

*G. Arthur Cooper
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Brachiopods
from
West Texas

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ABSTRACT

Thirty-five new genera are described, 27 of them based on new species. They are classified by superfamily as follows: ENTELETACEA: *Acosarina* (*A. dorsisulcata*, new species). DAVIDSONIACEA: *Goniarina* (*G. pyelodes*, new species), *Tropidelasma* (*T. culmenatum*, new species). CHONETACEA: *Chonetinetes* (*C. reversus*, new species), *Micraphelia* (*M. scitula*, new species), *Rugaria* (*Chonetes hessensis* R. E. King), *Sulcataria* (*Chonetina?* *rostrata* Dunbar and Condra), *Undulella* (*U. undulata*, new species). STROPHALOSIACEA: *Acritosia* (*A. magna*, new species), *Agelesia* (*Aulosteges triangularis* R. E. King). RICHTHOFENIACEA: *Collumatus* (*C. solitarius*, new species), *Cyclacantharia* (*C. kingorum*, new species), *Hercosestria* (*H. cribrosa*, new species), *Hercosia* (*Richthofenia uddeni* Böse), *Sestropoma* (*S. cribriferum*, new species). PRODUCTACEA: *Anemonaria* (*A. inflata*, new species), *Dasysaria* (*D. undulata*, new species), *Oncosarina* (*O. spinicostata*, new species), *Thamnosia* (*T. anterospinosa*, new species). LYTTONIACEA: *Petasmaia* (*P. expansa*, new species). RHYNCHONELLACEA: *Amphipella* (*A. arcaria*, new species), *Bryorhynchus* (*Camarophoria?* *bisulcata* Shumard), *Divaricosta* (*D. squarrosa*, new species), *Petasmatherus* (*P. opulus*, new species), *Phrenophoria* (*P. subcarinata*, new species), *Pontisia* (*P. stehlii*, new species), *Strigirhynchus* (*Rhynchonella?* *indentata* Shumard), *Tautosia* (*T. fastigiata*, new species). SPIRIFERACEA: *Lepidospirifer* (*L. angulatus*, new species). SPIRIFERINACEA: *Sarganostega* (*S. transversalis*, new species), *Xestotrema* (*Spirifera pulchra* Meek). RETICULARIACEA: *Anomaloria* (*A. anomala*, new species), *Astegosia* (*Squamularia guadalupensis subquadrata* Girty). DIELASMATAE: *Plectelasma* (*P. kingi*, new species). CRYPTONELLACEA: *Texasia* (*T. elongata*, new species).

The genus *Cooperina* Termier, Termier and Pajaud, based on material from the Glass Mountains, Texas, was assigned by its authors to the Thecideidina. Evidence is adduced here to show that it is classified more properly among the Strophalosiacea of the Productidina and that it is unrelated to the thecideids.

Introduction

The Permian rocks of western Texas contain probably the largest and most diversified Permian brachiopod fauna in the world, numbering nearly 1000 species in more than 200 genera. Strata exposed in the many small mountain ranges in the "trans-Pecos" area have come to be regarded as the standard for Permian correlations in all of North America, and therefore have been the subject of intensive study by many geologists. Pioneer work by G. H. Girty (1909) and P. B. King (1948) in the Guadalupe Mountains and by P. B. King (1931)

and R. E. King (1931) in the Glass Mountains has made these two ranges preeminent as type sections.

The brachiopods of this area have been the subject of study by the present writers for many years. Brachiopod workers, other paleontologists, and stratigraphers have learned of this study and have become acquainted with the quality of much of the silicified material through the media of lectures, preliminary notes, formal and informal field trips, visits to the U. S. National Museum, and personal conversations. Therefore, it seems advisable to establish some of the new taxa that will be described more fully later, to make available names that already are informally current, and to name common genera that are important to discussions of age and correlation. This avoids the awkward necessity of referring to unnamed taxa in shorter discussions of

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stratigraphy, age, and correlation such as those already presented by Cooper and Grant (1964, 1966).

This paper establishes about half of the genera that we expect to describe as new from this area. A few of these are based upon species already described in the literature, most are based on new species. Those that remain to be established are relatively rare or of lesser importance to considerations of stratigraphic relationships. In addition, we have taken this opportunity to discuss the taxonomic position of the genus *Cooperina*, recently established by H. Termier, G. Termier, and Pajaud (1967), rather than delay it and thus risk having what we consider an erroneous interpretation become "fossilized" in the literature.

Occurrences are given in the most recently adopted stratigraphic terminology by P. B. King (1948), Ross (1959), and Cooper and Grant (1964, 1966), but older equivalent names are mentioned for clarity in the detailed listing of locations. Abbreviations: USNM=U.S. National Museum, USGS=U. S. Geological Survey, YPM=Yale Peabody Museum, AMNH=American Museum of Natural History, T=University of Texas, T-BEG=Texas, Bureau of Economic Geology.

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Superfamily ENTELETACEA Waagen, 1884

Acosarina Cooper and Grant, new genus

DIAGNOSIS.—Shell small and strongly biconvex, widest at midlength; anterior commissure rectimarginate to sulcate; palintropes well developed, interareas distinctly visible on articulated shell. Pedicle valve interior with low but long median septum, extending to or slightly beyond midlength; dental plates short.

TYPE-SPECIES.—*Acosarina dorsisulcata* Cooper and Grant, new species.

REMARKS.—This genus most nearly resembles *Orthotichia*, differing in its rectimarginate to sulcate anterior commissure, and long but low median septum in the pedicle valve. Its distinct interarea and conspicuously wider hinge distinguish it readily from *Rhipidomella* Oehlert, as do its other undoubtedly orthotichiid internal features.

Acosarina dorsisulcata Cooper and Grant, new species

PLATE 5: FIGURES 19-23

Shell small for genus, slightly wider than long, subequally biconvex; surface multicostellate and with randomly scattered tubules; anterior commissure weakly sulcate, normally slightly emarginate as well. Hinge width about half the valve width, interarea distinct, longitudinally curved reflecting curvature of pedicle beak; pedicle valve slightly swollen to form low fold.

Pedicle valve interior with small teeth, short dental plates; median septum low, fairly thick, extending beyond dental plates to near midlength of valve. Brachial valve interior with long curved brachiophores having thick, widely flaring supports; cardinal process thick and triangular.

TYPES.—Holotype USNM 150242b.

STRATIGRAPHIC OCCURRENCE.—Bone Spring Limestone.

LOCALITY.—USNM 728e, Sierra Diablo.

REMARKS.—This species is characterized by its relatively small size and its sulcate commissure. It differs from *Rhipidomella mesoplatys* R. E. King (1931) (herein assigned to *Acosarina*) in these two features and in its stronger biconvexity.

Superfamily DAVIDSONIACEA King, 1850

Goniarina Cooper and Grant, new genus

DIAGNOSIS.—Small conical schuchertellids with long interarea; rectimarginate; pseudopunctate; costellate, costellae with filae. Pedicle valve interior with deep delthyrial cavity; dental plates absent. Brachial valve interior with 2 lobes of cardinal process bisected by thin septum but lobes and septum all fused into thick curved plate covered by arched chlidium; adductor muscle field bisected by short median ridge extending forward beyond muscle marks.

TYPE-SPECIES.—*Goniarina pyelodes* Cooper and Grant, new species.

REMARKS.—This genus most nearly resembles *Schuchertella* Girty and *Derbyoides* Dunbar and Condra. It differs from *Schuchertella* in its conical shell with consequent elongated and flat interarea and, internally, by its originally septate cardinal process, its unusually long, slender, and curved brachiophores (unusual in any davidsoniacean),

and especially by its irregular myophragm in the brachial valve. The myophragm begins between the adductor marks and extends to the anterior edge of muscle field, in contrast to that of *Schuchertella* in which the median ridge or myophragm, if present, begins behind the muscle area and extends only to near its middle.

Goniarina differs from *Derbyoides* externally in the conical shape of the shell and the long interarea; it differs internally in the lack of a secondary median septum in the pedicle valve and in the lack of the cuplike structures that enclose the brachiophores of *Derbyoides*.

***Goniarina pyelodes* Cooper and Grant, new species**

PLATE 4: FIGURES 26-30

Small for genus, highly variable, normally twisted or bent, shallowly to deeply conical; hinge slightly narrower than maximum width of shell, ends slightly auriculate. Costellae low, rounded, weakly crenulated, increasing in number by intercalation, numbering 15-22 per 5 mm on pedicle valve, 18-24 per 5 mm on brachial valve; attachment scar normally present near pedicle valve beak; interarea wide, long, nearly flat; perideltidial area obscurely marked, occupying more than half the width of interarea.

Pedicle valve interior with hinge teeth keeled, but without dental plates. Brachial valve interior with cardinal process short, bifid, longitudinally grooved; brachiophores nearly buried in sides of socket plates, fused to sides of cardinal process; muscle area bisected by long, low median ridge.

TYPES.—Holotype USNM 150411g.

STRATIGRAPHIC OCCURRENCE.—Neal Ranch Formation of Ross (1959).

LOCALITY.—USNM 701k, Glass Mountains.

REMARKS.—Another species that belongs to *Goniarina* is *Schuchertella permiana* Stehli (1954, p. 298, pl. 17: figs. 19-23). *Goniarina pyelodes* differs in its smaller size, more deeply conical shape with higher interarea, weaker costellation, and lack of a node near the anterior end of the septum in the brachial valve.

***Tropidelasma* Cooper and Grant, new genus**

DIAGNOSIS.—Medium sized to large, finely costellate with elongated pedicle valve and convex, lid-

like brachial valve. Interarea broad; pseudodeltidium with narrow elevated longitudinal fold. Pedicle valve interior with greatly elongated cardinal process having deeply slit prongs. Resembles *Streptorhynchus* in its lack of dental plates but the folded pseudodeltidium and greatly elongated cardinal process separate the two.

TYPE-SPECIES.—*Tropidelasma culmenatum* Cooper and Grant, new species.

***Tropidelasma culmenatum* Cooper and Grant, new species**

PLATE 1: FIGURES 27-29

Variable in form, usually subconical; pedicle valve elongated; brachial valve a moderately convex lid. Interarea long; pseudodeltidium nearly flush with the interarea but marked medially by a prominent narrow, longitudinal fold. Greatest width at about midvalve. Surface costellate, costellae numbering about 3 in one millimeter at anterior margin.

Pedicle valve often distorted; beak small and usually acute; sides concave to gently convex; median region longitudinally subcarinate. Brachial valve with prominent swollen umbo; median and anterior regions gently flattened.

Measurements in mm

	brachial valve		width	hinge	thickness
	length	length		width	
holotype	32.4	32.4	39.2	36.0	51.9
147829a	42.9	30.0	50.6	44.5	47.6

TYPES.—Holotype USNM 147829b; paratypes 147829a, c-l.

STRATIGRAPHIC OCCURRENCE.—Neal Ranch Formation of Ross (1959).

LOCALITY.—USNM 701h, Glass Mountains.

REMARKS.—Resembles *Streptorhynchus? undulatum* R. E. King from the Skinner Ranch Formation but is much larger, more elongate, with a wider hinge, and with a wider pseudodeltidium that occupies one-third of the interarea.

Superfamily CHONETACEA Bronn, 1862

***Chonetinetes* Cooper and Grant, new genus**

DIAGNOSIS.—Small, alate, dorsally deeply concave, anteriorly tapering chonetid with erect cardi-

nal process having a deep alveolus; median septum short; anderidia reduced but anterior slope of brachial valve deeply sulcate and lateral regions elevated. Suggests *Chonetina* Krotov in exterior form but is smooth and its interior is not biseptate as in *Chonetina*.

TYPE-SPECIES.—*Chonetinetes reversus* Cooper and Grant, new species.

***Chonetinetes reversus* Cooper and Grant, new species**

PLATE 3: FIGURES 1-7

Small, subtriangular with wide hinge and acutely pointed ears. Deeply concavo-convex with anterior tapering and narrowly rounded. Spines oblique, numbering 3 or 4 on each side of the beak.

Pedicle valve medially sulcate posteriorly, the sulcus disappearing anteriorly. Interarea moderately long, slightly curved, orthocline. Pseudodeltidium strongly curved, moderately long. Dorsal valve deeply concave, with a prominent, narrow, short fold at the posterior. Interarea short, hypercline.

Pedicle valve interior with deep umbonal chamber divided by a stout median septum. Apical callosity thick. Dorsal valve interior with large cardinal process, short median septum facing an anterior, longitudinal channel bounded by steep sides. Lateral areas swollen.

Measurements in mm

	brachial valve length	hinge width	mid- width	thickness
holotype	9.2	7.4	13.3	10.0

TYPES.—Holotype USNM 153193a; paratypes 153193b-l.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITY.—USNM 710h, Glass Mountains.

REMARKS.—This is the largest and most robust species of the three recognized in the collections.

***Micraphelia* Cooper and Grant, new genus**

DIAGNOSIS.—Small, subquadrate chonetid with smooth exterior; commissure not folded; hinge ends not extended; pedicle valve interior with short median septum; dorsal valve interior with small

cardinal process, thick anderidia, short median septum and prominently elevated lateral regions.

TYPE-SPECIES.—*Micraphelia scitula* Cooper and Grant, new species.

REMARKS.—The very small size of this chonetid invites comparison with only two other genera. It differs from *Tornquistia* Paeckelmann in absence of two prominent divergent ridges in the median region of the brachial valve. It differs from *Chonetina* in lacking the distinctive fold and sulcus that characterize that genus, and in its smooth rather than finely costellate surface.

