MOLLUSKS FROM THE LOWER MIOCENE POLLACK FARM SITE, KENT COUNTY, DELAWARE: A PRELIMINARY ANALYSIS[1]

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ABSTRACT

A previously undiscovered and undescribed assemblage of fossils was first exposed in a borrow pit for road construction near Cheswold, Delaware, in 1991. The assemblage, which consists principally of mollusks, is correlated with one from the Shiloh Marl Member of the Kirkwood Formation of New Jersey. The molluscan assemblage is analyzed, and 104 species are discussed and/or figured. The mollusks appear to have originated in a deltaic setting where fresh-water, brackish-water, and marine mollusks have been mixed and rapidly deposited in a channel.

The site is unique in that it exposes Miocene macrofossil-bearing beds that are only encountered in boreholes in Delaware. The molluscan assemblage is remarkable because of its excellent preservation, the vast numbers of specimens, the co-mingling of mollusks from varied habitats, and the presence of subtropical and tropical taxa so far north. This collection supplements those from the Kirkwood of New Jersey and helps to shed light on a period important in the transition from the climates and molluscan assemblages of the Oligocene to the early Miocene.

INTRODUCTION

In November 1991, personnel at the Delaware Geological Survey requested my help in identifying an assemblage of molluscan fossils from near Cheswold, Kent County, Delaware (Figs. 1 and 2). This collection was obtained from an excavation on the Pollack Farm Site exposed during the Delaware Route 1 road-building project that paralleled the existing U.S. Highway 13, a north-south road that extends the length of the state. In one area, on the Pollack Farm between Smyrna and Dover, 1.2 km (0.75 mi) north of Bishops Corner and just south of the Leipsic River (Little Duck Creek on earlier maps), construction crews had exposed a soft sandy bed packed with shells, the upper shell bed at the site (Benson, 1998, fig. 2). Excavation during the winter of 1991-92 exposed the more extensive and more richly fossiliferous lower shell bed.

A cursory, on-site examination of the shell bed in November indicated it represents a mixed assemblage containing, possibly, Miocene to Pleistocene fossils. Later study of the molluscan assemblage revealed the entire fauna is of early Miocene age, similar to fossils from the Shiloh marl beds exposed and described in Cumberland County, New Jersey. The New Jersey deposits, known principally from exposures on Stow Creek, pits at Jericho and Shiloh, and wells at Millville, Cape May, and Sea Isle City, have been referred to the Kirkwood Formation.

It was clear, early in the study, that the quantity and quality of the newly discovered Delaware fossil material far exceeded any collections from the Miocene of New Jersey and was the first significant Miocene material from Delaware. A study of the existing literature on the New Jersey Miocene mollusks (Heilprin, 1888; Whitfield, 1894; Dall and Harris, 1892; Pilsbry and Harbison, 1933; Richards and Harbison, 1942) made it clear that much of the material available to those early workers was fragmentary and sparse. On the other hand, descriptions of Miocene fossils from Delaware are nearly nonexistent. The only worker who mentioned Miocene mollusks was Booth (1841), who mentioned only molds and casts. Later workers who bothered to mention the Miocene of Delaware (Dall and Harris, 1892; Miller, 1906) merely referred to the observations of Booth. It also was clear that the Pollack Farm excavation was one with an expected short life and needed intense study while it was still available. Accordingly, the site was visited and collected almost weekly from November 1991 until September 1992. Shortly thereafter, the fossiliferous portion of the pit was again covered. Because of this short life, collections from the pit were large and duplicative. Most of the molluscan material is housed at the Virginia Museum of Natural History. Duplicate material has been distributed to the Delaware Geological Survey and the National Museum of Natural History.

The relative rarity of available Miocene fossil material in New Jersey and especially Delaware made the discovery of the shell bed at the Pollack Farm Site very important. The collection will enable paleontologists to identify mollusks previously known only from fragments, and it has also provided a number of new taxa, previously unknown and unexpected, in so old a unit and so far north a location. Additionally, the knowledge of previously known taxa has been expanded by virtue of the large numbers of specimens collected.

This fossil deposit has provided a large array of data concerning the first appearances of various taxa and the last appearances of others. It contains a number of taxa that appear in Delaware in the early Miocene and do not reappear until the late Pliocene in Virginia or farther south. The assemblage has a number of species that are clearly European emigrants and others that only could have arrived from a southern route. It contains a surprising mixture of temperate, subtropical, and tropical taxa as well as brackish, back-barrier, shallow shoreface, and open-marine taxa.

Because of its large size and diversity, the molluscan collection from the Pollack Farm Site is invaluable. It is probably most important because it helps to fill a gap in our knowledge of the period after deposition of the upper Oligocene/lower Miocene Belgrade Formation in North Carolina and before deposition of the Plum Point Marl Member (Bed 10) of the Calvert Formation in Maryland. The Delaware fossils record the transitional event when the middle Atlantic continental margin changed from a tropical setting to a temperate one. This temperate environment, with thriving molluscan populations, persisted until the late Pliocene when a severe cooling event caused the extinction of many of the taxa.

[1] *In* Benson. R.N., ed., 1998, Geology and paleontology of the lower Miocene Pollack Farm Fossil Site, Delaware: Delaware Geological Survey Special Publication No. 21, p. 59–131.
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lower blue clay overlain by a ferruginous sandstone with molds of mollusks. At "Wales' mill-dam" Booth (1841) reports the presence of the following fossils (molds):

Mactra sp.	*Venus alveata*
Balanus sp.	*Venus inoceroides*
Serpula sp.	*Nucula laevis*
Cardium sp.	*Myoconcha* sp.

This is the first and only list of Miocene molluscan fossils from Delaware, unless those from the borehole at Brandywine lighthouse in Delaware Bay are included, said by Richards and Harbison (1942) to come from a few hundred yards inside New Jersey.

Later descriptions of Tertiary deposits in Delaware have been brief and based mainly on the comments of Booth (1841). Some of these papers are by F. D. Chester (1884) and Dall and Harris (1892). Shattuck (1904) concluded that Delaware was so covered by Pleistocene sands and gravels that the underlying formations were obscured and difficult to determine. Miller (1906) mapped the 30-minute Dover quadrangle in the U.S. Geological Survey's Geologic Atlas–Folio Series. In the accompanying text, he repeated much of the data from Booth but included a well log from Dover. Miller (1906) also referred the Miocene beds on the Dover sheet to the Calvert Formation, which had recently been described by Shattuck (1902, 1904). The present practice of the Delaware Geological Survey is to include those beds in the Calvert (Benson et al., 1985; Benson and Spoljaric, 1996).

Another name, the Kirkwood Formation, was proposed for correlative Miocene beds of similar lithology and molluscan composition just to the northeast across Delaware Bay in New Jersey. The Kirkwood appeared in Knapp's (1904) description of the beds in the Coastal Plain Province section. The description was enlarged upon by Kümmel (1909); two members, the Alloway Clay and the Shiloh Marl, were named by Ries et al. (1904). These names are approved for use as mappable units by the Geologic Names Committee of the U. S. Geological Survey (Swanson et al., 1981), though they are rarely used.

Jordan (1962) reviewed the nomenclature of the Miocene stratigraphy in Delaware and assigned those strata to the Chesapeake Group, undifferentiated. Owing to the lack of well developed control by deep wells at that time, Jordan did not recognize the formations of the Chesapeake Group of Maryland. It was clear to him that the Kirkwood lithologies should interfinger with the Maryland ones, but lacking stratigraphic precision, the name Chesapeake Group was preferred. Jordan (1962) did recognize informal aquifer units within the Chesapeake Group, however, one of which is the Cheswold. The sands exposed at the Pollack Farm Site are the Cheswold sands, an informal unit of the Calvert in Delaware (Benson, 1998). Benson (1990), in a study of a borehole near Lewes, Delaware, described the Miocene beds and subdivided them into the Calvert, Choptank, and St. Marys formations on the basis of geophysical log correlation to Maryland Eastern Shore boreholes where the formations are recognized in the subsurface.

It appears, after studying the sediments from the type locality of the Calvert Formation in Maryland and those of the type locality of the Kirkwood Formation in New Jersey, that the two units interfinger in the area of Delaware (Fig. 3; see also Benson, 1998). The New Jersey type area of the Kirkwood and the area around Kent County, Delaware, clearly were sites of deltaic accumulation, where large amounts of coarse clastic material were prograding basinward toward the southwest where finer sediments, typical of the type Calvert, were being deposited.

The beds exposed in the type area of the Kirkwood are lithologically similar to, and contain many of the same fossils as, those at the Pollack Farm Site in Delaware. The mollusks, most of which depended on a clayey-silty-sand substrate to support life and growth, apparently could not survive on silty or clayey bottoms. The result was mollusks abound in the sandy facies of the beds but become rare to absent in the regions where soft, soupy bottom conditions prevailed, remote from areas of coarser sediment deposition. For this reason the abundantly shelly sands found in New Jersey and Delaware can be traced only as far as the Eastern Shore of Maryland. Equivalent beds that appear on the western shore of Chesapeake Bay are silts and clayey silts, which have only fragile poor molds in them.

All of these facies, however, contain a key diatom that allows correlation from Maryland to New Jersey. *Actinoptychus heliopelta* is abundant in the Kirkwood of New Jersey, is present at the Pollack Farm Site in Delaware, and is found in only one of Shattucks's (1904) "zones" (beds). Andrews (1978, 1988) based his East Coast Diatom Zone (ECDZ) 1 on the appearance of *A. heliopelta* and found it only in the lower 3 m (10 ft) of Shattuck's (1904) Bed 3. This bed is exposed along the Patuxent River (see Shattuck, 1904, p. LXXXVI, section 1; Ward, 1992, p. 47, fig. 31) where it consists of a diatom-rich silty clay. An indurated sand (Bed 2) at its base, containing molds of mollusks, probably represents the basal transgressive facies of this unit. The diatom bed, termed Bed 3-A by Andrews (1988) and Ward (1992), can be traced across Maryland, Delaware, and New Jersey in the subsurface. Benson (1990, 1998), however, shows that in subsurface rocks of Delaware, *A. heliopelta* has a long stratigraphic range, almost the entire lower Miocene, and although not useful for high resolution biostratigraphy, it is a good marker for recognition of the lower part of the Calvert Formation and its equivalents in New Jersey.

The molluscan assemblage in the Kirkwood Formation also contains a number of marker species that help to correlate that unit with the Calvert in Delaware and Maryland. Those taxa from the Delaware site are the main topic of this paper, but species listed and figured by Shattuck (1904) from Centerville, Church Hill, and Tilghman Station made it possible to trace the Kirkwood-equivalent beds across the Eastern Shore of Maryland. Those equivalents are present across Chesapeake Bay, but their sediments are finer as they were deposited distally from the deltas in New Jersey and Delaware, and they no longer could support a well developed benthic molluscan population.

The coarse to fine shelly sands exposed at the Pollack Farm Site are most similar to the Shiloh Marl Member of the Kirkwood Formation, but the muddy units above the sands are much more like the finer-grained Calvert Formation. The sandy beds of the Kirkwood, which thin and finally pinch out to the southwest, might best be termed tongues of the Kirkwood that extend deep into the Calvert Formation. Until these relationships are resolved using various subsurface stratigraphic techniques, the shelly sands at the Pollack Farm Site are considered to be an exposure of the informal unit, the Cheswold sands, of the lower Calvert Formation (Benson, 1998).

MOLLUSCAN BIOSTRATIGRAPHY AND CORRELATION

The molluscan assemblages of the Kirkwood Formation and the Pollack Farm Site are clearly intermediate in stratigraphic position between the well-known Calvert Formation, Plum Point Marl Member, Bed 10 assemblage (above), and that of the Haywood Landing Member of the Belgrade Formation in North Carolina (below). It falls within Ward's (1992) Interval-zone M13. The lower boundary of M13 is marked by the appearance of *Pecten humphreysii* (appears first in Calvert Bed 2) and the upper boundary by the appearance of *Marvacrassatella turgidula* (appears first in Calvert Bed 14). It is here proposed that the lower portion of Interval-Zone M13 be called Subzone M13-A (Fig. 3). This subzone is characterized by the presence of *Astarte distans* Conrad; this species is common in the type Kirkwood in New Jersey, abundant in the Pollack Farm beds in Delaware, and present in the G.D. Harris collections from Tilghman Station (USGS 2361, 2362, 2363) and Centerville, Maryland (USGS 2360), at the National Museum of Natural History.

Tables 1 and 2 show the distribution of the molluscan taxa from the Pollack Farm Site in the Oligocene, Miocene, and Pliocene beds of the middle Atlantic Coastal Plain. The Pollack Farm species are plotted in the Fairhaven Member, Beds 2–3A, and are annotated according to their abundance. Several of the taxa also occur in the older Oligocene unit, the Haywood Landing Member of the Belgrade Formation. Some of these taxa are:

Mytilus incurva Conrad	*Mya producta* Conrad
Stewartia anodonta (Say)	*Bicorbula idonea* (Conrad)
Tagelus plebeius ssp.	*Turritella tampae* Heilprin
Semele subovata (Say)	*Calyptraea aperta* (Solander)
Leptomactra marylandica (Dall)	

The Pollack Farm assemblage has its clearest affinities to the "Plum Point" fauna of Glenn (1904) and Martin (1904) (=Bed 10 of the Plum Point Marl Member of the Calvert Formation). The two units share over 50 species, but the beds in Delaware contain a number of stratigraphically confined taxa that should facilitate their recognition in field and subsurface work. Some of the more notable include:

Bivalves

Dallarca sp.	*Glossus* sp.
Astarte distans Conrad	*Iphigenia* sp.
Astarte sp.	*Caryocorbula subcontracta* (Whitfield)
Cyclocardia castrana (Glenn)	

Gastropods

Turritella cumberlandia Conrad
Diastoma insulaemaris (Pilsbry and Harbison)
Epitonium charlestonensis Johnson
Urosalpinx cumberlandianus (Gabb)
Tritonopsis ecclesiastica (Dall)
Nassarius sopora (Pilsbry and Harbison)
Oliva simonsoni new species
Inodrillia whitfieldi (Martin)

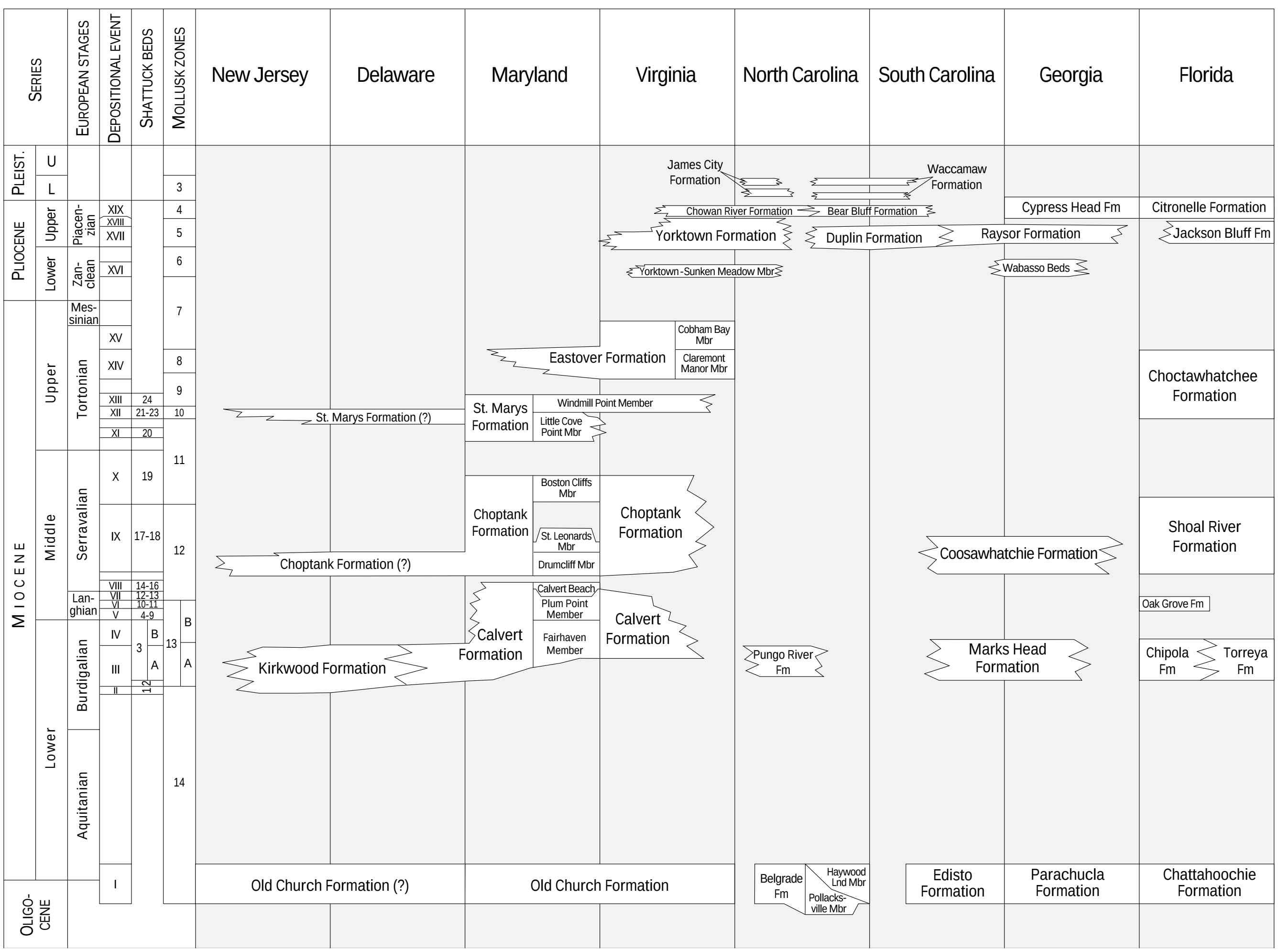

Figure 3. Correlation chart showing stratigraphic relations, based on molluscan biostratigraphy, of the outcropping geologic units referred to in this study.

Table 1.—Gastropod and scaphopod occurrences. Data for Bed 2–3A includes the taxa found at the Pollack Farm site.

STRATIGRAPHY / Gastropoda & Scaphapoda	Belgrade Formation	Calvert Formation						Choptank Formation			St. Marys Formation			Eastover Formation		Yorktown Formation		
	Haywood Landing Mbr.	Fairhaven Member				Plum Pt. Mbr.								Clare. Mbr.	Cob. Mbr.	S. M. Mbr.	R./M.B. Mbrs.	M. H. Mbr.
		1	2–3A	4–9	10–11	12–13	14–16	17	18	19	20	21–23	24					
GASTROPODA																		
Diadora griscomi (Conrad)	G		R															
Tegula marylandicum (Martin)			C		R													
Calliostoma eboreus (Wagner)			C		X													
Littorina sp.			U															
Caecum calvertense Martin			R		X													
Solariorbis lipara (H. C. Lea)			R		X					X		X	X	X	X	X	X	X
Teinostoma nana (I. Lea)			R									X X	X		X	X	X	X
Diastoma insulaemaris (Pilsbry & Harbison)			A															
Carinorbis dalli (Whitfield)			A		C													
Turritella cumberlandia Conrad			C		?													
Turritella tampae Heilprin	X		C															
Turritella plebeia subspecies			R															
Serpulorbis granifera (Say)			C		X								X	X	X	X	X	X
Crepidula fornicata Linné			A		X					X		X X	X				X	X
Crepidula plana Say			R		X			X				X	X				X	X
Calyptraea centralis (Conrad)			R										C					X
Calyptraea aperta (Solander)	X		A		X		?											
Crucibulum costatum (Say)			U		C		X			X		X X	X	X	X			
Polinices duplicatus (Say)			A		X		X			X		X X	X	X	X	X	X	X
Lunatia hemicrypta (Gabb)			P		X													
Lunatia heros (Say)			A		X		X			X		X X	X	X	X	X	X	X
Sinum chesapeakensis Campbell			P		P		X					X X	X				X	X
Ficus harrisi (Martin)			R		P													
Seila adamsii (H. C. Lea)			U		X					X		X X	X		X	X	X	X
Epitonium charlestonensis Johnson			R															
Melanella migrans (Conrad)			R		X													
Melanella eborea (Conrad)			R		X					X		X X	X				X	X
Murexiella cumberlandiana (Gabb)			R		P													
Urosalpinx subrusticus (d'Orbigny)			C									X X	X					
Typhis acuticosta (Conrad)			R		X							X X	X					
Cymia woodii (Gabb)	G		A		R													
Tritonopsis ecclesiastica (Dall)			U															
Ecphora tricostata Martin	G		C	P	C													
Chrysodomus patuxentensis Martin			R		X													
Siphonalia devexa (Conrad)			C		X													
Ptychosalpinx sp.			R															
Mitrella c. mediocris Pilsbry & Harbison			P															
Nassarius trivitattoides (Whitfield)			C		X													
Nassarius trivitattoides elongata (Whitfield)			P		X													
Nassarius spopora (Pilsbry & Harbison)			A															
Metula sp.			R															
Busycotypus scalarispira (Conrad)	G		C		X													
Scaphella virginiana Dall			P		P					P								
Scaphella solitaria (Conrad)			C		X								X					
Oliva simonsoni Ward			A															
Trigonostoma biplicifera (Conrad)	G		P		P													
Cancellaria alternata Conrad			C		P													
Cymatosyrinx limatula (Conrad)			P		X							A	A					
Polystira communis (Conrad)			C		?							A	A					
Leucosyrinx rugata (Conrad)			P		X													
Inodrillia whitfieldi (Martin)			C															
Terebra inornata Whitfield			C										X					
SCAPHAPODA																		
Cadulus conradi Pilsbry & Harbison			R		G		G G			G		G G	G	G	G	G	G	G

KEY: U–uncommon; P–present; C–common; R–rare; A–abundant; E–exists at this horizon in equivalent formations; ?–species closely resembles; G–genus present.

Table 1. Occurrence chart for the Gastropoda recovered from the Pollack site.

Table 2.—Bivalve occurrences. Data for Bed 2–3A includes the taxa found at the Pollack Farm site.

STRATIGRAPHY	Belgrade Formation	Calvert Formation						Choptank Formation			St. Marys Formation			Eastover Formation		Yorktown Formation		
	Haywood Landing Mbr.	Fairhaven Member				Plum Pt. Mbr.								Clare. Mbr.	Cob. Mbr.	S. M. Mbr.	R./M.B. Mbrs.	M. H. Mbr.
BIVALVIA		1	2–3A	4–9	10–11	12–13	14–16	17	18	19	20	21–23	24					
Nucula prunicola Dall			C		X													
Nucula taphria Dall			R					X					X				X	X
Nuculana sp.			R															
Nuculana liciata (Conrad)			R		X													
Yoldia sp.			C															
Dallarca (?) subrostrata Conrad			A		X													
Dallarca sp.			A															
Glycymeris parilis (Conrad)			A		X													
Mytilus (Mytiloconcha) incurva Conrad	C		A		C		P	P									E	
Modiolus ducatellii (Conrad)			P		P		P P	P		P		P	P	P	P		P	P
Isognomon (Hippochaeta) sp.			P		P		C A	A		P		P	P	A	A			
Crassostrea virginica (Gmelin)			A															
Pecten humphreysii woolmani Heilprin			P	P	C													
Chesapecten coccymelus (Dall)			C	P	A													
Chesapecten sayanus (Dall)			A		R													
Parvalucina crenulata (Conrad)	A		U		C		P	C		C		C	C		C	P	C	C
Stewartia anodonta (Say)			A		A			C		C		C	C		C	A	C	C
Carditamera aculeata Conrad			C															
Cyclocardia castrana (Glenn)			A															
Marvacrassatella melinus Conrad			A		A													
Astarte distans Conrad			A															
Astarte sp.			A															
Dinocardium sp.	G		A															
Chesacardium craticuloides (Conrad)			A		A													
"Cardium" calvertensium Glenn			P		U		C											
Leptomactra marylandica (Dall)	?		P															
" Mactra" sp.			A															
Ensis directus Conrad			P		X		X	X		X		X	X	X	X	X	X	X
Strigilla sp. cf. *S. georgiana?* Gardner			P															
Florimetis biplicata (Conrad)			P															
Semele subovata (Say)			P					X		X		X	X					
Tagelus plebeius subspecies	X		C															
Donax idoneus subspecies	X		P															
Donax sp.	?		P															
Iphigenia sp.			C															
Mytilopsis erimiocenicus Vokes			A															
Glossus sp.			R															
Lirophora latilirata (Conrad)			A		A	G	G						G	G	G		G	G
Mercenaria ducatelli (Conrad)	G		A															
Dosinia acetabulum blackwelderi Ward			A		C		C	C		C								
Macrocallista marylandica (Conrad)	G		A		C		X	A		A		R?						
Clementia grayi Dall			P		G					G	G	G	G					
Mya producta Conrad	X		C					X										
Caryocorbula cuneata (Say)			P		X		X	X		X		X	X	X	X	X	X	X
Caryocorbula subcontracta (Whitfield)			P															
Varicorbula elevata (Conrad)			R	A	C													
Bicorbula idonea (Conrad)	X		R		X			A		C				R				
Panopea americana Conrad			P		X			C		C								
Panopea whitfieldi Dall	?		P		?													
Thovana sp.			R															
Martesia ovalis (Say)			P					X										
Periploma peralta Conrad			C									X						

KEY: U–uncommon; P–present; C–common; R–rare; A–abundant; E–exists at this horizon in equivalent formations; ?–species closely resembles; G–genus present.

