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NEW CHONETIDAE AND PRODUCTIDAE FROM PENNSYLVANIAN AND PERMIAN STRATA OF NORTH-CENTRAL TEXAS

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ABSTRACT

The 17 new brachiopods described and figured represent the genera *Chonetes*, *Chonetina*, *Lissochonetes*, *Mesolobus*, *Paeckelmannia*, *Dictyoclostus*, *Juresania*, *Marginifera*, *Heteralosia* (n. gen.), *Overtonia*, *Linoproductus*, and *Cancrinella*.

The Chonetidae constitute one of the most abundant groups of organisms comprising the varied and well-preserved fossil fauna in the Pennsylvanian and early Permian strata in the Brazos and Colorado valleys of north-central Texas. Representatives of the family occur throughout the section and have been found at nearly every locality where fossils have been collected. Their comparatively complex structure tended to promote rapid evolution and consequently limited vertical range. Hence they are useful zone markers. In addition, their geographical distribution is so extensive that they can be used in making correlations almost anywhere in the mid-continent area.

Only in recent years have American paleontologists begun to divide the group into its finer recognizable subdivisions, and the process is not yet complete. Dunbar and Condra (1) made the first notable advance, adding two new genera and about nine new forms deserving varietal or specific rank. Their work has been followed rather closely in this paper, but with some hesitation in respect to the genus *Chonetina*. The forms referred to that genus by Dunbar and Condra constitute a compact phylogenetic unit, as deserving of a generic name as any group in the family, perhaps, but their right to that particular name is questionable, inasmuch as only one species, *C. verneuiliana* (Norwood and Pratten), bears any marked resemblance to the genotype. However, these and related forms are provisionally referred to *Chonetina* for want of definite evidence that they are distinct. Without specimens of the genotype for comparison there is not sufficient justification for establishing a new genus.

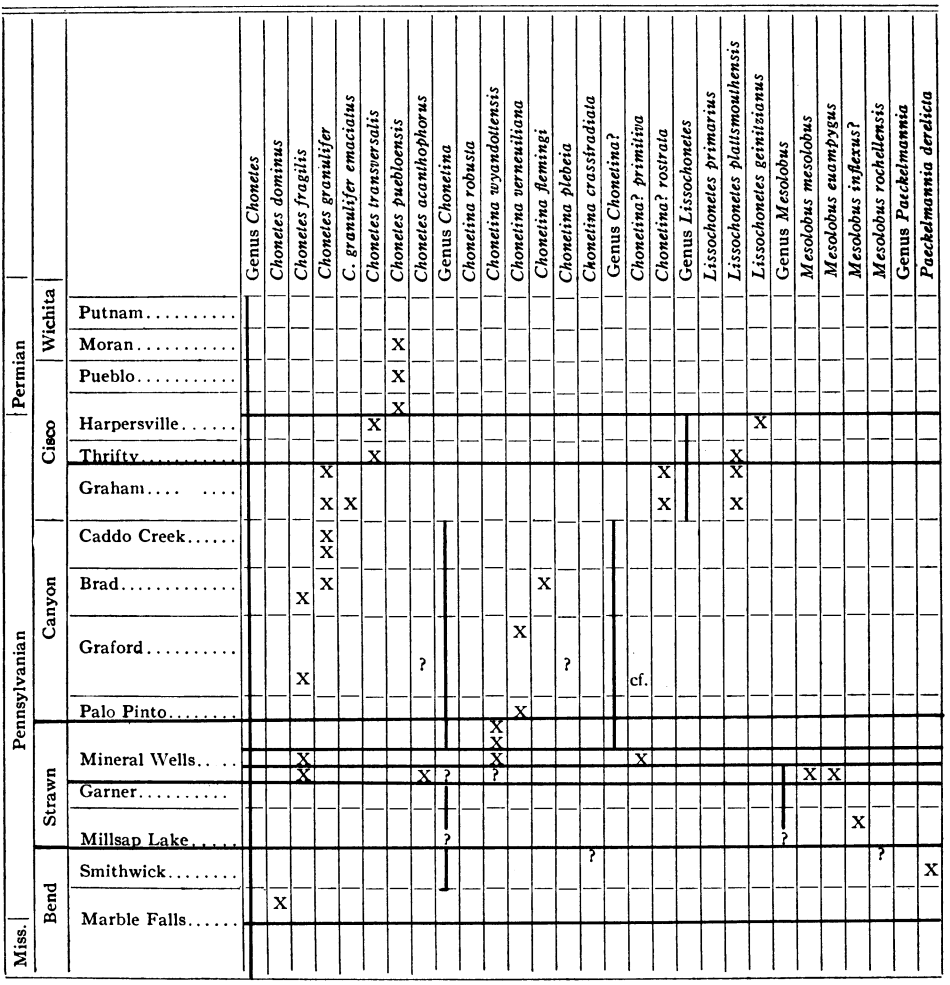
Chonetina? rostrata Dunbar and Condra and *Chonetina(?) primitiva* King, n. sp., might well have been referred to a new genus or subgenus, but again uncertainty as to the true nature of *Chonetina* has been the restraining influence.

The contention of Weller and McGehee (2) that *Mesolobus mesolobus* (Norwood and Pratten) is a smooth rather than a lirate form was verified with the aid of Dr. Dunbar, the specimens examined being topotypes in the collection of Dr. J. Brookes Knight.

The accompanying range table is as complete as the condition of the collections will permit. Specimens of most of the established species have been compared with Dunbar and Condra's types and some specimens were identified by Dr. Dunbar. Dr. Newell identified specimens of *Chonetina wyandottensis* Newell. The new species introduced are distinct and recognizable in Texas and some are found also in Kansas. These latter were known to Dunbar and Condra, who refrained from describing them because they were in doubt as to whether or not the geographic distribution was sufficient to warrant their introduction as new species.

Most of the hitherto undescribed species of Productidae of north-central

Stratigraphic range of Chonetidae of north-central Texas



Questionably identified specimens have been omitted. The symbol ? refers to stratigraphic position rather than identification. Horizontal heavy rules represent unconformities; vertical, range of the genus.

Texas appear to have only local geographic distribution. However, unless a species has been named and carefully described so that paleontologists can recognize it, it is not possible to say definitely that it is limited to a particular area. The distribution of a well known species cannot be known until all strata in which it is likely to occur have been carefully examined, which is usually a task beyond the capabilities of any one individual. The fact that a species has not been previously described is good evidence that it is not common in areas that have been examined, but it is not conclusive proof that it is unrepresented. In areas that have received only superficial study it may be abundant. It is unsafe, therefore, to state that the distribution of an undescribed species is limited to a certain area.

If the geographic distribution of a

species can be determined, together with the nature of the strata in which the form occurs, the factors governing the distribution can be more accurately postulated. The complex whole of the environmental causes of restricted geographic range cannot be inferred from a partial summation of the effects. The ecologic factors active at present should not be assumed to have been active in the past with identical results unless substantiated with geologic evidence. On the contrary, the factors governing the range of a fossil species should be determined from contemporary evidence, supported as much as possible by current events. For purposes of paleo-ecology, therefore, a species of limited distribution is more valuable than one of unknown geographic range, although it has, perhaps, less practical utility.

SYSTEMATIC DESCRIPTIONS

Class BRACHIOPODA Cuvier, 1802

Order PROTREMATA Beecher, 1891

Family CHONETIDAE Hall and Clarke, 1893

Genus CHONETES Fischer, 1837

CHONETES DOMINUS King, n. sp.

Plate 36, figures 1–7

Individuals belonging to this species are subquadrate in outline. The anterior margin may be broadly curved or sinuate but is nearly straight across the median two-thirds of the shell and rounds sharply into the straight parallel lateral margins. A slight constriction of the lateral margins just in front of the hinge line gives the extremities the appearance of being somewhat extended, but the length of the hinge line does not exceed the greatest width of the rest of the shell by more than 1 mm. and may not equal it. The posterior margins meet at an angle of about 170° at the beak.

Most individuals are almost imperceptibly sinuate but some specimens have a distinct sinus on the anterior third of the shell. Some shells that have a prominent sinus in the early stages appear to be crushed specimens. The umbo is very broad and low, scarcely differentiated from the rest of the shell. The posterolateral concave slope is bordered by the indistinct lateral humps and the posterior one-third or one-half of the lateral margins. The longitudinal curvature of the shell is uniform or slightly flattened on the umbo. The transverse curvature at mid-length is only slightly flattened medially and, although it is not so sharp as the longitudinal curve, it has a smaller radius than is common among species of the genus *Chonetes*. The shells are therefore deep, some specimens being nearly a fourth as deep as wide.

Uncrushed dorsal valves are very rare. They are evenly concave longitudinally, but nearly flat. Transversely they are slightly concave near the lateral margins except on the posterior third, which is flat or nearly so. Just in front of the hinge line the lateral margins are depressed, the concavity thus formed coinciding with the constrictions in the lateral margins of the ventral valve.

Faintly lamellose growth lines are prominent near the anterior margin of both valves, but are somewhat less conspicuous on the lateral margins, where they are more closely spaced. The entire surface of both valves is sculptured with fine closely spaced rounded radial lirae, of which about 5 or 6 occupy a space of 1 mm. near the margins. The number of lirae is increased by intercalation and by splitting.

There are about 11 spines on the posterior margin on each side of the beak. The cardinal area of each valve is noticeably striate longitudinally, the ventral more so than the dorsal, but transverse striae are visible only at high magnification.

The ventral median septum rises sharply just ahead of the beak, with an anteriorly directed point, and then declines rapidly and continues as a low ridge to a point just in front of the mid-length. The rounded lateral ridges are

parallel and extend from the anterior end of the adductor muscle scars to a point just beyond the mid-length of the valve. These ridges and the septum end at the same line. Papillae cover the valve surface except the muscle scars, and are especially abundant and closely spaced near the margins. The largest ones are at the anterior end of the septum.

In the dorsal valve the thickened border of the visceral disc rounds into the ends of the crura, which are separated under the cardinal process by a small pit. On the median third of the shell the median septum forms a low triangle, which rises rapidly from the low posterior portion. The lateral ridges diverge at an angle of about 30° and extend across the posterior third of the shell.

Dimensions (in millimeters) and proportions of four specimens:

Width	Length	Thickness	L/W	T/W
20.3	14.0	4.6	.69	.23
18.8	12.2	4.1	.65	.22
16.9	11.3	3.4	.67	.20
14.7	10.0	3.0	.68	.20

Chonetes multicosta Winchell has a somewhat similar outline but is markedly umbonate. No other form known to the writer bears enough resemblance to *C. dominus* to necessitate comparison.

This species has thus far been found only in black shale partings near the top of the Marble Falls limestone, where it is locally very abundant.

Syntypes.—Bureau of Economic Geology nos. K-260, K-261, K-262, K-263, K-267, K-268, K-271, K-272, K-273, K-274, K-275, K-276, a total of 276 specimens and 33 free ventral and 10 free dorsal valves in addition, from the Marble Falls limestone exposed in a cut on the Llano road near the top of a hill 2.7 miles south of San Saba, San Saba County, Texas.

CHONETES FRAGILIS King, n. sp.
Plate 36, figures 8–13

Chonetes granulifer Owen. PLUMMER and MOORE, *1921*, Univ. Texas Bull. 2132, pl. 13, figs. 19–20.