***Micraphelia scitula* Cooper and Grant, new species**

PLATE 5: FIGURES 10-12

Shell small, transversely subquadrate; posterior margin with about 4 oblique spines; umbonal and medial regions of pedicle valve strongly inflated; lateral slopes steep; brachial valve less strongly inflated.

Pedicle valve interior with small teeth, thick apical callosity, short median septum continued as low ridge to near midlength. Brachial valve interior with small cardinal process and short, poorly defined prosocket ridges; brevisseptum slender; visceral disc marginally thickened progressively with age; margin with broad granulose flattening; visceral region with abundant endospines.

TYPES.—Holotype USNM 153725b; paratype 153725e.

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Hegler, Pinery, and Rader Members).

LOCALITY.—Holotype: USNM 731, Delaware Basin.

REMARKS.—Shumard's (1859) specimens of *Chonetes permianus* also may belong to this species, but they are irretrievably lost. Since their relationships cannot be ascertained, the name is left with the lost specimens and is effectively nullified.

***Rugaria* Cooper and Grant, new genus**

DIAGNOSIS.—Small, strongly costate Chonetacea having a large cardinal process with deep alveolus, short median septum and a broad, strongly endospinose anterior slope in the brachial valve. Re-

sembles *Micraphelia* in form but is costate; resembles some species assigned to *Plicochonetes* Paeckelmann but has a well-developed median septum.

TYPE-SPECIES.—*Chonetes hessensis* R. E. King (1931, p. 61, pl. 9: figs. 21, 22).

TYPES.—Lectotype YPM 10820 (R. E. King, 1931, pl. 9: fig. 22); paratype T 10589.

STRATIGRAPHIC OCCURRENCE.—Hess Formation (Taylor Ranch Member).

LOCALITY.—R. E. King 107 (1931), Glass Mountains.

Sulcataria Cooper and Grant, new genus

DIAGNOSIS.—Small, smooth chonetacean having the pedicle valve deeply sulcate and brachial valve flatly concave and with a fairly strong dorsal median fold. Pedicle valve interior with broad, elevated adductor ridge and flattened margins; brachial valve interior with thick median septum and strongly lobed anterior visceral region. Resembles *Chonetinella* Ramsbottom externally but differs in being smooth and having more strongly developed visceral region in the brachial valve.

TYPE-SPECIES.—*Chonetina? rostrata* Dunbar and Condra (1932, p. 150, pl. 19: figs. 1-3, 5-7).

TYPES.—Lectotype YPM S2166a (Dunbar and Condra, 1932, pl. 19: fig. 1); paratypes YPM S2166b-f.

STRATIGRAPHIC OCCURRENCE.—Pennsylvanian, South Bend Sandstone and Shale of Plummer and Moore (1922).

LOCALITY.—2.5 miles southeast of Gunsight, Texas.

Undulella Cooper and Grant, new genus

DIAGNOSIS.—Small, smooth, chonetacean with a broad median sulcus in the pedicle valve and long spines given off at a right angle. Brachial valve with small cardinal process, without adductor dividing ridges and with a short brevisseptum. Anteromedian part of visceral region with a deep pit. Suggests *Sulcataria* in external form but has vertical posterior spines and different brachial valve interior.

TYPE-SPECIES.—*Undulella undulata* Cooper and Grant, new species.

Undulella undulata Cooper and Grant, new species

PLATE 2: FIGURES 1-7

Small, transversely rectangular with rounded sides; cardinal extremities nearly a right angle; posterior margin with 4 erect spines, the outer 2 attaining a length of 2.5 mm. Pedicle valve with the posterior half flatly convex and the anterior half strongly bent in a gentle curve toward the brachial valve. Beak small; interarea moderately long, apsacline; pseudodeltidium strongly convex. Brachial valve with cardinal extremities flattened; most concave posteromedially; anterior half gently curved in a dorsad direction to form a broad undulation.

Measurements in mm

	brach- ial valve length	sur- face length	hinge width	mid- width	height	thick- ness
holotype	7.1	6.2	8.5	12.2	12.0	2.3
152070g	6.4	6.0	7.0	11.3	11.0	2.0

TYPES.—Holotype USNM 152070b; paratypes 152070b, a, c-r; 153186a.

STRATIGRAPHIC OCCURRENCE.—Word Formation (Willis Ranch Member).

LOCALITY.—USNM 706e, Glass Mountains.

REMARKS.—No other species of this genus has been described to which this one may be compared. Two other species are present in the collections.

Superfamily STROPHALOSIACEA Schuchert, 1913

Acritosia Cooper and Grant, new genus

DIAGNOSIS.—Low conical, oblique in youth but becoming more symmetrical with growth; cup margin flaring; attached by numerous rhizoid spines with circular cross sections without webbing. Pedicle valve interior lacking septum; protective spines on anterior side only; brachial valve lodged obliquely. Brachial valve flat to slightly concave; interior with short, erect cardinal process; muscle area slightly thickened; endospines few but strong.

TYPE-SPECIES.—*Acritosia magna* Cooper and Grant, new species.

REMARKS.—*Acritosia* most nearly resembles *Teguliferina* Schuchert and LeVene externally, but

differs in having rhizoid spines that are circular in cross section and have no weblike shelly material on them or between them. It differs from the new genus *Hercosia* (described below) in lacking a median septum in the pedicle valve. It differs from the new genus *Cyclacantharia* (also described below), which also is without a septum, in its lack of an elevated muscle mound in the apex of the pedicle valve and in its protective spines, which are located only at the anterior of the inner margin of the pedicle valve rather than surrounding it completely as in *Cyclacantharia*.

Acritosia magna Cooper and Grant, new species

PLATE 5: FIGURES 17, 18

Large, thin shelled, narrow or spreading; margin flared; anterior side flattened, bearing many short spines just inside anterior margin; apex blunt, pointing posteriorly; attachment surface small; surface wrinkled; rhizoid spines slender.

Pedicle valve interior with low median myophragm bisecting muscle area; aulacoterma distinct, just inside protective spines, extending obliquely around valve. Brachial valve interior with narrow cardinal process; buttress ridge and brevisseptum low and obscure.

TYPES.—Holotype USNM 151739a.

STRATIGRAPHIC OCCURRENCE.—Neal Ranch Formation of Ross (1959).

LOCALITY.—USNM 701k, Glass Mountains.

REMARKS.—This is the largest species of the genus, distinguished by its flared pedicle valve margin and relatively thin shell walls. Of described species that belong to this genus, *A. magna* differs from *Teguliferina? teguliferoides* Stehli, 1954 (not R. E. King, 1931), in its large size, thinner shell, and somewhat fewer and more slender rhizoid spines.

Agelesia Cooper and Grant, new genus

PLATE 5: FIGURES 30, 31

DIAGNOSIS.—Small, triangular aulostegid with dorsal valve pitted but not spinose; pedicle valve with narrow hinge and strong muscle callosity; brachial valve with thickened adductor scars but widely bilobed cardinal process. This genus is similar to *Giriasia* De Gregorio, 1930, in possessing a widely bilobed cardinal process but differs in hav-

ing thick rhizoid spines on the ears and lateral slopes and the interarea vestigial or absent.

TYPE-SPECIES.—*Aulosteges triangularis* R. E. King (1931, p. 94, pl. 27: figs. 1a, b).

TYPES.—Holotype YPM 11833; illustrated hypotypes, USNM 151514a, 153834a.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITY.—Holotype: R. E. King 231 (1931). Hypotypes: USNM 703bs, Glass Mountains.

Superfamily RICHTHOFENIACEA Waagen, 1885

Collumatus Cooper and Grant, new genus

DIAGNOSIS.—Small, noncolonial or solitary richthofeniacean forming squat cylinders attached by a broad base. Aperture of pedicle valve covered by a calcareous net as in *Hercosestria* Cooper and Grant (described below). No septum in the pedicle valve. Attachment spines absent, their place being taken by concentric sheets of shell substance surrounding the cup and cementing the shell to the substrate. Lack of anchoring spines sets this genus apart from all other richthofeniaceans.

TYPE-SPECIES.—*Collumatus solitarius* Cooper and Grant, new species.

Collumatus solitarius Cooper and Grant, new species

PLATE 1: FIGURES 22-26

Small, subcylindrical to laterally elliptical and with expanded base. Aperture of cylinder usually constricted and covered by a protective calcareous net. Pedicle valve interior with low myophragm and flabellate diductor scars. Dorsal valve located about one-third the valve length above the floor; cardinal process small, bilobed; adductor scars elongate, thickened.

Measurements in mm

	length	width	thickness
holotype	12.0	12.5	6.5

TYPES.—Holotype USNM 153548a; paratypes 153548b-g.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation (top).

LOCALITY.—USNM 736x, Glass Mountains.

COMPARISON.—This species is unique, and its absence of anchoring spines distinguishes it from *Hercosestria* and *Sestropoma*, both of which have calcareous nets covering the aperture.

Cyclacantharia Cooper and Grant, new genus

DIAGNOSIS.—Richthofeniaceans having the entire rim of the ventral valve provided with protective spines; ventral valve having a thick muscle callosity but no median septum. In the latter respect it is unlike *Hercosia* Cooper and Grant (described below).

TYPE-SPECIES.—*Cyclacantharia kingorum* Cooper and Grant, new species.

Cyclacantharia kingorum Cooper and Grant, new species

PLATE 5: FIGURES 13-16

Richthofenia permiana Girty [not Shumard], 1909, p. 283 pl. 31: figs. 1-3.—Böse [not Shumard], 1916, p. 37, pl. 1: figs. 1-16; pl. 2: figs. 8, 15; pl. 3: figs. 1, 4-7.

Prorichthofenia permiana R. E. King [not Shumard], 1931, p. 99, pl. 29: figs. 6-9; pl. 30: figs. 9-13.—Muir-Wood and Cooper [not Shumard], 1960, p. 139, pl. 29: figs. 1-15.

Fairly large cones, the width about three-fifths the length of the cone with aperture surrounded by striated spines, those of the anterior side longer and extending beyond the middle of the cup. Aperture flared widely in some specimens. Surface smooth. Anchor spines moderately thick and stout. Brachial valve thin, located three-fifths to two-thirds the length from the apex; surface finely spinose.

Pedicle valve interior with vesiculose tissue extending for about half the length of the cone; muscle callosity thick, subcarinate but without a septum. Brachial valve interior with small bilobed cardinal process and a few long, stout endospines at the anterior.

Measurements in mm*

	brachial valve				
	length	length	width	thickness	height
holotype	22.0	23.7	23.2	22.0 ^p	31.0

* According to measurement directions of Muir-Wood and Cooper, 1960, p. 19.

TYPES.—Holotype USNM 153831; figured paratypes USNM 123917, 123918, 124138, 124139,

124140a,b, 124164a-c, 124165a, 124166 (all figured by Muir-Wood and Cooper, 1960, pl. 29: figs. 1-8, 10, 14).

STRATIGRAPHIC OCCURRENCE.—Word Formation (Willis Ranch Member).

LOCALITY.—USNM 706e, Glass Mountains.

REMARKS.—This is larger than the common *Richthofenia uddeni* Böse of the Leonard Series (Cathedral Mountain Formation) and differs further in having a complete ring of spines around the inner margin of the cup and in not having a median septum in the pedicle valve.

Hercosestria Cooper and Grant, new genus

DIAGNOSIS.—Small richthofeniacean with strong bladelike median septum in the pedicle valve, the aperture of which is covered by a slightly convex netlike cover. Brachial valve with aborted anterior endospines. Differs from *Sestropoma* Cooper and Grant (described below) in having a strong ventral median septum and a low net across the aperture.

TYPE-SPECIES.—*Hercosestria cribrosa* Cooper and Grant, new species.

Hercosestria cribrosa Cooper and Grant, new species

PLATE 1: FIGURES 1-3

Medium-sized, widely conical richthofeniacean with aperture covered by a fine-meshed calcareous net; brachial valve deeply inset at about midway of the cone. Rim of cone squamose; sides smooth, spines numerous.

Measurements in mm

	length	width	thickness	height
holotype	18.2	26.2	16.7	34.5

TYPES.—Holotype USNM 151804; paratype USNM 153199.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITY.—USNM 702c, 703a, Glass Mountains.

Hercosia Cooper and Grant, new genus

DIAGNOSIS.—Medium-sized richthofeniaceans having a long bladelike median septum in the pedicle valve and protective spines only on the ventral

side of the cup rim. Suggests *Hercosestria* internally but lacks the netlike calcareous cover over the cup.

TYPE-SPECIES.—*Richthofenia uddeni* Böse (1916, p. 43, pl. 2: figs. 1-7, 9, 13; pl. 3: fig. 2).

TYPES.—Lectotype T-BEG 7643 (Böse, 1916, pl. 2: figs. 4, 7, 9).

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITY.—Old Word Ranch, Glass Mountains, Hess Canyon quadrangle, Texas.

Sestropoma Cooper and Grant, new genus

DIAGNOSIS.—Like *Cyclacantharia* internally but with a strongly convex netlike cover over the aperture of the cone.

TYPE-SPECIES.—*Sestropoma cribriferum* Cooper and Grant, new species.

Sestropoma cribriferum Cooper and Grant, new species

PLATE 2: FIGURES 19-21

Prorichthofenia species Newell, et al., 1953, pl. 21: fig. 33.

