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A PELECYPOD FAUNA FROM THE GAPTANK FORMATION (PENNSYLVANIAN) WEST TEXAS

By

SAMUEL O. BIRD

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April 24, 1968

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A PELECYPOD FAUNA FROM THE GAPTANK FORMATION (PENNSYLVANIAN), WEST TEXAS

S. O. Bird

ABSTRACT

The Gaptank Formation crops out in the vicinity of the North American standard Lower Permian in the Marathon Basin of Texas. The formation contains a rich, largely unstudied invertebrate fauna. The richest fossiliferous zone of the Gaptank Formation is Bed ten for which a Missourian age is indicated.

The Pelecypoda fauna from Bed ten is diverse and includes nine new species. Some of these species are so unique that they do not compare well to any known species. For this reason and because internal characters could not be determined, open nomenclature is used in appropriate places. The Bed ten faunal assemblage seems to belong to what Johnson (1962) termed the *Chonetina* association, a normal marine assemblage. Further, the association of pelecypod and gastropod genera with an abundant calcareous brachiopod assemblage would seem to indicate a deep water environment; perhaps deeper than other described North American Pennsylvanian faunas. It is suggested that depth of water accounts for the uncommon diversity of the Bed ten pelecypods. Because species of the various systematic groups are normal in size and ornamentation and because many species are common Pennsylvanian forms, an isolated normal or restricted abnormal environment does not explain the unique morphological types and unique associations found in Bed ten.

INTRODUCTION

The geology of the Marathon Basin in Brewster and Pecos Counties of southwestern Texas is famous, yet little has been done with the rich Pennsylvanian fauna of the Gaptank Formation. Bed ten of the Gaptank Formation contains a rich pelecypod fauna including nine new species and a new unnamed genus. The purpose of this paper is to describe and illustrate the Pelecypoda from Bed ten. In addition, the results of a brief study of the paleoecology of Bed ten and of a quantitative study of some population samples of *Astartella* spp. are included in the work.

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PREVIOUS WORK

The Gaptank Formation was named by J. A. Udden (1917, p. 38) from a cattle tank located in Stockton Gap, Pecos County, 23 miles north of Marathon, Texas. J. W. Beede identified some of the fauna and included a list of fossils in Udden's paper. Other workers have discussed the Gaptank Formation in several publications, the most complete being that of P. B. King (1930). This is a detailed report of the stratigraphy of the Gaptank Formation which includes a faunal list prepared by R. E. King. More recently Bostwick (1962) and Ross (1965) studied the stratigraphy and fusulines of the Gaptank Formation.

STRATIGRAPHICAL AND HISTORICAL GEOLOGY

The Gaptank Formation crops out at three major localities in the Marathon Basin; at the type locality on the Marathon-Fort Stockton highway 23 miles northeast of Marathon; at the Dugout Creek area eight miles west of Marathon; and at Black Peak, located on the north side of Doubtful Canyon (southwest of the Dugout Creek area) in the Del Norte Mountains.

At its type locality, the Gaptank Formation is folded into a broad anticline. The lower one-half of the formation may be observed on the southeast flank of the anticline. Here the formation consists of a series of conglomerates, sandstones, and shales. The upper part of the Gaptank Formation crops out on the northwest flank of the anticline. Five dense limestones separated by sandstones constitute this portion of the formation. The lower part of the Gaptank has been assigned to the Desmoinesian-Virgilian Series; the upper beds to the Virgilian Series (Moore, *et al.,* 1944). The lithologic break from coarse and fine clastics to carbonates and clastics is not accompanied by an unconformity. This change in rock type occurs within the Virgilian beds. About 200 feet below this change in lithology is Bed ten which is richly fossiliferous.

Exposures of the upper part of the Gaptank may be followed from the type locality to the southwest for six or seven miles. These exposures are covered by wash and are somewhat scattered in distribution.

At the Dugout Creek area, west of Marathon, a window in an overthrust sheet exposes the autochthonous Gaptank Formation. Outcrops of the formation are spotty and the structure is complex. Indeed, it has been difficult to determine how much of the Gaptank Formation is represented in this area. The Black Peak locality to the southwest seems to be structurally related to the Dugout Creek area and here too stratigraphic relations are difficult to interpret (King, 1930, p. 46).

The sediments of the Gaptank Formation were deposited in a geosynclinal trough. The extent of this trough was apparently altered by positive elements which were periodically raised above the marine waters. Evidence of cannibalism is found in the five conglomerates in the lower one-half of the formation. According to King (1930, pp. 43-44), the conglomerates thin to the north and contain fragments of the underlying Dimple Limestone (Morrowan), Marvillas Chert (probably Ordovician), and the Caballos Novaculite (probably Devonian). The angularity of pebbles and boulders from these formations seems to indicate short transportation and rapid burial. The environment during deposition of most of the Gaptank Formation either was not well suited for the growth of organisms or was not conducive to their preservation.

Orogenic uplift began in the area near the beginning of Gaptank time, and moving from south to north through time, produced geanticlines and associated troughs. The full force of these movements was exerted near the end of Gaptank time. During this orogeny, beginning in Desmoinesian time and continuing into middle Virgilian time, the sediments at the type locality were folded into the broad anticline seen today. The uplift that produced the thrusting in the Dugout Creek area has been dated as post-Cretaceous (King, 1930, pp. 43-44).

Under these rigorous conditions one would not expect to find an environment suitable for marine life. Indeed, the 1800 foot section of the Gaptank Formation at the type locality, contains only the following noteworthy faunas: (1) *Chaetetes* Limestone, which marks the base of the Gaptank Formation (pre-orogeny); (2) Bed 6, from which King reported a molluscan fauna; (3) Bed 10, the zone primarily studied here; and (4) Beds 13 and 21 from which have been reported *Triticites mooreii* Dunbar and Condra (1932) and *Triticites cullomensis* Dunbar and Condra (1932), respectively.

BED TEN COLLECTIONS

Bed ten consists of about 165 feet of green shale with interbedded argillaceous limestone units. The limestone units are 25 feet, 65 feet, and 85 feet above the base of Bed ten at a locality about two miles south and east from Gaptank. These units are two to three feet thick and are abundantly fossiliferous.

The bulk of specimens studied from Bed ten of the Gaptank Formation were collected near the type locality at Gaptank. The U.S. National Museum collections are: (1) locality 700 – 2 miles S. 17° E. of Gaptank, 1¼ miles E. of a point on the Fort Stockton road 2 miles S. of Gaptank, about 23½ miles NE of Marathon, Texas; (2) locality 700a – same as locality 700 but ¼ mile E. in a small canyon. These collections were made by Dr. G. A. Cooper, 1940 and Drs. Cooper and N. D. Newell, 1941. The writer made further collections in the close vicinity of localities 700 and 700a during the summer of 1956. For the most part, the specimens were collected on the shaly slopes of two arroyos below the limestone units of Bed ten from which the specimens had been weathered and transported.

Other zones of the Gaptank Formation are sparsely fossiliferous or characterized by only a few species. An extensive, more general collection from the Gaptank Formation is deposited at the Bureau of Economic Geology, University of Texas.

The writer's personal collections of pelecypods from Bed ten have been deposited at the U.S. National Museum.

STRATIGRAPHIC AGE OF BED TEN

Few species from Bed ten of the Gaptank Formation are useful as zone fossils. Those present that are regarded by Moore, *et al.* (1944), as Pennsylvanian Series indicators are: Missouri Series — *Enteletes* spp., not older than Missourian; *Enteletes hemiplicatus; Hystriculina splendens* (also Desmoinesian); *Streblopteria (Streblochondria) sculptilus;* and Virgil Series — *Kozlowskia wabashensis. Triticites irregularis,* a Missourian Series indicator, is abundant in Bed ten. Hence the Bed ten fauna suggests a Missourian age.

Comparison of the Bed ten fauna with faunas of North Central Texas as identified by Plummer and Moore (1921) indicates the following number of species in common: Bendian Series 3; Desmoinesian (Strawn) Series 9; Missourian (Canyon) Series 12; and Virgilian (Cisco) Series 12. In some cases the same species is found in more than one series. On the basis of this comparison alone, Bed ten would correlate as well with the Cisco Series as with the Canyon. However as noted above, on the basis of the few guide fossils, the age of Bed ten is Missourian. The same conclusion was reached by Ross (1965) for beds equivalent to Bed ten (Ross's beds A, B, and C) on the basis of the fusulines.

FAUNAL LIST FROM BED TEN, GAPTANK FORMATION

Fauna	Abundance	Group No.*
PROTOZOA		
Triticites irregularis Schellwien and Staff, 1912	CC	
PORIFERA		
Wewokella solida Girty, 1911	A	
CNIDARIA		
Hadrophyllum sp.	RR	
Lophophyllum profundum (Milne-Edwards and Haime), 1851	C	12
BRYOZOA		
Rhombopora sp.	C	5
ECHINODERMATA		
Archeocidaris sp.	RR	
Crinoid Stems	A	
BRACHIOPODA		
Enteletes hemiplicatus plattsburgensis Newell, 1931	C	
Derbya bennetti Hall and Clark, 1892	R	1
Derbya crassa (Meek and Hayden), 1859	C	1
Rhychopora illinoisensis (Worthen), 1884	CC	
Antiquatonia portlockiana (Norwood and Pratten), 1854	R	1
Reticulatia huecoensis (R. E. King), 1931	R	1

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* Group numbers are from Johnson (1962)

Fauna	Abundance	Group No.*
Hystriculina wabashensis (Norwood and Pratten), 1885	C	
Kozlowskia splendens (Norwood and Pratten), 1885	C	1
Neospirifer cameratus (Morton), 1836	R	1
Neospirifer triplicatus (Hall), 1852	R	1
Condrathyris perplexa (McChesney), 1859	CC	7
Cleiothyridina orbicularis (McChesney), 1859	R	
Composita subtilita (Hall), 1852	CC	
Composita trilobita Dunbar and Condra, 1932	C	
Composita elongata Dunbar and Condra, 1932	C	
Hustedia sp.	RR	1
Punctospirifer kentuckensis (Shumard), 1852	C	1
MOLLUSCA - GASTROPODA		
Warthia kingi Moore, 1941	CC	
Straparolus (Amphiscapha) reedsi (Knight), 1934	A	16
Mourlonia sp.	C	
Glabrocingulum (Ananias) sp.	C	
Worthenia tabulata (Conrad), 1835	C	
Gosseletina sp.	C	7
Glyptotomaria (Glyptotomaria) apiarium Knight, 1945	RR	
Platyceras (Orthonychia) parvum (Swallow), 1858	A	
Anomphalus sp.	C	
Trachydomia nodosa (Meek and Worthen), 1860	AA	
Stegocoelia sp.	R	
Pseudozygopleura sp.	C	
Orthonema sp.	C	
Ianthinopsis typicus (Meek and Worthen), 1860	C	
Ianthinopsis paludinaeformis (Hall), 1858	C	2
MOLLUSCA - CEPHALOPODA		
Goniatites sp.	RR	
MOLLUSCA - PELECYPODA		
"Edmondia" sp.	R	
"Edmondia" cf. *"E." subtruncata* Meek, 1872	AA	
Wilkingia terminale (Hall), 1852	RR	14
Pleurophorella costata (Meek and Worthen), 1869	RR	
Nuculopsis girtyi Schenck, 1934	RR	2
Grammatodon erectumbona Bird, n. sp.	RR	
Grammatodon hexacostata Bird, n. sp.	RR	15
Grammatodon kansasensis (Sayre), 1930	RR	
Grammatodon carbonaria (Cox), 1857	C	
Conocardium parrashi Worthen, 1890	C	
Pteria longa (Geinitz), 1866	RR	
"Promytilus" postumbonus Bird, n. sp.	RR	
Goniophora gnoma Bird, n. sp.	RR	
Acanthopecten carboniferus (Stevens), 1858	R	
Annuliconcha interlineata (Meek and Worthen), 1860	C	
Clavicosta cf. *C. echinata* Newell, 1937	RR	
Streblopteria (Streblopteria) sp.	RR	
Streblopteria (Streblopteria) obliqua Bird, n. sp.	RR	

Fauna	Abundance	Group No.*
Streblopteria (Streblochondria) aff. *S. (S.) sculptilus* (Miller), 1891	RR	18
Streblopteria (Streblochondria) fila Bird, n. sp.	RR	
Streblopteria (Streblochondria) tenuilineata (Meek and Worthen), 1860	RR	
Streblopteria (Streblochondria) semicosta Bird, n. sp.	RR	
Streblopteria (Obliquipecten) sp.	RR	
Cypricardinia questa Bird, n. sp.	RR	
"Stutchburia" corrucostata Bird, n. sp.	C	
Astartella varica McChesney, 1859	CC	

ABBREVIATIONS

RR—very rare	R—rare
CC—very common	C—common
AA—very abundant	A—abundant

The abundance data refer only to general impressions of relative abundance. Actual quantification of data was not done.

PALEOECOLOGY

The paleoecological findings presented here are based on studies of brachiopods, gastropods, and pelecypods. General ecological statements concerning taxa within these groups are presented below. Outer neritic as used here refers to marine zones with relatively minor fluctuations in physical factors of environment; perhaps depths of 150 meters and more. Near shore means the zone where waters are somewhat agitated and subject to wide environmental fluctuations.

The information presented in this section is based on studies of Mid-Missourian faunas and faunal lists from a variety of lithologies. These studies and comparisons with the results of studies by Johnson (1962) and Mudge and Yochelson (1962) suggest that the Bed ten faunule indicates outer neritic conditions. The Bed ten assemblage compares well to what Johnson terms the *Chonetina* association.

In a quantitative study of 63 Middle and lower Upper Pennsylvanian species from the area of Fulton County, Illinois, Johnson (1962) delimited 19 groups which he combined into three types of associations. A brief description of these associations follows: *Chonetina* association – consisting largely of articulate brachiopods and apparently representing a neritic assemblage living on a relatively firm substrate; *Orbiculoidea* association – dark shale assemblage thought to represent near-shore zones and soft substrate conditions; Gastropod association — bonded to both of the other associations, conditions intermediate to those indicated in the preceding associations.

Unfortunately, fusulines were not a part of the faunas studied by Johnson. Fusulines are abundant in Bed ten, but because the megafossils were mainly collected after they had weathered out of the matrix, the association of the larger invertebrates and the fusulines is not established for Bed ten. Mudge and Yochelson (1962) recognized 13 groups, including four with fusulines, from their study of Upper Pennsylvanian and Lower Permian rocks of Kansas. Group 4 (which included fusulines), groups 5 and 6, and group 7 of Mudge and Yochelson (1962, p. 109) appear to coincide respectively with Johnson's *Chonetina* association, *Orbiculoidea* association, and gastropod association.

Ignoring the fusulines, the fauna of Bed ten appears to be a *Chonetina* association though no species of *Chonetina* are present in Bed ten. Johnson's Groups I and V comprise the *Chonetina* association; Group I contains 13 species and Group V contains four species. Ten species from Bed ten may be assigned to Johnson's Group I and one may be assigned to his Group V. Of the ten Groups bonded to the *Chonetina* association in the original study, four Groups, represented by five species, are present in Bed ten. Of the nine groups present in Bed ten[1], five are bonded to the *Chonetina* association and two more belong to the association proper. The other two Groups present in Bed ten are Groups 2 and 15. Group 2, represented by two species in Bed ten, belongs to the gastropod association proper and Group 15, represented by one species in Bed ten, bonds the gastropod and *Orbiculoidea* associations. (The three Bed ten species referred to these last two Groups may not be the same species as those included in these Groups in the original study, however.) The gastropod association has species in common with the *Chonetina* association and the two associations are not mutually exclusive. The *Orbiculoidea* association, which Johnson stated to be distinct in time or space from the *Chonetina* association, is not represented by a single

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[1] See Faunal List from Bed Ten for distribution of species within the various Groups.

species in Bed ten of the Gaptank formation though, as noted above, one species bonds at once to the *Orbiculoidea* and to the gastropod associations. Hence from these qualitative comparisons with Johnson's study, the Bed ten fauna, in so far as comparisons are possible, appears to be a *Chonetina* association.

Below, three systematic groups from Bed ten of the Gaptank Formation are analyzed individually.

Brachiopoda. — This group is well represented in Bed ten of the Gaptank Formation. Species of *Composita* are by far the most abundant elements of the Bed ten macrofauna. Productid and spiriferid types are also common. The productid assemblage is represented by species of the genera *Reticulata, Kozlowskia,* and *Hystriculina;* the spiriferids by species of *Neospirifer* and *Condrathyris. Reticulata, Kozlowskia, Hystriculina,* and *Neospirifer* seem to be found in both near-shore and outer neritic assemblages while *Condrathyris* seems to have preferred only normal marine conditions. *Crurithyris,* the common relatively near-shore Pennsylvanian spiriferid, as well as the better known near-shore dwellers, *Lingula* and *Orbiculoidea,* are absent. *Derbya* and the less widely distributed genera *Enteletes* and *Rhynchopora* are common in Bed ten.

Brachiopoda in Bed ten have several species in common with the faunas studied by Johnson (1962). Of those species or closely related species from Bed ten that can be compared to those of Johnson's study, 10 out of a possible 11 total comparisons (belonging to 7 genera) belong to Johnson's Group I, a limestone assemblage. Ten species of 10 genera comprise the articulate brachiopod group of his Group I. His assemblage in Group I includes 10 of the 21 species of articulate brachiopods studied by him. This, together with the finding of the nearly complete match out of the possible comparisons of the Bed ten articulate brachiopods, indicates that articulate brachiopods form tightly knit communities in Pennsylvanian limestone faunules, and that the occurrence of members of Group I can be predicted if a few other members of the Group are known.

Gastropoda. — The pleurotomariids are abundant in Bed ten. The main components of this superfamily in Bed ten are species of *Worthenia, Glabrocingulum, Mourlonia,* and *Gosseletina.* Species of *Worthenia* seem to tolerate a variety of environments and are found in both near-shore and outer neritic assemblages. Pleurotomariaceans that seem to thrive in near-shore conditions are *Phanerotrema* and *Trepospira,* neither of which are found in Bed ten. Species of *Mourlonia* and *Gosseletina,* on the other hand, appear to prefer outer neritic conditions.