Chonetes fragilis has a broadly rounded anterior margin, which rounds more sharply into the nearly straight lateral margins. The latter are commonly very slightly concave just in front of the posterior margin, the cardinal extremities being very slightly extended. The lateral margins converge anteriorly at an angle of 35° or less; on most specimens the angle is between 25° and 30°. On a very few individuals the sides are almost parallel. The shape varies, therefore, from arcuate to subquadrate, but neither of these extremities is well represented. The posterior margins meet at an angle of about 172°.

The ventral valve has a low, broad umbo, which is scarcely set off from the rest of the shell. The posterolateral surfaces are very broadly concave. A very few specimens have an almost imperceptible sinus amounting to little more than a flattening of the anterior median portion of the shell. The longitudinal curvature decreases regularly anteriorly, the greatest thickness being back of midlength. The transverse profile at midlength is a broad, even curve, somewhat flattened medially on the most convex specimens.

The curvature of the dorsal valve follows that of the ventral. The concavity gradually decreases anteriorly, and transversely is almost regular. The lateral margins are slightly depressed just in front of the hinge line, corresponding to the constrictions of the margin of the ventral valve. In front of this depression the margins are elevated slightly above the plane including the posterior and anterior margins.

There are about seven spines on each side of the beak, diverging from the posterior margin at an angle of about 35°. The ventral cardinal area is very narrow, scarcely wider than the dorsal. Extremely faint radial lirae cover the surface of both valves except very narrow areas along the posterior margin. About nine occupy a space of 2 mm. at the margin. Around the outer one-fourth or one-third of the shell faint growth lines are visible.

Within the dorsal valve the crura are short, broad, and low, and limit deep dental sockets. The visceral disc is not sharply set off, but a faint ridge extends the ends of the crura to the lateral margins. Under the cardinal process is a triangular pit with thickened margins. The lateral ridges diverge from the posterior angles of this pit, forming with its thickened border a distinct **M**. They are short and diverge at an angle of about 45°. The median septum has a long posterior but an abrupt anterior slope, and extends only to the mid-length of the valve. Small round papillae cover the marginal third of the valve. They increase in number and decrease in size toward the margin, and are arranged in distinct radial rows. The ventral interior has not been observed.

Dimensions (in millimeters) and proportions of five specimens:

Width	Length	Thickness	L/W	T/W
17.8	11.6	3.2	.65	.18
17.3	10.0	3.3	.58	.19
16.3	9.8	2.5	.60	.15
15.8	9.9	2.8	.63	.18
14.9	9.5	2.6	.64	.18

Chonetes fragilis is much less convex than any other species except *C. granulifer* var. *emaciatus* King, n. var. and *C. dominus* King n. sp. The latter has a very different longitudinal profile and is subquadrate and sinuate; it is therefore readily distinguishable. *C. granulifer* var. *emaciatus* most closely resembles *C. fragilis* but is somewhat smaller and more arcuate in outline, and its lirae are fine and widely spaced rather than low and broad with very narrow interspaces. *C. granulifer* Owen, s.s., is much more convex, with a strong umbo and sinus, and most specimens are longer than *C. fragilis*. In the Brad formation, however, the specimens of *C. fragilis* are more convex than in lower formations, and there seems to be some intergradation with *C. granulifer*, which makes its first appearance in the Brad. *C. transversalis* Dunbar and Condra and its descendants are so much more transverse and convex than *C. fragilis* that comparison is scarcely necessary. The interior of the dorsal valve of *C. transversalis* is, however, remarkably like that of *C. fragilis*. The small, extremely convex, sinuate *Chonetes acanthophorus* Girty (3) does not require comparison.

C. fragilis is abundant in the East Mountain shale member of the Mineral Wells formation in the vicinity of Mineral Wells, and occurs in the Graford and Brad formations, apparently grading into *C. granulifer* in the latter.

Syntypes.—Bureau of Economic Geology nos. K-709 (from the East Mountain shale member of the Mineral Wells formation in the bluff west of the cemetery at Mineral Wells, Palo Pinto County, Texas, 29 individuals) and P-4477 (from the same member exposed in the clay pit at Mineral Wells, 21 individuals and one free dorsal valve).

CHONETES GRANULIFER Owen var. EMACIATUS King, n. var.

Plate 36, figures 14–18

In calcareous sediments the typical form of *C. granulifer* Owen is a long, narrow subquadrate shell, markedly convex in profile. In intervening arenaceous or argillaceous strata only a few feet or even a few inches thick it is transverse with a subarcuate margin, and has a very low convexity(3a). This latter form must be regarded as an ecologic variant and should not be afforded unwarranted stratigraphic value.

As previously stated, this variant is transverse, with only slight convexity. The anterior margin is rounded, and almost regularly rounded into the nearly straight lateral margins, giving the shell a subarcuate form. The cardinal extremities are very slightly extended on a few specimens, which makes the lateral margins very gently concave in their posterior portion. Commonly the extremities are not extended. The median angle of the posterior margin is 170° to 175°.

The umbo is small and narrow, scarcely extending beyond the hinge line, but it is sharply delimited for about 2 mm. by almost vertical lateral slopes,

which form an umbonal angle of 80° to 90°. It loses definition back of the mid-length and passes into the regular curvature of the valve. The posterolateral slopes are very broadly concave. There is no trace of a sinus on any of the uncrushed specimens observed. The longitudinal curvature is regular, the greatest thickness being at mid-length. The transverse profile at mid-length is flattened on the lateral slopes and evenly convex over the median third of the valve.

The dorsal valve is gently and evenly concave except posterolaterally where it is transversely flattened, and just before the beak, where there is a deeper depression corresponding to the ventral umbo.

About six fine spines diverge from each side of the posterior margin at an angle of about 40°. The surface of both valves is covered with fine, rather sharply rounded radial lirae, of which about 4 or 5 occupy a space of 1 mm. They are, however, almost imperceptible on the posterolateral surfaces. They increase by splitting and are very prominent on most specimens. Faint growth lines are visible on the anterior third of the shell.

The shell substance is very thin and light, so the muscle scars are not deeply impressed. They seem to follow the pattern of *C. granulifer* Owen. The papillae are finer and somewhat more obviously radial in arrangement. The visceral disc, except for a narrow longitudinal median band, has no papillae.

Dimensions (in millimeters) and proportions of five specimens:

Width	Length	Thickness	L/W	L/W
6.8	3.6	1.3	.53	.19
9.0	5.5	1.3	.61	.15
12.2	6.8	1.5	.56	.12
13.4	8.1	1.6	.60	.12
16.5	8.4	2.3	.51	.14

This form resembles *C. fragilis* King n. sp. but has more arcuate margin and the radial lirae are much more prominent on most specimens. Its maximum size is somewhat less than that of *C. fragilis*. It also resembles *C. transversalis* Dunbar and Condra, but it is somewhat smaller and less transverse and is also less convex and thinner than that species. It scarcely resembles *C. granulifer* Owen, s.s., which is a longer, heavier, more nearly quadrate shell with a more prominent umbo. *C. granulifer*, s.s. did, however, develop out of such a shell, as is shown by the growth lines. They indicate a transverse juvenile stage from which the subquadrate shape was developed by disproportionately rapid growth at the anterior margin.

C. granulifer var. *emaciatus* has thus far been found only in the South Bend shale member of the Graham formation.

Syntypes.—Bureau of Economic Geology no. K-192, from the South Bend shale member of the Graham formation in a low bluff on the old Jacksboro road 2.2 miles east of Bryson, Jack County, Texas, 39 individuals and one free ventral valve.

CHONETES PUEBLOENSIS King, n. sp.

Plate 37, figures 1–6

Chonetes meekianus Girty. PLUMMER and MOORE, *1921*, Univ. Texas Bull. 2132, pl. 24, figs. 2–5.

This is a large alate species of moderate convexity. The anterior margin is very gently curved except on strongly sinuate specimens, which have a slightly sinuate margin. The anterolateral margins are only a little more abruptly rounded into the rapidly converging lateral margins, which are concave posteriorly but become convex at the mid-length of the shell. The lateral margins converge at an angle of 40° to 60°, but on most specimens the size of the angle is less than 50°. The posterior margin is almost straight, the angle at the beak being about 175°.

The sinus is extremely faint to imperceptible on all but about one-tenth of the specimens, which have a distinct but very broad and shallow depression, which appears at a point behind the mid-length of the shell but in front of the umbo. The umbo itself is small and low but sharp, and distinctly set off from the rest of the shell. Its sides for 2 or 3 mm. in front of the posterior margin slope steeply to the nearly flat posterolateral

surfaces and diverge at an angle of about 98°, but lose definition in the regular curvature of the valve. Near the lateral margins just back of the mid-length of the shell the posterolateral surfaces are broadly concave and round evenly to the central portion of the valve. The longitudinal curvature is uniform. The transverse profile at mid-length is broadly and evenly rounded except medially, where it is almost flat.

The dorsal valve is gently concave, with a faint dimple corresponding to the umbo. For about 3 mm. a small triangular area is sharply depressed below the valve surface, the sides meeting posteriorly at a 98° angle. The anterior side of the triangle is absorbed by the general concavity of the valve. There is a slight depression of the lateral margins just before the hinge line. The lateral and anterior valve margins lie in a plane; the posterior margin rises medially slightly above the others. The median fold is indistinguishable except on the few strongly sinuate specimens.

There are 11 or 12 spines on each side of the beak. They diverge at an angle of about 40° from the posterior margin. Striae are visible on both the cardinal areas. The dorsal area is somewhat wider medially than at the extremities. The surface of both valves is covered with low rounded lirae, of which about 4 occupy a space of 1 mm. They increase by splitting. Faint and sparse growth lines are visible on the anterior third of the shell.

The hinge teeth are strong, extending nearly 1 mm. in front of the hinge line and about 2.5 mm along it. The median septum is small; it is not as large as one of the hinge teeth in any dimension. It appears to have had a rudimentary anteriorly directed spine. The lateral ridges are low and poorly defined. They arise at the anterior end of the adductor muscle scars and extend over the median third of the valve. Low rounded papillae cover the valve surface but are decidedly finer and more closely spaced and are more obviously arranged in radial rows over a distinct narrow zone about 1.5 mm. in width around the edge of the shell.

The crura are broad and short and limit large dental sockets. They diverge at an angle of about 140°. The thickened border of the visceral disc is very close to the shell margin and rounds into the posterior side of the crura. The median septum has a gentle posterior but an abrupt anterior slope and extends over two-thirds the length of the valve. The unusually prominent but short lateral ridges diverge at an angle of about 55° to 60°. They are as large as the septum but only about half as long. Papillae cover the anterolateral surfaces and the border is ornamented as in the ventral valve.

Dimensions (in millimeters) and proportions of five specimens:

Width	Length	Thickness	L/W	T/W
26.2	12.7	4.7	.49	.18
28.4	15.2	5.2	.54	.18
26.5	14.8	5.6	.56	.21
26.1	14.8	4.0	.57	.15
25.8	13.6	4.2	.53	.16

C. puebloensis is intermediate between *C. transversalis* Dunbar and Condra and *C. meekianus* Girty both genetically and stratigraphically. It is larger than *C. transversalis* and not quite so alate. Internally the narrow sharply defined border of very fine, regularly arranged papillae seems to be distinctive. It is a smaller, lighter shell than *C. meekianus* and the posterior margins do not form as sharp an angle as in that form. It is also slightly less convex than *C. meekianus*. It is much more transverse than *C. granulifer* Owen, with which it is not likely to be confused.

