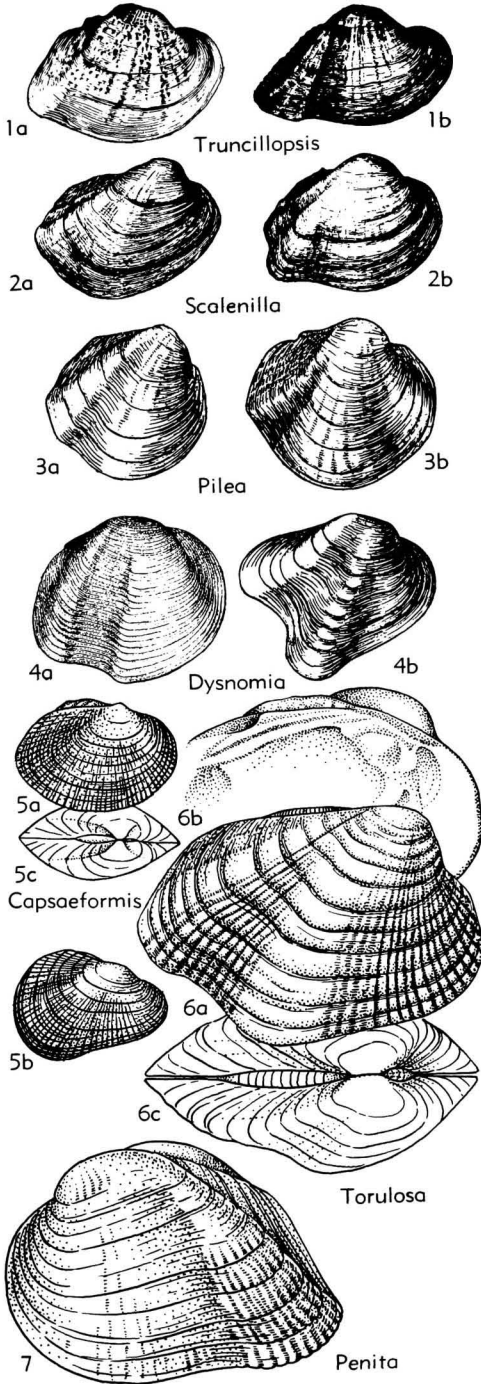


FIG. D46. Unionidae (Lampsilinae) (p. N452–N453).

saeformis (LEA); 5a-c, ♂ RV ext., ♀ RV ext., both valves dorsal, $\times 0.5$ (497).

D. (Penita) FRIERSON, 1927 [**Unio penitus* CONRAD, 1834; OD]. Somewhat quadrate, not sharply truncate behind; swelling of female in front of postero-basal point and rounded below. *Rec.*, N.Am.—FIG. D46,7. *D. (P.) *penita* (CONRAD); LV ext., $\times 1$ (Reeve).

D. (Pilea) SIMPSON, 1900 [**Unio personatus* SAY, 1829; OD]. Male shell with wide shallow, radiating depression in front of posterior ridge, those of females with rounded, foliaceous swelling at posterior base. *Rec.*, N.Am.—FIG. D46,3. *D. (P.) *personata* (SAY); 3a,b, ♂ RV ext., ♀ RV ext., $\times 0.5$ (Walker).

D. (Scalenilla) ORTMANN & WALKER, 1922 [**Unio sulcatus* LEA, 1830; OD]. Male shell with wide radiating shallow depression in front of posterior ridge; that of female with small well-defined radial postbasal swelling. *Rec.*, N.Am.—FIG. D46,2. *D. (S.) *sulcata* (LEA); 2a,b, ♂ RV ext., ♀ RV ext., $\times 0.5$ (Walker).

D. (Torulosa) FRIERSON, 1927 [**Amblema torulosa* RAFINESQUE, 1820; OD]. Shell of male with median and posterior radiating ridges, both usually nodose; postbasal expansion of female rounded, large, thin, placed far back. *Rec.*, N. Am.—FIG. D46,6. *D. (T.) *torulosa* (RAFINESQUE); 6a-c, RV ext., LV int., both valves dorsal, $\times 0.7$ (535).

D. (Truncillopsis) ORTMANN & WALKER, 1922 [**Truncilla triquetra* RAFINESQUE, 1820; OD]. Greatly inflated, sharply truncate posteriorly; inflation of female shell at extreme postero-basal point. *Rec.*, N.Am.—FIG. D46,1. *D. (T.) *triquetra* (RAFINESQUE); 1a,b, ♂ RV ext., ♀ RV ext., $\times 0.5$ (Walker).

Frierosonia ORTMANN, 1912 [**Lampsilis iridella* PILSBRY & FRIERSON, 1908; OD]. Subelliptical, without distinct posterior ridge; disc unsculptured; beak sculpture consisting of 6 to 8 ridges, later ones being distinctly double-looped and interrupted in middle; periostracum greenish-yellow rayed; sexual dimorphism of shells not marked. *Rec.*, N.Am.(Mex.).—FIG. D47,6. *F. *iridella* (PILSBRY & FRIERSON); 6a,b, LV ext., RV int., $\times 1$ (Pilsbry & Frierson).

Glebula CONRAD, 1853 [**Unio rotundata* LAMARCK, 1819; OD]. Short, elliptical, biangularly pointed behind, heavy, much inflated, with low posterior ridge; beaks compressed, their sculpture not known; periostracum brownish, clothlike; hinge plate very narrow, cardinals split, in each valve, into many (up to 12) irregularly radiating, compressed, granular processes; lamellar teeth short, remote; cavity of beaks shallow; shell of females swollen at posterior base. *Rec.*, N.Am.—FIG. D47,7. *G. *rotundata* (LAMARCK); 7a,b, LV ext., both valves dorsal, $\times 0.8$ (497).

Leptodea RAFINESQUE, 1820 [**L. leptodon*; OD]

[=*Lasmonos* RAFINESQUE, 1831; *Monelasmus* L. AGASSIZ, 1846; *Monelagmus* PAETEL, 1875; *Pareptera* FRIERSON, 1914]. Elongate elliptical, compressed, rather thin, pointed behind; beaks low, their sculpture feeble, with postdorsal wing in young shells and some with vestiges of anterior wing; shell gaping ventrally in front and behind; hinge very imperfect, cardinals commonly want-

ing, lamellar teeth faint or absent. *Rec.*, N.Am. —FIG. D47,4. **L. leptodon*; 4a-c, LV ext., RV int., both valves dorsal, $\times 0.5$ (497). [= *Paraptera* ORTMANN, 1911.]

Ligumia SWAINSON, 1840 [**Unio recta* LAMARCK, 1819; OD] [= ?*Potamilus*, ?*Potamila* RAFINESQUE, 1818; ?*Sintoxia* RAFINESQUE, 1820; *Ligumea* SWAINSON, 1840; ?*Syntoxia* L. AGASSIZ, 1847;

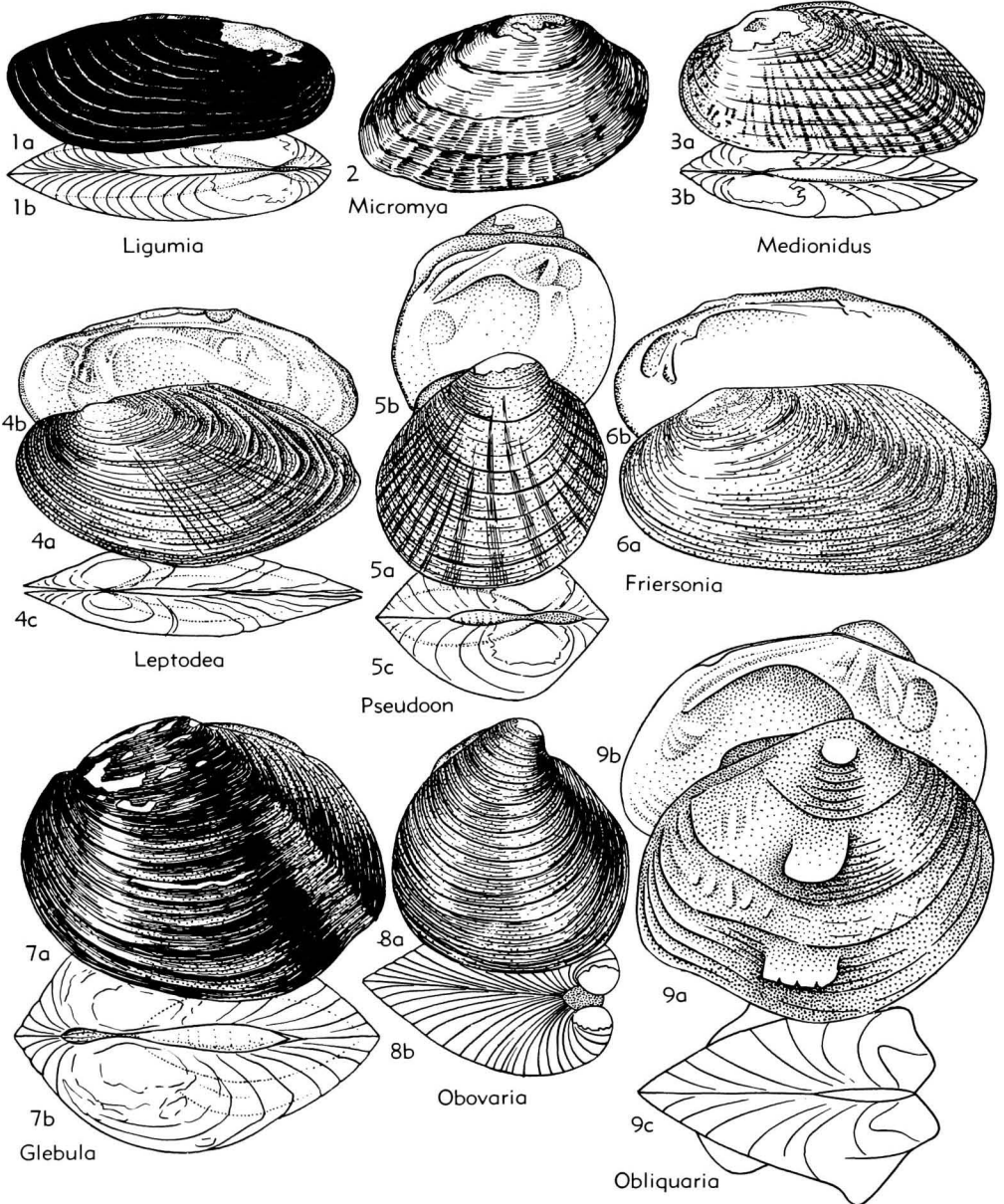


FIG. D47. Unionidae (Lampsilinae) (p. N453-N455).

- Legumia* L. AGASSIZ, 1852; *Ligumina* PHILIPPI, 1853; ?*Syntonia* SCHAUFUSS, 1869; ?*Syntonia* PAETEL, 1875]. Somewhat elongate, smooth, inflated, moderately heavy, sharply pointed behind; female shell much produced at posterior base; periostracum very lustrous, feebly rayed; beaks low, marked with very delicate regular sculpture, posterior loop commonly open behind; cardinals smooth, mostly compressed. *Pleist.-Rec.*, N.Am.—FIG. D47,1. **L. recta* (LAMARCK), *Rec.*; 1a,b, RV ext., both valves dorsal, $\times 0.3$ (497).
- Medionidus** SIMPSON, 1900 [**Unio conradianus* LEA, 1834; OD]. Elongate, arcuate in adults, rather inflated, dorsal slope (and adjoining portion of disc in some) wrinkled; beak sculpture of rather fine ridges in 2 loops, anterior rounded, posterior somewhat angular; periostracum lustrous with green rays and irregular spots; cardinals small, massive, more or less roughened, lamellar teeth rather short, remote, slightly curved and club-shaped; shell of females slightly swollen just behind middle of base. Marsupium occupying central posterior portion of outer gills. [*Unio senectus*, from the Paleocene, originally referred to *Medionidus*, is now considered to belong to *Rhabdotophorus*.] *Rec.*, N.Am.—FIG. D47,3. **M. conradianus* (LEA); 3a,b, LV ext., both valves dorsal, $\times 1$ (497).
- Micromya** L. AGASSIZ, 1852 [**Unio fabalis* LEA, 1831; OD]. Small to medium, triangular-oval or subelliptical, not very long or much pointed behind; beak sculpture double-looped, commonly obsolete, posterior loop tending to be open; inner edge of the mantle in front of branchial opening of females with row of rather irregular, larger and smaller papillae, reaching not quite to middle of lower margin. *Rec.*, N.Am.—FIG. D47,2. **M. fabalis* (LEA); RV ext., $\times 1$ (Walker).
- Obliquaria** RAFINESQUE, 1820 [**O. (Quadrula) reflexa*; OD] [= *Oblicaria* D'ORBIGNY, 1846]. Inflated, solid, oval, pointed behind, with row of large longitudinal knobs running from beaks to center of base; posterior ridge well developed, space between it and row of tubercles somewhat excavated; posterior slope corrugated; beaks prominent, incurved, pointing forward, their sculpture strong and consisting of 4 or 5 heavy parallel ridges low in front, curving upward behind; cardinals strong, ragged, lamellar teeth short, nearly straight; male and female shells essentially alike. *Pleist.-Rec.*, N.Am.—FIG. D47,9. **O. reflexa*, *Rec.*; 9a-c, RV ext., LV int., both valves dorsal, $\times 1$ (497).
- Obovaria** RAFINESQUE, 1819 [**Unio retusa* LAMARCK, 1819; SD SIMPSON, 1900]. Short, oval, rounded or retuse, solid, inflated, thicker in front; beaks high, sculptured with very faint irregular nodulose ridges which tend to fall into 2 loops, posterior commonly open behind; periostracum dull, silky, or clothlike, rarely rayed; cardinals massive, lamellar teeth short, club-shaped. *Pleist.-Rec.*, N.Am.
- O. (Obovaria)**. Shell retuse to oval, short; beaks high, central; cardinals rarely parallel with lamellar teeth; cavity of beaks deep, subcompressed; nacre bluish-white or purple. *Pleist.-Rec.*, N.Am.—FIG. D47,8. **O. (O.) retusa* (LAMARCK), *Rec.*; 8a,b, RV ext., both valves dorsal, $\times 0.6$ (497).
- O. (Pseudoon)** SIMPSON, 1900 [**Unio ellipsis* LEA, 1828 (= **Amblema olivaria* RAFINESQUE, 1819); OD] [= *Actionaias* ORTMANN, 1925]. Elliptical, inflated, heavy, that of males pointed behind; periostracum dark, rayless or feebly rayed; beaks anterior, cardinals short or somewhat elongated, massive, tending to be parallel lamellar teeth; nacre silvery. *Rec.*, N.Am.—FIG. D47,5. **O. (P.) olivaria* (RAFINESQUE); 5a-c, RV ext., LV int., both valves dorsal, $\times 0.75$ (497).
- Pachynaias** CROSSE & FISCHER, 1893 [**Unio spheniopsis* MORELET, 1849; OD] [= *Artonaias* MARTENS, 1900; *Ptychoderma* SIMPSON, 1900]. Triangularly ovate or rounded, heavy, with tolerably well-marked posterior ridge; surface marked by strong, irregular concentric sulcae; beaks small, rather prominent, sculptured with fine, irregular, broken ridges which are somewhat double-looped, front loop larger and more rounded; periostracum olive to tawny, wrinkled, feebly rayed in some; hinge plate narrow, cardinals compressed, ragged, lamellar teeth short, slightly curved, obliquely striated; female shells produced in postbasal region. *Rec.*, C.Am.—FIG. D48,6. **P. spheniopsis* (MORELET); LV ext., $\times 1$ (306).
- Plagiola** RAFINESQUE, 1819 [**Unio securis* LEA, 1829 (= **Obliquaria depressa* RAFINESQUE, 1820); OD] [= *Plagiolopsis* THIELE, 1934]. Heavy, elongate triangular, more inflated posteriorly in females, with concentrically striate posterior ridge; beaks high, sculptured with fine parallel double-looped ridges, anterior loop rounded, posterior angular; cardinals ragged, lamellar teeth club-shaped, more or less straight; cavity of beaks moderate. *Pleist.-Rec.*, N.Am.—FIG. D48,4. **P. depressa* (RAFINESQUE), *Rec.*; 4a-c, RV ext., LV int., both valves dorsal, $\times 1$ (535).
- Proptera** RAFINESQUE, 1819 [**Unio alatus* SAY, 1825; SD HERRMANNSEN, 1846] [= *Megaptera* RAFINESQUE, 1820; *Symphynota* LEA, 1829; *Naidea*, *Lymnadea*, *Lymnadia* SWAINSON, 1840; *Symphynota* VILLA, 1841; *Limnadea* L. AGASSIZ, 1846; *Noidea* SCHAUFUSS, 1869; *Symphynota*, *Symphynota* PHILIPPI, 1853]. Rather large, gaping at anterior base and edge of dorsal slope, winged along dorsal region, at least when young; where present, beak sculpture feeble, consisting of anterior and posterior loops, former commonly wanting, latter somewhat rarely nodulose; periostracum clothlike when young, rayless or feebly

rayed; teeth compressed, cardinals usually imperfect or wanting, laterals remote; nacre purplish. *Pleist.-Rec.*, N.Am.—FIG. D48,5. **P. alata* (SAY), *Rec.*; 5a,b, RV ext., LV int., $\times 0.4$ (497).

Ptychobranchus SIMPSON, 1900 [**Unio fasciolaris* HILDRETH, 1828; OD]. Elliptical to triangular, heavy, umbonal region rather elevated; beak sculpture of discontinuous ridges, double-looped in

some; hinge normal, cardinals low, rather small, lamellar teeth club-shaped, remote; cavities of beaks shallow. *U.Oligo.(Cyrenen.-Mergel.)-Rec.*, C.Eu.-N.Am.

P. (Ptychobranchus). Triangular, some arcuate when old; posterior slope rounded, well developed; periostracum usually with wavy fine rays or broken, radiating bands, which tend to form

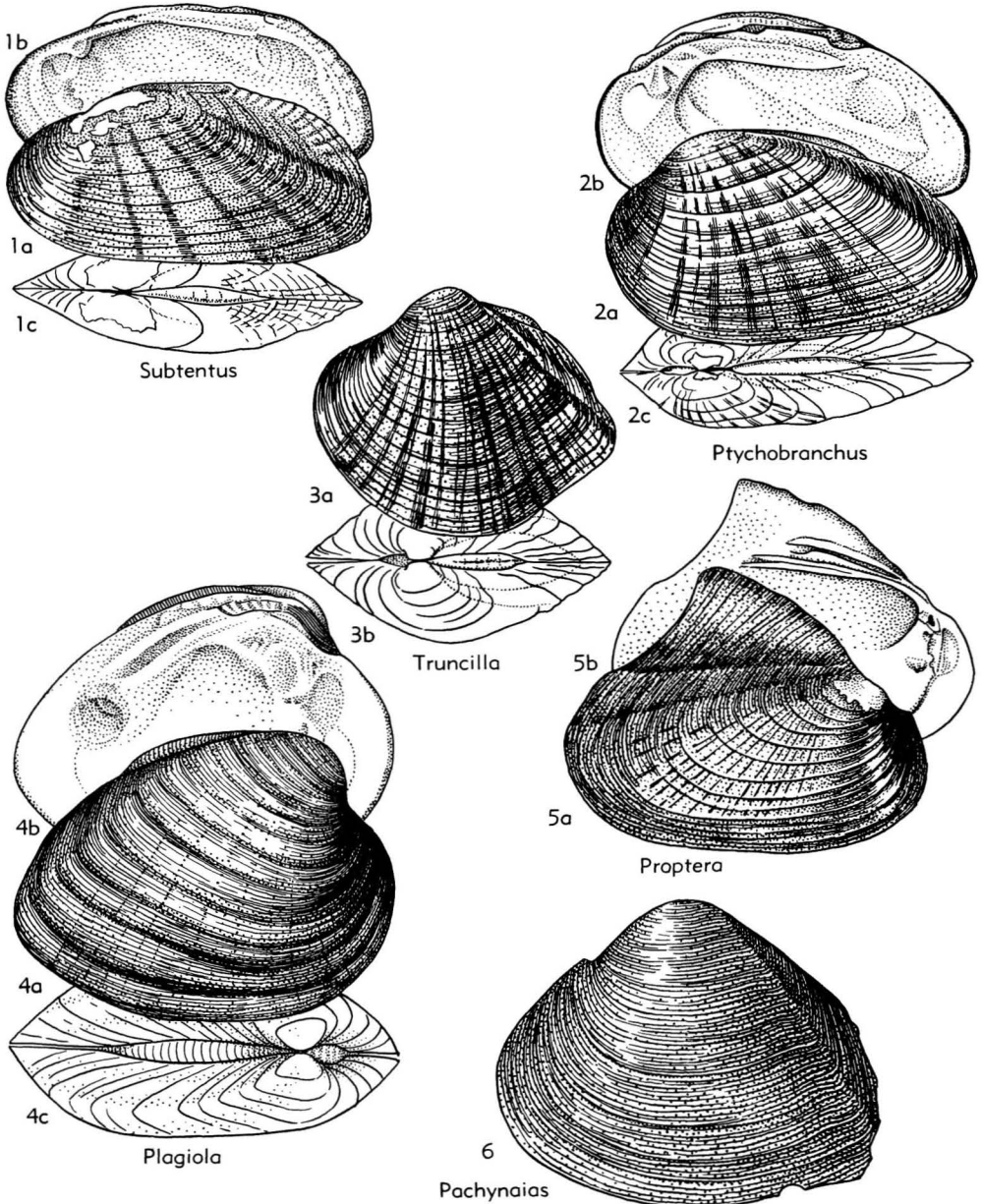


FIG. D48. Unionidae (Lampsilinae) (p. N455-N457).

square spots. *U. Oligo.* (Cyrenen.-Mergel.)-Rec., C. Eu.-N.Am.—FIG. D48,2. **P. (P.) fasciolaris* (HILDRETH), Rec., C.Eu.; 2a-c, LV ext., RV int., both valves dorsal, $\times 0.5$ (497).

P. (Subtentus) FRIERSON, 1927 [**Unio subtentus* SAY, 1825; OD]. Elongate elliptical, only slightly inflated, with ill-defined posterior ridge and posterior slope strongly wrinkled; periostracum bright, with broken rays which may form irregular patches but usually develop into square spots; shell of female slightly inflated behind middle of base. Rec., N.Am.—FIG. D48,1. **P. (S.) subtentus* (SAY); 1a-c, LV ext., RV int., both valves dorsal, $\times 0.8$ (497).

Truncilla RAFINESQUE, 1820 [**T. truncata*; SD HERRMANNSEN, 1849] [= *Amygdalonia* CROSSE & FISCHER, 1893]. Inflated at posterior slope, posterior ridge sharp and well defined; area of beaks flattened but not compressed, beak sculpture delicate, somewhat broken and double-looped, anterior loop rounded, posterior loop sharp below; periostracum lustrous, with pattern of broken or arrow-shaped rays; hinge delicate, on narrow plate, cardinals rather compressed, high, ragged; female shell slightly swollen at posterior base. *Pleist.-Rec.*, N. Am.—FIG. D48,3. **T. truncata*, Rec.; 3a,b, LV ext., both valves dorsal, $\times 0.6$ (497).

Subfamily HYRIINAE Ortman, 1911

[This family-group name, based on a junior synonym of *Prisodon*, is retained in accordance with provisions of the Zoological Code (1961), Art. 40]

Shell of variable shape high rounded to long narrow; beak sculpture invariably radial, ranging from restricted to tips and poorly developed to extended over most of disc and well developed; hinge normal, well developed, cardinals tending to become divided radially; anal opening closed above and marsupium occupying only inner gills. *Cret.-Rec.*

Prisodon SCHUMACHER, 1817 [**P. obliquus*; SD SIMPSON, 1896] [= *Triquetra* KLEIN, 1753 (*nom nud.*, pre-Linnean); *Hyria* LAMARCK, 1819; *Hyri.* DE BLAINVILLE, 1821; *Ilyria* FLEMING, 1822; *Prysdon* STEFANESCU, 1896; *Hyriana* SIMPSON, 1900]. Aviculiform, solid, somewhat inflated; with well-developed posterior ridge beneath excavated area, generally incurved from its postero-ventral extremity to end of posterodorsal wing; posterior slope with row of radial plications; disc concentrically sculptured and having delicate radiating lirae throughout, so that surface is finely reticulate; beaks full, not elevated, their sculpture not seen; periostracum yellowish-green, bronze or brownish, lustrous; hinge narrow under beaks, widening in front and behind; LV with 2 elongate compressed cardinals which tend to separate into denticles, and 2 vertically granulostriate

lamellar teeth; RV with 2 or more similar cardinals and single lamellar tooth; beak cavities not deep. *Mio.-Rec.*, S.Am.—FIG. D49,1. **P. obliquus*, Rec.; LV ext., $\times 0.4$ (Sowerby).