Table 2. Occurrence chart for the Bivalvia recovered from the Pollack site.

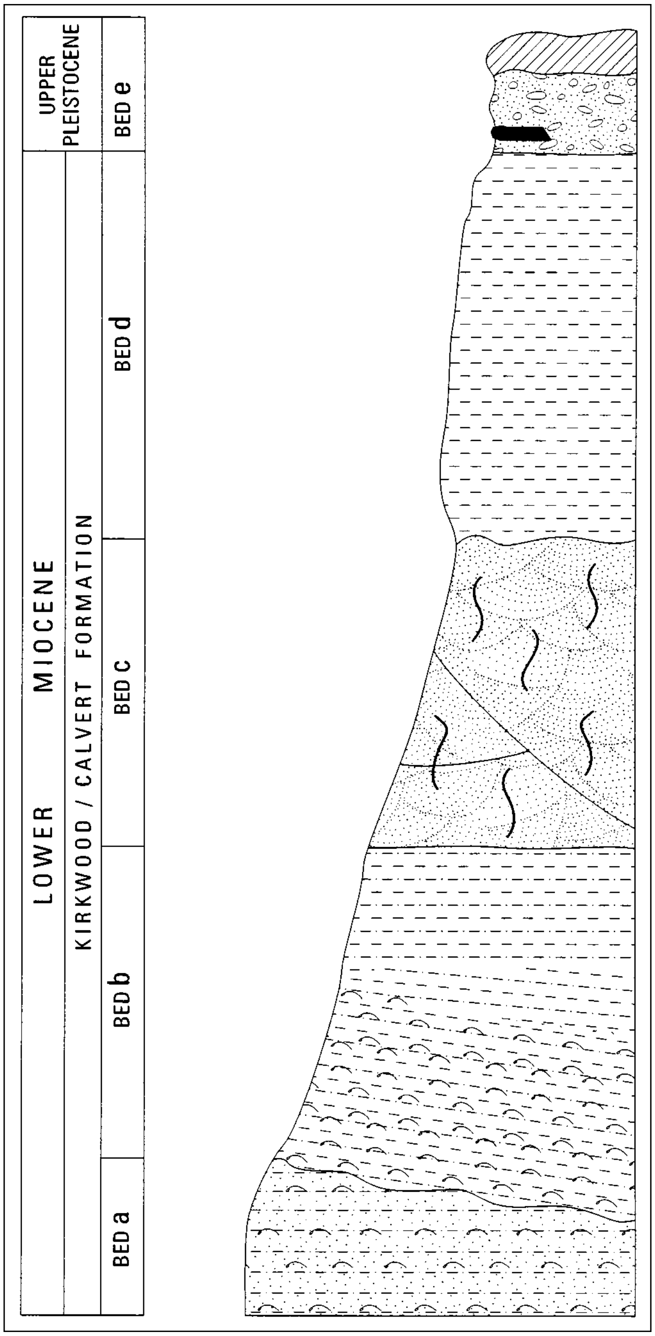

Figure 4. Composite stratigraphic section exposed at the Pollack Farm site and referred to in this study. For comparison with the composite section of (1) Benson (1998, fig. 2), bed a=shelly mud bed; bed b=lower shell bed, lower sand, and parallel-bedded sand including sandy silts with radiolarians and diatoms; bed c=cross-bedded sand, including upper shell beds; bed d=upper mud; and bed e=Columbia Formation; with (2) Ramsey's (1998, fig. 9) lithologic units, bed a=shelly mud; bed b=lower shell, lower sand, and interbedded sand and mud; bed c=cross-bedded sand; bed d=upper mud; and bed e=Columbia Formation.

It can be seen from tables 1 and 2 that the Pollack Farm collection contains a number of taxa best known from the St. Marys or other formations. The appearance of these taxa gave early workers the impression the Shiloh, New Jersey, assemblage was mixed with younger species and was reworked. The Pollack Farm collection helps to make clear the origin and stratigraphic position of the assemblage. No taxa are suspected of being reworked from older or younger beds.

On the basis of its molluscan and diatom assemblages, the Kirkwood and its Delaware equivalent are correlative with a number of stratigraphic units from New Jersey to Florida. In addition $^{87}Sr/^{86}Sr$ data have helped to corroborate these correlations (see Jones et al., 1998). In the Pungo River Formation, northeastern North Carolina, the presence of the Pollack Farm *Chesapecten sayanus* (Plate 11, Figure 5), and the diatom *Actinoptychus heliopelta* indicates with certainty the Kirkwood is stratigraphically equivalent with that unit. In southeastern South Carolina and northeastern Georgia, the Marks Head Formation, as described by Huddlestun (1988), is also a stratigraphic equivalent of the Kirkwood. In addition, the Torreya Formation and Chipola Formation of western Florida are equivalents (Huddlestun, 1988; Bryant et al., 1992).

PALEOENVIRONMENTAL SETTING

The entire molluscan assemblage reflects a number of environments, all consistent with deltaic and marginal marine settings. The abundance of *Crassostrea virginica* and *Mytilopsis* indicate brackish water conditions. The overwhelmingly marine fauna, however, indicates normal marine conditions. A number of the snails are usually found in intertidal, mudflat environments, while some of the clams, such as *Donax*, suggest high-energy, shoreface settings.

The general stratigraphic sequence was well exposed in the sides of the Pollack Farm borrow pit (Fig. 4). The excavation bottomed in a dark gray, silty sand (Bed a) with scattered *in situ* mollusks, many in living position (Fig. 5). At one time, over 2 m of Bed a were exposed. The upper surface of this sand (Bed a) is somewhat uneven, and, in one area, a shallow channel was cut into it. In this channel, a steeply cross-bedded, well-sorted array of clean sand and shells (Bed b) was deposited. At the deepest part of the channel, Bed b is approximately 4 m thick (Fig. 6). Most of the shell consists of broken and rolled fragments, but many whole and a few very fragile mollusks are buried in this coarse matrix. No specimens were found as paired valves or in living position in the channel deposit. The molluscan diversity is greatest in this bed, and it is clear that all of the taxa had been transported at least a short distance and rapidly buried in the channel. At various locations, thin strata of

Figure 5. Beds exposed in the lowest part of the excavation at the Pollack Farm Site. Bed a, a dark grayish green, silty sand, occupies the lowest 1.0 m in the photograph. The very shelly sands of bed b are in sharp contact with the underlying bed a. Within bed b, a thin discontinuous bed of blue-green clay is exposed (arrow) that may have originated when the channel was cut off for a short period.

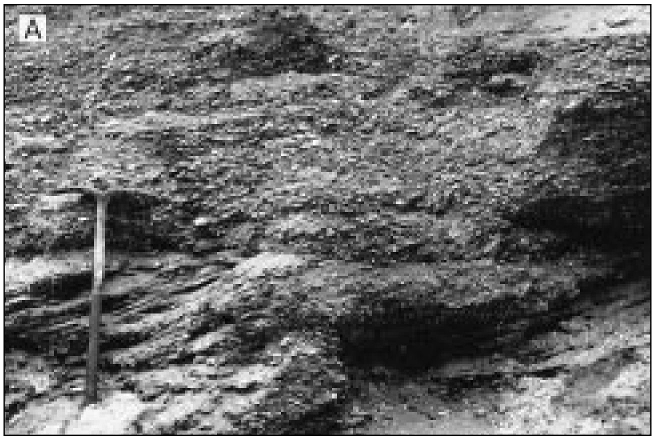

Figure 6A. Bed b showing the cross-bedded, size-sorted nature of the principal mollusk-producing unit.

Figure 6B. Bed b showing the cross-bedded, imbricated nature of the shell accumulation.

blue-green clay are present in the shelly sands. These clay stringers are somewhat lensoid and discontinuous (Fig. 5). Bed b fines abruptly upward into a cross-bedded, clean, fine sand (Bed c). This sand exhibits delicately preserved flaser bedding and trace fossils (Fig. 7) and is about 4 m thick. Most of the trace fossils appear to be *Ophiomorpha* burrows, but a number of smaller, worm-like tubes are also preserved. Within the sand body, a few small, scattered, lens-shaped channels were cut and filled with a laminated clayey silt (Fig. 8). Above the fine burrowed sands, a laminated silty clay (Bed d) was exposed, which is as much as five meters thick (Fig. 9). This clay has some small molds of mollusks in the lower portions, but these are indeterminate. The contact between the cross-bedded sand (Bed c) and the clay (Bed d) is sharp and abrupt, but there is no lag deposit or other indication of a diastem. Rather, it appears to be an abrupt transition between environmental regimes. The laminated clay is overlain by a 1.5-m-thick, gravelly, cobbly sand containing rare, large, silicified tree trunks (Bed e; Fig. 9).

The sequence of the lower four units is interpreted to be a series of beds deposited in a prograding deltaic setting. Bed a appears to be a nearshore, open-marine, quiet water setting. *Mytilus, Mercenaria, Panopea, Astarte,* and *Clementia* all occur scattered throughout the bed, in living position, and are not concentrated in any one horizon. The channel cut into the upper surface of Bed a could be the result of tidal scour or it could be the channel cut by an outflowing river at the mouth of a delta. The entire extent of the channel was not fully exposed in the small excavation at the Pollack Farm. The amount of coarse material in Bed b that infilled the channel indicates strong currents and a nearby sediment source. The interpretation is that most of the mollusks were shallow-water, near-shore in origin, and were swept into the channel and preserved. The presence of brackish-water and mud-flat dwelling taxa in an otherwise marine shelf assemblage could be explained by the cutting of a channel through a barrier or by the migration of a barrier island shoreward, during which the transgressive beach erosion incorporated older, back-barrier

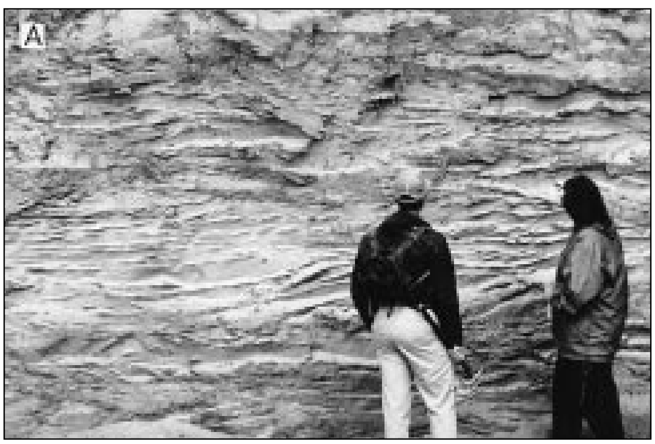

Figure 7A. Bed c, a fine, cross-bedded sand overlying bed b.

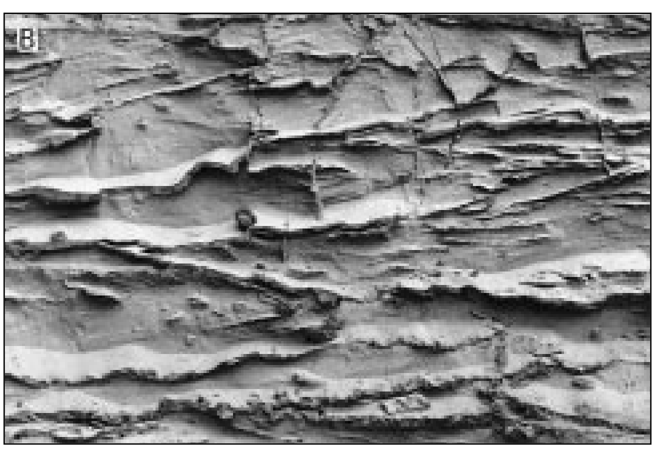

Figure 7B. A closeup of bed c showing the flaser-like bedding of the clean fine sand and the *Ophiomorpha* burrows that run vertically and horizontally in the bed.

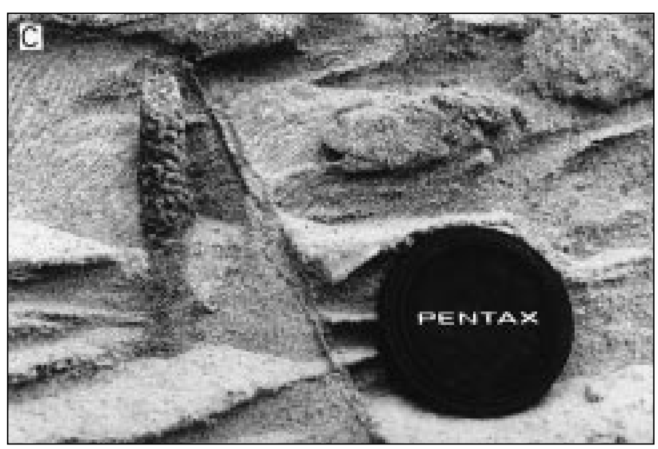

Figure 7C. Detail of one of the exposed *Ophiomorpha* burrows to the left of the lens cap.

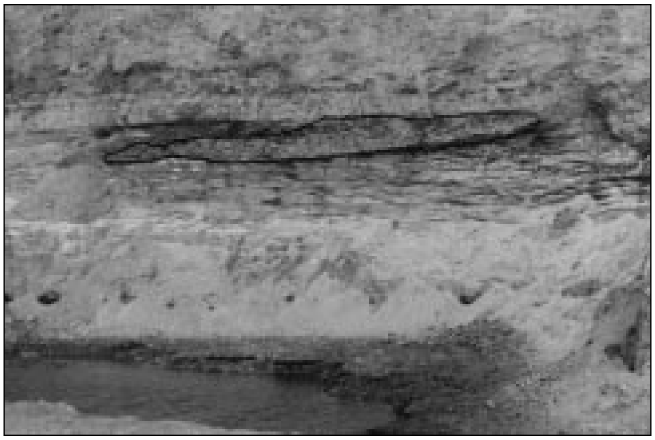

Figure 8. Bed c, with a small channel filled with a lens-shaped bed of laminated clay. Such clay bodies are believed to represent intermittent closures of active channels. The resulting quiet conditions allowed the fine sediments to settle before the channel was reopened.

Figure 9. Southwest corner of the pit showing the light-colored sands of bed c overlain by the laminated clays of bed d and the gravelly, cobbly sands of bed e. Bed d may represent back-barrier, quiet water conditions. It contains only a few poor molds of mollusks.

taxa in the marine fauna. Rare fresh-water snails are believed to have been derived from fresh water ponds on the barrier islands or deltaic lobes. The fine blue clays that appear as very thin lenses in otherwise coarse shelly sand may reflect periods when the channel became blocked and the ensuing very quiet water allowed silts and clays to settle out. The channel then reopened, and coarse sedimentation resumed. Bed b generally fines upward and the shell content decreases dramatically. This may be partly due to dissolution. The fine cross-bedded sand (Bed c) that overlies the channel deposit still reflects marine influences but appears to be farther up-delta. Bed c contains abundant *Ophiomorpha* burrows probably built by callianassid types of crustaceans. These and other forms of burrows occur in fine, very well-sorted quartz sand and indicate high energy conditions where sediments bypassed. A few small lens-shaped channels within Bed c are filled with laminated clay. These probably represent short-lived cutoffs in which clays and silts could settle. The thick sequence of laminated clay, Bed d, that overlies the sands of Bed c may represent lagoonal deposits behind a barrier island. The poor molds of mollusks present in the unit make it difficult to interpret. It is part of the Kirkwood–Calvert sequence at the Pollack Farm Site. The overlying gravelly, cobbly sand, Bed e, is a Pleistocene fluvial deposit and is included in the Columbia Formation.

MOLLUSCAN COMPOSITION AND ANALYSIS

The molluscan composition at the Pollack Farm Site represents a mixed assemblage of brackish and normal-saline marine taxa. It also includes back-barrier, intertidal, shoreface, and shallow shelf forms. This mixture of environmental regimes has served to accumulate one of the most curious assemblages of the Atlantic Coastal Plain. Very nearshore, brackish water, and back-barrier settings are rarely preserved in the stratigraphic record on the Atlantic Coastal Plain as the later transgressions tend to bevel off the regressive sediments of the previous depositional sequence. For this reason the Pollack Farm assemblage is very important, because it gives us access to a part of the fauna that is usually lost.

It is also clear that this assemblage contains a mixture of tropical, subtropical, and temperate taxa that probably has no Holocene counterpart. Subsequent Calvert, Choptank, St. Marys, and Eastover transgressive events apparently never reached the warm water conditions present in the middle-late early Miocene. Not until the late Pliocene did some of the taxa common in the Pollack Farm beds reappear in the middle Atlantic. Some of these taxa are *Strigilla* and *Dinocardium*. Others have never been recorded at all, such as *Iphigenia* and *Mytilopsis*.

The specifics on each of the molluscan taxa are discussed in the systematics section. It is clear that the Pollack Farm assemblage reflects a tropical to subtropical, shallow-shelf assemblage, situated near a freshwater, deltaic influence. A number of taxa made their first appearance in the western Atlantic at that time after being present in the eastern Atlantic during the Oligocene. A number of taxa are subtropical to tropical forms that made their last appearance until conditions warmed up again in the late Pliocene. The bulk of the assemblage consists of taxa, arriving just before a period of cooling, that continued to thrive in the Miocene and Pliocene in the Salisbury Embayment and characterized the temperate environment for millions of years. Some of these taxa are *Isognomon, Glossus, Dallarca, Chesapecten, Marvacrassatella, Chesacardium, Leptomactra,* and *Ecphora*.

A number of individual taxa present add significantly to our knowledge of Coastal Plain mollusks. The presence of *Crassostrea virginica* was a surprise and is the only known occurrence of that species stratigraphically below the upper Pliocene in North Carolina. The same is true of *Dinocardium*, a subtropical to tropical genus. It is not seen again until the late Pliocene in North and South Carolina. *Strigilla* follows this same pattern, emerging in the late Pliocene. I can find no record of *Iphigenia* on the Atlantic Coastal Plain. *Crepidula fornicata* made its first appearance in the Delaware Miocene and was as large then as Holocene individuals of the species. *Polinices duplicatus* and *Lunatia heros* first appeared and are also as large as their Holocene counterparts. Some specimens of *Urosalpinx* exceed in size any known species of the genus. The *Busycon* are nearly as big as the largest specimens found today. It could be expected that genera such as *Urosalpinx* and *Busycon*, and species such as *C. fornicata, P. duplicatus,* and *L. heros* might have made their first appearances in the Tertiary as relatively small individuals, with a trend towards increasing size with time. These taxa, however, appeared first as large as Holocene specimens.

Figure 10. Gordy Simonson (site foreman) at work with backhoe at the Pollack Farm Site. Simonson stacked piles of material from bed b and then washed them down with bucket loads of water from the containment pond. Since the matrix in bed b consists of soft, unconsolidated, clean sand, the contained shell material was immediately exposed.

PREVIOUS WORK ON KIRKWOOD AND EQUIVALENT MOLLUSKS

Previous work on the Kirkwood mollusks involves only a few authors. T.A. Conrad named several species in the early 1800s, Gabb named a few in the middle 1800s, and Heilprin named a few more in the late 1800s. The first comprehensive study on the Miocene mollusks of New Jersey was that of Whitfield (1894), who monographed the fauna based on existing collections. Dall (1898) made some corrections and additions to this work and in 1903 discussed the origin of the Miocene fauna in New Jersey.

Martin (1904) and Glenn (1904) named several species from Church Hill and Centerville, Maryland, that occur in the bed (Shattuck's Bed 3-A) stratigraphically equivalent to the Kirkwood and might be considered a tongue of that formation. In addition, many of the species that they treated from the Calvert, Choptank, and St. Marys also occur in the Kirkwood. Pilsbry and Harbison (1933) had material from a number of cores in the New Jersey Coastal Plain available to them, and they named several new taxa. The last comprehensive report on the New Jersey Miocene was that of Richards and Harbison (1942). They figured all of the taxa previously named and also named several new ones. Stratigraphically equivalent strata in Florida received much attention from Dall (1890–1903), Maury (1902, 1910), and Gardner (1926–1950) who studied the Chipola Formation. Several taxa from the Chipola also occur in the Kirkwood.

In Whitfield's (1894) and Richards and Harbison's (1942) monographs, a puzzling array of mollusks are illustrated, which at a glance appear to be anomalous associations. The presence, for instance, of *Dallarca idonea* (known to this author to occur only in the St. Marys Formation) and *Sectiarca lienosa* (known to this author to occur only in the Yorktown Formation and equivalent and later beds) in a lower Miocene unit was disturbing indeed. In fact, identifications such as these have made authors, such as Dall (1903), believe that the Kirkwood, as it has come to be known, was a mixed assemblage of several different ages.

A closer look at the material that was available to the early authors shows that, in many cases, they were working with fragments and made their identifications based on that imperfect material. For purposes of illustration they would then figure the species they believed the fragment to represent. This involved specimens from other formations and other states.

The large suites of specimens available from the Pollack Farm Site helped to decide the authenticity or correctness of many of these early identifications. Where the early workers had fragments or a single specimen, in many cases the Pollack Farm material affords access to thousands of individuals.

SUMMARY

This study has led to the following observations:

1. The Miocene deposits of Delaware are rich in fossil remains, though most remain unexposed.
2. The prolific fauna uncovered at the Pollack Farm Site is the equivalent of that collected from the Kirkwood Formation near Shiloh, New Jersey.
3. The Pollack Farm molluscan assemblage contains many of the previously known Kirkwood species, but also consists of a number of new species, first occurrences, last occurrences, subtropical and tropical species, and taxa not previously reported from North America.
4. The assemblage reflects deposition in a deltaic environment where brackish-water and marine mollusks are mixed.
5. The preservation of this fossil material and its abundance were made possible by its being swept into a channel and buried rapidly.

SYSTEMATICS

Gastropoda

Diadora griscomi (Conrad)

Plate 1, Figures 1, 3

Fissurella griscomi Conrad, 1834, p. 143.

Fissurella griscomi Conrad. Whitfield, 1894, p. 136–137, Pl. XXIV, figs. 11–14.

Fissurella griscomi Conrad. Richards and Harbison, 1942, p. 203, Pl. 21, fig. 9.

Discussion.—Conrad (1834) named this species from Stow Creek, New Jersey, and Whitfield (1894) reported it as abundant in the New Jersey Miocene. At the Pollack Farm Site the species is rare with only six specimens collected. Whitfield (1894, p. 136) described the species as being variable in its morphologic features, and the specimens from the Pollack Farm Site show some of that variability. Several specimens have coarse radial ribs while others have much finer ribs.

The species was reported by Martin (1904) from the Choptank Formation, and the specimen figured by him (pl. LXIII, fig. 5) as *Fissuridea nasssula* from Jones Wharf looks very much like one of the Delaware specimens.

Geologic range.—Kirkwood, Calvert, and Choptank (?) formations.

Tegula marylandicum (Martin)

Plate 1, Figures 2, 5

Calliostoma marylandicum Martin, 1904, p. 263, Pl. LXI, figs. 15a, b.

Discussion.—This species, although represented by more than 100 individuals at the Pollack Farm Site, has not been reported from the Kirkwood of New Jersey. A single, imperfect specimen was described by Martin (1904) as a species of *Calliostoma*. This specimen, as described, has the same color patterns as the Delaware specimens and came from Bed 10 of the Plum Point Marl Member, Calvert Formation. The color consists of mottled or striped patterns of reddish brown, much like that of *T. fasciata* (Born) from south Florida, a species that it resembles in overall form and sculpture. Recent species of *Tegula* from the Atlantic are all found in tropical settings.

[3]Geologic range.—Kirkwood Formation and Bed 10 of Plum Point Marl Member, Calvert Formation.

Calliostoma eboreus (Wagner)

Plate 1, Figures 4, 6

Trochus eboreus Wagner, 1839, p. 52–53, Pl. 1, fig. 5.
Monilia (Leiotrochus) eborea Wagner. Whitfield, 1894, p. 135, Pl. XXIV, figs. 7–10.
Calliostoma eboreum (Conrad). Richards and Harbison, 1942, p. 203, Pl. 18, fig. 3.

Discussion.—*Calliostoma eboreus* was reported as moderately common by Whitfield (1894), but Richards and Harbison (1942) indicated that it was rare. Wagner's (1839) type came from the lower Choptank Formation at Jones Wharf on the Patuxent River, but specimens from the Pollack Farm Site seem to be identical with that species. Seventy-five individuals were collected that exhibit a fair degree of variation in the shape and ornamentation of the whorls and the apical angle. The most obvious variation is the outline of the whorls. Some specimens have well-rounded, globose whorls while others, at the opposite end of the scale, have a well-defined carina at the edge of the whorl. Specimens in the Delaware collections exhibit all of the gradations between rounded and keeled. Several specimens have two carinae that form a shallow peripheral canal. Only a few have the "raised spiral lines" referred to by Whitfield (1894, p. 135) and figured by Richards and Harbison (1942, p. 203, pl. 18, fig. 3).