About medium size for a richthofeniacean, elongate, conical with an apex angle of about 40°. Surface smooth but with numerous thick attachment spines. Pedicle valve with keeled muscle callosity but no septum. Brachial valve with scattered nodes in place of endospines.

Measurements in mm

	length	width	thickness	height
holotype	17.4	24.7	37.8	?

TYPES.—Holotype USNM 151656b; paratypes 151656a, c-k.

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Hegler Limestone Member).

LOCALITY.—USNM 731, Guadalupe Mountains.

REMARKS.—*Sestropoma* is very much like *Hercosestria* in the possession of a calcareous net over the cup, but the latter has a flattish net and possesses a strong bladelike median septum.

Superfamily PRODUCTACEA Gray, 1840

Anemonaria Cooper and Grant, new genus

DIAGNOSIS.—Outline subrectangular, widest at hinge, ears extended; profile deeply concavo-con-

vex; trail with distinct sulcus. Surface nearly smooth except for numerous indistinct costellae on trail; spines few: 1 row on each lateral slope, scattered individual spines on trail and visceral disc. Pedicle valve interior with rudimentary ear baffles; brachial valve interior with small sessile cardinal process with broad zygidium; brevisseptum reduced.

TYPE-SPECIES.—*Anemonaria inflata* Cooper and Grant, new species.

REMARKS.—The most obvious external resemblance of *Anemonaria* is to *Kozlowskia* Frederiks. *Anemonaria* differs in having a different arrangement of spines, a zygidium in the brachial valve, and in lacking the marginal ridge and the numerous short brachial trails often so conspicuous on *Kozlowskia*. Its spine arrangement is similar to that of *Liosotella* Cooper, but it lacks the strong costae of that genus.

Anemonaria inflata Cooper and Grant, new species

PLATE 5: FIGURES 28, 29

Marginifera sublaevis R. E. King, 1931 [part], p. 89, pl. 23: figs. 15a-c, 19 [not figs. 13, 14, 17; fig. 16 uncertain].

Size average for genus; outline subrectangular except for extension of large ears; anterior margin rounded and only slightly sulcate; surface only weakly costellate, primarily near anterior margin. Spines in 1 row below each ear, occasionally 1 spine on each ear; spines widely and randomly scattered on venter and trail.

Pedicle valve interior with flabellate diductor marks and elongate adductor marks; ear baffles distinct. Brachial valve interior with short cardinal process having broad zygidium and narrowly rounded lophidium; muscle marks and brachial ridges indistinct; brevisseptum extending forward only to midlength of adductor marks.

TYPES.—Holotype USNM 153833a; paratype USNM 153833b.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITY.—USNM 721u, Glass Mountains.

REMARKS.—This is the only known species of *Anemonaria*; the other specimens attributed by R. E. King (1931, pl. 23: figs. 13, 14, 17) to *Marginifera sublaevis* now are considered species of *Kozlowskia*.

***Dasysaria* Cooper and Grant, new genus**

DIAGNOSIS.—Shell large, widest at hinge, ears extended; surface finely and irregularly semireticulate; spines numerous, with thick tuft on ears and posterior margin, fine spines on visceral disc and trail, but absent from brachial valve. Pedicle valve interior with adductor field moderately thickened; muscle scars dendritic. Brachial valve interior with cardinal process small, widely trilobate, typically dictyoclostid; lateral ridges and brevisseptum strong.

TYPE-SPECIES.—*Dasysaria undulata* Cooper and Grant, new species.

REMARKS.—The general form of *Dasysaria* recalls that of its nearest relative, *Squamaria* Muir-Wood and Cooper. *Dasysaria* differs primarily in its entire lack of dorsal spines, but also in its finely costellate trail.

***Dasysaria undulata* Cooper and Grant, new species**

PLATE 5: FIGURES 32-34

Productus hessensis R. E. King 1931 [part], p. 68, pl. 11: figs. 3, 4.

Productus wolfcampensis R. E. King 1931 [part] p. 74, pl. 16: figs. 4, 5?

Shell large, about as long as wide, but ears extended. Ornament semireticulate, visceral discs of both valves crossed by strong costellae and closely spaced concentric undulations; trails of both valves costellate. Halteroid spines in tufts above ears; thin body spines abundant on trail and visceral disc; sulcus shallow or absent.

Pedicle valve interior with diductor marks broadly flabellate; adductor marks moderately thickened. Brachial valve interior with cardinal process short but wide and thick, supported by secondary median ridge connected to brevisseptum; adductor marks strongly dendritic but not much thickened.

TYPES.—Holotype USNM 148914.

STRATIGRAPHIC OCCURRENCE.—Hueco Formation.

LOCALITY.—USNM 720a, Sierra Diablo.

REMARKS.—This species is characterized by its large size, strongly reticulate visceral discs, strong costellae, and squarish outline. The two other known species, *Productus wolfcampensis* R. E. King (1931, part only: pl. 16: figs. 1-3, but not figs. 4-5), and *Productus welleri* R. H. King (1938, p. 273, pl. 39: figs. 5-8), are smaller and proportionately nar-

rower than the quadrate *D. undulata*. In addition, the strong undulations on the visceral discs of both valves are distinctive.

***Oncosarina* Cooper and Grant, new genus**

DIAGNOSIS.—Deeply concavo-convex marginiferid with strongly costate trail, narrow ears, and concentrically wrinkled visceral region; spines scattered, confined to pedicle valve, where they occur on costae and on lateral slopes just proximal to the ears. Dorsal valve interior with small cardinal process; adductor scars elongated, elevated; median brevisseptum short, slender.

TYPE-SPECIES.—*Oncosarina spinicostata* Cooper and Grant, new species.

REMARKS.—*Oncosarina* resembles *Semicostella* Muir-Wood and Cooper, differing in its more spiny pedicle valve exterior, elevated adductor muscle platforms, and its short, slender brevisseptum. It also resembles *Elliottella* Stehli, differing in the strongly rounded profile and lack of a sulcus on the pedicle valve.

***Oncosarina spinicostata* Cooper and Grant, new species**

PLATE 5: FIGURES 24, 25

Marginifera manzanica R. E. King [not Girty] 1931, p. 87, pl. 21: figs. 22-24.

Shell small; outline transversely subrectangular, hinge width equal to or greater than midwidth, sides nearly straight; ears small. Profile concavo-convex with deep visceral cavity; costae variable; concentric wrinkles indistinct on both valves; spines halteroid, with 1 row along posterior margin, 1 row on each ear, a cluster on posterolateral slopes, scattered spines on venter.

Pedicle valve interior with low adductor muscle platform and rudimentary ear baffles. Brachial valve interior with adductor platform of 2 laterally tilted plates separated by brevisseptum; cardinal process small and bilobed in juveniles, thick and trilobed in adults; ear baffles high, continuing around anterior as indistinct marginal ridge.

TYPES.—Holotype USNM 149824.

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (Decie Ranch, Poplar Tank, and Sullivan Peak Members).

LOCALITY.—Holotype: USNM 707ha, Glass Mountains.

REMARKS.—This species is smaller than the other known species of the genus, *Marginifera? whitei* R. E. King (1931), and has less uniform costae and much less distinct concentric wrinkling of both valves.

***Thamnosia* Cooper and Grant, new genus**

DIAGNOSIS.—Shell deeply plano- to concavo-convex; pedicle valve deep; brachial valve with sharply geniculated trail; hinge wide, ears extended; surface costellate, visceral discs of both valves concentrically wrinkled. Spines numerous, small on ears; thick brush of spines on posterolateral slopes over ears; many spines on trail; brachial valve with fine hairlike spines.

Pedicle valve interior with ear baffles and widely flabellate diductor scars not enclosing adductors. Brachial valve interior with cardinal process bilobed in juveniles, becoming thick and trilobed in adults, united to weak brevisseptum by long slender buttress.

TYPE-SPECIES.—*Thamnosia anterospinosa* Cooper and Grant, new species.

REMARKS.—This genus most nearly resembles *Kutorginella* Ivanova (1951), of which *Retaria* Muir-Wood and Cooper is a junior synonym, differing in possession of a thick brush of spines on the lateral slopes, and numerous spines on the trail, whereas *Kutorginella* has but a single row of spines on the lateral slopes and widely scattered spines elsewhere.

***Thamnosia anterospinosa* Cooper and Grant, new species**

PLATE 5: FIGURES 26, 27

Shell outline rectangular, hinge width as great or greater than midwidth; cross section plano-convex; both valves costellate and spinose; visceral disc of pedicle valve slightly rugose on lateral slopes and just proximal to ears; costellae more prominent on visceral disc, flatter on trail, separated by fine striae. Thick brush of strong spines on lateral slopes; spines on visceral disc short, fine, widely

scattered; long strong spines concentrated on anterior of trail; spines on brachial valve thin, short.

Pedicle valve interior with adductor field slightly elevated and elongated; ear baffles absent. Brachial valve interior with rounded cardinal buttress elevated and continuous with long brevisseptum; cardinal process elongate, strongly trilobed in adult; ear baffles present, continuous around anterior as marginal ridge; adductor muscle field large, lateral scars strongly dendritic.

TYPES.—Holotype USNM 149852.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITY.—USNM 702un, Glass Mountains.

REMARKS.—The most distinctive features of *T. anterospinosa* are its relatively large size, and numerous strong spines around the anterior, culminating in a thick brush of long strong spines on the posterolateral slopes, with few spines elsewhere. It differs from *Alexenia? parvispinosa* Stehli (1954) (herein assigned to *Thamnosia*) in its much longer and thicker spines. *Thamnosia parvispinosa* has many spines, but they are short and delicate.

Superfamily LYTTONIACEA Waagen, 1883

***Petasmaia* Cooper and Grant, new genus**

DIAGNOSIS.—Large, flattish, expanding lyttoniaceans having well-developed dental plates. Commonly much narrowed at the rear because of habitual, although not universal, attachment to crinoid stems; consequently, usually has a posteriorly directed posterior flap. Differs from *Eolyttonia* in absence of a hood and in presence of dental plates.

TYPE-SPECIES.—*Petasmaia expansa* Cooper and Grant, new species.

***Petasmaia expansa* Cooper and Grant, new species**

PLATE 2: FIGURES 15-18

Large, usually narrowed posteriorly but rapidly and widely expanded medially; maximum width variable but usually near midvalve. Exterior smooth. Interior of pedicle valve with deep lateral grooves bounded by strong, thin, high loops directed anteriorly. Brachial valve with bilobed cardinal process and twelve or more lateral lobes.

Measurements in mm

	length	maxi- mum width	hinge width	thick- ness
holotype	71.0	65.4	10.6	5.1
paratype 151341a	85.9	83.8	12.9	?

TYPES.—Holotype USNM 151343; paratypes USNM 151341a-g.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITY.—USNM 702un, 702b, Glass Mountains.

REMARKS.—*Petasmaia* is readily recognized by its narrowed posterior and is distinguished from other lyttoniaceans in the Glass Mountains (except *Coscynophora*) by the presence of the dental plates and the strong, oblique loops. It differs from *Coscynophora*, which also has dental plates, in not having beaded loops.

Superfamily RHYNCHONELLACEA Gray, 1848***Amphipella* Cooper and Grant, new genus**

DIAGNOSIS.—Small rhynchonellacean with smooth exterior and retimarginate anterior commissure. Delthyrium open. Posterior with 3 foramina, the lateral 2 leading into interior shelly pouches. Dental plates short; hinge plate divided. Crura short. Unlike any other known rhynchonellacean in the presence of the shelly pouches.

TYPE-SPECIES.—*Amphipella arcaria* Cooper and Grant, new species.

***Amphipella arcaria* Cooper and Grant, new species**

PLATE 1: FIGURES 13–21

Small, subpentagonal in outline, subequally bi-convex in outline; widest near midvalve; sides nearly straight, anterior truncated to faintly emarginate, beak forming an angle of 108°. Beak straight to suberect; postero- and anterolateral extremities narrowly rounded. Surface smooth.

Ventral valve gently convex with narrow umbonal region, broadly flattened median region and slightly depressed anterior region that forms a weak sulcus. Brachial valve swollen umbonally, flattened medially and depressed to gently sulcate anteriorly;

sides with steep slopes. Interior as defined for the genus.

Measurements in mm

	brachial valve length	width	hinge width	thick- ness
holotype	3.8	3.7	4.0	2.2

TYPES.—Holotype USNM 148098a; paratypes 148098b-z, a'-d'.

STRATIGRAPHIC OCCURRENCE.—Base of Cathedral Mountain Formation.

LOCALITY.—USNM 708u, Glass Mountains.

***Bryorhynchus* Cooper and Grant, new genus**

DIAGNOSIS.—Similar to *Leiorhynchus* Hall and *Leiorhynchoidea* Cloud externally but differs from the former in its low, often obsolete median ridge and strongly denticulate sockets. The low median ridge distinguishes it also from *Leiorhynchoidea* as do its divided hinge plate and crural cavity.

TYPE-SPECIES.—*Camarophoria? bisulcata* Shumard (1858, p. 296).

TYPES.—Neotype (selected because Shumard's types were destroyed by fire), USNM 118558 (figured by Girty, 1909, pl. 21: figs. 11a-c).

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation.

LOCALITY.—USGS 2930, Guadalupe Mountains.

***Divaricosta* Cooper and Grant, new genus**

DIAGNOSIS.—Small, uniplicate; fold low; costae increasing anteriorly by intercalation and bifurcation. Pedicle valve beak short, blunt; delthyrium nearly completely closed by large deltidial plates; brachial valve more strongly convex than the ventral one. Pedicle valve interior with vertical dental plates, fused to valve sides by secondary shell in some species. Brachial valve interior with large undivided hinge plate; no median septum, just a rather thick median ridge bisecting muscle area; crura gently curved, not twisted.