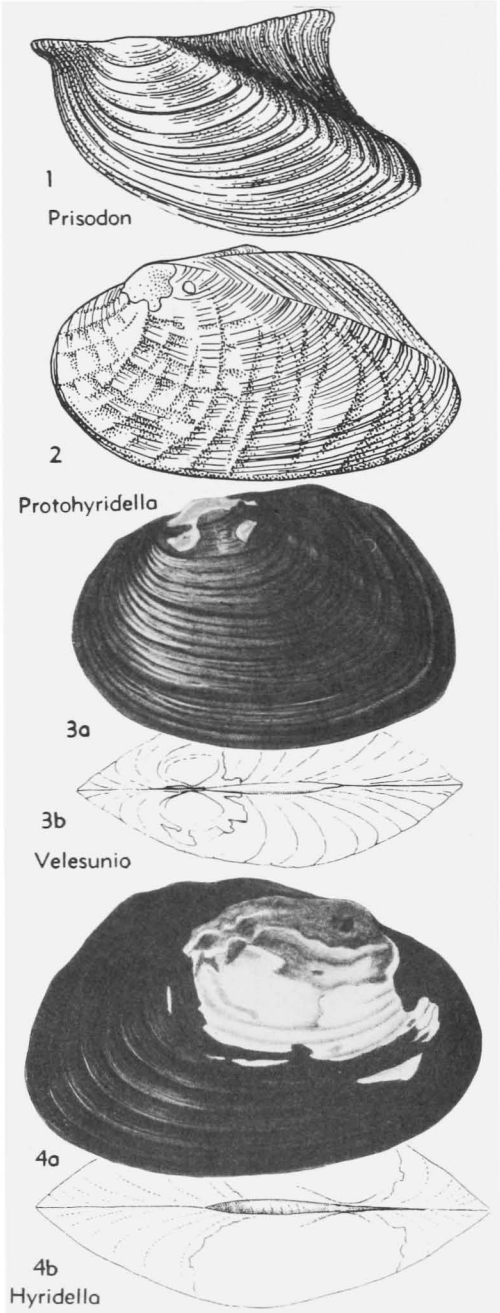


FIG. D49. Unionidae (Hyriinae) (p. N457, N460-N461).

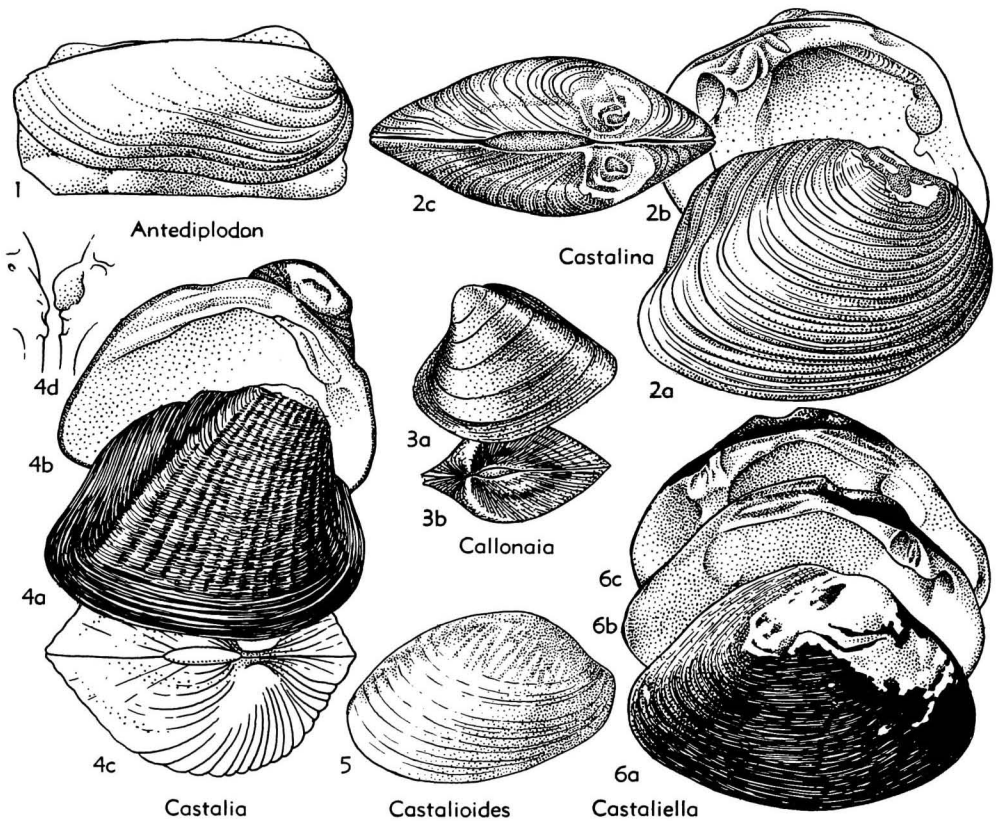


FIG. D50. Unionidae (Hyriinae) (p. N458-N460).

Antediplodon MARSHALL, 1929 [**Unio dumblei* SIMPSON, 1896; OD]. Characterized by elongate form, abrupt anterior end, and especially by sculpture of the beaks, which consists of several fine, radiating ribs. *Plio.*, USA (Tex.).—FIG. D50,1. **A. dumblei* (SIMPSON); RV ext., $\times 0.8$ (584).

Callonaia SIMPSON, 1900 [**Castalia duprei* RECLUZ, 1843; OD]. Triangular, thin, inflated, with very high, full beaks apparently devoid of sculpture; shell truncated above; very high, sharp posterior ridge extending to base; anterior end somewhat pointed above, rounded below; ligament very short; disc nearly smooth but somewhat sulcate anteriorly; periostracum bright greenish-yellow, lustrous; hinge line arched, teeth high, compressed; 2 cardinals in each valve, side by side and interlocking; 1 lamellar tooth in RV and 2 in LV, granular and vertically striate; beak cavities very deep, not compressed. *Rec.*, S.Am. (Brazil).—FIG. D50,3. **C. duprei* (RECLUZ); 3a,b, LV ext., both valves dorsal, $\times 0.5$ (Sowerby).

Castalia LAMARCK, 1819 [**C. ambigua*; OD] [= *Tetraplodon* SPIX, 1827]. Triangular, heavy,

inflated, with high sharp posterior ridge, behind which margin is distinctly truncate; beaks very full and high, sculpture radial or with 1 or 2 pairs of central ribs coalescing below, whole extending over disc as strong ridges; periostracum thick, dark, dull; hinge line arched, all teeth vertically ridged; 1 strong compressed cardinal in LV, 2 in RV, all in front of beaks, behind which lie denticles; 1 lamellar tooth in RV and 2 in LV; beak cavities deep, not compressed. *Rec.*, S.Am.—FIG. D50,4. **C. ambigua*; 4a-d, RV ext., LV int., both valves dorsal, hinges, $\times 1$ (497).

Castaliella SIMPSON, 1900 [**Castalia sulcata* KRAUSS, 1849; OD]. Subtriangular, greatly inflated, moderately heavy and strongly sulcate; beaks high, radiately sculptured; posterior ridge well defined, sharp; periostracum reddish chestnut; hinge margin narrow, arched; 2 vertically striated cardinals in RV, 3 in LV, side by side; 1 granular lamellar tooth in RV and 2 in LV; beak cavities deep, not compressed; nacre purple. *Rec.*, NE.S.Am.—FIG. D50,6. **C. sulcata* (KRAUSS); 6a-c, RV ext., LV int., RV int., $\times 0.8$ (Haas).

Castalina IHERING, 1891 [**C. martensi*; OD].

Somewhat triangular, sides slightly flattened, heavy, with strong posterior ridge, subtruncate posterior slope rising almost to wing above; beaks full, high, with radial sculpture; disc covered by weak irregular, concentric sulci, posterior slope generally plicate or corrugated; periostracum thick, blackish, rayless; hinge plate arched, wide; cardinals radially divided in each valve, with 2 to several denticles; 2 vertically or obliquely striate

lamellar teeth in LV and 1 in RV; beak cavities deep. *Rec.*, S.Am.—FIG. D50,2. **C. martensi*; 2a-c, RV ext., int., both valves dorsal, $\times 0.8$ (427).

Castalioides MARSHALL, 1934 [**C. laddei*; OD]. Shell with strong sculpture of radial ribs, several of innermost pairs arranged to form very long V's; ribs crossing anterior and posterior slopes forming divaricate pattern with radial ribs. *Pleist.*,

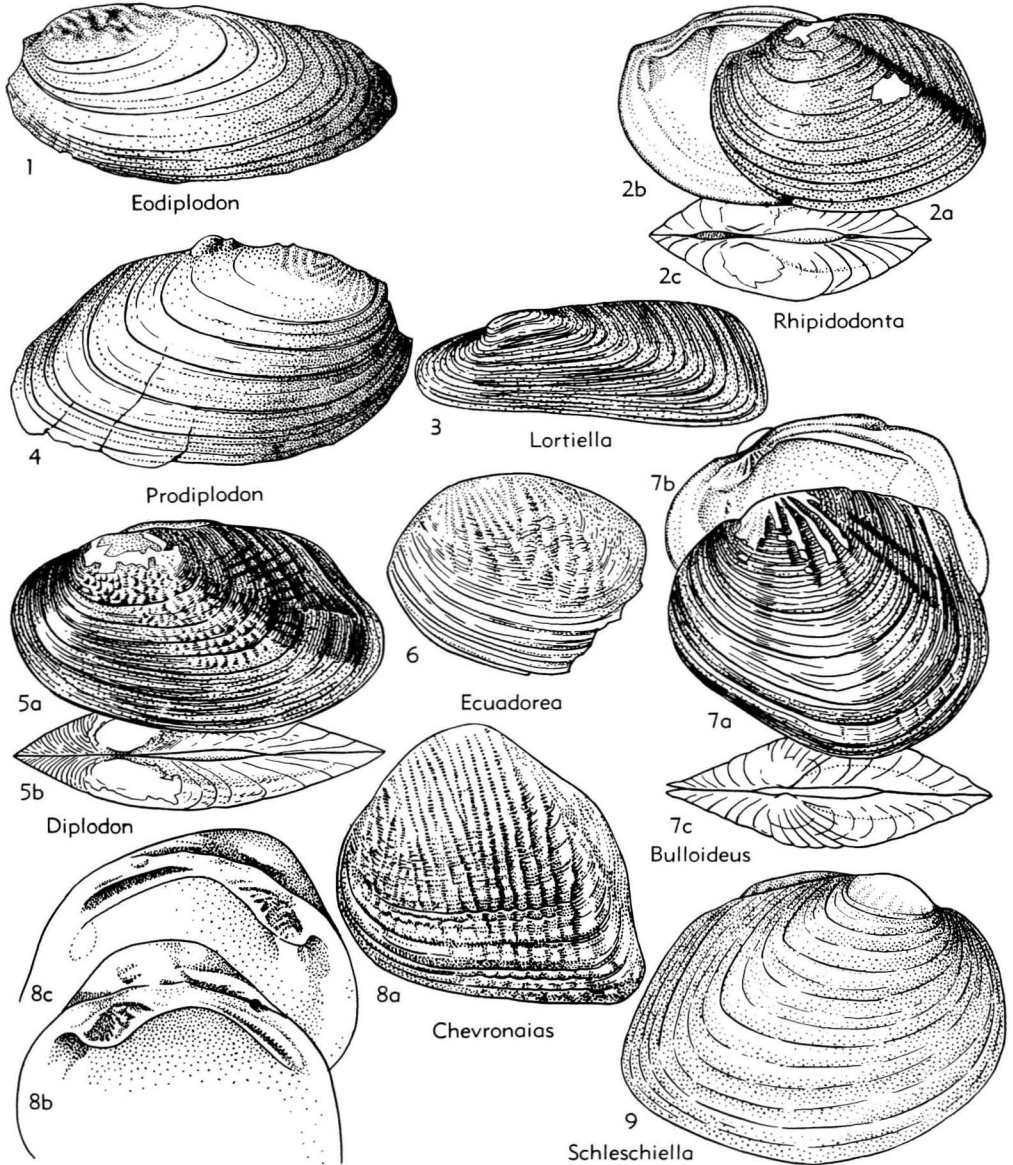


FIG. D51. Unionidae (Hyriinae) (p. N460-N461).

S.Am.(Venez.).—FIG. D50,5. **C. laddei*; RV ext., $\times 1$ (586).

Chevronaias OLSSON & WURTZ, 1951 [**C. colombiana*; OD]. Small, solid, subrhomboidal, bearing strong umbonal angle that divides flattened, depressed, subtruncated posterior slope from disc; hinge as in *Triplodon*; right cardinals low, with deep intervening socket having frilled, minutely pustulate sides; surface of disc with inset chevron-like folds radiating from beaks and spreading over posterior slope; shell cavity deep. *Rec.*, S.Am. (Colom.).—FIG. D51,8. **C. colombiana*; 8a-c, LV ext., RV int., LV int., $\times 1$ (690).

Diplodon SPIX, 1827 [**D. ellipticum*; OD] [= *Iridella* SWAINSON, 1840]. Elliptical, rounded, elongate or trapezoidal, with rather low radially sculptured beaks, ridges usually curved and approaching one another below; posterior ridge low or scarcely developed; surface concentrically sculptured, broken in some into fine nodules or corrugations; periostracum dull, rayless; hinge with 2 compressed cardinals (one in front of other) and 2 compressed lamellar teeth in LV; beak cavities shallow. *Cret.-Rec.*, N.Am.-S.Am.

D. (Diplodon). Unbroken ridges covering whole beaks. *Cret.-Rec.*, N.Am.-S.Am.—FIG. D51,5.

**D. (D.) ellipticus*, *Rec.*; 5a,b, LV ext., both valves dorsal, $\times 1$ (497).

D. (Bulloideus) SIMPSON, 1900 [**Unio bulloides* LEA, 1859; OD]. Thin, rounded, inflated, truncate behind and slightly so before, with rather sharp posterior ridge and dorsal wing; beaks full, subcentral, rather high, regularly radially sculptured; periostracum smooth, olive-bronze; cardinals compressed, commonly splitting into denticles, 2 in RV and 1 in LV, 2 lamellar teeth in LV and 1 in RV. *Rec.*, S.Am.—FIG. D51,7. **D. (B.) bulloides* (LEA); 7a-c, LV ext., RV int., both valves dorsal, $\times 1$ (497).

D. (Rhipidodonta) MÖRCH, 1853 [**Unio paranensis* LEA, 1834; OD] [= *Cyclomya* SIMPSON, 1900]. Obovate to suborbicular, narrow in front, produced just behind center of base, generally slightly pointed behind, with very low posterior ridge and slight dorsal wing behind; beaks high, marked by irregular radial ribs; hinge line strongly arched, curved behind and incurved in front of beaks; lower right cardinal largest, commonly subdivided. *Tert. (Guanabanas)-Rec.*, S. Am.—FIG. D51,2. **D. (R.) paranensis* (LEA), *Rec.*; 2a-c, LV ext., RV int., both valves dorsal, $\times 0.8$ (497).

D. (Schleschiella) MODELL, 1950 [**Unio burroughianus* LEA, 1834; OD], Heavy, short, oval or subsquarish to elongate rectangular, with distinct posterior ridge; beaks rather full, with regularly radiating, widely separated, sharp ridges; cardinals compressed, rough, usually subdivided in each valve, lamellar teeth curved, compressed.

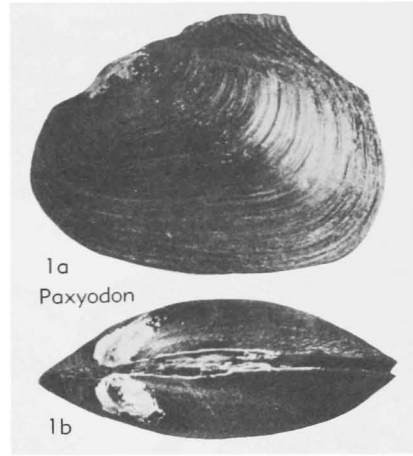


FIG. D52. Unionidae (Hyriinae) (p. N461).

Rec., S.Am.—FIG. D51,9. **D. (S.) burroughianus* (LEA); RV ext., $\times 0.8$ (535).

Ecuadorea MARSHALL & BOWLES, 1932 [**E. bibliana*; OD]. Beaks with radial sculpture similar to that of *Diplodon* and *Prisodon*; radial ribs arranged in a V-pattern, each V nesting in succeeding one; posterodorsal area crossed obliquely by several plicae to the margin. ?*Plio.*, *Rec.*, S.Am.—FIG. D51,6. **E. bibliana*, ?*Plio.*; LV ext., $\times 1$ (587).

Eodiplodon MARSHALL, 1928 [**E. gardnerae*; OD]. Beaks with very coarse, nearly direct radial undulations, some of which are broken up into nodules; close to tip of beak each pair of undulations unites into V, but later ones become nearly direct, not forming V. *Tert.*, S.Am.(Peru).—FIG. D51,1. **E. gardnerae*; LV ext., $\times 0.8$ (583).

Hyridella SWAINSON, 1840 [**Unio australis* LAMARCK, 1819 (= *Unio napeonensis* CONRAD, 1840); OD] [= *Propehydella* COTTON & GABRIEL, 1932]. Elongate elliptical to short ovoid or subrhomboid; beaks rather low, sculpture consisting of curved, generally nodulose ridges, which approach each other below but usually remain separated by smooth area; surface almost smooth, or slightly nodose; periostracum rayless; teeth rather delicate, compressed, somewhat rudimentary in some. *Rec.*, Australia-N.Guinea-N.Z.

H. (Hyridella). Solid, similar to *H. (Vesunio)*, but ornamented in juveniles by divaricate, irregular wrinkles, becoming gradually smooth in adults; periostracum lustrous, smooth; hinge teeth well developed. *Rec.*, Australia.—FIG. D49,4. **H. (H.) australis* (LAMARCK); 4a,b, RV ext., both valves dorsal, $\times 0.7$ (497).

H. (Lortietta) IREDALE, 1934 [**Mycetopus rugatus* SOWERBY, 1868; OD]. Elongate, thin, narrow,

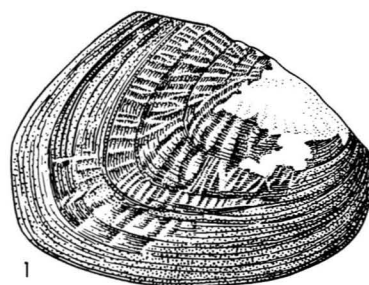
produced and rounded in front, acuminate lengthened and winged behind, ventral margin nearly straight; posterior ridge rounded, posterior area flattened; growth lines heavy; teeth thin, delicate, lamellar teeth elongate, cardinals small, tending to disappear, 2 in RV when young, only 1 in adult. *Rec.*, Australia.—FIG. D51,3. **H. (L.) rugata* (SOWERBY); LV ext., $\times 0.5$ (Sowerby).

H. (Protohyridella) COTTON & GABRIEL, 1932 [**Unio glenelgensis* DENNANT, 1898; OD]. Solid, subrhomboidal, subdepressed, rather produced posteriorly; indistinct rib extending from beak to posteroventral margin divides surface into anterior corrugated disc and posterior smooth area; beaks not prominent; hinge teeth well developed. *Rec.*, Australia.—FIG. D49,2. **H. (P.) glenelgensis* (DENNANT); LV ext., $\times 0.75$ (168).

H. (Vesunio) IREDALE, 1934 [**Unio balonnensis* CONRAD, 1850 (= **Unio ambiguus* PHILIPPI, 1847); OD]. [= *Microdontia* TAPPARONE-CANEVRI, 1883; *Hyridella* COTTON & GABRIEL, 1932 (non SWAINSON, 1840); *Westralunio*, *Alathyria*, *Centralhyria*, *Hyridunio*, *Rugoshyria* IREDALE, 1934]. Shape variable, beak sculpture not strong, consisting of broken, nodulose ridges curving toward each other below, generally with smooth space between, restricted to umbonal area. *Rec.*, Australia-N. Guinea-N. Z.—FIG. D49,3. **H. (V.) ambigua* (PHILIPPI), 3a,b, LV ext., both valves dorsal, $\times 0.8$ (497).

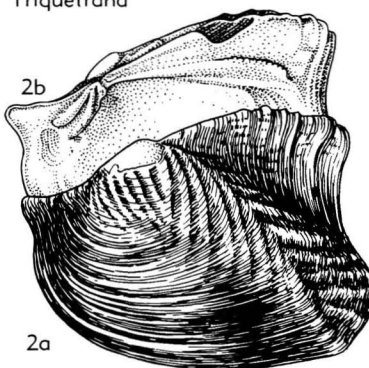
Paxyodon SCHUMACHER, 1817 [**P. ponderosus* (= **Mya symmatophora* GRONOVIVS, 1781); OD] [= *Pachyodon* DE BLAINVILLE, 1825; *Paxydonta* DESHAYES, 1832]. Medium-sized, subtriangular, aviculiform, alate before and behind, solid, inflated, with well-developed posterior ridge which becomes sharp edge near beaks; area above ridge deeply excavated; surface of entire shell smooth excepting very fine and crowded incremental striae; beaks full, low, their sculpture not seen, cavities moderately deep; periostracum, rather dull, hinge margin long, straight, narrow, cardinals compressed, reaching from beaks almost to anterior margin, 2 in RV, 1 in LV, where commonly shorter and weaker auxiliary cardinal occurs under normal one; lamellar teeth long, reaching from beaks almost to posterior margin, 1 in RV, 2 in LV; all teeth somewhat vertically and granularly striate; small radially arranged denticles between cardinals and lamellar teeth occur under beaks. *Rec.*, S.Am.—FIG. D52,1. *P. alatus* (SOWERBY); 1a,b, LV ext., both valves dorsal, $\times 0.8$ (Ortmann).

Prodiplodon MARSHALL, 1928 [**P. singewaldi*; OD]. Beak sculpture resembling that of *Diplodon* and *Prisodon*, consisting of several V-shaped undulations, larger ones embracing smaller, and other undulations on anterior and posterior umbonal areas, each pair of which, if continued,



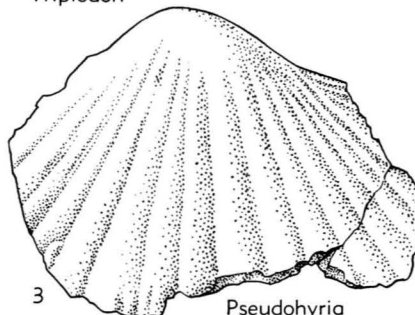
1

Triquetrana



2a

Triplodon



3

Pseudohyria

FIG. D53. Unionidae (Hyriinae) (p. N461-N463).

would form another V in the series. *Tert.*, S.Am. (Peru); *Plio.*, S.Am.(Venez.).—FIG. D51,4. **P. singewaldi*, *Tert.*, Peru; RV ext., $\times 0.8$ (583).

?**Pseudohyria** MACNEIL, 1936 [**P. gobiensis*; OD]. Subquadrangle, rounded anteriorly, somewhat angulate posteriorly, broadly arcuate ventrally; beaks about central, prominent, their sculpture unknown; surface sculptured with well-defined slightly elevated radial ribs that enlarge posteriorly and crenulate margin deeply; shell thicker in front than behind; cardinals moderately heavy, elongate, double in RV and single in LV, bounded anteriorly by impressed adductor scar; lamellar teeth not well known, apparently short and curved; ligament short. *Cret.*, Asia (Inner Mongol.).