C. puebloensis is apparently restricted to the Pueblo formation and the strata immediately above and below it. It has been found in this zone from northern McCulloch County to northeastern Callahan County. This is quite probably the form listed by Dunbar and Condra in their range table (1,*a*) as *C.* aff. *meekianus* Girty.

Syntypes.—Bureau of Economic Geology nos. K-352 and K-353 (from Camp

Colorado limestone of Pueblo formation in a cut on the Cisco-Moran road 1 mile north of Pueblo, Callahan County, Texas, 19 individuals and 3 free dorsal valves) K-363 (from Camp Colorado limestone member in a road cut 1.7 miles east of Santa Anna, Coleman County, Texas, 27 individuals and 1 free ventral valve), and P-5773 (from road cut northeast of Randolph College, Cisco, Eastland County, Texas).

Genus CHONETINA Krotow, 1888
CHONETINA? PRIMITIVA
King, n. sp.
Plate 37, figures 7–11

This species is long and narrow, rather large, and nearly quadrate. The anterior margin is very broadly rounded, the anterolateral margins very sharply rounded. The lateral margins are straight or rounded, commonly slightly constricted just in front of the cardinal extremities, which appear somewhat extended as a result. The lateral margins are subparallel on most specimens but may converge or diverge at an angle of as much as 20°. If they converge, the greatest width is at the hinge line; if they diverge, it is in front of the mid-length. Young specimens are more transverse than mature ones. The average length varies from about 0.63 to about 0.68 of the width and the width increases from about 11 mm. to about 19 mm.

The beak is low and prominent and extends a little beyond the posterior margin. From the very earliest stages it is deeply divided by a sharp sinus, which broadens anteriorly. Its sides diverge at an angle of about 40° as prominent sharp humps, flattened laterally, which extend to the anterior margin. The posterolateral areas are broadly concave. The longitudinal curvature is fairly regular but may increase somewhat anteriorly. The evenly rounded transverse profile is interrupted medially by the deep rounded notch of the sinus.

The dorsal valve conforms to the ventral. There is a subtriangular depression on each side of the high, broad fold. The valve margins lie in a plane except for the fold, which is strongly elevated, and the posterior margin, which may be slightly depressed. Specimens having a less strongly elevated fold have depressed anterolateral margins as well.

The cardinal areas are narrow and coarsely striate longitudinally. There are about seven very small spines on each side of the posterior margin. On a specimen with a transparent shell the tubes connecting the spines with the interior are visible and they are situated as in *Chonetes* s.s. These tubes show that there were originally at least nine spines, the innermost of which are no longer discernible. The surface of both valves is covered with rounded radial lirae, which are faint on the umbo and much stronger at the margins. There are commonly nine to eleven in a space of 2 mm. They increase by splitting. The ventral valve of most specimens shows numerous regularly spaced small crescentic fractures in the outer shell layer, where surface spines have been broken away. Growth lines are discernible at early stages but are lamellose and prominent on the anterior one-third or one-fourth of the shell.

This species is obviously closely related to the somewhat younger *C. rostrata* Dunbar and Condra. The growth lines indicate a rather transverse juvenile stage, the long, narrow mature stage being attained by disproportionately rapid growth at the anterior margin. The growth lines on *C. rostrata* show a similar juvenile stage, a long, narrow intermediate stage, and a transverse mature stage arrived at by disproportionately rapid growth at the lateral margins. On *C. primitiva* the sinus and lateral humps continue strong and regularly increasing to the anterior border. On *C. rostrata* they change rather abruptly at mid-length, the sinus becoming rapidly wider and the humps much farther apart and lower. *C. primitiva* is strongly and evenly convex. *C. rostrata* Dunbar and Condra is less convex, being somewhat flattened anteriorly, though strongly convex over the umbo. As previously

stated, the ratio of length to width of *C. primitiva* increases from about 0.63 at 11 mm. width to about 0.68 at 19 mm. width. These figures are averages, the length and width of about 50 specimens having been plotted and a curve drawn through the points. A similar curve for about 40 specimens of *C. rostrata* showed the ratio decreasing from about 0.69 at a width of 7 mm. to about 0.62 at a width of 19 mm. From these data and from the evidence of the growth lines it is concluded that the ancestral stock was a convex, sinuate, rather transverse form, which became long and narrow with strong sinus and lateral humps in *C. primitiva* and then assumed again the transverse form in *C. rostrata*, the sinus and humps declining.

It will be noticed that at a width of about 13 mm. the ratio of length to width is about the same in the two forms. However, the greater convexity of *C. primitiva* and the uniform increase in the width of its sinus with the consequent uniform divergence of its lateral humps, which continue straight and strong to the anterior margin, should distinguish this form from *C. rostrata* even at the stage of growth at which the ratio of length to width is the same.

C. primitiva occurs abundantly in the Salesville shale member of the Mineral Wells formation of the Strawn group. A closely related form from the lowest part of the Graford formation of the Canyon group has a slightly more arcuate margin, and the lateral humps diverge at a slightly greater angle, but the amount of intergradation makes it infeasible to distinguish them. The variant is interesting as an indication of the gradual transition to *C. rostrata* of the Graham formation. Dunbar and Condra's specimens from localities near Ada, Oklahoma, probably belong to *C. primitiva* rather than to *C. rostrata*.

Syntypes.—Bureau of Economic Geology nos. K-3 and K-4, from the Salesville shale member of the Mineral Wells formation on a hillside above the road 3 miles west and 1 mile northwest of the west city limits of Mineral Wells and east of Brazos River, Palo Pinto County, Texas, 52 individuals.

CHONETINA ROBUSTA
King, n. sp.
Plate 37, figures 12–16

Chonetina robusta is a very thick-shelled form, extremely convex, and unusually long in proportion to its width. The gently curving anterior margin rounds rather evenly into the lateral margins, which meet the posterior margin almost at right angles. The outline is subsemielliptical as the length is three-fifths to three-fourths the width. Immature specimens are much more transverse, and their cardinal extremities are extended.

The longitudinal curvature is uniform, the greatest depth of the shell being at mid-length. The transverse curvature at mid-length is somewhat flattened on the lateral flanks and sharply convex over the center, but it is interrupted by the deep, U-shaped sinus. The sinus becomes prominent at an early stage and continues to the anterior margin without greatly increasing either its width or depth, which are subequal throughout. The posterolateral surfaces are markedly concave. The umbo is rather narrow and prominent, extending beyond the hinge line.

The dorsal valve is concave, especially on the posterior portion, which is crushed down into the ventral valve. The median fold is low but prominent on the anterior half of the valve. The valve margins lie in two planes. The anterior and the greater part of the lateral margins lie in one plane except that on each side of the fold the anterior margin is depressed. The posterior margin and about 2.5 to 3 mm. of the posterior portion of the lateral margins lie in the second plane, which meets the first at an angle of about 165°. Some specimens have broad shallow grooves across the lateral margins just in front of the cardinal extremities.

There are eight or nine flat-lying spines on each side of the beak of mature speci-

mens. Smaller specimens have only five or six. The entire surface of both valves is sculptured with coarse rounded lirae, about 4 of which occupy a space of 1 mm. These are strongest on the umbo and weakest along the posterior border on the lateral slopes. On the dorsal valve they are very faint just in front of the cardinal extremities. They increase by splitting. Growth lines are visible over most of the shell but are most prominent near the margins, where they are also most closely spaced.

Small specimens are transverse and alate but growth is disproportionately more rapid at the anterior margin as is shown by the growth lines, so that the shape becomes progressively less transverse. As the convexity is uniform, mature shells are also much thicker in proportion to their width.

Dimensions (in millimeters) and proportions of three specimens:

Width	Length	Thickness	L/W	T/W
14.4	9.1	3.4	.63	.24
15.5	10.2	3.8	.66	.25
16.2	11.9	5.1	.73	.31

Immature specimens of *C. robusta* resembles *C. crassiradiata* Dunbar and Condra but may be distinguished by the deeper U-shaped sinus and stronger umbo. Specimens having a faint sinus can scarcely be differentiated. This would seem to indicate that *C. robusta* was derived from *C. crassiradiata*. Mature shells of the former are much longer in proportion to the width, and also much more convex, but the growth lines show that the most elongate shells were transverse in their early stages. The mature shells resemble *C. flemingi* (Norwood and Pratten) but are much heavier and somewhat longer. The most conspicuous difference, however, is the broader and deeper U-shaped sinus of *C. robusta*. Its radial lirae are more rounded, also, and its lateral margins more nearly parallel. *C. alata* Dunbar and Condra is even more alate than *C. flemingi* and its sinus is shallower. *C. plebeia* Dunbar and Condra is much smaller, with less curvature, and the lirae are much fainter and finer than in *C. robusta*. *C. verneuiliana* (Norwood and Pratten) and *C. wyandottensis* Newell are both very long and narrow with a much narrower umbo than *C. robusta*. The lateral slopes of both are much more strongly concave.

This form has been found at only one locality, where it occurs in association with *Prismopora triangulata* (White), which has not yet been found above the Millsap Lake formation in the Brazos Valley. Its stratigraphic position is probably in the Millsap Lake, but the outcrop is isolated and cannot yet be definitely correlated.

Syntypes.—Bureau of Economic Geology nos. K-132 and K-137, from a creek bed 3½ miles east and 1 mile south of Rochelle, McCulloch County, Texas, 16 individuals and half of a ventral valve.

Genus LISSOCHONETES Dunbar and Condra, 1932

LISSOCHONETES PRIMARIUS King, n. sp.

Plate 38, figures 1–6

This is a large species with a variable outline. It is commonly subquadrate with the cardinal extremities very slightly extended. The anterior margin is nearly straight but may be sinuate or curved, more commonly the latter. The anterolateral margins are sharply rounded and the lateral margins are nearly straight. They are parallel or converge at an angle of as much as 30°. The posterior margin is almost straight on uncrushed specimens, but the convexity is so great that on crushed individuals the median angle is prominent.

The convexity of the ventral valve decreases regularly and rapidly toward the anterior margin, the greatest thickness being, therefore, behind the mid-length. A broad faint sinus begins just in front of the beak and continues to the anterior margin becoming gradually broader, but it is deepest near the mid-length of most specimens. The posterolateral areas are strongly concave. The transverse profile at mid-length is concave medially, convex over the lateral

humps, and straight on the lateral slopes.

The configuration of the dorsal valve conforms to that of the ventral. Two broad shallow depressions corresponding to the lateral humps are separated by a broad low fold which rises just in front of the beak and becomes gradually broader anteriorly. It is strongest near the mid-length. The posterolateral surfaces are gently concave. If the anterolateral margins and the anterior portions of the lateral margins be regarded as forming the plane of the valve margins, the anterior margin rises above this plane and the posterior portions of the lateral margins slope downward from it to the posterior margin, which lies entirely below it.

Seven or eight spines diverge from each side of the posterior margin at an angle of about 45°. On very small specimens there are only five spines on each side of the beak. Very faint growth lines are visible near the anterior margin of most specimens. The entire surface of both valves bears minute pits, which were left by the breaking away of fine surface spines. The cardinal areas are narrow; the dorsal is wider than the ventral medially but narrower at the extremities.