The bellerophontids, represented by a single genus, *Warthia,* in Bed ten, seem generally to indicate near-shore conditions. This statement is supported by their distribution and chemical environment (high manganese and high iron content of sediments) in which they have been found (Parker, 1957, p. 116). *Warthia,* a common genus in Bed ten, seems to tolerate wider ranges of ecological conditions than most genera of this group. It is found with the apparent near-shore indicators, *Knightites (Retispira), Euphemites, Pharkidonotus,* and *Bellerophon* as well as with outer neritic faunas. Moore (1941, p. 124) reported *Bellerophon, Euphemites,* and *Warthia* from the oolitic part of the Ozawkie cyclothem (central Kansas) which appears to be a near-shore deposit.

Species of *Platyceras* are believed to be coprophagous on crinoids (Bowsher, 1956, p. 261). This genus is abundant in Bed ten as are remains of crinoids. *Trachydomia,* also abundant in Bed ten, seems to live in profusion only in outer neritic waters. *Straparolus,* on the other hand, is apparently found in both near-shore and deeper marine assemblages (Mudge and Yochelson, 1962, p. 105).

Pelecypoda. — Burrowing pelecypods are nearly absent in Bed ten of the Gaptank Formation. One specimen each of *Wilkingia, Nuculopsis,* and *Pleurophorella* were collected from Bed ten. The fauna of Bed ten comes from thin limestone units — most burrowing pelecypods occur in shales, sandy shales, or sandstones. Hence the substrate of Bed ten may not have been suitable for the burrowing forms.

Species that may have burrowed to shallow depths or else were vagrant epifauna belong to the genera *Cypricardinia, Stutchburia, Edmondia,* and *Astartella.* A pallial sinus is not present in these genera, hence none burrowed deeply, if at all. The last two genera rank, respectively, first and second in number of specimens per pelecypod genus. Both of these genera and *Cypricardinia* appear to occupy widely diverse ecological zones. Species of *Stutchburia* have been so infrequently recognized that an assessment of their niche is not now possible.

Those forms that spend at least part of their existence attached by byssal threads represent the bulk of the Bed ten pelecypods. The Bed ten genera of this group are: the pectinoids *Annuliconcha, Acanthopecten, Clavicosta,* and *Streblopteria* (three subgenera present); *Grammatodon* (=*Parallelodon*); and *"Promytilus."*

The Pectinacea is represented by more genera and species than any other pelecypod group in Bed ten, but no species of the group is common. The pectinaceans have a varied mode of existence: living attached by a byssus (commonly to seaweed), lying on the sea floor, and swimming freely about. Roger (1939) noted that the number of littoral species of pectinids is small, and that this group is more common in the 30 to 72 meter zone in modern seas. He further noted that they are also more common from this zone to the edge of the continental shelf than elsewhere and that pectinid pelecypods found from 500 meters down are of small size and are not common. The diverse assemblage of pectinoids in Bed ten, represented by more genera and species at one stratigraphic interval than, to the writer's knowledge, occur elsewhere, would then suggest an environment of fairly deep water. As is usually the case, probably owing to the lack of dentition in the pectinaceans, no specimen was found in the bivalve state. The valves are probably separated by scavengers or the waves of storms which penetrate to deep water.

Four species of *Grammatodon* were identified from Bed ten. The most common species is *G. carbonaria* (Cox), most specimens of which are single valved and some of which are in a more clastic matrix than the typical Bed ten specimen. The specimens of *G. carbonaria* may have been transported from higher energy zones. In general, species of *Grammatodon* occur in shales, shaly limestones, and limestones covering a wide range of ecological conditions.

Only one specimen of the superfamily Mytilacea, usually a common element in marine Late Paleozoic faunules, was found in Bed ten. Present day mytilaceans thrive in the littoral and shallow neritic zones, and though present in deeper water, are much less common there. The Myalinidae probably also preferred a habitat near shore, but seem to have done better if the waters were also quiet (Newell, 1942, pp. 16-19). The extreme paucity of this common group of pelecypods in Bed ten may indicate that the water was too deep for them.

DISCUSSION

Bed ten of the Gaptank Formation has a diverse assemblage of pelecypods. The Bed ten fauna also contains a large group of articulate brachiopods. Normally, Pennsylvanian faunas rich in articulate brachiopods are sparse, both in number of species and in total number of pelecypods (Mudge and Yochelson, 1962, p. 104). This mutual lack of association of articulate brachiopods and pelecypods in the Pennsylvanian has also been noted by Johnson (1962, Table 5, p. 42) and others. Yet it appears that the Bed ten fauna represents a biocoenose which lived below wave base for specimens show little abrasion, fragmentation, or sorting by size. Further, the pelecypods, with the exception of the pectinoids, are almost all in the bivalve condition.

The diversity of the pelecypod assemblage, particularly the diversity of the pectinoids, coupled with the absence of mytilaceans, the association of pelecypods with the large group of articulate brachiopods, the lack of evidence of wave energy (including the lithology) in Bed ten of the Gaptank Formation all indicate an outer shelf environment.

Beyond the evidence discussed above, an environment of normal marine, deep or moderately deep water is attested to by the great abundance of the fusuline *Triticites irregularis* Schellwien and Staff. Dunbar (1957, pp. 753-4) noted that the fusulines indicate well aerated, normal marine waters, and that they seem generally to have preferred zones free from wave agitation. Further evidence of well aerated water is the profusion of crinoidal remains in Bed ten. (Because Dunbar, *op. cit.,* stated that fusulines rarely occur with crinoids and mollusks, it might be that the fusulines represent a different cycle of deposition than the rest of the fauna discussed above).

BRIEF GLOSSARY AND ABBREVIATIONS OF SHELL MORPHOLOGY

Auricles, ears, wings — extensions along the dorsal margin of some valves, particularly well developed in pteriids, limiids, and pectinoids.

Byssal notch — excavation in the shell for passage of byssal threads which serve to attach the organism to the substrate. In pectinoids the notch is best developed on the anterior auricle of the lowermost (right) valve. In arcoids the notch is on the ventral margin of the valves and is equally developed on the two valves. In mytiloids the notch is usually in the anteroventral margin of both valves. (See sinus and sulcus below.)

Costae, costellae, ribs — radial ornament of variable weight.

Fila, lamellae, ridges — concentric ornament of variable weight, coarser and more regular than growth lines.

Gape — lack of complete contact along line of commissure.

Interspaces — areas between concentric or radial ornament.

Obliquity — A. Beaks—untwisted, *i.e.,* meeting the dorsal margin at right angles are orthogyre; anteriorly directed beaks are prosogyre; posteriorly directed beaks are opisthogyre.

B. Shell-umbonal ridge vertical between dorsal and ventral margin is termed acline; umbonal ridge concave posteriorly is prosocline; and umbonal ridge concave anteriorly is opisthocline.

Shell body — shell exclusive of auricles.

Sinus — a shallow groove in the left anterior auricle of pectinoids and in the antero-ventral portion of the shell of mytiloids and some arcoids.

Sulcus — depression between anterior auricle and shell body in pectinoids; depression extending dorsally from ventral margin in arcoids and mytiloids. In both cases the sulcus is formed by the migration of the byssal notch with shell growth and commonly can be seen in the growth lines or coarser concentric ornament.

Umbones — beaks and adjacent elevated portion of valve dorsal and lateral exterior, extending variable distances ventrally.

Umbonal folds — shoulders between shell body and auricles.

Umbonal midline — trace of the center of the umbones.

ABBREVIATIONS

BV — bivalved specimen.

LV — left valve.

RV — right valve.

C — convexity, the maximum depth of valve (s) measured perpendicularly to plane of commissure.

DAMB — distance from anterior margin of hinge line to tip of beak.

DPMB — distance from posterior margin of hinge line to tip of beak. Along with DAMB measures the inclination and position of beaks.

DUR — maximum distance between umbonal ridges, usually at posterior margin of valves.

Ht — height of valve, maximum dorsal-ventral dimension.

Lt — length of valve, the maximum anterior-posterior dimension measured parallel to hinge line.

LH — length of hinge line.

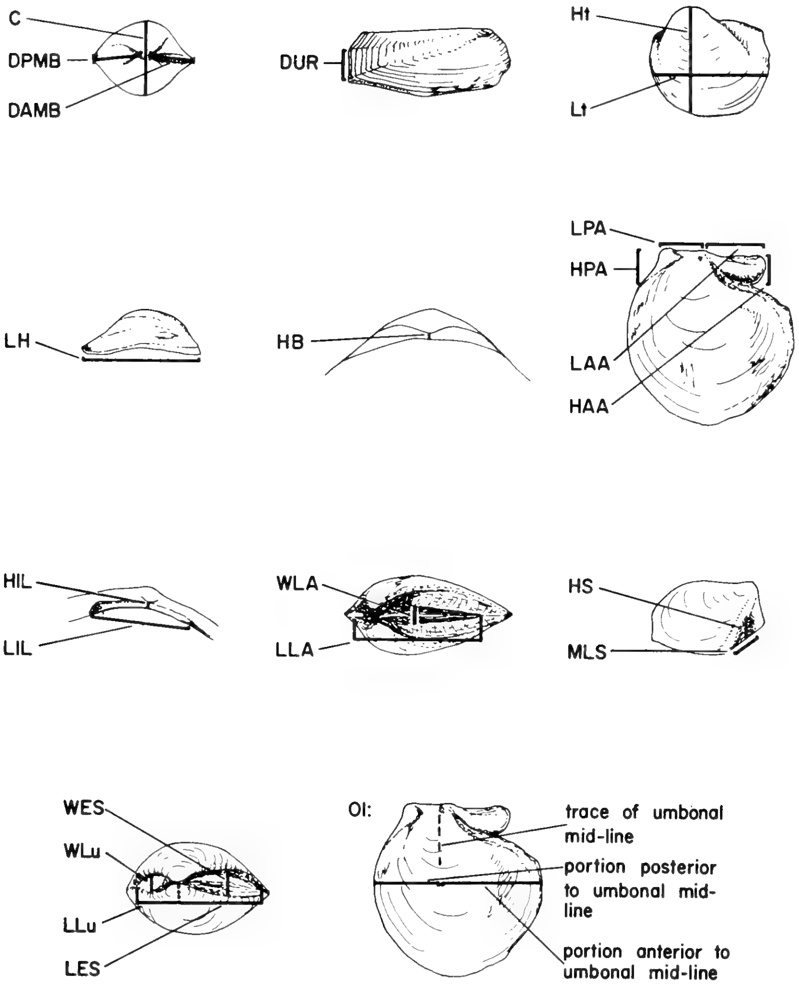
HB — height of beak, measured vertically from tip of beak to hinge line.

HAA — height of anterior auricle, maximum vertical dimension.

LAA — length of anterior auricle, maximum horizontal dimension.

HPA — height of posterior auricle.

LPA — length of posterior auricle.



Text-figure 1. Sketches to illustrate measurements symbols.

HIL — height of internal ligamental area or chondrophore, maximum vertical dimension.
LIL — length of internal ligamental area or chondrophore, maximum horizontal dimension.
LLA — length of external ligamental area, measured parallel to hinge line, at line of maximum dimension.
WLA — width of external ligamental area, measured along slope of ligamental area at line of maximum dimension.
HS — maximum height of sulcus formed in response to migration of byssal notch.
MLS — maximum length of sulcus.
LES — length of escutcheon, measured parallel to hinge line.
WES — maximum width of escutcheon, measured perpendicular to hinge line.
LLu — maximum length of lunule, measured parallel to hinge line.
WLu — maximum width of lunule, measured perpendicular to hinge line.
OI — obliquity index, distance measured parallel to hinge line from trace of umbonal midline of early ontogenetic stages to anteroventral and posteroventral margins. The index is the ratio of the anterior distance to posterior distance. Hence a value of one indicates an acline shell, a value of more than one indicates a prosocline shell, and a value of less than one indicates an opisthocline shell.
PC — peripheral commissure, measured by tracing the length of the line of commissure; a rough index of valve size and, with combinations, of valve shape.
(1) — measurements taken on one valve of a bivalved specimen.

SYSTEMATIC PALEONTOLOGY
Class PELECYPODA

Family **EDMONDIIDAE** King

Discussion. — Convergence in external morphology between, at least four edentulous Upper Paleozoic genera, is so strong that confusion in identification is possible; yet each of the genera is in a separate family. These genera are *Sanguinolites* McCoy, 1844; *Edmondia* de Koninck, 1844; *Pleurophorella* Girty, 1904; and *Wilkingia* Wilson, 1959. In ornamentation and shape these taxa overlap; ligamental areas are poorly known. Internal characters, of course, serve to resolve the difficulties, but these features can seldom be observed and hence are not well documented. Brief notes on distinguishing characteristics of these genera follow.

Wilson (1959, 1960) has been active in a search for understanding of some of the edentulous genera. He confirmed the presence of internal cartilage plates in the type species of *Edmondia, Isocardia unioniformis* Phillips, 1836. He also determined that *Hiatella sulcata* Fleming, 1828 = *Sanguinolaria*? *sulcata* Phillips, 1836 has these plates, and he judged Fleming's species to be an *Edmondia*. At least one other species assigned to *Edmondia* has these unique structures, *Edmondia primaeva* (Portlock), 1843, *fide* Hind (1899, pl. 30, fig. 2). These structures are now used to characterize *Edmondia s. s.* Subgenera have not been proposed for species of *Edmondia* which do not possess the cartilage plates but presumably will be.

At least some species of *Wilkingia* gape posteriorly and Wilson has verified the presence of a pallial sinus in the type species, *Venus elliptica* Phillips, 1836.

Internal characteristics of both *Sanguinolites* and *Pleurophorella* are virtually unknown. Hind (1900) included at least two species in his illustrations of the type species of *Sanguinolites, Sanguinolaria? angustata* Phillips, 1836; the holotype (pl. 40, fig. 1) is not illustrated to show the dorsal margin. The species represented by Hind's plate 40, figures 3, 3a, 5 are not conspecific with the holotype as supposed by Hind. These latter specimens are similar to *"Allorisma" costata* = *Pleurophorella costata* (Meek and Worthen), 1869. Hind's figure 3a shows this specimen to have the long narrow ligamental groove of *"Allorisma" costata*. What the ligamental area of the type species of *Sanguinolites* looks like is not known. If it does not have a ligamental area of the *"Allorisma" costata* type, *Sanguinolaria? angustata* Phillips, 1836 may prove to have internal cartilage plates as did what Phillips (1836) called *Sanguinolaria? sulcata* and thence be likewise assigned to *Edmondia*.

Girty's description of *Pleurophorella* did not serve to distinguish this genus from others. The internal characters of the type species, *P. papillosa* Girty, 1904 are completely unknown. Girty placed *Allorisma costata* Meek and Worthen, 1869 into his new genus. One specimen of Meek and Worthen's species, which is described later under *Pleurophorella,* shows this species to possess a chondrophore. Tentatively then, Girty's genus *Pleurophorella* is inferred to possess an internal ligamental area and the generic name is retained. It may turn out that the type species of *Sanguinolites* has external and internal ligamental areas like that of *Pleurophorella costata,* in which case this species would be assigned to *Sanguinolites.*

Genus **"EDMONDIA"** de Koninck, 1844

Diagnosis.—Shell equivalve, inequilateral, not gaping, subovate to subrectangular; beaks anterior, prosogyre; hinge edentulous; ligament internal?, external?, marginal?; adductors subequal; pallial line simple; valves smooth or with concentric ridges.

Type species. — *Edmondia unioniformis* (Phillips) = *Isocardia unioniformis* Phillips, 1836. Subsequent designation King (1850, p. 162); Stoliczka, 1871, p. xvii.

Range. — Devonian-Permian.

Discussion. — Much confusion exists concerning the characters of this common genus. De Koninck (1844, p. 66) included in his description the statement "lunule echancree". This statement has been interpreted by various authors to mean that the genus has a lunule and by others that its valves are gaping. That neither interpretation is correct may be determined from the characters of the type species. The first of the two *Edmondia* species described by De Koninck was identified by him as *Edmondia unioniformis* (Phillips), 1936. Although the species figured by De Koninck is likely congeneric with that of Phillips, the species appears to be distinct from Phillip's species as noted by Hind (1899, p. 288). The type species was designated by King (1850, p. 162). Girty (1915, p. 105) erroneously supposed that the type species need be that species which De Koninck figured.

Wilson (1960) studied three syntypes of the type species and designated a lectotype. These specimens show that the type species has neither lunule nor gape. However, according to Wilson all three of the type specimens possess cartilage plates or ossicles. These plates, first noted by King (1850) can be best understood from illustrations by Hind (1899, pl. 30, fig. 2) and by Wilson (1960, pl. 2, figs. 1-4). The function of these unique plates is not known; their presence may indicate that *Edmondia* had an internal ligament or had both internal and external ligaments or perhaps they served merely to strengthen the valves (possibly against a dorsally orienting predator).

From a systematic rather than a functional viewpoint the cartilage plates have introduced deeper problems. Many species, including perhaps all American species[2], previously assigned to

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[2] Elias (1957) reported cartilage plates in a specimen of *Edmondia* from the Red Oak Hollow Formation of Oklahoma; he did not illustrate this specimen however.

Edmondia have not been observed to have cartilage plates. Girty (1915, p. 105) noted that American shells assigned to *Edmondia* do not have these plates. No specimen from the Gaptank Formation was seen to have such structures. Therefore, open nomenclature is used here to refer to what would earlier have been considered to be typical species of *Edmondia.*

The hinge structure which Hind (1899) called a transverse lamella, but which was not mentioned by Wilson (1960), is a narrrow toothlike rumple on the posterior part of the hinge plate. A somewhat similar, elongate ridge is observed on the hinge areas of specimens of *"Edmondia" subtruncata* from the Gaptank Formation. This ridge is above the line of commissure in these specimens, however.