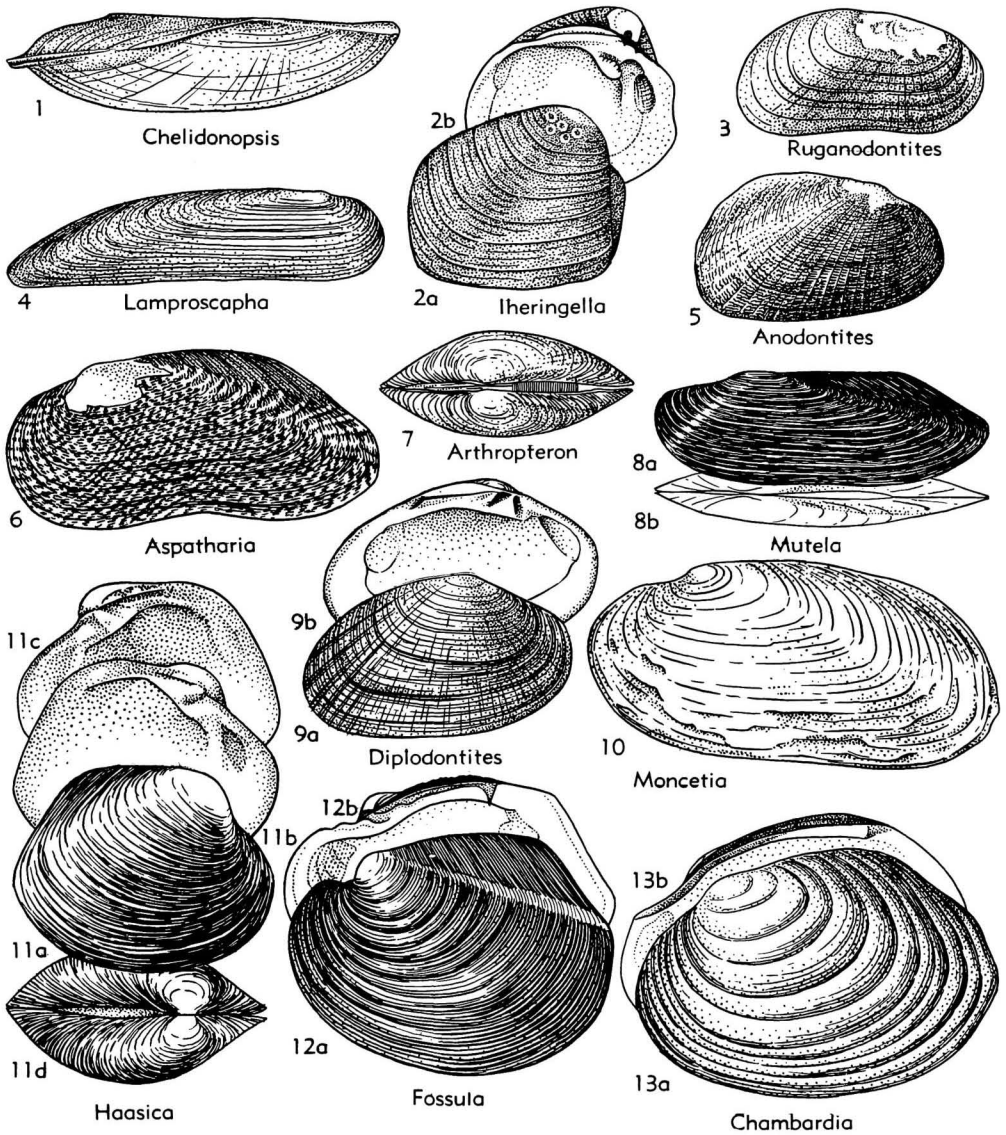


FIG. D54. Mutelidae (p. N463-N464).

—FIG. D53,3. **P. gobiensis*; RV ext., $\times 1$ (569).

Triplodon SPIX, 1827 [**T. rugosum*; OD] [= *Niäa* LEA, 1836; *Naia* SWAINSON, 1840; *Niaea* MÖRCH, 1853; *Harmandia* ROCHEBRUNE, 1881]. Sub-rhomboidal, heavy, slightly inflated, narrower and winged in front, with posterodorsal wing; posterior slope commonly double; beaks with strong, nearly radial sculpture, central ribs coalescing below, whole continuing as strong, radial, and zigzag ridges over most of disc; periostracum thick,

greenish when young, brownish or blackish when old; 2 or more short, compressed cardinals in each valve, becoming subdivided into denticles; 1 lamellar tooth in RV and 2 in LV. *Tert.-Rec.*, S.Am.

T. (Triplodon). Posterodorsal wing well developed. *Tert.-Rec.*, S.Am.—FIG. D53,2. **T. (T.) rugosus*, Rec.; 2a,b, LV ext., RV int., $\times 0.5$ (Sowerby).

T. (Triquetrana) SIMPSON, 1900 [**Unio stevensi* LEA, 1871; OD]. Compressed, with feebly de-

veloped posterior wing. *Rec.*, S.Am.—FIG. D53, 1. **T. (T.) stevensi* (LEA); RV ext., $\times 0.8$ (535).

Family MUTELIDAE Swainson, 1840

Shell mostly unsculptured; beaks smooth or faintly corrugated, without well-defined remains of embryonic shell; hinge with cardinals only or edentulous, few with secondary taxodont dentition; nacre soft, richly tinted, pallial line rarely with slight posterior sinus. Labial palps large, anal and superanal openings not separated; mantle generally closed behind into separate branchial and anal siphons; marsupium occupying inner gills; lasidium larva composed of three segments, median one bearing single shell. ?*Trias.*, *Cret.-Rec.*

Mutela SCOPOLI, 1777 [**Mytilus dubius* GMELIN, 1791; OD] [= *Purpurina* FÉRUSAC, 1826; *Spatha* LEA, 1838; *Calliscapha* SWAINSON, 1840; *Mutelina* BOURGUIGNAT, 1885; *Utela* MOORE, 1898; *Pseudomutela* SIMPSON, 1900]. Elongate, oblong to subtriangular, smooth, with low, unornamented beaks; posterior ridge rounded; periostracum moderately glossy, rayless; hinge straight, commonly with faint vestiges of denticles. *Cret.-Rec.*, Afr.-?Eu.

M. (Mutela). Posterior ridge low and smooth. *Cret.-Rec.*, Afr.—FIG. D54,8. **M. (M.) dubia* (GMELIN), *Rec.*; *8a,b*, LV ext., both valves dorsal, $\times 0.5$ (140).

M. (Chelidonopsis) ANCEY, 1887, [**Chelidonura arietina* ROCHEBRUNE, 1886 (= *Spatha hirundo* MARTENS, 1881); OD] [= *Chelidonura* ROCHEBRUNE, 1886 (non A. ADAMS, 1850); *Chelidoneura* GERMAIN, 1908]. Elongate, thin, gaping on anterior basal part, winged anteriorly along dorsal margin; posterior ridge acute, developing distally into tube; marked internally by deep furrow. *Rec.*, Afr.—FIG. D54,1. **M. (C.) hirundo* (MARTENS); RV ext., $\times 0.5$ (Pilsbry & Bequaert).

M. (Moncetia) BOURGUIGNAT, 1885 [**Moncetia anceyi*; OD] [= *Monoetia* PAETEL, 1890]. Oblong, with blunt ends, very much compressed and flattened; periostracum dull; hinge with single blunt tuberculose cardinal tooth in RV; beak sculpture unknown. *Rec.*, Afr.—FIG. D54,10. **M. (M.) anceyi* (BOURGUIGNAT); LV ext., $\times 1$ (Bourguignat).

Anodontites BRUGUIÈRE, 1792 [**A. cristata*; OD] [= *Patularia* SWAINSON, 1840; *Glabaris* GRAY, 1847; *Haplothaerus* CONRAD, 1847; *Euryanodon* CROSSE & FISCHER, 1894; *Styganodon* MARTENS, 1900; *Pachyanodon*, *Scolianodon* MARTENS, 1900; *Anodontites* MARSHALL, 1925; *Glabris* PRASHAD, 1932]. Rounded to elongate, inflated, moderately

heavy; beaks full, smooth, periostracum smooth or clothlike, rarely rayed faintly; hinge edentulous, hinge line straight or slightly curved; lunule distinct and large. *Tert.-Rec.*, S.Am.-C.Am.

A. (Anodontites). Rounded to elliptical; posterior ridge low or wanting. *Tert.-Rec.*, S.Am.-C.Am.—FIG. D54,5. **A. (A.) cristatus*, *Tert.*; RV ext., $\times 0.5$ (Marshall).

A. (Lamproscapha) SWAINSON, 1840 [**Anodon ensiformis* SPIX, 1827; SD HERRMANNSEN, 1846] [= *Virgula* SIMPSON, 1900]. Moderately heavy to heavy, very elongate, straight to falcate, rounded in front, pointed behind at posterior base, where high, sharply defined posterior ridge ends and above which it is somewhat truncated; beaks low; periostracum green to olive. *Rec.*, S.Am.—FIG. D54,4. **A. (L.) ensiformis* (SPIX); RV ext., $\times 0.4$ (140).

A. (Ruganodontites) MARSHALL, 1931 [**A. colombiensis* MARSHALL, 1921; OD]. Elongate, thick, usually somewhat falcate, with broad, shallow depression running from beaks to middle of ventral margin; periostracum thick, microscopically striate radially, much wrinkled, as also is underlying calcareous portion of shell; wrinkles obscurely divided into narrow, gradually widening rays extending from beaks to margin; nacre greenish-livid. *Rec.*, S.Am.—FIG. D54,3. **A. (R.) colombiensis*; RV ext., $\times 0.8$ (585).

Aspatharia BOURGUIGNAT, 1885 [**Margaritana vignouana* BERNARDI, 1859 (= *Anodonta rugifera* DUNKER, 1858); OD]. Oblong or oval; hinge plate essentially edentulous, abruptly terminated behind by deep triangular escutcheon but commonly low, blunt, toothlike prominence under beak of LV. *Pleist.-Rec.*, Afr.

A. (Aspatharia). Elongate, rhomboid, somewhat compressed, with full rounded posterior ridge from which curved rows of fine broken corrugations radiate; periostracum dark olive, wrinkled, rayless; beaks marked by corrugations that diverge as very broad inverted V's; hinge edentulous, in some shells with low, slightly elevated ridge in LV in front of beak; nacre bluish-green. *Rec.*, Afr.—FIG. D54,6. **A. (A.) rugifera* (DUNKER); LV ext., $\times 0.8$ (Reeve).

?**A. (Arthropteron)** ROCHEBRUNE, 1905 [**A. ouassouloui*; OD]. Oval, smooth, moderately convex; lunule large, narrowly lanceolate; beak sculpture unknown. [Subgenus of dubious validity.] *Rec.*, Afr.—FIG. D54,7. **A. (A.) ouassouloui*; both valves dorsal, $\times 0.7$ (Rochebrune).

A. (Chambardia) BOURGUIGNAT, 1890 [**C. letourneuxi*; SD HAAS, 1957] [= *Spathella* BOURGUIGNAT, Dec. 1885 (non T. HALL, Nov. 1885); *Spathopsis* SIMPSON, 1900; *Leptospatha* ROCHEBRUNE & GERMAIN, 1904; *Mitriodon* ROCHEBRUNE, 1904]. Long elliptical, compressed; beaks rather low, with short, concentric waves; surface smooth or rarely with corrugations on or near

posterior slope; lunule narrow, its border slightly higher in RV; faint compressed tooth in front of beak in LV hinge fitting into depression in RV; beak cavities shallow. *Pleist.-Rec.*, Afr.—FIG. D54,13. *A. (C.) rubens* (LAMARCK), *Rec.*; 13a,b, LV ext., RV int., $\times 0.4$ (140).

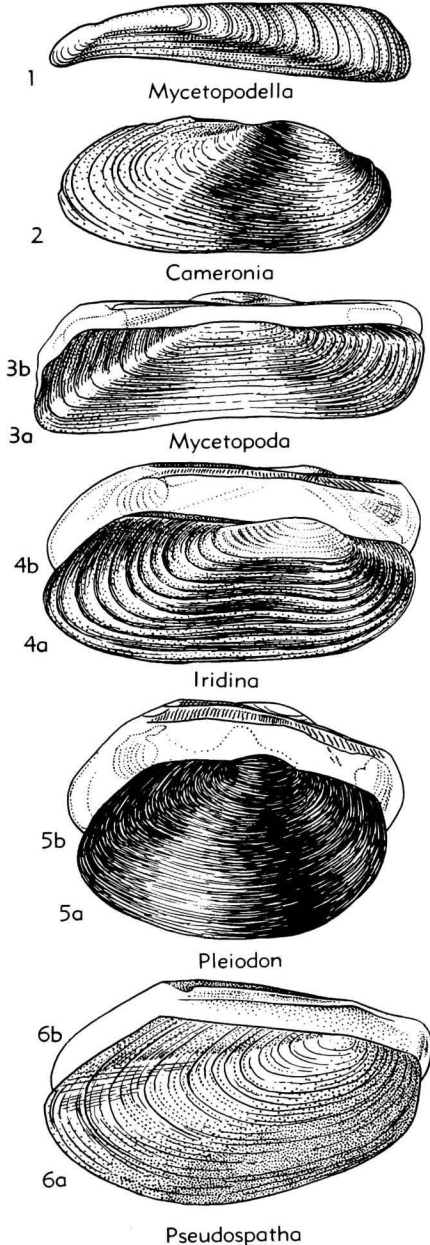


FIG. D55. Mutelidae (p. N464-N466).

Diplodontites MARSHALL, 1922 [**D. cooki*; OD]. Elliptical, moderately thick; beaks elevated; lunule triangular; periostracum clothlike, dull, yellowish-olive, with 10 radiating, greenish stripes on posterodorsal area; hinge with hinge plate; RV with 3 cardinals, anterior tooth strongest, posterior poorly differentiated; LV with 3 cardinals, anterior almost obsolete, middle triangular and very large, posterior long and low; socket between 1st and 2nd cardinal very deep. *Rec.*, S.Am.—FIG. D54, 9. **D. cooki*; 9a,b, RV ext., LV int., $\times 1$ (581).

Fossula LEA, 1870 [**Monocondylaea fossiculifera* D'ORBIGNY, 1835; OD] [= *Fossicula* MARSHALL, 1925]. Obovate, inflated, heavy, with rather high beaks and low posterior ridge; periostracum olive-brown, somewhat smooth, slightly rayed in some; hinge with irregular tooth in LV under beak, followed posteriorly by cavity and 2 irregular teeth separated by cavity under beak of RV; teeth and cavities somewhat pitted and partly covered with brown periostracum. *Rec.*, S.Am.—FIG. D54,12. **F. fossiculifera* (D'ORBIGNY); 12a,b, LV ext., RV int., $\times 0.5$ (140).

Haasica STRAND, 1932 [**Plagiodon balzani* IHERING, 1893; OD] [= *Marshalliella* HAAS, 1932 (non KIEFFER, 1913; nec POPPIUS, 1914)]. Externally like *Monocondylaea*; hinge plate with high narrow cardinal in RV, separated from low denticle behind by cuneiform groove; preumbonal callosity in RV, divided from high narrow tooth by narrow deep furrow which extends under beak; beak cavities deep, somewhat compressed. *Rec.*, S.Am.—FIG. D54,11. **H. balzani* (IHERING); 11a-d, RV ext., LV int., RV int., both valves dorsal, $\times 1$ (Haas).

Iheringella PILSBRY, 1893 [**Plagiodon isocardioides* LEA, 1856; OD] [= *Plagiodon* LEA, 1856 (non DUMERIL, 1841)]. Solid, inflated, rounded to subtriangular, with posterior ridge; beaks high, curved inward and forward, without sculpture; periostracum dull olive, clothlike; hinge teeth imperfectly developed, nodose or broken into denticles, irregular tooth in LV under beak, bifid in some and 2 in RV with intervening socket under beak. *Rec.*, S.Am.—FIG. D54,2. **I. isocardioides* (LEA); 2a,b, RV ext., LV int., $\times 1$ (497).

Iridina LAMARCK, 1819 [**I. exotica*; OD] [= *Platiris* LEA, 1838; *Platyris* L. AGASSIZ, 1846; *Eufira* GISTEL, 1848; *?Iridina* CONRAD, 1853; *Euphira* PAETEL, 1875]. Heavy, oblong or oval, with strongly developed hinge plate set with many short taxodont teeth. *?Cret.*, S.Am. (Brazil); *U. Plio.* or *Pleist.-Rec.*, ?S.Am.-Afr.

I. (Iridina). Elongate; teeth small and very numerous throughout length of heavy hinge plate which bears low prominence under beak of LV. *Rec.*, Afr.—FIG. D55,4. **I. (I.) exotica*; 4a,b, RV ext., LV int., $\times 0.3$ (140).

I. (Cameronia) BOURGUIGNAT, 1879 [**Iridina spekei* WOODWARD, 1859; OD]. Oblong, hinge

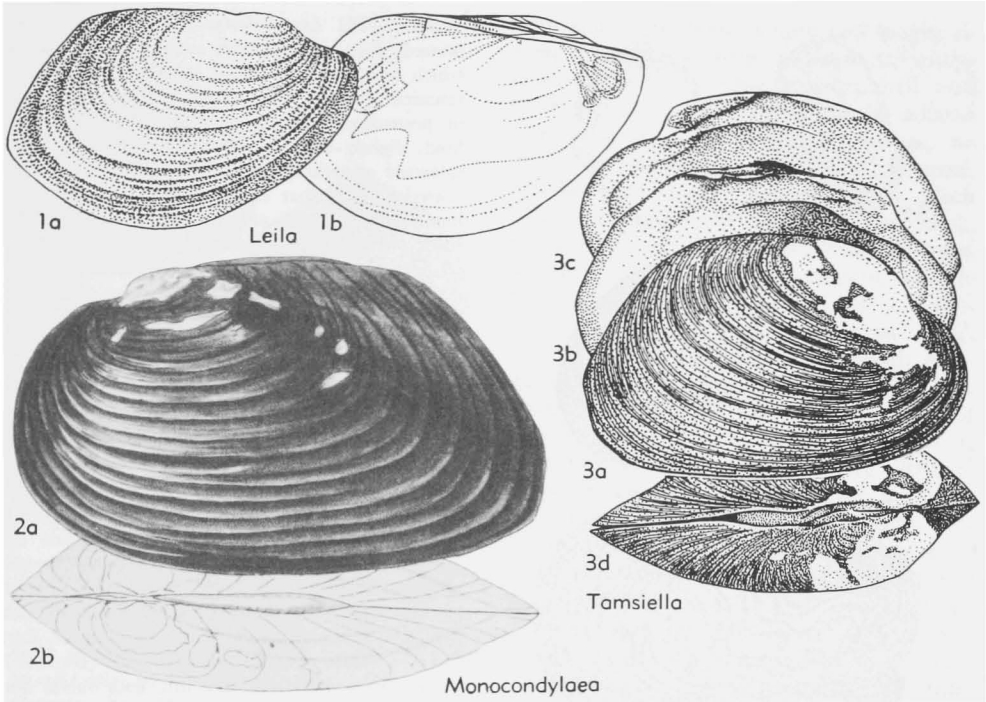


FIG. D56. Mutelidae (p. N465-N466).

plate constricted under beaks, teeth weak or obsolete anteriorly. *Rec.*, Afr.—FIG. D55,2. **I. (C.) spekei* WOODWARD; RV ext., $\times 0.3$ (Pilsbry & Bequaert).

I. (Pleiodon) CONRAD, 1834 [**Pleiodon macmurtrei* (= *Iridina ovata* SWAINSON, 1832); OD] [= *Pleiodon* SWAINSON, 1840; *Pliodon* L. AGASSIZ, 1846]. Oval, teeth and hinge plate strongly developed in front of beaks. ?*Cret.*, S.Am. (Brazil); *U. Plio.* or *Pleist.-Rec.*, Afr.-?S.Am.—FIG. D55,5. **I. (P.) ovata* SWAINSON, *Rec.*; 5a,b, RV ext., LV int., $\times 0.3$ (140).

Leila GRAY, 1840 [**Anodonta blainvilleana* LEA, 1834; OD] [= *Columba* LEA, 1834 (non LINNÉ, 1758)]. Large, obovate, inflated, with straight dorsal margin produced into slight wings before and behind, bluntly pointed posteriorly and somewhat truncate above, with faint posterior ridge; beaks smooth, full; periostracum olive, generally smooth; hinge edentulous; beak cavities rather shallow; pallial line commonly showing slight posterior sinus. *Rec.*, S.Am.—FIG. D56,1. **L. blainvilleana* (LEA); 1a,b, RV ext., LV int., $\times 0.6$ (140).

Monocondylaea D'ORBIGNY, 1835 [**M. paraguayana*; OD] [= *Aplodon* SPIX, 1827 (non RAFINESQUE, 1818); *Monocondyla* GRAY, 1840; *Monocondylea*

D'ORBIGNY, 1844; *Monocondylus* MORELET, 1866; *Monocondyloia* PAETEL, 1875; *Monocondylaea* CLESSIN, 1876; *Spixiconcha* PILSBRY, 1893]. Rounded to ovate, rather heavy with low posterior ridge; periostracum dull olive-green to olive-brown, clothlike; hinge with 2 irregular teeth under beak in LV and 2 in RV, interlocking with those of LV, all being somewhat tuberculate. *Tert.-Rec.*, S.Am.—FIG. D56,2. **M. paraguayana*, *Rec.*; 2a,b, LV ext., both valves dorsal, $\times 0.8$ (140).

Mycetopoda D'ORBIGNY, 1835 [**M. soleniformis*; OD] [= *Mycetopus* D'ORBIGNY, 1840]. Thin, elongate, truncate posteriorly, with low, posterior ridge and rather flat, smooth or slightly concentrically wrinkled beaks; periostracum smooth, lustrous, pale greenish-yellow or brownish, rayless; hinge line long, straight, edentulous or showing faint traces of fine denticles beneath the nacre; beak cavities shallow. Foot very long, developed at lower end into head or button. ?*Trias.*, *Rec.*, N. Am.-S.Am.—FIG. D55,3. **M. soleniformis*, *Rec.*; 3a,b, RV ext., LV int., $\times 0.3$ (140).

Mycetopodella MARSHALL, 1927 [**Mycetopus falcatus* HIGGINS, 1868; OD]. Very elongate, falcate, wide behind, narrow in front, abruptly descending, with swelling at anterior end; broad radial

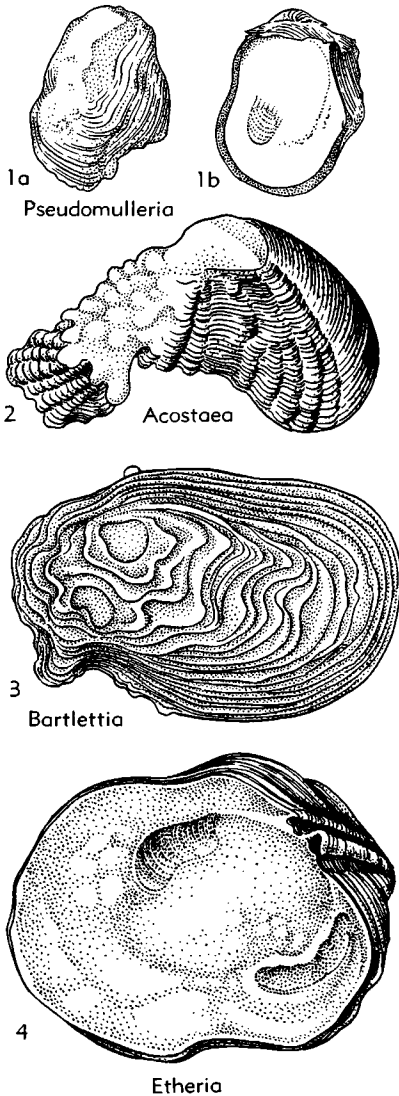


FIG. D57. Etheriidae (p. N466-N467).

constriction from anteriorly situated beaks to ventral margin; hinge edentulous, nearly straight except in front of beaks at lunule where it is slightly excavated; ligament very long; posterior ridge sharp, anterior ridge much more pronounced; periostracum dull, with numerous fine radiating striae, about 90 in 1 mm. *Rec.*, S.Am.—FIG. D55,1. **M. falcata* (HIGGINS); LV ext., $\times 0.5$ (582).