Within the ventral valve the teeth are oblique and curved downward laterally. Their slightly upturned inner points are somewhat thinner than the portion adjoining the valve. A small deltidium with a prominent ridge at its extremity partially fills the delthyrium. Below it the median septum extends anteriorly and then downward in a sharp arc to a point near the posterior end of the adductor muscle scars. It runs forward as an even, rounded ridge to a point well in front of the mid-length of the shell. The visceral area is clearly outlined by a marked thickening of the shell. The inner openings of the cardinal spines appear as two rows of pits about 0.3 mm. from the hinge line at its extremities and extending to the lateral ends of the teeth. The outer two or three openings are visible from a point directly above the valve. The whole interior of the valve except the muscle scars bears low, round papillae in radial rows. They are smallest and most numerous outside the visceral area.

Within the dorsal valve the median septum extends from the anterior end of the adductor muscle scars to the mid-length of the valve as a low narrow triangle, its posterior side much the longer. The visceral disc is set off by a thickening of the shell which forms a low ridge just inside the margin and posteriorly rounds into the ends of the crura from their posterior side. The crura are low and broad, and diverge at an angle of only 140°. This comparatively small divergence of the crura was not mentioned in the description of any other species of *Lissochonetes*. Radial rows of small rounded papillae cover the valve except in the vicinity of the muscle scars.

Dimensions (in millimeters) and proportions of five specimens:

Width	Length	Thickness	L/W	T/W
17.9	11.1	3.7	.62	.21
16.7	11.0	3.4	.66	.20
13.8	9.0	2.7	.65	.20
10.3	6.9	1.9	.67	.19
8.7	5.8	1.8	.67	.21

L. primarius attains a much larger size than any other American species so far described. *L. plattsmouthensis* Dunbar and Condra is not only smaller but more transverse and more convex and has a much deeper sinus than *L. primarius*. *L. geronticus* Dunbar and Condra is also smaller, more convex, and more strongly sinuate than this species, but no more transverse. *L. senilis* Dunbar and Condra is a longer subquadrate shell, with a fainter sinus. *L. geinitzianus* (Waagen) resembles *L. primarius* in many respects but is less convex and less strongly sinuate. It is the only species likely to be confused with the one here described. However, it occurs much higher in the section.

L. primarius is abundant in the Jacksboro limestone member of the Caddo Creek formation southeast and northeast of Jacksboro, Jack County, Texas.

Syntypes.—Bureau of Economic Geology nos. K-1488, K-1489, and K-1491

(from a shale parting in the Jacksboro limestone in the Rock Island Railroad cut 3.7 miles southeast of Jacksboro, Jack County, Texas, 56 individuals and one free dorsal and 11 free ventral valves) and K-1530 (from the Jacksboro limestone on a hillside north of the Chico road, 6.6 miles northeast of Jacksboro, 11 individuals, one free ventral and one free dorsal valve, all small).

Genus MESOLOBUS Dunbar and Condra, 1932

MESOLOBUS ROCHELLENSIS King, n. sp.

Plate 38, figures 7–15

This species is large for the genus and somewhat longer than most species. The anterior margin is very broadly rounded or straight, very rarely sinuate. The anterolateral margins are abruptly rounded into the lateral margins, which are nearly straight. They are commonly parallel but may converge at an angle of as much as 15°. The cardinal extremities may be slightly extended or rounded but on most specimens they form right angles. The posterior margins form an angle of about 160°, but very convex specimens appear even more pointed because of the extension of the umbo beyond the margin.

The sinus, which appears about 2 mm. from the beak, is very deep and narrow and is nearly filled by the sharp median fold. The fold is set off from the higher lateral humps by deep sharply angular grooves, which diverge at an angle of 15°, more or less. The lateral humps are clearly defined on their inner slopes, but the lateral slopes are nearly flat except posteriorly. The umbo is low and broad and not sharply defined, so the posterolateral slopes are gently and evenly concave. The longitudinal curvature is almost uniform, but the greatest thickness is at a point a little back of mid-length, and the umbo is somewhat flattened on some specimens. Transversely the profile at mid-length is broadly rounded or flattened on the lateral slopes and sharply rounded into the angular grooves of the modified sinus. The fold is a little broader than high, and noticeably lower than the lateral humps.

The dorsal valve is deeply concave. The fold rises about 2 mm. in front of the hinge line and becomes gradually higher and broader. However, the sinus in the fold is so broad and deep that the median portion of the valve appears to have two sharply angular plications rather than a sinus within a fold. The sinus is somewhat broader than deep and not so deeply depressed as the lateral areas.

There are about nine spines on each side of the beak, diverging from the posterior margin at an angle of about 65°. The cardinal areas are noticeably wider medially than at the extremities, and are very finely striate longitudinally. The surface of both valves is smooth except for the faint lamellose growth lines. These are prominent on the anterior third of the shell but are visible over most of the surface. They indicate a much more transverse juvenile stage, the mature shape being attained by dis-

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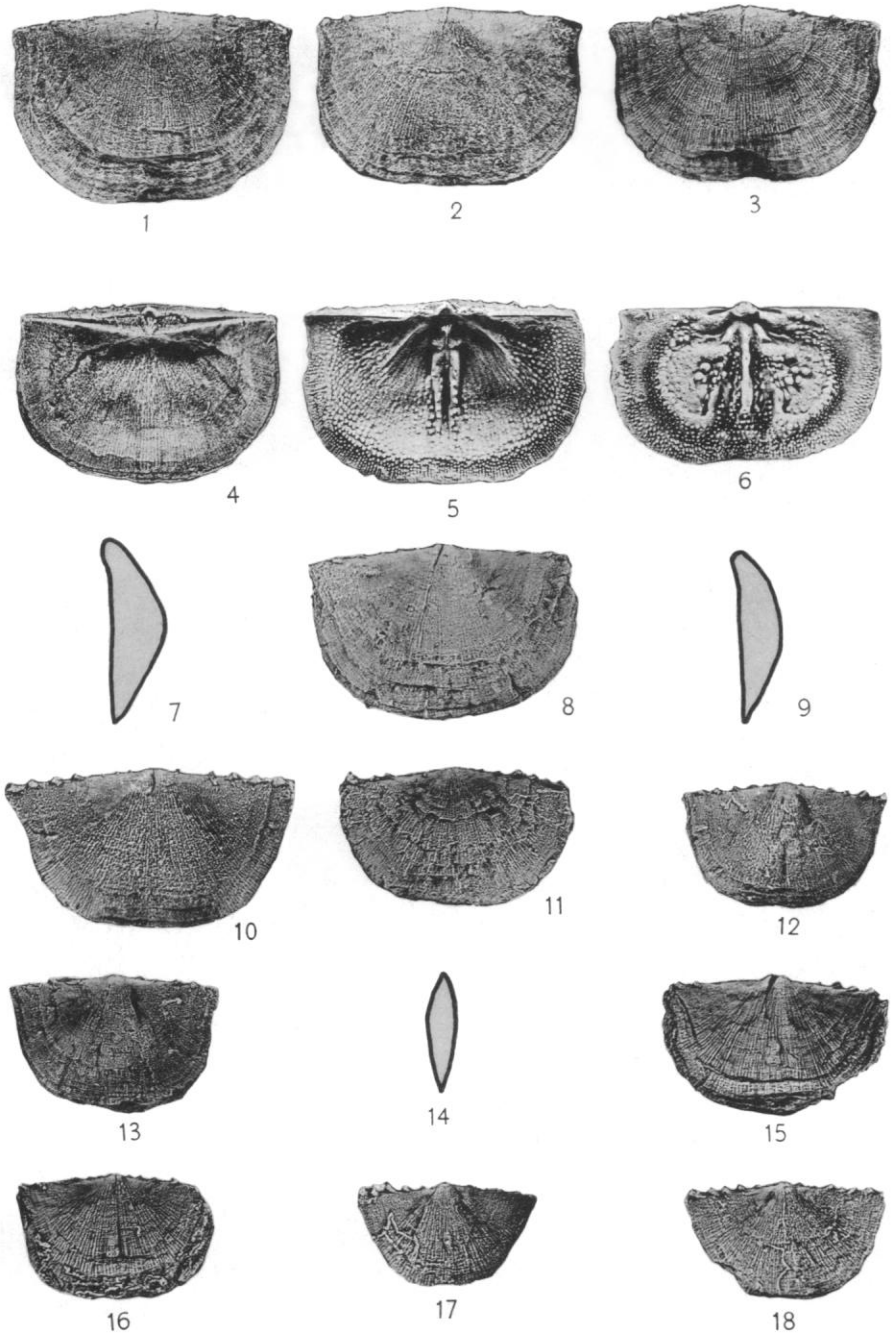
EXPLANATION OF PLATE 36

FIGS. *1–7—Chonetes dominus* King, n. sp. *1–3*, Ventral view of three individuals from the Marble Falls formation in a cut on the Llano road 2.7 miles south of San Saba, San Saba County, Texas, K-262, K-276, K-268; *4*, dorsal view of another individual from the same locality, K-273; *5*, *6*, ventral and dorsal interior of free valves from the same locality, K-274, K-260; *7*, a profile. (p. 259)

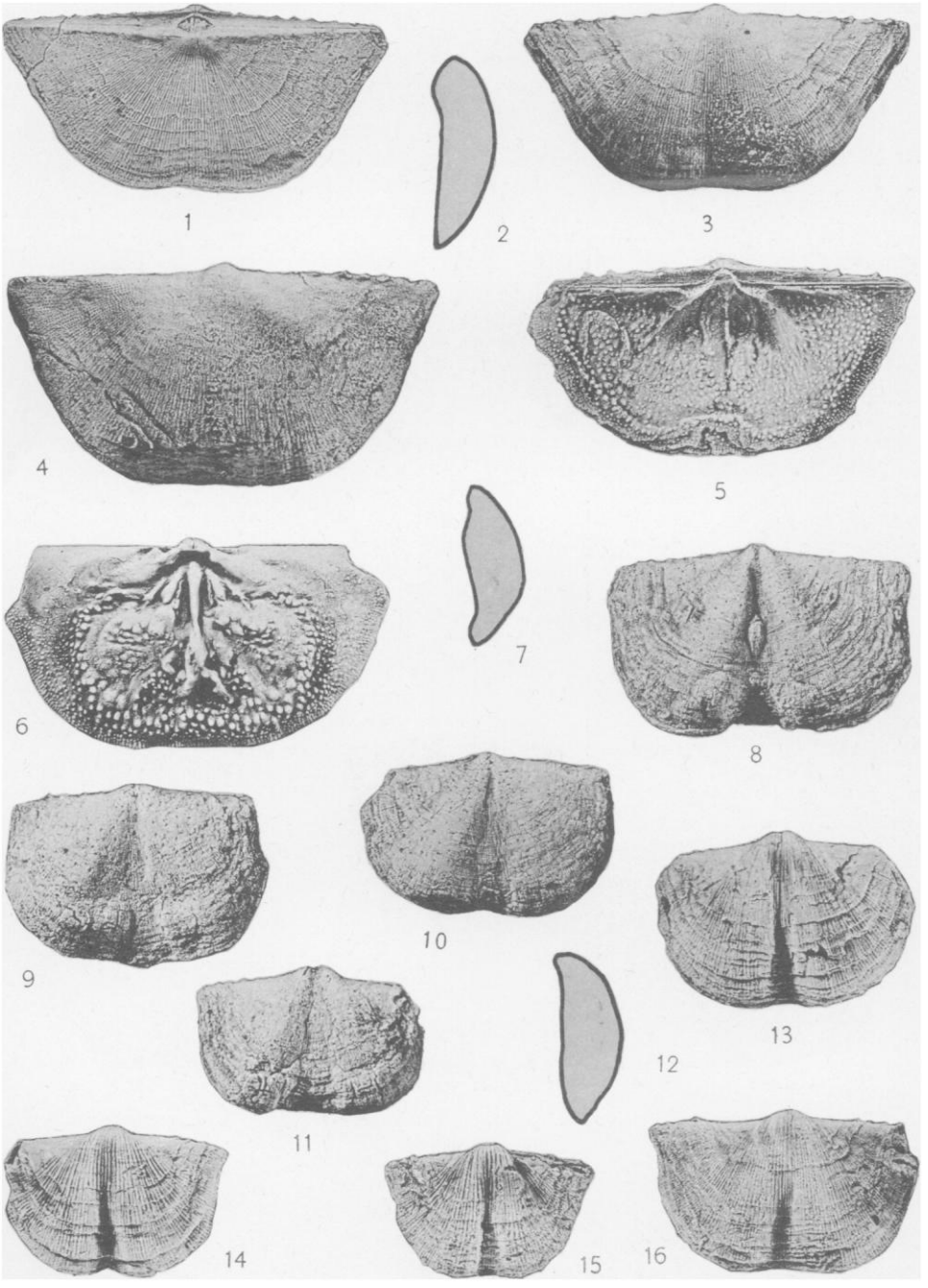
8–13—Chonetes fragilis King, n. sp. A profile and ventral views of five individuals from the East Mountain shale member of the Mineral Wells formation west of the cemetery at Mineral Wells, Palo Pinto County, Texas, K-709. (p. 260)

14–18—Chonetes granulifer Owen var. *emaciatus* King, n. var. A profile and ventral views of four individuals from the South Bend shale member of the Graham formation on the old Jacksboro road 2.2 miles east of Bryson, Jack County, Texas, K-172.