Species of *Edmondia* are difficult to characterize. They are generally ornamented only by irregular fila, leaving gross form as the basis for distinction. Until more species of the genus are studied quantitatively and an idea of the variation in form obtained, it will continue to be difficult to make correct identifications and comparisons.

Edmondia is closely related to *Cardiomorpha* de Koninck, 1844; the characteristics of *Cardiomorpha* have been only poorly defined and much latitude has been permitted in the interpretation of the generic characters. Several genera were included in the 17 species originally assigned to *Cardiomorpha* by De Koninck.

The type species of *Cardiomorpha, C. elongata* de Koninck, 1844 designed by King (1850, p. 179), is easily distinguished from species of *Edmondia* by its being higher than long and by its incurved beaks. In subsequent works, thick-shelled edentulates with strongly incurved beaks, some with distinctly longer than high valves, have been referred to *Cardiomorpha.*

Now the only consistent difference between *Cardiomorpha* and *"Edmondia"* is that species of *Cardiomorpha* have strongly incurved beaks. Whether this characteristic alone should be given generic significance and whether other differences such as shell structure and musculature exist between species of the two genera must be answered by further study.

"Edmondia" sp. Pl. 11, fig. 1

Diagnosis. — Shell large, thick subovate; anterior margin broadly rounded; posterior margin truncate; ventral margin subparallel to dorsal margin; umbones prominent, broad; umbonal ridge indistinct; beaks prosogyre, anterior; ligamental area opisthodetic, wide; convexity high, maximum convexity midway between top of umbo and ventral margin; external ornament of indistinct lamellae and faint, irregular, closely spaced radial lines.

Range. — Bed ten of Gaptank Formation.

Measurements. — (Mm).

	Ht	Lt	C
R.V.	45.5	63.8	18.8
R.V.	42.5	54.3	14.0

Material. — U.S. National Museum, No. 155826.

Discussion. — Three specimens of this thick-shelled form were collected from Bed ten of the Gaptank Formation. One well-preserved specimen displays minute, irregularly spaced and developed radial striations. The other two specimens are more deeply eroded and no trace of the radial ornament is present on them. The radial striations may be produced by slight weathering of the outer ostracum with the resultant fine striations reflecting the radial tangential prismatic structure of that shell layer. If, on the contrary, the striations are true ornament, the ribbing is restricted to the outer surface of the valves.

"Edmondia" cf. **"E." subtruncata** Meek, 1872 Pl. 11, figs. 2-6

Edmondia subtruncata Meek, 1872, U.S. Geol. Sur., Nebraska, Final Rept., p. 215, pl. 2, fig. 7.

E. ovata Meek and Worthen, 1873. Geol. Sur. Illinois, vol. 5, pl. 26, fig. 13; Meek, 1874; Amer. Jour. Arts and Sci., 3d ser., vol. 7, p. 580; Girty, 1915, U.S. Geol. Sur. Bull. 544, p. 106, pl. 14, fig. 13

Diagnosis. — Shell subovate to subrectangular; hinge line nearly straight to gently convex; anterior margin subtruncate to sharply rounded; posterior margin gently rounded to straight, meeting dorsal margin at obtuse or nearly right angle; umbonal ridge distinct, round; convexity rapidly decreasing posterior to ridge; maximum convexity on umbones near dorsal margin; beaks prosogyre; umbones prominent, wide and inflated; valves smooth except for growth lines and irregularly spaced fila.

Range. — Pennsylvanian.

Measurements. — (See Appendix).

Material. — Hypotypes, U.S. National Museum, Nos. 155827, 155828.

Discussion. — Meek and Worthen's *Edmondia ovata* was not accompanied by a description. Meek (1874, p. 580) later stated that he doubted if *E. ovata* was distinct from *E. subtruncata.* Judging by the figures of the two proposed species and the amount of variation noted in Gaptank representatives tentatively referred to *"E." subtruncata,* it appears that the name *E. ovata* is unnecessary.

Wide variation in form exists in the specimens collected from the Gaptank Formation. Some are elongate posteriorly, others are truncated posteriorly and anteriorly and others are as high as long. Elongate specimens compare well to Meek's original figure except in ornament. In the few Gaptank specimens in which the ornament is preserved, the fila are more irregularly spaced and of more unequal weight than in Meek's figured specimen.

Length of hinge, portion of hinge posterior to beak, and peripheral commissure are other variable characters. Height of beak and portion of hinge anterior to beak show relatively little variation.

The marked variability of the hinge posterior to beak compared to the relative lack of it anterior to the beak suggests that most growth anteriorly is attained early in the life of the organism and that growth posteriorly continues for a longer period of time. This allometry is not related to development of siphons in *Edmondia* for the pallial line is simple. Hence if species of *Edmondia* burrowed, they did so only to shallow depths.

Specimens here assigned to *"Edmondia" subtruncata* are the most common members of the pelecypod fauna in Bed ten of the Gaptank formation. The vast majority of the specimens collected were in the bivalve condition, though in many, one valve is rotated with respect to the other. Incongruously, the ornament of only a few specimens is well preserved. Apparently the ornament, consisting of fine fila, was present only in the upper layer of the shell material and has been removed during diagenesis of the sediment. The notion that the fila are resorbed during later ontogenetic stages is untenable because young forms show the same poorly preserved ornamentation as older specimens.

Family **PHOLADOMYIDAE** Gray

Genus **WILKINGIA** Wilson, 1959

(*Allorisma* King, 1844 and 1850)

Type species. — *Venus elliptica* Phillips, 1836. Original designation.

Range. — Mississippian-Permian.

Discussion. — This well-known genus has been recently investigated by Wilson (1959), who gave it the new name *Wilkingia*. King (1844) originally chose *Sanguinolaria? sulcata* Phillips, 1836 = *Edmondia sulcata* (Phillips), 1836; Wilson, 1960 as the type species of *Allorisma* King, 1844. In 1850 King revised the genus *Allorisma* and, using the name *Allorisma*, selected a new type species, *Hiatella sulcata* Fleming, 1828, thereby apparently creating a homonym. However, according to Wilson (1959, 1960), *H. sulcata* Fleming, 1828 = *Edmondia sulcata* (Fleming), 1828 = *Edmondia sulcata* (Phillips), 1836. Hence *Allorisma* King, 1844 is synonymous not homonymous with *Allorisma* King, 1850. In spite of King's selection of an *Edmondia* for the type species of *Allorisma*, his later description of *Allorisma* is essentially that of *Wilkingia*. The reason for the similarity of descriptions is that King, (1850) based his description on *Venus elliptica* Phillips, 1836, the type species of *Wilkingia*, which he figured and erroneously identified as *Hiatella sulcata* Fleming.

Wilkingia terminale (Hall), 1852 Pl. 12, fig. 16

Allorisma terminale Hall, 1852, Stansbury's Expedition to Great Salt Lake, p 413, pl. 2, fig. 4.

A. subcuneata Meek and Hayden, 1858a, Acad. Nat. Sci. Philadelphia, Proc., p. 263.

A. terminale (Hall), Girty, 1903, U.S. Geol. Sur., Prof. Paper 16, p. 437, pl. 9, figs. 4-6.

Diagnosis. — Shell elongate, maximum length near ventral margin; anterior margin rounded to nearly straight; posterior margin gently rounded; ventral margin gently convex, maximum depth about two-thirds way from anterior to posterior margin; umbones prominent, erect, wide; beaks orthogyre, located far anteriorly; umbonal ridge broad, rounded, gently concave dorsally; convexity high in relation to height of valves, maximum convexity just posterior and ventral to umbones; lunule and escutcheon large, distinct; surface marked with widely spaced, prominent concentric ridges, more closely spaced ventrally, without fine lines in interspaces.

Range. — Pennsylvanian.

Measurements. — (Mm).

	Ht.	Lt.	LLu	WLu	C	DAMB
*B.V.	38.1	82.3	15.6	9.0	37.2	2.7
**B.V.	36.1	74.6	21.7	9.3	28.4	10.8
**B.V.	54.0	107.3	24.2	13.6	40.7	14.6
**B.V.	56.8	123.8	41.1	14.6	38.0	12.8
**B.V.	43.0	84.8	26.5	8.7	30.9	19.6
**B.V.	55.2	128.0			40.0	15.4
**B.V.	29.0	50.4			20.6	5.5

* Holotype. **Labeled "cotypes" of *Allorisma subcuneata.*

Material. — Holotype, U.S. National Museum No. 15072, type collection. "Cotypes" of *Allorisma subcuneata.* U.S. National Museum, No. 6608, type collection. Hypotype, U.S. National Museum, No. 155829.

Discussion. — The external mold which is the holotype of this species can be distinguished from specimens at the U.S. National Museum labeled as "cotypes" of *Wilkingia subcuneata* by its more anteriorly located beaks, its deeper, wider lunule, and by its umbonal ridge which is more concave upward. However, Girty's (1903, p. 438) interpretation that the holotype is a distorted specimen appears to be correct. Hence specimens that Meek and Hayden called *Allorisma subcuneata* are now considered more typical representatives of *A. terminale.*

Hind (1900, p. 421) wrote that *Wilkingia maxima* (Portlock), 1843 cannot be separated from *W. subcuneata.* Hind had the holotype of Portlock's species but did not note the number or nature of the specimens of the American shells that he compared to *W. maxima.* The holotype of Portlock's species is incomplete, the whole posterior portion of the shell is missing. Until more complete comparisons are made, it seems best to treat Portlock's species as distinct from Hall's.

One specimen of *W. terminale,* an external mold, was collected from Bed ten of the Gaptank Formation.

Family **ANATINIDAE** Dall

Genus **Pleurophorella** Girty, 1904

Allorisma of authors; *Sanguinolites pars* of Hind, 1900; *Permophorus pars* of Newell, 1957.

Diagnosis[3]. — Shell equivalve, strongly inequilateral, gaping (?), elongate; beaks well anterior, small, prosogyre; umbones broad, flat; umbonal ridge sharp, distinct; ligament opisthodetic, set in distinct grooves; resilium set on triangular chondrophore (s) extending on both sides of the beak; lunule indistinct, escutcheon prominent; adductors and pallial line unknown; ornament consisting of well-developed concentric lamellae or ridges and tiny papillae.

Type species. — *Pleurophorella papillosa* Girty, 1904. Original designation.

Range. — Pennsylvanian.

Discussion. — The original description of this genus does not include characteristics which separate the genus from *Wilkingia.* The internal features of the type species are unknown. Newell (1957, p. 9) suggested that the type species may be a *Permophorus* Chavan, 1954. Newell's evidence for this view is a similarity in external form between *Pleurophorella papillosa* and some smooth forms of *Permophorus.* If Newell is correct in his interpretation, a new genus will need to be erected for what is here called *Pleurophorella costata.* It is also remotely possible that with further study the species will be placed in *Sanguinolites* as was suggested under the discussion of the Edmondiidae.

The description of the genus above is an emended one based on an excellently preserved specimen of *Allorisma costata* Meek and Worthen, 1869. This specimen (Plate 11, fig. 7) from the Graham Formation of North Central Texas, displays a chondrophore. Girty's intuitive separation of this species from *Allorisma* is therefore sound. The chondrophore has been observed only in

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[3] Emended diagnosis based on specimen of *"Allorisma" costata* Meek and Worthen, 1869.

the left valve; preservation has not permitted judgment as to whether the right valve also has this structure. Other internal characters of the genus remain unknown. It is not yet known if the valves gape posteriorly.

The presence of a chrondrophore in *Pleurophorella costata* is of great interest for, with the exception of the nuculoids, it is the earliest probable burrower possessing this type structure. Hence *Pleurophorella* may prove to be the progenitor of the long line of edentulous, chondrophore bearing burrowers of the Mesozoic and Cenozoic Eras. Further work on the nature of shell structure, musculature, and pallial line is needed to show this proposed relationship to be correct.

Pleurophorella may be separated from the closely related genera *Wilkingia* Wilson, 1959 and *Sanguinolites* McCoy, 1844 by its possession of the chondrophore. It also distinguishes *Pleurophorella* from the earlier genera *Orthonota* Conrad, 1841 and *Sphenotus* Hall, 1885, both of which closely resemble *Pleurophorella* externally.

Pleurophorella costata (Meek and Worthen), 1869 Pl. 11, figs. 7-14

Allorisma costata Meek and Worthen, 1869, Acad. Nat. Sci. Philadelphia, Proc., p. 171; Meek and Worthen, 1873, Geol. Sur. Illinois, vol. 5. p. 585, pl. 26, fig. 15.

Sanguinolites angustatus pars (Phillips), Hind, 1900, British Carboniferous Lamellibranchs, vol. 1, p. 366.

Pleurophorella costata (Meek and Worthen), Girty, 1904. U.S. Nat. Mus., Proc., vol. 27, p. 723.

Diagnosis. — Shell elongate, thin; anterior margin short, gently rounded, gradually rounded to dorsal margin; posterior margin truncate, nearly straight, proceeding linearly forward to join dorsal margin at obtuse angle, joined to ventral margin in slightly obtuse angle; ventral margin gently arched, with a slight sulcus under umbones; umbones wide, prominent, slightly compressed, low; umbonal keel sharp, nearly straight to gently concave upward; dorsally a fainter, lower ridge occurs, becoming obsolete anteriorly; hinge edentulous; directly beneath beaks is a small triangular process (chondrophore) separated from main, external ligamental area by a thin ridge running obliquely posteriorly; ligament mainly external, opisthodetic, set in long narrow, unornamented groove; lunule indistinct, escutcheon prominent; beaks small, nearly orthogyre; ornament of concentric ridges with irregularly spaced, and irregularly raised, discontinuous lamellae; ornament dorsal to umbonal ridge slightly subdued.

Range. — Pennsylvanian.

Measurements. — (Mm).

	Ht	Lt	HB	C(2)	DUR	LH	LLA	WLA	LES	WES	LIL	HIL
R.V.[4]	14.0	30.0										
B.V.	16.1	38.8	1.5	12.7	4.7	36.8	19.8	0.8	4.1	1.0	8.1	0.9
R.V.	11.0	26.8			3.3							
L.V.	10.2	16.2										
B.V.	9.5	22.0		10.0								
L.V.	9.2	23.1										
L.V.	11.6	28.1										

Material. — Hypotypes, U.S. National Museum, Nos. 155830, 155831. Illinois Geological Survey — collections of H. C. Wanless and J. M. Weller. Meek and Worthen specimens: Probable holotype and three paratypes; Illinois State Museum.

Discussion. — Meek and Worthen's specimens at the Illinois State Museum do not possess labels clearly indicating a holotype (Richard Leary, written communication). The specimens are fragile and as a result could not be sent to me for examination. The best preserved specimen is a mature right valve which is figured in Plate 11, figure 13. According to Leary this specimen is probably the holotype of *Pleurophorella costata* (Meek and Worthen), 1869 = *Allorisma costata* Meek and Worthen, 1869. Measurements of this specimen are close to those cited by Meek and Worthen and the specimen illustrated by them later (1873) was a right valve.

Pleurophorella costata is more elongate in relation to height than *P. papillosa* Girty. *P. costata* also has much more prominent concentric ridges than *P. papillosa.* Both species have one prominent umbonal keel and a fainter umbonal keel dorsal to this. Two specimens of what Hind (1900, pl. 30, figs. 3, 3a, 5) considered to be *Sanguinolites angustata* (Phillips), 1836, are close to *Pleurophorella costata* in form and ornamentation. The interior of these specimens is unknown. Judging from the figures, Hind's identification of these two specimens is incorrect. The generic assignment may also be inaccurate. The single dorsal view (pl. 30, fig. 3a) shows an external ligamental area like that of *Pleurophor-*

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[4] Probable holotype.

ella costata; no indication of a chondrophore is observable in this view.

Pleurophorella costata has been reported from several areas of the Mid-Continent Pennsylvanian but seems never to have been abundant. Its range is here extended to the Graham Formation of North Central Texas and to the Gaptank Formation of West Texas where one specimen was found.

Family **NUCULINIDAE** d'Orbigny

Genus **NUCULOPSIS** Girty, 1911

Type species.—*Nucula ventricosa* Hall, 1858 *non* Hinds, 1843 = *Nuculopsis girtyi* Schenck, 1934. Original designation.

Range.—Mississippian-Pennsylvanian.

Discussion.—*Nuculopsis* is the name given by Girty to nuculoids with supposedly anteriorly located beaks. Species of *Nucula s.s.* Lamarck, 1799 have the beaks at the posterior end of the shell. Girty (1911, p. 133) regarded the long portion of the hinge as posterior in *Nuculopsis* and hence as having the more typical pelecypod relationship between beak position and anterior end of shell. Girty's basis for this conclusion was his observation that what he took for a ligamental groove is on the long portion of the hinge on the type species. A pallial sinus is absent in *Nuculopsis* as it is also in *Nucula*. Schenck (1934), however, believed that specimens of the type species had an internal ligament and a chondrophore and believed, therefore, that the short side of the shell is posterior in *Nuculopsis* as in *Nucula*. Schenck's evidence is not convincing. Elias (1957, p. 747) confirmed Schenck's interpretation that an external ligament was not present in the type species of *Nuculopsis*. That the short side of *Nuculopsis* is posterior has also been suggested by Driscoll (1964) on the basis of his study of pedal musculature. Elias further noted that a chondrophore is present in *Nuculopsis girtyi*. The chondrophore, according to Elias, does not interrupt the dental series in *Nuculopsis girtyi,* whereas in *Nucula* spp. the dental series is interrupted by this structure. Hence the nature of the dental structure and chondrophore offer a basis of generic distinction in the group. Species of *Nuculopsis* are further characterized by having smooth inner ventral margins. Species of *Nucula s. l.* also may lack ventral denticles.

The interpretation of Schenck and Elias that the posterior is the short end of the shell is used here.