Pseudospatha SIMPSON, 1900 [**Spatha tanganyicensis* E. A. SMITH, 1880; OD] [= *Burtonia* BOURG-

UIGNAT, 1883 (*non* BONAPARTE, 1850)]. Compressed, thin, oblique, with straight dorsal margin which ends in small wing in front and behind; rounded and cut away at anterior base, produced in posterobasal region, gaping in front and behind, slightly twisted on its axis and usually bent sideward posteriorly; with low, commonly double posterior ridge that ends in biangulate point behind; beaks situated anteriorly, compressed, sculptured with faint irregular concentric ridges which continue over shell and at beaks commonly are rather sharply pustulose; periostracum yellowish-brown, delicately rayed in some; hinge rudimentary, one or more faint, compressed cardinals and single lamellar tooth in each valve; nacre coppery or purple, commonly rayed. *Rec.*, Afr.—FIG. D55,6. **P. tanganyicensis* (SMITH); 6a,b, RV ext., LV int., $\times 0.55$ (E. A. Smith).

Tamsiella HAAS, 1931 [**Monocondylaea tamsiana* DUNKER, 1858; OD]. Resembles *Monocondylaea*; hinge without hinge plate; low cardinal in RV bordered behind by shallow furrow which terminates at beak; adjoining part of dorsal margin thickened callosity; shallow groove in LV in front of beak, followed under beak by feeble denticle which is bordered behind by shallow furrow. *Rec.*, S.Am.—FIG. D56,3. **T. tamsiana* (DUNKER); 3a-d, LV ext., RV int., LV int., both valves dorsal, $\times 1$ (Haas).

Family ETHERIIDAE Swainson, 1840

Shell nacreous, regular and free when young (orthothetic), becoming irregular, attached by surface of one valve when adult (pleurothetic); shell substance foliaceous or lamellar, covered by thick, olive-colored, commonly deciduous periostracum; hinge edentulous; anterior adductor muscle in some forms reduced. Foot obsolete in adults. *Plio.-Rec.*

Etheria LAMARCK, 1807 [**E. semilunata* LAMARCK, 1807; SD SWAINSON, 1840 (= *E. elliptica* LAMARCK, 1807)] [= *Etheriigenus* RENIER, 1807; *Aetheria* OKEN, 1818; *Etherea* SCHWEIGER, 1820; *Ethaeria* L. AGASSIZ, 1839]. Irregular, inequivalve, adherent by beak and tubular prolongations of one of valves; substance of shell foliaceous; hinge margin curved, edentulous; ligament external, tortuous, partially sunk in groove in dorsal margin of attached LV. *Plio.-Rec.*, Afr.-Ind.O. (Madag.).—FIG. D57,4. **E. semilunata*, *Rec.*; LV int., $\times 0.4$ (Sowerby).

Acostaea D'ORBIGNY, 1851 [**Mulleria lobata* FÉRUS-SAC, 1823; OD] [= *Mulleria* FÉRUS-SAC, 1823 (*non* *Müllera* LEACH, 1814); *Mulleria* PHILIPPI, 1853; *Acostea* GRAY, 1854; *Eumulleria* ANTHONY, 1907].

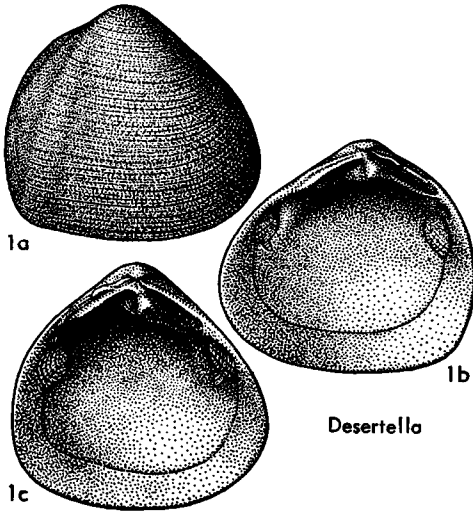


FIG. D58. Desertellidae (p. N467).

Shell of adults irregular, heavy, inequivalve, attached only by RV; periostracum thick; beaks elongate; ligament in marginal groove; young shell regular, free, shaped like *Anodontites*. Both anterior and posterior adductor muscles in young free, anterior adductor obsolete in adult attached state. *Rec.*, S.Am., India.

A. (Acostaea). With narrow, anterior projection including embryonic shell. *Rec.*, S.Am.—FIG. D57,2. **A. (A.) lobata* (FÉRUSSAC); RV ext., $\times 0.6$ (Sowerby).

A. (Pseudomulleria) ANTHONY, 1907 [**Mulleria dalyi* E. A. SMITH, 1898; OD] [= *Pseudomulleria PILSBRY*, 1911]. Irregularly quadrate, without decided anterior projection; anterior adductor muscle obsolete. *Rec.*, India.—FIG. D57,1. **A. (P.) dalyi* (SMITH); 1a,b, RV ext., LV int., $\times 0.5$ (E. A. Smith).

Bartlettia A. ADAMS, 1866 [**Etheria stefanensis* MORICAND, 1856; OD] [= *Bartlettia* PAETEL, 1875; *Rochanaia* MORRETES, 1945]. Solid, elongate, loosely attached or not at all; beaks low, shell surface with irregular rough zones of growth, with triangular escutcheon behind strong ligament, latter marginal and not sunk in groove. *Rec.*, S.Am.—FIG. D57,3. **B. stefanensis* (MORICAND); LV ext., $\times 0.5$ (Sowerby).

?Family DESERTELLIDAE Dechaseaux, 1946

[Materials for this family prepared by L. R. Cox]

Shell medium-sized, equivalve, subequilateral, subtrigonal, but with posterior end

high and subtruncate; length and height almost equal; blunt diagonal ridge delimiting relatively narrow posterior area; shell wall thick; umbones moderately well inflated and incurved, slightly opisthogyrous; no lunule or escutcheon; ligament external, opisthodontic; nymph short and thick. Each valve with two teeth diverging from beak, LV anterior and RV posterior almost equal in size, very stout and prominent, bluntly pointed, received in deep recesses; LV posterior and RV anterior also almost equal, less prominent than other two, each elongated and close to margin, and each received in recess between major tooth of opposite valve and margin adjacent to it; dentition of valves thus appearing identical when interior of shell is viewed; adductor scars subequal, placed rather dorsally, posterior ones almost superficial, each with small accessory scar above it, anterior one slightly impressed, each with low buttress-like thickening of shell wall on its posterior side in some specimens, and small accessory scar on its posteroventral side; pallial line entire. Surface with fine concentric striae. Original shell structure (whether nacreous or not) unknown. [Habitat nonmarine.] *L.Cret. (? Alb.)*.

Desertella MUNIER-CHALMAS in HAUG, 1905 [**D. joureaui*; M]. Characters of family. *L.Cret.*, N. Afr.—FIG. D58,1. **D. joureaui*, Fort Flatters, N.Afr. (Alg.); 1a-c, RV ext., RV int., LV int., $\times 1.3$ (Cox, n).

?Family PACHYCARDIIDAE Cox, 1961

[Materials for this family prepared by L. R. Cox]

Ovate, trapeziform or cuneiform, inequilateral, equivalve, of weak to moderately strong convexity; ligament external, opisthodontic. Subumbonal ("cardinal") teeth strong to more or less obsolete, not more than two in each valve; posterior "laterals" always present, although weak in some forms, extending in more typical genera below nymph almost to beak, anterior "laterals" present or absent; adductor scars subequal, pallial line simple; interior of shell originally nacreous in some, possibly in all, genera. Surface smooth or (rarely) with concentric ornament. [Fresh-water, brackish-water and marine.] *Perm.-U.Trias.*, ?*L. Jur. (Lias.)*.

The more typical genera of this family were formerly included in the Cardiniidae, but they are not true heterodonts like *Cardinia*. Evidence of an originally nacreous interior has been found in specimens of *Trigonodus*.

Pachycardia HAUER, 1857 [**P. rugosa*; OD] [= *Pacycardia* MOJSISOVICS, 1879 (*nom. null.*)]. Medium-sized, cuneiform, strongly inequilateral, well inflated, some specimens substrate and weakly carinate posteriorly; umbones prominent, well incurved, strongly prosogyrous; lunule wide, cordiform, distinctly bordered; no escutcheon; ligament external. LV with stout, triangular main cardinal tooth separated by broad recess from weaker, variable anterior cardinal close to lunular margin; and with elongate posterior lateral which is parallel to margin and projects rather prominently near its posterior end; RV with stout, variable, commonly grooved, anteriorly placed cardinal and elongate posterior lateral which extends to below beak and is received in recess above lateral of other valve. Surface smooth. [Brackish-water or marine.] *M.Trias.-U.Trias.*, Eu.(S.Alps-Balkans).—FIG. D59,3. **P. rugosa*, U.Trias.(Carn.); *3a,b*, Yugo.; LV ext., LV int., $\times 1$ (950); *3c*, S.Tyrol, RV int., $\times 1$ (Broili, 1904).

?**Cardinioides** KOBAYASHI & ICHIKAWA, 1952 [**C. japonicus*; OD]. Medium-sized, trigonally ovate, more or less inequilateral; moderately inflated, some forms with weak posterodorsal carination; no lunule or escutcheon. LV with large, irregularly triangular, commonly grooved, mesially placed cardinal tooth and short, remote posterior lateral; RV with 2 weak, widely divergent cardinal teeth, bordering recess for main tooth of other valve, and posterior lateral which originates below hinge plate and increases in strength posteriorly. Surface smooth except for growth threads. [Marine.] ?*Perm.*, N.Afr.; *U.Trias.(Carn.)-L.Jur.(Lias.)*, Japan.—FIG. D59,5. *C. varidus* HAYAMI, Lias., Japan; *5a-c*, LV ext., LV int., RV int., $\times 1$ (Hayami, 1957 and Cox, n).

Kidodia COX, 1936 [**K. stockleyi*; OD]. Small, elongate-ovate, inequilateral, of feeble convexity. No cardinal teeth; LV with thin posterior lateral tooth occupying posterodorsal corner, RV with thin anterior lateral; between each of these teeth and dorsal margin is narrow, elongate recess for reception of projection of margin of opposite valve. [Fresh-water.] *Perm.(Karoo or Gondwana)*; E. Afr.-S.Am.(Arg.).—FIG. D59,2. **K. stockleyi*, Tanganyika; *2a,b*, RV int., LV int., $\times 2.2$ (178).

Trigonodus SANDBERGER in ALBERTI, 1864 [**T. sandbergeri*; SD STOLICZKA, 1871]. Medium-sized, ovate to trapeziform, strongly inequilateral, moderately inflated; no lunule or escutcheon; ligament external, but rather submerged in some

species. LV with stout, triangular, commonly grooved, main cardinal tooth separated by broad recess from anterodorsal margin (where presence of weak anterior cardinal is inconstant) and with 2 thin, elongate posterior laterals; RV with stout, triangular, commonly grooved, anteriorly placed cardinal tooth and elongate posterior lateral which is received in recess between 2 laterals of other valve; some species with internal radial buttress which passes from umbo to anterior side of posterior adductor scar. Surface smooth or concentrically ridged. [Brackish-water or marine.] *M.Trias.-U.Trias.*, Eu.-Asia-N. Am.-N. Z.—FIG. D59,4a,b. **T. sandbergeri*, U.Trias.(Lettenkohle), Ger.; *4a,b*, LV int., RV int., from wax impressions, $\times 1$ (Sandberger, 1864).—FIG. D59,4c,d. *T. carniolicus* BITTNER, U.Trias.(Carn.), Yugo.; LV ext., LV int., $\times 1$ (950).—FIG. D59,4e. *T. problematicus* (KLIPSTEIN), U.Trias.(Carn.), Yugo.; RV int., $\times 1$ (950).

Unionites WISSMANN, 1841 [**U. muensteri*; OD] [= *Anoplophora* ALBERTI, 1864 (*non* HOPE, 1840); *Uniona* POHLIG, 1880 (type, *U. leuckarti*, = *Venulites donacinus* VON SCHLOTHEIM, 1820; SD COX, 1961); *Anodontophora* COSSMANN, 1897 (*pro* *Anoplophora* ALBERTI) (type, *Myacites fassaensis* WISSMANN in MÜNSTER, 1841; SD STOLICZKA, 1871); *Anaplophora* HEALEY, 1908 (*nom. null.*); *Anoplophoria* ZELLER, 1908 (*nom. null.*); *Unionina* DIENER, 1923 (*nom. null.*); *Anodontophora* PARONA, 1928 (*nom. null.*)]. Small, ovate rectangular or trapeziform, inequilateral, of feeble to moderate convexity; lunule and escutcheon present or absent; ligament external, opisthodontic; nymphs not prominent. Submarginal teeth, if distinguishable at all, usually weak and amorphous, one in each valve; anterior laterals usually absent; one distinguishable in RV in some forms; weak, elongate posterior lateral present in both valves, extending almost to beak, that of LV formed by lamina projecting from margin; shorter and more remote lateral may occupy posterodorsal angle of valves; some species with weak internal radial buttress on posterior side of anterior adductor scar. Surface smooth. [Brackish-water or marine.] *L.Trias.-U.Trias.*, Eu.-Asia-Arctic O.(Spitz.-Bear I.-N.Z.).—FIG. D59,1a-c. **U. muensteri*, U.Trias.(Carn.), S.Tyrol; RV ext., RV hinge, LV hinge, all $\times 1$ (58).—FIG. D59,1d. *U. rectus* (GÜMBEL), U.Trias.(Carn.), N.Tyrol; RV int., $\times 1.3$ (1001).

?Family ACTINODONTOPHORIDAE Newell, new family

[Material for this family prepared by N. D. NEWELL]

Shell elongate to subelliptical; beaks prosogyre, located about one-fourth of shell length from anterior margin; lunule and escutcheon distinct; surface smooth or orna-

mented with radial costae, and (in some) with concentric undulations; ligament external, opisthodetic, nymphs elongate; an-

terior adductor stout, strongly impressed, with myophoric buttress, posterior adductor impression larger, shallow; pedal retractor

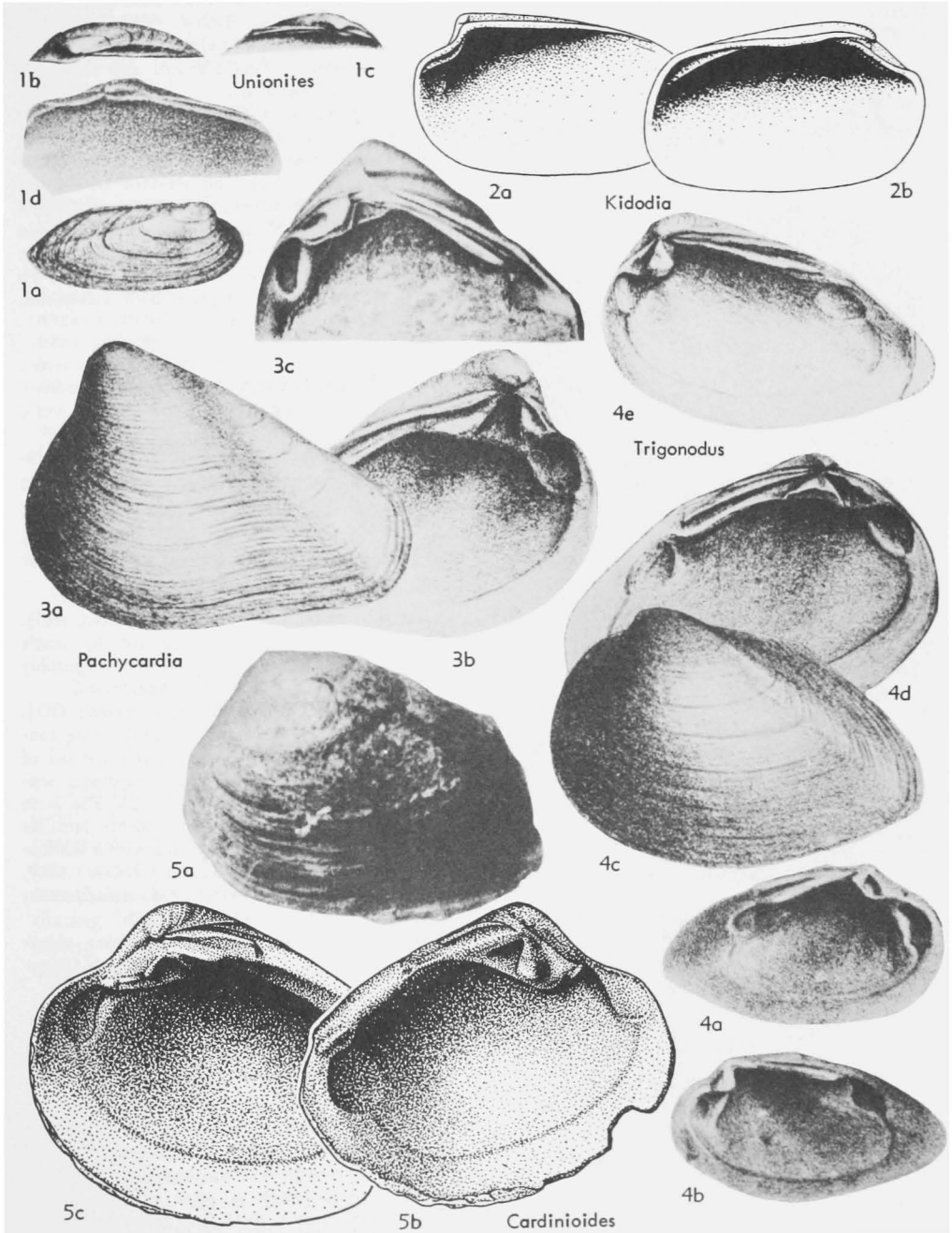


FIG. D59. Pachycardiidae (p. N468).

scar deep, situated just behind buttress, cardinal teeth numerous, elongate, radiating from beaks; one or more strong lateral teeth in each valve, that of the RV lying in deep furrow below lateral tooth of LV. *Perm.-U.Trias.*

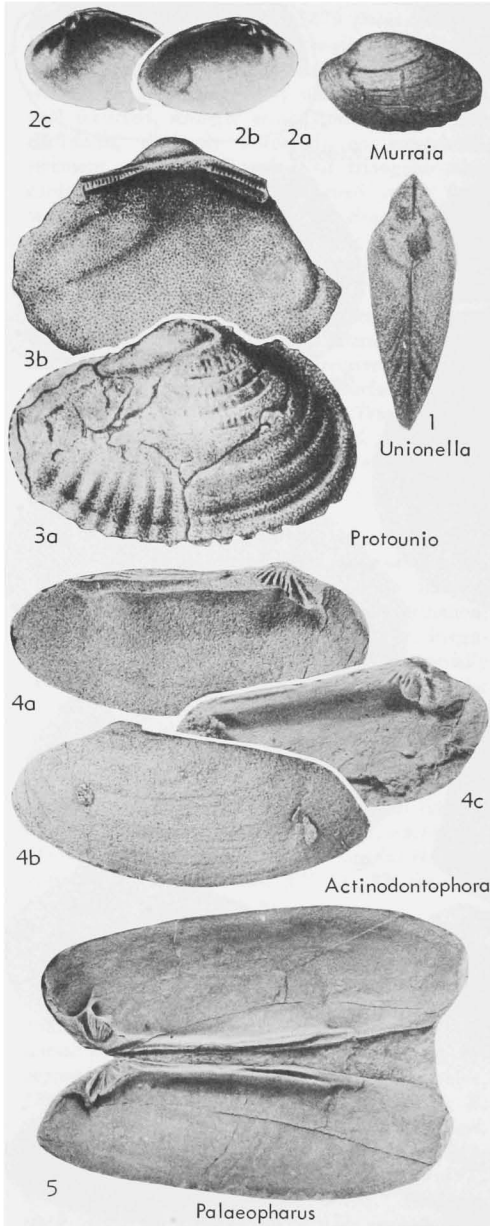


FIG. D60. Actinodontophoridae (4-5); Family Uncertain (1-3) (p. N470-N471).

Actinodontophora ICHIKAWA, 1951, p. 327 [**A. katsurensis*; OD]. With several radial cardinals anterior elements of which are relatively long and massive, grading posteriorly to short and thin; anterior tooth of cardinal series occurring in RV. *Perm.*, Japan.—FIG. D60,4. **A. katsurensis*, Kanakura F.; 4a, latex replica int. (holotype), $\times 1$; 4b,c, latex replicas LV ext. and int., $\times 1$; (Nakazawa & Newell, n).

Palaeopharus KITTL, 1907, p. 34 [**P. scheii*; SD DIENER, 1915, p. 229]. Similar to *Actinodontophora*, but first and last teeth of cardinal series relatively massive, long and elevated with intervening denticles bundled in single broad pseudo-cardinal tooth in LV and corresponding socket in RV. *U.Trias.*, Bear Is.(Arctic)-Ellesmereland-Japan.—FIG. D60,5. *P. paucicostatus* NAKAZAWA, N₃ Nabae F., Japan; latex replica, both valves, int. molds, $\times 1$ (Nakazawa, n).

Superfamily and Family UNCERTAIN

Some fossil pelecypods of doubtful relationships, apparently distantly related to the Unionacea, are included here. Since they are known by their original descriptions, the authors' diagnoses are either quoted or given in a somewhat condensed form.

Bisulcus HITCHCOCK, 1865 [**B. undulatus*; OD]. Continuous paired grooves separated by single ridge, as trail of fresh-water bivalve (possibly primitive unionid). *Trias.*, USA (Mass.).

Murraia RUSSELL, 1932 [**M. naiadiformis*; OD]. Small thin, slightly gaping, LV slightly more convex than RV; beaks broad, placed at about 0.3 of shell length; RV with 2 divergent cardinals, separated by deep subtrigonal socket; LV also with 2 cardinals, anterior more prominent; lamellar teeth apparently lacking; pallial line with a shallow sinus. [May not be a unionacean.] *L.Cret.(Alb.)*, N.Am.(Can.).—FIG. D60,2. **M. naiadiformis*; 2a-c, LV ext., int., RV int., $\times 1$ (807).

Nakamuraia SUZUKI, 1943 [**Leptesthes chingshanense* GRABAU, 1923; OD]. *L.Cret.*, N.China-S.Korea. [NEWELL]

?*Protounio* MARTINSON, 1953 [**P. cardiiformis*; OD]. Shell big, oval, obese, with thick valves; umbo wide, almost always situated centrally, turned slightly forward and inside, sloping in some; posterior half of shell low-ribbed, hardly visible, ribs running radially from above to below, almost vanishing on anterior half of shell, radial ribs crossed by fine, hardly visible concentric striation which is more obvious toward edge of shell; hinge peculiarly schizodont, hinge line curved, cardinal teeth absent; 2 laterals in

LV both in front and behind umbo, teeth showing fine perpendicular striation; 1 lateral in RV (?both in front and behind umbo); anterior laterals shorter and thicker than posterior ones; ventral margin scalloped, interior face covered by mother-of-pearl. *U.Cret.*, Asia (Mongol.).—FIG. D60,3. **P. cardiiiformis*; 3*a,b*, RV ext., LV int., $\times 0.8$ (590). [Considered by Cox to be a synonym of *Trigonioides*.]

?*Trisulcus* HITCHCOCK, 1865 [**T. laqueatus*; OD]. Like *Bisulcus* but with 3 grooves separated by ridges which may show slight protuberances. *Trias.*, USA (Mass.).

Unionella ETHERIDGE, 1888 [*non Unionella* HAAAS, 1913] [**U. bowralensis*, 1888; OD]. Quadrangular to irregularly trapeziform, equivalve, inequilateral; umbones depressed and continuous, eroded; ligament external; anterior adductor impression single, bounded posteriorly by oblique ridge; posterior adductor impression single and inconspicuous; supplementary umbonal muscular scar pitlike, either forming circular line or clustered; pallial line simple. *U.Trias.* (*Wianamatta Ser.*), New S. Wales.—FIG. D60,1. **U. bowralensis*; both valves, dorsal, $\times 1$ (299).