With this large suite of specimens, it may be possible to evaluate the validity of several named species of *Calliostoma* from the Calvert and Choptank Formations. *Calliostoma aphelium* Dall (1892) seems to be a *C. eboreus* with rounded, non-keeled whorls. *Calliostoma calvertanum* Martin (1904) appears to be a well-carinated *C. eboreus*, but its large, open umbilicus probably rules that out.

Geologic range.—Kirkwood, Calvert, and Choptank formations.

Littorina sp.

Discussion.—A minute species of *Littorina* is present at the Pollack Farm Site in small numbers, with over 50 specimens collected. It may be more common than is apparent, but its small size (adults are about 4 mm) makes detection difficult. The species is notable for its sharp shoulder, which is noticeably angular. This keel marks the position of the future, shallow suture between the whorls.

A living species, *L. angustior* (Mörch), has much the same overall shape as the Delaware taxon and is similarly carinate. It also is small, but ranges up to 9 mm.

Except for this Delaware taxon, there are only a few references to the genus *Littorina* in the Tertiary of the Atlantic Coastal Plain. The only reference in the Miocene is to a single specimen from the upper Choptank on the Choptank River (Martin, 1904, p. 240). No later collections have confirmed this occurrence. The only other reported occurrences are in the upper Pliocene of Virginia (Gardner, 1948) and South Carolina (Tuomey and Holmes, 1856).

Geologic range.—Kirkwood Formation.

Caecum calvertense Martin

Caecum calvertense Martin, 1904, p. 231, Pl. LV, fig. 10.

Discussion.—No taxa assignable to the Caecidae have been reported from the Kirkwood Formation of New Jersey. Only five specimens have been found at the Pollack Farm Site. The specimens appear to be the same species described by Martin (1904) as *C. calvertense*, though that description is very brief. The beds at Martin's locality, Church Hill, Maryland, are stratigraphically equivalent with the Shiloh Marl in New Jersey.

The species has very fine, closely set annulations, except near the anterior aperture where several annulations are somewhat stronger and wider. *Caecum greensboroense* Martin is probably synonymous with *C. calvertense*.

Geologic range.—Kirkwood and Calvert formations. Lower Choptank Formation if *C. greensboroense* = *C. calvertense*.

Solariorbis lipara (H.C. Lea)

Delphinua lipara H.C. Lea, 1843, p. 261, Pl. 36, fig. 71.

Discussion.—A single specimen of *Solariorbis lipara* was found at the Pollack Farm Site. No mention is made in the literature of any specimens of that species, or even that genus, in the Kirkwood of New Jersey. The species was reported by Martin (1904, p. 264–265) in the Calvert, Choptank, and St. Marys Formations of Maryland.

Geologic range.—Kirkwood, Calvert, Choptank, St. Marys, Eastover, and Yorktown formations.

Teinostoma nana (I. Lea)

Rotella nana I. Lea, 1833, p. 214, Pl. VI, fig. 225.

Discussion.—Lea's specimen was collected by John Finch at Yorktown, Virginia, (probably in the Yorktown Formation) and not at "St. Mary's, Maryland" as reported by Lea (1833, p. 214; see Ward and Blackwelder, 1975, for details). The six specimens from the Pollack Farm Site are very small compared to the later St. Marys and Yorktown specimens, but they exhibit the nearly concealed spire and the heavy callus in the umbilicus. The species from the Calvert Formation, named *T. calvertense* by Martin (1904, p. 264, pl. LXII, fig. 3), has a lower spire and lacks the heavy callus in the umbilicus.

No specimens of *Teinostoma* have been reported from the Kirkwood of New Jersey. *Teinostoma calvertense* was reported by Martin (1904) from Church Hill, Maryland, in beds stratigraphically equivalent to the Shiloh Marl.

Geologic range.—Kirkwood and Calvert formations.

Diastoma insulaemaris (Pilsbry and Harbison)

[3] Although the author refers to Kirkwood for the geologic range and occurrence of taxa from the Pollack Farm Site, the Delaware Geological Survey recognizes the Calvert Formation in Delaware and at the site instead of the Kirkwood Formation. ED.

Plate 1, Figures 7–9

Cerithidea insulaemaris Pilsbry and Harbison, 1933, p. 115, Pl. 4, figs. 20, 21.

Cerithidea insulaemaris Pilsbry and Harbison. Richards and Harbison, 1942, p. 206, Pl. 21, fig. 18.

Discussion.—The type lot of *Diastoma insulaemaris* was obtained from a well at Sea Isle City, New Jersey, at 600–700 ft. The taxon has not been reported by previous or subsequent authors in the Kirkwood Formation. Over 2500 specimens have been recovered from the Pollack Farm Site, making it one of the more common taxon at that locality.

Diastoma insulaemaris was originally assigned to the genus *Cerithidea*, but that genus has rounded whorls with strong axial ribs; spiral ornamentation is very faint. In *Diastoma* the whorls are flatter sided, the axial ribs are less prominent, and they are crossed by somewhat weaker spiral riblets. This gives a cancellate appearance with small nodes where the ribs cross. Adults of *Diastoma* exhibit a slight tendency towards pupaeform growth.

The Delaware species is similar in appearance to the living *Diastoma alternatum* (Say) but is much larger than that species, with adults commonly 20 mm in height. It is roughly similar to a late Oligocene/early Miocene species named *Cerithium insulatum* by Dall (1916) but has finer ribs than that taxon. No other occurrence of *Diastoma* has been reported from the Miocene of the Atlantic Coastal Plain.

Geologic range.—Kirkwood Formation.

Carinorbis dalli (Whitfield)

Plate 1, Figures 10, 13

Trichotropis Dalli Whitfield, 1894, p. 127, Pl. XXIII, figs. 1–4.

Fossarus dalli (Whitfield). Richards and Harbison, 1942, p. 207, Pl. 18, fig. 16.

Discussion.—*Carinorbis dalli* is an abundant element of the molluscan assemblage at the Pollack Farm Site with some 600 specimens collected. Whitfield listed the species from Shiloh and Jericho, New Jersey, but Richards and Harbison (1942) noted that it is rare from those localities.

Geologic range.—Kirkwood and Calvert formations (Bed 10 of the Plum Point Marl Member).

Turritella cumberlandia Conrad

Plate 1, Figures 11, 12; Plate 2, Figure 1

Turritella Cumberlandia Conrad, 1863b, p. 584.

Turritella cumberlandia Conrad. Whitfield, 1894, p. 129, Pl. XXIII, figs. 9–11.

Turritella cumberlandia Conrad. Richards and Harbison, 1942, p. 203–204, Pl. 18, figs. 5, 6.

Discussion.—*Turritella cumberlandia* is the most abundant species of the genus with over 200 specimens collected from the Pollack Farm Site. They are variable in ornamentation, but most possess two prominent revolving ribs near the base of the whorl and another, less prominent rib at the top of the whorl. In the young stages the suture is hardly impressed, but in later whorls it is profoundly excavated, giving the whorls a rounded appearance. *Turritella secta* Conrad (1855) is similar in appearance to *T. cumberlandia* and may be the same species. In that case the name *T. secta* would have priority. At this time it is preferable to keep them separate as several problems concern *T. secta*. The principal problem is the locality information given by Conrad as "Mullica Hill," [New Jersey]. According to Richards and Harbison (1942), "there are no Miocene deposits in that vicinity." Conrad's (1863b) description of *T. cumberlandia* sounds very much like that of *T. secta*, but he fails to compare the two. It is possible that Conrad failed to remember his earlier name.

Geologic range.—Kirkwood and Calvert formations.

Turritella tampae Heilprin

Plate 2, Figures 2, 3

Turritella tampae Heilprin, 1886, p. 113.

Turritella tampae Heilprin. Ward, 1992, p. 119–120, Pl. 26, fig. 3.

Discussion.—The *Turritella tampae–T. identa* lineage is clearly represented by the 55 specimens of that group found at the Pollack Farm Site. Neither species has been previously reported in the Kirkwood of New Jersey. *Turritella tampae* and *T. identa* are very similar in appearance and may prove to be the same species. Of the comparative material available from Maryland and North Carolina, the Delaware specimens are more like *T. tampae* in their large size. The smaller size of *T. identa* may be a product of environmental conditions, but the Delaware specimens are consistently larger than those from the Calvert Formation in Maryland. The specimens rival the size of the neotype of *T. tampae* (see Ward, 1992, p. 119) and specimens of that taxon from the Haywood Landing Member of the Belgrade Formation.

Geologic range.—Belgrade and Kirkwood formations; Tampa Member of the Arcadia Formation.

Turritella plebeia subspecies

Plate 2, Figure 4

Turritella plebeia Say, 1824, p. 125, Pl. VII, fig. 1.

Turritella (Mesalia?) plebeia Say. Whitfield, 1894, Pl. XXIII, figs. 6–8.

Turritella plebeia Say. Richards and Harbison, 1942, p. 204, Pl. 18, figs. 4, 9.

Discussion.—Twenty specimens of this early representative of the *Turritella plebeia* lineage were collected at the Pollack Farm Site. They mark the first appearance of that lineage and exhibit the finely striate, rounded whorls that are so characteristic. They also show the single revolving rib that is present on the center of the whorl for the first eight volutions. The specimens, however, are very small, very high for their size, and very well-rounded after the initial eight whorls. Specimens of the lineage in Bed 10 of the Calvert approach the form of the Delaware specimens but have finer spiral ornamentation, a greater width-to-height ratio, and flatter whorls in the adult stages. The specimens figured by Whitfield (1894) are fragmentary but appear to be *T. plebeia*. It is unclear that they are the same as the taxon found in Delaware. The specimens figured by Richards and Harbison are also a stouter taxon than the Delaware specimens.

Geologic range.—Kirkwood Formation.

Serpulorbis granifera (Say)

Plate 2, Figure 5

Serpula granifera Say, 1824, p. 154, Pl. 8, fig. 4.

Anguinella Virginiana Whitfield, 1894, p. 132–133, Pl. XXIV, figs. 1–5. [Not *Serpula Virginica* of Conrad, 1839; Not *Anguinella virginiana* of Conrad, 1845]

Vermetus graniferus (Say). Richards and Harbison, 1942, p.

205, Pl. 18, figs. 12, 13.

Discussion.—Whitfield (1894) reported the presence of *Anguinella virginiana* in the Kirkwood of New Jersey, but the specimens on which his identifications were based were very small (10 mm and less). Richards and Harbison (1942) later referred Whitfield's specimens and additional material from wells in New Jersey to *Vermetus graniferus*. In this assignment, they are probably correct. *Serpulorbis,* where unworn, has numerous, small rows of very fine striae, which are made up of individual stubby spines. *Anguinella* lacks the striae and instead, has an angular tube with transverse wrinkles.

It is difficult to get an accurate count on the specimens from the Pollack Farm Site due to the fragmentary nature of the fossils, but in excess of 40 individuals were recovered. The diameter of the broken tubes of some specimens (13 mm) is larger than any specimens I have seen in later deposits. Most of the specimens have been worn by reworking so that only a trace of the striae remain. The specimen illustrated by Martin (1904, pl. LV, fig. 14) from Church Hill, Maryland is *S. granifera* and is from beds stratigraphically equivalent to the Delaware and Shiloh, New Jersey, beds.

Geologic range.—Kirkwood, Calvert, Choptank, St. Marys, Eastover, and Yorktown formations.

Crepidula fornicata Linné
Plate 2, Figures 6, 7

Patella fornicata Linneaus, 1758, p. 781.
Crepidula fornicata Say?. Whitfield, 1894, p. 123.
Crepidula fornicata (Linné). Richards and Harbison, 1942, p. 208, Pl. 18, fig. 17.

Discussion.—Whitfield (1894) reported only a single cast of *Crepidula fornicata* from the Miocene of New Jersey. Richards and Harbison (1942) mentioned specimens from Shiloh and Bridgeton, but queried those localities. They also mentioned specimens from a well at Cape May Court House, but seemed unsure whether the specimens came from the Pleistocene or Miocene.

Crepidula fornicata is abundant at the Pollack Farm Site with over 700 specimens collected. Its occurrence in the Kirkwood marks the first known appearance of this long-lived species. Specimens found there are as large as Recent specimens (50 mm), whereas those in the Calvert, Choptank, and St. Marys are much smaller. The species is not known to reattain this size until the late Pliocene and Pleistocene.

Geologic range.—Kirkwood Formation–Recent.

Crepidula plana Say
Plate 2, Figures 8, 9

Crepidula plana Say, 1822, p. 226.
Crepidula plana? Say. Whitfield, 1894, p. 124
Crepidula plana Say. Richards and Harbison, 1942, p. 208, Pl. 18, figs. 18–20.

Discussion.—*Crepidula plana* is rare in the Kirkwood of New Jersey, Whitfield (1894) having only one broken specimen and Richards and Harbison (1942) having only a few. The species is also rare at the Pollack Farm Site with only two specimens recovered.

The species is present in all of the stratigraphic units in the Chesapeake Group, but it is never common.

Geologic range.—Kirkwood, Calvert, Choptank, St. Marys, Eastover, Yorktown, and Chowan River formations. Recent.

Calyptraea centralis (Conrad)
Plate 2, Figure 10

Infundibulum centralis Conrad, 1841b, p. 348.
Calyptraea centralis (Conrad). Martin, 1904, p. 248, Pl. LIX, figs. 2a, 2b, 2c.

Discussion.—*Calyptraea centralis* is present, but not common, at the Pollack Farm Site with 15 specimens collected. The species was not reported by Whitfield (1894) or Richards and Harbison (1942), and it has not been reported stratigraphically below the St. Marys Formation. It was originally named from the Duplin Formation (upper Pliocene) at Natural Well, North Carolina. That assemblage is subtropical in nature. Today *Calyptraea centralis* is found from North Carolina to Brazil.

Geologic range.—Kirkwood, St. Marys, Yorktown, and Duplin formations and numerous other stratigraphic equivalents. Recent.

Calyptraea aperta (Solander)
Plate 2, Figures 11–15

Trochus apertus Solander, 1766, p. 9, figs. 1, 2.
Infundibulum perarmatum Conrad, 1841a, p. 31.
Trochita perarmata Conrad. Whitfield, 1894, p. 124–125.
Trochus apertus Solander. Martin, 1904, p. 247, 248, Pl. LIX, fig. 1.
Calyptraea aperta (Solander). Richards and Harbison, 1942, p. 207–208, P. 18, figs. 23, 24.

Discussion.—*Calyptraea aperta* is common at the Pollack Rarm Site with over 400 specimens collected. It was reported by Whitfield (1894) and Richards and Harbison (1942) to be common in the Kirkwood of New Jersey. Martin (1904) listed the species from beds equivalent to the Kirkwood (Church Hill, Centerville) and from Bed 10 at Plum Point. The species is known in North America from the Eocene to the Miocene (Harris and Palmer, 1946) and in Europe from the upper Paleocene to the upper Eocene. It appears that the last occurrence of *C. aperta* is in Bed 10 of the Calvert Formation. Smooth-sided specimens of *Calyptraea*, such as *C. centralis,* are present in beds higher than the Calvert, but they are smaller and never develop the rows of foliated spines.

Geologic range.—North America: lower Eocene to Miocene. Europe: upper Paleocene to upper Eocene. Kirkwood, Calvert, Belgrade, and Old Church formations.

Crucibulum costatum (Say)
Plate 3, Figures 1, 4

Calyptraea costata Say, 1820, p. 40.
Crucibulum costatum Say. Whitfield, 1894, p. 122–123, Pl. XXII, figs. 11–14.
Crucibulum costatum (Say). Richards and Harbison, 1942, p. 208, Pl. 18, figs. 21, 22.

Discussion.—Whitfield (1894) and Richards and Harbison (1942) mentioned *Crucibulum costatum* as common in the Kirkwood deposits of New Jersey. The taxon is present in the Delaware exposure but is not abundant, with only 15 specimens collected. The specimens vary in external sculpture from having a number of strong raised ribs to being nearly smooth. Some specimens are strongly ribbed in young stages and become smoother in later stages.

Geologic range.—Kirkwood, Calvert, Choptank, St. Marys, and Eastover formations and a number of other stratigraphic equivalents.

***Polinices duplicatus* (Say)**
Plate 3, Figure 7

Natica duplicata Say, 1822, p. 247.
Neverita duplicata Say. Whitfield, 1894, p. 121–122, Pl. XXI, figs. 13–16.
Polinices duplicatus (Say). Richards and Harbison, 1942, p. 209–210, Pl. 19, figs. 3, 4.

Discussion.—*Polinices duplicatus* was reported from the Miocene of New Jersey by Whitfield (1894), but only as juveniles (largest 15.9 mm). Richards and Harbison (1942) described the species as uncommon in the Kirkwood, but it is abundant at the Pollack Farm Site with over 200 specimens collected. Individual specimens range up to 45 mm in height, which is nearly the size of a large Recent specimen. The presence of the species in the Kirkwood marks the first known appearance of the taxon.

Geologic range.—Kirkwood Formation–Recent.

***Lunatia hemicrypta* (Gabb)**
Plate 3, Figures 2, 3

Natica hemicrypta Gabb, 1860, p. 375, Pl. 67, fig. 5.
Natica (Lunatia) hemicrypta Gabb. Whitfield, 1894, p. 118–119, Pl. XXII, figs. 1–5.
Polinices hemicrypta (Gabb). Richards and Harbison, 1942, p. 210, Pl. 19, figs. 8, 9.

Discussion.—The presence of *Lunatia hemicrypta* in the Kirkwood of New Jersey was noted by Whitfield (1894) and by Richards and Harbison (1942). The species is small, but present at the Pollack Farm Site. It is clearly different from the young of the more globose *Lunatia heros* and the umbilically plugged *Polinices duplicatus*. About 20 individuals have been found.

Geologic range.—Kirkwood, Calvert, and Choptank formations.

***Lunatia heros* (Say)**
Plate 3, Figure 5

Natica heros Say, 1822, p. 248.
Natica (Lunatia) heros Say. Whitfield, 1894, p. 119–120.
Polinices heros (Say). Richards and Harbison, 1942, p. 209, Pl. 19, fig. 6.

Discussion.—Whitfield (1894) listed *Lunatia heros* from the New Jersey Miocene only as immature specimens. Richards and Harbison (1942) described the species as uncommon in the Kirkwood. The species is abundant at the Pollack Farm Site with over 200 specimens collected. The specimens here range up to 45 mm in height, a size which rivals Recent forms. The presence of *Lunatia heros* in the Kirkwood marks the first known appearance of that long- lived taxon.

Geologic range.—Kirkwood Formation–Recent.

***Sinum chesapeakensis* Campbell**
Plate 3, Figures 6, 9

Natica fragilis Conrad, 1830, p. 222, Pl. IX, fig. 3. [Not of Leach, 1819]
Sinum fragile (Conrad). Richards and Harbison, 1942, p. 210, Pl. 19, fig. 13.
Sinum chesapeakensis Campbell, 1993, p. 73, Pl. 32, fig. 353.

Discussion.—*Sinum fragilis* [renamed *S. chesapeakensis* by Campbell (1993) because the name was preoccupied] did not appear in Whitfield's (1894) monograph on the New Jersey Miocene, but it was listed as "very rare" by Richards and Harbison (1942, p. 210) who had two specimens. The species is also rare at the Pollack Farm Site with only five specimens collected. Several individuals are complete, however, making sure its identification. The taxon, which is present in Miocene and Pliocene beds of the Atlantic Coastal Plain, is somewhat more globose than its Oligocene predecessors. The genus is somewhat conservative in its evolutionary changes making it difficult to easily discern species or morphologic trends. The presence of *S. chesapeakensis* in the Kirkwood marks the first appearance of that long- lived taxon.

Geologic range.—Kirkwood, Calvert, Choptank, St. Marys, Eastover, and Yorktown formations.

***Ficus harrisi* (Martin)**
Plate 3, Figures 8, 10

Pyrula harrisi Martin, 1904, p. 226, Pl. LV, fig. 3.

Discussion.—*Ficus harrisi* has not previously been reported from the Kirkwood Formation of New Jersey and is represented by only one specimen at the Pollack Farm Site. Except for this occurrence, it is known only from Bed 10 of the Plum Point Marl Member. In that unit, Martin (1904) reported it to be common, though usually fragmentary.

Geologic range.—Kirkwood Formation and Bed 10 of the Plum Point Marl Member of the Calvert Formation.

***Seila adamsii* (H.C. Lea)**

Cerithium Adamsii H.C. Lea, 1845, p. 268.
Seila adamsii (H.C. Lea). Martin, 1904, p. 228–229, Pl. LV, fig. 6.
Seila clavulus (Lea). Richards and Harbison, 1942, p. 206, Pl. 18, fig. 15.

Discussion.—H.C. Lea (1845, p. 268) proposed the name *Cerithium clavulus* for a species of *Seila* in the upper Yorktown Formation (upper Pliocene). In the same paper, on the same page in a footnote, he proposed the name *C. adamsii* for *C. terebrale* Adams because the name was preoccupied. *Seila adamsii* appears to be the same species as *S. clavulus*, and as such, the renamed species should take priority; however, if the comments by Martin (1904, p. 170–171, footnote) are correct, then the publication date of *S. clavulus* is 1843, giving it priority. Until the validity of Lea's preprint dates are decided, I will use *S. adamsii*.

Seila adamsii is an element of the molluscan assemblages of the Atlantic Coastal Plain during the Miocene and Pliocene and is common today from Massachusetts to Brazil. At the Pollack Farm Site it is rare and only 10 specimens have been recovered. Previously it had been mentioned from the Kirkwood in equivalent strata by Richards and Harbison (1942) and Martin (1904).

Geologic range.—Kirkwood, Calvert, Choptank, St. Marys, Eastover, and Yorktown formations and Recent.

Epitonium charlestonensis Johnson

Plate 3, Figure 11

Epitonium charlestonensis Johnson, 1931, p. 8, Pl. 1, fig. 4.

Discussion.—Whitfield (1894, p. 126, pl. XXIII, fig. 5) and Richards and Harbison (1942, p. 206, pl. 18, fig. 14) both figured specimens of *Epitonium* from the Kirkwood of New Jersey, but their specimens were very worn and very young, making certain identification impossible. Whitfield (1894) used the name *Scalaria multistriata* of Say (1830), but that species is smaller and living on the southeast shelf. Say described the species as having "numerous, approximate, equidistant, impressed lines" between the costae. The Delaware specimens have raised spiral riblets. Richards and Harbison (1942) used the name *Scala marylandica* of Martin, 1904, but that species has no spiral sculpture.

Four specimens were collected from the Pollack Farm Site that should allow identification. They are large, high-spired, have strong axials (~12 per whorl), have fairly strong spiral, raised riblets seen between the axials, and have a strong spiral cord near the base, upon which succeeding whorls attach at the point of suture.

In all these characters, the Delaware specimens are identical to specimens collected from the Cooper River at Charleston, South Carolina. The species was reported as late Eocene, but is probably from the late Oligocene Edisto Formation (stratigraphically equivalent to the Belgrade Formation).

Epitonium charlestonensis is much larger (30+ mm) than, but similar in general form to, *E. marylandica* of the Calvert Formation. It differs from *E. marylandica* in having spiral riblets. *Epitonium calvertensis*, also from the Calvert Formation and also much smaller, has spiral riblets, but the axial ribs are stronger, wider, and closer together, nearly hiding the spiral ornamentation from view.

Melanella eborea (Conrad)

Eulima eborea Conrad, 1846, p. 20, Pl. 1, fig. 21.
Eulima eborea Conrad. Martin, 1904, p. 216–217, Pl. LIII, figs. 9, 10.

Discussion.—Martin (1904) was the first to report the presence of the genus *Eulima*, now known as *Melanella*, in beds equivalent to those at the Pollack Farm Site and to the Kirkwood Formation, when he listed *M. eborea* from Church Hill, Maryland. Pilsbry and Harbison (1933) were the first to identify the genus *Melanella* from the Kirkwood of New Jersey. Their species, *M. retrocita*, may be the same as *M. eborea*, but is somewhat atypical in its somewhat bulbous final whorl. *Melanella eborea* is rare at the Pollack Farm Site, with only four specimens collected.

Geologic range.—Kirkwood, Calvert, Choptank, St. Marys, Yorktown, Chowan River, and James City formations.

Melanella migrans (Conrad)

Eulima migrans Conrad, 1846, p. 20, Pl. 1, fig. 22.
Eulima migrans Conrad. Martin, 1904, p. 217–218, Pl. LIII, fig. 12.

Discussion.—*Melanella migrans*, a thinner more elongate species than *M. eborea*, is represented by a single specimen at the Pollack Farm Site and is the first report of the taxon in the Kirkwood Formation or its equivalents.