Nuculopsis girtyi Schenck, 1934 Pl. 13, fig. 4

Nucula ventricosa Hall, 1858, Iowa State Geol. Sur., vol. 1, pt. 2, p. 716, pl. 29, figs. 4, 5 [*non N. ventricosa* Hinds, 1843].
Nuculopsis ventricosa (Hall), Girty, 1915, U.S. Geol. Sur., Bull. 544, p. 117, pl. 15, figs. 1-8.
Nuculopsis girtyi Schenck, 1934, Mus. Roy. d'Hist. Nat. Belgique, Bull., vol. 10, No. 20, p. 29, pl. 2, fig. 19; pl. 4, fig. 2.
Nucula (Nuculopsis) girtyi (Schenck), Hoare, 1961, Desmoinesian Brachiopoda and Mollusca from Southwest Missouri, p. 101, pl. 13, figs. 7, 8.

Diagnosis. — Shell subovate; posterior margin just projecting in back of beaks, short, rounded; anterior margin sharply rounded; ventral margin gently convex; dorsal margin gently arched; umbones prominent, posteriorly placed, broad; umbonal ridge not distinct; surface marked with concentric lamellae of two sizes.

Range. — Pennsylvanian.

Measurements. — Hypotype, bivalved, (mm). Ht. 9.0; Lt 17.0; C 7.0.

Material. — Hypotype, U.S. National Museum, No. 155832. Bureau of Economic Geology, University of Texas Locality 185-T-4.

Discussion. — Only one specimen of this species is on hand from Bed ten of the Gaptank Formation. However, at Texas University Locality 185-T-4, a locality north of Gaptank, in strata younger than Bed ten, the species is very abundant.

Family **GRAMMATODONTIDAE** Branson

Genus **GRAMMATODON** s. l. Meek and Hayden, 1860

Type species. — *Arca inornata* Meek and Hayden, 1858 (1858b). Original designation.

Range. — Devonian-Cretaceous.

Discussion. — The taxonomy of this family remains in confusion though several paleontologists have treated the group, to wit, Arkell (1930), Branson (1942), and Driscoll (1961). The confusion arises in part from the question of systematic relationships of Mesozoic and Paleozoic representatives of the group and in part from legal aspects of names. *Grammatodon* Meek and Hayden, 1860 has priority with respect to *Parallelodon* Meek and Worthen,

1866. Branson (1942) considered the two genera, each represented by distinct species, as belonging to one genus. However, Nicol (1954) considered *Grammatodon* to belong to the family Cucullaeidae. Nicol's evidence is not convincing, and he stated that his conclusions were tentative. Branson's treatment of Paleozoic arcoids with elongate posterior teeth, subovoid to rectangular shape, cancellate to nearly smooth shells, with or without byssal gape as belonging to one genus, *Grammatodon,* is followed here. No attempt is made to apply subgeneric designations.

Grammatodon erectumbona Bird, n. sp. Pl. 12, figs. 12-14

Diagnosis. — Shell subrhomboid; anterior margin gently rounded; posterior margin slightly obliquely truncate to nearly straight; ventral margin nearly straight; umbones broad, erect, not inclined; umbonal ridge prominent, sharp, distinct to postero-ventral margin; beaks slightly prosogyre; ornament of fine, sharply rounded, closely spaced radial ribs, ribs nearly equal in weight all around shell in young forms, more uneven in adults, concentric ornament of growth lines only.

Range. — Bed ten of Gaptank Formation.

Measurements. — (Mm).

		Ht	Lt	C	LH
Holotype	B.V.	7.4	12.8	7.8	12.1
Paratype	R.V.	12.7	19.8		
Paratype	L.V.	9.8	16.0		

Material. — Holotype, U.S. National Museum, No. 155833. Paratypes, U.S. National Museum, No. 155834, 155852.

Discussion. — This species is distinguishable from all others by its erect broad umbones; its lack or near lack of a ventral sinus and by its ornamentation. The ornament consists of sharply rounded ribs which become less sharp posteriorly. The ribs are not regular in weight across the valves but do not increase in size posteriorly as in *G. biplicata.* Some of the ribs are bifid, especially on the anterior portion of the shell — where they branch about one-halfway from beaks to ventral margin — and on the concave region of the shell posterodorsal to the umbonal ridge — where they branch about three-fourths of the way from beak to posterior margin.

The internal features could not be observed in any of the three specimens collected of this species. Two of the specimens are single valves, a left and a right, embedded in calcareous matrix; the other, the holotype, is a fine bivalved specimen.

Grammatodon hexacostata Bird, n. sp. Pl. 13, figs. 1, 2

Diagnosis. — Shell elongate, low; anterior margin nearly straight; posterior margin obliquely truncate; ventral margin gently convex with distinct shallow groove just below umbones and becoming obsolete about two-thirds up from ventral margin, maximum depth of ventral margin near posterior extremity; umbones low, gently inclined anteriorly; umbonal ridge distinct, broad becoming obsolete near posteroventral margin; ligamental area wide, marked with three — five faint, minute, chevron-shaped grooves; central teeth tiny, slightly convergent, lateral teeth not observed; ornament of numerous, distinct, rounded ribs of nearly equal weight all around shell, except where bifurcate and except in the ventral sulcus where there are six ribs of smaller size than adjacent ribs, concentric ornament of growth lines which become coarse enough dorsally and posteriorly, beginning on posterior portion of umbones and extending posteriorly beyond umbonal ridge, to impart a nodose aspect to ribs.

Range. — Bed ten of Gaptank Formation.

Measurements. — (Mm).

		Ht	Lt	C	LH
Holotype	B.V.	10.5	18.2	8.0	13.2
Paratype	R.V.	10.1	13.0	4.5	

Material. — Holotype, U.S. National Museum, No. 155835. Paratype, U.S. National Museum, No. 155836.

Discussion. — This species is similar to the specimens identified and illustrated by Meek and Worthen (1873) as *Parallelodon tenuistriata* (Meek and Worthen), 1866. *Grammatodon hexacostata* is distinct in that the ribs are equal in prominence in the anterior and posterior portions of the shell. Further, *G. hexacostata* has a more pronounced ventral sinus and sulcus and the ribs of this region of the shell are six in number and are smaller than adjacent ribs. Finally, some of the ribs in *G. hexacostata* are irregularly bifid, the branching taking place at irregular distances from the ventral margin. The position of the bifid ribs is differerent from that in *G. erectumbona.* In *G. hexacostata,* the ribs anterior and posterior to the ventral sinus, but not posteroventral to the umbonal ridge, are bifurcate. In *G. erectumbona,* the ribs on the anterior portion of the shell and those above the umbonal ridge are bifid.

Two specimens, one bivalved (the holotype) and the other a fragmentary right valve, were collected from Bed ten of the Gaptank Formation.

Grammatodon cf. **G. kansasensis** (Sayre), 1930 Pl. 12, fig. 15

Parallelodon kansasensis Sayre, 1930, Univ. Kansas Bull., vol. 31, p. 108, pl. 9, figs. 4-7.

Diagnosis. — Shell elongate, low; anterior margin acute, narrow; posterior margin obliquely truncate, narrow; ventral margin nearly straight, with vague ventral sinus, subparallel to dorsal margin; umbones low, broad; umbonal ridge distinct, sharp, extending nearly to posteroventral margin; beaks widely spaced; ligamental area wide; ornament of concentric lamellae and poorly defined radial ribs, ribs observable only on posteroventral and anterior portion of valves.

Range. — Pennsylvanian.

Measurements. — Bivalved specimen (mm). Ht. 7.0; Lt 19.0; LH 16.0; C 7.0.

Material. — Hypotype, U.S. National Museum, No. 155837.

Discussion. — This species, which is represented by a single specimen collected from Bed ten, is readily distinguished from other species of the genus by its sharp anteroventral margin; its low, rounded beaks; and by its faint, irregularly developed radial ornament. The Gaptank specimen referred to this species is larger and more convex than Sayre's specimens and has a hint of radial ribbing on the anterior end of the shell.

Grammatodon carbonaria (Cox), 1857 Pl. 12, figs. 4-9

Arca carbonaria Cox, 1857, Third Rept. Geol. Sur. Kentucky, p. 567, pl. 7, fig. 5.

[*Non*] *Parallelodon carbonaria* Morningstar, 1922, Geol. Sur. Ohio, 4th ser., Bull. 25, p. 209.

Diagnosis. — Shell elongate, rectangular or slightly expanded posteriorly; anterior margin sharply to gently rounded; posterior margin rounded to obliquely truncate, meeting dorsal margin at obtuse to nearly right angle; ventral margin gently arched to nearly straight, gently but distinctly sinuate under umbones, sulcus shallow; hinge line straight, much shorter than maximum length of shell; dental series unknown; umbones broad, low, but high in relation to total height of valves; umbonal ridge nearly straight, sharp to gently rounded; ligamental area wide, inclined to nearly flat, amphidetic, marked with chevron-shaped grooves; surface of valves covered by numerous, rounded, fine, closely spaced radial ribs, nearly equal in weight across valves, and distinct, coarse widely spaced, wrinkled lamellae, with fine, wavy lamellae between.

Range. — Pennsylvanian.

Measurements. — Hypotypes. (mm).

	Ht	Lt	C	LLA (1)	WLA (1)
B.V.	15.0	29.6	7.8 (1)	10.2	0.8
L.V.	35.2	19.2	5.8		
R.V.	12.2	25.5	6.3		
R.V.	12.0	29.1			
B.V.	11.9	24.0	9.1		
L.V.	13.0	24.0	6.8		

Material. — Hypotypes, U.S. National Museum, Nos. 155838-155842. Illinois Geological Survey, No. 216. Identified by Dr. J. M. Weller, 1928.

Discussion. — The holotype of this species is lost and no topotype material, "limestone over coal no. 11 at Providence, Hopkins Co., Kentucky," is available. The dental series of the species has never been determined; it has, however, the fine radial ribs, the medial sinus, and corresponding sulcus, and the chevron-shaped grooves of the ligamental area characteristic of the family. [In form and ornament, *Grammatodon carbonaria* closely resembles *Permophorus pricei* (Branson), 1930, a poorly known taxon whose systematic position is obscure.] The chevron ornamentation of the ligamental area in *G. carbonaria* was observed in only one otherwise poorly preserved specimen collected by J. M. Weller from the St. David Limestone from the Pennsylvanian of Illinois. This specimen, and the one figured on Plate 12, figure 9, are deposited at the Illinois Geological Survey Museum.

The radial ribs of *Grammatodon carbonaria* are restricted to the outer shell layer; slightly corroded specimens appear nearly smooth. The ornament tends to disappear especially on the umbonal areas and on the posterior portion of the shells. The concentric ornament consists of widely spaced, coarse lamellae between which are minutely fine, wavy lines which produce tiny nodes at the intersection of radial ribs.

Grammatodon carbonaria attains a large size and shows considerable variation in shape, ranging from rectangular to posteriorly produced and expanded forms. Several specimens show a tendency to slough off shell layers around the umbones and along the dorsal margins. The result is that the "ligamental area" becomes extremely wide since younger as well as older portions of this structure are exposed to view. Also the umbones become narrow and steep on the hinge line side of the valve.

The species is represented by several poorly preserved specimens in Bed ten of the Gaptank Formation. Some of the valves are in a slightly coarser matrix than the normal Bed ten fossils, and nearly all specimens are univalved, indicating transportation of these specimens from a higher to a lower energy zone.

Grammatodon biplicata Bird, n. sp. Pl. 12, figs. 10, 11

Parallelodon carbonaria Morningstar, 1922, Geol. Sur. Ohio, 4th ser., Bull. 25, p. 209.

[*Non*] *Arca carbonaria* Cox, 1857, Third Rept. Geol. Sur. Kentucky, p. 567, pl. 7, fig. 5.

Diagnosis. — Shell elongate, rectangular; anterior margin sharply rounded; posterior margin truncate, nearly straight, meeting dorsal margin at nearly right angle; ventral margin gently convex outward, apparently not sinuate; hinge line straight, nearly as long as valves; dental series unknown; umbones broad, not gibbous; umbonal ridge sharp to low; ligamental area a narrow groove posterior to beaks, not observed anteriorly; radial ribs of unequal weight, becoming coarser dorsal to umbonal ridge, coarsest ribs on umbonal ridge, ribs rounded anteriorly becoming flattened posteriorly, ribs bifurcated just ventral of midline all across valves, concentric ornament of growth lines only.

Range. — Pennsylvanian.

Measurements. — (Mm).

		Ht	Lt
Holotype	B.V.	13.6	31.7
Paratype	B.V.	11.8	30.5

Material. — Holotype and paratype, Orton Museum Ohio State University, No. 9188. Both collected by Morningstar from the lower Mercer Limestone, near Somerset, Ohio.

Discussion. — This species is based on two bivalved specimens identified by Morningstar as *Parallelodon carbonaria* (Cox), 1857. The shape of the two species is close but *Grammatodon biplicata* has irregularly weighted ribs which are bifid and which become coarse near the umbonal ridge. The radial ornament of *G. carbonaria* is regularly developed and the ribs are not bifid. *G. biplicata* has a hint of a ventral sinus as seen in progressive growth stages, but unlike *G. carbonaria,* the sinus is located just anterior to the umbonal ridge in *G. biplicata.*

The valves of *Grammatodon biplicata* are more elongate in relation to height than in G. *erectumbona* and in G. *biplicata* the ribs become coarser at the umbonal ridge while they do not in G. *erectumbona.*

Family **CONOCARDIIDAE** Neumayr

Genus **CONOCARDIUM** Bronn, 1835

Diagnosis. — Shell equivalve, inequilateral, slightly opisthocline; gaping at both ends; anterodorsal margin produced into rostrum; anterior margin often markedly concave, steeply or gently sloping to ventral margin posterodorsal margin alate, broad, gently concave to convex; ventral margin broadly rounded to acute and narrow; dorsal margin straight, coincides with maximum length of shell; umbones small, sharp; umbonal ridge often a sharp keel; beaks prosogyre, located just anterior to center of hinge line; ligament external and possibly internal; anisomyarian; ornament of radial ribs and concentric lamellae, discrepant anterior and posterior to umbonal ridge.

Type species. — *Cardium (Conocardium) elongatum* J. deC. Sowerby, 1812. Monotypy (*fide* Dickens, 1963, p. 105).

Range. — Ordovician-Pennsylvanian, Triassic?

Conocardium parrashi Worthen, 1890 Pl. 13, fig. 3

Conocardium parrashi Worthen, 1890, Geol. Sur. Illinois, vol. 8, p. 112, pl. 20, fig. 7.

C. missouriensis Girty, 1915, Missouri Bureau Geol. Mines, 2d ser., vol. 13, p. 353, pl. 28, fig. 3.

C. parrashi (Worthen), Sayre, 1930, Univ. Kansas Bull., vol. 31, p. 109, pl. 9, fig. 20.

Diagnosis. — Shell small, slightly opisthocline; posterodorsal margin acute; anterior rostrum small; umbones sharply raised; umbonal ridge sharp, with spines on axis, spines becoming larger ventrally, ridge gently concave anteriorly; beaks small, indistinct, slightly prosogyre; ornament anterior to umbonal ridge of coarse costae, nodose, bifurcated near margin of shell, posterior to umbonal ridge, costae more numerous and finer, crossed by numerous, fine, distinct concentric lines to give cancellate appearance.

Range. — Pennsylvanian.

Measurements. — Hypotypes, (mm).

	Ht	Lt	C
B.V.	7.2	7.1	6.8
B.V.	7.0	6.8	
B.V.	4.9	3.8	3.2

Material. — Hypotypes, U.S. National Museum, No. 155843.

Discussion. — The distinguishing characteristics of this species are its small size, its spiny umbonal ridge, its slight backward obliquity and its highly discrepant ornamentation anterior and posterior to the umbonal ridge. *Conocardium carinatum* Hall, 1856 from the Mississippian of Indiana has the bifid posterior costae of *C. parrashi,* but *C. parrashi* is not so opisthocline as *C. carinatum* and has cancellate ornamentation anterior to the umbonal ridge while *C. carinatum* has only costellae in this zone.

Family **PTERIIDAE** Meek

Genus **PTERIA** Scopoli, 1777

Diagnosis. — Shell strongly inequivalve, left valve more convex than right, obliquely elongate, prosocline, alate; posterior ear larger than anterior ear; anterior ear with shallow byssal notch; hinge line long; two teeth in each valve; ligament external; adults monomyarian; ornament of growth lines and fila, some forms with one or more ridges on the anterior margin.

Type species. — *Mytilus hirundo* Linnaeus. Original designation.

Range. — Devonian-Recent.

Pteria longa (Geinitz), 1866 Pl. 13, fig. 6

Gervillia longa Geinitz, 1866, Carb and Dyas in Nebraska, p. 32, tab. 2, fig. 15.
Avicula longa (Geinitz), Meek, 1872, U.S. Geol. Sur., Nebraska, Final Rept., p. 199, pl. 9, fig. 8.
Pteria longa (Geinitz), Beede, 1900, Univ. Geol. Sur. Kansas, vol. 6, p. 125, pl. 16, fig. 4; Sayre, 1930, Bull. Univ. Kansas, vol. 31, p. 100, pl. 9, figs. 13-14.

Diagnosis. — Shell elongate, narrow; strongly prosogyre; posterior margin beyond auricle nearly straight, inclined; anterior margin subparalled to posterior margin; ventral margin broadly rounded; umbones strongly inclined, rather gibbous, meeting hinge at highly oblique angle; umbonal folds both well defined, sharp; anterior ear much smaller than posterior, posterior ear straight along dorsal margin, gently concave outward at posterior margin; ornament of fine, distinct fila, extending regularly onto auricles and following contour of them.

Range. — Pennsylvanian.

Measurements. — Hypotype, right valve, (mm). Ht. 11.0; Lt 13.0; LPA 10.0; HPA 4.4

Material. — Hypotype, U.S. National Museum, No. 155844.

Discussion. — This species is easily distinguished from *Pteria sulcata* (Geinitz), 1866 by its shape and ornament. The posterior margin of *P. sulcata* is concave and the anterior margin is convex so that the shell expands posteriorly and becomes increasingly more prosocline posteriorly in a manner reminiscent of *Monopteria*. In *P. longa* the posterior and anterior margins are nearly parallel and the shell does not expand posteriorly nor become more strongly prosocline. *Pteria longa* lacks the alternating grooves and ridges under the anterodorsal margin and the coarse, wavy concentric lines of *P. sulcata*.