All figures ×2. (p. 261)



King, Paleozoic Chonetidae from Texas



King, Paleozoic Chonetidae from Texas

proportionately rapid growth at the anterior margin. Weathered shells appear lirate, which is a common occurrence among smooth Chonetidae.

The delthyrium is partially filled by a small deltidium. Below this in mature shells there is a recession out of which projects the posterior portion of the median septum. On young specimens this portion is narrow but on fully mature individuals it is a square blade with a horizontal dorsal and a vertical anterior edge, which descends nearly to the valve floor before meeting the dorsal edge of the long anterior portion of the septum. This portion extends to the anterior edge of the visceral area as a low rounded ridge of almost uniform height. The diductor muscle scars are long and narrow and are restricted to the area representing the lateral humps. Posterolaterally they are limited by extremely high steps, especially remarkable in view of the thinness of the shell. Anteromedially they are limited by the ridges representing the grooves that separate the fold in the sinus from the lateral humps. The adductor muscle scars have the form of low, broad triangles with their bases separated by the median septum and with their apices at mid-length and directed laterally. They are bounded by shallow grooves. In a few large specimens there are low short lateral ridges. They are about the same size as the septum and are parallel to it, but separated from it by a space about equal to their width. They gradually die out well back of the mid-length of the valve. Most individuals do not show this feature. The surface except the muscle scars is covered with radial rows of very low, rounded papillae, more noticeable but less regularly arranged on the outer flange.

In the dorsal valve the crura are low and broad and are directed laterally parallel to the hinge line. Their inner ends curve posteriorly to the cardinal process and partially enclose a small pit. The front edge of the pit is a low ridge rounding into the crura. The median septum runs forward, low, broad, and flat-topped, to near the mid-length, where it begins to rise sharply to form a thin triangle, descending rapidly thereafter to disappear near the edge of the shell. On each side of the septum is a high rounded asymmetric lateral ridge. The inner faces of the ridges are steep slopes with an anteriorly directed, low-lying spine forming the crest. The outer slopes are longer and convex. The ridges broaden out and terminate rather abruptly just back of the mid-length. The muscle scars are sharply outlined by the crura, the lateral ridges, and the median septum, but are so faintly impressed in the thin shell that their anterior limits are indiscernible. Just within its lateral and posterior margins the shell is thickened into a low ridge, which joins the crura on their posterior sides near their lateral extremities, but the

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EXPLANATION OF PLATE 37

FIGS. *1–6—Chonetes puebloensis* King, n. sp. *1–4*, A profile and dorsal and ventral views of one individual and ventral view of another from the Pueblo formation on the Cisco-Moran road 1 mile north of Pueblo, Callahan County, Texas, K-353; *5, 6*, ventral and dorsal interior of two free valves from the Harpersville formation in a road cut northeast of Randolph College, Cisco, Eastland County, Texas, P-5773. (p. 262)

7–11—Chonetina? primitiva King, n. sp. A profile and ventral views of four individuals from the Salesville shale member of the Mineral Wells formation on a hillside above the road 3 miles west of the city limits of Mineral Wells and east of Brazos River, Palo Pinto County, Texas, K-3, K-4. (p. 264)

12–16—Chonetina robusta King, n. sp. A profile and ventral views of four individuals from the Millsap Lake formation in a creek bed 3½ miles east and 1 mile south of Rochelle, McCulloch County, Texas, K-137. (p. 265)

All figures ×2.

anterior part of the visceral area is not delimited. On the anterior portion of the shell on each side of the fold there is a greatly thickened subtriangular area ornamented with strong radial ridges, some of which are broken up into individual strong papillae. Around the margins of the shell are very fine papillae, closely spaced in radial rows.

Dimensions (in millimeters) and proportions of five specimens:

Width	Length	Thickness	L/W	T/W
14.9	9.9	2.8	.66	.19
14.4	10.0	2.8	.69	.19
14.4	9.6	2.8	.67	.19
13.4	9.0	2.3	.67	.17
8.8	5.7	1.8	.65	.20

The large size, strong lobation, and low convexity will distinguish *M. rochellensis* from any other now known, except possibly *M. inflexus* (Girty). That form, however, has a very narrow, very depressed median lobe, so that the anterior margin is deeply sinuate. If, as Girty states, it has radial lirae, that would serve further to distinguish the two forms. However, the Chonetidae are very deceptive in this respect, and some Texas specimens otherwise indistinguishable from *M. inflexus* are smooth.

This species is very abundant at an isolated locality in Colorado River valley where it occurs in association with *Chonetina robusta* King, n. sp. in strata tentatively correlated with the Millsap Lake formation.

Syntypes.—Bureau of Economic Geology nos. K-142, K-1721, and K-1722, from a creek bed $3\frac{1}{2}$ miles east and 1 mile south of Rochelle, McCulloch County, Texas, 271 individuals, 71 free ventral and 52 free dorsal valves.

Genus PAECKELMANNIA Licharew, 1936

PAECKELMANNIA DERELICTA

King, n. sp.

Plate 38, figures 16–22

Specimens of this species have an arcuate margin with the curvature of the anterolateral margins only slightly exceeding that of the anterior and lateral margins. The lateral margins commonly converge slightly but on some individuals they are parallel and rarely are divergent. The cardinal extremities are nearly right angles. The posterior margins meet at the beak at an angle of about 168°. There is no trace of a fold or sinus.

The umbo is high and prominent, extending back of the cardinal border if not crushed. The posterolateral areas are markedly concave. The longitudinal curvature decreases regularly toward the front of the shell. The transverse profile is sharply rounded over the median third of the shell, but the lateral slopes are straight and would, if extended, meet at an angle of about 65°. Most specimens are flattened by crushing, but the height of an undistorted specimen is nearly a fourth the width. The dorsal valve is almost uniformly concave.

The entire surface of the shell except a small portion of the umbo and the corresponding part of the dorsal valve is covered with thin lamellose growth lines. There are numerous rather regularly arranged pits left by the removal of the fine surface spines from both valves. The surface is smooth, but the outer shell layer is transparent, and the radial structure of the underlying layer gives the shell the appearance of being radially lirate. About five of these pseudolirae occupy a space of 1 mm. near the margin. There are five or six large erect spines on each side of the beak. They diverge from the posterior margin at an angle of about 65°. The cardinal areas are longitudinally striate. The ventral is a little wider than the dorsal and both are wider medially than at the extremities.

Within the ventral valve the median septum extends from the middle of the deltidium downward and forward to the floor of the valve at a point just back of the anterior end of the adductor muscle scars. It continues forward for about a millimeter as a low, thickened ridge, and dies out well back of the mid-length of the shell. The lateral ridges diverge very slightly and continue beyond the end of

the septum, gradually declining to about the mid-length of the shell where they disappear. The adductor muscle scars are elongate oval and outlined by a broad groove except where separated by the median septum. The diductor muscle scars are roughly triangular and partially enclose the adductor muscle scars. Their anterior margins form an almost straight line, which is slightly convex forward, and a distinct but low ridge limits their posterolateral margins. The papillae are low and rounded and rise from slight depressions. They are comparatively scarce and are prominent only near the margins. The largest ones occur just within the visceral area near the hinge line.

In the dorsal valve the crura are prominent ridges parallel to the hinge line. A thickened ridge running roughly parallel to the margins limits the visceral disc and rounds into the anterior side of the crura near their outer extremities at an angle of about 30°. The posterior muscle scars are deep and smooth, and are limited posterolaterally by the ridge delimiting the visceral area. Medially they are bounded by the lateral ridges, which diverge at an angle of about 30°. Each ridge has an anteriorly directed spine at its anterior end. The anterior muscle scars are deep and elongate and are separated by a very low median septum. Over the posterior third of the shell it is much less prominent than the lateral ridges, but it rises and descends abruptly, forming a sharp triangle just back of the center of the shell. There are two large blunt anteriorly directed spines on its anterior slope. The visceral area is smooth near the ridge limiting the anterolateral portions, but the remainder is covered with strong papillae, which might almost equally well be termed spines. They are low-lying and variously but predominantly anteriorly directed. Outside the visceral disc the papillae are very numerous but small and fine.

Dimensions (in millimeters) and proportions of two somewhat crushed specimens:

Width	Length	Thickness	L/W	T/W
18.9	13.6	4.5		
12.0	8.8	3.5	.73	.29

The writer knows of no other species of this genus from the Pennsylvanian of North America. The absence of a sinus will distinguish it from specimens of *Lissochonetes* and *Mesolobus* except possibly *M. decipiens* (Girty), which is a subquadrate shell without the prominent umbo of this species.

This species occurs in the so-called Smithwick black shales overlying the Marble Falls limestone in the vicinity of Bend, San Saba County, Texas.

Syntypes.—Bureau of Economic Geology no. K-218, from dry gully 1.3 miles from Bend on the Cherokee road, San Saba County, Texas, 18 individuals, one free dorsal and one free ventral valve.

Superfamily STROPHOMENACEA Schuchert, 1896

Family PRODUCTIDAE Gray, 1840

Sub-family PRODUCTINAE Waagen, 1884

Genus JURESANIA Fredericks, 1928

JURESANIA RECTANGULARIA King, n. sp.

Plate 39, figures 9–12

Juresania rectangularia is a small, short, very transverse species with a noticeable sinus, which is most strongly developed at the mid-length of the shell. The anterior margin is straight or nearly so. The lateral margins are straight and subparallel or very broadly rounded and slightly divergent anteriorly. The greatest width of the shell is well in front of the mid-length except on shells with parallel lateral margins.

The umbo is low and broad and the beak scarcely extends beyond the hinge line. The longitudinal curvature is sharp, but decreases somewhat anteriorly. The lateral slopes are steep, but the small arched ears are not sharply set off from the rest of the shell. The umbonal slopes are very steep and form an angle of about 90°, but the angle decreases somewhat anteriorly. In transverse profile the flat-

tened or sinuate median portion of the shell rounds sharply into the flattened lateral slopes.