Geologic range.—Kirkwood, Calvert, Choptank, St. Marys, and Yorktown formations.

Murexiella cumberlandiana (Gabb)

Plate 3, Figure 12

Cantharus Cumberlandiana Gabb, 1860, p. 375, Pl. 67, fig. 6.
Cantharus Cumberlanisanus Gabb. Whitfield, 1894, p. 103–104, Pl. XVII, figs. 3–6.
Coralliophila cumberlandia (Gabb). Richards and Harbison, 1942, p. 213, Pl. 19, fig. 18.

Discussion.—*Muriexella cumberlandiana* is present but rare at the Pollack Farm Site, with only one specimen recovered. It is rare in the Kirkwood of New Jersey, also, with only a few specimens available to Whitfield (1894) or Richards and Harbison (1942).

Geologic range.—Kirkwood Formation.

Urosalpinx subrusticus (d'Orbigny)

Plate 3, Figures 13, 14

Fusus rusticus Conrad, 1830, p. 230, Pl. IX, fig. 2.
Fusus subrusticus d'Orbigny, 1852, p. 69.

Discussion.—The specimens from the Pollack Farm Site, which number over 100, look very much like *U. subrusticus* (d'Orbigny, 1852) [= *U. rusticus* (Conrad, 1830)]. It is noteworthy that, in spite of the abundance of *Urosalpinx* at the Pollack Farm Site, it is not reported from the Kirkwood and Calvert formations, and only a single occurrence is noted by Martin (1904) in the Choptank Formation. The taxon reappears in the late Miocene and commonly occurs in the St. Marys and higher units.

The occurrence of *Urosalpinx* in the lower Miocene appears to be the first appearance of that taxon. *Murex veatchi* from the Chipola, named by Maury (1910), was later referred to *Urosalpinx* by Gardner (1948) but does not belong to that genus (see Vokes, 1968, p. 101). The specimen, named by Mansfield (1937, p. 134) *Urosalpinx? hillsboroensis*, is incomplete, hence that author's query about its generic placement. Two taxa, *Urosalpinx xustris* and *U. tribaka*, were named by Gardner (1947) from the Oak Grove of western Florida, a slightly higher unit.

Geologic range.—Kirkwood, Calvert, Choptank, and St. Marys formations.

Typhis acuticosta (Conrad)

Plate 4, Figure 1

Murex acuticosta Conrad, 1830, p. 211, 217, Pl. IX, fig. 1.
Typhis acuticosta Conrad. Martin, 1904, p. 201, Pl. LI, figs. 1–3.

Discussion.—*Typhis acuticosta* is rare at the Pollack Farm Site, with only four specimens collected, and is previously unreported from the Kirkwood. The species is known from the Calvert, Choptank, and St. Marys formations.

Geologic range.—Kirkwood, Calvert, Choptank, and St. Marys formations.

Cymia woodii (Gabb)

Plate 4, Figures 2–6

Fasciolaria Woodii Gabb, 1860, p. 375, Pl. LXVII, fig. 7.
Fasciolaria Woodi Gabb. Whitfield, 1894, p. 98, Pl. XVII, figs. 7, 8.
Fasciolaria woodi Gabb. Richards and Harbison, 1942, p. 216, Pl. 19, fig. 17.
Cymia woodii (Gabb). E.H. Vokes, 1989, p. 92, Pl. 12, fig. 12.

Discussion.—Whitfield (1894) and Richards and Harbison (1942) noted that this species is rare in the Miocene in New Jersey; however, it is common to abundant at the Pollack Farm Site with over 1000 specimens collected. This large suite shows a fair amount of variability within the species. Some specimens have fine spiral ribs and smooth whorls, others have strong spiral riblets, and still others develop strong nodes on the shoulders of the whorls. In this regard the species has many of the same growth characteristics as *Cymia henekeni* Maury, from the Dominican Republic (see Vokes, 1989, pl. 12, figs. 3–11). Except for the specimens from the Kirkwood Formation, only a single specimen has been found in Bed 10 of the Plum Point Marl Member of the Calvert Formation. Members of the genus are found in subtropical to tropical water, some in intertidal settings.

Geologic range.—Kirkwood and Calvert (Plum Point Marl Member, Bed 10) formations.

Tritonopsis ecclesiastica **(Dall)**

Plate 4, Figure 7

Fasciolaria (Lyrosoma) sulcosa Conrad. Whitfield, 1894, p. 100, Pl. XVII, figs. 9, 10.

Rapana tampaënsis Dall, 1890, p. 153.

Rapana tampaënsis var.? Dall, 1892, p. 244, Pl. XX, fig. 14.

Ecphora tampaënsis (Dall). Martin, 1904, p. 210–211, Pl. LII, figs. 9, 10.

Rapana ecclesiastica Dall, 1915, p. 78. [Not *Rapana ecclesiastica* Dall. Richards and Harbison, 1942, p. 211, Pl. 19, fig. 19].

Discussion.—Whitfield (1894, pl. XVII, figs. 9, 10) had a single specimen that is probably *Tritonopsis ecclesiastica*, but he called it *Fasciolaria (Lyrosoma) sulcosa*. Dall (1890) figured a specimen from Church Hill, Maryland, but called it *Rapana tampaensis*. This identification was followed by Martin (1904, pl. 52, fig. 9), but was corrected by Dall (1915, p. 78) who gave it the name *Rapana ecclesiastica*. Richards and Harbison (1942) could not find Whitfield's specimen, but had an additional specimen from a well that they identified as *Rapana ecclesiastica*. Seven specimens from the Pollack Farm Site are referred to *Tritonopsis ecclesiastica*.

Geologic range.—Kirkwood Formation; Bed 3-A of the Calvert Formation.

Ecphora tricostata **Martin**

Plate 4, Figures 8–10

Ecphora tricostata Martin, 1904, p. 209–210, Pl. LII, figs. 5–8.

Ecphora tricostata Martin. Richards and Harbison, 1942, p. 211, Pl. 17, fig. 15.

Discussion.—The only record of *Ecphora tricostata* in the Miocene of New Jersey is that of Richards and Harbison (1942), who reported several specimens from two wells near the coast. The species is fairly common at the Pollack Farm Site with over 80 specimens collected. The specimens there, as a whole, tend to be less variable in their ornamentation than those in Bed 10 of the Plum Point Marl Member. In addition, the Delaware specimens tend to uncoil less and at a later stage of growth.

Geologic range.—Kirkwood Formation. Calvert Formation, Fairhaven Member and Plum Point Marl Member (up to and including Bed 10).

Chrysodomus patuxentensis **Martin**

Plate 4, Figure 11

Chrysodomus patuxentensis Martin, 1904, p. 184, Pl. XLVII, figs. 2, 3.

Discussion.—*Chrysodomus patuxentensis* was named by Martin (1904) and reported from Bed 10 of the Plum Point Marl Member and Bed 17 or the Drumcliff Member. There has been no mention of the taxon in the Kirkwood. It is rare at the Pollack Farm Site with only five specimens collected. I am unable to confirm the generic placement of the taxon. The only other species that resembles this form is *Lirofusus thoracicus* (Conrad, 1833a) from the middle Eocene of Alabama. The two are similar in exterior form, rib configuration, and even have a subsutural channel. The Miocene species, however, shows no sign of nodes on the ribs where the incremental growth lines intersect them as is common in the Eocene species. Palmer (1937, p. 348) mentions that specimens from the middle Eocene at Orangeburg, South Carolina, lack the nodes, and the channel is less pronounced, both characteristics more like the Kirkwood species.

Geologic range.—Kirkwood, Calvert, and Choptank formations.

Siphonalia devexa **(Conrad)**

Plate 5, Figure 1

Fusus devexus Conrad, 1843a, p. 309.

Siphonalia devexa (Conrad). Martin, 1904, p. 185–186, Pl. XLVII, figs. 5, 6.

Siphonalia devexa (Conrad). Richards and Harbison, 1942, p. 213, Pl. 20, fig. 1.

Discussion.—No specimens of *Siphonalia devexa* have been obtained from surface exposures in the Miocene beds of New Jersey, but several were reported from wells by Richards and Harbison (1942). Specimens of this species are fairly common at the Pollack Farm Site with over 40 collected.

Geologic range.—Kirkwood, Calvert, and Choptank formations.

Ptychosalpinx **sp.**

Discussion.—The single specimen found at the Pollack Farm Site is possibly the earliest occurrence of that taxon. There is no report of *Ptychosalpinx* in units below Bed 10 of the Plum Point Marl Member. The specimen, somewhat broken, looks similar to *Ptychosalpinx pustulosus* Petuch, but lacks the nodes on the ribs that species exhibits. It may be a smooth variety of that taxon or a new subspecies.

Geologic range.—Kirkwood Formation.

Mitrella communis mediocris **Pilsbry and Harbison**

Mitrella communis mediocris Pilsbry and Harbison, 1933, p. 114, Pl. 4, fig. 16.

Mitrella communis mediocris Pilsbry and Harbison. Richards and Harbison, 1942, p. 213, Pl. 19, fig. 20.

Discussion.—Whitfield (1894) reported this taxon as *Amycla communis*. Pilsbry and Harbison (1933) recognized it as distinct from the larger St. Marys form, *M. communis*, and gave it a subspecific name. Richards and Harbison (1942) followed this assignment and found it abundant at Shiloh, New Jersey, in the Kirkwood. Specimens are present at the Pollack Farm Site, but they are not common, with only 30 individuals collected.

Geologic range.—Kirkwood Formation.

Nassarius trivittatoides (Whitfield)

Plate 5, Figure 3

Tritia trivittatoides Whitfield, 1894, p. 104–105, Pl. XIX, figs. 1–3.

Nassarius trivittatoides (Whitfield). Richards and Harbison, 1942, p. 214, Pl. 20, figs. 7, 11.

Discussion.—Previously reported from the Miocene of New Jersey, *Nassarius trivittatoides* is present but not common at the Pollack Farm Site with less than 100 specimens collected. It is also reported from Bed 10 of the Calvert Formation and the Drumcliff Member of the Choptank Formation.

Geologic range.—Kirkwood, Calvert, and Choptank formations.

Nassarius trivittatoides elongata (Whitfield)

Plate 5, Figure 2

Tritia trivittatoides var. *elongata* Whitfield, 1894, p. 105–106, Pl. XIX, figs. 4–6.

Nassarius trivittatoides elongata (Whitfield). Richards and Harbison, 1942, p. 214, Pl. 20, fig. 10.

Discussion.—Whitfield (1894) had a number of specimens that were markedly more slender than *N. trivittatoides* and placed them in *N. t. elongata*. Martin (1904) reunited the two under *N. trivittatoides,* considering the differences to be slight. Richards and Harbison (1942) figured *N. t. elongata* but repeated Martin's comments.

The specimens from the Pollack Farm Site, about 50 in number, are clearly smaller and more elongate than *Nassarius trivittatoides* and are here considered a valid subspecies.

Geologic range.—Kirkwood Formation. Martin (1904) lists the species from Bed 10 of the Calvert Formation and Bed 17 (Drumcliff Member) of the Choptank Formation.

Nassarius sopora (Pilsbry and Harbison)

Plate 5, Figures 4–6

Nassa sopora Pilsbry and Harbison, 1933, p. 114–115, Pl. 3, figs. 9, 10.

Nassarius sopora (Pilsbry and Harbison). Richards and Harbison, 1942, p. 215, Pl. 20, figs. 8, 9.

Discussion.—This species, if my identification is correct, is the most abundant gastropod taxon in the sands at the Pollack Farm Site with over 7000 specimens collected. The specimens, on which the description of *Nassarius sopora* is based, appear to be immature. The description of the early whorls is identical to that of the Delaware specimens, but in the later whorls, growth stages not exhibited on the type material, the axial ribs and the spiral ornamentation becomes progressively less prominent until, in many specimens, the last whorls are nearly smooth. This feature is apparently the adult condition.

Geologic range.—Kirkwood Formation.

Metula sp.

Plate 5, Figures 7, 9

Discussion.—Two specimens that appear to belong to the genus *Metula* were found at the Pollack Farm Site. Metulas commonly have sculpture consisting of very fine longitudinal riblets and very fine spiral riblets that, together, give a finely cancellate appearance. The Delaware species has longitudinal striae that are extremely fine, giving it a much less cancellate look.

Metula is present in the Paleocene, Eocene, and lower Oligocene of the Gulf Coast and, except for the Delaware species, does not reappear until the late Pliocene in Florida. The genus is known only from tropical to subtropical settings.

Geologic range.—Kirkwood Formation.

Busycotypus scalarispira (Conrad)

Plate 5, Figures 8, 10; Plate 6, Figures 1, 3, 4, 6

Busycon scalarispira Conrad, 1863b, p. 584.

Busycon scalarispira Conrad. Whitfield, 1894, p. 102–103, Pl. XVII, figs. 11, 12.

Busycon carica Linn. Whitfield, 1894, p. 101–102, Pl. XVIII, fig. 1.

Busycon tuberculatum (Conrad). Richards and Harbison, 1942, p. 214, Pl. 20, figs. 2, 3.

Busycon scalarispira Conrad. Richards and Harbison, 1942, p. 214, Pl. 20, figs. 4–6.

Busycotypus calvertensis Petuch, 1989, p. 74–75, Pl. 1, figs. 6, 7.

Discussion.—There are over 1000 specimens of the Busyconidae from the Pollack Farm Site in Delaware. Previously, reports of members of the family in the Kirkwood were few. The suite of specimens available from this site, many longer than 130 mm, makes it possible to evaluate the considerable variation in form and conclude which characters distinguish species. That variation is partially demonstrated in the figures on Plates 5 and 6. Possibly as many as three busyconids occur in the beds at the Pollack Farm, but only *B. scalarispira,* the most abundant species, will be considered in the present report. Specimens assigned by Whitfield (1894) to *B. carica* and *B. scalarispira* both belong to this species. The specimens assigned to *B. tuberculatum* and *B. scalarispira* by Richards and Harbison (1942) both belong to the latter. *Busycotypus calvertensis* Petuch (1989) is identical to *B. scalarispira*. The majority of the specimens are weakly canaliculate. This condition is most noticeable in the adult shells, but can be traced along the suture on most of the whorls in the spire. The various morphologies present in the Kirkwood have their beginnings in the Oligocene Belgrade Formation and older units.

Scaphella virginiana Dall

Plate 6, Figure 2

Scaphella (Aurinia) virginiana Dall, 1890, p. 80.

Scaphella (Aurinia) typus Martin, 1904, p. 175, Pl. XLIV, fig. 10. [Not *Volutifusus typus* Conrad, 1866].

Scaphella virginiana Dall. Ward, 1992, p. 135–136, Pl. 19, fig. 9.

Discussion.—There is no previous record of *Scaphella virginiana* in the Kirkwood or its equivalents. The species has been reported from the Calvert Formation (Bed 10) and the Choptank Formation (Bed 17) (Martin, 1904; Ward, 1992). At the Pollack Farm Site ten specimens assignable to this species were found. The Delaware specimens represent the earliest known appearance of the taxon. Several early authors used the name *"Scaphella typus"* for this species, but this is a late Pliocene–Pleistocene species from North Carolina. See Ward (1992) for the derivation of this name.

Geologic range.—Kirkwood, Calvert, and Choptank formations.

Scaphella solitaria (Conrad)
Plate 6, Figure 5

Voluta solitaria Conrad, 1830, p. 218, Pl. IX, fig. 7.
Scaphella solitaria (Conrad). Martin, 1904, p. 173, Pl. XLIV, fig. 7.
Scaphella coronaspira Petuch, 1989, p. 76, Pl. 1, figs. 13, 14.
Scaphella sanctaemariae Petuch, 1989, pl. 76–77, Pl. 2, figs. 7, 8.

Discussion.—There is no mention of *Scaphella solitaria* in the Kirkwood or its equivalents in the literature. It is fairly well-represented at the Pollack Farm Site with 38 individuals collected. The sharpness of the shoulders and the strength of the tubercles on the shoulder, as well as misinformation on the type locality of *S. solitaria*, have spawned two junior synonyms for this species, *S. sanctaemariae* and *S. coronaspira* (see Petuch, 1989, p. 76). Conrad (1830, p. 210–212) explicitly described the type locality of *S. solitaria* as being on the western shore of the St. Marys River (upriver of Windmill Point). There and elsewhere the species is variable in ornamentation, but the specimens from the Kirkwood, Calvert, and St. Mary formations have numerous small tubercles in the early whorls and, as adults, usually lack these tubercles. The shoulder varies from slightly rounded to sharply keeled. The Pliocene species, with fewer heavier tubercles, has recently been named *S. s. ricei* by Campbell (1993, p. 87). The Pollack Farm specimens mark the earliest known occurrence of *Scaphella solitaria*.

Geologic range.—Kirkwood, Calvert, and St. Mary formations.

Oliva simonsoni new species
Plate 7, Figures 1–3

Oliva Carolinensis Whitfield, 1894, p. 109–110. [Not *O. carolinensis* of Conrad, 1862]
Oliva sayana Richards and Harbison, 1942, p. 216, Pl. 17, fig. 20, Pl. 21, fig. 6. [Not *O. sayana* of Ravenel, 1834]
Oliva litterata Martin, 1904, p. 169, Pl. XLIV, figs. 1a, b. [Not *O. litterata* of Lamarck, 1810]

Diagnosis.—Shell small, ovoid, with low spire, on which sutural channel is covered by parietal material on all but last whorl.

Description.—Shell of moderate size for group, moderately thick and heavy, smooth and polished, ovoid in outline, with low spire; spire covered by callus, 5 mm in height, rounding broadly with greatest width approximately midlength. Sutural channel narrow, sharply defined, covered by posterior parietal callus, except on last whorl. Incremental growth lines visible in late stages of shell, causing slight undulation in area just posterior to aperture. Aperture narrow, outer lip thickened, parietal callus thick and wide anteriorly, marked by raised transverse corrugations. Base of columella thickened by several overlapping folds. Parietal callus posteriorly becomes narrow and obsolete below suture; above suture, callus thickened to form continuous slope with outer lip; callus obscuring sutural channel in all but last whorl.

Measurements.—Holotype (VMNH I 595): height 36.8 mm; length 17.2 mm.

Discussion.—Fragments of *Oliva* have been reported in the Miocene of New Jersey for a number of years (Whitfield, 1894; Richards and Harbison, 1942) but were assigned to various non-related species, probably because of their condition. Martin (1904) figured a specimen of the new species from the stratigraphically equivalent beds at Church Hill, Maryland, but incorrectly assigned it to a Recent species. The specimens at the Pollack Farm Site in Delaware afford a better chance at describing this new species, as over 900 specimens were collected.

Oliva simonsoni is a much larger species than *O. harrisi* Martin and has a much more rounded, heavy outline than that high-spired, elongate taxon. *Oliva sayana* Ravenel is a much more elongate species, that is more cylindrical in outline and has a higher spire. *Oliva litterata* Lamarck is the same species as *O. sayana*.

The only other *Oliva* with a rounded outline even close to that of *O. simonsoni* is *O. idonea* (Conrad, 1839) from the Eastover Formation (upper Miocene) of Virginia. That species is much shorter, thicker, and does not obscure the sutural channel with parietal material (see Ward, 1992, pl. 4, fig. 5).

Etymology.—Named in honor of Gordon Simonson, who was instrumental in helping me gain access to the excavation, and who, with his family, helped me collect much of the material used in this report (see Figure 10).

Type information.—Holotype, VMNH I 595. Paratypes: VMNH I 594, 596–610. Type locality: Pollack Farm, just south of the Leipsic River, 0.8 km (0.5 mi) southeast of the spillway at Garrisons Lake, Kent County, Delaware, in the Calvert Formation.

Figured specimens.—Holotype VMNH I 595 and Paratype VMNH I 594.

Geologic range.—Kirkwood and Calvert formations, New Jersey and Delaware.

Trigonostoma biplicifera (Conrad)
Plate 7, Figures 5–7

Cancellaria biplicifera Conrad, 1841a, p. 31.

Discussion.—Pilsbry and Harbison (1933) and Richards and Harbison (1942) have named species of *Trigonostoma* from the Miocene of New Jersey and they may be valid, but my feeling at this time is that they, and the 20 specimens from the Pollack Farm Site, belong in the taxon *Trigonostoma biplicifera*. A number of the Delaware specimens are over 40 mm in height and look identical to specimens from Bed 10 of the Plum Point Marl Member (probably Conrad's type locality).

Geologic range.—Kirkwood, Calvert, and Choptank formations.

Cancellaria alternata Conrad
Plate 7, Figure 4

Cancellaria alternata Conrad, 1834, p. 155.
Cancellaria alternata Conrad. Whitfield, 1894, p. 112–113, Pl. XX, figs. 5–10.
Cancellaria alternata Conrad. Pilsbry and Harbison, 1933, p. 108, Pl. 3, figs. 2, 3.
Cancellaria alternata Conrad. Richards and Harbison, 1942, p. 216, Pl. 21, fig. 1.

Discussion.—*Cancellaria alternata* was reported in the New Jersey Miocene by Whitfield (1894), Pilsbry and Harbison (1933), and Richards and Harbison (1942). The species is fairly common at the Pollack Farm Site with over

30 specimens collected. The species is reported stratigraphically as high as the St. Marys Formation, but apparently makes its first appearance in the Kirkwood.

Geologic range.—Kirkwood, Calvert, Choptank, and St. Marys formations.

Cymatosyrinx limatula (Conrad)
Plate 7, Figure 8

Pleurotoma limatula Conrad, 1830, p. 224, Pl. 9, fig. 12.
Drillia limatula Conrad. Martin, 1904, p. 158–159, Pl. XLII, figs. 12, 13.

Discussion.—A number of taxa of the genus *Cymatosyrinx* have been reported from the Miocene of New Jersey. Ten specimens of that genus have been found at the Pollack Farm Site, but I find them closer in form to the species *C. limatula*, abundant in the St. Marys Formation. Several other forms are present in the sample that may represent different species, but they appear unnamed.

Geologic range.—Kirkwood, Calvert, Choptank, and St. Marys formations.

Polystira communis (Conrad)
Plate 7, Figure 9

Pleurotoma communis Conrad, 1830, p. 224, Pl. 9, fig. 23.
Pleurotoma (Hemipleurotoma) communis Conrad. Martin, 1904, p. 147, Pl. XLI, figs. 2, 3.

Discussion.—*Polystira communis* is common at the Pollack Farm Site with over 40 specimens collected. It appears identical with the species from the type locality in the St. Marys Formation on the St. Marys River, Maryland. Specimens are present, though rare, that may be the more ribbed species *P. protocommunis* (Martin). Living *Polystira* are subtropical to tropical in habitat.

Geologic range.—Kirkwood, Calvert (?), and St. Marys formations.

Leucosyrinx rugata (Conrad)
Plate 7, Figures 10, 11

Surcula rugata Conrad, 1862, p. 285.
Surcula rugata Conrad. Martin, 1904, p. 149, Pl. XLI, figs. 12a, b.

Discussion.—A number of large turrids, over 25, were collected from the Pollack Farm Site and apparently are previously unrecorded from the Kirkwood. They are provisionally assigned to the genus *Leucosyrinx* and the species *L. rugata*. Some specimens measure over 50 mm in height. The species has been previously reported from Jones Wharf (Choptank Formation, Bed 17) and Plum Point (Calvert Formation, Bed 10) (Martin, 1904).

Geologic range.—Kirkwood, Calvert, and Choptank formations.

Inodrillia whitfieldi (Martin)
Plate 7, Figures 12, 13

Drillia elegans Whitfield, 1894, p. 115, Pl. XXI, figs. 2–4. [Not *Drillia elegans* of Emmons, 1858].
Drillia whitfieldi Martin, 1904, p. 157–158.

Discussion.—The most abundant turrid present at the Pollack Farm Site, with over 100 specimens collected, is *Inodrillia whitfieldi*. That taxon was first identified as *Drillia elegans* by Whitfield (1894) from the Miocene of New Jersey. It was reported by Martin (1904, p. 158) from Church Hill, Maryland, from beds stratigraphically equivalent to those in Delaware.

Geologic range.—Kirkwood and Calvert (Fairhaven Member, Bed 3A) formations.

Terebra inornata Whitfield
Plate 7, Figure 14

Terebra inornata Whitfield, 1894, p. 114, Pl. 20, figs. 11–13.
Terebra (Hastula) inornata Whitfield. Martin, 1904, p. 144, Pl. XL, figs. 12, 13.
Terebra inornata Whitfield. Richards and Harbison, 1942, p. 220, Pl. 21, figs. 31, 32.

Discussion.—Whitfield's (1894) specimens came from a well at Cape May, and Martin (1904) thought that they occurred there in a St. Marys assemblage. *Terebra inornata* is common at the Pollack Farm Site with over 200 specimens collected. The species is variable in its ornamentation, with some specimens possessing fine axial riblets well into the adult stages, while the majority are smooth. Some individuals have slightly rounded whorls while others are flat-sided. All of the specimens from Delaware have a smaller apical angle than *Terebra simplex* from the St. Marys and accordingly are more slender in outline.