The shape of *P. longa* is more similar to that of *P. welleri* Sayre, 1930; Sayre's species has one or more ridges near the anterodorsal margin, however, and tends to have a smaller posterior auricle in relation to shell size than does *P. longa*. Finally, Sayre (1930, p. 111) stated that his species has a reticulate ornament on the posterior auricle. Noncorroded specimens, at least, of *P. longa*, do not have reticulate pattern of the posterior ear.

A fragmentary bivalved specimen and a nearly perfect right valve of this species were collected from Bed ten of the Gaptank Formation.

Family
INQUIRENDA

Genus and species indeterminate Pl. 13, fig. 7

Diagnosis. — Slightly inequivalve left valve more convex than right, inequilateral, subtrigonal, extremities of dorsal margin auricle-like; anterior margin short, rounded; posterior margin nearly as high as maximum valve height; ventral margin gently rounded; umbones prominent, pointed, extending high above anterior portion of hinge, not markedly raised above posterior portion; umbonal folds prominent; ligament, muscle scars and pallial line unknown; ornament of two valves possibly discrepant, both valves with fine fila, left valve with subdued, wide costae on ventral margin only.

Measurements. — Bivalved, (mm). Ht 15.7; Lt 16.5; C 9.1.

Material. — U.S. National Museum, No. 155845.

Range. — Bed ten of Gaptank Formation.

Discussion. — With all critical features of this species concealed it is not possible to assign it to a genus or yet even a family with any degree of certainty. Externally the form is unlike any Upper Paleozoic bivalve and should warrant erection of a new genus were the single, bivalved specimen representing it better preserved or had there been more specimens of the species.

Family **MYTILIDAE** Fleming

Genus **PROMYTILUS** Newell, 1942

Type species. — *Promytilus annosus* Newell, 1942. Original designation.

Range. — Carboniferous-Permian, Mesozoic?

"Promytilus" postumbonus Bird, n. sp. Pl. 13, fig. 8

Diagnosis. — Equivalve, thin-shelled, subovate; anterior lobe distinct, large; posterior margin broadly rounded; ventral margin gently convex, with a distinct, deep sinus located under the umbones and a corresponding sulcus extending over one-half distance from ventral to dorsal margin; dorsal margin short, forming a sharply acute angle with ventral margin at anterior end; umbones prominent, gibbous at anterior one-third of hinge; umbonal ridge broadly rounded, inflated, distinct; shell smooth except for growth lines and irregularly spaced lamellae.

Range. — Bed ten of the Gaptank Formation.

Measurements. — Holotype, bivalved, (mm). Ht 10.4; Lt 15.0; HS 4.2; MLS 4.3; C 7.1.

Material. — Holotype, U.S. National Museum, No. 155846.

Discussion. — The taxonomic position of this species is uncertain. The microstructure of the single specimen of the species is recrystallized. Because no evidence of a duplivincular ligament can be observed, the species is assigned to the Mytilidae rather than to the Myalinidae. The characters of *"Promytilus" postumbonus* appear to be midway between the characters of Newell's (1942) *Promytilus* and *Volsellina,* two genera which may need revision or may prove to be unnecessary when more Upper Paleozoic mytiloids become known. The character of *"P." postumbonus* which it shares with typical representatives of *Promytilus,* is the distinct ventral sinus and corresponding sulcus. With the two originally designated species of *Volsellina, "Promytilus" postumbonus* shares the posterior of terminal position of the beaks. Though Newell (1942, p. 37) inferred otherwise in his proposed evolutionary sequence from *Promytilus* to *Mytilus,* it is suggested that the ventral sinus, produced in response to the formation of byssal threads, is a more important index to classification than position of the beak. Therefore, this taxon is tentatively referred to *Promytilus* rather than to *Volsellina,* which has only a vague ventral sinus. However, *"P." postumbonus* certainly departs from typical representatives of the genus in its convex rather than concave ventral margin, which contracts rather than expands posterior to the ventral sinus so that in *"P." postumbonus* there is no spatulate aspect to the shell. Further, the shell of representatives of *Promytilus* are smooth while that of *"P." postumbonus* is marked with distinct concentric lines. In these last two respects *"P." postumbonus* is more like representatives of *Volsellina.*

Recently, Dickens (1963, p. 60) also described a species, *Modiolus koneckii,* from the Permian of Western Australia, which he regards as morphologically intermediate to Newell's *Volsellina* and *Promytilus.* Dickens' species, however, can not be confused with *"P." postumbonus;* the former species has a more spatulate shape and is longer with relation to height and has radial ornament. The systematic position of *"P." postumbonus* as intermediate between *Promytilus* and *Volsellina* was deduced before I saw Dickens' work thereby adding doubt to the need for Newell's two genera.

"Promytilus" postumbonus is not closely related in morphology to any known Paleozoic species. It is remarkably similar to *Modiolus johnsoni* (Whitfield), 1885 from the Cretaceous of Maryland. This similarity strongly attests to Newell's (1942, p. 36) observation concerning the extreme conservation in external shape of this group of organisms.

A single bivalved specimen of this species is the sole representative of the Mytilacea in Bed ten of the Gaptank Formation. The rarity of the superfamily Mytilacea, a common element in many Pennsylvanian faunas, is to be expected. According to Newell (1942, p. 19) and Yochelson (personal communication) the mytiloids are typically shallow-water inhabitants and seem to always have been euryhaline. The common occurrence of mytiloids in the bivalve condition indicates that they preferred, in ancient as well as in modern times, areas where the water was quiet, *i.e.,* shallow-water areas protected from vigorous wave activity such as lagoons and estuaries where species of the family Mytilidae are most common today (all members of the Myalinidae are extinct). The Bed ten fauna indicates that the water depth was too great for mytiloids to be well represented.

Family **MODIOMORPHIDAE** Miller

Genus **GONIOPHORA** Phillips, 1848

Diagnosis. — Equivalve, inequilateral, subrectangular to subtrigonal; anterior margin rounded to nearly straight; posterior margin truncated obliquely; ventral margin nearly straight to highly sinuate; hinge with central tooth in right valve, corresponding groove in left valve; ligament external, opisthodetic; lunule and escutcheon well formed; beaks small, strongly prosogyre, incurved; umbones prominent, umbonal ridge sharp, extending without reduction in prominence to posteroventral margin; pallial line entire; adductors subequal; ornament of concentric lamellae, radial striae or growth lines only.

Type species. — *Cypricardia cymbaeformis* J. de C. Sowerby, 1839. Original designation.

Range. — Devonian-Permian.

Discussion. — Post-Devonian species of this genus tend to be small. In addition, these forms tend to have a highly sinuate ventral margin, great convexity in relation to length of valves, and maximum convexity located high on shell. Species illustrating these features are the apparently closely related *G. crista* Chronic, 1952 from the Kaibab Formation; *G. acutacarinata* (Armstrong), 1865 (*in* Hind, 1899, p. 359, pl. 39, figs. 14-19) from the Upper Limestone Series of Scotland; and *G. gnoma* Bird, n. sp. from the Gaptank Formation. This group may prove to deserve generic or subgeneric status with further investigation.

Goniophora gnoma Bird, n. sp. Pl. 13, fig. 5

Diagnosis. — Shell small, subtrigonal; anterior margin rounded; posterior margin narrow, scarcely more than being the intersection of dorsal and ventral margins; ventral margin convex anteriorly, becoming concave posterior to umbones; flattened perpendicularly to the plane of commissure; dorsal margin convex; sloping steeply posterior to beaks, lunule and escutcheon deep, prominent; umbones broad; umbonal keel acute, posterodorsally is another acute keel; beaks nearly terminal, strongly incurved; smooth except for growth lines.

Range. — Bed ten of Gaptank Formation.

Measurements. — (Mm).

		Ht	Lt	C
Holotype	B.V.	3.5	6.4	5.4
Paratype	B.V.	4.6	6.3	5.3

Material. — Holotype, U.S. National Museum, No. 155847. Paratype, U.S. National Museum, No. 155848.

Discussion. — This species, represented by two bivalved specimens from Bed ten of the Gaptank Formation, somewhat resembles *Goniophora acutacarinata* (Armstrong), 1885 but is readily distinguished from it by having two umbonal keels and a greatly reduced posterior margin. The latter feature gives *G. gnoma* a trigonal shape. In shape and size *G. gnoma* is closely similar to *G.*

crista Chronic, 1952 but is distinguished from Chronic's species by its two umbonal keels and by its complete lack of concentric lamellae.

Family **AVICULOPECTINIDAE** Etheridge, Jr.

Subfamily **AVICULOPECTININAE** Meek and Hayden

Genus **ACANTHOPECTEN** Girty, 1903

Type species.—*Pecten carboniferus* Stevens, 1853. Original designation.

Range.—Mississippian-Permian.

Acanthopecten carboniferus (Stevens), 1858 Pl. 13, figs. 16, 17

Pecten carboniferus Stevens, 1858, American Jour. Sci. (2), vol. 25, p. 261.

Aviculopecten (Acanthopecten) carboniferus (Stevens), Girty, 1903. U.S. Geol. Sur., Prof. Paper 16, p. 418.

Acanthopecten carboniferus (Stevens), Newell, 1937 (1938), State Geol. Sur. Kansas, vol. 10, pt. 1, p. 72, pl. 12, figs. 8-10.

Diagnosis.—Shell shape variable, usually suborbicular; anterior margin rounded becoming gently concave near auricle; posterior margin nearly straight from anteroventral margin to auricle; ventral margin rounded, cuspate; umbones sharp, distinct; anterior umbonal folds distinct; posterior umbonal fold poorly defined; posterior auricle small, anterior auricle elongate, subtriangular; left valve with broad costae with gently sloping flanks, each topped with narrow, rounded costella, crossed by regular coarse fila which swing down in sharply defined troughs to form ventrally pointing spines; at least anterior auricle costate with fila produced into spines ventrally, strongly notched for byssus; ornament of right valve dissimilar to left, consisting of widely spaced, narrow, costellae, interspaces nearly flat, fila absent.

Range.—Pennsylvanian.

Measurements.—Hypotypes (mm).

	Ht	Lt	LAA	C
R.V.	13.2	12.7	10.3	
L.V.	14.0	20.3		4.0

Material.—Hypotypes, U.S. National Museum, Nos. 155849, 155850.

Discussion.—A rare right valve along with a well-preserved left valve and an external replica of a left valve are at hand from

Bed ten of the Gaptank Formation. The ornamentation of the valves is highly discrepant; the anterior auricle of the right valve is more than one-half as long as the shell itself and has four strong costae, the most dorsal one is strongest. The upper umbonal surface of the left valve shows that, in early stages of growth, ornamentation consists of costellae and normal fila. The result is a pattern of ornament similar to typical species of *Streblopteria (Streblochondria)*. A short distance ventrally the riblets are nodose at the intersections with the fila and within four or five fila ventrally, they become pointed in the troughs and arched over the costellae. The costellae at the same time are thickened so that the adult pattern is assumed.

Genus **ANNULICONCHA** Newell, 1937 (1938)

Type species. — *Aviculopecten interlineatus* Meek and Worthen, 1860. Original designation.

Range. — Mississippian-Permian.

Annuliconcha interlineata (Meek and Worthen), 1860 Pl. 13, figs. 14, 15

Aviculopecten interlineatus Meek and Worthen, 1860, Acad. Nat. Sci. Philadelphia, Proc. p. 454; 1866, Geol. Sur. Illinois, vol. 2, p. 329, pl. 26, fig. 7.
Posidonomya lasallensis Miller and Gurley, 1896, Illinois State Mus. Nat. History, Bull. 11, p. 12, pl. 1, figs. 17, 18.
Annuliconcha interlineata (Meek and Worthen), Newell, 1937 (1938), State Geol. Sur. Kansas, vol. 10, pt. 1, p. 76, pl. 13, figs. 6-10.

Diagnosis. — Shell essentially circular, acline or gently prosocline; anterior, posterior, and ventral margins gently rounded; umbones broadly rounded; umbonal folds distinct; auricles triangular; ornament of shell body of raised concentric ridges and interspaced fila; concentric ornament extending onto auricles, in auricular sulcii ornament bends toward umbones then turns outward to parallel outer surface of auricles.

Range. — Pennsylvanian.

Measurements. — Height and length of specimens of this species are nearly equal. No specimens at hand have complete auricles.

Material. — Hypotype, U.S. National Museum, No. 155851.

Discussion. — This species is the most common of the Gaptank pectinoids. Besides the ten adult specimens, what appear to be spat of *Annuliconcha interlineata* occur on some adult pectinoid specimens. One such spat on the posterior auricle of the left valve specimen of *Acanthopecten carboniferus* mentioned above is almost certainly a specimen of *Annuliconcha interlineata*. Presumably, young individuals of *A. interlineata* settled on older members of their species and on other pectinoids and possibly on other organisms or on hard substrate and attached themselves by byssal threads. Subsequently, the attachment was severed and the organism again became free. Hence only the young are found attached to other shells and this attachment — which appears to be accomplished by cementation of one valve — is probably effected by byssal threads. The apparent cementation is the result of diagenesis. If this interpretation is correct, the spat were attached tightly or were inhabitants of quiet water so that after death they were not dislodged from their hosts. The spat have been most frequently seen on auricles of adult pectinoids.

Genus **CLAVICOSTA** Newell, 1937 (1938)

Type species. — *Clavicosta echinata* Newell, 1937 (1938). Original designation.

Range. — Pennsylvanian-Permian.

Clavicosta cf. **C. echinata** Newell, 1937 Pl. 13, figs. 10, 11

Clavicosta echinata Newell, 1937 (1938), State Geol. Sur. Kansas, vol. 10, pt. 1, p. 79, pl. 13, figs. 1-5.
Clavicosta sp. Mudge and Yochelson, 1962, U.S. Geol. Sur., Prof. Paper 332, p. 90, pl. 16, fig. 3.

Range. — Pennsylvanian-Permian.

Measurements. — Hypotype, right valve (mm). Ht 15.1, Lt 13.0.

Material. — Hypotypes, U.S. National Museum, Nos. 155853, 155854.

Discussion. — Two separate presumably right valves and an external replica from Bed ten of the Gaptank Formation are referred to this taxon. The specimens appear to be inclined, and because opisthocline shells are not known for the subfamily Aviculopectininae, it is inferred that they are slightly prosocline. In none of the three specimens is the hinge or auricles preserved, and it was at first thought that these shells were a species of *Pseudomonotis* such as *P. hawni* (Meek and Hayden), 1858. Pseudomonotids are also prosocline. The hinge area of species of *Pseudomonotis* are commonly poorly represented because of the attachment of these forms to the substrate. However, if the specimens here considered are truly prosocline, they are right valves, and right valves of species of *Pseudomonotis* are flat or only slightly convex while the specimens at hand are decidedly convex. Further, the ornament, though similar to that of *Pseudomonotis hawni,* is consistent rather than varied and the costae are tuberculose instead of scaly. Finally, none of the specimens at hand show attachment scars at the umbonal area on what is presumed to be the right valve.

Well-preserved bivalved representatives of *Pseudomonotis* and *Clavicosta* are readily distinguished. Both valves of species of *Clavicosta* are convex and neither valve was attached, while the right, attached valve of species of *Pseudomonotis* is typically flat or concave.

The ornament of the specimens from Bed ten of the Gaptank Formation shows the characteristic features of the genus, coarse costae between which occur two somewhat depressed slightly finer costae. From these specimens it could not be determined that the costae were, respectively first and second order. The coarse costae of these specimens are sharp crested and ornamented by a series of slightly overlapping tubercles. The tubercles are irregularly spaced with the rounded apex situated on the costae and directed dorsally; the prongs extending ventrally down the flanks of the costae. The tubercles become shorter, hence more numerous and the costae and the tubercules become finer posteriorly. Between the major costae, the minor costae are less elevated, narrower, and more gently rounded than the major ones. The fine ornament reported by Newell is not present on these specimens. The finer costae are closer to the major one on either side than they are to each other. Both sets of ribs extend deep into the shell structure producing a rumpling of the entire shell material present at the ventral margin.

Subfamily **STREBLOCHONDRIINAE** Newell

Discussion. — The three proposed genera of the subfamily can be distinguished only with considerable difficulty. Each of the genera has been recognized from Mississippian faunas and yet by Upper Pennsylvanian time divergence between the genera has not produced distinct generic boundaries or, alternately, the genera are polyphyletic. Because of this lack of distinction *Streblochondria*

Newell, 1937 (1938) and *Obliquipecten* Hind, 1903 are here treated as subgenera of *Streblopteria* McCoy, 1851.

Species of *Streblopteria s. s.* are characterized by having no trace of radial ornamentation on the shell body and only vague ribbing on the anterior auricles; the posterior auricles are much reduced. Species of *Streblopteria (Streblochondria)* typically have well-developed ornament on the shell body and on the auricles; here too the posterior auricle may be nearly obsolete. In the type species and closely related species of *Streblopteria (Streblochondria)* the shell body is ornamented by distinct fila and closely spaced costellae to produce a cancellate effect. Other species questionably referred to this subgenus have microscopic cancellate ornamentation on the upper umbonal surface only, have weak costellae, or are smooth. A new species from the Gaptank Formation, *Streblopteria (Streblochondria) fila,* has prominent fila and weak costellae which become slightly better developed anteriorly. Another new species, *S. (Streblochondria) semicosta,* has only growth lines and costellae restricted to the anterior portion of the shell body and has distinct costae on the anterior auricle. In short, the range of ornamentation in species of *S. (Streblochondria)* is from smooth to only concentric to both concentric and radial to the peculiar, microscopic cancellate ornament of *Streblopteria (Streblochondria)*? *tenuilineata* (Meek and Worthen).