Order TRIGONIOIDA Dall, 1889

[*nom. correct.* NEWELL, 1965 (ex order Trigoniacea DALL, 1889)] [Diagnosis by N. D. NEWELL]

Characters of superfamily Trigoniacea.
?M.Ord., *Dev.-Rec.*

Superfamily TRIGONIACEA Lamarck, 1819

[*nom. transl.* DALL, 1900 (ex "les trigonées" LAMARCK, 1819)] [Diagnosis by L. R. COX]

Shell equivalve; trigonal; ovate or rhomboidal; posteriorly truncate or subtruncate; posterior slope carinate or subcarinate; surface smooth or ornamented; ligament external, short, opisthodontic. Hinge teeth radiating from beak; left valve typically with strong median tooth and weaker one on each side; right valve typically with two main teeth received in recesses between those of left; additional and weaker teeth may be present, however, or some of teeth mentioned may be obsolete; adductor scars small, placed close to hinge teeth, anterior scar in each valve bordered on its inner side in many forms by buttress which passes under adjacent tooth or part of hinge plate; more rarely, similar buttress may border posterior adductor scar; pallial line entire except in Scaphellinidae; ostracum nacreous.

[This diagnosis does not apply to the Trigonioididae, reference of which to the superfamily is very doubtful.] *?M.Ord.*, *Dev.-Rec.*

Authorities have differed in their application of BERNARD's hinge teeth notation to shells of this superfamily. While DOUVILLÉ has regarded all teeth as cardinals, the three main ones of the left valve being (from rear to front) 4*b*, 2 and 4*a*, and the two main teeth of the right valve 3*b* and 3*a*, OHNER has suggested that they include homologues of laterals (Fig. D61). It has been decided not to adopt any system of tooth notation in the present account. Several well-known monographs are devoted to members of this superfamily, particularly the family Trigoniidae, and allusion may be made to certain descriptive terms which have come into fairly general use. The ridge which passes diagonally from the umbo to the posteroventral corner in each valve is termed the "marginal carina," the main part of the surface lying anterior to it, the "flank," and the part behind it, the "area." Dorsally, the area may be separated from the escutcheon (if present) by a second ridge, the "escutcheon carina."

The anatomical characters are known only in *Neotrigonia*, the sole surviving genus of the superfamily, and are referred to briefly under the family Trigoniidae.

?Family LYRODESMATIDAE Ulrich, 1894

[Materials for this family prepared by N. D. NEWELL & AURÉLE LA ROCQUE]

Shell small, subtrigonal, rounded in front, acuminate posteriorly and commonly obliquely truncate; umbonal fold rounded or carinate; beaks small; hinge plate semi-circular, with several angular, crenulated teeth radiating more or less symmetrically from beneath the beak. *M.Ord.-U.Ord.*

Lyrodesma CONRAD, 1841, p. 51 [**L. planum*; M] [=?*Lyronucula* FISCHER, 1886, p. 987 (type, *Lyrodesma gallicum* MUNIER-CHALMAS, 1876; M] [=?*Pseudaxinus* SALTER, 1864 (type, *Anodontopsis securiformis* M'COY, 1851)]. Anterior surface smooth; postumbonal slope with faint radial costellae; sinupalliate. *M.Ord.-U.Ord.*, E.N.Am.-Eu.—FIG. D62,1. *L. acuminatum* (ULRICH), M. Ord., USA (Cannon Falls, Minn.); 1*a,b*, RV ext., LV int., $\times 2$; 1*c*, RV hinge, $\times 3$ (929).

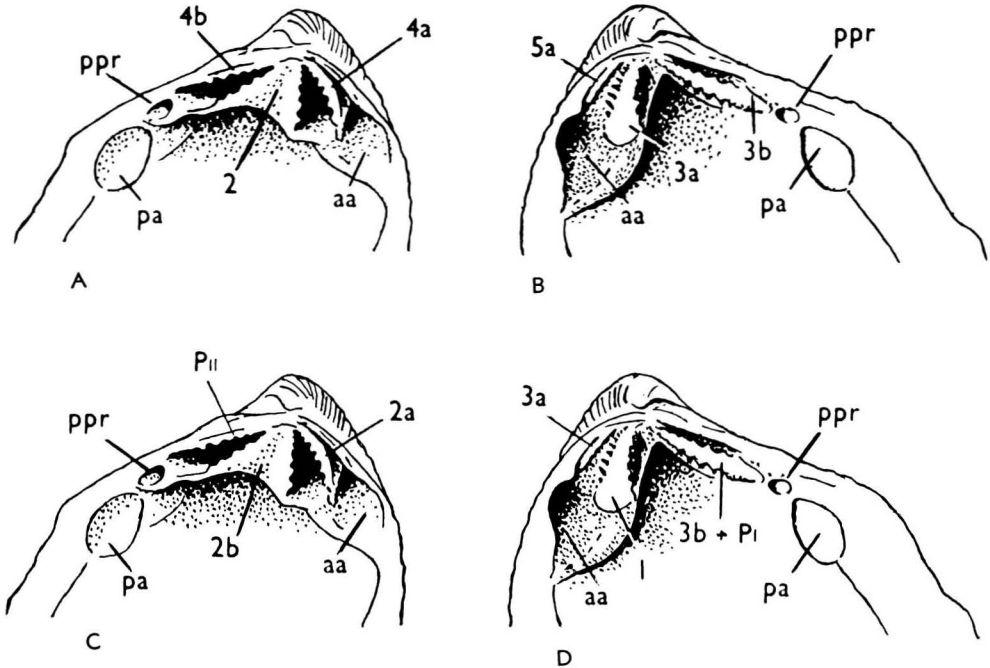


FIG. D61. *Trigonia* sp., showing alternative interpretations of trigoniacean dentition in terms of Bernard notation.

A,B, DOUVILLE's interpretation (more usual).
 C,D, ODHNER's interpretation.

Teeth of left valve: (A) 4b, 2, 4a; (C) PII, 2b, 2a.
 Teeth of right valve: (B) 3b, 3a, 5a; (D) 3b + PI,

1, 3a. [Explanation: aa, ant. adductor muscle scar; pa, post. adductor muscle scar; ppr, post. pedal retractor muscle scar.]

Family MYOPHORIIDAE Bronn, 1849

[nom. correct. COX, 1951 (pro Myophoriacae BRONN, 1849)]
 [Materials for this family prepared by L. R. COX]

Shell small to moderate in size, quadrate, ovate or subtrigonal, mostly diagonally carinate and posteriorly truncate; beaks usually but not always prosogyrous. Main tooth of left valve directed posteriorly, simple or bilobed; two main teeth of right valve asym-

metrically disposed, posterior one narrower and more elongate; these teeth may be smooth or transversely striated, but less strongly than in Trigoniidae; an additional and weaker tooth may be present on one or both sides of main tooth in left valve, and in right valve third, relatively weak tooth may lie anterior to two mentioned; anterior myophorous buttress present in some forms, its impression forming groove on internal molds; pallial line entire. Surface of shell smooth, or bearing radial or concentric, but only rarely oblique, costae; ornament of flank and posterior area similar in most but not all genera. *Dev.-U.Trias., ?L.Jur.*

Myophoria BRONN in ALBERTI, 1834, p. 54 [**Trigonellites vulgaris* VON SCHLOTHEIM, 1820, p. 192; SD HERRMANNSEN, 1847, p. 80] [= *Trigonellites* VON SCHLOTHEIM, 1820 (non PARKINSON, 1811); *Cryptina* DESHAYES in BOUÉ, 1835, p. 47

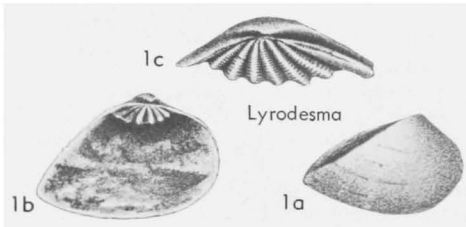


FIG. D62. Lyrodesmatidae (p. N471).

- (type, *C. raibeliana*); *Trigonella* HEHL, 1842 (non CONRAD, 1837); *Miophoria* BONI, 1935 (nom. null)]. Trigonally ovate, very inequilateral, diagonal or marginal carina pronounced; no escutcheon; flank with one to few narrow radial ribs, impersistent in some specimens, with smooth, commonly shallowly concave interspaces; area smooth or with impersistent ribs; left valve with median tooth strong, simple or obscurely bifid, anterior tooth moderately strong, marginal, and posterior tooth obscure; right valve with strong, triangular anterior tooth, bifid in some forms, but posterior tooth obscure; main teeth smooth or transversely striated, striation confined to umbonal end in some specimens; myophorous buttress well developed. *L.Trias.-U.Trias.*, Eu.-Asia-N.Afr.—FIG. D63,1. **M. vulgaris* (VON SCHLOTHEIM), M. Trias.(Muschelkalk), Ger.; 1a,b, RV ext. and int., $\times 2$; 1c, LV int., $\times 2$ (Hohenstein, 1913).
- Costatoria* WAAGEN, 1906, p. 393 [**Donax costata* ZENKER, 1833, p. 55; SD NAKAZAWA, 1960, p. 52]. Trigonally ovate to rhomboidal, moderately inequilateral; marginal carina more or less pronounced; escutcheon defined but small; flank with number of prominent, unevenly spaced radial ribs and smooth or concentrically striated interspaces; area smooth or with weak radial ribs; left valve with median tooth strong and simple, anterior tooth moderately strong, short, and posterior tooth thin, elongate, and marginal; right valve with anterior and posterior teeth moderately strong, subequal; sides of teeth transversely grooved in larger species; myophorous buttress present. *L.Perm.*, USA (Tex.-Wyo.); *U.Perm.*, Japan-Eu. (Alps); *L.Trias.-U.Trias.*, cosmop.—FIG. D63, 3a. *C. goldfussi* (ALBERTI), M.Trias.(Muschelkalk), Ger., LV ext., $\times 3.3$ (Hohenstein, 1913). —FIG. D63,3b,c. *C. whateleyae* (VON BUCH), U.Trias., S.Tyrol; 3b,c, RV ext. and int., $\times 1.6$ (58).
- ?*Cytherodon* HALL & WHITFIELD, 1873 [**Nuculites appressus* CONRAD, 1842; M]. Form and musculature similar to *Rhenania* and *Schizodus*, posteriorly obliquely truncate and posteroventrally acute, with well-defined, narrow umbonal carina; hinge poorly known, consisting of few cardinal teeth. *M.Dev.*, N.Am.(Ohio-Va.).
- Eoschizodus* COX, 1951, p. 369 [pro *Kefersteinia* NEUMAYR, 1891, p. 788 (non QUATREFAGES, 1865)] [**Megalodus truncatus* GOLDFUSS, 1837, p. 184] [=? *Curtonotus* SALTER, 1863, p. 494 (non STEPHENS, 1827); ?*Cyrtionotus* FISCHER, 1886, p. 996 (non LUCAS, 1844)]. Subtrigonal to ovate, smooth, subequilateral to strongly inequilateral, subtruncate or rounded posteriorly; umbones prosogyrous or orthogyrous; marginal carina well defined in some species, absent in others; no escutcheon; left valve with triangular, simple or bilobed median tooth, anterior tooth of moderate strength and posterior tooth narrow, marginal; right valve with anterior tooth stoutly triangular and posterior tooth elongate; teeth not striated; myophorous buttress absent or indistinct. *Dev.-Perm.*, cosmop.—FIG. D63,4. **E. truncatus* (GOLDFUSS), Dev., Ger.; 4a,b, LV ext. and int. hinge, $\times 1$; 4c, RV int. hinge, $\times 1$ (47).
- Gruenewaldia* WÖHRMANN, 1889, p. 215 [**Cardita decussata* VON MÜNSTER, 1837, p. 185; M] [= *Elegantinia* WAAGEN, 1906, p. 393 (obj.); *Trigomyphoria* KOBAYASHI, 1954, p. 66 (obj.)]. Rhomboidal, gibbose, very inequilateral, sharply truncate posteriorly; marginal carina prominent, commonly wide and blunt, with deep depression in front of it and corresponding sinus of ventral margin; escutcheon moderate in width, bordered by prominent carina; flank and area ornamented with concentric ridges, most closely spaced on area and antecarinal depression; radial riblets also present on flank in some species; left valve with simple, triangular median tooth, its apex separated by gap from margin in some specimens, anterior tooth short but only slightly weaker than median tooth, and posterior tooth obscure; right valve with strong tuberculiform or triangular anterior tooth and more elongate posterior tooth, fused together at proximal end in some specimens; teeth with strong transverse grooving; myophorous buttress inconspicuous. *M.Trias.-U.Trias.*, Eu.-Asia-Bear Is. —FIG. D63,2. **G. decussata* (VON MÜNSTER), U. Trias., S.Tyrol; RV ext., $\times 1.5$ (58).
- Hefteria* DAHMER, 1948, p. 125 [**Cardinia carinata* ROEMER, 1855, p. 125; OD]. Oblong, elongate; marginal carina sharp and prominent, sigmoidal; flank ornamented with narrow, sharp, regular concentric costae; hinge teeth simple, arranged as in *Eoschizodus*, and with right posterior tooth well developed. *L.Dev.*, Eu.(Ger.).
- Heminajas* NEUMAYR, 1891, p. 789 [**Myophoria fissidentata* WÖHRMANN, 1889, p. 213; M]. Elongate-ovate, inequilateral, tapering and truncated posteriorly; marginal carina weak; surface smooth; left valve with widely triangular median tooth, grooved in some specimens, anterior tooth strong and well separated from margin, and posterior tooth thin and elongate; right valve with 3 well-defined teeth, most anterior of which is short and stout, median strong and grooved in some specimens, and posterior very thin and elongate; myophorous buttress present. *L.Trias.-U.Trias.*, Eu. (Aus.-Hung.)—FIG. D63,10. **H. fissidentata* (WÖHRMANN), U.Trias., Aus.; 10a,b, LV ext. and int., $\times 1$; 10c, RV int., $\times 1$ (Arthaber, 1905; 1002).
- ?*Liotrignia* COX, 1952, p. 53 [**Trigonia lingonensis* DUMORTIER, 1869, p. 275; OD]. Trigonally ovate, slightly inequilateral, larger than typical Myophoriidae; umbones prominent, sharply rounded, beaks orthogyrous; marginal carina well marked, coinciding with most inflated part of valve; area slightly concave, smooth, escutcheon

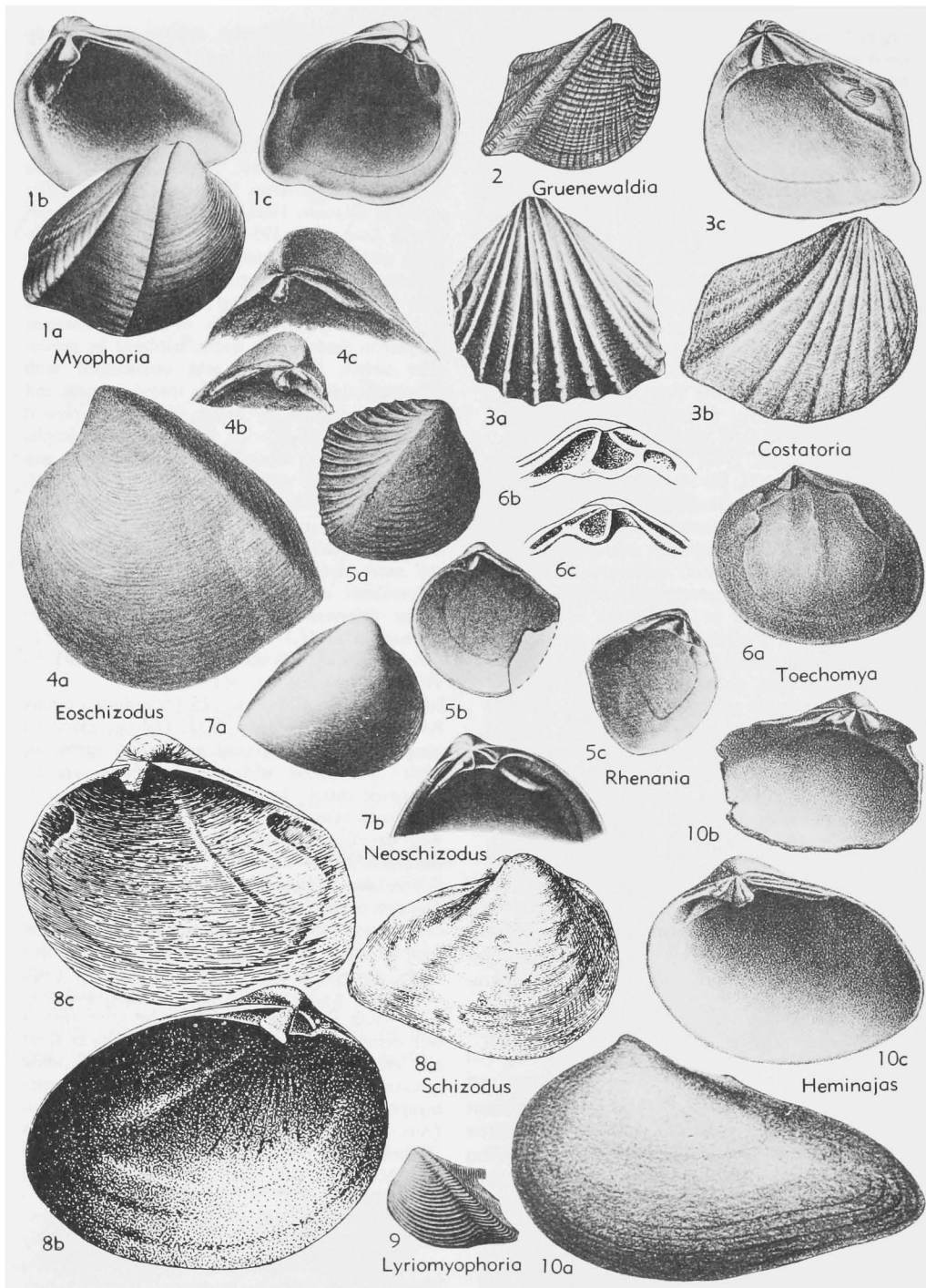


FIG. D63. Myophoriidae (p. N472-N473, N475-N476).

wide, depressed; flank evenly convex, smooth except for narrow, irregular, subconcentric wrinkles mostly confined to its anterior part; left valve with strong triangular median tooth having concave lower margin, weaker anterior tooth, each transversely grooved on side facing other, and thin posterior tooth fused with nymph; dentition of right valve unknown; myophorous buttress well-developed. *L. Jur. (M. Lias.)*, Eu. (France)-Eng.-USSR (E. Sib.).—FIG. D64, 1. **L. lingonensis* (DUMORTIER); 1a, LV ext., Eng., $\times 1$ (554); 1b, LV int., France, $\times 1$ (Dumortier, 1869).

Lyriomyophoria KOBAYASHI, 1954, p. 66 [**Lyriodon elegans* DUNKER, 1849, p. 15; OD]. Outline and concentric ornament as in *Gruenewaldia*, but less gibbous, with marginal carina not prominent and with depression in front of it correspondingly shallow; no radial ornament. *Perm.-U. Trias. (Rhaet.)*, Eu.-Asia-N. Afr.-N. Z.—FIG. D63, 9. **L. elegans* (DUNKER), M. Trias. (Muschelkalk), Ger.; $\times 1$ (Assmann, 1916).

Neoschizodus GIEBEL, 1855, p. 35 [**Lyrodon laevigatum* GOLDFUSS, 1837, p. 197; SD STOLICZKA, 1871, p. xx] [= *Leviconcha* WAAGEN, 1906, p. 393 (type, *Lyrodon ovatum* GOLDFUSS, 1837, p. 197); *Tropiphora* WAAGEN, 1906, p. 393 (type, *Lyrodon laevigatum* GOLDFUSS; SD Cox, herein); *Okunometania* ICHIKAWA, 1954, p. 62 (type, *Neoschizodus* (O.) *okunometaniensis*); *Middalaya* DICKENS, 1956 (type, *M. johnstonei*)]. Shape, smooth surface, and dentition as in *Eoschizodus*, except that main teeth may be transversely striated; myophorous buttress well developed. *L. Perm.-U. Trias.*, cosmop.—FIG. D63, 7. **N. laevigatus* (GOLDFUSS), M. Trias. (Muschelkalk), Ger.; 7a, b, RV ext., LV int., $\times 2$, $\times 2.7$ (Hohenstein, 1913).

Rhenania WAAGEN, 1907, p. 149 [**Myophoria schwelmensis* BEUSHAUSEN, 1895, p. 132; SD Cox, herein] [= *Rhenania* WAAGEN, 1906, p. 393 (*nom. nud.*)]. Small, quadrate or oblong; umbones terminal or subterminal; marginal carina nearly straight; area relatively large, with curved, oblique ridges; flank smooth or with concentric rugae; left valve with simple, broadly triangular median tooth; anterior and posterior teeth subequal and moderately strong; right valve with stout anterior tooth, widely divergent from thin, elongate, marginal posterior tooth; myophorous buttress absent. *Dev.*, Eu. (Ger.).—FIG. D63, 5. **R. schwelmensis* (BEUSHAUSEN), Givet; 5a, b, RV ext. and int., $\times 2$; 5c, LV int., $\times 1$ (47).

Schizodus DE VERNEUIL & MURCHISON, 1844, p. 505 (*ex* KING, MS) [**Axinus obscurus* J. SOWERBY, 1821, p. 12; SD DE VERNEUIL, 1845, p. 308] [= ?*Leptodomen* M'COY in GRIFFITH, 1844, p. 66 (*non* SCHOENHERR, 1843); *Prisonaia* CONRAD, 1867, p. 10 (type, *P. ventricosa*); *Axinopsis* TATE, 1868, p. 412 (*pro* *Schizodus* "KING," *non* *Schizodon* WATERHOUSE, 1842); ?*Niobe* DE

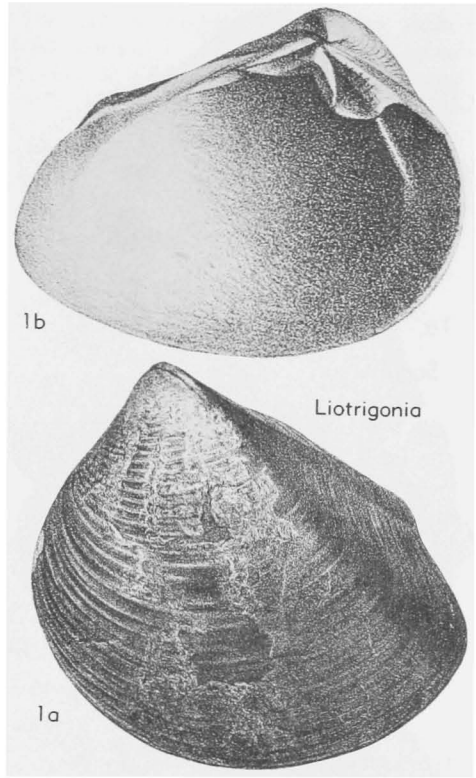


FIG. D64. Myophoriidae (p. N473, N475).

KONINCK, 1885, p. 77 (*non* ANGELIN, 1851); ?*Protoschizodus* DEKONINCK, 1885, p. 125 (*pro* *Niobe* DEKONINCK); *Schizodon* COSSMANN, 1912 (*nom. van.*); ?*Protoschizodon* COSSMANN, 1912 (*nom. van.*). Ovate or trigonally ovate, sub-equilateral to strongly inequilateral, obliquely truncated and in some forms attenuated posteriorly, smooth; umbones usually feebly prosogyrous, more rarely opisthogyrous; marginal carina rounded off; no escutcheon; left valve with strong, bilobed median tooth, anterior tooth small and marginal, and posterior tooth obsolete or almost so; right valve with single stout, forward-directed tooth, posterior tooth being obsolete; no myophorous buttress. *Carb.-Perm.*, cosmop.—FIG. D63, 8a. **S. obscurus* (SOWERBY), U. Perm., Eng.; RV ext., $\times 1$.—FIG. D63, 8b, c. *S. harii* MILLER, Penn., USA (Mo.); 8b, c, LV int., RV int., $\times 1$ (Miller, 1892; Beede, 1900).