Geologic range.—Kirkwood Formation. Choptank and St. Marys formations, fide Martin, 1904.

Bivalvia

Nucula prunicola Dall

Nucula proxima Say. Whitfield, 1894, p. 50, Pl. VII, figs. 7–10. [Not *Nucula proxima* of Say, 1822].
Nucula prunicola Dall, 1898, p. 576, Pl. XXXII, fig. 9.

Discussion.—This species was listed as *Nucula proxima* by Whitfield (1894, p. 50–51) and Richards and Harbison (1942, p. 180). These authors described it as being common at Shiloh, Jericho, and Bridgeton, New Jersey. *Nucula prunicola* is a well-characterized species with a general outline and form like *Nucula proxima*, but with noticeable concentric lamellae as described by Dall (1898, p. 576):

> . . . on the anterior third sculpture of moderately elevated concentric lamellae separated by wider radially grooved interspaces; these lamellae break off abruptly anteriorly, and posteriorly become gradually obsolete in front of the middle of the shell . . .

At the Pollack Farm Site 310 specimens were collected, most in excellent condition.

Geologic range.—Kirkwood Formation and Calvert Formation (Fairhaven and Plum Point Marl members).

Nucula taphria Dall

Nucula taphria Dall, 1898, p. 576, Pl. XXXII, fig. 14.
Nucula taphria Dall. Glenn, 1904, pl. 400–401, Pl. CVIII, figs. 9–11.

Discussion.—*Nucula taphria* has not previously been recorded in any units stratigraphically below the Choptank Formation. The species is rare at the Pollack Farm Site, where only three specimens were recovered.

Geologic range.—Kirkwood Formation (Calvert in Delaware); Choptank Formation, Drum Cliff Member; St. Marys Formation, Windmill Point Member; Yorktown Formation, Rushmere and Moore House members; Chowan River Formation; James City Formation.

Nuculana sp.

Discussion.—Known only from a single specimen. This could be *Nuculana leioryncha* (Gardner, 1926) or *N. diphya* (Gardner, 1926), both of which come from age-equivalent units in Florida.

Geologic range.—Kirkwood Formation.

Nuculana liciata (Conrad)

Nucula liciata Conrad, 1843a, p. 305.

Nuculana liciata (Conrad). Glenn, 1904, p. 395–396, Pl. CVII, figs. 5–8.

Nuculana liciata (Conrad). Richards and Harbison, 1942, p. 180, Pl. 7, fig. 3.

Discussion.—Richards and Harbison (1942) list this species as rare and only three specimens were recovered at the Pollack Farm Site.

Geologic range.—Kirkwood Formation, Shiloh Marl Member; Calvert Formation, Plum Point Marl Member; lower Choptank Formation (fide Glenn, 1904).

Yoldia sp.

Plate 8, Figures 1–4

Yoldia limatula Say. Whitfield, 1894, p. 51, Pl. VII, figs. 11, 12 [Not *Yoldia limatula* of Say, 1831].

Yoldia laevis (Say). Richards and Harbison, 1942, p. 181, Pl. 7, figs. 5, 6. [Not *Yoldia laevis* of Say, 1824].

Discussion.—This apparently unnamed taxon is similar to *Yoldia soror* (Gardner, 1926) but is thicker shelled and deeper valved than that species. It seems to be similarly distinct from *Yoldia laevis* (Say, 1824), which is present in much of the Miocene and Pliocene, and from *Yoldia limatula* (Say), which is a Recent form that ranges from Labrador to off North Carolina (Abbott, 1974). *Yoldia* sp., at the Pollack Farm Site, is fairly common; over 100 specimens were recovered.

Geologic range.—Kirkwood Formation.

Dallarca subrostrata (Conrad)

Plate 8, Figures 5–7

Arca subrostrata Conrad, 1841a, p. 30.

Arca (Scapharca) subrostrata Conrad. Whitfield, 1894, p. 45, Pl. VI, figs. 11–13.

Arca subrostrata Conrad. Richards and Harbison, 1942, p. 181, Pl. 7, fig. 13.

Discussion.—*Dallarca subrostrata* (Conrad) is one of the well-represented taxa recovered from the Pollack Farm Site with over 2000 specimens collected. The species was not reported from New Jersey by Conrad and was represented only by fragments in the Whitfield (1894) and Richards and Harbison (1942) study material. Because of the fragmentary condition of the Shiloh Marl arcids, those authors admittedly guessed at the identity of those specimens and incorrectly reported the presence of a number of species in the Kirkwood. They include the following:

- *Arca callipleura* Conrad [=*Dallarca elevata* (Conrad)], Boston Cliffs Member, Choptank Formation
- *Arca lienosa* Say [=*Sectiarca lienosa* (Say)], Rushmere and Moore House members, Yorktown Formation
- *Arca idonea* Conrad [=*Dallarca idonea* (Conrad)], Windmill Point Member, St. Marys Formation
- *Arca staminea* Say [=*Dallarca staminea* (Say)], Duplin and Raysor formations

These taxa range in age from the middle Miocene to the late Pliocene and were not present in the well-preserved mollusks at the Pollack Farm Site.

Specimens of *Dallarca subrostrata* from Delaware are larger, on average, than those found in Bed 10 of the Plum Point Marl Member, the only other unit in which they are common to abundant.

Geologic range.—Kirkwood Formation; Calvert Formation, Plum Point Marl Member (Bed 10); Pungo River Formation.

Dallarca sp.

Plate 8, Figures 8–10

Discussion.—One of the most abundant taxa at the Pollack Farm Site is an unidentified species of *Dallarca*. Represented by over 2500 valves, the species resembles *Dallarca staminata* (Dall, 1898) but seems to be more elongate and rounded posteriorly than that species. The abundant material should make final identification of the Pollack species possible. The species is known only from that site and was not represented in the material from New Jersey studied by Whitfield (1894) or Richards and Harbison (1942) and has not been reported from the Calvert Formation.

Geologic range.—Kirkwood [Calvert] Formation in Delaware.

Glycymeris parilis (Conrad)

Plate 9, Figures 1, 3, 7, 9

Pectunculus parilis Conrad, 1843a, p. 306.

Axinea lentiformis? Whitfield, 1894, p. 49–50, Pl. VII, figs. 5, 6.

Glycymeris parilis (Conrad). Richards and Harbison, 1942, p. 183, Pl. 7, figs. 16, 17.

Discussion.—Whitfield (1894) had only small, young specimens available to him and was uncertain as to the exact identity of the material. Richards and Harbison (1942) reported only young specimens from the pits near Shiloh, New Jersey, but illustrated a young adult from a borehole at Sea Isle City, New Jersey. The material at the Pollack Farm Site consists of numerous large valves, many of which are larger than any found in Bed 10 of the Plum Point Marl Member (Calvert Formation). Bed 10 contains the only other large accumulation of *G. parilis*. Approximately 650 complete specimens were obtained from the Pollack Farm Site.

Geologic range.—Kirkwood Formation; Calvert Formation, Fairhaven Member, Plum Point Marl Member (Bed 10).

Mytilus (Mytiloconcha) incurva Conrad

Plate 9, Figures 4, 5

Myoconcha incurva Conrad, 1839, inside new back cover, Pl. XXVIII, fig. 1.

Mytiloconcha incrassata Conrad. Whitfield, 1894, p. 38, Pl. V, figs. 10, 11, Pl. VI, figs. 1, 2.

?Mytilus incurvus (Conrad). Richards and Harbison, 1942, p. 184, Pl. 7, fig. 18.

Discussion.—Numerous large fragments consisting principally of beaks are present at the Pollack Farm Site; however, several whole individuals were obtained in the lower, finer-grained portions of the exposure. Glenn (1904) reported and figured specimens that he named *M. incurvus* and *M. conradinus* (=*M. incrassata*). The two taxa co-occur at most of the localities mentioned. The differences mentioned by Glenn can be resolved with large numbers of specimens. There seems to be no significant difference between the Miocene specimens referred to *M. incurva* and those from the late Pliocene of North Carolina (Duplin Formation), South Carolina (Raysor Formation), and Florida (Pinecrest Formation); in that case *Mytilus incurva* would be the appropriate name.

Geologic range.—Appears to range from the early Miocene to the late Pliocene, but it is not known to occur higher than the Choptank Formation in the Chesapeake Group.

***Modiolus ducatellii* (Conrad)**
Plate 9, Figure 2

Modiola Ducatellii Conrad, 1840, p. 53, Pl. XXVIII, fig. 2.
Modiola inflata Tuomey and Holmes. Whitfield, 1894, p. 39, Pl. VI, figs. 3, 4.
Modiolus ducatellii Conrad. Glenn, 1904, p. 366, Pl. XCVII, figs. 6, 7.
Modiola inflata Tuomey and Holmes. Richards and Harbison, 1942, p. 183, Pl. 7, fig. 15.

Discussion.—Only a single, imperfect valve of this very delicate species was found. *Modiola inflata* appears to be a junior synonym of *M. ducatellii*. The elongate adult form illustrated by Conrad (1840) can be united with the small, wide juvenile form illustrated by Tuomey and Holmes (1856) by a continual growth series where large collections are available.

Geologic range.—Ranges from the early Miocene to the late Pliocene in all of the stratigraphic units of the Chesapeake Group.

***Isognomon (Hippochaeta)* sp.**
Plate 9, Figures 6, 8

Perna torta Say, 1820, p. 38.
Perna torta Say. Whitfield, 1894, p. 36, Pl. V, figs. 12, 13.
Perna maxillata Lam. Heilprin, 1888, p. 402 [list only].
Perna maxillata Lamarck. Conrad, 1840, p. 52, Pl. 27.
Perna conradii d'Orbigny, 1852, p. 127.
Melina maxillata (Deshayes). Glenn, 1904, p. 383–384, Pl. CII, fig. 3, Pl. CIII, fig. 1.
Melina maxillata (Deshayes). Richards and Harbison, 1942, p. 184, Pl. 8, fig. 1.

Discussion.—Heilprin (1888), Whitfield (1894), and Richards and Harbison (1942) all described the abundant though fragmentary specimens of *Isognomon (Hippochaeta)*. Only three very worn beaks of this taxon were recovered from the shell hashes at the Pollack Farm Site. The obviously high-energy environment was probably not conducive to the preservation of these massive, but fragile, bivalves.

A number of names have been used in describing and illustrating the Miocene *Isognomon (Hippochaeta)*, including European ones, but the most likely to be correct is *Perna torta* (Say, 1820) [*Isognomon (Hippochaeta) torta* (Say, 1820)]. A species name is not employed here because of the fragmentary condition of the specimens.

Isognomon (Hippochaeta) was abundant on the Atlantic Coastal Plain during the Cretaceous, but became very rare in the Paleocene and is not known to occur in any units above the Paleocene until the upper Oligocene. It reappears on the Atlantic Coastal Plain in the Old Church Formation in Virginia, after an absence of approximately 45 million years. In the Miocene, the genus reestablishes itself as a dominant form, but then disappears at the end of the Miocene in North America, and during the Pliocene in Europe. It is now believed to be extinct.

Geologic range.—The genus ranges from the Cretaceous to the Pliocene.

***Crassostrea virginica* (Gmelin)**
Plate 10, Figures 1, 2, 5–8

Ostrea virginica Gmelin, 1791, p. 3336.
Ostrea mauricensis Gabb, 1860, p. 376, Pl. 67, fig. 26.
Ostrea Virginiana (Gmelin). Whitfield, 1894, p. 27–28, Pl. II, figs. 1–7.
Ostrea virginiana var. *procyon* Tuomey and Holmes. Whitfield, 1894, p. 28–29, Pl. I, figs. 4–6.
Ostrea virginica Gmelin. Richards and Harbison, 1942, p. 187, Pl. 9, fig. 4.

Discussion.—The Pollack Farm Site yielded large numbers of *Crassostrea virginica*, apparently the earliest appearance of the species. More than 1600 specimens were collected. Many attain large size and massive thickness but are obviously much smaller than their predecessor *C. gigantissima*, from the Haywood Landing Member of the Belgrade Formation (upper Oligocene/lower Miocene). The specimens of *C. virginica* from the Pollack Farm Site fall fully within the size range of *C. virginica* described by Galtsoff (1964). Many of the specimens are very elongate forms, a shape that is commonly found associated with tidal channels and high-energy, fast-flowing currents near inlets. Such a form is the synonymous species *Ostrea virginiana* var. *procyon* (attributed to Tuomey and Holmes, 1855, by Whitfield but is actually Holmes, 1858). This taxon is usually associated with brackish water, marginal marine settings. These peripheral and usually thin deposits are generally eroded and destroyed during subsequent marine transgressions. As a result, the record of such settings is poor and accounts for the lack of *C. virginica* in most of the Miocene and much of the Pliocene.

Geologic range.—Kirkwood, Yorktown, Chowan River, and James City formations and Recent.

***Pecten humphreysii woolmani* Heilprin**
Plate 10, Figures 3, 4

Pecten humphreysii Conrad, 1842, p. 194, Pl. 2, fig. 2.
Pecten humphreysii var. *woolmani* Heilprin, 1888, p. 405.
Vola humphreysii Conrad. Whitfield, 1894, p. 32–34, Pl. IV, figs. 6–9.
Pecten humphreysii Conrad. Richards and Harbison, 1942, p. 186, Pl. 8, fig. 45.
Pecten humphreysii woolmani Heilprin. Richards and Harbison, 1942, p. 186, Pl. 8, figs. 12, 13, Pl. 9, fig. 2.

Discussion.—The material from New Jersey available to Whitfield (1894) and Richards and Harbison (1942) was mainly fragmentary, as is the present material from the Pollack Farm Site. Those authors concluded that their material agreed well with Conrad's (1842) description and figure. They admitted, however, that their specimens had very square ribs as described by Heilprin (1888). Gibson (1987) figured a number of specimens of *P. humphreysii humphreysii*, *P. humphreysii woolmani*, and *P. mclellani*, and it appears to this author that they may all be variants of the same species. It seems safe at this time to treat the Delaware material as a distinct subspecies; however, because of the fragmentary material this distinction is uncertain. Apparently the forms with the very squared ribs occur only in the lower Calvert (Bed 3A), the Shiloh Marl of the Kirkwood, and the Pungo River Formation, all stratigraphically equivalent units.

Geologic range.—Kirkwood Formation; Calvert Formation, Fairhaven Member (Bed 3A); Pungo River Formation.

***Chesapecten coccymelus* (Dall)**
Plate 11, Figures 1, 2, 6

Pecten (Chlamys) coccymelus Dall, 1898, p. 741–742, Pl. 34, fig. 1.
Pecten Madisonius Say. Whitfield, 1894, p. 30, Pl. IV, figs. 1–4.
Pecten madisonius Say. Richards and Harbison, 1942, p. 185, Pl. 8, fig. 11.

Discussion.—Specimens available to Whitfield (1894) and Richards and Harbison (1942) were all juveniles or fragments and were identified as *"Pecten madisonius"* by those authors. That species occurs only in the upper Pliocene strata of the Yorktown Formation and its stratigraphic equivalents to the south (Ward and Blackwelder, 1975). Gibson (1987) and Ward (1992) have more recently described and illustrated *Chesapecten coccymelus*. The specimens from Delaware are typical of the species, but none exhibit the extreme development of the center row of scales on the ribs that was described by Dall (1898). The material recovered consists of more than 20 nearly complete valves and numerous fragments. The species is relatively small with adults averaging 40 mm. It is also abundant in Bed 10 of the Plum Point Marl Member.

Geologic range.—Kirkwood Formation; Calvert Formation, Fairhaven Member (Bed 3A), Plum Point Marl Member (Beds 4 and 10).

***Chesapecten sayanus* (Dall)**
Plate 11, Figures 3–5

Pecten Madisonius Sayanus Dall, 1898, p. 725, Pl. 26, fig. 6.
?Pecten Madisonius Say. Whitfield, 1894, p. 30, Pl. II, fig. 8.

Discussion.—The most abundant species of pectinids at the Pollack Farm Site is a fairly large *Chesapecten* that is characterized by numerous scaly ribs that are prominent during the early stages of development, but gradually become less elevated in the adults to the point that the disk is nearly flat in many specimens. The entire disk is covered by rows of very fine scales. In this regard, the species closely resembles "*Pecten madisonius sayanus*," described by Dall (1898) from the Oak Grove in western Florida and is here considered to be that species. A single valve of *C. sayanus* was found by the author in Bed 10 of the Plum Point Marl at Camp Roosevelt, Calvert County, Maryland. The only other specimens known to the author are several collected by Julia Gardner from Wye Island, Maryland, and a number of individuals collected by the author from the Pungo River Formation at the Lee Creek Mine, Aurora, North Carolina.

This appearance of *Chesapecten* in the early Miocene marks the first known occurrence of that taxon.

Geologic range.—Kirkwood Formation; Calvert Formation, Plum Point Marl Member (Bed 10); Pungo River Formation.

***Parvalucina crenulata* (Conrad)**
Plate 12, Figures 5–7

Lucina crenulate Conrad, 1840, p. 39, Pl. XX, fig. 2.
Lucina crenulata Conrad. Whitfield, 1894, p. 63, Pl. X, figs. 7–15.
Phacoides crenulatus (Conrad). Richards and Harbison, 1942, p. 192, Pl. 11, figs. 11, 12.

Discussion.—This species, rather small and almost ubiquitous in the Chesapeake Group, is rather uncommon at the Pollack Farm Site with only 25 specimens collected. Richards and Harbison (1942) list the taxon as common in the Kirkwood of New Jersey.

Geologic range.—Kirkwood, Calvert, Choptank, St. Marys, Eastover, Yorktown, and Chowan River formations.

***Stewartia anodonta* (Say)**
Plate 12, Figures 1–3

Lucina anodonta Say, 1824, p. 146, Pl. X, fig. 9.
Phacoides anodonta (Say). Richards and Harbison, 1942, p. 192, Pl. 11, figs. 11, 12.

Discussion.—*Stewartia anodonta* is known from the Kirkwood of New Jersey only by specimens from deep wells at Sea Isle City, New Jersey (Richards and Harbison, 1942). There is no record of the species from Shiloh, but it is common to abundant in the stratigraphically equivalent beds in Delaware with over 500 specimens collected. It is equally abundant in Bed 10 of the Plum Point Marl Member of the Calvert Formation and in the Choptank Formation.

Geologic range.—Belgrade, Kirkwood, Calvert, Choptank, St. Marys, Eastover, Yorktown, Chowan River, and James City formations.

***Carditamera aculeata* Conrad**
Plate 12, Figures 4, 8, 9

Carditamera aculeata Conrad, 1863b, p. 585.
Cardita arata (Conrad). Whitfield, 1894, p. 57, Pl. IX, figs. 5, 6.
Carditamera aculeata Conrad. Whitfield, 1894, p. 58, Pl. IX, figs. 7, 8.

Discussion.—Whitfield (1894) and Richards and Harbison (1942) both listed and figured specimens that they identified as *C. arata* (a species that first appears in the late Pliocene), but in their discussions they compare their material favorably with the smaller and more elongate species *C. protracta* Conrad. The specimens of *C. protracta* available to me have a pronounced keel on the posterior slope and fewer ribs than the Kirkwood specimens. I believe the Delaware specimens belong in *C. aculeata*, the type of which was collected at Shiloh, New Jersey. The material available included 60 single valves.

Geologic range.—Known only from the Kirkwood Formation, Shiloh Marl Member.

***Cyclocardia castrana* (Glenn)**
Plate 12, Figures 10, 12

Cardita granulata Say. Whitfield, 1894, p. 56, Pl. IX, figs. 1–4.
Venericardia castrana Glenn, 1904, p. 345, Pl. XCI, figs. 11, 12.
Venericardia granulata (Say). Richards and Harbison, 1942, p. 141, Pl. 11, figs. 1, 2.

Discussion.—Whitfield (1894) and Richards and Harbison (1942) mentioned specimens of *Cyclocardia* only from deep wells along the New Jersey coast; apparently none had been collected in the pits at Shiloh. By contrast, *Cyclocardia* is abundant in Delaware at the Pollack Farm Site with over 1400 specimens collected. The juvenile specimens available to previous authors caused them to assign the Kirkwood specimens to *C. granulata*, a much larger, robust species with beaded ribs that first appears in the Pliocene. Martin (1904) first described the Kirkwood species from Church Hill, Maryland, a locality that clearly has beds stratigraphically equivalent to those at Shiloh and the Pollack Farm Site.

Geologic range.—Kirkwood Formation, Shiloh Marl Member.

Marvacrassatella melinus **(Conrad)**

Plate 12, Figures 11, 13, 14

Crassatella melina Conrad, 1832, p. 23–24, Pl. 9, fig. 2.

Crassatella melina Conrad. Whitfield, 1894, p. 60, Pl. VIII, figs. 11–13.

Eucrassatella melina (Conrad). Richards and Harbison, 1942, p. 190, Pl. 10, figs. 14, 15.

Discussion.—Whitfield (1894) and Richards and Harbison (1942) both found *Marvacrassatella melinus* to be a common species in the Kirkwood Formation in New Jersey. Whitfield (1894) knew of only the Shiloh occurrences, but Richards and Harbison (1942) mentioned a number of localities and wells where specimens had been obtained. The species was common to abundant at the Pollack Farm Site; 320 valves were obtained. The species is equally abundant in the Calvert Formation, Plum Point Marl Member, Bed 10, in Calvert County, Maryland.

Geologic range.—Kirkwood Formation; Calvert Formation, Fairhaven Member (Bed 2), Plum Point Marl Member (Bed 10).

Astarte distans **Conrad**

Plate 13, Figures 1, 2, 4, 5

Astarte distans Conrad 1862, p. 288.

Astarte distans Conrad. Whitfield, 1894, p. 53, Pl. VII, figs. 13–17.

Astarte castrana Glenn, 1904, p. 353–354, Pl. XCIII, figs. 7–9.

Astarte distans Conrad. Richards and Harbison, 1942, p. 188, Pl. 10, figs. 1, 2.

Discussion.—Specimens of *Astarte distans* are extremely abundant at the Pollack Farm Site with over 1500 specimens collected. They resemble *A. undulata*, but are different in the profound, large undulations that extend over the entire disk. *Astarte castrana* Glenn (1904) is probably an ecophenotypic variation of this species. *Astarte* responds to substrate conditions with higher energy, sandy substrates by producing thicker shelled, well-ribbed specimens, while thinner valved, ribless specimens occur in finer, silty sediments. This condition was reported by Ward (1992, p. 84) relative to *Astarte thisphila* Glenn.

Geologic range.—Kirkwood Formation, Shiloh Marl Member.

Astarte **sp.**

Plate 13, Figures 3, 6

Astarte symmetrica Conrad. Whitfield, 1894, p. 54, Pl. VIII, figs. 1, 2.

Discussion.—A small, very triangular species of *Astarte* occurs at the Pollack Farm Site in large numbers. The taxon has only two to three small undulations on its beak and, otherwise, its disk is smooth except for irregularly spaced growth interruptions. It appears that the specimens figured by Whitfield (1894, pl. VIII, figs. 1, 2) belong to this species and not *A. symmetrica* or *A. cuneiformis*. The specimen wrongly figured as *Astarte vicina* Say by Glenn (1904, pl. XCIII, figs. 10, 11) has a similar exterior sculpture pattern, but is much more profoundly prosocline and deeper valved. The material collected from Delaware consists of 2500 valves.

Geologic range.—Known only from the Kirkwood [Calvert] at the Pollack Farm Site and the questionable New Jersey material from wells at Atlantic City.

Dinocardium **sp.**

Plate 13, Figures 7, 8

Discussion.—Specimens of an early form of *Dinocardium* are abundant at the Pollack Farm Site with over 116 specimens collected. Less abundant, but well-represented, is the cardiid species *Chesacardium craticuloides* (Conrad). Cardiids were found only as juveniles or fragments in the Kirkwood by Whitfield (1894) and Richards and Harbison (1942). This species of *Dinocardium* has the discerning characteristics of the genus, including the very tumid umbones and the wide, low ribs with prominent crescent-shaped cross-threads; but it has only a trace of the later hinge modification, in which the hinge plate is reflected upward and attaches to the beaks (see Ward, 1992, p. 89 for further discussion of this feature). Glenn (1904, pl. LXXXVI, fig. 5) figured a specimen obtained from external molds in Bed 2 of the Fairhaven Member that appears to be a *Dinocardium*, but it has considerably more ribs than the Delaware specimens (52 versus 35). That species, named *Cardium (Cerastoderma) patuxentium* by Glenn, occurs at the same stratigraphic level as the Delaware beds, but the significantly different rib counts suggest the Delaware taxon is a different species. Comparison of the Pollack Farm material with other species of *Dinocardium* suggests that the species is new. *Dinocardium* has not been reported in other beds in the Chesapeake Group and apparently did not reinhabit the Salisbury Embayment. It is reported from the Chowan River Formation by Campbell (1993); however, it occurs in older Pliocene units in North Carolina, South Carolina, Georgia, and in the Miocene and Pliocene of Florida. *Dinocardium* is today a subtropical to tropical bivalve, and the evidence in the earlier occurrences of the genus indicates that it occupied similar settings in the Oligocene and Miocene.