Streblopteria (Obliquipecten), the third subgenus of the subfamily, is poorly known. Only recently has it been known from material other than the type species from the Lower Carboniferous of England. Ciriacks (1963, p. 55) reported a species of *Obliquipecten* from the Permian of Wyoming and two specimens, a left and a right valve, from the Gaptank Formation are here referred to the subgenus. The Gaptank specimens are not flat like the type species but do have the marked backward obliquity and the obsolete posterior auricles of the type species. The umbones are prominent and gibbous. Distinction between *Streblopteria (Streblopteria)* and *Streblopteria (Obliquipecten)* is based primarily upon the degree to which the posterior auricles is reduced and the degree of backward obliquity of the shell. Species of *S. (Obliquipecten)* have only the slightest hint of posterior auricles or none at all and the shell is markedly opisthocline.

Genus **STREBLOPTERIA** McCoy, 1851

Subgenus **STREBLOPTERIA** McCoy, 1851

Type species.—Meleagrina laevigata McCoy, 1844. Subsequent designation Meek and Worthen 1866, *fide* Newell [1937, (1938), p. 88].

Range. — Mississippian-Permian.

Streblopteria (Streblopteria) obliqua Bird, n. sp. Plate 13, fig 12

Diagnosis. — Shell higher than long, strongly opisthocline; dorso-anterior margin gently concave outward; anterior margin short ventrally, sharply rounded; posterior margin sharply rounded, but gradually rounded to meet posterior auricle; umbones distinct, not gibbous; anterior umbonal fold distinct; posterior umbonal fold obscure; posterior auricle indistinctly set off from shell body, higher than long; anterior auricle incompletely preserved; shell and auricles smooth except for irregularly thickened lamellae.

Range. — Bed ten of Gaptank Formation.

Measurements. — Holotype, right valve (mm). Ht 20.9; Lt 18.8; C 4.6; OI 0.48.

Material. — Holotype, U.S. National Museum, No. 155855.

Discussion. — The presence of a posterior auricle and posterior umbonal fold of the single specimen of this highly opisthocline species favors its designation to *Streblopteria (Streblopteria)* rather than to the subgenus *Obliquipecten.* The valve is, however, flattened. Though the shell layers are well preserved, there is no hint of ornamentation besides growth lines.

The growth lamellae show that *S. (Streblopteria) obliqua* becomes relatively shorter with respect to length. The posterior portion of the shell is the faster growing of the heterogenous characters, height and length, so that the shell becomes more strongly opisthocline with advancing ontogeny.

Streblopteria (Streblopteria) sp. Pl. 14, figs. 1, 2

Diagnosis. — Shell high in relation to length, opisthocline; anterior margin gently rounded, rumpled near dorsal extremity;

posterior margin gently rounded, meeting dorsal margin at slightly obtuse angle; ventral margin gibbous, prominent; posterior umbonal fold indistinct; anterior umbonal fold undefined; posterior auricle tiny, obsolete; anterior auricle not observed; ornament absent except for growth lines.

Range. — Bed ten of Gaptank Formation.

Measurements. — (Mm).

	Ht	Lt	C	OI
R.V.	25.7	19.6	4.1	0.75
R.V.	20.1	19.7	4.5	0.81

Material. — U.S. National Museum, Nos. 155856, 155857.

Discussion. — Two right-valved specimens, which are probably conspecific, are tentatively placed in this genus. Both specimens are fragmentary. One is crushed anteroventrally so that it appears to have a distinct anterior umbonal fold. The shell has largely been broken away anterior to this region. The actual shell margin can be seen in the limy matrix, however, and shows that the apparent umbonal fold is not real. The smaller specimen lacks a ventral margin, and the tip of the umbone has been broken so that this structure appears too low.

Subgenus **STREBLOCHONDRIA** Newell, 1937 (1938)

Type species. — *Aviculopecten sculptilus* Miller, 1891. Original designation.

Range. — Mississippian-Permian.

Streblopteria (Streblochondria) aff. **S. (Streblochondria) sculptilus** (Miller), 1891 Pl. 13, fig. 13

Aviculopecten sculptilus Miller, 1891, Indiana Geol. Sur., Ad. Sheets, 17th Rept., p. 92, pl. 20, fig. 5.

Streblochondria sculptilus (Miller), Newell, 1937 (1938), State Geol. Sur. Kansas, vol. 10, pt. 1, p. 82, pl. 16, figs. 5, 7, 9, 11.

Discussion. — One specimen of this species was collected from Bed ten of the Gaptank Formation. The shell body of the specimen is nearly complete, but the auricles are wanting. *Streblochondria sculptilus* differs from *S. hertzeri* (Meek), 1871 mainly in being higher in relation to length and in having a smaller umbonal angle. *S. sculptilus* is distinguished from *S. stantonensis* Newell, 1937 (1938) only by the nature of the auricles which are not present in the specimen at hand.

Range. — Missourian.

Measurements. — Hypotype, right valve, (mm). Ht 12.7; Lt 9.5; C 1.1.

Material. — Hypotype, U.S. National Museum, No. 155858.

Streblopteria (Streblochondria) fila Bird, n. sp. Pl. 14, figs. 7, 8

Diagnosis. — Shell subcircular, distinctly though slightly opisthocline; umbones prominent, moderately gibbous; anterior umbonal fold prominent, posterior umbonal fold gradually rounded, distinct; anterior auricle longer than high, much longer than posterior auricle, byssal notch apparently well developed; convexity high; ornament of shell body of prominent, regular, closely spaced fila and faint radial lines, radial ornament most prominent under anterior auricle where the fine costellae are sharply raised and closely spaced; auricular ornament not known.

Range. — Bed ten of Gaptank Formation.

Measurements. — Holotype, right valve, (mm). Ht 14.0; Lt 14.7; LAA 5.5; LPA 2.8; C 3.2; OI 0.80.

Material. — Holotype, U.S. National Museum, No. 155859. Paratype, U.S. National Museum, No. 155860.

Discussion. — This species fits in well with the apparent subgeneric trend to a more orbicular outline. The trend is the result of the reduction of height in relation to length of shell. There is no recognizable trend in the type of ornamentation in species of *Streblochondria. S. (Streblochondria) fila* has subdued radial ornament.

Streblopteria (Streblochondria) fila is represented by two right valves. One specimen is nearly complete, the anterior auricle is covered by matrix and the posterior extremity of the posterior ear is missing. The species is distinctive for its high convexity and its ornamentation. The regularly spaced fila are strongly developed and crossed by closely spaced, feebly developed radial riblets. The characteristic cross-hatched effect commonly seen in the genus is not displayed because of the lack of development of the radial ornament. Anteriorly, the radial riblets are relatively sharply raised but even here they are subdued and narrow. The nature of ornamentation of *S. (Streblochondria) fila* most closely conforms to that of *S. (Streblochondria) hertzeri* (Meek), 1871 but *S. (Streblo-*

chondria) fila has a higher convexity and is more orbicular than that species. As in *S. (Streblochondria?) tenuilineata* (Meek and Worthen), 1860 the outer ostracum of the shell is coarsely developed. The shell structure is radial crossed lamellar and can be easily seen with a hand lens.

Streblopteria (Streblochondria?) tenuilineata (Meek and Worthen), 1860

Pl. 14, figs. 3-6

Pecten tenuilineatus Meek and Worthen, 1860, Acad. Nat. Sci. Philadelphia, Proc., p. 452.
Streblopteria? tenuilineata Meek and Worthen, 1866, Geol. Sur. Illinois, vol. 2, p. 334, pl. 26, fig. 9.
Crenipecten foerstii Herrick, 1887, Denison Univ. Sci. Lab., Bull., vol. 2, p. 28, pl. 3, fig. 9.
Crenipecten foerstii (Herrick), Morningstar, 1922, Ohio Geol. Sur., Bull. 25, 4th ser., p. 230, pl. 13, figs. 7-8.
Streblopteria tenuilineata (Meek and Worthen), Sayre, 1930, Kansas Geol. Sur., Bull. 17, p. 121, pl. 11, fig. 3.
Streblochondria? tenuilineata (Meek and Worthen), Newell, 1937 (1938), State Geol. Sur. Kansas, vol. 10, pt. 1, p. 84, pl. 1, fig. 3; pl. 15, figs. 10-16.

Diagnosis. — Shell suborbicular, acline or slightly opisthocline to strongly opisthocline; anteroventral margin rounded to nearly straight, anterior margin near auricles concave outward, posterior margin broadly rounded; umbones gibbous; beaks orthogyre to prosogyre; anterior and posterior umbonal folds well defined; posterior auricles subquadrate, anterior auricles longer, rounded at extremities; shell body of both valves with microscopic cancellate ornament on dorsal part of umbones, absent elsewhere; posterior auricle normally with four or five broad or narrow distinct costae, with or without concentric ridges, posterior auricle with only concentric ornament or no ornamentation.

Range. — Pennsylvanian.

Measurements. — Hypotypes (mm).

		Ht	Lt	LAA	LPA	OI
1.	R.V.	18.0	16.5	5.0	4.0	0.98
2.	R.V.	19.7	19.6	7.3	4.4	0.54
3.	R.V.	17.8	17.6	5.8	3.0	0.64
4.	L.V.	17.1	17.2	4.8	4.6	

Material. — Hypotypes, U. S. National Museum, No. 155861. Orton Museum of the Ohio State University, No. 15289.

Discussion. — One fragmentary right valve of this species was found in Bed ten of the Gaptank Formation. This valve bears the microscopic cancellate ornamentation of the umbonal area that has been previously reported for the left valve.

Newell's [1937 (1938), p. 84] citation of *Crenipecten foerstii* Mark is a misprint for *C. foerstii* Morningstar. Morningstar's three specimens of this species were kindly loaned to me by Dr. Schopf of the Orton Museum, Ohio State University. These specimens, as noted by Newell (*op. cit.*, p. 85), are highly oblique for *Streblopteria (Streblochondria?) tenuilineata*; also these specimens, because of preservation, show no trace of the umbonal ornamentation so characteristic of the species. According to Newell *(loc. cit.)*, topotypes of Herricks *Crenipecten foerstii,* which like Morningstar's specimens, are from the Pottsville Series of Flint Ridge, Ohio, are conspecific with *S. (Streblochondria?) tenuilineata*. However, based on Newell's figures *(op. cit.*, pl. 15, figs. 10-13) as well as on Morningstar's specimens, the auricular costae of the Ohio forms are much more distinct and narrow and the umbones are lower (project less above the shell body). The auricles of the Pottsville form are not so high in relation to their length as Middle Pennsylvanian representatives of *S. (Streblochondria?) tenuilineata*. The Ohio forms may prove to be a distinct species or at least subspecies.

As in specimens of *Streblopteria (Streblochondria) fila,* the structure of the outer ostracum in *S. (Streblochondria?) tenuilineata* is coarsely radial cross lamellar and can be seen throughout the shell with slight magnification.

Streblopteria (Streblochondria) semicosta Bird, n. sp. Pl. 13, fig. 9

Diagnosis. — Shell small opisthocline; anterior margin short, gently rounded ventrally, gently concave upward and outward dorsally; ventral and posterior margins rounded; umbones high, gibbous; umbonal folds prominent; posterior auricle short, subquadrate; anterior auricle relatively large, convex rather than flat, rounded anteriorly; byssal notch distinct but shallow; anterior margin of shell body ornamented by fine, low, radial ribs, ribs becoming obsolete dorsally near base of anterior ear, additional fainter ribs situated posterioventrally restricted to ventral margin, general surface with fine lines of growth only; anterior auricle with six long costae extending from tip to base of ear, crossed by numerous growth lines, ribs not present on dorsal one-third of ear.

Range. — Bed ten of Gaptank Formation.

Measurements. — Holotype, right valve (mm). Ht 11.6; Lt 9.7; LAA 4.3; LPA 2.6; OI 0.66.

Material. — Holotype, U. S. National Museum, No. 155862.

Discussion. — The costate anterior auricle and the faint but distinct anterior costation of the anterior part of the shell body bring me to place this species in the subgenus *Streblochondria.* This unique ornamentation distinguishes this species, which is represented by a single right valve, from any known species of the genus.

Subgenus **OBLIQUIPECTEN** (Hind), 1903

Type species. — *Obliquipecten laevis* Hind, 1903. Original designation.

Range. — Mississippian-Permian.

Streblopteria (Obliquipecten) sp. Pl. 14, figs. 10, 11

Diagnosis. — Shell suborbicular, higher than long, strongly opisthocline; anterior margin gently rounded, strongly concave outward under beaks; posterior and ventral margins gently rounded; umbones prominent, gibbous, extending high above anterior margin; beaks prosogyre; anterior umbonal fold prominent; posterior umbonal fold absent; left valve with small, poorly defined anterior wing; anterior auricle of right valve apparently broken off; posterior auricles absent; ornament of right valve lacking; left valve with distinct, closely spaced, flattened costae on anteroventral portion of shell, becoming obsolete a short distance dorsally.

Range. — Bed ten of Gaptank Formation.

Measurements. — (Mm).

	Ht	Lt	C	OI
R.V.	30.2	21.8	7.7	0.33
L.V.	22.0	15.0	6.5	0.27

Material. — U. S. National Museum, Nos. 155863, 155864.

Discussion. — The two valves are tentatively referred to the same species. The species is placed in the subgenus *Obliquipecten* because of the shape and strongly opisthocline attitude of the shell, the radiating costae of the anterior portion of the left valve, the lack of a posterior ear on the right valve, and the triangular ligamental area of the right valve which is set posterior to the beaks as that of the left valve illustrated by Newell (1937, p. 90, fig. 32).

The specimens collected from the Gaptank Formation do not have the flattened umbones nor flattened valves of the type species.

Family
INQUIRENDA

Genus **CYPRICARDINIA** Hall, 1859

Type species. — *Cypricardinia lamellosa* Hall, 1859; subsequent designation by Hall (1885, p. xlvi).

Range. — Devonian-Permian.

Discussion. — Several students of Paleozoic Pelecypoda (see Dickens, 1963, p. 98) have expressed doubt as to whether the name *Cypricardinia* should be used for Upper Paleozoic pelecypods. Unlike earlier forms, Upper Paleozoic species referred to *Cypricardinia* have equal valves and a marginal rather than an external ligamental area (Dickens, 1963, p. 98). In general external morphology, Upper Paleozoic and Devonian representatives of the genus are much alike. Because further study is needed to show the differences noted above to be consistent, the genus *Cypricardinia* is used here without recourse to open nomenclature.

Cypricardinia questa Bird, n. sp. Pl. 12, fig. 3

Diagnosis. — Shell oblong, thin, slightly expanded posteriorly; anterior short, gently rounded; posterior margin sharply rounded ventrally but gradually rounding into dorsal margin; ventral margin gently convex; dorsal margin straight, shorter than maximum length of shell; umbones small, gently inflated; umbonal ridge distinct near beaks, becoming rounded and indistinct posteriorly; ligamental area narrow, amphidetic; beaks small, prosogyre; ornament of numerous, regularly spaced, gently raised, imbricated concentric lamellae with fine, regular lines between, radial ornament absent.

Range. — Bed ten of Gaptank Formation.

Measurements. — Holotype, bivalved, (mm). Ht 12.0; Lt 11.0; DBAM 1.6; C 8.8.

Material. — Holotype, U. S. National Museum, No. 155865.

Discussion. — *Cypricardinia questa* does not closely resemble any known species of the genus. Its total lack of radial ornamentation is apparently unique. This condition is not the product of corrosion for the ornament is in an excellent state of preservation. *Cypricardinia questa* is distinguished from *C ? elegantula* Dickens, 1963 by having a less spatulate outline, more prominent umbones, more regular concentric ornament, and its lack of radial costation. The general shape of *C. questa* is close to that of the type species, *C. lamellosa* Hall, 1859, but *C. questa* has much higher beaks and again has no radial ornament.

Cypricardinia questa is represented by a single, broken, bivalved specimen from Bed ten of the Gaptank Formation.

Family **MYOCONCHIDAE** Newell

Genus **STUTCHBURIA** Etheridge, Jr., 1900

Type species. — *Orthonota*? *costata* Morris, 1845. Original designation.

Range. — Pennsylvanian-Permian.

Discussion. — Newell (1957) and Dickens (1963) have studied the type species of this genus and found it to possess poorly developed, obsolescent, cardinal teeth. Newell recognized one cardinal tooth in each valve; Dickens two in the left and one in the right valve. In addition there are two posterior laterals in the right valve and one in the left. *Permophorus* Chavan, 1954 = *Pleurophorus* King, 1850 is a closely related genus distinguishable by its better developed cardinal dentition.

No teeth were observed on the species here tentatively referred to *Stutchburia,* yet most of the hinge was observable on one specimen.

"Stutchburia" corrucostata Bird, n. sp. Pl. 11, fig. 15; Pl. 12, figs. 1, 2

Diagnosis. — Shell subrectangular; anterior margin gently rounded; posterior margin obliquely truncate; ventral margin gently convex; dorsal margin nearly straight; umbones low, broad; umbonal ridge indistinct; ligamental area narrow, opisthodetic, marginal rather than external; lunule small, well defined, escutcheon indistinct; ornament of coarse costae, becoming coarser posteriorly and concentric lamellae; costae wider than interspaces.

Range. — Bed ten of Gaptank Formation.

Measurements. — (Mm).

	Ht	Lt	C
Holotype—B.V.	9.8	18.3	6.5
Paratype—L.V.	15.0	24.0	5.1
Paratype—L.V.	9.2	17.8	6.2

Material. — Holotype, U. S. National Museum, No. 155866. Paratypes, U. S. National Museum, Nos. 155867, 155868.

Discussion. — *"Stutchburia" corrucostata* is not closely similar to any known Carboniferous species. The species attains a moderate size and is ornamented with coarse costae at all observed stages of ontogeny. Though these ribs are coarse, they are not deeply impressed in the shell for slight corrosion produces a smooth valve. The ribs become progressively coarser posteriorly. The concentric lamellae are coarse all across the shell and bend ventrally at the junction with ribs to produce a fluted or nodose aspect.