Toechomya CLARKE, 1899, p. 96 [**Schizodus transversus* BEUSHAUSEN, 1884, p. 95; SD Cox, 1951, p. 368]. Smooth, ovate, only slightly inequilateral, subtruncate posteriorly, not carinate; umbones orthogyrous; hinge plate present in both valves; left valve with simple, narrowly triangular

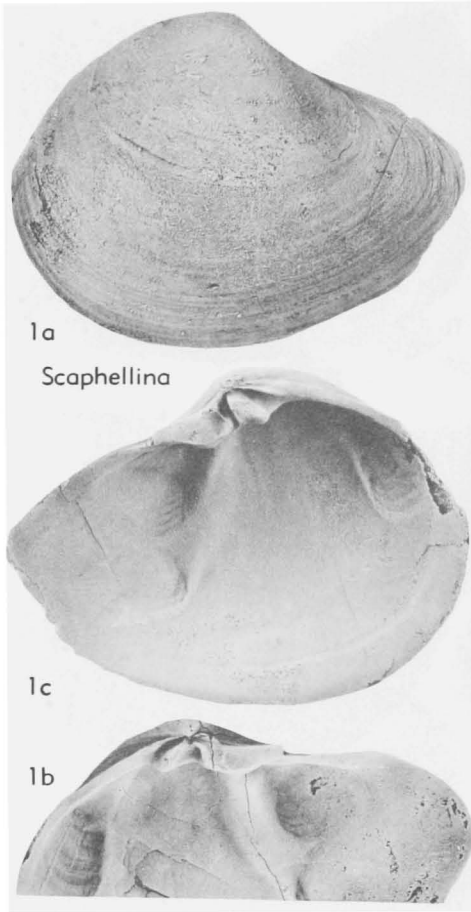


FIG. D65. Scaphellinidae (p. N476).

median tooth, separated by broad sockets from thin anterior tooth and obscure, thin, elongate posterior tooth adjacent to margin; right valve with stoutly triangular, anteriorly directed subumbonal tooth separated by narrow furrow from thin anterior tooth and by triangular socket from elongate posterior tooth which is parallel to and separated by narrow socket from margin; myophorous buttresses, posterior stronger, bordering 2 adductor scars. *M.Dev.*, Eu.—FIG. D63,6. **T. transversa* (BEUSHAUSEN), *M.Dev.*, Ger.; 6a, LV int. mold, $\times 1$ (46); 6b,c, LV and RV hinge teeth, enlarged (135).

?Family SCAPHELLINIDAE Newell & Ciriacks, 1962

[Scaphellinidae NEWELL & CIRIACKS, 1962, p. 4] [Materials for this family prepared by N. D. NEWELL]

Ovoid, opisthogyrate, opisthodetic shells

with obscure escutcheon but lacking lunule; with strong myophoric buttress in front of posterior adductor; adductor scars deeply impressed, anterior adductor slightly smaller than posterior, higher than wide; dentition (A)(R)010101/(L)101010(P) consisting of three cardinal teeth and three sockets in each valve, of which posterior tooth of RV and corresponding socket of LV are rudimentary and not visible on worn valves; lateral teeth absent; median tooth as in many trigoniaceans, broad, distally notched and gable-shaped; floor of median socket deeply notched. [As in the Myophoriidae, the anterior cardinal tooth in these forms is in the LV, contrary to the situation in heterodonts, in which the anterior cardinal tooth characteristically is in the RV.] *L. Perm.*

Scaphellina NEWELL & CIRIACKS, 1962, p. 4 [**S. bradyi* (= *Schizodus concinnus* C. C. BRANSON, 1930); OD]. Gibbous, heavy, about 0.25 to 0.3 longer than high, unornamented; lateral profile broadly rounded anteriorly, somewhat attenuated and slightly gaping posteriorly; beaks depressed, situated slightly ahead of mid-point of hinge. *L. Perm.* (Kaibab, Park City), N.Am.—FIG. D65, 1. **S. concinna* (BRANSON), Park City, USA (Wyo.), 1a, RV ext., $\times 1.1$; 1b,c, RV and LV int., $\times 1.1$ (Newell, n).

Family TRIGONIIDAE Lamarck, 1819

[*nom. Latine redditum* GRAY, 1823 (as "Trigoniina") *et correct.* KING, 1850, *pro* "les trigonées" LAMARCK, 1819 (examination of literature has led to conclusion that "general acceptance" has been accorded to LAMARCK's publication of the family name in the French vernacular as establishing him as founder of the family (International Code, Art. 11 (c)iii) [Materials for this family prepared by L. R. Cox]

Shell usually larger than in Myophoriidae, highly variable in shape and ornament; umbones most commonly opisthogyrous, but orthogyrous or prosogyrous in a few groups; escutcheon usually present; area and flank differentiated and differently ornamented in most genera; flank ornament generally concentric or oblique, but radial in some forms; median tooth of left valve broad, grooved, strongly concave to deeply emarginate below; posterior left weak or obscure, marginal; anterior left of moderate strength; right valve with two subequal and more or less symmetrically divergent teeth not borne on hinge plate, and with very obscure an-

terior marginal tooth in some species; two main teeth of right valve and sides of left valve teeth against which they fit bear strong transverse ridges (*Praegonia* FLEMING is an exception); anterior myophorous buttresses well developed; pallial line entire; Recent forms filibranchiate; mantle lobes free; nonbyssiferous. *M.Trias.-Rec.*

The family Trigoniidae as now interpreted coincides with the single genus *Trigonia* of older authors. The genus was divided by some into several sections, of which the Costatae, Clavellatae, Undulatae, Scaphoideae, Glabrae, and Scabrae were the most important. Latterly numerous genera, mostly even more restricted than these

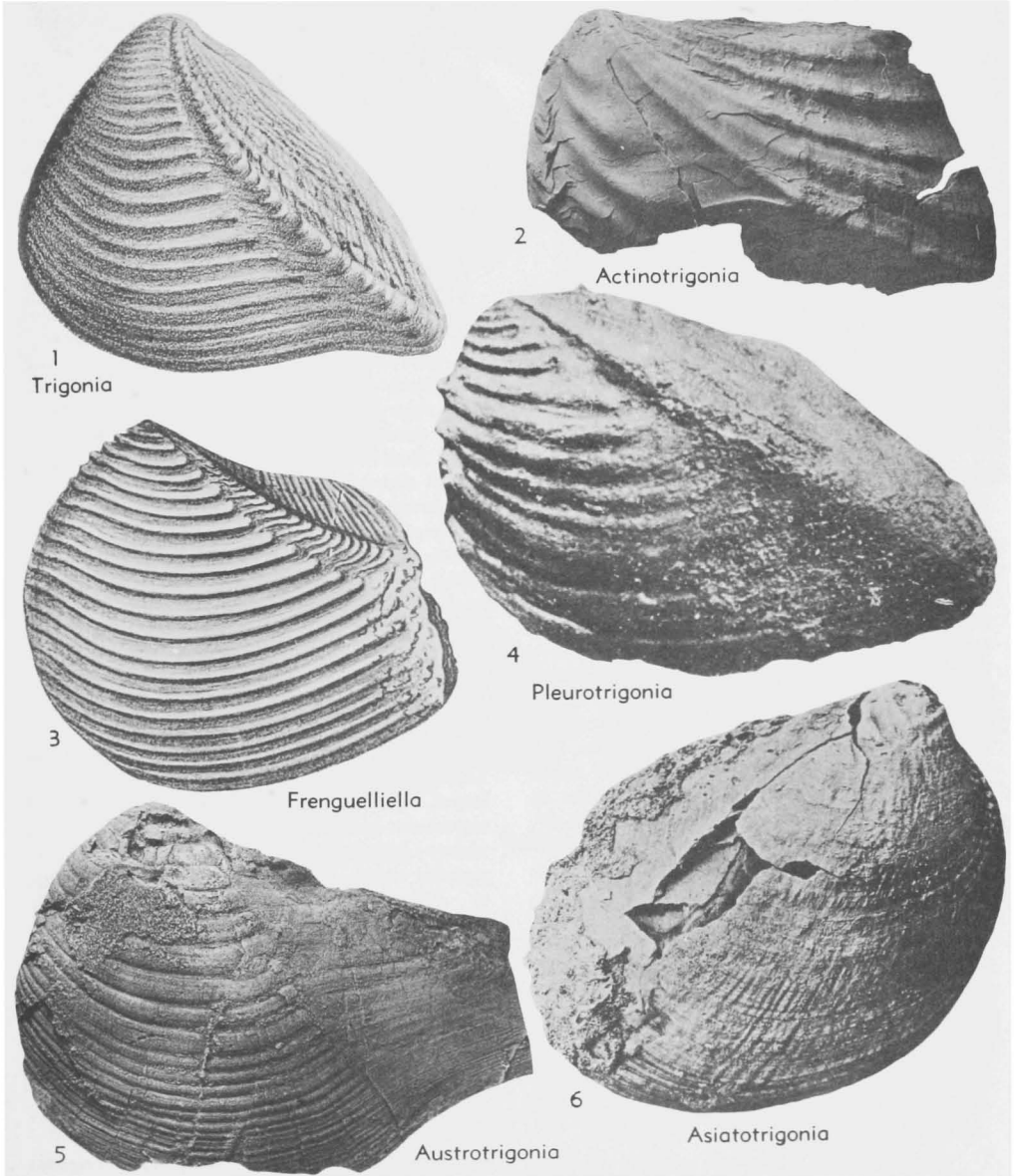


FIG. D66. Trigoniidae (p. N478).

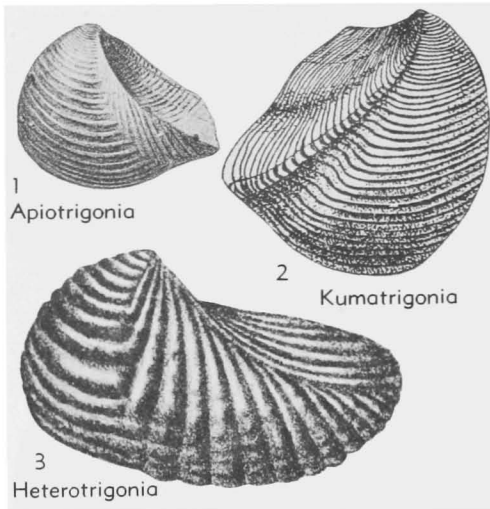


FIG. D67. Trigoniidae (p. N478, N480).

sections, have come to be recognized. A few authors have divided the family into sub-families, but these are not adopted in the present work.

Trigonia BRUGUIÈRE, 1789, p. xiv [*Venus sulcata* HERMANN, 1781, pl. 4, fig. 9; ICZN Opinion 327 (1955)] [=Lyridon J. DE C. SOWERBY, 1823 (obj.); Lyridon BRONN, 1834 (*nom. van.*); Lyrodon GOLDFUSS, 1837 (*nom. van.*)]. Trigonal to trigonally ovate; marginal carina prominent, serrated, escutcheon carina obtuse; escutcheon smooth or transversely ridged; flank (except in a Triassic representative) with continuous concentric costae. *M.Trias.-U.Cret.*, cosmop.

T. (Trigonia). Trigonal, umbones prominent; area wide, bipartite, radially costate; flank costate (except in a Triassic representative), ends of costae commonly separated from marginal carina in left valve or in both by smooth radial space. *M. Trias. (Anis.)-U. Cret. (Cenoman.)*, cosmop.—FIG. D66,1. **T. (T.) sulcata* (HERMANN), L.Jur. (Toarc.), France(Alsace); LV ext., $\times 0.7$ (Bayle, 1878).

T. (Frenguelliella) LEANZA, 1942, p. 164 [*T. inexpectata* JAWORSKI, 1915, p. 377; OD]. Trigonal-ly ovate, umbones less prominent than in *T. (Trigonia)*; area without radial ornament, transversely ridged, smooth in later growth stages in some species. *L. Jur. (Lias.)-U. Cret. (Senon.)*, cosmop.—FIG. D66,3. **T. (F.) inexpectata* JAWORSKI, L.Jur.(Domer.), Arg.; LV ext., $\times 1$ (Jaworski, 1916).

T. (Kumatrigonia) TAMURA, 1959, p. 213 [*Frenguelliella (Kumatrigonia) tanouensis*; OD]. Like *T. (Frenguelliella)*, but taller and

more trigonal, and with each transverse ridge of area connected with flank costa. *U.Trias.*, Japan.—FIG. D67,2. **T. (K.) tanouensis* (TAMURA); RV ext., $\times 1.5$ (901).

T. (Latitrigonia) KOBAYASHI in KOBAYASHI & TAMURA, 1957; p. 36 [*Latitrigonia pyramidalis* KOBAYASHI & TAMURA, 1957; OD]. Rather small, subquadrangle, with wide, mostly smooth area occupying almost half of surface in some species; flank costae widespaced, each thickened at its posterior end to form a node in some forms. *M.Jur.-U.Jur.*, Japan.

T. (Pleurotrigonia) VAN HOEPEN, 1929, p. 33 [*Trigonia blanckenhorni* NEWTON, 1909, p. 40; OD]. Elongate, strongly inequilateral; umbo depressed; escutcheon carina obscure, marginal carina rounded off after mid-growth; area wide, smooth except for radial threads in earliest growth stages; flank costae rounded, absent from narrow anterior face set at right angles to commissure. *L.Cret.(Alb.)*, S.Afr.—FIG. D66,4. **T. (P.) blanckenhorni* NEWTON; LV ext., $\times 1$ (785).

Actinotrigonia COX, 1963, p. 49 [*A. bathurstensis*; OD]. Oblong, strongly inequilateral; umbones not protruding, slightly opisthogyrous; escutcheon ill-defined; marginal carina well-marked but obtuse ridge; area very broad, ornamented with small number of radial ridges with broader intervals; flank with broad, smooth, shallow antecarinal depression to which sinus of ventral margin corresponds, rest of its surface bearing broad, depressed, oblique rounded ribs. *U.Cret. (Cenoman.)*, Bathurst I., N.Australia.—FIG. D66,2. **A. bathurstensis*; LV ext., $\times 1$ (Cox, n).

Agonisca FLEMING, 1963, p. 843 [*A. corbiensis*; OD]. Rather small for family, trigonally ovate, with low prosogyrous beaks; lacking marginal carina and area; ornament of irregular concentric folds; hinge as in *Praegonia*. *M.Trias.(Ladin., Kaihikuan)*, N.Z.

Apiotrigonia COX, 1952, p. 59 [*Trigonia sulcataria* LAMARCK, 1819, p. 64; OD]. Strongly inequilateral, pyriform or subovate; marginal and escutcheon carinae obscure except near umbo; area narrow; posterior part of flank with nearly vertical, rounded costae, anterior part with subconcentric or only slightly oblique costae. *Cret.(Alb.-Maastricht.)*, Eu.-Asia-W.N.Am.

A. (Apiotrigonia). Relatively small, pyriform, with rather prominent umbo; escutcheon with transverse ribbing, area smooth; anterior series of flank costae simple or tuberculate, occupying greater part of surface. *Cret.(Alb.-Maastricht.)*, Eu.-Asia-W.N.Am.—FIG. D67,1. *A. (A.) pennata* (J. SOWERBY), L.Cret.(Alb.), Eng.; LV ext., $\times 1$ (554).

A. (Heterotrigonia) COX, 1952, p. 63 [*Trigonia diversicostata* WHITEAVES, 1876, p. 68; OD]. Less tapering than *A. (Apiotrigonia)*; area with few

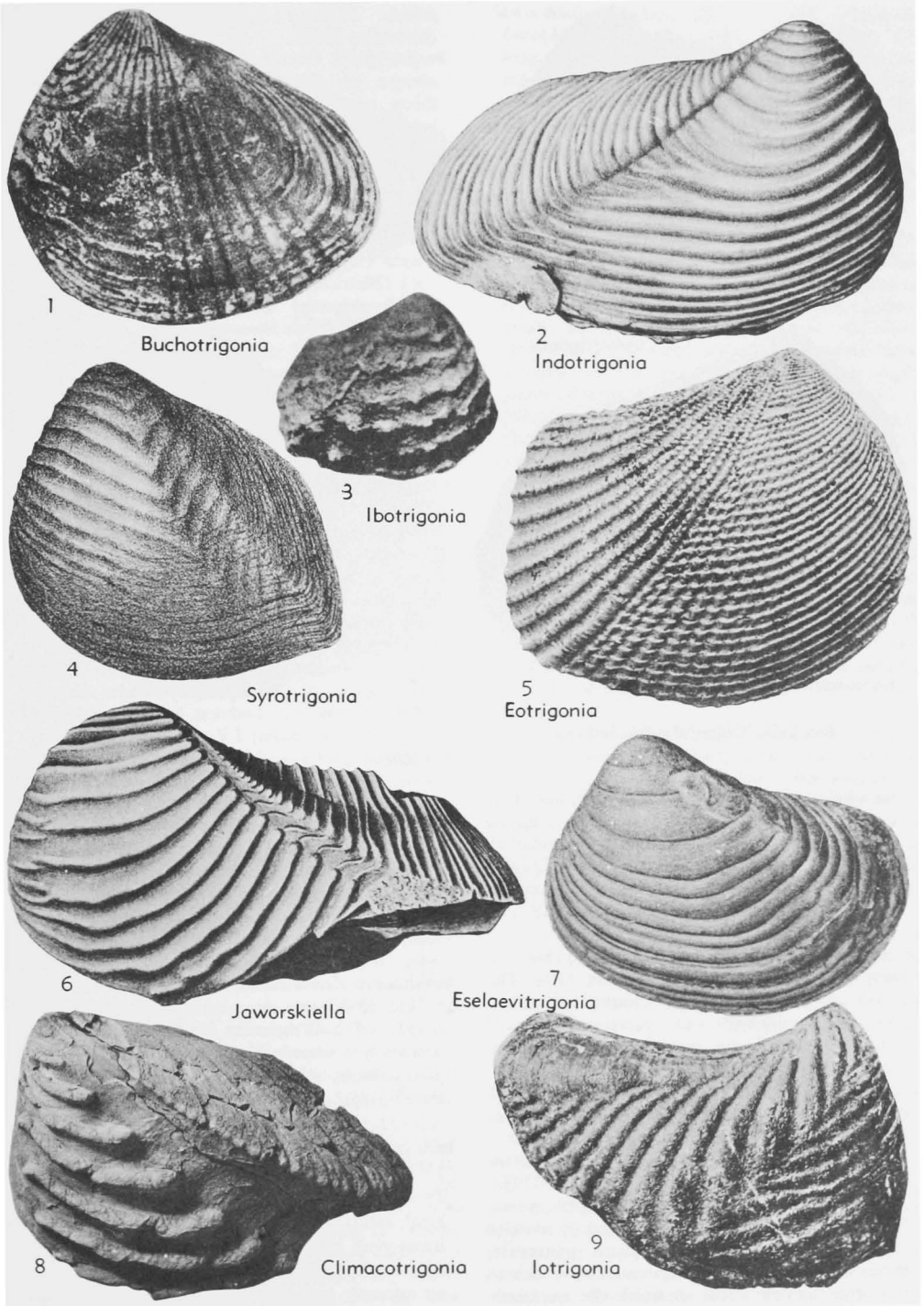


FIG. D68. Trigoniidae (p. N480-N481).

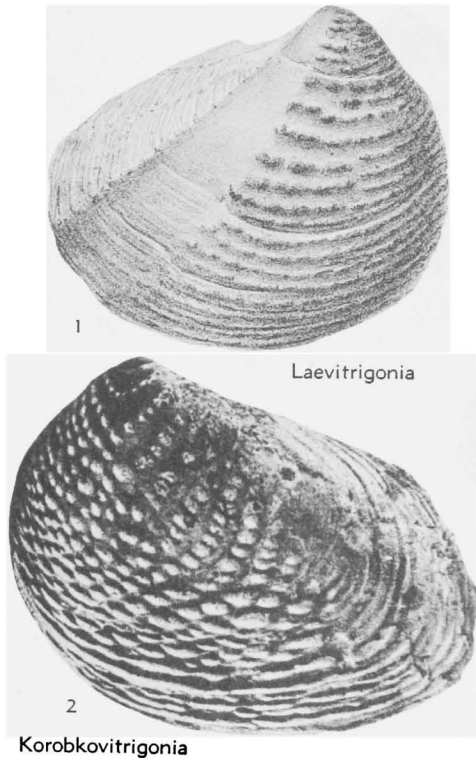


FIG. D69. Trigoniidae (p. N481).

rounded radial ribs; flank costae broader than in *A. (Apiotrigonia)*, anterior series occupying smaller proportion of surface and becoming almost obsolete in later growth stages. *U.Cret.*, B.C.-Japan.—FIG. D67,3. **A. (H.) diversicostata* (WHITEAVES), Haida F., B.C.; LV ext., $\times 1$ (Whiteaves, 1876).

Asiatotrigonia COX, 1952, p. 63 [**Trigonia sultanuisi* ARCHANGELSKI, 1916, p. 32; OD]. Obliquely ovate, not tapering or truncated posteriorly, strongly inequilateral; no carinae; area and escutcheon undefined; posterior region unornamented; flank smooth except for few obscure V-shaped costae near umbo and more or less radial, irregular, narrow wrinkles present on its anterior part in later growth stages. *U.Cret. (Cenoman.)*, Turkestan.—FIG. D66,6. **A. sultanuisi* (ARCHANGELSKI); RV ext., $\times 0.7$ (Archangelski, 1916). **Austrotrigonia** SKWARKO, 1963, p. 33 [**A. prima*; OD]. Very inequilateral, broad and gently rounded anteriorly, produced and attenuated posteriorly; flank with low irregular concentric ribs, behind it a broad shallow sulcus on which ribs are faintly continued; area narrow, with growth lines only. *L.Cret. (Neocom.)*, Australia.—FIG. D66,5. **A.*

prima, N.Terr.; LV ext. (holotype), $\times 0.7$ (Skwarko, 1963).

Buchotrigonia DIETRICH, 1938, p. 97 [**Trigonia abrupta* VON BUCH, 1838, p. 65; M]. Trigonal, short; area wide, transversely ribbed in early growth stages, later smooth; flank with narrow, nontuberculate costae discrepantly or obliquely arranged. *L.Cret.-U.Cret.*, S.Am.-Spain-Syria-N.Z.

B. (Buchotrigonia). Marginal carina ill-defined except in early growth stages. *L.Cret.-U.Cret.*, S.Am.-Spain-N.Z.—FIG. D68,1. **B. (B.) abrupta* (VON BUCH), *L.Cret.*, Colombia; LV ext., $\times 1$ (Dietrich, 1938).

B. (Syrototrigonia) COX, 1952, p. 61 [**B. (S.) fraasi* = **Trigonia libanotica* VOKES, 1942, p. 168; OD]. Marginal carina prominent, broad antecarinal depression in front of it; flank with slightly oblique costae which bend up steeply at edge of depression and cross it. *L.Cret. (Apt.)*, Syria.—FIG. D68,4. **B. (S.) libanotica* (VOKES); LV ext., $\times 1$ (Noetling, 1886).

Climacotrigonia COX, 1963, p. 50 [**C. dailyi*; OD]. Trapeziform, strongly inequilateral; umbones orthogyrus, not protruding; no escutcheon; marginal carina a prominent ridge; area flat, broad, unornamented except for growth rugae; flank with broad, smooth antecarinal depression with corresponding sinus of ventral margin, and with rest of its surface bearing small number of very prominent, slightly irregular and oblique, round-topped ribs with rather broader intervals. *U.Cret. (Cenoman.)*, Bathurst I., N.Australia.—FIG. D68,8. **C. dailyi*; LV ext., $\times 1$ (Cox, n).

Eotrigonia COSSMANN, 1912, p. 26 [**Trigonia semiundulata* M'COY, 1866 = **T. subundulata* JENKINS, 1865, p. 362; OD]. Rather small, oblong; marginal carina obtuse, marked by rounded costa; area rather wide, bearing several radial costae with delicate serrations; flank ornamented with narrow costae which are slightly oblique to concentric, sloping down toward marginal carina. *L.Eoc.-Mio.*, Australia.—FIG. D68,5. **E. subundulata* (JENKINS), Oligo., Australia; RV ext., $\times 2$ (161).

Geratrigonia KOBAYASHI in KOBAYASHI & MORI, 1954, p. 171 [**Trigonia hosourensis* YOKOYAMA, 1904, p. 11; OD]. Trigonal, ovate; marginal carina obtuse; area smooth, bipartite; flank with narrow, subconcentric, nontuberculate costae which are rather irregular, particularly in early growth stages. *L.Jur. (L.Lias.)*, Japan.