Geologic range.—Kirkwood Formation, Shiloh Marl Member.

Chesacardium craticuloides **(Conrad)**

Plate 13, Figure 10

Cardium craticuloides Conrad, 1845, p. 66, Pl. 37, fig. 3.

Cardium (Cerastoderma) craticuloides Conrad. Whitfield, 1894, p. 66, Pl. X, figs. 16–19.

Cardium laqueatum Conrad. Richards and Harbison, 1942, p. 193, Pl. 12, fig. 6.

Cardium patuxentium Glenn. Richards and Harbison, 1942, p. 193, Pl. 12, fig. 4.

Discussion.—*Chesacardium craticuloides* is common to abundant at the Pollack Farm Site with 58 specimens and a large number of fragments collected. This occurrence marks the first known appearance of *Chesacardium*, a temperate-water taxon. The co-occurrence of *Dinocardium* and *Chesacardium* in the Kirkwood is the only known appearance of these two genera together until the late Pliocene (3.5 Ma.). At that time their geographic ranges overlapped in the Duplin Formation of North and South Carolina and Raysor Formation of South Carolina.

Geologic range.—Kirkwood Formation, Shiloh Marl Member; Calvert Formation, Plum Point Marl Member (Bed 10).

"Cardium" calvertensium Glenn

Plate 13, Figures 9, 11

Cardium (Cerastoderma) calvertensium Glenn, 1904, p. 321, Pl. LXXXVI, fig. 4.

Discussion.—*"Cardium" calvertensium* is present but never common in the beds at the Pollack Farm Site with 18 specimens collected. The species was not mentioned by Whitfield (1894) or Richards and Harbison (1942). Two species resemble *"Cardium" calvertensium* in terms of number of ribs, but their ribs are V-shaped. The two, *Cardium ctenolium* Dall (1900) and *Cardium panastrum* Dall (1900) both occur in the Oak Grove of Florida, a stratigraphic equivalent of the upper Calvert Formation.

Geologic range.—Kirkwood Formation, Shiloh Marl Member; Calvert Formation, Fairhaven Member, Plum Point Marl Member, Calvert Beach Member.

Leptomactra marylandica (Dall)

Plate 14, Figures 1, 2

Spisula (Hemimactra) marylandica Dall, 1898, p. 897, Pl. XXVIII, fig. 5.

Spisula (Hemimactra) marylandica Dall. Glenn, 1904, p. 287, Pl. LXIX, fig. 11.

Leptomactra marylandica (Dall). Ward, 1992, p. 94–95, Pl. 17, figs. 3, 5.

Discussion.—A number of mactrids were mentioned by Whitfield (1894) and Richards and Harbison (1942) as occurring in the Miocene of New Jersey. The specimen (fragment) identified as *Mactra delumbis* by Whitfield (1894, p. 82–83) may be a *L. marylandica* and not a *L. delumbis* as he concluded. The specimens identified by Richards and Harbison (1942, pl. 15, figs. 16, 17) as *Mactra delumbis* are not that species, which ranges from the St. Marys to the Yorktown Formation, nor is it *L. marylandica*, but rather it probably is a specimen of *"Mactra"* sp. described below and figured on Plate 14, figures 3–6.

The specimens found in Delaware are large (eight specimens are 75+ mm) and nearly complete making their identification certain. Rare specimens from the Haywood Landing Member of the Belgrade Formation appear to be identical to the Delaware specimens. This would extend the range of the genus *Leptomactra* back into the late Oligocene and indicate that *L. marylandica* lived from the late Oligocene until the late Miocene.

Geologic range.—Belgrade (Haywood Landing Member), Kirkwood, Calvert, Choptank, and St. Marys formations.

"Mactra" sp.

Plate 14, Figures 3–6

Discussion.—Whitfield's (1894, pl. XV, figs. 1–6) specimens may be identical to the mactrid species so common at the Pollack Farm Site in Delaware. It is clear that his identifications, *Mactra lateralis* for figures 1–3 and *Rangia (Perissodon) minor* for figures 4–6, are incorrect. *Mulinia lateralis* is a Pleistocene to Recent species and *Rangia minor* (which is probably not a *Rangia*) is known only from the upper Pliocene Duplin Formation in North Carolina.

Pilsbry and Harbison (1933) named and figured a mactrid, *Mactra insulaemaris*, that is similar in form and size to the Delaware species, but it was described as having strongly crenulated lateral teeth. The species at the Pollack Farm Site, which numbers in excess of 500 specimens, shows no trace of the striations on the lateral teeth. *"Spisula" subcuneata* (Conrad) figured by Glenn (1904, pl. LXIX, figs. 7–9) and Ward (1992, pl. 11, fig. 4) is shaped much like the Delaware species, but it too has crenulated lateral teeth.

A specimen figured by Glenn from Plum Point, Maryland (probably Bed 10 of the Calvert Formation) resembles the Delaware specimens, but it was identified as *Spisula subparilis*, an upper Pliocene species from the Duplin Formation in North Carolina. The specimens figured by Richards and Harbison (1942, pl. 15, figs. 1, 2–4, 8, 20) may be identical to the Delaware species, but they were called *Mulinia lateralis* and *Mactra clathrodon* by the authors. The poor figures and inadequate species descriptions make identification difficult.

The Delaware species, therefore, seems undescribed. It is thin, almost equilateral, with the beaks slightly prosocline. Specimens are most numerous in the 20 mm range, but some specimens are as large as 60 mm. In general form, it resembles the Recent *Hemimactra solidissima*. That species exhibits very fine striations on the lateral teeth, a condition not observed in the lower Miocene taxon. The Delaware species is also not nearly as deep-valved as *Leptomactra marylandica*.

Geologic range.—Kirkwood Formation; possibly Bed 10 of the Plum Point Marl Member of the Calvert Formation.

Ensis directus Conrad

Plate 14, Figures 7, 8

Ensis directus Conrad, 1843b, p. 325.

Ensis directus Conrad. Richards and Harbison, 1942, p. 200, Pl. 16, figs. 7, 8.

Discussion.—Broken valves of *Ensis* are common at the Pollack Farm Site, and over 100 specimens were collected, though none were even half complete. Specimens from the St. Marys River (where the type of *E. ensiformis* Conrad, 1843, originates) and the Neuse River below New Bern, North Carolina (type locality of *E. directus*) were compared with the specimens from Delaware, and no important differences were noted. Thus, the name *E. directus* is used as it appeared first in Conrad's 1843b paper.

Whitfield (1894) did not mention the presence of *Ensis* in the New Jersey Miocene, but Richards and Harbison (1942) report fragments in several deep wells. The material from Delaware, though fragmentary, is sufficient to make comparisons with specimens from younger units. *Ensis* occurs in European beds as old as the Eocene, but the presence of that taxon in the Kirkwood beds marks its first known appearance on the Atlantic Coastal Plain. *Ensis directus* occurs in the Recent in shallow shelf conditions from Labrador to Florida.

Geologic range.— Kirkwood, Calvert, Choptank, St. Marys, Eastover, Yorktown, Chowan River, James City formations, and younger units to the Recent.

Strigilla sp. cf. _S. georgiana?_ Gardner
Plate 14, Figures 9–11

Strigilla georgiana Gardner, 1928, p. 199, Pl. XXX, figs. 12, 13.

Discussion.—*Strigilla* is fairly common in the Pollack Farm collection with some 200 valves collected. The valves average 17–20 mm in length. The exterior V- or W-shaped divaricate sculpture is very weak, even in the best preserved specimens, and can scarcely be seen without magnification. In this way it seems to differ from *S. georgiana*, which has much stronger sculpture. The Delaware species also resembles the Recent taxon, *S. pisiformis* (Linné).

Strigilla was not reported by Whitfield (1894) or Richards and Harbison (1942). In addition, there is no report of the taxon in any stratigraphic unit in the Chesapeake Group, except the Chowan River Formation, an upper Pliocene unit, which is essentially subtropical in nature. There is, therefore, an approximately 16 million year absence of *Strigilla* in the mid- Atlantic region. The genus today is characterized by Abbott (1974) as "worldwide and tropical." Its presence in Delaware is strong evidence of tropical influences during the early Miocene at least as far north as the 39°30´ north latitude.

Geologic range.—Not known outside of the Kirkwood [Calvert] Formation of Delaware and the Oak Grove Sand of Florida and Georgia.

Florimetis biplicata (Conrad)
Plate 15, Figure 1

Tellina biplicata Conrad, 1834, p. 152.
Metis biplicata (Conrad). Richards and Harbison, 1942, p. 196, Pl. 12, figs. 2, 3.

Discussion.—The only record of this taxon in the Kirkwood Formation is that of Richards and Harbison (1942), who, besides fragments, record only one specimen at 310 ft in a core from a well at Millville, New Jersey. *Florimetis biplicata* is represented at the Pollack Farm Site by at least 10 specimens, four of which are essentially complete. The species is present during most of the Miocene, but is common only during the early middle Miocene in the Drumcliff Member of the Choptank Formation. The occurrence of this taxon in the Kirkwood marks its earliest known appearance on the Atlantic Coastal Plain. A species of *Metis*, *Metis chipolana*, was described by Dall (1900) from the Chipola Formation in Florida, a stratigraphic equivalent of the Kirkwood Formation in New Jersey.

The large, thin valves of *Florimetis* are fragile and easily broken, hence the few preserved specimens at the Delaware site.

Geologic range.—Kirkwood, Calvert, Choptank, St. Marys, and Eastover formations.

Semele subovata (Say)
Plate 15, Figure 2

Amphidesma subovata Say, 1824, p. 152, Pl. X, fig. 10.
Amphidesma Burnsi Whitfield, 1894, p. 79, Pl. XIV, figs. 16–18.
Abra aequalis Conrad. Whitfield, 1894, p. 80, Pl. XIV, figs. 11–15.
Semele johnsoniana Pilsbry and Harbison, 1933, p. 18, Pl. 5, figs. 4–6.
Semele burnsi (Whitfield). Richards and Harbison, 1942, p. 199, Pl. 15, figs. 18, 19.
Semele johnsoniana Pilsbry and Harbison. Richards and Harbison, 1942, p. 199, Pl. 15, figs. 11, 12.

Discussion.—Specimens of *Semele subovata* were named *Amphidesma burnsi* and also identified as *Abra aequalis* by Whitfield (1894) who reported the species to be common at Shiloh, New Jersey. Pilsbry and Harbison (1933) described and named another species of *Semele* from the Kirkwood, *S. johnsoniana*. Examination of specimens present in the stratigraphic units from the Belgrade Formation (upper Oligocene/lower Miocene) to the Yorktown Formation (upper Pliocene) shows only very minor differences between the populations over this geologic interval. For this reason I have included all of these specimens in *Semele subovata*, a species whose type came from the upper Yorktown Formation. Young specimens tend to be noticeably longer than high, but later growth changes their outlines to make adult specimens nearly as high as they are long. This species was present, but never common, at the Delaware site with 13 valves collected.

Geologic range.—Belgrade (Haywood Landing Member), Kirkwood, Calvert, Choptank, St. Marys, Eastover, and Yorktown formations.

Tagelus plebeius subspecies
Plate 15, Figure 3, 5

Solen plebeius [Lightfoot], 1786, p. 42.

Discussion.—*Tagelus* is common at the Pollack Farm Site, though most specimens are broken and incomplete due to their fragility. Whole individuals suggest that the Delaware taxon is somewhat more elongate than the Recent *T. plebeius* (Lightfoot). Specimens collected by the author from the upper Oligocene Haywood Landing Member of the Belgrade Formation in North Carolina are probably the same species as the Delaware taxon. Some 55 specimens were collected at the Pollack Farm Site. In the Atlantic Coastal Plain the genus is not known to reappear until the late Pliocene in the Moore House Member of the Yorktown Formation. *Tagelus* becomes common in the late Pliocene and Pleistocene of the Atlantic Coastal Plain.

Geologic range.—Belgrade and Kirkwood formations.

Donax idoneus subspecies?
Plate 15, Figures 4, 6, 9

Donax idoneus Conrad, 1872, p. 216, Pl. 7, fig. 2.
?Donax variabilis Say. Whitfield, 1894, p. 79, Pl. XIV, figs. 19, 20. [Not *Donax variabilis* of Say, 1822].
?Donax abseconi Richards and Harbison, 1942, p. 197–198, Pl. 15, figs. 5, 6.

Discussion.—*Donax idoneus* is common in the Haywood Landing Member of the Belgrade Formation (upper Oligocene/lower Miocene) in North Carolina. It is a very large species for the genus with specimens commonly exceeding 40 mm in length. The Pollack Farm specimens are fairly common with 35 specimens collected, and they average approximately the same length as *D. idoneus*, except one incomplete valve that suggests a length of about 60 mm. There are several significant differences between the Delaware and North Carolina forms that may indicate they are different subspecies. The Delaware form has a smaller hinge plate and teeth, a very sharply angled and straight posterior slope, and finer crenulations along the basal margin. The North Carolina form is deeper valved, and its posterior slope is more rounded and slightly curved. Whitfield (1894) and Richards and Harbison (1942) each figured a single specimen of a *Donax* from a well at Atlantic City, New Jersey. Richards and Harbison (1942, p. 197–198) named their specimen *D. abseconi*. It appears this specimen, an incomplete valve, could be the young of *D. idoneus* subspecies as could the juvenile specimen illustrated by Whitfield (1894). Further study may help to determine if *D. abseconi* is the proper name for this remarkable taxon.

Donax striatus Linné, a living West Indian species, approaches the shape and size of the Delaware species but is smaller. *Donax peruvianus* Deshayes, a living West Coast species, is very near the shape of the Delaware form and nearly as big. *Donax* lives in high-energy environments, typically near sandy beaches and is strong evidence that dynamic currents were present during the development of the beds at the Pollack Farm Site. Most species are subtropical to tropical.

Geologic range.—*Donax* ranges from the early Eocene to the Recent; *D. idoneus* is known from the Belgrade Formation in North Carolina, and *D. idoneus* subspecies is known only from the Kirkwood [Calvert] in Delaware.

***Donax* sp.**

Plate 15, Figures 11–14

Discussion.—A small, very elongate species of *Donax* is sparingly present in the beds at the Pollack Farm Site. Twenty-five specimens have been collected, the longest of which is about 12 mm. An imperfect specimen described by Richards and Harbison (1942) from a well at Atlantic City at an unknown depth appears to be distinct from the Delaware species. That taxon, *Donax abseconi*, based on a single incomplete specimen, may be the young of *Donax idoneus* subspecies? and is much more triangular in shape than the elongate species under consideration here. A very similar, but much larger species of *Donax* is present in the Belgrade Formation in North Carolina. *Donax aldrichi* Gardner, based on a single specimen from the Oak Grove Sand on the Yellow River in Florida, is similarly shaped and nearly the same size, but the very obvious radial lines developed on the type cannot be seen on the Delaware specimens.

Except for the Kirkwood occurrence, no other species of this genus is known to occur in Chesapeake Group sediments until the late Pliocene, in the upper beds of the Yorktown Formation, an approximately 15 million year absence.

Geologic range.—Kirkwood [Calvert] Formation in Delaware. Possibly Belgrade Formation in North Carolina, and possibly the Oak Grove Sand in Florida.

***Iphigenia* sp.**

Plate 15, Figures 7, 8, 10

Discussion.—An unnamed species of *Iphigenia* is common at the Delaware site. It was not reported by Whitfield (1894) or by Richards and Harbison (1942), but is represented by over 2000 specimens at the Pollack Farm Site. I can find no reference to the genus in the literature on the Atlantic and Gulf Coasts, but it is represented in the Recent by *I. brasiliana* (Lamarck). That taxon occurs in subtropical to tropical settings from south Florida to Brazil. The genus is reported from the Miocene to the Recent in West Africa and Central and South America (Cox and others, 1969).

The Delaware species is broadly trigonal in outline but does not exhibit the broad medial fold that flexes the margin of *I. brasiliana*. It is also smaller than that species with the largest individuals slightly larger than 40 mm.

Geologic range.—Kirkwood [Calvert] Formation in Delaware.

***Mytilopsis erimiocenicus* Vokes**

Plate 16, Figures 1–3

Mytilopsis erimiocenicus Vokes, 1985, p. 163–165, figs. 1–3.

Discussion.—*Mytilopsis erimiocenicus* is common to abundant at the Pollack Farm Site with over 2100 specimens collected. The taxon was not mentioned by Whitfield (1894) or Richards and Harbison (1942) in their studies on the New Jersey early Miocene. There is no record of the genus on the Atlantic Coastal Plain except in the Chipola Formation (lower Miocene) of west Florida and in the late Pliocene of south Florida (Dall, 1898). Cox and others (1969) give the range of the genus from the late Oligocene to the Recent in western South America, Africa, and the East Indies. Presently, there is a single species on the North American Atlantic Coast, *M. leucophaeata*, which first appeared in the late Pleistocene. That species occurs from New York to Mexico and is found in brackish water where rivers run into the sea. Except for this species, the others mentioned in the literature occur in subtropical and tropical environments.

The specimens from Delaware closely resemble *M. leucophaeata* in shape and size, but for the present, I am placing the species in *Mytilopsis erimiocenicus* of Vokes. The Florida Pliocene species, *M. lamellata* (Dall), is much heavier and has a more triangular shell.

Geologic range.—Kirkwood [Calvert] Formation in Delaware, Chipola Formation in Florida, and possibly Recent, if this species is identical to *M. leucophaeata*.

***Glossus* sp.**

Plate 16, Figure 4

?Isocardia fraterna Say var. *marylandica?* Schoonover, 1941, Pl. 9, fig. 5.

Discussion.—No species of *Glossus* has been reported from the Kirkwood of New Jersey nor has a specific species been reported in the Calvert Formation below Bed 10 of the Plum Point Marl Member. A possible exception is *Glossus ignolea*, based on a single specimen (both valves), from an uncertain locality, either the lower St. Marys Formation or Plum Point (=Bed 10). The author, Glenn (1904), was inclined to believe the Plum Point *Glossus*, similar to *G. ignolea*, was present in Beds 4–9 of the Calvert. A species of *Glossus* does occur in those beds, in vast numbers, along single bedding planes, but they exist only as molds and casts or poorly preserved, eroded specimens. A specimen called *"Isocardia fraterna* var. *marylandica?"* by Schoonover, and illustrated by her, came from Bed 5 of the Calvert and may be the same species as the Delaware taxon. However, that specimen (pl. 9, fig. 5) is not Schoonover's *I. f.* var. *marylandica* (=*Glossus marylandica* [Schoonover])

The specimens from the Pollack Farm Site differ from the stratigraphically higher Maryland forms in being less elongate and lacking the more pronounced ridge on the posterior slope. The Delaware species is rare, with only one whole individual and two partial specimens collected. The material, however scant, marks the first known appearance of the genus in North America. Some species, belonging to the family Glossidae, have been reported from the Paleocene and Eocene in North America, but the earliest appearance of true *Glossus* was in northern Europe in the early Oligocene.

Geologic range.—Kirkwood Formation, Shiloh Marl Member.

***Lirophora latilirata* (Conrad)**
Plate 16, Figures 5, 6

Venus latilirata Conrad, 1841a, p. 28.
Chione latilirata (Conrad). Glenn, 1904, p. 309–310, Pl. LXXVII, figs. 3, 4, 6.

Discussion.—*Lirophora latilirata* is common to abundant in the beds at the Pollack Farm Site with 350 specimens collected. The species is equally abundant in the Plum Point Marl Member (Bed 10) of the Calvert Formation. The name *"L. latilirata"* has been applied to species in the Pliocene, Pleistocene, and Recent, but it is properly only applied to the Kirkwood and Calvert species. Recent taxa referred to *Lirophora* live in subtropical and tropical settings. There is no mention of this species in the Kirkwood of New Jersey by either Whitfield (1894) or Richards and Harbison (1942).

Geologic range.—Kirkwood and Calvert (Plum Point Marl Member, Bed 10) formations.

***Mercenaria ducatelli* (Conrad)**
Plate 16, Figures 7, 8; Plate 17, Figures 1–3

Venus Ducatelli Conrad, 1838, p. 8, Pl. IV, fig. 2.
Mercenaria Ducateli Conrad. Whitfield, 1894, p. 67, Pl. XI, figs. 1–7.
Venus ducatelli Conrad. Glenn, 1904, p. 304, Pl. LXXV, figs. 7, 8.
Venus ducatelli Conrad. Palmer, 1927, p. 192–193, Pl. XXXV, figs. 5, 9.
Venus ducatelli Conrad. Richards and Harbison, 1942, p. 194–195, Pl. 13, fig. 5.

Discussion.—*Mercenaria ducatelli* is extremely abundant at the Pollack Farm Site, with over 1200 specimens collected. Only a meager number of specimens were available to Whitfield (1894) from New Jersey, and Richards and Harbison (1942, p. 194) reported the species to be "Rare and usually broken." The forms figured by Whitfield (1894, pl. XI, figs. 1–7) are typical of the species. Other ecophenotypic varieties are present in the Pollack Farm collections. Those specimens have their lamella fused together, or nearly so, as is typical of back-barrier or quiet water, lagoonal-living *Mercenaria*. To see the several morphs mixed together is no surprise as the entire Pollack Farm collection shows the mixing of brackish, back-barrier mollusks with normal-salinity, open-shelf taxa. The species named *"M. cancellata"* Gabb (figured by Whitfield, 1894, pl. XII, figs. 2, 3) may be merely a variety of *M. ducatelli* that grew in a lagoonal, muddy setting. *Mercenaria plena* Conrad (figured by Whitfield, 1894, pl. XII, figs. 4–6) may also be referable to *M. ducatelli*. *Mercenaria langdoni* (Dall, 1900), which lived in the stratigraphically equivalent Chipola Formation in Florida, is also probably the same species as the Delaware form.

Geologic range.—Kirkwood Formation, Shiloh Marl Member.

***Dosinia acetabulum blackwelderi* Ward**
Plate 17, Figure 4

Dosinia acetabulum blackwelderi Ward, 1992, p. 102–103, Pl. 18, fig. 2.
Dosinia acetabulum Conrad. Whitfield, 1894, p. 73. [Not Plate XIII, fig. 2].
Dosinia acetabulum (Conrad). Richards and Harbison, 1942, p. 194, Pl. 12, fig. 5. [Not Plate 12, fig. 1].

Discussion.—This taxon is common to abundant at the Pollack Farm Site with more than 100 whole or nearly whole individuals collected. By contrast, Whitfield (1894) and Richards and Harbison (1942) reported only a few fragments from deep wells in New Jersey. Whitfield figured Conrad's (1832) type of *Dosinia acetabulum acetabulum* from the Yorktown Formation (upper Pliocene) of Virginia, and Richards and Harbison figured Ward's (1992) *Dosinia acetabulum thori* from the St. Marys Formation (late Miocene) of Maryland. Neither of these taxa occur in the Kirkwood. The occurrence of *Dosinia* in the Kirkwood marks the first known appearance of that genus on the North American Atlantic Coastal Plain. The *D. acetabulum* lineage is represented through the entire Chesapeake Group, apparently becoming extinct during the cooling event after the deposition of the Yorktown Formation and before the deposition of the Chowan River Formation. The *D. acetabulum* lineage clearly prefers temperate habitats, and it is replaced in subtropical and tropical settings by the *D. concentrica* lineage. That lineage survived the cooling event and is extant.

Geologic range.—Kirkwood Formation; Calvert Formation, Plum Point Marl Member, Calvert Beach Member; Choptank Formation.

***Macrocallista marylandica* (Conrad)**
Plate 17, Figures 5–7

Cytherea marylandica Conrad, 1833b, p. 343.
Dione marylandica Conrad. Whitfield, 1894, p. 74. [Plate XIII, fig. 1 is a copy of Conrad's (1838) figure, probably from the Choptank Formation].
Macrocallista marylandica (Conrad). Richards and Harbison, 1942, p. 193, Pl. 10, fig. 13.

Discussion.—*Macrocallista marylandica* is very abundant at the Pollack Farm Site with at least 800 whole valves collected. Whitfield (1894) had only two fragments of a hinge and Richards and Harbison (1942) had only fragments, all of which came from deep wells in the Kirkwood of New Jersey. The large suite of specimens exhibits a fair amount of variation in shape that involves a number of very short, stout individuals, as well as very elongate ones. This author believes that the Delaware specimens are all the same species and that they seem identical to *M. marylandica* from the type locality on the Choptank River. Ward (1992) was unsure about the identity of the *Macrocallista* specimens from Bed 10 of the Plum Point Marl Member because of their small size and corresponding thinness, but it seems clear, with the Delaware material in hand, that *M. mary-*

landica was present in the Kirkwood, Calvert, and Choptank formations. Specimens present in the Belgrade Formation, Haywood Landing Member (upper Oligocene/lower Miocene) of North Carolina would be difficult to differentiate from *M. marylandica*, though other distinctly different species of *Macrocallista* are also present in that unit. The genus is clearly a slowly evolving one, which, because of its conservative morphologic changes, is difficult to determine to the specific level.