TYPE-SPECIES.—*Divaricosta squarrosa* Cooper and Grant, new species.

REMARKS.—The intercalated and bifurcated costae resemble those of *Fascicosta* Stehli (1955),

which was based on the species *Rhynchonella? longaeva* Girty (1909) from the Capitan Limestone. Stehli's specimens and others from the Getaway Limestone Member of the Cherry Canyon Formation, however, are not the same as Girty's specimens. Because Stehli chose Girty's species as the type, it remains the basis for the genus *Fascicosta*, and the name *Divaricosta* is herein introduced for the Getaway species that differs from *F. longaeva* in the generic characters of large and conjunct deltidial plates, undivided hinge plate, and merely a low median ridge rather than a well-defined median septum in the brachial valve.

***Divaricosta squarrosa* Cooper and Grant,
new species**

PLATE 4: FIGURES 1-6

Fascicosta longaeva Stehli [not Girty] 1955, p. 71, 73, figs. 1-17.

Outline bluntly subtrigonal to subpentagonal; uniplicate commissure with low fold beginning inconspicuously. Costae strong, narrow, ropelike, beginning at beaks, numbering 3-5 on fold, 6-9 on each flank at anterior of adults, having increased from few at beaks by intercalation and bifurcation. Pedicle valve beak short, slightly attenuate; delthyrium wide, nearly completely closed by large, thick, conjunct deltidial plates, leaving small subapical foramen; brachial valve moderately convex, with slightly flattened or indented umbonal region.

Pedicle valve interior with strong tusklike hinge teeth continuous with nearly vertical dental plates. Brachial valve interior with hinge plate large, semicircular, undivided, bounded laterally by deep, wide, strongly corrugated hinge sockets leaving high thin outer socket ridges; crural bases vertical, extending as keels along underside of hinge plate; median ridge thick, rounded, extending one-fourth to one-fifth length of valve.

TYPES.—Holotype AMNH 27904:1; hypotype USNM 148221.

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Limestone Member).

LOCALITY.—AMNH 512 (=USNM 728), Delaware Mountains, Texas.

REMARKS.—*Divaricosta squarrosa* is the only established species of the genus although another remains to be described.

***Petasmatherus* Cooper and Grant, new genus**

DIAGNOSIS.—Small to minute, costate, straight-hinged rhynchonellids with a well-developed interarea on the pedicle valve and short crura. Externally suggests *Allorhynchus*, but that genus lacks the interarea and wide hinge.

***Petasmatherus opulus* Cooper and Grant,
new species**

PLATE 2: FIGURES 8-14

Small, flatly biconvex, subtriangular in outline; apex variable but averaging about 90°; gently uniplicate with low fold and shallow sulcus; costae strong, 3 to 4 on the fold, 3 or 4 on the flanks. Pedicle valve interior with small teeth, short dental plates. Brachial valve interior with divided hinge plate and short slightly divergent crura; median septum absent, but low median ridge present.

Measurements in mm

	length	width	brachial valve length	hinge width	thickness
holotype	5.8	4.9	5.9	2.9	3.6
148305b	5.8	4.7	5.4	2.5	3.1

TYPES.—Holotype USNM 148305a; paratypes 148305b-f.

STRATIGRAPHIC OCCURRENCE.—Word Formation (between Willis Ranch and Appel¹ Ranch Members).

LOCALITY.—USNM 706b, Glass Mountains.

REMARKS.—Resembles *Pugnax? pusilla* Girty (1909), which belongs to the genus *Petasmatherus*, in general form but is much larger and more strongly costate.

***Phrenophoria* Cooper and Grant, new genus**

DIAGNOSIS.—Exterior suggestive of a coarse-ribbed *Leiorhynchus* or *Leiorhynchoidea*. Brachial valve interior with undivided hinge plate supported by a long thin median septum, unlike the above-named genera, which have a divided hinge plate.

TYPE-SPECIES.—*Phrenophoria subcarinata* Cooper and Grant, new species.

¹ When adopted in 1965 by the U.S. Geological Survey, this name was incorrectly spelled "Apple."

***Phrenophoria subcarinata* Cooper and Grant, new species**

PLATE 1: FIGURES 4-12

Large, biconvex, the brachial valve more strongly convex; uniplicate; beak suberect; foramen small; deltidial plates conjunct. Valves semicostate, the posterior smooth but the anterior marked by strong rounded costae.

Pedicle valve subcarinate posteriorly but forming a shallow sulcus occupied by 3 costae anteriorly. Costae adjacent to sulcus low; flanks marked by 3 costae. Tongue long, broad, and serrate at its end. Brachial valve strongly swollen but flattened to faintly sulcate in the posterior third. Fold low, flattened, poorly defined.

Pedicle valve interior with strong dental plates; diductor scars anterior to delthyrial chamber. Brachial valve interior with inner hinge plates united; socket ridges low, median septum supporting hinge plate thin, delicate and high, reaching to midvalve.

Measurements in mm

	length	brachial valve length	maximum width	thickness
holotype	17.3	15.6	18.7	14.2
148385a	13.00	11.1	11.1	9.4

Types.—Holotype USNM 148385e; paratypes USNM 148385a-d, f-i.

STRATIGRAPHIC OCCURRENCE.—Word Formation (between Willis Ranch and Appel Ranch Members).

LOCALITY.—USNM 706b, Glass Mountains.

REMARKS.—This species suggests "*Pugnax pinguis* Girty, which belongs to *Phrenophoria*, but differs in its greater convexity, larger size, less prominent fold and sulcus, and stronger costae.

***Pontisia* Cooper and Grant, new genus**

DIAGNOSIS.—Shell small, semicostate, uniplicate, with dental plates and conjunct deltidial plates in pedicle valve. Brachial valve interior with undivided hinge plate but no median septum. Externally like *Wellerella* Dunbar and Condra and *Tautosia* Cooper and Grant (described below) but lacking median septum.

TYPE-SPECIES.—*Pontisia stehlii* Cooper and Grant, new species.

REMARKS.—Externally and in the pedicle valve this genus resembles *Wellerella*, but the brachial valve has fundamental differences. *Pontisia* has the inner hinge plate completely unsupported, with no trace of a median septum (only a low ridge through the muscle area). In gerontic adults the ridge is augmented by secondary shell material to form a boss beneath the hinge plate, but this is not high enough to be mistaken for a true septum. Its differences from *Tautosia* are in the absence of a median septum in the brachial valve and in some external features such as its weaker costae and its normally depressed median costa of the fold.

***Pontisia stehlii* Cooper and Grant, new species**

PLATE 4: FIGURES 7-10

Pugnoides texanus R. E. King, 1931 [not Shumard] p. 108, pl. 34: figs. 5-9.

Pugnoides elegans R. E. King, 1931 [part; not Girty] p. 106, pl. 33: figs. 12, 13; pl. 34: fig. 4 [not pl. 34: figs. 2, 3].

Shell average size for genus, but rather bulbous, with the brachial valve deeper and more strongly convex than the pedicle valve; outline transversely trigonal to nearly oval. Fold low, beginning anterior to flattened umbonal area; sulcus strongly convex in profile, beginning anterior to inflated beak; costae strong and sharp, normally 3 on fold, 2-6 on each flank. Valve margins abruptly flexed to produce adult thickening.

Pedicle valve interior with widely triangular delthyrium, elongate teeth, vertical dental plates; muscle marks distinct. Brachial valve interior with triangular hinge plate undivided but deeply notched; crura anteriorly divergent, ventrally curved, and strongly twisted with carinate dorsal edges. Muscle area bisected by low median ridge.

Types.—Holotype USNM 153835a.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITY.—USNM 702c, Glass Mountains.

REMARKS.—This species is characterized primarily by its strongly convex brachial valve, broad but closely crowded costae, smooth beaks and umbonal regions. Three previously published species are as-

signed to *Pontisia*: *Pugnoides mesicostalis* Girty (1909), *Camerophoria swallowiana* Shumard (1859) (but not the species called "Pugnax" or "Pugnoides" *swallowiana* by R. E. King, 1931, or Hall and Clarke, 1894), and *Wellerella nanas* Stehli (1954).

Pontisia stehlii differs from *P. mesicostalis* (Girty) in its smaller size, more bulbous shape, and fewer, broader costae. It differs from *P. swallowiana* (Shumard) in its inflated or flattened (not depressed) umbonal regions, stronger costae, and internally by its well-developed dental plates. It is larger than *P. nanas* (Stehli), is transverse rather than anteriorly narrowed, and lacks the depressed median costa of the fold.

***Strigirhynchia* Cooper and Grant, new genus**

DIAGNOSIS.—Medium-sized rhynchonellaceans, uniplicate with costae covering entire surface, with strong dental plates and complete hinge plate supported by a high median septum. In the latter respect it is unlike *Allorhynchus* Weller, which it resembles externally. Dorsal valve with depressed to concave umbo.

TYPE-SPECIES.—*Rhynchonella?* *indentata* Shumard (1859, p. 393); Girty (1909, p. 321, pl. 15: figs. 20a-c).

TYPES.—Neotype USNM 118572.

STRATIGRAPHIC OCCURRENCE.—Capitan Limestone.

LOCALITY.—USGS 2926, Guadalupe Mountains.

***Tautosia* Cooper and Grant, new genus**

DIAGNOSIS.—Small, semicostate, uniplicate, with costae strong at anterior. Pedicle valve interior with strong dental plates; brachial valve interior with complete hinge plate supported by strong median septum.

TYPE-SPECIES.—*Tautosia fastigiata* Cooper and Grant, new species.

REMARKS.—This genus resembles *Wellerella* Dunbar and Condra externally, but differs in its strong median septum in the brachial valve. The new genus *Phrenophoria* (described above) also retains a high median septum, but *Tautosia* is distinguished by its angularly costate anterior and its external resemblance to *Wellerella*, whereas *Phrenophoria* more nearly resembles *Leiorhynchus* externally.

***Tautosia fastigiata* Cooper and Grant, new species**

PLATE 4: FIGURES 11-14

Large for genus, outline transversely triangular; fold high, terminating abruptly at anterior; sulcus deep, beginning farther forward than fold. Costae strong, angular, normally numbering about 5 on fold, 5-7 on each flank, with nearly concordant crests. Pedicle valve beak elongate, may have low median crest, sharp beak ridges; foramen mesothyrid; apex of brachial valve curved beneath deltidial plates of pedicle beak.

Pedicle valve interior with strong dental plates; muscle area beginning anterior to dental plates. Brachial valve interior with undivided hinge plate bounded by deep, elongated, corrugated hinge sockets; crura strongly curved but only slightly twisted; median septum high, with muscle area beginning on floor about midway along septum.

TYPES.—Holotype USNM 148345f.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITY.—USNM 702b, Glass Mountains.

REMARKS.—Three other species are assigned to *Tautosia*. The first is *Pugnax elegans* Girty (1909) (but not *Pugnoides elegans* of R. E. King, 1931, nor *Wellerella elegans* of Stehli, 1954). *Tautosia fastigiata* differs from Girty's *P. elegans* in its stronger costae, of which the median one in the fold is not depressed. It differs from *T. magnisepta* (Stehli) in its larger size, more transverse outline, stronger and more numerous costae, and lack of a depressed median costa. It is distinguished from *T. shumardiana* (Girty) (not R. E. King) in its costae that are everywhere stronger, and strikingly more numerous on the flanks, and its convex rather than flattened brachial umbonal area.

Superfamily SPIRIFERACEA King, 1846

***Lepidospirifer* Cooper and Grant, new genus**

DIAGNOSIS.—Most nearly resembling *Neospirifer* Frederiks, but with costellae only weakly fasciculate and much finer; raised growth laminae on crests of costellae give a tiled-roof appearance. The pedicle valve beak is relatively straight, with a well-developed apical plate and a high internal myophragm.

TYPE-SPECIES.—*Lepidospirifer angulatus* Cooper and Grant, new species.

REMARKS.—The tiled-roof appearance of the raised growth laminae also is seen on some species of *Neospirifer*; it is not, in itself, the diagnostic difference between the genera, which is the multicostellate exterior. This feature is, however, more consistent in species of *Lepidospirifer* and covers the entire shell in some. In others the scaly raised laminae begin farther forward, possibly having been removed by abrasion of the posterior parts of the shell.

***Lepidospirifer angulatus* Cooper and Grant, new species**

PLATE 4: FIGURES 22-25

Spirifer (*Neospirifer*) *costella* R. E. King, 1931 [part], p. 115, pl. 37: fig. 1, 2.

Shell transverse, with rounded hinge extremities; widest just anterior to hinge. Costellae fine, numbering about 7 in 5 mm, bundled sporadically into indistinct fascicles that tend to die out anteriorly; raised growth laminae present over most of shell. Both valves deep, fold and sulcus beginning at beaks; sulcus extended at anterior to form long tongue extending into strongly angular fold at margin.

Pedicle valve interior with small teeth and broad dental ridges supported by short dental plates; myophragm extending to near midvalve; muscle marks weakly impressed. Brachial valve interior with strong socket ridges, small cardinal process, and broad concave hinge plate.

TYPES.—Holotype USNM 152940.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITY.—USNM 702, Glass Mountains.