Family **ASTARTIDAE** d'Orbigny

Genus **ASTARTELLA** Hall, 1858

Diagnosis. — Shell essentially equivalve, subovate to subquadrate, truncated posteriorly, ventral margin straight to broadly rounded; two cardinal teeth in each valve, two posterolateral teeth in left valve, one posterolateral in right valve; one anterolateral tooth in left valve, two anterolaterals in right valve; lunule and escutcheon well defined; ligament external, opisthodetic; adductor scars nearly equal; pallial line simple; ornament of concentric ridges of variable weight and spacing; beaks anterior, prosogyre; umbonal ridge usually low, broad, not well defined.

Type species. — *Astartella vera* Hall, 1858. Original designation; monotypy.

Range. — Pennsylvanian-Permian.

Discussion. — Externally this widely distributed Late Paleozoic genus is sometimes difficult to distinguish from *Cypricardella* Hall, 1858 (Hall, 1858a). However, species of *Cypricardella* are reported to have but one cardinal tooth in each valve whereas in species of *Astartella* there are two cardinal teeth in each valve. Further, the umbonal ridge of *Cypricardella* is better defined and the valves are typically more elongate than in species of *Astartella.* (Compare also to *Kaibabella* Chronic, 1952 and to *Eoastartella* Ciriacks, 1962).

Species of *Astartella* have been described primarily on the basis of ornamentation, position of beak, and nature of posterior margin. The latter two characteristics were not found to be useful for determining species. Ornamentation in *Astartella* is of two main types;

concentric ridges without lamellae between; *A. varica* McChesney, 1867, *A. compacta* Girty, 1915 (1915a), and *A. subquadrata* Girty, 1908 are examples; and concentric ridges with fine lamellae in interspaces, exemplified by *A. vera* Hall, 1858 and probably *A. concentrica* (Conrad), 1842. These small concentric lines between the ridges are developed to various intensities, being prominent in some specimens and barely visible with a hand lens in others.

Several proposed species are similar to *Astartella vera* Hall, 1858. Among these are: *Astartella concentrica* (Conrad), 1842; *Edmondia concentrica* McChesney, 1859 = *Astartella concentrica* (McChesney), 1867; *Astartella newberryi* Meek, 1875; and *Astartella gurleyi* White, 1872. Of these, I have been able to obtain type material of only *A. vera* Hall and *A. gurleyi* White. Because of this lack of comparative material, actual synonymization is not made except in the case of *A. vera* and *A. gurleyi.*

In the course of the study of *Astartella,* topotypes of *A. vera* Hall were kindly loaned to me by Dr. J. M. Weller of the Walker Museum of the University of Chicago (now in Field Natural History Museum). These specimens were compared to three other samples identified as *A. vera* and one sample of *A. varica.* In these comparisons only one of 28 possible combinations of characters tested proved valuable in species separation, to wit, height of beak versus length of valve. The results are shown in Table 1.

From Table 1 above it can be seen that, with the exception of the Wildhorse sample, each of the samples of *Astartella vera* is significantly different from *A. varica* for the regression of height of beak on length. The slope for this combination is so high for the "Coal Measures" sample that this sample showed significantly greater slope for the combination than the Heumader Shale and the Wewoka Formation samples of the same species. From this study it is seen that the regression of height of beak on length for species of *Astartella* is useful but not completely reliable for separation of samples of the species. In the course of this study no better sets of characters were recognized, however.

The extreme variation of the combination height of beak and length of valve in the samples of *A. vera* suggests that height of beak alone is not sufficient for distinguishing closely related species of the genus. The variation of this combination of characters shows

TABLE 1

Statistical Comparisons of *Astartella* spp.
for the Regression of HB on Lt

Samples	H	We	"C.M."	G.T.
Wi	0	0	0	0
H		0	+	—
We			+	—
"C.M."				—

Symbols: 0—no significant difference at 5% level, one-sided.
+—regression slope of column sample significantly greater than row sample at 5% level, one-sided.
——regression slope of column sample significantly smaller than row sample at 5% level, one-sided.
regression equations are given with species descriptions below.

Wi — Wildhorse Formation, Wildhorse, Oklahoma; *A. vera*.
H — Heumader Shale, Elk County, Kansas; *A. vera*.
We — Wewoka Formation, Ada, Oklahoma; *A. vera*.
"C.M." — "Coal Measures", Springfield, Illinois; *A. vera*.
G.T. — Bed ten of Gaptank Formation; *A. varica*.

neither vertical nor horizontal directional variation in the samples of *A. vera* studied. Further study may warrant the erection of subspecies for extreme variants of *A. vera*.

Species of *Astartella* are widely distributed in the Pennsylvanian. They are found commonly in both near-shore and normal marine assemblages and do not seem to be valuable as tools for ecological interpretation.

Astartella vera Hall, 1858 Pl. 14, figs. 12-17

Astartella vera Hall, 1858, Rept. Geol. Sur. Iowa, vol. 1, pt. 2, p. 715, pl. 29, fig. 1.
A. gurleyi White, 1878, Acad. Nat. Sci. Philadelphia, Proc., p. 35.

Diagnosis. — Shell subtrigonal to subquadrate; anterior margin rounded to nearly straight; posterior margin nearly straight, meeting dorsal margin in distinctly obtuse angle; ventral margin nearly straight to broadly convex; dorsal margin gently arched; umbones prominent, gibbous; beaks relatively high in relation to length of valves; umbonal ridge broadly to rather sharply rounded; ornament of closely spaced concentric ridges and concentric lamellae of variable prominence in interspaces.

Range. — Pennsylvanian.

Measurements. — (See Appendix).

Growth equations. — Essentially linear. $Y = HB$; $X = Lt$; in the form $Y = a_y + b_{yx}X$. Computed by least squares.

"Coal Measures", Springfield, Ill.	$Y = -0.16 + 0.460X$
Heumader Shale, Elk Co., Kansas	$Y = 0.03 + 0.266X$
Wildhorse Fm., Wildhorse, Okla.	$Y = 0.04 + 0.317X$
Wewoka Fm., Ada, Okla.	$Y = 0.07 + 0.306X$

Material. — Topotypes of *Astartella vera* Hall. Walker Museum, University of Chicago, No. 13303, now in the Field Museum of Natural History. Hypotypes, Pennsylvanian collections of Drs. L. M. Cline and L. R. Laudon, University of Wisconsin.

Discussion. — The relation of this species to closely related or possibly synonymous species is discussed above. One species, *Astartella gurleyi* White, is here placed in synonymy with *A. vera.* A small number of poorly preserved topotypes of *A. gurleyi,* along with topotypes of *A. vera,* were loaned to me by Dr. J. M. Weller. The two species occur together and *A. gurleyi* was apparently based on juveniles of *A. vera.*

Astartella compacta Girty, 1915 (1915a), another small form, is apparently distinct. Hoare (1961, p. 127) reported that fine lamellae do not occur in the interspaces of concentric ridges in Girty's species.

Astartella vera was not collected from the Gaptank Formation, although *A. varica,* with which it is sometimes associated, is common in Bed ten of the formation.

Astartella varica McChesney, 1859 Pl. 14, figs. 9, 18, 19

Astartella varica McChesney, 1859, Chicago Acad. Sci. Ext. Trans.; McChesney, 1867, Chicago Acad. Sci., Trans., vol. 1, p. 42, pl. 2, fig. 21; Girty, 1915, U.S. Geol. Sur., Bull. 544, p. 145, pl. 18, fig. 1.

Diagnosis. — Shell subquadrate, early stages subtrigonal; anterior margin rounded to straight; posterior margin straight, meeting dorsal margin at oblique or nearly right angles; ventral margin nearly straight; dorsal margin essentially straight; umbones broad; beaks low with respect to length of valves; umbonal ridge indistinct; ornament of relatively widely spaced, sharp concentric ridges, no lamellae in interspaces.

Range. — Pennsylvanian.

Measurements. — (See Appendix).

Growth equations. — Essentially linear. $y = HB$; $x = Lt$; in the form $Y = a_y + b_{yx}X$. Computed by least squares.

Bed ten, Gaptank Formation $Y = 0.13 + 0.135X$.

Material. — Hypotypes, U.S. National Museum, Nos. 155869, 155870.

Discussion. — *Astartella varica* is readily distinguished from other species of the genus by having coarser, more widely spaced concentric ridges without smaller lamellae in the interspaces. Judging from the description and illustrations of *Cypricardella sectoralis* Girty, 1927 (1927a), this species may be conspecific with *A. varica.* The hinge of Girty's species is not known, however, and it may prove to truly be a *Cypricardella.*

Excepting *"Edmondia" subtruncata* Meek, *A. varica* is the most common Bed ten pelecypod.

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APPENDIX

Appended Tables of Raw Measurement Data (in millimeters).

Table I. See page 165.

TABLE II

Measurements of Specimens of Astartella varica McChesney, 1860
from Bed Ten, Gaptank Formation

Specimen	Ht	Lt	LH	HB	C	PC	DAMB	DPMB
BV 1	10.3	10.4	8.9	3.4	8.0	37.9	6.0	11.5
BV 2	10.8	12.9	12.7	3.0	—	40.2	6.1	8.5
BV 3	14.8	—	15.1	4.6	10.4	—	6.8	11.7
BV 4	12.8	14.7	13.2	4.0	8.1	44.2	5.7	8.9
BV 5	12.2	14.5	13.2	4.4	7.0	42.1	6.2	9.9
BV 6	11.8	13.9	11.9	3.2	9.1	41.1	6.0	7.9
BV 7	13.5	14.7	11.0	2.5	8.7	46.2	6.0	7.7
BV 8	10.5	12.9	11.3	2.5	7.7	36.4	4.6	8.2
BV 9	—	12.9	11.3	2.1	6.9	—	—	—
BV10	9.8	11.9	9.0	2.5	7.7	35.2	—	—
BV11	11.6	14.7	12.8	2.6	7.9	41.3	4.0	9.4
BV12	12.0	13.9	12.3	4.4	7.2	40.1	5.3	9.0
BV13	10.1	12.3	10.9	2.6	6.9	36.6	4.8	8.2
BV14	10.1	11.9	9.9	3.3	7.1	36.1	—	—
BV15	7.2	9.1	7.9	2.2	5.4	26.9	4.2	5.5
BV16	13.0	14.1	13.0	3.3	8.7	42.2	5.8	10.0
BV17	13.0	14.9	12.0	3.4	7.9	45.9	6.0	12.0
BV18	13.0	14.5	13.8	3.7	7.8	43.0	5.3	9.9
BV19	11.9	13.4	12.2	3.5	7.4	40.2	5.2	8.4
BV20	12.0	15.8	14.0	3.3	9.8	45.0	5.4	10.9
BV21	14.2	15.8	15.9	5.0	10.5	48.0	—	—
BV22	13.2	18.0	15.8	2.6	8.0	51.0	5.3	11.9

TABLE III

Measurements of Astartella vera Hall, 1858
Heumader Shale, Elk County, Kansas

Specimen	Ht	Lt	LH	HB	C	PC	DAMB	DPMB
BV 1	8.2	10.8	9.8	3.0	5.1	29.9	4.8	7.3
BV 2	8.2	9.3	9.0	2.6	5.7	27.3	4.3	7.7
BV 3	8.0	10.8	8.8	3.6	6.1	30.9	4.0	7.3
BV 4	9.2	12.1	11.3	4.4	7.6	33.0	5.0	8.3
BV 5	8.7	11.0	10.0	3.1	6.8	30.5	4.6	7.4
BV 6	9.3	12.5	11.2	3.3	7.0	35.0	4.7	8.9
BV 7	8.0	9.2	8.9	3.0	5.0	27.3	3.6	6.4
BV 8	10.2	12.0	11.3	3.4	5.9	34.7	4.8	9.1
BV 9	8.8	10.8	9.9	3.1	5.8	29.8	4.8	8.0
BV10	9.6	12.0	10.2	3.5	6.0	35.6	5.0	9.0
BV11	9.1	10.9	10.0	3.3	6.6	30.6	4.1	8.1
BV12	8.9	10.8	9.7	2.5	5.4	31.6	4.0	7.8
BV13	10.0	12.8	10.9	3.6	6.2	35.2	5.1	9.1
BV14	7.0	8.0	7.2	2.4	5.2	23.8	3.2	6.0
BV15	8.1	9.8	8.9	3.0	6.2	27.8	4.1	7.1
BV16	7.5	9.6	9.0	3.0	6.1	26.8	3.7	7.1
BV17	8.6	11.5	10.5	3.1	5.8	32.8	3.7	7.6
BV18	9.9	11.1	10.4	2.8	6.0	32.8	5.2	8.5
BV19	7.0	8.8	7.9	2.5	5.4	24.6	3.4	6.4
BV20	8.8	10.6	9.0	2.3	5.5	29.5	4.0	7.0

TABLE IV

Measurements of Astartella vera Hall, 1858
Wildhorse Limestone, Wildhorse, Oklahoma

Specimen	Ht	Lt	LH	HB	C	PC	DAMB	DPMB
BV 1	15.2	17.5	14.2	7.2	11.1	59.1	7.0	11.4
BV 2	14.2	19.0	16.8	7.2	10.1	53.4	7.9	13.9
BV 3	20.3	25.1	21.0	8.8	15.7	70.5	8.2	17.0
BV 4	19.2		19.9	7.3	10.8	67.9	9.0	19.9
BV 5	16.0	19.6	17.6	6.0	10.6	55.8	7.3	13.0
BV 6	17.2	19.7	17.0	5.9	14.0	55.4	7.4	12.9
BV 7	12.9	16.0	14.3	5.6	10.0	44.9	6.6	11.8
BV 8	9.2	12.1	10.2	4.1	6.7	34.2	4.8	8.0
BV 9	16.2	18.8	18.8	6.0	8.6	57.8	7.5	17.0
BV10	16.5	19.8	17.1	6.0	10.9	57.5	7.6	12.8

TABLE V

Measurements of *Astartella vera* Hall, 1858
Wewoka Formation, Ada, Oklahoma

Specimen	Ht	Lt	LH	HB	C	DAMB	DPMB
BV 1	16.1	19.9	17.9	5.2	10.6	6.9	14.1
BV 2	16.9	19.1	17.0	5.2	10.5	5.2	13.2
BV 3	16.0	21.2	19.4	6.0	12.7	7.8	16.0
BV 4	7.8	9.5	8.4	2.4	5.1	4.0	6.5
BV 5	9.7	11.0	10.0	2.8	5.0	4.5	8.0
BV 6	8.3	10.9	8.8	2.2	5.7	4.0	5.7
BV 7	8.0	9.9	8.5	2.6	4.0	4.0	7.0
BV 8	8.9	10.9	10.0	2.6	6.1	4.5	7.5
BV 9	8.8	11.1	10.0	2.9	6.1	4.0	8.0
BV10	8.8	10.9	9.9	2.4	6.5	4.0	7.5

TABLE VI

Measurements of *Astartella vera* Hall, 1858
"Coal Measures", Springfield, Illinois

Specimen	Ht	Lt	LH	HB	C	DAMB	DPMB
BV 1	10.9	13.3	12.6	4.1	8.2	4.7	9.9
BV 2	13.0	16.0	14.0	4.5	10.0	6.0	11.0
BV 3	10.7	12.0	11.0	3.9	7.0	4.8	8.1
BV 4	16.6	18.6	17.2	7.6	11.2	6.8	13.0
BV 5	14.1	17.3	15.0	6.7	12.2	7.1	11.0
BV 6	9.0	12.0	11.0	3.3	7.0	4.4	8.8
BV 7	12.2	15.0	13.9	5.4	9.2	5.1	10.7
BV 8	9.1	10.9	10.0	3.7	6.8	4.2	8.0
BV 9	10.2	11.5	11.0	4.1	7.1	5.1	8.0
BV10	9.3	11.0	10.2	3.9	7.0	5.0	8.0

TABLE VII

Measurements of "*Edmondia*" *subovata* Meek and Worthen, 1869
from Bed Ten, Gaptank Formation

Specimen	Ht	Lt	LH	HB	C	PC	DAMB	DPMB
BV 1	18.2	22.7	15.0	3.1	14.9	62.4	6.0	12.4
BV 2	17.1	24.9	20.7	5.8	16.7	66.6	5.5	7.9
BV 3	13.9	16.0	10.9	2.7	11.7	55.8	4.8	7.0
BV 4	19.3	23.1	17.9	4.3	16.0	66.8	5.0	13.2
BV 5	16.3	18.2	15.9	4.8	13.3	56.0	4.8	20.9
BV 6	16.9	21.1	14.9	5.3	14.9	66.0	5.2	19.2
BV 7	15.5	19.6	15.9	4.1	18.4	55.3	4.2	11.9
BV 8	12.8	16.0	11.0	2.8	10.3	45.8	—	12.0
BV 9	14.2	17.0	13.3	4.7	13.2	50.6	4.8	6.6
BV10	19.8	21.5	18.2	4.1	15.1	62.8	6.9	13.3
BV11	16.7	18.0	15.3	4.0	13.5	56.0	5.3	8.3
BV12	18.7	21.9	16.8	4.8	13.7	60.3	5.1	9.5
BV13	16.0	18.9	15.9	3.2	10.7	56.5	5.1	7.2
BV14	16.9	20.9	16.4	3.8	14.4	57.6	4.9	10.9
BV15	14.0	17.0	13.6	3.6	11.5	49.2	5.2	7.4
BV16	16.4	18.6	14.2	4.0	13.4	54.8	4.9	11.0
BV17	—	—	—	—	—	—	—	—
BV18	—	—	—	—	—	—	—	—
BV19	16.0	19.2	17.9	3.7	14.2	55.8	4.9	8.2
BV20	19.0	25.1	21.6	4.6	16.1	70.4	5.8	11.8
BV21	18.7	22.1	16.0	4.8	14.9	62.4	4.9	12.6
BV22	18.9	21.0	15.8	4.1	13.9	61.7	6.9	9.8
BV23	12.9	17.0	15.3	3.9	11.8	49.8	4.1	8.8
BV24	—	34.6	30.0	7.2	—	—	9.2	21.4
BV25	17.2	23.3	19.8	4.2	17.0	66.2	7.3	9.8

PLATES

EXPLANATION OF PLATE 11

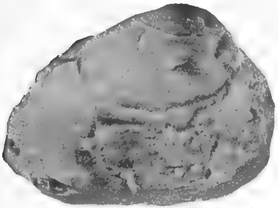
Figure Page

1. **"Edmondia"** sp. 129
Bed ten, Gaptank Fm. USNM, loc. 700a; USNM, No. 155826. Left valve, hint of radial striae shows; X 0.8.