Geologic range.—Kirkwood Formation, Calvert Formation, and Choptank Formation.

Clementia grayi Dall
Plate 18, Figures 1, 4

Clementia grayi Dall, 1890, p. 193, Pl. 37, fig. 12.
Clementia (Egesta) grayi Dall. Woodring, 1926, p. 37, Pl. 15, fig. 4.
Clementia (Egesta) inoceriformis (Wagner). Woodring, 1926, Pl. 15, fig. 6. [Only hinges of specimens labeled "Shiloh, N. J." glued to holotype of *C. inoceriformis*].
Clementia inoceriformis (Wagner). Richards and Harbison, 1942, p. 175, fig. 4. [Only hinges of specimens labeled "Shiloh, N. J." (ANSP 4303)].

Discussion.—The Pollack Farm specimens are provisionally placed in *Clementia grayi*. This species has a posterior slope more flattened than that of *C. inoceriformis*. In addition, the concentric undulations extend farther down the shell in *C. inoceriformis* than in *C. grayi*. The specific determination, in this case, is based principally on the only complete specimen, a double-valved individual. The remaining 20 specimens consist of the beak and hinge portion of the taxon, the only thick part of the shell. Using only broken specimens, I would have concluded that the species was *C. inoceriformis* because the concentric undulations on the beak are regular and strong. The whole specimen, however, shows that the undulations become irregular in the lower two-thirds of the disk and are replaced by numerous, closely placed, fine, concentric growth lines. This is a characteristic described by Dall (1900) and Woodring (1926) in their description of *C. grayi*. The species is known from a number of lower Miocene localities in Florida, including the stratigraphically equivalent Chipola Formation. Richards and Harbison (1942, p. 175) and Woodring (1926) both figured *Clementia* hinges collected by Conrad and said to come from Shiloh, New Jersey. The Delaware material leaves little doubt that the genus was present in the Kirkwood Formation in New Jersey as well as Delaware.

Geologic range.—Kirkwood Formation, Shiloh Marl Member; Oak Grove Sand and Chipola Formation in Florida.

Mya producta Conrad
Plate 18, Figures 2, 5

Mya producta Conrad, 1838, p. 1, Pl. 1, fig. 1.
Mya producta Conrad. Glenn, 1904, p. 283, Pl. LXVIII, figs. 1, 2.
Mya producta Conrad. Richards and Harbison, 1942, p. 202, Pl. 16, fig. 11. [Fig. 12 is from the Choptank Formation in Maryland].

Discussion.—The first report of *Mya producta* in the Kirkwood Formation in New Jersey was that of Richards and Harbison (1942), but that report was based on "fragments only." Glenn (1904) reported the species only from Jones Wharf, St. Marys County, Maryland (= Bed 17 of the Choptank Formation), and there this author has found it rather common. I can find no evidence of the species in Bed 10 of the Plum Point Marl Member, but it is fairly common at the Pollack Farm Site in Delaware, where over 130 valves have been recovered, mostly broken, but many nearly whole. The adult specimens commonly range from 90–100 mm in length, are relatively thick-valved, and have a prominent medial fold. Young specimens do not exhibit this fold. Several young specimens found in the Haywood Landing Member of the Belgrade Formation in North Carolina look identical to the Delaware material and may indicate that this species was present from the late Oligocene to the middle Miocene.

Geologic range.—Belgrade Formation (Haywood Landing Member), Kirkwood Formation, Choptank Formation (Drumcliff Member).

Caryocorbula cuneata (Say)
Plate 18, Figures 13, 14

Corbula cuneata Say, 1824, p. 152, Pl. XIII, fig. 3.
Corbula cuneata Say. Glenn, 1904, p. 282, Pl. LXVII, figs. 15–19.

Discussion.—The most common corbulid species present in the Pollack Farm assemblage is *Caryocorblula cuneata*, which is common from the Miocene to the Pliocene. It is most readily identified by its exterior sculpture of fine, equally spaced, close-set, concentric ribs. The other corbulid species, which commonly co-occurs with *C. cuneata*, is *C. inaequalis* Say, but that taxon has very unequal, irregular ribs, and is more rounded. *Caryocorbula cuneata* is represented by over 1000 specimens from Delaware, though it has not been previously reported from the Kirkwood Formation of New Jersey. The species is not particularly abundant, despite the numbers, as similar volumes of sediment in the other beds of the Chesapeake Group commonly would yield many times more individuals.

The specimens from Delaware identified by myself as *C. cuneata* are similar to, and may be identical with, specimens from the Chipola Formation that Dall named *Corbula (Cuneocorbula) sarda* (Dall, 1898).

Caryocorbula subcontracta (Whitfield)
Plate 18, Figures 3, 6

Corbula subcontracta Whitfield, 1894, p. 88–89, Pl. XV, figs. 11–14.
Corbula inaequalis Say. Glenn, 1904, p. 281–282, Pl. LXVII, figs. 6, 10. [Not *C. inaequalis* of Say, 1824].
Corbula inaequalis Say. Richards and Harbison, 1942, p. 198, Pl. 15, figs. 13, 14. [Not *C. inaequalis* of Say, 1824].

Discussion.—*Caryocorbula subcontracta* is present in small numbers in the molluscan material from Delaware. It was named by Whitfield (1894) based on specimens from Shiloh, New Jersey. Glenn (1904) and Richards and Harbison (1942) considered *C. subcontracta* to be a junior synonym of *C. inaequalis* (Say, 1824), but *C. subcontracta* has strong, equal-sized, equidistant, concentric ribs (fewer and stronger than in *C. cuneata*) and not the "rough, unequal coarse wrinkles" described by Say (1824, p. 153) for *C. inaequalis*.

Over 100 specimens have been obtained from the

Pollack Farm material, but considering the large amount of material picked, this species is somewhat uncommon. Several of the specimens figured by Glenn (1904, pl. LXVII, figs. 6, 10, 12) appear to be *C. subcontracta*. The specimen in his figure 6 comes from Church Hill, Maryland, in a bed stratigraphically equivalent to the Shiloh Marl and the beds at the Pollack Farm Site. The specimen shown in his figure 12, if it is properly a *C. subcontracta*, extends the range of that species up to Bed 10 of the Plum Point Marl Member.

Geologic range.—Kirkwood Formation; possibly Bed 10 of Plum Point Marl Member, Calvert Formation.

Varicorbula elevata (Conrad)
Plate 18, Figures 9, 12

Corbula elevata Conrad, 1838, p. 7, Pl. IV, fig. 3.
Corbula elevata Conrad. Whitfield, 1894, p. 86–87, Pl. XV, figs. 15–19.
Corbula elevata Conrad. Richards and Harbison, 1942, p. 198, Pl. 15, figs. 9, 10.
Varicorbula elevata (Conrad). Ward, 1992, p. 113, Pl. 21, fig. 2.

Discussion.—*Varicorbula elevata* is comparatively rare at the Pollack Farm Site with only 20 valves recovered. Conrad's type came from Stow Creek, near Shiloh, New Jersey, and both Whitfield (1894) and Richards and Harbison (1942) mention that locality. The heaviest concentration of the taxon is in the bottom beds of the Plum Point Marl Member, Bed 4–9 and Bed 10, where they are extremely abundant and dominate the fauna.

Geologic range.—Kirkwood and Calvert (Beds 2–10) formations.

Bicorbula idonea (Conrad)
Plate 18, Figures 7, 8, 10, 11

Corbula idonea Conrad, 1833b, p. 341.
Corbula idonea Conrad. Whitfield, 1894, p. 88, Pl. XV, fig. 20.
Corbula idonea Conrad. Richards and Harbison, 1942, p. 198, Pl. 15, figs. 7, 15.
Bicorbula idonea (Conrad). Ward, 1992, p. 112–113. Pl. 21, fig. 1.

Discussion.—*Bicorbula idonea* is reported from the Kirkwood Formation of New Jersey, based only on a small fragment found in a well at Atlantic City and listed by Heilprin (1888). Whitfield (1894, pl. XV, fig. 20) refers to this citation and reproduces Conrad's (1838, pl. 10, fig. 6) figure. Richards and Harbison (1942) also cite the Atlantic City well specimen and figure the fragment.

The 26 specimens from the Pollack Farm Site are adults as large as 30 mm in length. Ward (1992) reported *B. idonea* from the Belgrade Formation (Haywood Landing Member, upper Oligocene). The specimens from that unit are generally small and have a noticeably produced posterior in both valves, apparently to accommodate the siphons. Immature specimens from the Choptank Formation, in which the species is common, exhibit the same condition, but the valves become increasingly less produced in the adults. Ward and Blackwelder (1990) reported *B. idonea* from the Edisto Formation in South Carolina, a unit stratigraphically equivalent to the Haywood Landing Member. Also, Ward (1985) reported the species from the Old Church Formation in Virginia, also an upper Oligocene/lower Miocene unit.

Geologic range.—Old Church, Belgrade, Edisto, Kirkwood, Calvert, Choptank, St. Marys (rare), and Eastover (rare) formations.

Panopea americana Conrad
Plate 18, Figure 16

Panopaea Americana Conrad, 1838, p. 4, Pl. II.
Panopaea americana Conrad. Glenn, 1904, p. 278, Pl. LXVI, fig. 2.

Discussion.—There is no report on the presence of *Panopea americana* in the Kirkwood Formation, or any older units, in the literature. Glenn did report the taxon from Wye Mills, Queen Anne County, Maryland, where it probably was found in beds equivalent to those in Delaware and the Kirkwood of New Jersey. The species is not known to occur stratigraphically higher than the Choptank Formation. *Panopaea americana* is present in relatively small numbers and fragmentary condition at the Pollack Farm Site. More than 30 fragments and one nearly complete valve are available for study. The thickness, size, and reflected nature of the anterior and posterior margins of the valves make the identification of this species certain. The Delaware specimens mark the first known appearance of this species. The taxon occurs in sediment that indicates fairly high-energy conditions. Another species, *P. whitfieldi*, and the stratigraphically higher *P. goldfussi*, occur in finer, more silty beds that reflect quieter conditions. *Panopea reflexa* Say, a Pliocene species, may be a representative of the same lineage as *P. americana*. It also has heavy, thick valves, but it is a smaller taxon with a much more rounded anterior margin, lacking the extreme anterior gape of *P. americana.*

Geologic range.—Kirkwood, Calvert, and Choptank formations.

Panopea whitfieldi Dall
Plate 18, Figure 15

Panopea goldfussi Wagner. Whitfield, 1894, p. 89–90, Pl. XVI, figs. 9–13.
Panopea whitfieldi Dall, 1898, p. 829.
Panopea whitfieldi Dall. Glenn, 1904, p. 276–277, Pl. LXV, fig. 10.
Panopea whitfieldi Dall. Ward, 1992, p. 114, Pl. 21, fig. 4.

Discussion.—Whitfield (1894) figured and described a specimen from Shiloh, New Jersey, that is roughly rectangular in shape, and assigned it to *Panopea goldfussi*. Dall (1898) recognized differences in the New Jersey species and named it *P. whitfieldi*. Specimens from Bed 10 of the Plum Point Marl Member figured by Glenn (1904, pl. LXV, fig. 10) and Ward (1992, pl. 21, fig. 4) both appear to be *P. whitfieldi* as does Gardner's (1928, p. 237–238, pl. XXXVI, figs. 11, 12) *P. parawhitfieldi* and Mansfield's (1940, p. 200–201, pl. 25, fig. 49) *P. taylorensis* from the Chickasawhay Marl of Mississippi.

The seven specimens found at the Pollack Farm Site are mostly incomplete single valves. Whitfield (1894, p. 90) mentioned its occurrence in the "gray marly beds" at Shiloh. Richards and Harbison (1942) reiterated this locality information. The species appears to be a thin-valved, quiet-water form like the stratigraphically higher *P. goldfussii*, and it occurs in living position only in the silty, finer sediments.

Geologic range.—Kirkwood and Calvert (Bed 10 of

Plum Point Marl Member) formations. Possibly Belgrade Formation (Haywood Landing Member). Edisto and Arcadia (Tampa Member) Formations. Probably the Oak Grove Formation of Florida and Chickasawhay Marl of Mississippi.

Thovana sp.

Plate 19, Figure 1

Discussion.—Broken specimens of a species of *Thovana* are present, though rare, at the Pollack Farm Site. The specimens are all less than 25 mm long and resemble the Recent species *T. campechiensis*. That species, however, is 75–100 mm long. It ranges from North Carolina to Brazil (subtropical and tropical) and is probably evidence of those climates during the lower Miocene.

Geologic range.—Kirkwood Formation.

Martesia ovalis (Say)

Plate 19, Figures 2–8

Pholas ovalis Say, 1820, p. 39.
Martesia? ovalis Dall, 1898, p. 820, 821.
Martesia (Aspidopholas) ovalis Say. Dall, 1900, Pl. XXXVI, fig. 5.
Martesia ovalis (Say). Glenn, 1904, p. 275–276, Pl. LXV, figs. 4–9.

Discussion.—Specimens of *Martesia* are relatively common at the Pollack Farm Site, although they have not been previously reported in the Kirkwood of New Jersey. Most specimens are found in the valves of *Mercenaria* and *Crassostrea,* from which they are difficult to obtain whole. Those taxa apparently become a desirable substrate after death, disarticulation, and reworking of the valves because of their thickness. Some valves are thoroughly riddled with the borings made by *Martesia*.

Glenn (1904) reported *Martesia ovalis* from the Calvert, Choptank, and St. Marys Formations, but most of his specimens came from the Choptank, where they occupied the valves of *Isognomon*.

Geologic range.—Kirkwood, Calvert, Choptank, and St. Marys formations.

Periploma peralta Conrad

Periploma alta Conrad, 1863a, p. 572, 585. [Not *Anatina alta* C. B. Adams, 1852].
Periploma peralta Conrad, 1867, p. 188.
Periploma (?) alta Whitfield, 1894, Pl. XVI, figs. 7, 8.
Periploma peralta Conrad. Glenn, 1904, p. 359, Pl. XCV, fig. 3.
Periploma peralta Conrad. Richards and Harbison, 1942, p. 202, Pl. 17, fig. 2.

Discussion.—*Periploma* is common at the Pollack Farm Site, but is known only from fragments of beaks containing the spoon-like chondrophore. The shell fragments have a pearly sheen characteristic of the genus.

Geologic range.—Kirkwood Formation; Calvert Formation, Fairhaven Member (Bed 3A); St. Marys Formation.

Scaphapoda

Cadulus conradi Pilsbry and Harbison

Cadulus conradi Pilsbry and Harbison, 1933, p. 117, Pl. 4, figs. 18, 19.
Cadulus conradi Pilsbry and Harbison. Richards and Harbison, 1942, p. 222, Pl. 22, figs. 18, 19.

Discussion.—Pilsbry and Harbison's (1933) name for this species of *Cadulus*, "*C. conradi*," is used here provisionally. The nine specimens from the Pollack Farm Site are worn and small, but seem to fall within the description of *C. conradi* rather than the larger and more compressed species *C. thallus* (Conrad).

Geologic range.—Kirkwood Formation.

Miscellaneous Taxa

A number of small species occur in the fines from the Pollack Farm Site. These taxa are only partially studied at this time but include the following genera: *Odostomia, Actaeon, Cylichna, Turbonilla, Strombiformis, Aligena,* and *Geukensia*. It is expected that further study will allow determination of these species as well as others in the fine fraction.

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PLATES

(Unless otherwise indicated, all specimens are from the Pollack Farm Site, Delaware)

PLATE 1

1, 3. *Diadora griscomi* (Conrad)
- 1. Lateral view; VMNH I 533; l. 43.7 mm; ht. 19.2 mm.
- 3. Apical view of same specimen.

2, 5. *Tegula marylandicum* (Martin)
- 2. Apertural view of coated specimen; VMNH I 534; ht. 13.5 mm; w. 19.0 mm.
- 5. Apertural view of same specimen, uncoated, showing color on primary spiral ribs.

4, 6. *Calliostoma eboreus* (Wagner)
- 4. Apertural view of specimen with single carina; VMNH I 535; ht. 15.9 mm; w. 12.5 mm.
- 6. Apertural view of specimen with two carinae; VMNH I 536; ht. 11.2 mm; w. 11.7 mm.

7–9. *Diastoma insulaemaris* (Pilsbry and Harbison)
- 7. Apertural view; VMNH I 537; ht. 20.5 mm; w. 7.0 mm.
- 8. Apertural view; VMNH I 538; ht. 20.5 mm; w. 7.3 mm.
- 9. Apertural view; VMNH I 539; ht. 23.4 mm; w. 7.3 mm.

10, 13. *Carinorbis dalli* (Whitfield)
- 10. Apertural view; VMNH I 540; ht. 12.5 mm; w. 8.9 mm.
- 13. Dorsal view; VMNH I 541; ht. 15.6 mm; w. 8.0 mm.

11, 12. *Turritella cumberlandia* Conrad
- 11. Apertural view; VMNH I 542; ht. 61.0 mm; w. 15.5 mm.
- 12. Apertural view; VMNH I 543; ht. 29.4 mm; w. 6.2 mm.

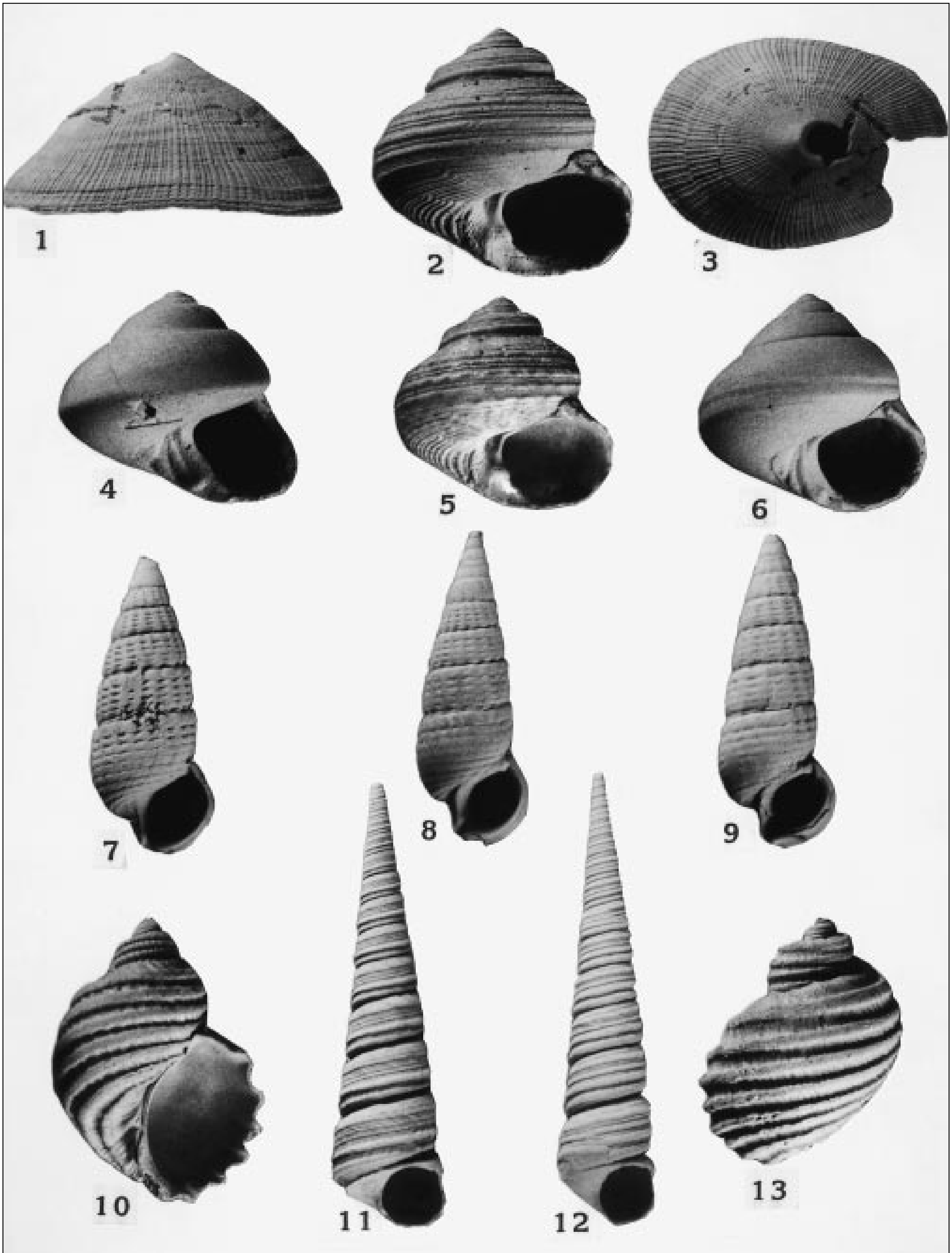
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PLATE 2

1. *Turritella cumberlandia* Conrad
Apertural view of an immature specimen; VMNH I 544; ht. 23.3 mm; w. 9.9 mm.

2, 3. *Turritella tampae* Dall
2. Apertural view; VMNH I 545; ht. 41.8 mm; w. 11.9 mm.
3. Apertural view; VMNH I 546; ht. 77.0 mm; w. 21.9 mm.

4. *Turritella plebia* ssp.
Apertural view; VMNH I 547; ht. 24.4 mm; w. 5.7 mm.

5. *Serpulorbis granifera* (Say)
View of a number of individual with uncoiled whorls intertwined; VMNH I 548. One relatively regularly whorled specimen appears just above center. Height of illustrated specimen group 90.0 mm. Collected by G. Simonson.

6, 7. *Crepidula fornicata* Linné
6. Dorsal view of specimen exhibiting exposed tube-burrows probably of the marine worm *Polydora*; VMNH I 549; ht. 47.9 mm; w. 35.0 mm.
7. Dorsal view; VMNH I 550; ht. 46.0 mm; w. 33.1 mm.

8, 9. *Crepidula plana* Say
8. Dorsal view of immature specimen; VMNH I 551; ht. 15.9 mm; w. 7.9 mm.
9. Dorsal view; VMNH I 552; ht. 38.1 mm; w. 31.0 mm.

10. *Calyptraea centralis* (Conrad)
Dorsal view; VMNH I 553; ht. 9.7 mm; w. 21.9 mm.

11–15. *Calyptraea aperta* (Solander)
11. Dorsal view of large specimen; VMNH I 554; ht. 21.0 mm; w. 41.7 mm.
12. Apertural view of same specimen.
13. Side view of same specimen.
14. Dorsal view of incomplete specimen with strongly developed spines; VMNH I 555; ht. 18.0 mm.
15. Side view of specimen with high spire; VMNH I 556; ht. 16.1 mm; w. 24.1 mm.

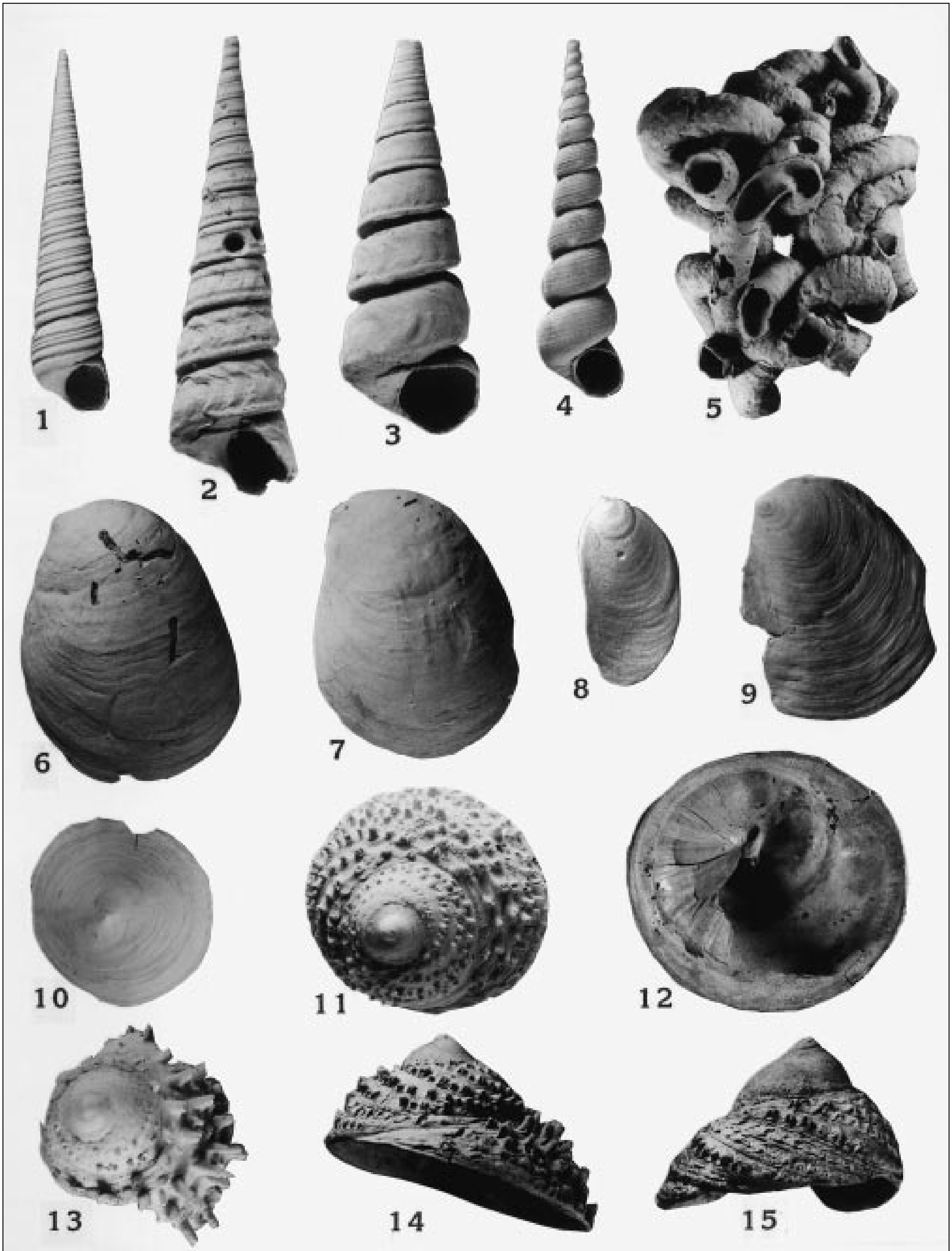
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PLATE 3

1, 4. *Crucibulum costatum* (Say)
1. Dorsal view of a weakly ribbed, incomplete, specimen; VMNH I 557; ht. 7.4 mm; w. 21.6 mm.
4. Dorsal view of a strongly ribbed specimen; VMNH I 558; ht. 6.4 mm; w. 26.1 mm. Collected by G. Simonson.