REMARKS.—This species is characterized by its proportionately great width, strongly convex valves that produce a thick shell, and its strongly angular fold. It differs from *L. costellus* (R. E. King) in its greater width, absence of strong fascicles and plications on the flanks, and by its rather strong curvature at the anterior that amounts nearly to a geniculation of the valves, especially of the anterior tongue of the sulcus.

Superfamily SPIRIFERINACEA Davidson, 1884

***Sarganostega* Cooper and Grant, new genus**

DIAGNOSIS.—Shell small, conical, very strongly punctate; punctae expanding toward exterior, reducing shell to mere network, effectively obscuring most growth laminae. Fold transversely rounded, with convex profile, lateral plications low and rounded. Pedicle valve interior with high median septum typical of spiriferinaceans, apical end buried in a secondary shell, anterior edge concave forward; dental plates short.

TYPE-SPECIES.—*Sarganostega transversalis* Cooper and Grant, new species.

REMARKS.—*Sarganostega* is characterized primarily by its very coarse external punctation, coarser than any known genus excepting only *Reticulariina* Fredericks. It differs from *Reticulariina* in its normally smaller size and more conical shape, lack of exospines, and in its reduced dental plates. Punctae of *Reticulariina* may be as large as those of *Sarganostega*, but as the shell normally is larger, the proportional size of punctae is less in *Reticulariina*.

***Sarganostega transversalis* Cooper and Grant, new species**

PLATE 4: FIGURES 20, 21

Shell wide for genus, widest at hinge, with hinge ends mucronate; fold high but rounded; sulcus narrow, with flat floor, extending far forward to fill high crest of fold at margin. Lateral costae low, weakening distally, numbering 2 or 3 on each side; growth laminae obscure, widely and irregularly spaced. Pedicle valve only moderately convex, but beak rather strongly hooked; brachial valve more strongly convex longitudinally.

Pedicle valve interior with weak dental ridges, dental plates discrete and somewhat divergent; brachial valve interior with hinge sockets roofed by thin plates, cardinal process bulbous, striated.

TYPES.—Holotype USNM 153172.

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Pinery Limestone Member).

LOCALITY.—USNM 725n, Guadalupe Mountains.

REMARKS.—The only other published species that belongs to *Sarganostega* is *Spiriferina pyramidalis* Girty (1909, p. 378, pl. 14: figs. 20, 21) from the Capitan Formation. *Sarganostega transversalis*

differs from that species in its more strongly transverse outline with mucronate hinge ends and in its more convex brachial valve with higher fold.

Xestotrema Cooper and Grant, new genus

PLATE 4: FIGURES 15-19

DIAGNOSIS.—Wide-hinged to mucronate spiriferinids with finely pitted exterior but no spines or other ornament than growth lines and ridges. Suggests *Reticulariina* or *Sarganostega* externally but differs from the first in lacking spines and from the second in having fine rather than coarse pits on the exterior.

TYPE-SPECIES.—*Spirifera pulchra* Meek (1860, p. 310); Meek (1877, p. 85, pl. 8: figs. 1a-c.).

TYPES.—Holotype USNM 649a (Meek, 1877, pl. 8: figs. 1a, b); paratype USNM 649b; hypotype USNM 153836, 153837.

STRATIGRAPHIC OCCURRENCE.—Park City Formation.

LOCALITY.—Lat. 40°N, long. 115°20'W, Cherry Creek Range, northeastern Nevada. Also USNM 760, Fremont County, Wyoming.

Superfamily RETICULARIACEA Waagen, 1883

Anomaloria Cooper and Grant, new genus

DIAGNOSIS.—Closely resembling *Phricodothyris* George and *Neophricadothyris* Likharev externally, but pedicle valve has a prominent strongly rounded pseudodeltidium; dorsal valve has cuplike socket ridges and extensions (notothyrial plates) from them to the exterior that meet the pseudodeltidium, nearly closing the space between the valves. No cardinal process.

TYPE-SPECIES.—*Anomaloria anomala* Cooper and Grant, new species.

Anomaloria anomala Cooper and Grant, new species

PLATE 3: FIGURES 8-13

About medium size, roundly elliptical in outline, valves subequally convex; sides and anterior rounded; greatest width at midvalve. Delthyrium and notothyrium respectively closed by a rounded, convex pseudodeltidium and notothyrial plates. Surface marked by concentric lamellae bearing thin, minute spines.

Pedicle valve having swollen umbonal and median regions with steep anterior and lateral slopes. Brachial valve evenly convex in lateral profile, umbonally and medially swollen but not so much as the opposite valve. Lateral and anterior slopes moderately steep.

Pedicle valve interior without dental plates but with a thickened marginal ridge below the delthyrial edge. Brachial valve interior with short socket ridges extended dorsally to protrude beyond the posterior margin forming notothyrial plates with a medial slit. Spiral cones directed posterolaterally.

Measurements in mm

	length	brachial valve length	width	hinge width	thick- ness
holotype	22.0	20.2	23.2	10.5	15.6

TYPES.—Holotype USNM 153197a; paratypes USNM 153197b-d

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Lamar Limestone Member).

LOCALITY.—USNM 728p, Guadalupe Mountains.

COMPARISON.—This species occurs with "*Squamularia*" *guadalupensis* Girty but is distinguished from it by its beak characters, finer ornament, and less prominently extended beak on the pedicle valve.

Astegosia Cooper and Grant, new genus

DIAGNOSIS.—Differs from *Neophricadothyris* in not having a pseudodeltidium but having in its place a shelf-like apical plate. It differs from *Anomaloria* in having a cardinal process and in not possessing the notothyrial flanges so characteristic of that genus.

TYPE-SPECIES.—*Squamularia Guadalupensis subquadrata* Girty (1909, p. 369, pl. 14: fig. 2, 3).

TYPES.—Holotype USNM 118596a (Girty, 1909, pl. 14: fig. 3); paratype USNM 118596b.

STRATIGRAPHIC OCCURRENCE.—Capitan Limestone.

LOCALITY.—USGS 2926, Guadalupe Mountains.

Superfamily DIELASMATACEA Schuchert, 1913

Plectelasma Cooper and Grant, new genus

DIAGNOSIS.—Resembling *Dielasma* W. King in general form, in cardinalia and loop, and in presence of dental plates, but differing in its plicated

anterior margin. A plicated margin recalls that of *Dielasma* Waagen, but *Plectelasma* differs in possession of dental plates that do not unite with a median septum and that are well separated on the valve floor. Adults of *Dielasma* attain exaggerated thickness and a "humpbacked" appearance by marginal growth nearly perpendicular to the plane of commissure. *Plectelasma* retains the more normal growth trend of *Dielasma* except for the anterior plication.

TYPE-SPECIES.—*Plectelasma kingi* Cooper and Grant, new species.

REMARKS.—The genus is characterized by a combination of *Dielasma*-like interior, and *Dielasmina*-like folding. As the folding begins only in the anterior one-third of the adult shell, juveniles are difficult to distinguish from specimens of *Dielasma* of similar size. They differ primarily in large pedicle collar, short dental plates, and long, slender hinge teeth.

***Plectelasma kingi* Cooper and Grant,
new species**

PLATE 5: FIGURES 1-6

Dielasmina guadalupensis R. E. King [not Girty], 1931, p. 133, pl. 44: figs. 15a-d.

Shell small, oval, widest near midlength, flatly to moderately biconvex; fold, sulcus, and 2 strong lateral costae beginning anterior to midlength of adults. Convexity of brachial valve somewhat less than that of pedicle valve. Dental plates in pedicle valve long for genus; loop of brachial valve short and wide.

TYPES.—Holotype USNM 153355a; paratype 153355b.

STRATIGRAPHIC OCCURRENCE.—Hess Formation.

LOCALITY.—R. E. King 223; USNM 726n, Glass Mountains.

REMARKS.—Girty's (1909) species *Dielasmina guadalupensis* belongs to *Plectelasma* and differs from *P. kingi* in its larger size, more convex valves, and stronger costation.

**Superfamily CRYPTONELLACEA Thomson,
1926**

***Texasia* Cooper and Grant, new genus**

DIAGNOSIS.—Shell elongate, ovate, resembling *Cryptonella* Hall externally; beak small, erect, with

small foramen, telate, not labiate, and with the symphytium completely exposed. Anterior commissure sulcinate; loop with long ascending element; spines on descending branches at junction of descending and ascending elements.

TYPE-SPECIES.—*Texasia oblongata* Cooper and Grant, new species.

***Texasia oblongata* Cooper and Grant,
new species**

PLATE 5: FIGURES 7-9

Notothyris species Girty, 1909, p. 337, pl. 31: fig. 7.

Shell elongate, elliptical, widest near midlength, apical angle near 60°; anterior commissure sulcinate, shell otherwise smooth, anterior margin narrowly rounded. Sulcus with low median costa; fold poorly defined, merely a continuation of umbonal swelling.

Pedicle valve interior with small hinge teeth and bowed dental plates. Brachial valve interior with hinge plate nearly flat and straight or slightly emarginate at anterior edge.

TYPES.—Holotype USNM 153415.

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank, Willis Ranch and Appel Ranch Members).

LOCALITY.—Holotype: USNM 706, Glass Mountains.

REMARKS.—*Dielasma problematicum wordense* R. E. King (1931, p. 131, pl. 44: figs. 16a-e) also belongs in this genus. *Texasia oblongata* differs in its more elongate and more narrowly elliptical form, larger size, less abruptly blunted anterior margin, and more prominent fold.

**Taxonomic Position of *Cooperina* Termier,
Termier and Pajaud, 1967**

PLATE 3: FIGURES 14-27

This genus is based on specimens derived from a block of limestone from the Word Formation sent to G. Termier in exchange for other fossils. The genus was considered by its authors to be the earliest representative of the Thecideidina, a link that has long been sought by students of brachiopods. Naturally, we have many specimens of this genus and its several species in our collections, not only from

the Word Formation but also from most of the other Permian formations as well. At first we too thought that the genus might be related to the Thecideidina since, at first glance, the brachial valve with its broad cardinal process and strong anteromedian partition suggests such a relationship. Spines on both valves, however, indicate that this interesting little genus belongs in the Productidina (Strophalosiaceae) and is not a forerunner of the Thecideidina.

Strophalosiacean characters appear in both valves: (1) presence of spines on both valves, (2) straight hinge without teeth, (3) probable pseudopunctate shell structure, (4) lobate cardinal process, (5) brachial ridges in the brachial valve, (6) flabellate musculature, (7) manner of attachment to the substrate.

1. *Cooperina* has spines on both valves, two sets on the pedicle valve but only one type on the brachial valve. Rhizoid or attachment spines appear at the posterior, often forming a ring of radii around the posterior and all cemented to the substrate (Plate 3: figure 18). The second set is of ornamental or protective spines that extend at a low angle from the shell in an anterior direction. In well-preserved specimens these curve over the anterior margin and may have served a protective function guarding the anterior gape of the shells.

2. The hinge region is most like that of the Aulostegidae of the Strophalosiaceae in consisting of a thin plate or palintrope covering the posterior region corresponding to the delthyrial cavity of other brachiopods. As no teeth are present, it is impossible to homologize this flat palintrope with a pseudodeltidium. Furthermore, it is not notched and has no elytridium. The cardinal process is inserted under the palintrope and occupies most of the apex. This is the only articulation and, in opening, the posterior margin of the brachial valve moved against the edge of the palintrope.

In some specimens the palintrope is broken along almost the exact outline of the cardinal process. If one has only such damaged specimens, he might conclude that the cardinal process plugged a somewhat rectangular "delthyrium." Such damage is a good indication that the specimens underwent considerable mechanical agitation after death.

3. In silicified specimens it is usually difficult to determine shell structure; however, many silicified

terebratuloids show punctae quite clearly. Taleolae are often clearly visible, as one may see in silicified chonetids. Our specimens of *Cooperina* show no trace of punctae, which, if present, might be a suggestive but not conclusive link to the Thecideidina. A suggestion of taleolae in the form of small nodes may be seen on the anterior slopes of the brachial valve (Plate 3: figures 23, 26). Similar nodes such as these are usual in some Thecideidina and often are present in punctate Thecideidae. The shell structure of *Cooperina* is inconclusive, but, if pseudopunctate, is in accordance with that of the Aulostegidae; it clearly is not punctate, precluding relationship to many of the Thecideidina.

4. The cardinal process of *Cooperina* is variable although consistently lobate; none of its variations suggest relationship to the Thecideidina. Variability is in the degree of lobation, usually trilobed, but also externally quadrilobed while internally bilobed. This variation is in complete accordance with the Aulostegidae.

5. Well-preserved or old specimens of the brachial valve of *Cooperina* show elongated, somewhat reniform, markings between the median and lateral ridges. These have exactly the same form and are in the same position as the brachial ridges of the Productidina.

6. The musculature of *Cooperina* is not easy to distinguish, but examination of several hundred pedicle valves makes it clear that the musculature is that of the Productidina. The apical part of the pedicle valve has a low myophragm on which (or on the sides of which) the adductors were usually attached. Outside of the myophragm and extending partly into the main cavity of the valve, longitudinal and radial marks indicate broadly flabellate adductor scars. This is quite unlike the musculature of the pedicle valve of the Thecideidina. In the brachial valve of *Cooperina* the adductor muscles appear to have been confined to the two small transverse platforms at the rear of the shell. We were unable to find any lateral scars near the ears, like those of the Thecideidina.

7. Attachment of *Cooperina* to the substrate was initially by cementation, but the shell came to be supported further by an aureole of rhizoid spines around the beak region. The presence of these spines and the protective spines on both valves are typically productoid characters.