Ibotrigonia KOBAYASHI in KOBAYASHI & TAMURA, 1957, p. 38 [**I. masatanii* KOBAYASHI & TAMURA, 1957; OD]. Rather small, roundly trigonal; marginal carina irregularly serrated; area smooth or transversely ridged and with median carina; flank with small number of subconcentric costae, broken up unevenly into tubercles. *M.Jur.*, Japan.—FIG. D68,3. **I. masatanii* KOBAYASHI & TAMURA; RV ext., $\times 2$ (Kobayashi & Tamura, 1957).

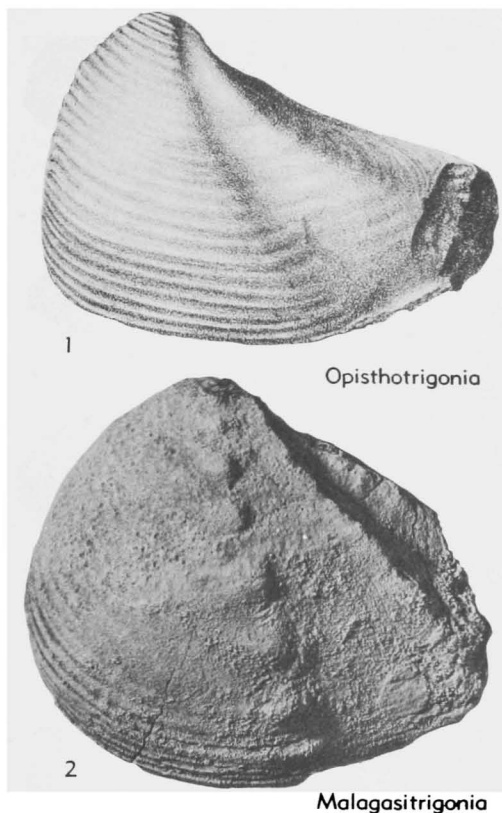


FIG. D70. Trigoniidae (p. N481, N485).

Indotrigonia DIETRICH, 1933, p. 30 [**Trigonia smeei* J. DE C. SOWERBY, 1840, expl. pl. 61; OD]. Oblong, elongate, strongly inequilateral, with rather prominent umbo; marginal and escutcheon carinae ill-defined, escutcheon not impressed; area convex, with rather coarse, irregular transverse ridges and with radial threads in earliest growth stages; flank with rounded concentric costae which are discontinuous in some specimens and are more depressed and rounded than in *Trigonia*. *U.Jur. (Oxford.)-L.Cret. (Neocom.)*, India-E.Afr.—FIG. D68,2. **I. smeei* (SOWERBY), *U.Jur. (Oxford.)*, India(Kutch); RV ext., $\times 0.7$ (Kitchin, 1903).

Iotrigonia VAN HOEPEN, 1929, p. 6 [**I. crassitesta*; OD]. Elongate, ovate or subovate, strongly inequilateral; umbones prominent; marginal and escutcheon carinae rounded off; area smooth, with median groove; flank costae belonging to 2 series, which in earlier or in all growth stages meet in an acute, down-pointing V. *L.Cret.-U.Cret.*, S.Afr.-Asia-S.Am.-Australia-N.Z.-Antarctic.—FIG. D68, 9. *I. haughtoni* (RENNIE), *L.Cret. (Neocom.)*, S. Afr.; RV ext., $\times 0.7$ (785).

Jaworskiella LEANZA, 1942, p. 166 [**Trigonia burckhardtii* JAWORSKI, 1914, p. 299; OD]. Oblong, strongly inequilateral; marginal carina well marked; area with strong transverse ridges, flank with narrow, more or less sinuous, simple costae which are subconcentric except near their well-upcurved posterior end. *L.Jur. (M.Lias.)-U.Jur.*, S. Am.-Port.—FIG. D68,6. **I. burckhardtii* (JAWORSKI), *L.Jur. (Lias.)*, Arg.; LV ext., $\times 0.7$ (Jaworski, 1915).

Korobkovitrigonia SAVELIEV, 1958, p. 99 [**K. korobkovi*; OD]. Ovate to suborbicular, unelongated, commonly oblique; no distinct marginal carina; area with small tubercles in earlier growth stages, later with coarse growth rugae only; flank with 2 series of steep, oblique, tuberculate costae meeting in V's except in later growth stages, where anterior or both series may be replaced by irregularly arranged tubercles or coarse rugae. *Cret. (Barrem.-Turon.)*, C.Asia-Spain-Port.-Alg.-S. Am.—FIG. D69,2. **K. korobkovi*, *L.Cret. (Alb.)*, C.Asia(Mangyshlak); LV ext., $\times 0.85$ (Saveliev, 1958).

Laevitrigonia LEBKÜCHNER, 1932, p. 35 [**Trigonia gibbosa* J. SOWERBY, 1819, p. 61; OD] [= *Laevitrigonia* DEECKE, 1925 (*nom. nud.*)]. Ovate, inequilateral; smooth, shallow antecarinal depression usually present; flank, if not almost smooth, ornamented with weak, irregularly spaced concentric costae commonly broken up into pustules, or with oblique rows of pustules. *L.Jur. (Lias.)-U.Cret.*, cosmop.

L. (Laevitrigonia). Marginal and escutcheon carinae ill-defined except near umbo; antecarinal depression usually well marked, but obscure or absent in a few species; area of moderate width, with median groove, smooth except for growth lines. *L.Jur. (Lias.)-U.Jur. (Tithon.)*, Eu.-Asia-E. Afr.—FIG. D69,1. **L. (L.) gibbosa* (J. SOWERBY), *U.Jur. (Portland.)*, Eng.; RV ext., $\times 0.85$ (554).

L. (Eselaevitrigonia) KOBAYASHI & MORI, 1954, p. 161 [**Trigonia meridiana* WOODS, 1917, p. 6; OD]. Antecarinal depression with ill-defined borders, marginal and escutcheon carinae rounded off; flank costae well separated, not broken up into pustules, continued across antecarinal depression and area; area with radial costellae in early growth stages. *U.Jur. (Tithon.)-U.Cret. (Turon.)*, India-N.Z.—FIG. D68,7. **L. (E.) meridiana* (WOODS), *U.Cret. (Turon.)*, N.Z.; LV ext., $\times 1$ (Woods, 1917).

L. (Malagasitrigonia) COX, 1963, p. 51 [**L. (M.) collignoni*; OD]. Antecarinal depression broad, smooth, bordered posteriorly by series of large tubercles; marginal and escutcheon carinae sharp and prominent; area narrow, smooth, strongly convex; flank costae weak, mostly narrow, irregular. *L.Cret.*, Madag.—FIG. D70,2. **L. (M.) collignoni*; LV ext., $\times 1$ (Cox, n).

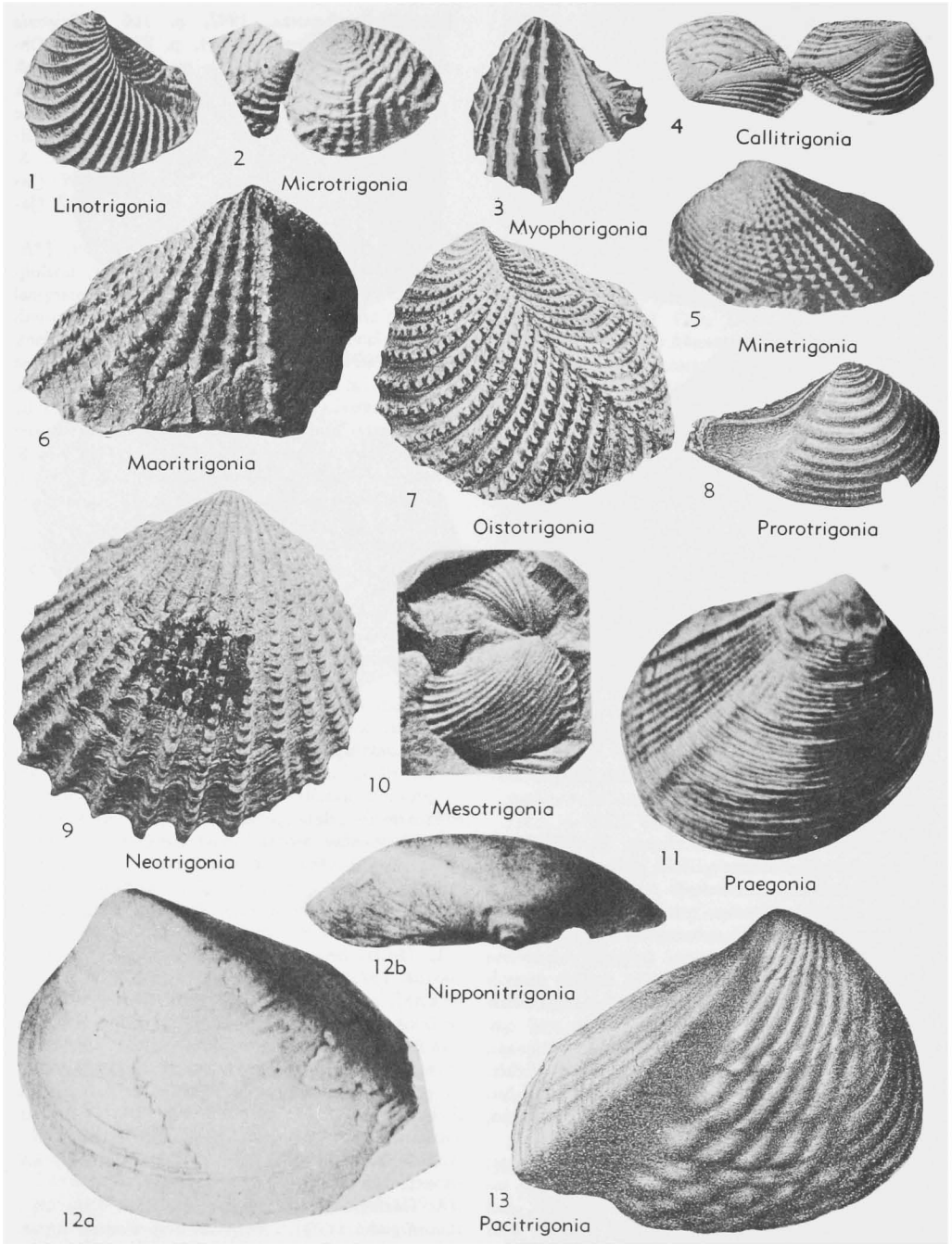


FIG. D71. Trigoniidae (p. N483, N485).

Linotrigonia VAN HOEPEN, 1929, p. 15 [**L. linitifera*; OD]. Trigonal to suborbicular, more or less compressed; marginal and escutcheon carinae obtuse; area wholly or partly ornamented with oblique costae, each of which corresponds to and diverges in chevron-like manner from one on flank; flank with steeply inclined, smooth or nodose costae. *U.Jur.-U.Cret.*, cosmop.

L. (Linotrigonia). Umbo protruding slightly; oblique costae of area commonly confined to early growth stages; flank costae relatively wide-spaced. *U.Jur.-U.Cret.*, cosmop.—FIG. D71,1. *L. (L.) elegans* (BAILY), *L.Cret.(Alb.)*, S.Afr.; LV ext., $\times 2$ (Woods, 1906).

L. (Oistotrigonia) COX, 1952, p. 60 [**Trigonia spinosa* PARKINSON, 1811, p. 176; OD]. Suborbicular or oval; umbones depressed; posterior end and area relatively wide; oblique costae usually present on all or most of area; flank costae close-spaced in most species, transversely crenulated, or bearing small sharp tubercles commonly continued by transverse ridges on sides of costae. *L.Cret.-U.Cret.*, cosmop.—FIG. D71,7. **L. (O.) spinosa* (PARKINSON), *L.Cret.(Alb.)*, Eng.; LV ext., $\times 1$ (554).

Maoritrigonia FLEMING, 1962, p. 3 [**Myophoria nuggetensis* TRECHMANN, 1918, p. 210; OD]. Trigonal, with prominent umbo; escutcheon impressed, with tuberculate radial ornament; marginal carina tuberculate; area with median groove and fine trellised ornament; flank with narrow antecarinal depression and dominant, unevenly spaced, tuberculate radial costae and weak concentric lamellae. *U.Trias.(Carn.-Nor.)*, N.Z.-N. Caledonia.—FIG. D71,6. **M. nuggetensis* (TRECHMANN), N.Z.; RV ext., $\times 1$ (Cox, n).

Megatrigonia VAN HOEPEN, 1929, p. 3 [**M. obesa*; OD]. Large, pyriform; marginal and escutcheon carinae absent except near umbo; area narrow, smooth; escutcheon deep, smooth; flank with steeply sloping, mostly oblique, rounded costae, of which those on its anterior half are broad and well separated but those on its posterior half narrow and close. *U.Jur.(Tithon.)-L.Cret.*, S.Afr.-E. Afr.-India-S.Am.—FIG. D72,2. **M. obesa*, *L.Cret.(Neocom.)*, S.Afr.; LV ext., $\times 0.45$ (van Hoepen, 1929).

Mesotrigonia FRENEIX, 1958, p. 165 [**M. tarameahensis*; OD]. Small, oval, only slightly inequilateral, with scarcely protruding umbones; marginal and escutcheon carinae inconspicuous, formed by rounded radial ribs of same strength as several present on area; posterior part of flank with closely spaced, narrow, oblique ribs, anterior part with more distant subconcentric ribs; all ribs finely tuberculate. *U.Cret.(Senon.)*, N.Caledonia.—FIG. D71,10. **M. tarameahensis*; RV and LV ext., $\times 1$ (Freneix, 1958).

Microtrigonia NAKANO, 1957, p. 116 [**M. amanoi*; OD]. Small, suborbicular; marginal carina in-

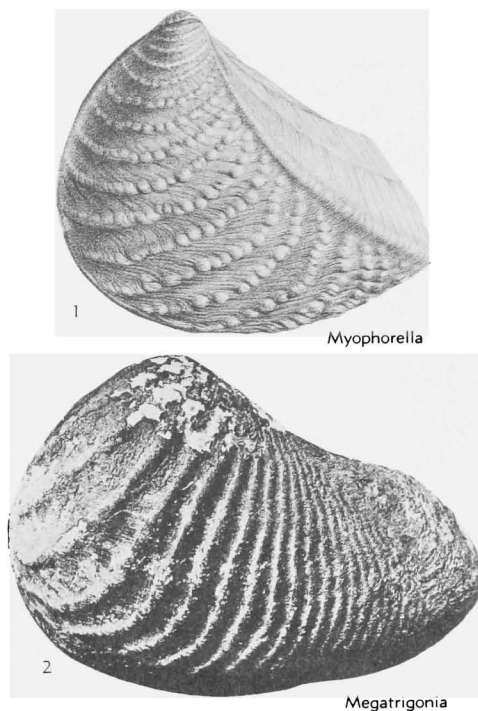


FIG. D72. Trigonidae (p. N483, N485).

distinct, area with transverse costae; flank with concentric costae on umbonal region, later with 2 series of tuberculate costae, anterior ones oblique, posterior radial. *U.Cret.(Maastricht.)*, Japan.—FIG. D71,2. **M. amanoi*, RV and LV ext., $\times 2$ (Nakano, 1957).

Minetrigonia KOBAYASHI & KATAYAMA, 1938, p. 187 [**Trigonia hegiensis* SAEKI, 1925, p. 35; OD]. Trigonal, ovate; umbo broad, depressed; marginal carina very obtuse, escutcheon carina sharp; escutcheon and area with fine trellised ornament, area also with median furrow; flank with numerous intersecting radial and concentric costae, of which former are more strongly developed on its posterior half, with small tubercles present at their intersections. *U.Trias.*, Japan-B.C.-S.Am.—FIG. 71,5. **M. hegiensis* (SAEKI), Japan; LV ext., $\times 1.5$ (Kobayashi & Ichikawa, 1952).

Myophorella BAYLE, 1878, expl. pl. 120 [**M. nodulosa* BAYLE=**Trigonia nodulosa* LAMARCK, 1801, p. 117; SD CRICKMAY, 1932, p. 458]. Trigonal, ovate to oblong, strongly inequilateral; marginal carina obtuse; escutcheon shallow; area bipartite, variously ornamented; flank bearing rows of tubercles or tuberculate costae which are usually oblique but subconcentric in some species. *L.Jur.(Lias.)-L.Cret.*, cosmop.

[CRICKMAY designated *M. nodulosa* BAYLE (non LAMARCK)

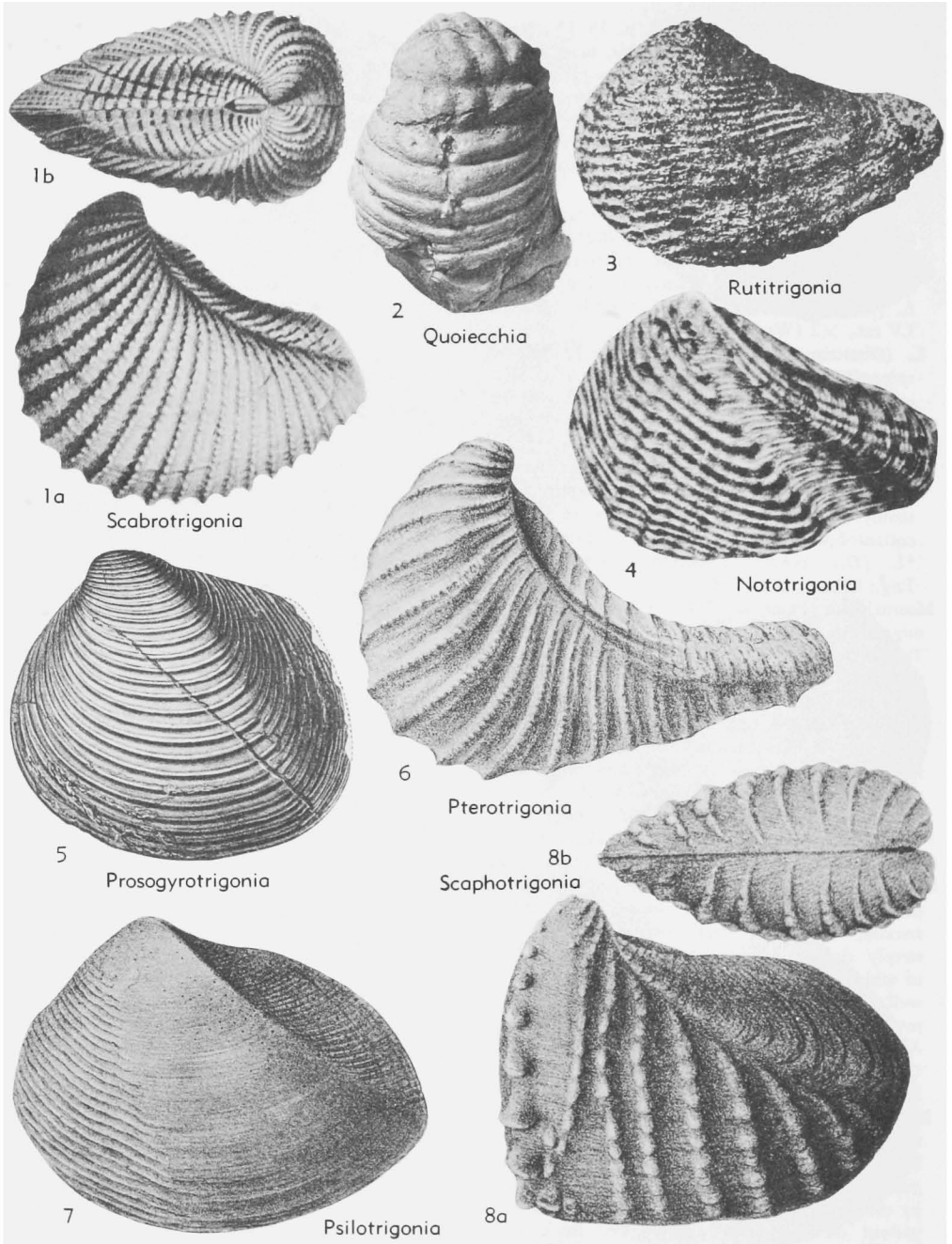


FIG. D73. Trigoniidae (p. N485-N487).

- as type. Some authors have stated that BAYLE's figures do not represent the Lamarckian species, but FAVRE, who has figured LAMARCK's type, has shown that it belongs to the species represented by figs. 1, 2 and 6 of BAYLE.]
- M. (Myophorella)** [= *Haidaia* CRICKMAY, 1930, p. 51 (type, *Trigonia dawsoni* WHITEAVES, 1878, p. 154); *Scaphogonia* CRICKMAY, 1930, p. 51 (type, *S. argo*); *Scaphitrigonia* CRICKMAY, 1930, p. 50 (*nom. null.*); *Clavotrigonia* LEBKÜCHNER, 1932, p. 38 (type, *Trigonia clavellata* J. SOWERBY, 1815, = *T. clavellata* TOWNSEND, 1813, p. 441); *Clavitrigonia* LEANZA, 1942, p. 162 (type, *T. clavellata* J. SOWERBY, 1815; *Promyophorella* KOBAYASHI & TAMURA, 1955, p. 96 (type, *Myophorella (Promyophorella) sigmoidalis*)]. Area transversely ridged or smooth, without radial ornament; escutcheon smooth; flank costae uninterrupted throughout growth in some species, discontinuous and broken up anteriorly in later growth stages in others. *L.Jur. (M. Lias.)-L.Cret. (Neocom.)*, cosmop.—FIG. D72,1. ***M. (M.) nodulosa**, *U.Jur. (Oxford.)*, France; LV ext., $\times 0.45$ (Bayle, 1878).
- M. (Pseudomyophorella)** NAKANO, 1961, p. 85 [**Pseudomyophorella savelievi*; OD]. Like *M. (Myophorella)* except that area bears radial ribs. *U.Jur. (?Oxford.)*, C.Asia (W. Turkmenia).
- Myophorigonia** COX, 1952, p. 52 [**Myophoria paucicostata* JAWORSKI, 1922, p. 126; OD] [= *Myophorigonia* KOBAYASHI, 1954 (*nom. null.*)]. Relatively small, unelongated; marginal carina sharp; escutcheon narrow or absent; area flat or concave, smooth or transversely ridged; flank with strong, unevenly arranged radial costae and subordinate concentric costae confined in some forms to its anterior part. *U.Trias.-M.Jur. (Bajoc.)*, Peru-Mex.-BearIs.-Eng.—FIG. D71,3. ***M. paucicostata** (JAWORSKI), *U.Trias.*, Peru; LV ext., $\times 2$ (446).
- Neotrigonia** COSSMANN, 1912, p. 25 [**Trigonia pectinata* LAMARCK, 1819, p. 63; OD]. Rather small, trigonally ovate; entire surface bearing tuberculate radial costae, of which 2 coincide with obtuse angles representing marginal and escutcheon carinae; escutcheon not impressed. *Oligo-Rec.*, Australia.—FIG. D71,9. ***N. pectinata** (LAMARCK), *Rec.*; RV ext., $\times 1$ (161).
- Nipponitrigonia** COX, 1952, p. 53 [**Trigonia kikuchiana* YOKOYAMA, 1891, p. 363; OD]. Trigonally ovate, short, subequilateral to moderately inequilateral; marginal carina obtuse, rounded off in later growth stages; area smooth, escutcheon undefined; flank with weak concentric costae which in later growth stages fade away entirely or persist only on its anterior side. *U. (?M.) Jur.-U.Cret. (Cenoman.)*, Japan.—FIG. D71,12. ***N. kikuchiana** (YOKOYAMA), *L.Cret.*; 12a,b, LV ext., lat. and hinge views, $\times 1$ (Yehara, 1915).
- Nototrigonia** COX, 1952, p. 62 [**Trigonia cinctata* ETHERIDGE, 1902, p. 28; OD]. Pyriform, elongate, posteriorly substrate; escutcheon carina well defined, escutcheon unimpressed; area narrow, radially ribbed; flank with a broad antecarinal depression; remainder of its surface with rounded costae. *L.Cret.*, Australia.
- N. (Nototrigonia)**. Antecarinal depression smooth; flank costae moderately oblique, rather sinuous. *L.Cret.*, S.Australia.—FIG. D73,4. ***N. (N.) cinctata** (ETHERIDGE); LV ext., $\times 1$ (Etheridge, 1902).
- N. (Callitrigonia)** COX, 1963, p. 51 [***N. (C.) twidalei**; OD]. Small; marginal carina broad rounded rib; antecarinal depression of right valve but not of left with fine tuberculate radial riblets; flank costae almost concentric. *L.Cret.*, NW. Queensland.—FIG. D71,4. ***N. (C.) twidalei**; RV ext., RV ext., $\times 1$ (Cox, n).
- Opisthotrigonia** COX, 1952, p. 62 [**Trigonia retrorsa* KITCHIN, 1903, p. 57]. Elongate, very inequilateral, with narrow, prominent, strongly opisthogyrous umbones and substrate posterior extremity; marginal carina well defined, at least near umbo; area narrow, smooth; flank with broad, smooth or transversely ridged antecarinal depression, remainder of its surface with rather irregular, mostly subconcentric costae. *U.Jur. (Tithon.)*, India-E.Afr.—FIG. D70,1. ***O. retrorsa** (KITCHIN), India (Cutch); LV ext., $\times 1$ (Kitchin, 1903).
- Pacitrigonia** MARWICK, 1932, p. 507 [**P. sylvesteri*; M]. Oblong, strongly inequilateral, marginal carina rounded off in later growth stages; flank with broad, smooth antecarinal depression, rest of its surface bearing broad, irregular undulations which may be broken up into elongated pustules, oblique in early growth stages but later almost concentric; area smooth or with radial ribs confined to earlier growth stages. *U.Cret. (U.Senon.)*, S. Am.-N. Z.—FIG. D71,13. **P. hanetiana** (D'ORBIGNY), Chile; RV ext., $\times 1$ (Moericke, 1895).
- Praegonia** FLEMING, 1962, p. 2 [**P. coombsi*; OD]. Ovate, with low prosogyrous umbones; without marginal carina but with area defined by change in ornament; escutcheon carina sharp, escutcheon narrow, impressed; flank with weak, rounded concentric threads, area with radial riblets; main tooth of left valve weak, ungrooved. *M.Trias. (Ladin.)*, N.Z.—FIG. D71,11. ***P. coombsi**; RV ext., $\times 1$ (Fleming, 1962).
- Prorotrigonia** COX, 1952, p. 57 [**Trigonia seranensis* KRUMBECK, 1923, p. 211; OD]. Elongate-pyriform, attenuated and substrate posteriorly; marginal carina not defined; flank with concentric costae which do not reach smooth posterior area. *U.Trias.*, Ceram.—FIG. D71,8. ***P. seranensis** (KRUMBECK); RV ext., $\times 1$ (486).
- Prosogyrotigonia** KRUMBECK, 1924, p. 244 [**P. timorensis*; M]. Evenly ovate, strongly inequilateral, beaks prosogyrous; marginal carina absent, border of area marked only by change in ornament; anterior part of flank with fairly regular concentric costae, posterior part with weaker and

more numerous concentric ridges. *U.Trias.*, Timor-Indochina.—FIG. D73,5. **P. timorensis*, Timor; LV ext., $\times 0.7$ (487).