The dorsal valve is flat with a sharply upturned margin. There is a small shallow depression just in front of the beak, and the ears are slightly concave.

There is a small cicatrix of attachment on the ventral valve. The hinge is linear. The dorsal valve is ornamented with rounded concentric wrinkles, which become lamellose on the upturned margins. These are swelled into small pustules from which project fine spines. On some specimens these swellings have the appearance of low, rounded, radial costae, especially along the median line. The ventral valve is ornamented with several concentric rows of small oblique spines. Except on the umbo there are also scattered erect spines, much larger than the oblique ones. They are about 0.8 mm. in diameter and usually arise just behind the rows of small spines. The growth lines are lamellose around the margins of the shell.

Dimensions (in millimeters) of three specimens, disregarding the marginal flange:

Width	Length	Thickness
22.3	16.6	9.6
20.2	16.7	8.4
21.8	17.1	9.6

Juresania rectangularia has thus far been found only in the Brad formation, where it is associated with *J. ovalis* Dunbar and Condra. It is not likely to be confused with that shell, which attains a much larger size, is much more elongate, has much finer spines, and lacks the marginal flange. *J. nebraskensis* (Owen) resembles *J. rectangularia* much more closely, but may be distinguished by its much larger size, its lower convexity, somewhat more elongate outline, and coarser spines.

Syntypes.—Bureau of Economic Geology no. K-86, 6 specimens from the Brad formation in the gullies northwest of McAdam's Peak, 1½ miles east of Pickwick, Palo Pinto County, Texas.

Genus DICTYOCLOSTUS Muir-Wood, 1930

DICTYOCLOSTUS NEWELLI King, n. sp.

Plate 39, figures 1–4

Dictyoclostus newelli is a rather large, very transverse species. The anterior margin is broadly sinuate but the trail is broken off all the specimens so far seen. The lateral margins are subparallel and nearly straight. The umbo is broad and low and extends but little beyond the hinge line. The umbonal angle is about 105° to 115°. The ears are large and arched, and are sharply set off from the rest of the shell. The greatest width is at the hinge line. A broad shallow sinus appears behind the mid-length and continues to the anterior margin, but is commonly strongest at the mid-length of the shell.

The visceral area of the dorsal valve is very broadly concave except for a low broad median fold and a shallow depression in front of the beak. The margins are sharply upturned, but, as previously stated, the trail is broken off all the available specimens. The ears are concavely arched.

The dorsal valve is ornamented except on the ears and probably the trail with very fine radial costae and concentric rugae of about equal strength. The costae increase by splitting so that there are about 5 in a space of 5 mm. near the margins, but they are finer and more closely spaced near the beak. The ventral valve is similarly reticulate on the umbo but only the costae continue over the anterior portion. They number about 4 in a space of 5 mm. on this part of the shell. There are numerous small scattered spines on the ventral valve and a single row of larger spines along its posterior border.

Dimensions (in millimeters) of three specimens, the trail being broken off:

Width	Length	Thickness
48.7	36.2	19.4
44.5	34.6	18.2
45.2	32.9	18.3

D. newelli is larger than *D. portlockianus* (Norwood and Pratten) and has finer and more even costae. It is also much more transverse than that species and its umbo is less inflated. *D. crassicostatus* Dunbar and Condra is also a smaller less transverse form than *D. newelli* and has very much coarser costae. *D. americanus* Dunbar and Condra attains a much larger size and is a more elongate form without a distinct sinus. *D. welleri* King, n. sp. is a much more convex form with an inflated umbo and extended beak, and it also is much less transverse. *D. newelli* is not likely to be confused with any form so far known except possibly *D. americanus* Dunbar and Condra.

D. newelli occurs in the Caddo Creek and Graham formations but is not abundant in either. Some fragments from the Thrifty formation apparently belong to this species but cannot be positively identified.

Syntypes.—Bureau of Economic Geology no. K-1101, 2 specimens, and K-1621, 1 specimen, all from the Graham formation in a bluff south of the road two miles east of Fife, McCulloch County, Texas.

DICTYOCLOSTUS WELLERI
King, n. sp.

Plate 39, figures 5–8

Productus semireticulatus var. cf. *hermosanus* Girty. PLUMMER and MOORE, *1921*, Univ. Texas Bull. 2132, pl. 25, figs. 3, 4.

Dictyoclostus welleri is a rather large extremely convex species with an elongate outline. The anterior margin is broadly rounded and rounds more sharply into the lateral margins, which are straight except for the extended ears. The ears are large and very strongly arched, but are not sharply set off from the rest of the shell. The umbo is strongly inflated and extends well back of the hinge line. The umbonal angle is about 97°. Most specimens show a distinct sinus, but on many it is scarcely more than a flattening of the median portion of the shell. The lateral slopes are very steep to sub-parallel.

The dorsal valve is deeply and evenly concave, with a sharply defined depression just in front of the beak. The intersection of the arched ears with the concave surface forms two broad low ridges extending from the beak to the lateral margins.

On the dorsal valve the costae and rugae are of about equal prominence. The rugae are broadly rounded; the costae are narrow and rather widely separated. On the ventral valve the costae are finer and more closely spaced than the rugae. They are sharp as on the dorsal valve, and the rugae are broadly rounded. Numerous rather fine spines ornament the ventral valve, and the posterior slopes of the ears are covered with much larger, more closely spaced spines. The body spines are commonly situated on costae that are stronger than the rest. All costae increase in size toward the anterior margin, where they number about 5 in a space of 5 mm. but they are much finer and more closely spaced on the umbo.

On several shells the umbo and even some parts of the anterior slope have been attacked by some boring organism.

Dimensions (in millimeters) of three specimens:

Width	Length	Thickness
58	41.6	23.2
45	34.7	22.4
49	35.2	23.2

The greater size and elongate outline will distinguish *D. welleri* from *D. portlockianus* (Norwood and Pratten) and *D. crassicostatus* Dunbar and Condra. The umbo of *D. welleri* is narrower and more inflated than in those species, also. *D. americanus* Dunbar and Condra is a larger, broader form, with less convexity, and its umbo is broader. *D. newelli* King, n. sp. is much more transverse and somewhat flattened on the umbo instead of fully rounded. *S. wolfcampensis* R. E. King resembles *D. welleri* more closely than does any other form. However, it is

slightly less convex and has finer, more even costae and finer, more closely spaced rugae. With specimens of both species in hand *D. welleri* can be distinguished at a glance by its rough appearance, which is due to the very marked unevenness of the costae.

D. welleri is rather abundant in the lower part of the Putnam formation and it is present in the lower part of the overlying Admiral and the upper part of the underlying Moran formations.

Syntypes.—Bureau of Economic Geology nos. K-1008, 3 specimens; K-1009, 2 specimens; K-1010, 3 specimens; K-1011, 2 specimens; K-1016, 2 specimens; K-1017, 2 specimens, all from the lowest limestone of the Putnam formation, which is exposed in an outlier south of the road 2.3 miles west of Putnam, Callahan County, Texas.

Genus MARGINIFERA Waagen, 1884
MARGINIFERA SCINTILLATA
King, n. sp.

Plate 39, figures 13, 14

Marginifera scintillata is a small, very convex form. The anterior margin is broadly rounded to slightly sinuate, but is nearly straight. The lateral margins are nearly straight and sub-parallel; the anterolateral margins are sharply rounded. The ears are large, arched, and quadrate. The greatest width is at the hinge line. The tightly incurved beak projects but little beyond the hinge line. The sinus is faint and is strongest at mid-length. The lateral, anterior, and umbonal slopes are all very steep. The umbonal angle is about 95°. The umbo is somewhat flattened and the shell is geniculate.

The surface is ornamented with fine low rounded costae, of which there are about 9 or 10 in a space of 5 mm. near the anterior margin. They increase by splitting. There are also a few scattered spines.

Dimensions of the holotype: width, 13.2 mm.; length, 10.9 mm.; thickness, 10.9 mm.

M. scintillata resembles *M. missouriensis* Girty in some respects but it has finer costae and coarser spines than that species, it is more sharply geniculate, and its lateral slopes are more nearly parallel. *M. wabashensis* (Norwood and Pratten) is a more transverse shell with a deeper sinus and a shorter, broader beak, and is not apt to be confused with *M. scintillata* as it occurs much higher in the section. *M. haydenensis* Girty is much more sharply geniculate and is also more transverse, and its beak is broader and not extended beyond the hinge line.

Holotype and three paratypes.—Bureau of Economic Geology no. K-1117, from the Kickapoo Falls limestone member of the Millsap Lake formation at Kickapoo Falls of Kickapoo Creek in Hood County, Texas, about a mile south of the Parker County line.

Genus LINOPRODUCTUS Chao, 1927
LINOPRODUCTUS INORNATUS
King, n. sp.

Plate 39, figures 23–26

The outline of juvenile specimens of *Linoproductus inornatus* is transversely elliptical, but by disproportionately rapid growth at the anterior margin the outline grades through subcircular to elongate elliptical on old specimens. The anterior margin becomes more abruptly rounded and the anterolateral margins become more broadly rounded with advancing growth. The hinge line is very short and the ears are little more than an outward flare of the umbonal slopes. The umbo is broad, and the beak does not extend far beyond the hinge line. There is no trace of a sinus, but specimens from the youngest strata in which the species occurs are somewhat flattened medially. The longitudinal curvature gradually decreases anteriorly. The transverse profile is broadly rounded medially and rounds sharply into the straight lateral slopes, which are only moderately steep. The umbonal angle is about 110°.

The dorsal valve is broadly concave,

the curvature gradually decreasing anteriorly. The ears are slightly concave. On specimens which are flattened medially on the ventral valve there is a low, broad fold on the dorsal valve. A few widely spaced lamellose growth lines cover the anterior half of the valve.

There is a very small cicatrix on the beak of some specimens but apparently not on all. The hinge is linear. Both valves are covered with low, rounded lirae or costae, which increase by splitting and occasionally by intercalation. Near the margin of a specimen of average size they number quite uniformly 8 in a space of 5 mm. but they are somewhat finer and more closely spaced on the umbo. There are a few spines scattered about the ventral valve, most of which are about 8 or 10 mm. apart. On some specimens there are about two or three spines on each ear arranged in a row along the posterior margin. The ears are strongly wrinkled, but the wrinkles do not encroach on the umbonal slopes.

Dimensions (in millimeters) of four specimens:

Width	Length	Thickness
40.5	42.2	20.9
29.1	26.9	14.0
28.4	26.5	13.5
17.6	14.8	6.5

L. inornatus appears in the East Mountain shale member of the Mineral Wells formation and is abundant in the Salesville and Keechi Creek shales of that formation. It continues upward to the top of the Graham formation but is not abundant in that very fossiliferous formation.

The very short hinge line, small ears, and low convexity will distinguish *L. inornatus* from any of the other similar linoproductids except possibly *L. meniscus* Dunbar and Condra, which is a much larger, more convex species with a narrower umbo. However, even *L. meniscus* Dunbar and Condra has a longer hinge line in proportion to its size and has larger ears ornamented with numerous spines.

Syntypes.—Bureau of Economic Geology no. K-1487, 4 specimens from the Jacksboro limestone member of the Caddo Creek formation in the Rock Island Railroad cut 3.7 miles southeast of Jacksboro, Jack County, Texas.