Localities

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512. See USNM 728.

R. E. KING LOCALITIES (with supplemental map measurements). Stratigraphic terminology of R. E. King (1931) with modern equivalents in Glass Mountains by Ross (1959) and by Cooper and Grant (1964, 1966).

107. Hess Formation (*Perrinites compressus* zone of King = Taylor Ranch Member). Escarpment west of Hess Canyon fault, 3.81 miles N 66.5° E of Hess Ranch, just southeast of hill 5725, Hess Canyon quadrangle, Texas.

223. Hess Formation (uppermost). One mile S 58° W of Old Word Ranch, Hess Canyon quadrangle, Texas.

231. Leonard or uppermost Hess = Skinner Ranch Formation. Limestone containing chert pebbles directly below Leonard shale on south face of mountain 0.25-0.3 mile N 65° W of benchmark 5860 on Leonard Mountain, Hess Canyon quadrangle, Texas.

U. S. GEOLOGICAL SURVEY (quoted from Girty, 1909)

2926. "Guadalupe Mountains, Texas. Just below knob on crest of spur running northward from El Capitan. Part of material from horizon above or below. About 1000 feet below summit of El Capitan and the top of the Capitan limestone."

2930. "Guadalupe Mountains, Texas. Chiefly float, almost entirely from north side of Pine Spring Canyon, from two spurs embracing the spring. Supposed to be from the 'dark limestone' [= Bell Canyon Formation (Hegler Member)] immediately above the sandstones of the Delaware Mountain Formation; some of it in place."

U. S. NATIONAL MUSEUM

701h. Neal Ranch Formation of Ross (1959) (beds 9-12 by Cooper's measurement = beds 12-14 of P. B. King, 1931). Crest of knob 0.75 mile S 77° W of hill 5060, Wolfcamp Hills, Hess Canyon quadrangle, Texas.

701k. Neal Ranch Formation, west side of hill, 0.97 mile S 82° W of hill 5060, west end of Wolfcamp Hills, Hess Canyon quadrangle.

702. Cathedral Mountain Formation (*Institella* zone), south side of road, 0.2 to 0.5 mile east of Split Tank, 1.9 miles N 56° E of Old Word Ranch, Hess Canyon quadrangle.

702b. Cathedral Mountain Formation (beds with *Institella*). 0.5 mile southwest of Split Tank, 0.95 mile N 51° E of Old Word Ranch, Hess Canyon quadrangle, Texas.

702un. Cathedral Mountain Formation (beds with *Institella*). Near junction of lateral gully with main stream and along lateral gully, 0.58 mile N 69° E of Split Tank, 2.08 miles N 58° E of Old Word Ranch, Hess Canyon quadrangle, Texas.

703a. Road Canyon Formation (base). On northwest side of road between road fork and sheep tank, 0.2 mile N 10° E of Old Word Ranch, Hess Canyon quadrangle, Texas.

703bs. Cathedral Mountain Formation (base). Smooth light gray limestone 0.17 mile S 39° W of Old Word Ranch, Hess Canyon quadrangle, Texas.

706b. Word Formation (lens between the Willis Ranch and Appel Ranch Members). 0.2 mile southwest of junction of Hess Canyon with its south branch, 1.9 miles N 65° W of Old Word Ranch, 4.78 miles N 34° E of Hess Ranch, Hess Canyon quadrangle, Texas.

706c. Word Formation (near the top of the Willis Ranch Member). East side of small arroyo, 4.13 miles N 34° E of Hess Ranch, 0.55 mile N 15° W of hill 5611, Hess Canyon quadrangle, Texas.

707ha. Skinner Ranch Formation (Poplar Tank Member). Loose on small knob southeast of hill 5300, 2.7 miles N 12° W of Decie Ranch, Altuda quadrangle, Texas.

708u. Cathedral Mountain Formation (just above base). Loose pieces just above basal conglomerate on south slope of gully, 0.5 mile N 83° E of Split Tank, 1.95 miles N 62° E of Old Word Ranch, Hess Canyon quadrangle, Texas.

710h. Road Canyon Formation (upper). 0.96 mile S 3° E of Sullivan Peak and for 600 feet northeast around the hilltop and on east side of knob, Altuda quadrangle, Texas.

720a. Hueco Formation. Three Mile Mountain, northwest of Van Horn, Van Horn quadrangle, Texas.

712u. Cathedral Mountain Formation (lower), 0.57 mile N 80° E of hill 4910, Altuda quadrangle, Texas.

725n. Bell Canyon Formation (Pinery Limestone Member), 0.32 mile S 62° W of Hegler [= Ligon] Ranch, on Rader Ridge, Guadalupe Peak quadrangle, Texas.

726n. Hess Formation (upper), 1.33 miles S 7° E of hill 5507, 1.0 mile S 60° W of Old Word Ranch, Hess Canyon quadrangle, Texas.

728. [= American Museum Natural History locality 512.] Cherry Canyon Formation (Getaway Limestone Member). 0.45 mile S 35° E of benchmark 5426 in Guadalupe Pass, 2.55 miles S 5° W of Pine Spring Camp, Guadalupe Peak quadrangle, Texas.

728e. Bone Spring Limestone (lower), 2-foot bed of limestone 22 feet above top of clastic Hueco Formation 2.45 miles S 54° W of benchmark 3648, on south side of Victorio Canyon, Van Horn quadrangle, Texas.

728p. Bell Canyon Formation (Lamar Limestone Member). Lower massive beds in bluff on east side of road, 0.4 mile S 54° E of junction of D-Ranch Headquarters road and U. S. Highway 62-180, east of Hegler [now Ligon] Ranch, Guadalupe Mountains, Texas.

731. Bell Canyon Formation (Hegler Limestone Member). Top of hill 5130, 0.3 mile S, 13° W, of Pinyon Tank, 2.25 miles S 62° E of Airway Beacon, Guadalupe Peak quadrangle, Texas.

736x. Road Canyon Formation, 0.78 mile S 69° W of Old Payne Ranch site, 0.23 mile N 5° E of hill 4806, Monument Spring quadrangle, Texas.

760. Park City Formation (Franson Member), from 10-foot interval of resistant limestone, northwest side of Washakie Reservoir, SW ¼ NE ¼ sect. 17, T. 1S., R. 2 W,

Moccasin Lake quadrangle (1937), Fremont County, Wyoming.

Literature Cited

- Bösc, E.
1916. Contributions to the Knowledge of *Richthofenia* in the Permian of West Texas. *Texas University Bulletin*, 55:1-50, 3 plates.
- Cooper, G. A., and R. E. Grant
1964. New Permian Stratigraphic Units in Glass Mountains, West Texas. *American Association of Petroleum Geologists Bulletin*, 48 (9):1581-1588, 2 figures.
1966. Permian Rock Units in the Glass Mountains, West Texas. *United States Geological Survey Bulletin*, 1244-E:1-9, 2 plates.
- De Gregorio, A.
1930. Sul Permiano di Sicilia (fossili del calcare con Fusulina di Palazzo Adriano non descritti del Prof. G. Gemmellaro conservati nel mio privato gabinetto). *Annales de Geologie et de Paleontologie* (Palermo), 52:18-32, plates 4-11.
- Dunbar, C. O., and G. E. Condra
1932. Brachiopoda of the Pennsylvanian System in Nebraska. *Nebraska Geological Survey Bulletin*, series 5:1-377, 44 plates.
- Girty, G. H.
1909 [dated 1908]. The Guadalupian Fauna. *United States Geological Survey Professional Paper*, 58:1-651, 31 plates.
- Hall, James, and J. M. Clarke
1894. Introduction to the Study of the Genera of Paleozoic Brachiopoda, Part 2. *Paleontology of New York* (New York Geological Survey), 8:394, 84 plates.
- Ivanova, E. A.
1951. Novie Dannie po Sistema Productid (Rod *Kutorginella*). *Doklady Akademii Nauk SSSR*, 77 (2):329-331.
- King, P. B.
1931. The Geology of the Glass Mountains, Texas, Part I: Descriptive Geology. *Texas University Bulletin*, 3038:1-167, 6 plates, 43 figures, 1 geological map.
1948. Geology of the Southern Guadalupe Mountains, Texas. *United States Geological Survey Professional Paper*, 215:183, 23 plates, 24 figures.
- King, R. E.
1931 [dated 1930]. The Geology of the Glass Mountains, Part II: Faunal Summary and Correlation of the Permian Formations with Description of the Brachiopoda. *Texas University Bulletin*, 3042:1-245, 44 plates.
- King, R. H.
1938. New Chonetidae and Productidae from Pennsylvanian and Permian Strata of North-Central Texas. *Journal of Paleontology*, 12(3):257-279, 4 plates.
- Meek, F. B.
1860. Descriptions of New Fossil Remains Collected in Nebraska and Utah, by the Exploring Expeditions under the Command of Capt. J. H. Simpson . . . *Academy of Natural Science, Philadelphia, Proceedings*, 1860:308-315.
1877. Paleontology. Part I in volume 4, *Palaeontology and Ornithology*, in King, *Report of the Geological Exploration of the Fortieth Parallel*, 197 pages, 17 plates.
- Muir-Wood, H., and G. A. Cooper
1960. Morphology, Classification, and Life Habits of the Productoidea (Brachiopoda). *Geological Society of America Memoir*, 81:1-447, 135 plates.
- Newell, N. D., J. K. Rigby, A. G. Fischer, A. J. Whiteman, J. E. Hickox, and J. S. Bradley
1953. *The Permian Reef Complex of the Guadalupe Mountains Region, Texas and New Mexico*. 236 pages, 32 plates. San Francisco: W. H. Freeman and Company.
- Plummer, F. B., and R. C. Moore
1922. Stratigraphy of the Pennsylvania Formations of North Central Texas. *Texas University Bulletin*, 2132:237.
- Ross, C. A.
1959. The Wolfcamp Series (Permian) and New Species of Fusulinids, Glass Mountains, Texas. *Washington Academy of Science Journal*, 49 (9):299-316, 4 plates, 2 figures.
- Shumard, B. F.
1858 [dated 1850]. Notice of New Fossils from the Permian Strata of New Mexico and Texas . . . *Academy of Science, St. Louis, Transactions*, 1:290-297.
1859. Notice of Fossils from the Permian Strata of Texas and New Mexico . . . *Academy of Science, St. Louis, Transactions*, 1:387-403.
- Stehli, F. G.
1954. Lower Leonardian Brachiopoda of the Sierra Diablo. *American Museum of Natural History Bulletin*, 105 (3):261-358, plates 17-27.
1955. Notes on Permian Rhynchonellids. *Washington Academy of Sciences Journal*, 45 (3):70-74, 1 plate.
- Termier, G., H. Termier, and D. Pajaud
1967. Découverte d'une Thécidée dans le Permien du Texas. *Comptes Rendus des séances de l'Académie des Sciences* (Paris), series D, 263:332-335, 1 figure.

PLATES

PLATE 1

Hercosestria cribrosa Cooper and Grant, new species: 1, 2, Side and posterior views, \times 1, holotype USNM 151804, showing calcareous net over aperture, USNM loc. 703a. 3, Interior of brachial valve showing lobate cardinal process and stunted endospines, \times 1, paratype USNM 153199, USNM loc. 702c.

Phrenophoria subcarinata Cooper and Grant, new species, USNM loc. 706b: 4-8, Anterior, posterior, side, dorsal, and ventral views of holotype, \times 1, USNM 148385e. 9, Interior of pedicle valve, \times 1, paratype USNM 148385h. 10, Posterior of paratype USNM 148385c showing elongate oval foramen and conjunct deltidial plates, \times 3. 11, 12, tilted to side and ventral views of brachial valve interior, \times 1, showing undivided hinge plate and long slender median septum, paratype USNM 148385g.

Amphipella arcaria Cooper and Grant, new species, USNM loc. 708u: 13-17, Posterior, anterior, ventral, side, and dorsal views of the holotype, \times 6, showing three foramina, USNM 148098a. 18, Interior of the pedicle valve, \times 4, paratype USNM 148098c. 19, Posterior of the interior of a complete specimen showing the closed pouches, \times 6, paratype USNM 148098b. 20, Brachial valve interior, \times 6, showing hinge plate, crura, and dorsal half of pouches, paratype USNM 148098d. 21, Another broken specimen showing closed pouch and hinge plate in tilted view, \times 4, paratype USNM 148098e.

Collumatus solitarius Cooper and Grant, new species, USNM loc. 736x: 22, Apertural view of a specimen from which the calcareous net is missing but showing the interior of the brachial valve, \times 1, paratype USNM 153548f. 23-25, Anterior partial side and apertural (dorsal) views of the holotype, \times 2, preserving most of the calcareous net over the aperture, USNM 153548a. 26, Ventral or basal view showing attachment surface, \times 1, of the holotype.

Tropidelasma culmenatum Cooper and Grant, new species: 27, Posterior view of the cardinal process, \times 1, showing the long prongs and myophore slits; prong on right was aborted in life; paratype USNM 147829-1. 28, 29, Side and posterior views of the holotype, \times 1, USNM 147829b, showing the broad interarea and pseudodeltidium with narrow longitudinal fold.