2-6. **"Edmondia"** cf. **"E." subtruncata** Meek 129
Bed ten, Gaptank Fm. 2. Right valve with broad umbone, faint ridge; X 1. 3. Cardinal view; X 1. 4. Subquadrate left valve; umbones sharp, ridge distinct; X 1. 5. Hinge line of left valve; edentulous; depression under beaks housed ligament, below this is transverse ridge. USNM, No. 155827; X 1.8. 6. Right valve of bi-valve specimen; ornament shows. USNM, No. 155828; X 2.2.

7-14. **Pleurophorella costata** (Meek and Worthen) 134
7a. Cardinal view showing two umbonal keels, lunule and escutcheon, thin ligamental groove. Graham Fm., 4 mi. NE. of Jacksboro, Texas, coll. Renfros. USNM, No. 155830; X 1.3. b. Right valve; fine lamellae are between ridges; X 1.3. c. Left valve; X 1.3. d. Enlarged view showing triangular chondrophore just below beaks; X 2.9. 8a. Right valve; ornament extends dorsal to umbonal keel. Seaborne Ls., Fulton Co., Ill., coll. H. C. Wanless. Illinois Geol. Sur. Coll.; X 2.0. b. Cardinal view; X 2.0. 9. Right valve. Bed ten, Gaptank Fm.; USNM, loc. 700a; USNM, No. 155831; X 1.5. 10,11. Pyritized left valves; from the niggersheads over Rock Island Coal, Mercer Co., Ill., coll. H. C. Wanless, 1926; Illinois Geol. Sur. Coll.; X 2.0. 13,14. Types of Meek and Worthen's species. Warren County, Ill. Illustrated specimens came from the same block of limestone, now disjointed. Illinois State Museum, No. 2975. Photographs courtesy Richard Leary, Illinois State Museum, Springfield. 13. Large right valve, probable holotype; slightly oblique view. Two smaller, fragmentary paratypes are below the holotype; X 1.3. 14. Two paratypic left valves; X 1.3.

15. **"Stutchburia" corrucostata Bird,** n. sp. 162
Bed ten, Gaptank Fm.; holotype, USNM, No. 155866. a. Cardinal view of young, bivalve specimen; posterior costae nodose; ligamental area covered by matrix; X 2.0. b. Left valve; costae increase in weight posteriorly; X 2.0. c. Right valve; X 2.0.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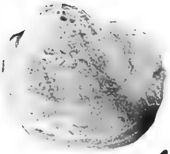
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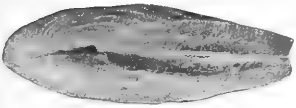
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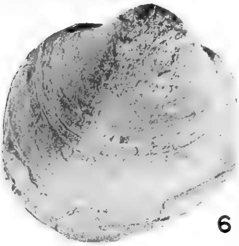
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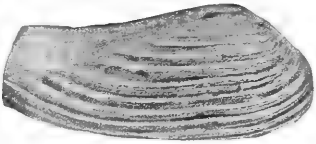
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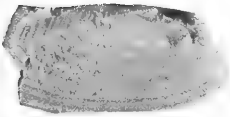
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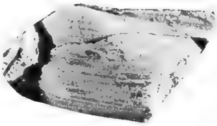
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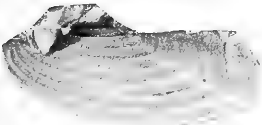
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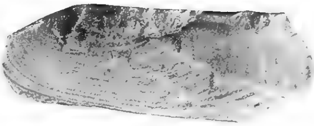
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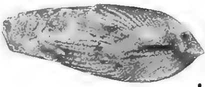
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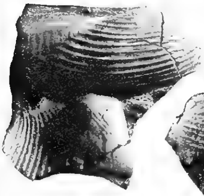
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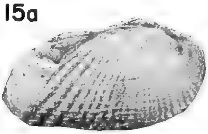
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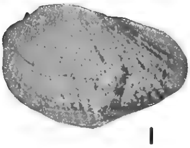
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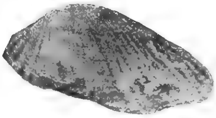
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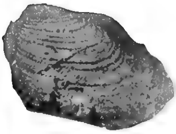
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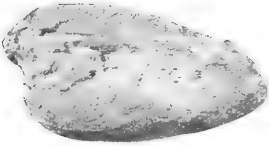
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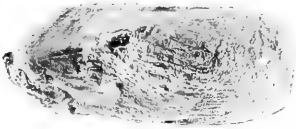
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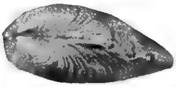
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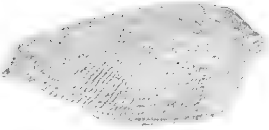
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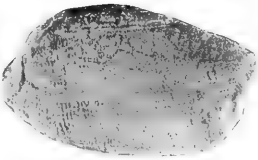
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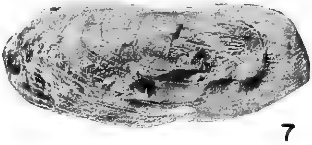
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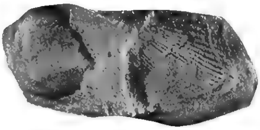
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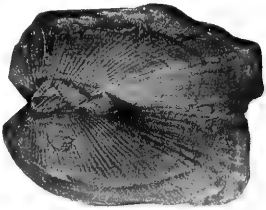
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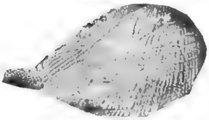
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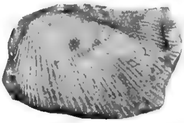
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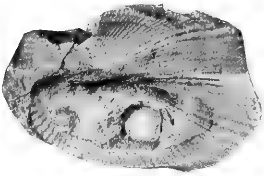
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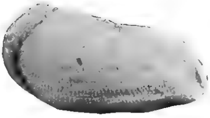
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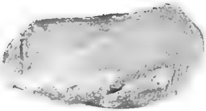
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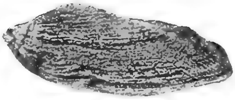
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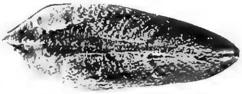
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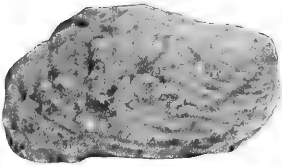
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Explanation of Plate 12

Figure Page

1,2. **"Stutchburia" corrucostata** Bird, n. sp. 162

Bed ten, Gaptank Fm.; paratypes. 1. Large left valve; USNM, No. 155867; X 1.5. 2a. Distorted left valve of bivalve specimen; radial ornament worn; USNM, No. 155868; X 2.7. b. Cardinal view; hinge edentulous; ligamental area obscure; X 2.7.

3. **Cypricardinia questa** Bird, n. sp. .... ;.......... 161

Bed ten, Gaptank Fm.; holotype, USNM, No. 155865. a. Fragmentary left valve of bivalve specimen; fine concentric lines between lamellae seen with hand lens : X 1.6. b. Cardinal view; X 1.6.

4,9. **Grammatodon carbonaria** (Cox) 140

4a. Bivalve specimen; transverse ridge at hinge posterior not a tooth; Gaptank Fm., Marathon Dist., Monument Springs, Texas; coll. King and Girty, 1929; USNM, No. 155838; X 1.6. b. Right valve; rib size unequal; X 1.6. 5. Right valve; Bed ten, Gaptank Fm.; valve corroded; faint medial sulcus; USNM loc. 700a; USNM, No. 155839; X 1.4. 6. Left valve; Bed ten, Gaptank Fm.; USNM, No. 155840; X 2.0. 7. Elongate, posteriorly expanded right valve; USNM loc. 700a; USNM, No. 155841; X 1.4. 8. Right valve; Bed ten, Gaptank Fm.; USNM, No. 155842; X 2.3. 9. Left valve. St. David Ls., Green Co., Ill.; Coll. J. M. Weller, 1928. Illinois Geol. Sur., No. 216; X 1.3.

10,11. **Grammatodon biplicata** Bird, n. sp. 142

Coll. Morningstar near Somerset, Perry Co., Ohio; lower Mercer Ls.; Pottsville Series; Orton Museum, No. 9188, Ohio State University. 10. Holotype; bivalve specimen; costellae coarsen posteriorly; some costae bifid, especially posterior; X 1.4. 11. Paratype; bivalve specimen; flattened costae; X 1.4.

12-14. **Grammatodon erectumbona** Bird, n. sp. 138

12. Paratype; weathered right valve; ribs bifid, irregular in weight; USNM loc. 700a; USNM, No. 155834; X 1.6. 13. Paratype; left valve; USNM loc. 700; USNM, 155852; X 1.9. 14a. Holotype; young left valve; ribs vaguely bifid at this growth stage; USNM loc. 700a; USNM No. 155833; X 2.6. b. Right valve; few ribs bifid; X 2.6.

15. **Grammatodon** cf. **G. kansasensis** (Sayre) 140

Bed ten, Gaptank Fm.; USNM loc. 700a; USNM, No. 155837. a. Long, low left valve; minute costellae near margins of valve; X 2.2. b. Cardinal view; X 2.2.

16. **Wilkingia terminale** (Hall) 131

Bed ten, Gaptank Fm.; USNM loc. 700; USNM, No. 155829; internal mold, right valve; X 1.1.

EXPLANATION OF PLATE 13

Figure Page

1,2. **Grammatodon hexacostata** Bird, n. sp. 139
Bed ten, Gaptank Fm.; USNM loc. 700a. 1a. Holotype; right valve; six ribs in medial sulcus; USNM, No. 155835; X 2.3. b. Cardinal view; X 2.3. 2a. Paratype; right valve; USNM, No. 155836; X 2.0. b. Hinge view, chevrons mark ligamental area; teeth tiny; X 2.0.

3. **Conocardium parrashi** Worthen 144
Bed ten, Gaptank Fm.; USNM, No. 155843. Right valve; X 4.9.

4. **Nuculopsis girtyi** Schenck 137
USNM loc. 700a; USNM, No. 155832. Left valve; X 1.5.

5. **Goniophora gnoma** Bird, n. sp. 149
Bed ten, Gaptank Fm. Holotype; USNM, No. 155847. a. Hinge view; high convexity; two umbonal keels; prominent escutcheon; X 2.5. b. Hinge view, incurved beaks; lunule; X 2.5. c. Oblique view of left valve; X 2.5.

6. **Pteria longa** (Geinitz) 145
Bed ten, Gaptank Fm.; USNM, No. 155844. Right valve; X 3.0.

7. Genus and species not determined 146
Bed ten, Gaptank Fm.; USNM loc. 700a; USNM, No. 155845. a. Hinge view obscured by matrix; X 1.8. b. Left valve; X 1.8. c. Right valve with broad, vague costellae; X 1.8.

8. **"Promytilus" postumbonus** Bird, n. sp. 146
Bed ten, Gaptank Fm.; USNM loc. 700a; holotype, USNM, No. 155846. a. Right valve with deep ventral sinus and sulcus; X 1.9. b. Left valve; X 1.9. c. Cardinal view; X 1.9.

9. **Streblopteria (Streblochondria) semicosta** Bird, n. sp. 159
Bed ten, Gaptank Fm. Holotype; USNM, No, 155862. Right valve; costellae faint, widely spaced; X 2.6.

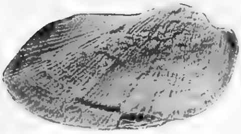
10,11. **Clavicosta** cf. **C. echinata** Newell 152
Bed ten, Gaptank Fm. 10. Right valve with ribs of two weights; USNM, No. 155853; X 2.5. 11. Fragmentary right valve with fluted costae; USNM, No. 155854; X 2.0.

12. **Streblopteria (Streblopteria) obliqua** Bird, n. sp. 155
USNM loc. 700a. Holotype; USNM, No. 155855. Right valve; X 1.6.

13. **Streblopteria (Streblochondria)** aff. **S. (S.) sculptilus** (Miller) 156
Bed ten, Gaptank Fm.; USNM, No. 155858. Right valve; X 2.4.

14,15. **Annuliconcha interlineata** (Meek and Worthen) 151
Bed ten, Gaptank Fm. 14. Left valve; X 2.0. 15. Right valve; USNM, No. 155851; X 3.0.

16,17. **Acanthopecten carboniferus** (Stevens) 150
Bed ten, Gaptank Fm. 16. Right valve; USNM, No. 155849; X 2.6. 17a. Umbonal area enlarged; X 30. 17b. Full view of same left valve; USNM , No. 155850; X 2.0.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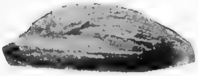
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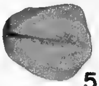
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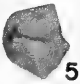
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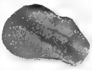
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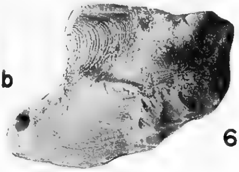
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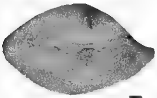
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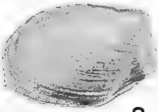
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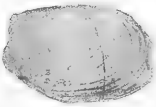
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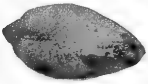
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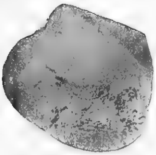
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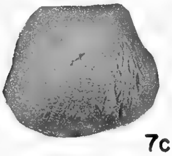
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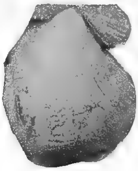
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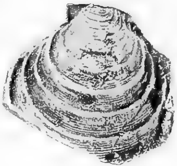
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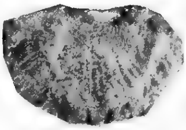
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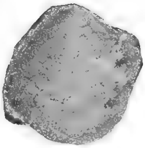
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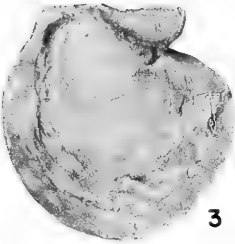
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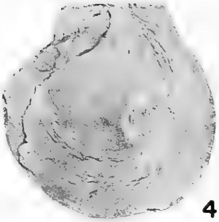
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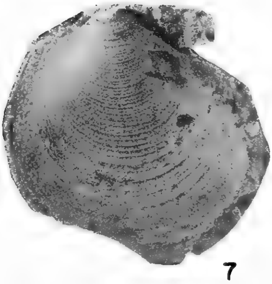
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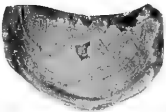
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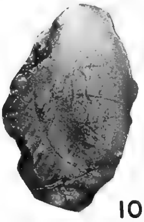
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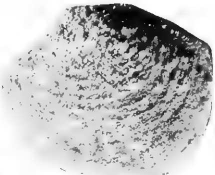
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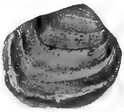
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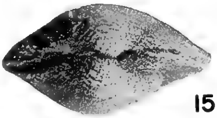
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19a


19b

EXPLANATION OF PLATE 14

Figure Page

1,2. **Streblopteria (Streblopteria)** sp. 155
1. Broken right valve; USNM loc. 700; USNM, No. 155856; X 1.4. 2. Broken right valve; USNM loc. 700a; USNM, No. 155857; X 1.4.

3-6. **Streblopteria (Streblochondria?) tenuilineata** (Meek and Worthen) 158
3-5. Mercer Ls. S.E. of Frazeysburg, Muskingum Co., Ohio; coll. Morningstar, Orton Museum, No. 15289, Ohio State Univ. 3. Opisthocline right valve; umbonal area eroded; X 2.1. 4. External replica of left valve; X 2.1. 5. Worn right valve; auricles markedly low; X 2.1. 6. Bed ten, Gaptank Fm.; USNM, No. 155861. a. Umbonal area of right valve enlarged to show cancellate ornament; X 30. b. Full view; ears typical height; X 2.4.

7,8. **Streblopteria (Streblochondria) fila** Bird, n. sp. 157
Bed ten, Gaptank Fm. 7. Holotype; right valve; prominent fila and vague, fine radial ribbing; coarse crossed lamellar structure; USNM, No. 155859; X 3.3. 8. Paratype; right valve; USNM, No. 155860; X 2.0.

9,18,19. **Astartella varica** McChesney 166
9. Gaptank Fm.; Texas Bureau Econ. Geol., Cat. No. 35393. Left valve; two prominent cardinal teeth; X 1.8. 18,19. Bed ten, Gaptank Fm.; USNM loc. 700. 18. Trigonal right valve; USNM, No. 155869; X 1.5. 19a. Left valve; USNM, No. 155870; X 1.5. b. Right valve; X 1.5.

10,11. **Streblopteria (Obliquipecten)** sp. 160
Bed ten, Gaptank Fm. 10. Broken left valve; part of anterior ear present; broad radial costae of anterior margin atypically prominent; USNM, No. 155863; X 1.6. 11. Larger right valve: anterior ear missing; USNM loc. 700; USNM, No. 155864; X 1.5.

12-17. **Astartella vera** Hall 165
12,13. Topotypes from the Desmoinesian near Springfield, Ill. Walker Museum, No. 13303. Chicago Univ. (now Field Mus. Nat. Hist.) 12. Right valve; X 2.0. 13. Cardinal view; X 2.0. 14,15. Topotypes of *A. gurleyi* White: from the Desmoinesian near Danville, Ill. Walker Museum, No. 13320. Chicago Univ. (now Field Mus. Nat. Hist.) 14. Left valve: X 4.0. 15. Hinge view: X 4.0. 16,17. Heumader Shale (middle Missourian), Elk Co., Kansas, Univ. Wisconsin, 16. Cardinal view; X 2.0. 17. Left valve; lamellae seen with hand lens; X 2.0.

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