Psilotrignonia Cox, 1952, p. 53 [**Trignonia beesleyana* LYCETT, 1874, p. 91; SD]. Ovate, compressed;

umbones broad, depressed; marginal carina well defined but obtuse; no escutcheon; area wide, slightly concave, with curved oblique striations; flank with thin, slightly oblique wrinkles on its anterior third but otherwise smooth. *M.Jur.*

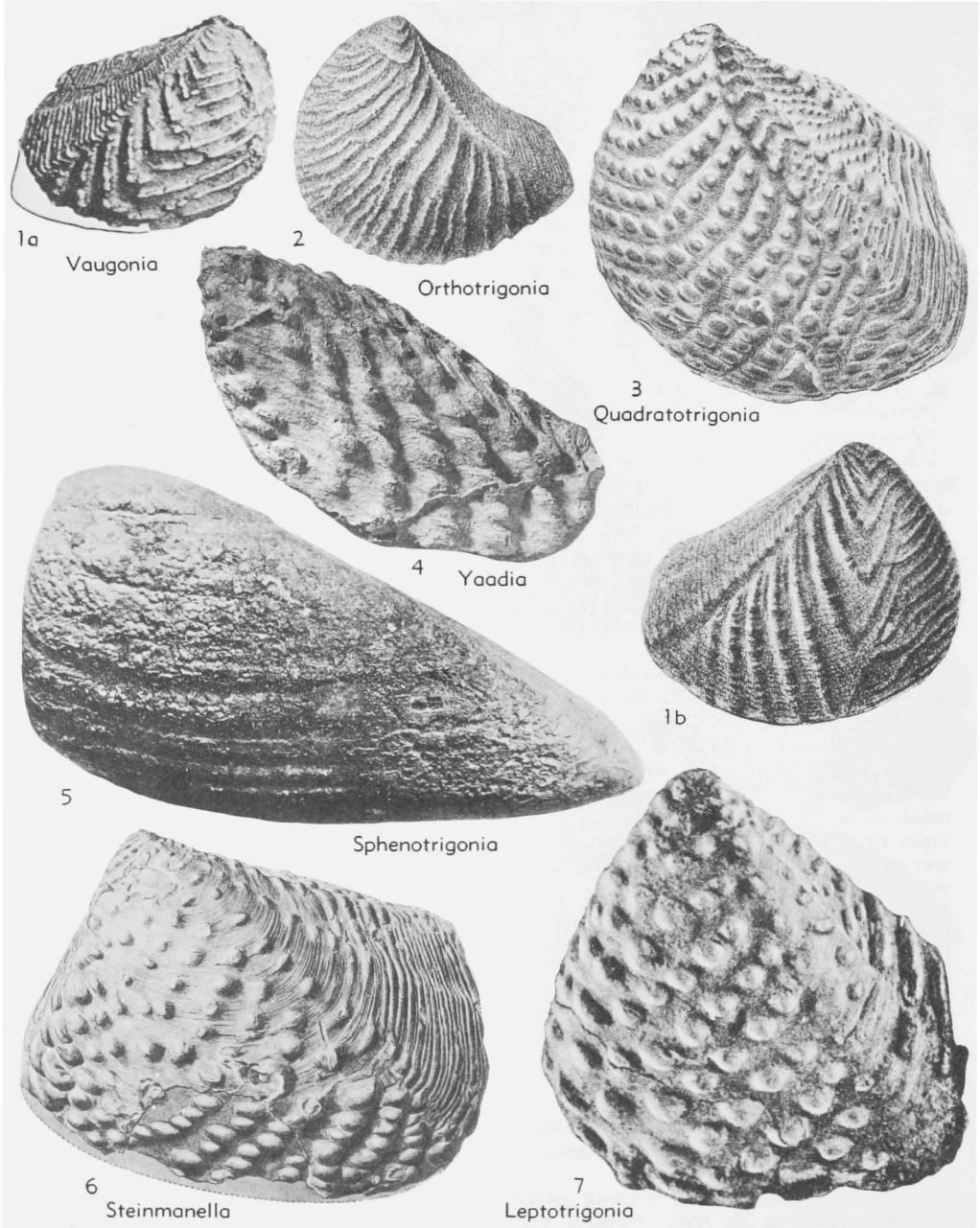
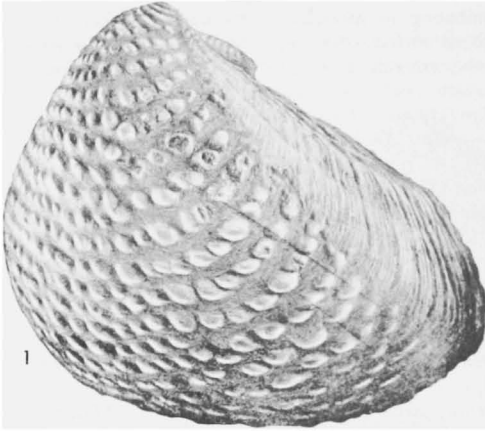


FIG. D74. Trignoniidae (p. N487-N488).

- (*Bajoc.*) - *U. Cret.*, Eng.-Italy-N. Afr.-India-Japan. —FIG. D73,7. **P. beesleyana* (LYCETT), *M. Jur.* (*Bajoc.*), Eng.; LV ext., $\times 1$ (554).
- Pterotrigonia** VAN HOEPEN, 1929, p. 9 [**P. cristata*; OD]. Club-shaped, gibbous, with narrow, elevated, strongly opisthogyrous umbones; marginal and escutcheon carinae ill-defined except near umbo; area very narrow, smooth or transversely ridged, strongly curved, with upward-facing concavity; escutcheon wide, well impressed near umbo, with transverse costellae; flank with steep, oblique, simple or tuberculate costae; internal radial ridge coinciding approximately with middle of area. *U. Jur.* (*Tithon.*)-*U. Cret.*, cosmop.
- P. (Pterotrigonia)** [= *Acanthotrigonia* VAN HOEPEN, 1929, p. 14 (type, *Trigonia shepstonei* GRIESBACH, 1871, p. 66); *Notoscabrotrigonia* DIETRICH, 1933, p. 331 (type, *Trigonia tocaimana* LEA, 1840, p. 256); *Pisotrigonia* VAN HOEPEN, 1929, p. 20 (type, *P. salebrosa*); *Pilotrigonia* VAN HOEPEN, 1929, p. 22 (type, *P. lauta*); *Rinetrigonia* VAN HOEPEN, 1929, p. 22 (type, *Lyrodon ventricosa* KRAUSS, 1850, p. 456)]. Posterior end attenuated and commonly rostrate. *U. Jur.* (*Tithon.*)-*U. Cret.*, cosmop.—FIG. D73,6. *P. (P.) caudata* (AGASSIZ), *L. Cret.* (Apt.), Eng.; LV ext., $\times 1$ (554).
- P. (Scabrotrigonia)** DIETRICH, 1933, p. 330 [**Trigonia scabra* LAMARCK, 1819, p. 63; OD]. Posterior end broader than in *P. (Pterotrigonia)* and not rostrate; costellae of escutcheon continued over area and forming chevrons with flank costae. *U. Cret.* (*Cenoman.-Maastricht.*), cosmop.—FIG. D73,1. **P. (S.) scabra* (LAMARCK), *U. Cret.* (Cenoman.), France; *lab.*, LV ext., hinge view of both valves, $\times 0.7$ (d'Orbigny, 1843-47).
- ?**Quoicchia** CRICKMAY, 1930, p. 51 [**Q. aliciae*; OD]. Rather small, oval, higher than long, without differentiated area or escutcheon; umbo directed anteriorly?; broad, rounded, almost radial folds, crossed by concentric grooves, present until mid-growth, when they are replaced by concentric folds. *L. Cret.*, B.C.—FIG. D73,2. **Q. aliciae*; holotype, ?LV, $\times 2$ (Cox, n).
- Rutitrigonia** VAN HOEPEN, 1929, p. 31 [**R. peregrina*; OD]. Pyriform to ovate; marginal and escutcheon carinae ill-defined except near umbo; area narrow, smooth; flank or its anterior part with thin, rather flexuous, subconcentric costae. *U. Jur.* (*Tithon.*)-*U. Cret.*, cosmop.—FIG. D73,3. **R. peregrina*, *L. Cret.*, S.Afr.; LV ext., $\times 1$ (van Hoepen, 1929).
- Scaphotrigonia** DIETRICH, 1933, p. 330 [**Trigonia navis* LAMARCK, 1819, p. 64; OD]. Trigonally ovate, with narrow, prominent umbones; marginal and escutcheon carinae ill-defined except in earlier growth stages; area with median furrow and at first transversely ridged, later smooth; escutcheon smooth; anterior end of shell broadly flattened in plane almost at right angles to commissure and bearing subhorizontal costae terminating in tubercles at angulation limiting flattened surface, this angle being separated by narrow, smooth zone from posterior part of flank, which bears steep, mostly tuberculate costae. *L. Jur.* (*U. Lias.*), Eu.; *M. Jur.*? (*Callov.*), USA (Calif.). —FIG. D73,8. **S. navis* (LAMARCK), *L. Jur.* (*U. Lias.*), France (Alsace); *8ab.*, LV ext., ant. view of both valves, $\times 0.7$ (9).
- Sphenotrigonia** RENNIE, 1936, p. 365 [**Trigonia (Sphenotrigonia) frommurzei*; OD]. Elongate-cuneiform, with obtuse, terminal, prosogyrous umbones; marginal and escutcheon carinae absent except in early growth stages; area smooth; flank with broad, irregular undulations. *L. Cret.* (*Neocom.*), S.Afr.—FIG. D74,5. **S. frommurzei*; LV ext., $\times 0.7$ (785).
- Steinmanella** CRICKMAY, 1930, p. 50 [**Trigonia holubi* KITCHIN, 1908, p. 103; OD] [= *Steinmannella* KOBAYASHI & AMANO, 1955 (*nom. van.*) (*non Steinmannella* WELTER, 1911); *Steinmanaea* CRICKMAY, 1962 (*pro Steinmanella*)]. Oblong to suborbicular; marginal carina rounded off or indistinct; area with median groove and with or without transverse ridges; escutcheon with transverse tuberculate ridges; most of flank ornamented with oblique tuberculate costae. *L. Cret.*-*U. Cret.*, S.Afr.-S.Am.-W.N.Am.-Japan.
- S. (Steinmanella)** [= *Transitrigonia* DIETRICH, 1933, p. 331 (type, *Trigonia transitoria* STEINMANN, 1881, p. 260); ?*Packardella* KOBAYASHI & AMANO, 1955 (*nom. nud.*)]. Oblong to sub-trigonal; area with strong irregular transverse ridges, invading posteroventral part of flank in some species; flank costae concentric near umbo, but oblique and tuberculate on most of surface, where they are either all continuous or become broken up and irregular anteriorly and ventrally. *L. Cret.*, S.Afr.-S.Am.-W.N.Am.—FIG. D74,6. **S. (S.) holubi* (KITCHIN), *L. Cret.* (Neocom.), S.Afr.; LV ext., $\times 0.7$ (Kitchin, 1908).
- S. (Litschkovitrigonia)** SAVELIEV, 1958, p. 97 [**Trigonia litschkovi* MORDVILKO, 1953, p. 341; OD]. Like *S. (Steinmanella)*, but early growth stages with costae which have V-shaped bend and extend across area, later stages commonly with tuberculate costae more densely arranged; area smooth or transversely ridged. *L. Cret.* (*Valangin.-Apt.*), C.Asia.—FIG. D75,1. *S. (L.) ovata* (LITCHKOV), *L. Cret.* (Hauteriv.), Mangyshlak; LV ext., $\times 0.6$ (Saveliev, 1958).
- S. (Setotrigonia)** KOBAYASHI & AMANO, 1955, p. 206 [**S. (Setotrigonia) shinoharai*; OD]. Suborbicular; area short, indistinctly delimited from flank; flank costae broken up into segments of varying lengths and continued on area as narrow, wavy transverse ridges. *U. Cret.* (*Campan.*), Japan.



Litschkovitrigonia

FIG. D75. Trigoniidae (p. N487).

S. (*Yeharella*) KOBAYASHI & AMANO, 1955, p. 200 [**Trigonia japonica* YEHARA, 1923, p. 10; OD]. Flank costae commonly broken up in later growth stages into irregular elongated protuberances instead of into rounded tubercles; area without transverse ridges. *M.Cret.-U.Cret.*, Japan-USA (Calif.).

Vaugonia CRICKMAY, 1930, p. 53 [**V. veronica*; OD]. Trigonally ovate, short; escutcheon and marginal carinae well defined; area bipartite, transversely ridged; simple or tuberculate V-shaped costae present on flank up to varying stage of growth, angle of V's situated in relatively posterior position; remainder of flank with rather irregular costae. *L.Jur.(L.Lias.)-U.Jur.(Portland.)*, cosmop.

V. (*Vaugonia*) [= *Hijitrigonia* KOBAYASHI in KOBAYASHI & MORI, 1955, p. 85 (type, *Vaugonia (Hijitrigonia) genticulata* KOBAYASHI & MORI; OD)]. Flank with V-shaped costae persisting to relatively late growth stage, and with costae on its anteroventral region only slightly oblique to concentric and usually more numerous than steep costae on its posteroventral region. *L.Jur.(L.Lias.)-U.Jur.(Portland.)*, cosmop.—FIG. D74, 1a. **V. (V.) veronica*, M.Jur., B.C.; RV ext., $\times 1$ (Crickmay, 1930).—FIG. D74, 1b. *V. (V.) literata* (YOUNG & BIRD), L.Jur.(U.Lias.), Eng.; RV ext., $\times 1$ (554).

V. (*Orthotrigonia*) COX, 1952, p. 56 [**Trigonia duplicata* J. SOWERBY, 1819, p. 63; OD]. Relatively small; V-shaped costae confined to earlier growth stages, remainder of flank with rather irregular, mostly steep costae, bifurcating anteriorly in some specimens. *L.Jur.(L.Lias.)-U.Jur.(Kimmerid.)*, cosmop.—FIG. D74, 2. **V. (O.)*

duplicata (SOWERBY), M.Jur.(Bajoc.), Eng.; LV ext., $\times 1$ (554).

Yaadia CRICKMAY, 1930, p. 50 [**Y. lewisagassizi*; OD]. Quadrate, ovate or trigonal, not elongated; marginal carina obtuse, commonly nodose; escutcheon narrow, tuberculate; area more or less distinctly bipartite, tuberculate or with transverse or oblique ridges; flank with oblique rows of large tubercles. *L.Cret.-U.Cret.*, cosmop.

Y. (*Yaadia*). Strongly inequilateral, obliquely ovate; area tubercles large, transversely elongated; flank tuberculate anteriorly and posteriorly, with narrow intervening smooth zone. *L.Cret.*, B.C.—FIG. D74, 4. **Y. (Y.) lewisagassizi*; rubber squeeze prepared from holotype, distorted LV ext. mold, $\times 0.7$ (Cox, n).

Y. (*Leptotrigonia*) SAVELIEV, 1958, p. 105 [**Quadratortrigonia (Leptotrigonia) craveciae*; OD]. Trigonal, with prominent angular umbones; tubercles on area variable, commonly replaced by transverse ridges in later growth stages; flank costae uninterrupted. *L.Cret.(Barrem.)-U.Cret.(Turon.)*, C.Asia.—FIG. D74, 7. **Y. (L.) craveciae* (SAVELIEV); *L.Cret.(Apt.)*, W.Turkmenia; LV ext., $\times 1$ (Saveliev, 1958).

Y. (*Quadratortrigonia*) DIETRICH, 1933, p. 331 [**Trigonia nodosa* J. DE C. SOWERBY, 1826, p. 7; OD]. Subquadrate, strongly inequilateral; tubercles on area variable in size and arrangement, commonly replaced by transverse rugae in later growth stages; flank ornament uninterrupted. *L.Cret.-U.Cret.*, cosmop.—FIG. D74, 3. **Y. (Q.) nodosa* (SOWERBY), *L.Cret.(Apt.)*, Eng.; LV ext., $\times 0.7$ (554).

?Family TRIGONIOIDIDAE Cox, 1952

[Materials for this family prepared by L. R. Cox]

Shell of medium size, ovate to subtrigonal, subequilateral to moderately inequilateral, variably elongated; umbones orthogyrous or almost so; posterior carina absent or confined to the neighborhood of umbo; ornament consisting of radial or oblique, rounded ribs; transversely crenulated posterior lateral teeth present, anterior laterals and cardinals present or absent; pallial line entire. *L.Cret.-U.Cret.*

Japanese authors include this family in the Trigoniacea, although KOBAYASHI has suggested that the unionid genus *Nippononaiia* may have been descended from *Trigonioides*. Cox has advocated reference of the family to the Unionacea and MARTINSON originally regarded *Protounio* as a unionid.

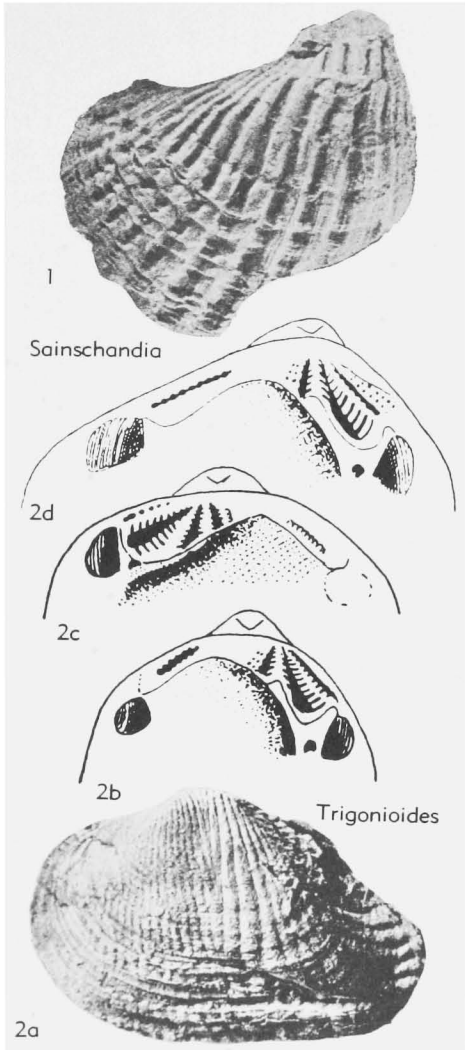


FIG. D76. Trigonioididae (p. N489).

Trigonioides KOBAYASHI & SUZUKI, 1936, p. 248 [**T. kodairai*; OD] [= *Hoffetrigonia* SUZUKI, 1940, p. 229 (type, *Trigonioides kobayashi* HOFFET, 1937)]. Shell form as defined for family; flank ornamented with steeply inclined ribs which converge ventrally so as to form acute V's on

median part of shell, ribs of posterior series being generally thicker; both extremities of shell or only posterior one bearing less steeply sloping, oblique ribs; ventral margin crenulated internally; hinge plate well developed, widening anteriorly; hinge teeth, all of which bear regular transverse crenulations, consisting of narrow posterior lateral in right valve, well separated from beak and received in recess between 2 teeth projecting from hinge plate in left valve, and of anterior series of radially disposed teeth, 3 or 4 in each valve, extending from below beak to anterior end of hinge plate, subumbonal ones relatively short, more anterior ones broad and elongated; adductor scars small, subequal, dorsally placed, anterior one with small accessory scar just behind it. [Fresh and brackish waters.] *L.Cret.-U.Cret.*, Japan-Laos-Korea-Manchuria.—FIG. D76,2a. **T. kodairai*, *L.Cret.*, S.Korea; LV ext., $\times 1.5$ (479).—FIG. D76,2b,c. *T. matsumotoi* KOBAYASHI & SUZUKI, *U.Cret.*(Turon.), Japan; 2b,c, LV int., RV int., $\times 1$ (Ota, 1959).—FIG. D76,2d. *T. kobayashi* HOFFET, *U.Cret.*(Senon.), Laos; LV int., $\times 1$ (Ota, 1959).

Sainschandia MARTINSON, 1957, p. 287 [**S. sculpturensis*; SD MARTINSON, 1961, p. 209]. Subtrigonal, subtruncate anteriorly, with prominent, anteriorly placed, orthogyrous umbones; ornament consisting of strong rounded ribs which form a single radially arranged series, crossed in later growth stages by concentric ridges; hinge devoid of short subumbonal teeth but with elongate, transversely crenulated anterior and posterior laterals. *U.Cret.*(Cenoman.-Turon.), SE. Mongolia.—FIG. D76,1. **S. sculpturensis*, Cenoman.; RV ext., $\times 1$ (Martinson, 1957).

Family UNCERTAIN

Classification of the following genera, based on species (questionably referred to *Trigonia*), is uncertain.

Anopisthodon R. A. PHILIPPI, 1899, p. 74 [**Trigonia? obesa*; M]. Founded on imperfect internal mold possibly referable to Trigoniidae, but said to lack impressions of posterior cardinal teeth. *Cret.*, S.Am.(Chile).

Aulacopleurum R. A. PHILIPPI, 1899, p. 94 [**Trigonia? trapezoidea*; SD Cox herein]. Based on imperfect internal molds probably not all congeneric and all of very doubtful affinities with Trigoniidae. *Cret.*, S.Am.(Chile).