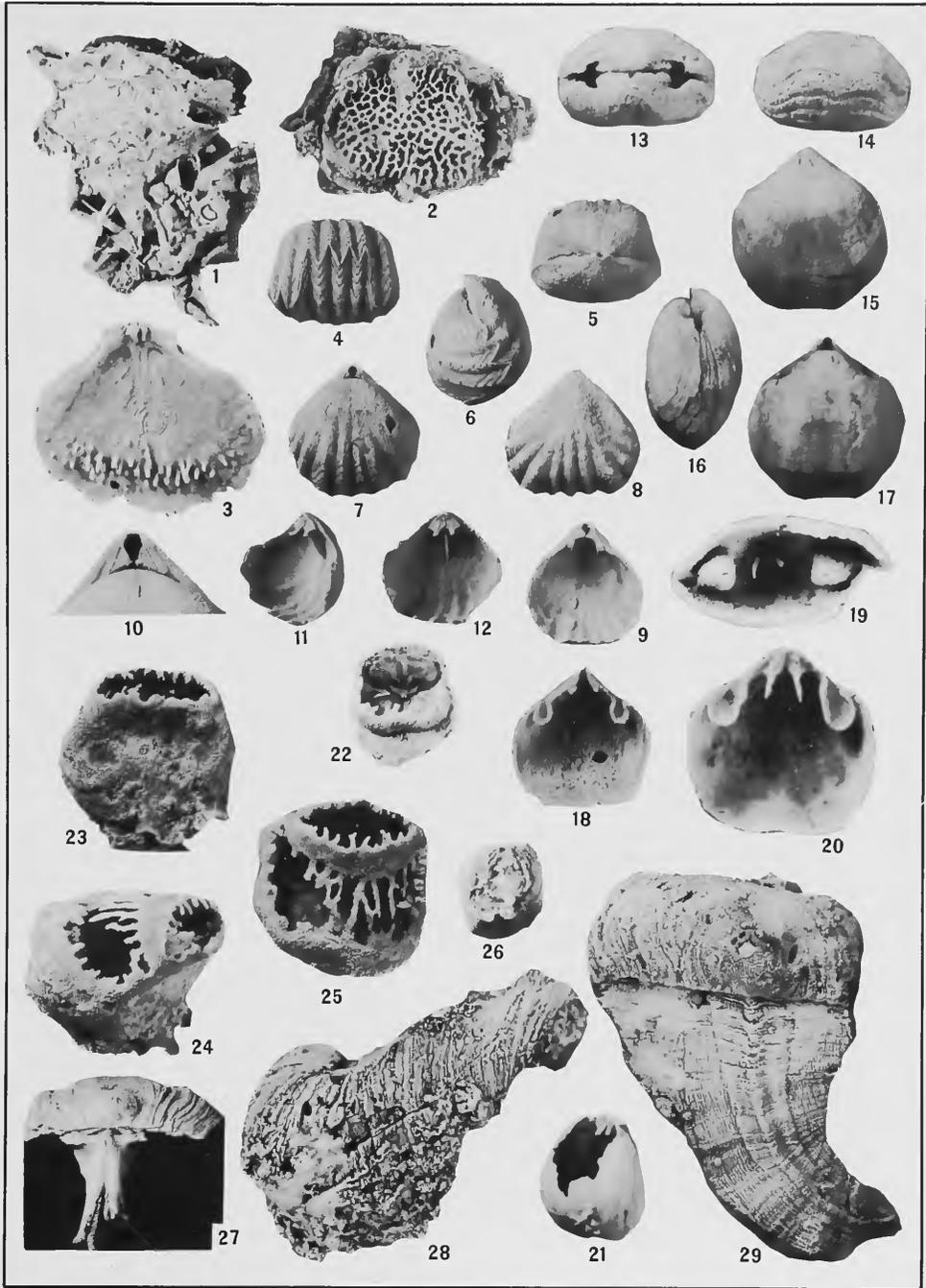


PLATE 2

Undulella undulata Cooper and Grant, new species, USNM loc. 706e: 1-4, Dorsal, ventral, anterior, and side views of the holotype, $\times 1$, USNM 152070b. 5, 6, Interior and posterior views of two brachial valves, $\times 2$, showing small cardinal process and deep anterior pit, paratype USNM 152070q, r. 7, Ventral view of a small individual, $\times 1$, showing erect spines on the posterior margin, paratype USNM 153186a.

Petasmatherus opulus Cooper and Grant, new species, USNM loc. 706b: 8, 9, Dorsal views of the holotype, $\times 2$, and USNM 148305a. 10, 11, Anterior and side views of the holotype, $\times 2$. 12, Interior of the pedicle valve showing the broad interarca and median ridge, $\times 3$, paratype USNM 148305d. 13, Interior of the brachial valve with part of the pedicle valve attached, $\times 3$, showing short crura and thickened apical region, paratype USNM 148305f. 14, Interior of the brachial valve, $\times 3$, showing short crura, paratype USNM 148305e.

Petasmaia expansa Cooper and Grant, new species, USNM loc. 702un: 15, Posterior part of the brachial valve interior showing small cardinal process and posterior lateral lobes, $\times 2$, holotype, USNM 151343. 16, Complete holotype, $\times 1$, showing preceding brachial valve in place. 17, 18, Exterior and interior of the pedicle valve of the holotype, $\times 1$.

Sestropoma cribriferum Cooper and Grant, new species, USNM loc. 731: 19-20, Apertural and side views of a complete specimen showing thick rhizoid spines, strongly elevated and rounded calcareous net over the aperture and, faintly, the brachial valve in place, $\times 1$, holotype USNM 151656b. 21, Interior of the brachial valve, $\times 3$, showing scattered nodes, paratype USNM 151656k.

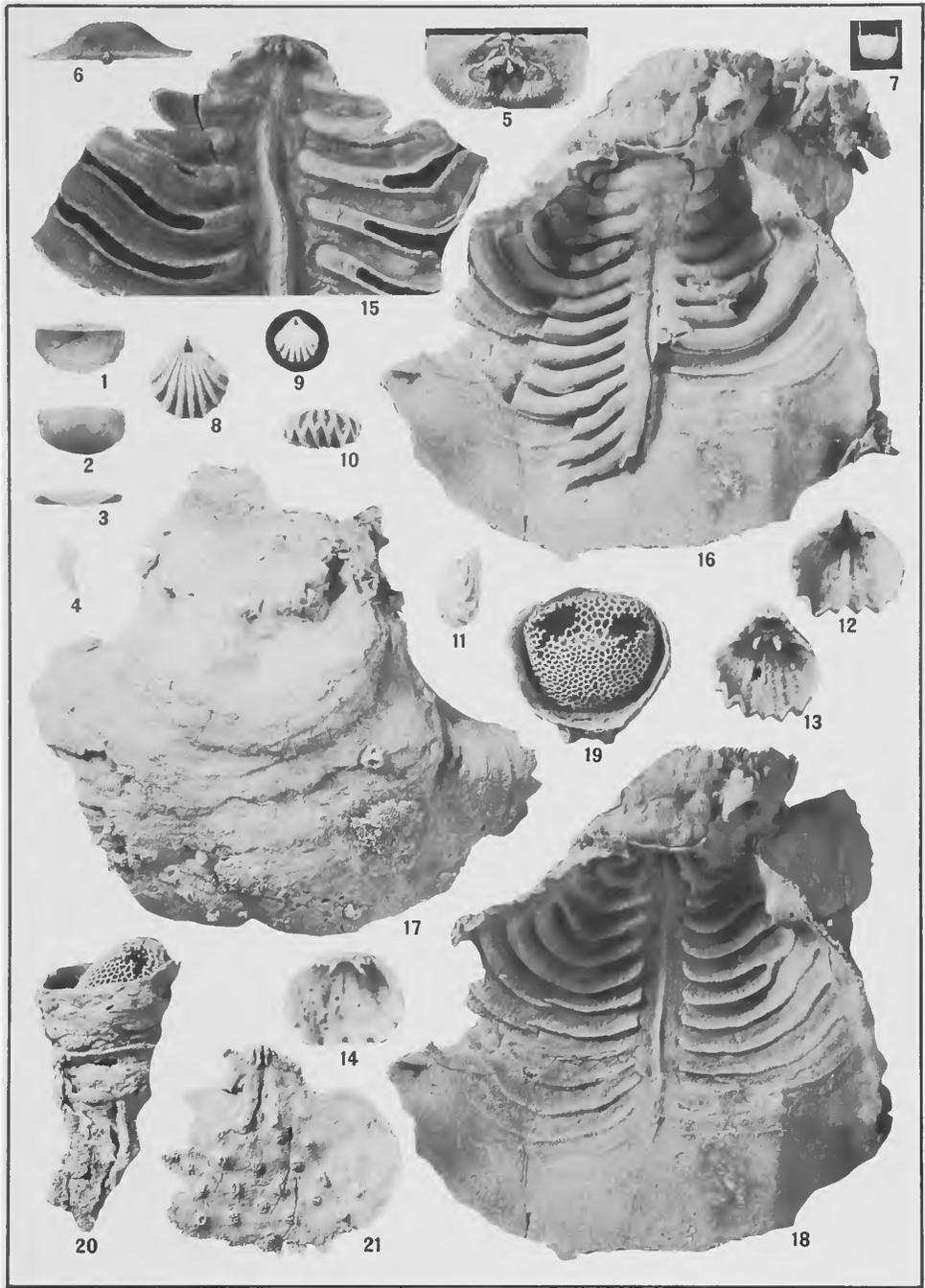


PLATE 3

Chonetinetes reversus Cooper and Grant, new species, USNM loc. 710h: 1-5, Dorsal, $\times 3$, side, ventral, anterior, and posterior views, $\times 2$, of the holotype, USNM 153193a. 6, 7, Posterior and interior views, $\times 3$, of the brachial valve showing the large cardinal process with its deep alveolus and the swollen lateral areas bounding the median sulcus, paratype USNM 153193b.

Anomaloria anomala Cooper and Grant, new species, USNM loc. 728p: 8-11, Dorsal, anterior, posterior, and side views of the holotype, $\times 1$, USNM 153197a. 12, Posterior of the holotype, $\times 2$, showing the pseudodeltidium and notothyrial plates. 13, Interior of the posterior part of both valves showing dental ridges of pedicle valve (down) and socket ridges (up) with their exterior extensions (notothyrial plates) and median slit, $\times 3$, paratype USNM 153197d.

Cooperina inexpectata Termier, Termier and Pajaud, USNM loc. 706c: 14, 15, Pedicle valves of *Cooperina* attached within shells of *Cyclacantharia*, $\times 2$, showing rhizoid and ornament spines, hypotypes USNM 153185a, b. 16, Fragment of the dorsal valve of a *Derbyia* with attached pedicle valves of *Cooperina*, $\times 1$, hypotype USNM 153184. 17-19, Side, posterior, and ventral views of a pedicle valve, $\times 8$, showing attachment surface with its aurcole of rhizoid spines and ornament spines on the trail, hypotype USNM 153198a. 20, Complete specimen with brachial valve in place, $\times 8$, hypotype USNM 153198e. 21-23, Exterior, interior, and anterior views of a well-preserved brachial valve, $\times 8$, showing adductor platforms, lobate cardinal process, anterior taleolae (?) and external spines, hypotype USNM 153198d. 24-26, Interior, side, and anterior views of another brachial valve, $\times 8$, hypotype USNM 153198b, showing typical productoid brachial ridges and taleolae (?). 27, Interior of pedicle valve, $\times 8$, showing straight hinge margin, absence of teeth, and broad aulostegid-type interarea, hypotype USNM 153198c.

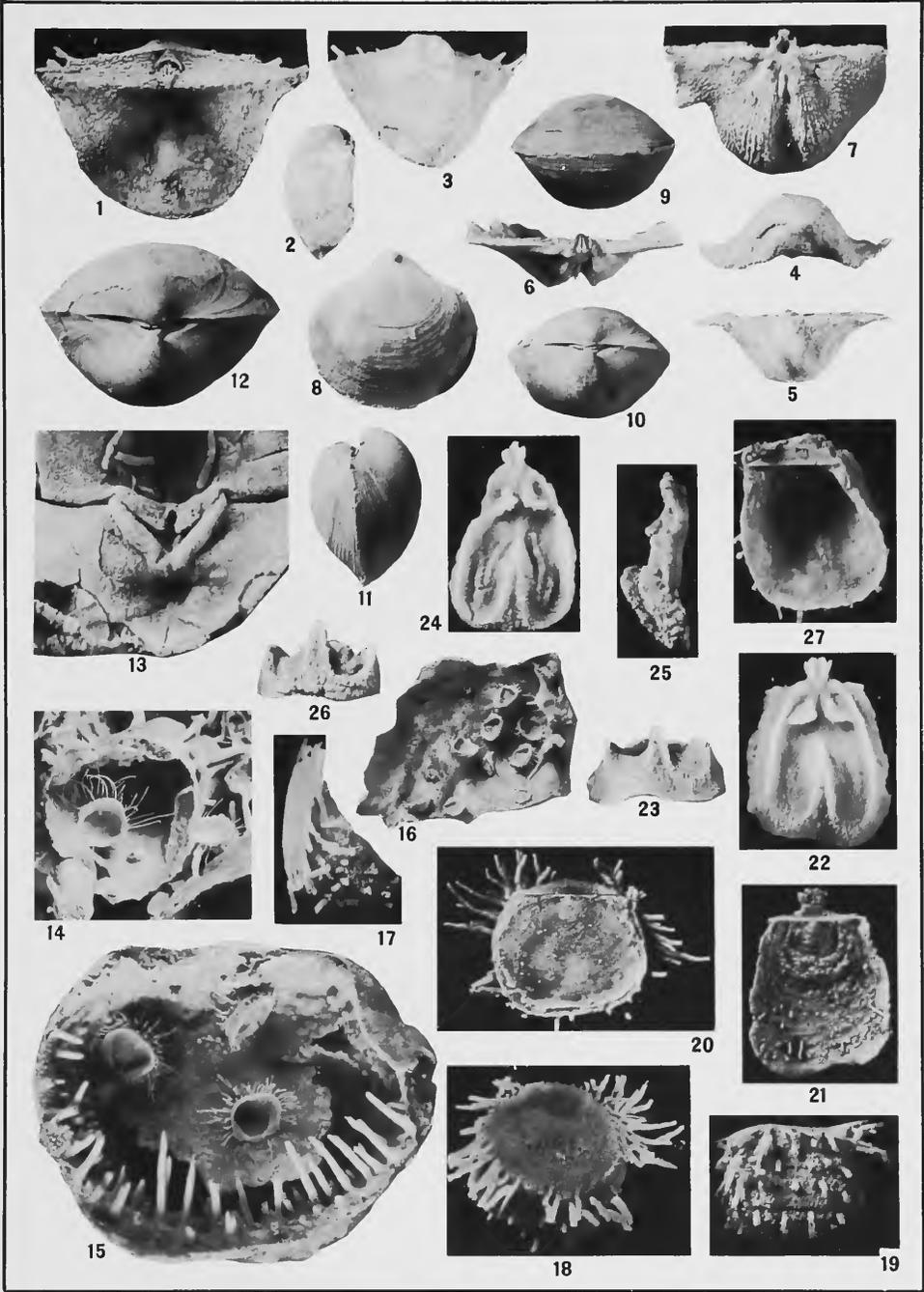


PLATE 4

Divaricosta squarrosa Cooper and Grant, new species: 1-5, Dorsal, ventral, posterior, anterior and side views, $\times 1$, of the holotype AMNH 27904:1, AMNH loc. 512 [= USNM loc. 728]. 6, Interior of the brachial valve, $\times 3$, hypotype USNM 148221, USNM loc. 728 [= AMNH loc. 512].