Genus CANCRINELLA Fredericks, 1928

CANCRINELLA ALTISSIMA

King, n. sp.

Plate 39, figures 27, 28

Cancrinella altissima is an extremely high, narrow, elongate form, broadly geniculate about 9 to 12 mm. from the beak. The best specimen, selected as the holotype, is 29 mm. in length, measured from the flattened posterior surface to the broken anterior margin. Following the curvature of the valve the length is 48.5 mm. One side of the specimen is damaged, but the maximum width was about 33 mm. The thickness was about 20 mm. There is an anterior prolongation of the ventral valve formed by constriction of the anterolateral margins, but this may be due to crushing, as there is some fracturing of the shell. The ears, though damaged, appear to have been extended, the greatest width being at the hinge line. The posterolateral or umbonal slopes are very steep. There is no trace of a sinus. Commonly the anterior trail is broken off, leaving only the umbonal portion as a subhemispherical body about 20 mm. in diameter and about 10 mm. in height.

The dorsal valve is evenly concave except for the ears, which are flat with a slight depression just in front of and parallel to the hinge line. The hinge is linear; there is no cardinal area.

The lirae are low and rounded and increase by splitting, especially at the spine bases. They become somewhat larger anteriorly. About 10 occupy a space of 3 mm. near the beak, but near the margin about 7 or 8 cover an equal space. The rugae are low, with the posterior slope more abrupt. The spines are erect and are arranged in diagonal rows, or quincunx.

A complete specimen would not be confused with *C. boonensis* (Swallow) but

the broken fragments commonly found are less easily distinguished. They are, however, much less convex ventrally and much less concave dorsally, have fewer and less conspicuous rugae, and have fewer spines on the umbonal portion. *C. boonensis* attains a maximum diameter of about 12 mm. and is obviously mature at that size, the thickness being nearly three fourths the length. *C. altissima*, however, is only about half as thick as long at a diameter of about 20 mm.

Holotype.—Bureau of Economic Geology no. P-7030, from the Graham formation on the west side of a small outlier one-half mile west of South Bend, Young County, Texas. Paratypes, P-4898 from the Graham formation 3 miles west of Bunger, Young County; P-4862 from the Graham formation 1 mile west of Graham, Young County; K-1091 from the Graham formation 2 miles east of Fife, McCulloch County, Texas; and K-1299 from the Graham formation south of Parks Mountain, Coleman County, Texas, five specimens in all.

Genus OVERTONIA Thomas, 1914

OVERTONIA PLUMMERI King, n. sp.

Plate 39, figures 19–22

Overtonia plummeri is small and subhemispherical. The lateral and anterior margins have a uniform curvature, which gives the shell a circular outline, with its greatest width at the mid-length. The umbo extends well back of the hinge line, but the beak is tightly incurved. The longitudinal curvature, therefore, gradually decreases anteriorly. The umbonal angle decreases from about 100° to about 80°. Because the hinge line is short and is greatly overarched by the umbo the ears are very small but are sharply set off. There is no trace of a sinus. The dorsal valve is concave except for the flattened ears, the curvature decreasing regularly anteriorly.

The hinge is linear. The ventral valve bears concentric rounded ridges that have about equal anterior and posterior slopes. The growth lines are more prominent between than upon ridges, because at the crest of each ridge there is a single row of large oblique spines. The buried base of each spine can be traced down the posterior slope of the ridge as a slight elevation. Near the anterior margin of the shell the spines are much more numerous but not much more widely spaced nor larger than near the beak. There are about 5 in a space of 5 mm. measured along the ridge. The ridges are about 2 mm. from crest to crest near the anterior margin. On the dorsal valve the spines are finer and project from lamellose growth lines. The spines on the ears are not differentiated from the rest on either valve. The lumen runs forward from the spine base within the shell substance, as Dunbar and Condra (1,*b*) have demonstrated to be true of other Productidae.

Dimensions (in millimeters) of three specimens:

Width	Length	Thickness
14.8	15.9	7.8
11.4	11.0	6.4
8.9	10.5	3.8

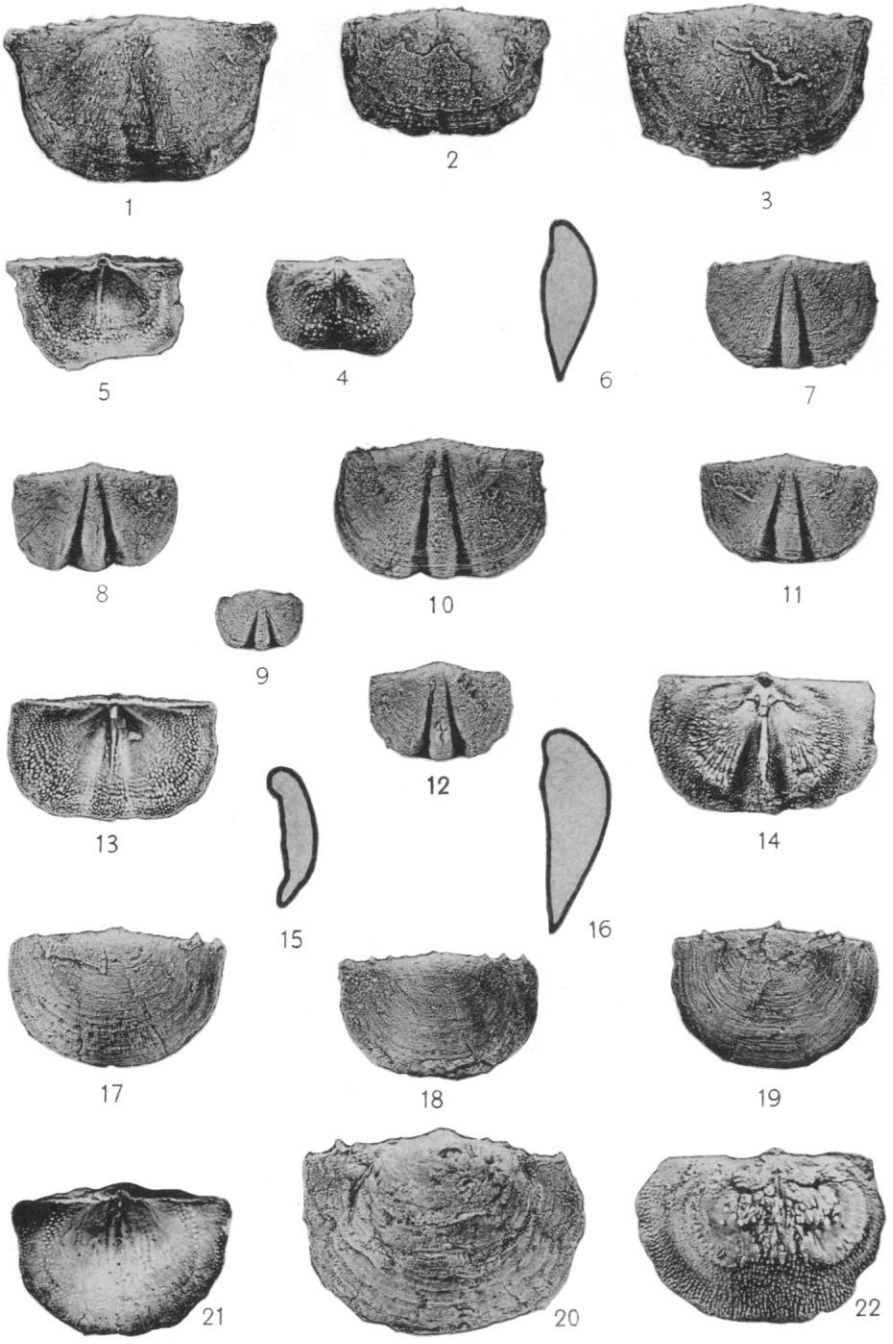
EXPLANATION OF PLATE 38

FIGS. *1–6—Lissochonetes primarius* King, n. sp. *1–3*, Ventral views of three individuals from a shale parting in the Jacksboro limestone in the Rock Island Railroad cut 3.7 miles southeast of Jacksboro, Jack County, Texas, K-1489; *4, 5*, dorsal and ventral interior of two free valves from the same locality; *6*, a profile. (p. 266)

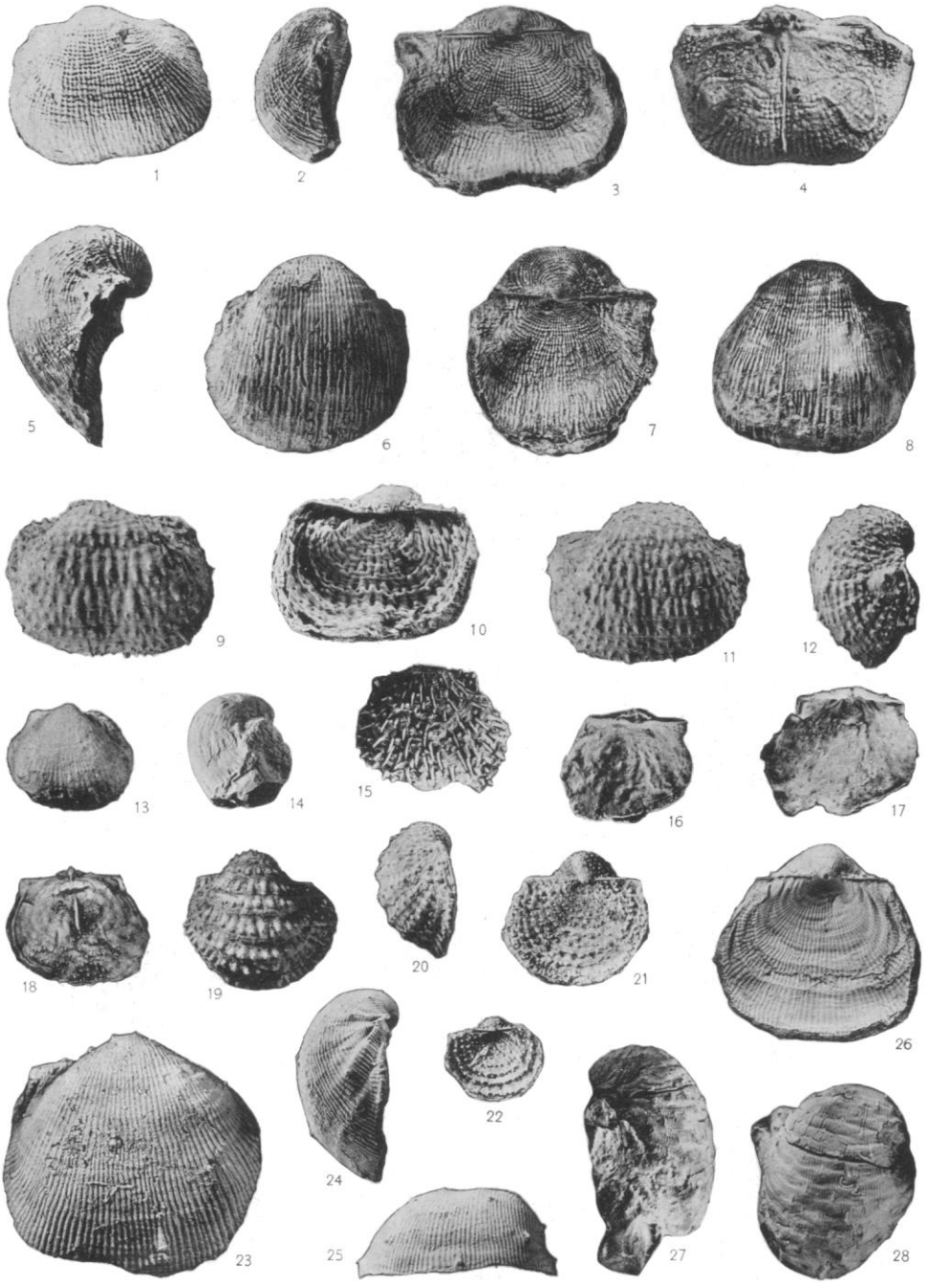
7–15—Mesolobus rochellensis King, n. sp. *7–12*, Ventral views of six individuals from the Millsap Lake formation in a creek bed 3½ miles east and 1 mile south of Rochelle, McCulloch County, Texas, K-1721; *13, 14*, ventral and dorsal interior of free valves from the same locality; *15*, a profile. (p. 268)

16–22—Paeckelmannia derelicta King, n. sp. *16*, A profile; *17–20*, ventral views of four individuals from the so-called Smithwick shale in a dry gully on the Cherokee road 1.3 miles from Bend, San Saba County, Texas, K-218; *21, 22*, ventral and dorsal interior of free valves from the same locality. (p. 270)

All figures ×2, except fig. 20, ×1.