Pontisia stehlii Cooper and Grant, new species, USNM loc. 702c: 7-10, Dorsal, ventral, side, and anterior views, $\times 1$, of the holotype USNM 153835a.

Tautosia fastigiata Cooper and Grant, new species, USNM loc. 702b: 11-14, Dorsal, ventral, anterior, and posterior views, $\times 1$, of the holotype USNM 148345f.

Xestotrema pulchrum (Meek): 15-18, Dorsal, ventral, side, and anterior views of a large complete specimen, $\times 1$, hypotype USNM 153836, Park City Formation, west of Lander, Wyoming. 19, Interior of the pedicle valve, $\times 1$, hypotype USNM 153837, USNM loc. 760.

Sarganostegã transversalis Cooper and Grant, new species, USNM loc. 725n: 20, 21, Dorsal and ventral views, $\times 1\frac{1}{2}$, of the holotype USNM 153172.

Lepidospirifer angulatus Cooper and Grant, new species USNM loc. 702: 22-25, Dorsal, side, anterior, and ventral views of the holotype $\times 1$, USNM 152940.

Goniarina pyelodes Cooper and Grant, new species USNM loc. 701k: 26-30, Dorsal, $\times 1$, $\times 4$, and ventral $\times 1$, $\times 4$ and side $\times 4$, views of the holotype, USNM 150411g.

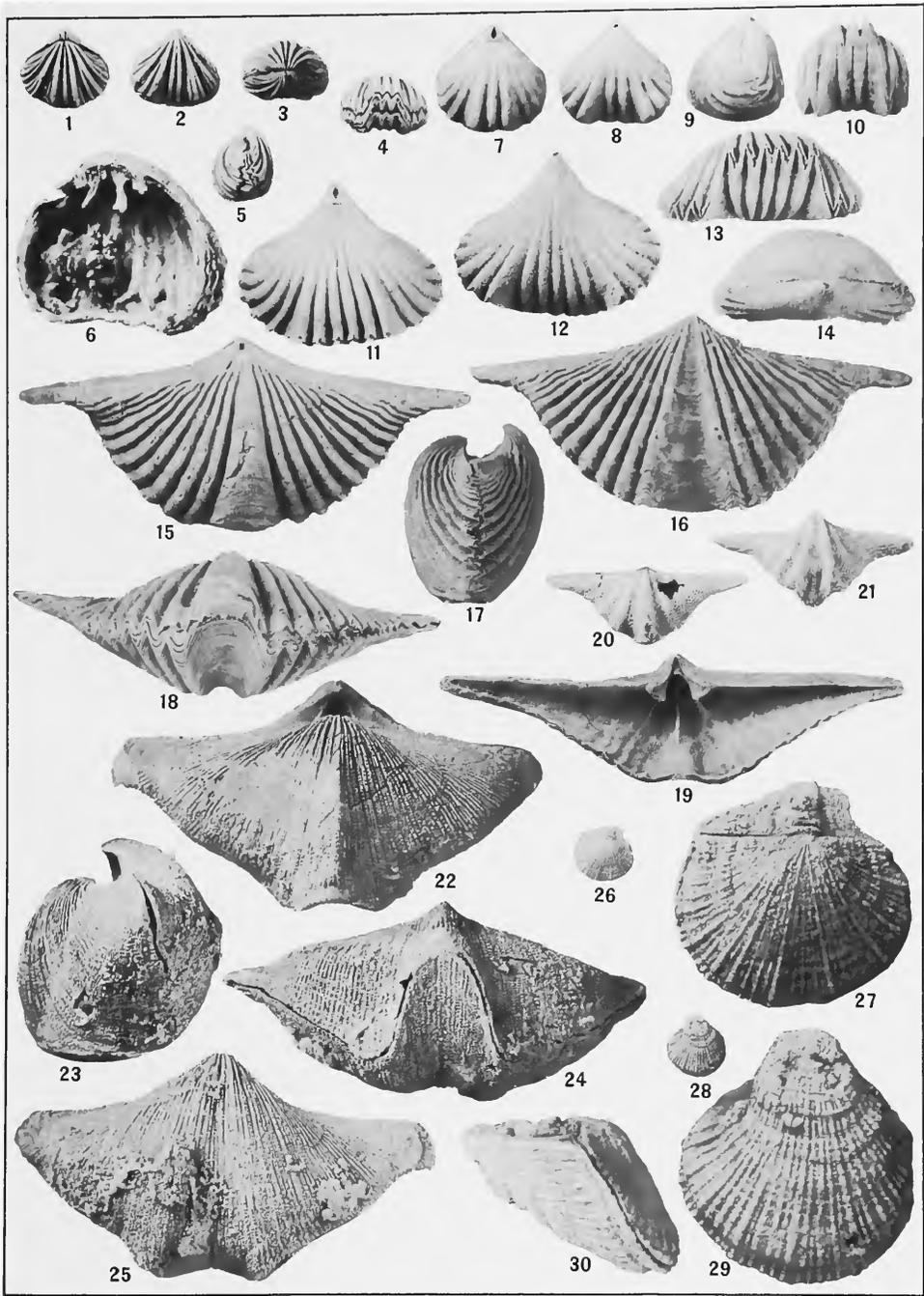


PLATE 5

Plectelasma kingi Cooper and Grant, new species, USNM loc. 726n: 1-6, Dorsal, ventral, side, posterior, and anterior views, $\times 2$, of holotype, USNM 153355a. 7, Dorsal interior, $\times 2$, showing loop, USNM 153355b.

Texasia oblongata Cooper and Grant, new species, USNM loc. 706b: 7-9, Dorsal, posterior, and side views, $\times 1$, of holotype, USNM 153415 (side view shows loop).

Micraphelia scitula Cooper and Grant, new species, USNM loc. 731: 10, 11, Ventral and dorsal views, $\times 1$, of holotype, USNM 153725b. 12, Dorsal interior, $\times 2$, showing cardinal process and brachial ridges, USNM 153725e.

Cyclacantharia kingorum Cooper and Grant, new species, USNM loc. 706e: 13, 14, Side and dorsal (apertural) views, $\times 1$, of holotype, USNM 153831, showing rhizoid exospines, and distribution of striated spines around aperture. 15, Interior of dorsal valve, $\times 1$, showing endospines, USNM 124140a. 16, Exterior of dorsal valve, $\times 1$, USNM 124140b.

Acritosia magna Cooper and Grant, new species, USNM loc. 701k: 17, 18, Side and dorsal views of the holotype, $\times 1$, USNM 151739a.

Acosarina dorsisulcata Cooper and Grant, new species, USNM loc. 728e: 19-23, Side, anterior, dorsal, posterior, and ventral views, $\times 1$, of the holotype USNM 150242b showing sulcate anterior margin.

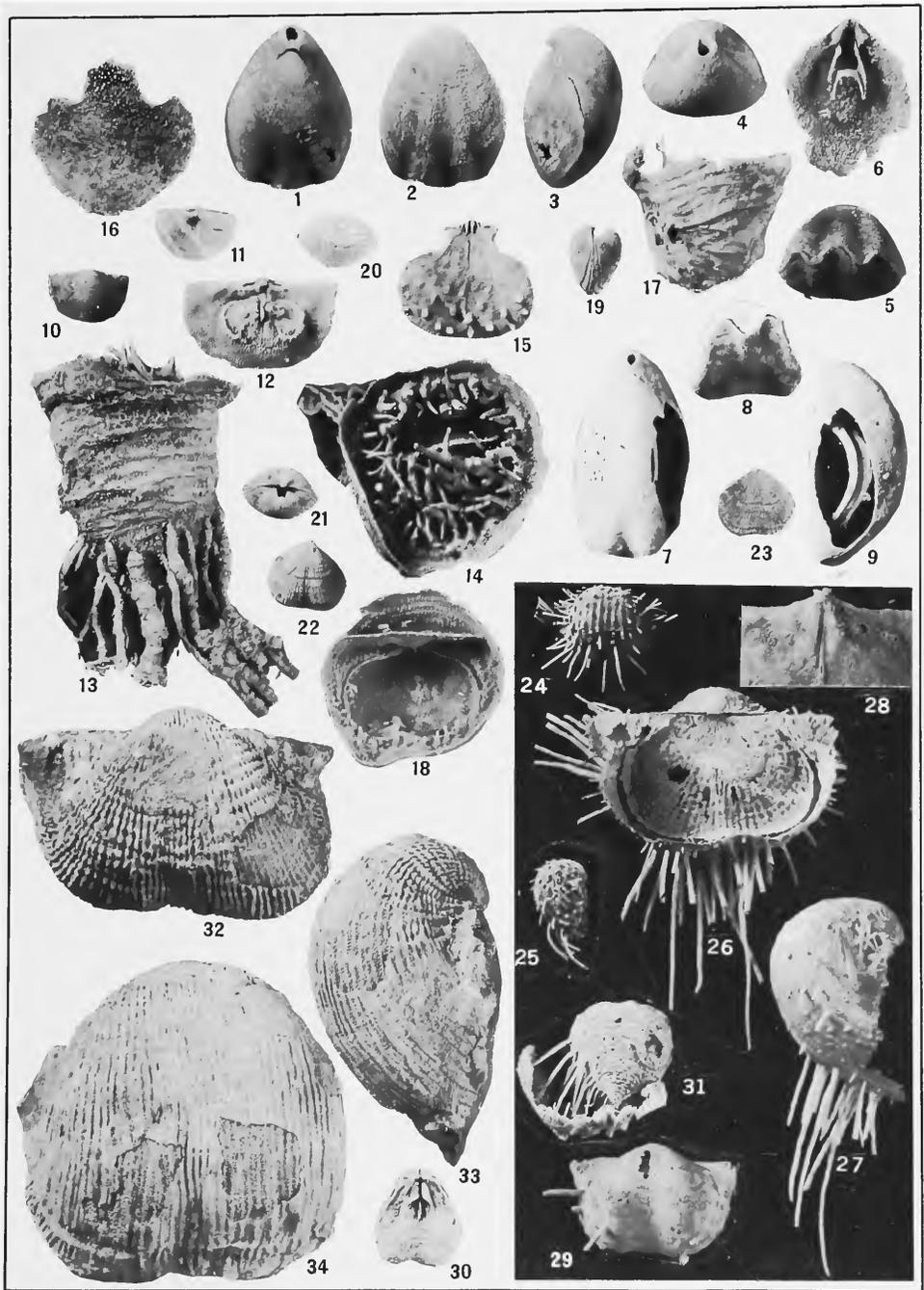
Oncosarina spinicostata Cooper and Grant, new species, USNM loc. 707ha: 24, 25, Ventral and side views, $\times 1$, of the holotype USNM 149824.

Thamnosia anterospinosa Cooper and Grant, new species, USNM loc. 702un: 26, 27, Dorsal and side views, $\times 1$, of the holotype USNM 149852.

Anemonaria inflata Cooper and Grant, new species, USNM loc. 721u: 28, Interior of the brachial valve, $\times 2$, showing the cardinal process, paratype USNM 153833b. 29, Ventral view of the holotype, $\times 1$, USNM 153833a.

Agelesia triangularis (R. E. King), USNM loc. 703bs: 30, Interior of the brachial valve, $\times 1$, hypotype USNM 151514a. 31, Ventral view, $\times 1$, of a specimen attached in its probable position of growth (beak down), hypotype USNM 153834a.

Dasysaria undulata Cooper and Grant, new species, USNM loc. 720a: 32-34, Posterior, side and ventral views, $\times 1$, of the holotype USNM 148914.



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