King, Paleozoic Chonetidae from Texas



King, Paleozoic Productidae from Texas

So far as is known to the writer no other species of *Overtonia* has yet been reported from North America with the exception of R. E. King's (4) citation of *Overtonia cristato-tuberculata* (Kozlowski)? from the Wolfcamp and Graham formations. His figures are poor, and even the specimen examined, the original of his figure 1, offers little to indicate the nature of the species except to show that it is not *O. cristato-tuberculata*. It is nearer to *O. plummeri* but it is impossible to say whether it is identical or not. *O. cristato-tuberculata* has only nine to eleven spines in each row, their size and the space between them increasing with the growth of the shell. The spines of *O. plummeri* are almost uniformly spaced and of equal size on all parts of the shell. Furthermore, the dorsal spines also are regularly arranged in concentric rows. *O. plummeri* differs from the genotype, *O. fimbriata* (Sowerby), in its much smaller size and its smaller, more closely spaced tubercle-bearing ridges.

The regular convexity of the ventral valve and the absence of any trace of a sinus or fold seem to be valid generic characteristics that will serve to distinguish the genus *Overtonia* from *Pustula* and other Productid genera.

O. plummeri has been found only in the Wayland shale and seems to be a rather rare form. A single immature individual from the Graford formation may belong to this species.

Holotype.—Bureau of Economic Geology no. P-4860, from the west bank of Salt Creek west of Graham, Young County, Texas. Paratypes, nos. 11980, 1 specimen; 12200, 2 specimens; and P-243, 1 specimen, all from the same locality; and P-719, 3 specimens, and K-320, 2 specimens, from 1 mile south of Gunsight, Stephens County, Texas.

EXPLANATION OF PLATE 39

FIGS. *1–4—Dictyoclostus newelli* King, n. sp., ×⅔. *1, 2,* Ventral and lateral views of specimens from Graham formation at bluff south of road, 2 miles east of Fife, McCulloch County, Texas, K-1101; *3, 4,* exterior and interior views of specimens from Graham formation one-half mile east-northeast of Weedon School, Brown County, Texas, P-6571, P-6796. (p. 272)

5–8—Dictyoclostus welleri King, n. sp., ×⅔. *5–7,* Lateral, ventral, and dorsal views of a specimen from an outlier of the lowest limestone of the Putnam formation south of road, 2.3 miles west of Putnam, Callahan County, Texas, K-1011; *8,* ventral view of another specimen from the same locality, K-1011. (p. 273)

9–12—Juresania rectangularia King, n. sp., ×1⅓. *9, 10,* Ventral and dorsal views of a specimen with slightly crushed umbo from the Brad formation northwest of McAdams Peak, Palo Pinto County, Texas, K-86; *11, 12,* ventral and lateral views of another specimen from the same locality, K-86. (p. 271)

13, 14—Marginifera scintillata King, n. sp., ×1⅓. Ventral and oblique views of the holotype from Kickapoo Falls limestone member of the Millsap Lake formation, Kickapoo Falls, Hood County, Texas, K-1117. (p. 274)

15–18—Heteralosia slocomi King, n. sp., ×1⅓. *15, 16,* Exterior of ventral and dorsal valves of genoholotype showing characteristic ornamentation, from Graham formation at Parks Mountain, 4 miles south of Whon, Coleman County, Texas, K-1311; *17, 18,* ventral and dorsal interior of same specimen. (p. 278)

19–22—Overtonia plummeri King, n. sp., ×1⅓. *19–21,* Ventral, lateral, and dorsal views of the holotype, a specimen from the Graham formation on the west bank of Salt Creek west of Graham, Young County, Texas, P-4860; *22,* dorsal view of another, slightly crushed, specimen from the same locality, P-243. (p. 276)

23–26—Linoproductus inornatus King, n. sp., ×1⅓. *23,* Ventral view of specimen from the Caddo Creek formation in the Rock Island Railroad cut 3.7 miles southeast of Jacksboro, Jack County, Texas, P-4872; *24, 25,* lateral and anterior views of another specimen from the same locality, K-1487; *26,* dorsal view of another specimen from the same locality, P-6987. (p. 274)

27, 28—Cancrinella altissima King, n. sp., ×1. Lateral and ventral views of the holotype from a small outlier of the Graham formation one-half mile west of South Bend, Young County, Texas, P-7030. (p. 275)

Subfamily STROPHALOSIANAE Schuchert, 1913

Genus HETERALOSIA King, n. gen.

Strophalosia, pars.

The genus *Strophalosia* as established by Wm. King (5) in 1844 included Productidae with a cardinal area, a "deltidium," and a denticulate hinge. It included forms with a spinose ventral valve and spinose, lamellose, or smooth dorsal valve. The type species, *Orthis excavata* Geinitz, has a spinose dorsal valve. Although this is not made clear in the original description (6) it is definitely stated in a later (7) paper. It now seems desirable to separate from *Strophalosia* the species that have a smooth dorsal valve, and to these it is here proposed to apply the name *Heteralosia*, n. gen.

The species included in *Heteralosia* are Productidae and Strophalosinae that have a cardinal area on each valve, a cicatrix of attachment on the umbo, a "delthyrium" at least partially filled by a "deltidium," teeth in the ventral valve and sockets in the dorsal valve, and spinose ornamentation on the ventral valve but none on the dorsal valve.

The genus is distinguished from *Strophalosia* Wm. King by the absence of ornamentation on the dorsal valve. The point of attachment on the umbo will distinguish *Heteralosia* from *Aulosteges* Helmerson, which is not attached, and from such forms as *Leptalosia* Dunbar and Condra, which are attached by the entire surface of the ventral valve. The cardinal area will distinguish it from the spinose Productinae.

Heteralosia is represented in the late Pennsylvanian and Permian by such species as *Strophalosia gerardi* Wm. King, *Strophalosia tenuispina* Waagen, and the genotype, *Heteralosia slocomi* King, n. sp.

HETERALOSIA SLOCOMI King, n. sp.
Plate 39, figures 15–18

Strophalosia spondyliformis White and St. John. HALL and CLARKE, *1921*, Paleontology of New York, vol. 8, pt. 1, pl. 17A, figs. 25, 26.

Specimens of *Heteralosia slocomi* are subcircular in outline with small scarcely extended ears. The greatest width is in front of the mid-length and exceeds the width along the hinge line by at least half. The anterolateral margins are somewhat more abruptly rounded than the anterior or lateral margins.

The umbo is low and broad and is truncated by the cicatrix of attachment. However, the umbonal slopes are steep and the small ears are sharply set off. The thickness is about one-third the width and there is no trace of a sinus or fold. The ventral valve is therefore broadly and evenly rounded, and the dorsal valve rather deeply and evenly concave. The shell substance is very thin.

The ventral valve is covered with spines about 4 mm. in length near the margin of a mature individual, but these are commonly broken to mere knobs. There is a row of spines along the cardinal border. The dorsal valve is smooth, but faint growth lines are discernible on the anterior half.

The ventral cardinal area is broadly triangular but is only about one-tenth as high as wide. It is striate in both directions. The angle of the "delthyrium" is about 25° or less and it is about two-thirds filled by a depressed convex "deltidium." The dorsal cardinal area is narrow, almost linear, except medially, where it is raised into a low triangle.

Within the ventral valve the teeth project at the borders of the "delthyrium." Low broadly rounded ridges hardly deserving the name of dental lamellae descend from the base of the teeth and limit a broad shallow umbonal cavity, the median third of which is more deeply excavated to form a pit under the "deltidium." There is no median septum except the rounded slightly elevated line between the adductor muscle scars. These are slightly raised and together form a transverse, nearly elliptical area of slight eccentricity with the long axis pulled somewhat anterior to the center, so that each has the form of an imperfect sagging **D**. The diductor muscle scars lie outside and behind the adductors and do not enclose

them. Each is traversed longitudinally by two strong rounded ridges on the median portion, the outer one extending to the base of the dental "plate." The lateral portion of each scar is deeply depressed. The entire area of muscle attachment is roughly semicircular. The inside of the valve, except the muscle scars, is covered with very small, scattered blunt spines. The lateral margins are deeply excavated in front of the hinge line.

In the dorsal valve the dental sockets are deep and the cardinal process is long and narrow. The median septum forms a high triangle on the median third of the valve, but the posterior portion is rather low. The muscle scars form a slightly raised disc divided medially by the septum and the grooves adjacent to it. The brachial impressions are very faint. They apparently enclosed an elliptical area except that their anterior ends are separated by nearly a third the width of the valve. Near the posterior margin the lateral margins are depressed, to form with the corresponding depression of the ventral valve a sizable cavity for some undetermined soft part. Except on the muscle scars and brachial impressions the valve is ornamented with small spines similar to those of the ventral valve.

Heteralosia slocomi is not likely to be confused with any other North American species so far known. Although Hall and Clarke referred it to *Strophalosia spondyliformis* White and St. John, it does not closely resemble that species, which Dunbar and Condra (1,*c*) referred to their new genus *Leptalosia*. Dunbar and Condra and also Girty (8) realized that Hall and Clarke's identification was erroneous. Dr. A. W. Slocom of the Walker Museum, for whom this species is named, writes (9) that the specimen figured by Hall and Clarke was not from Missouri, as stated, but from Graham, Texas, and that it bears no resemblance to *Leptalosia spondyliformis* (White and St. John). *Strophalosia hystricula* Girty resembles *Heteralosia slocomi* but it is more convex —not evenly convex but sharply rounded medially, and the ears are indistinct. The dorsal valve of Girty's species is unknown, but it seems inadvisable to refer it to *Heteralosia* on the basis of its similarity to *H. slocomi*.

H. slocomi has thus far been found only in the Graham formation in north-central Texas.

Holotype.—Bureau of Economic Geology no. K-1311, from the Graham formation in the gullies at the south end of Parks Mountain, 4 miles south of Whon, Coleman County, Texas, separated valves of one individual. Paratypes, nos. P-723, from the Wayland shale member of the Graham formation 1 mile south of Gunsight, Stephens County, Texas, 1 specimen, and 11964, from the Graham formation 1 mile northwest of Graham, Young County, Texas, free ventral valve.

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