2, 3. *Lunatia hemicrypta* (Gabb)
2. Apertural view; VMNH I 559; ht. 4.0 mm; w. 3.3 mm.
3. Apertural view; VMNH I 560; ht. 5.0 mm; w. 4.3 mm.

5. *Lunatia heros* (Say)
Apertural view; VMNH I 561; ht. 48.1 mm; w. 42.8 mm.

6, 9. *Sinum chesapeakensis* Campbell
6. Dorsal view; VMNH I 562; ht. 20.4 mm; w. 18.6 mm.
9. Apertural view of same specimen.

7. *Polinices duplicatus* (Say)
Apertural view; VMNH I 563; ht. 44.3 mm; w. 43.9 mm.

8, 10. *Ficus harrisi* (Martin)
8. Apertural view of an incomplete specimen; VMNH I 564; ht. 19.5 mm; w. 18.1 mm.
10. Dorsal view of same specimen.

11. *Epitonium charlestonensis* Johnson
Apertural view of a nearly complete specimen; VMNH I 565; ht. 31.1 mm; w. 17.5 mm.

12. *Murexiella cumberlandiana* (Gabb)
Apertural view; VMNH I 566; ht. 19.1 mm; w. 11.5 mm.

13, 14. *Urosalpinx subrusticus* (d'Orbigny)
13. Apertural view; VMNH I 567; ht. 46.1 mm; w. 31.5 mm.
14. Apertural view; VMNH I 568; ht. 28.8 mm; w. 16.0 mm.

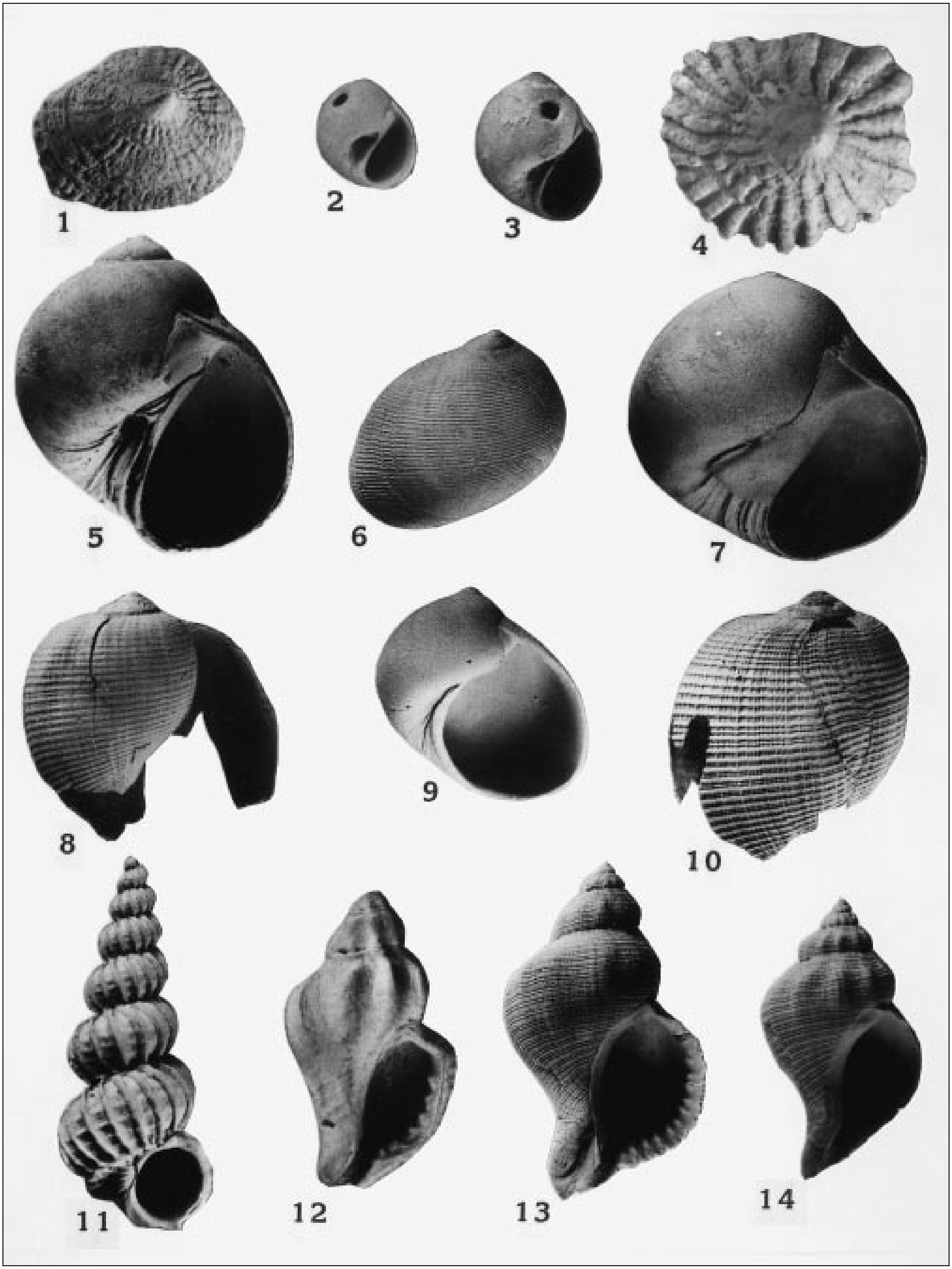
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PLATE 4

1. *Typhis acuticosta* (Conrad)
   Apertural view of an incomplete specimen; VMNH I 569; ht. 20.4 mm; w. 12.3 mm.

2–6. *Cymia woodi* (Gabb)
   2. Apertural view of specimen with strong shoulder and well-developed tubercles; VMNH I 570; ht. 28.8 mm; w. 18.2.
   3. Apertural view of specimen with moderately developed shoulder and weakly defined tubercles; VMNH I 571; ht. 28.2 mm; w. 14.9 mm.
   4. Apertural view of specimen with very weak shoulder and numerous, very weak tubercles; VMNH I 572; ht. 26.0 mm; w. 15.7 mm.
   5. Apertural view of specimen with smooth shoulder and finely reticulate sculpture; VMNH I 573; ht. 27.8 mm; w. 15.7 mm.
   6. Dorsal view of specimen with smooth shoulder and only spiral sculpture in the late whorls; VMNH I 574; ht. 34.5 mm; w. 21.5 mm. This specimen is close in appearance to Gabb's type.

7. *Tritonopsis ecclesiastica* (Dall)
   Apertural view of an incomplete specimen; VMNH I 575; ht. 21.3 mm; w. 15.9 mm.

8–10. *Ecphora tricostata* Martin
   8. Apertural view; VMNH I 576; ht. 72.0 mm; w. 60.2 mm.
   9. Apertural view; VMNH I 577; ht. 54.4 mm; w. 40.7 mm.
   10. Dorsal view of same specimen.

11. *Chrysodomus patuxentensis* Martin
   Apertural view; VMNH I 578; ht. 13.6 mm; w. 8.0 mm.

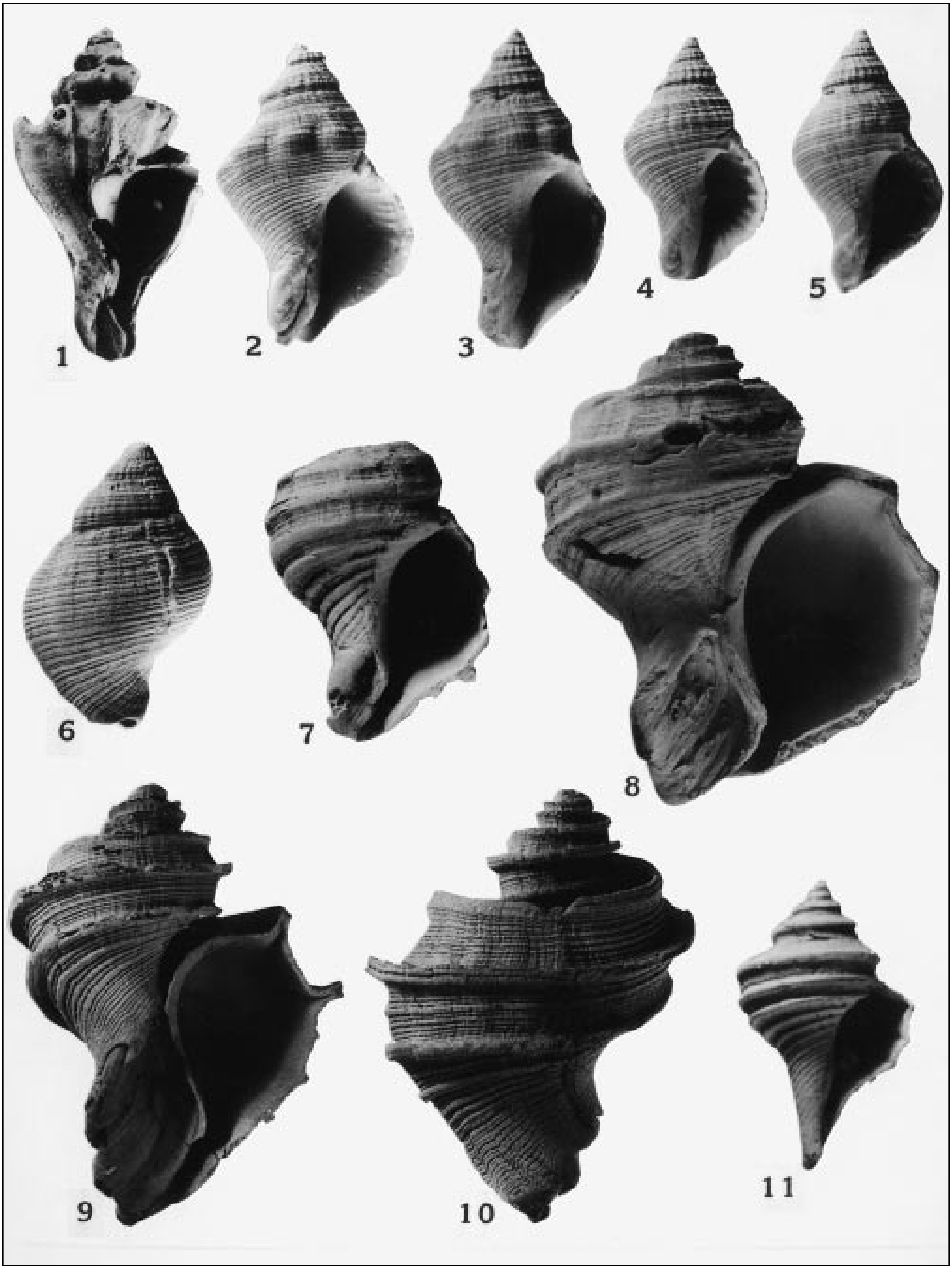
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PLATE 5

1. *Siphonalia devexa* (Conrad)
   Apertural view; VMNH I 579; ht. 55.6 mm; w. 24.0 mm.

2. *Nassarius trivitattoides elongata* (Whitfield)
   Apertural view; VMNH I 580; ht. 11.0 mm; w. 4.5 mm.

3. *Nassarius trivitattoides* (Whitfield)
   Apertural view; VMNH I 581; ht. 16.0 mm; w. 8.0 mm.

4–6. *Nassarius sopora* (Pilsbry and Harbison)
   4. Apertural view; VMNH I 582; ht. 12.1 mm; w. 6.8 mm.
   5. Apertural view; VMNH I 583; ht. 11.0 mm; w. 6.9 mm.
   6. Apertural view; VMNH I 584; ht. 10.0 mm; w. 5.6 mm.

7, 9. *Metula* sp.
   7. Apertural view; VMNH I 585; ht. 30.0 mm; w. 12.9 mm.
   9. Apertural view; VMNH I 586; ht. 34.9 mm; w. 16.1 mm.

8, 10. *Busycotypus scalarispira* (Conrad)
   8. Apertural view of specimen with high spire and strong tubercles; VMNH I 587; ht. 140.1 mm; w. 87.1 mm.
   10. Apertural view of specimen with high spire and strong tubercles along a persistent shoulder ridge; VMNH I 588; ht. 133.1 mm; w. 85.7 mm.

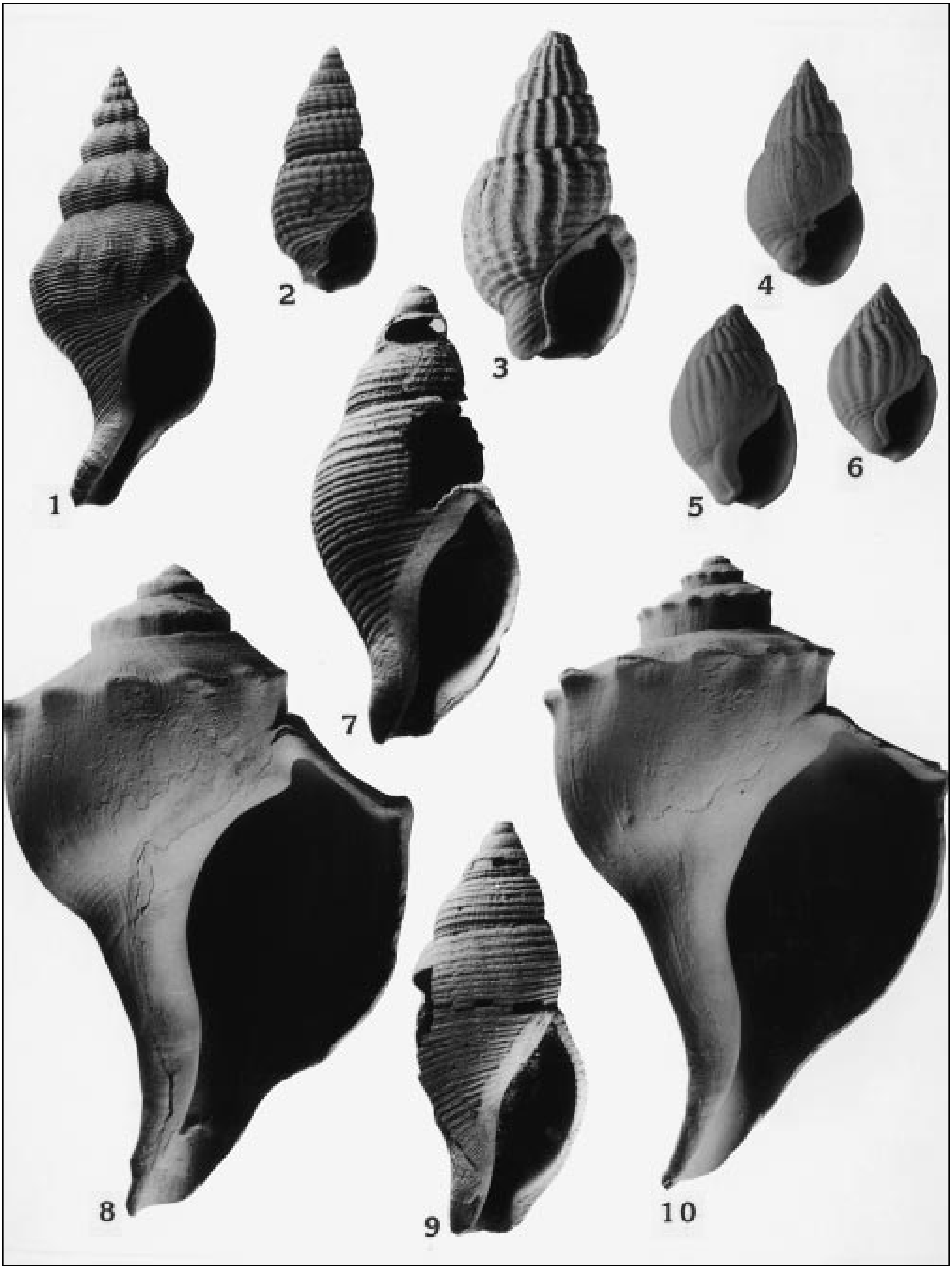
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PLATE 6

1, 3, 4, 6. *Busycotypus scalarispira* (Conrad)

1. Apertural view of specimen with low spire and moderately strong tubercles along a weaker shoulder; VMNH I 589; ht. 125.2 mm; w. 81.0 mm.
3. Dorsal view of same specimen.
4. Apertural view of specimen with low spire and weak tubercles becoming obsolete along a rounded shoulder; VMNH I 590; ht. 100.6 mm; w. 63.0 mm.
6. Apertural view of specimen with low spire and devoid of tubercles on a rounded shoulder; VMNH I 591; ht. 70.6 mm; w. 44.4 mm.

2. *Scaphella virginiana* Dall
Apertural view; VMNH I 592; ht. 73.1 mm; w. 37.5 mm.

5. *Scaphella solitaria* (Conrad)
Apertural view; VMNH I 593; ht. 36.1 mm; w. 17.7 mm.


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PLATE 7

1–3. *Oliva simonsoni* Ward, new species
1. Apertural view; Paratype VMNH I 594; ht. 37.9 mm; w. 17.2 mm.
2. Apertural view; Holotype VMNH I 595; ht. 36.8 mm; w. 17.9 mm.
3. Dorsal view of holotype.

4. *Cancellaria alternata* Conrad
Apertural view; VMNH I 611; ht. 24.8 mm; w. 14.3 mm.

5–7. *Trigonostoma biplicifera* (Conrad)
5. Apertural view; VMNH I 612; ht. 47.3 mm; w. 31.5 mm.
6. Dorsal view of same specimen.
7. Apertural view; VMNH I 613; ht. 31.2 mm; w. 22.5 mm.

8. *Cymatosyrinx limatula* (Conrad)
Apertural view; VMNH I 614; ht. 20.0 mm; w. 7.2 mm.

9. *Polystira communis* (Conrad)
Apertural view; VMNH I 615; ht. 28.0 mm; w. 9.5 mm.

10, 11. *Leucosyrinx rugata* (Conrad)
10. Apertural view; VMNH I 616; ht. 30.1 mm; w. 12.1 mm.
11. Apertural view; VMNH I 617; ht. 32.1 mm; w. 11.6 mm.

12, 13. *Inodrillia whitfieldi* (Martin)
12. Apertural view; VMNH I 618; ht. 23.4 mm; w. 8.8 mm.
13. Apertural view; VMNH I 619; ht. 23.0 mm; w. 8.6 mm.

14. *Terebra inornata* Whitfield
Apertural view; VMNH I 620; ht. 36.5 mm; w. 9.0 mm.

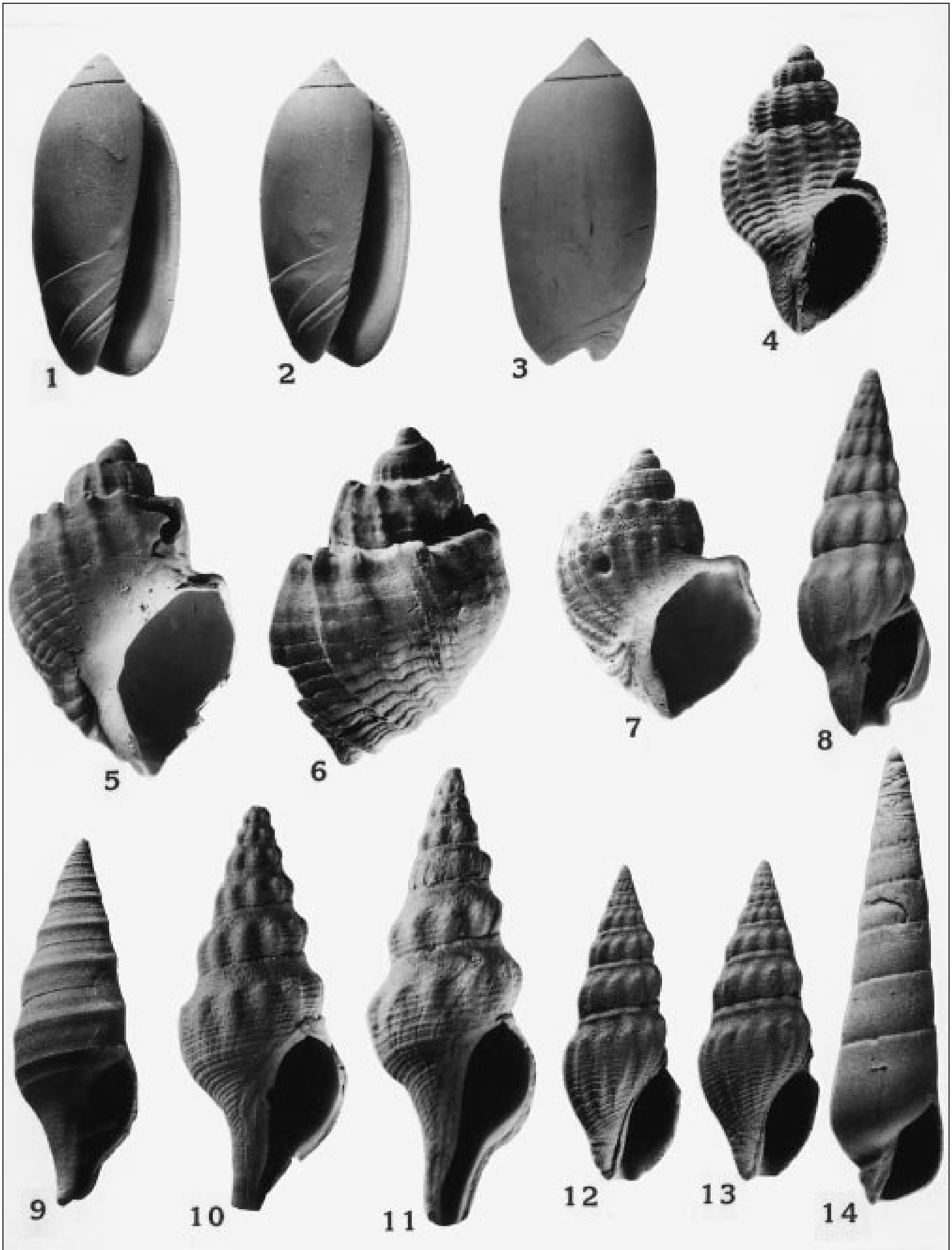
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PLATE 8

1, 3. *Yoldia* sp.
- 1. Exterior view right valve; VMNH I 621; ht. 18.5 mm; l. 42.0 mm.
- 3. Interior view of the same specimen.

2, 4. *Yoldia* sp.
- 2. Exterior view right valve; VMNH I 622; ht. 15.2 mm; l. 34.6 mm.
- 4. Interior view of the same specimen.

5–7. *Dallarca (?) subrostrata*
- 5 Exterior view left valve; VMNH I 623; ht. 39.1 mm; l. 52.0 mm. Collected by G. Simonson.
- 6. Exterior view left valve; VMNH I 624; ht. 37.2 mm; l. 49.1 mm. Collected by G. Simonson.
- 7. Exterior view left valve; VMNH I 625; ht. 33.5 mm; l. 44.9 mm.

8–10. *Dallarca* sp.
- 8. Exterior view left valve; VMNH I 626; ht. 24.1 mm; l. 34.1 mm.
- 9. Exterior view right valve; VMNH I 627; ht. 34.6 mm; l. 48.0 mm.
- 10. Exterior view right valve; VMNH I 628; ht. 33.2 mm; l. 45.5 mm.

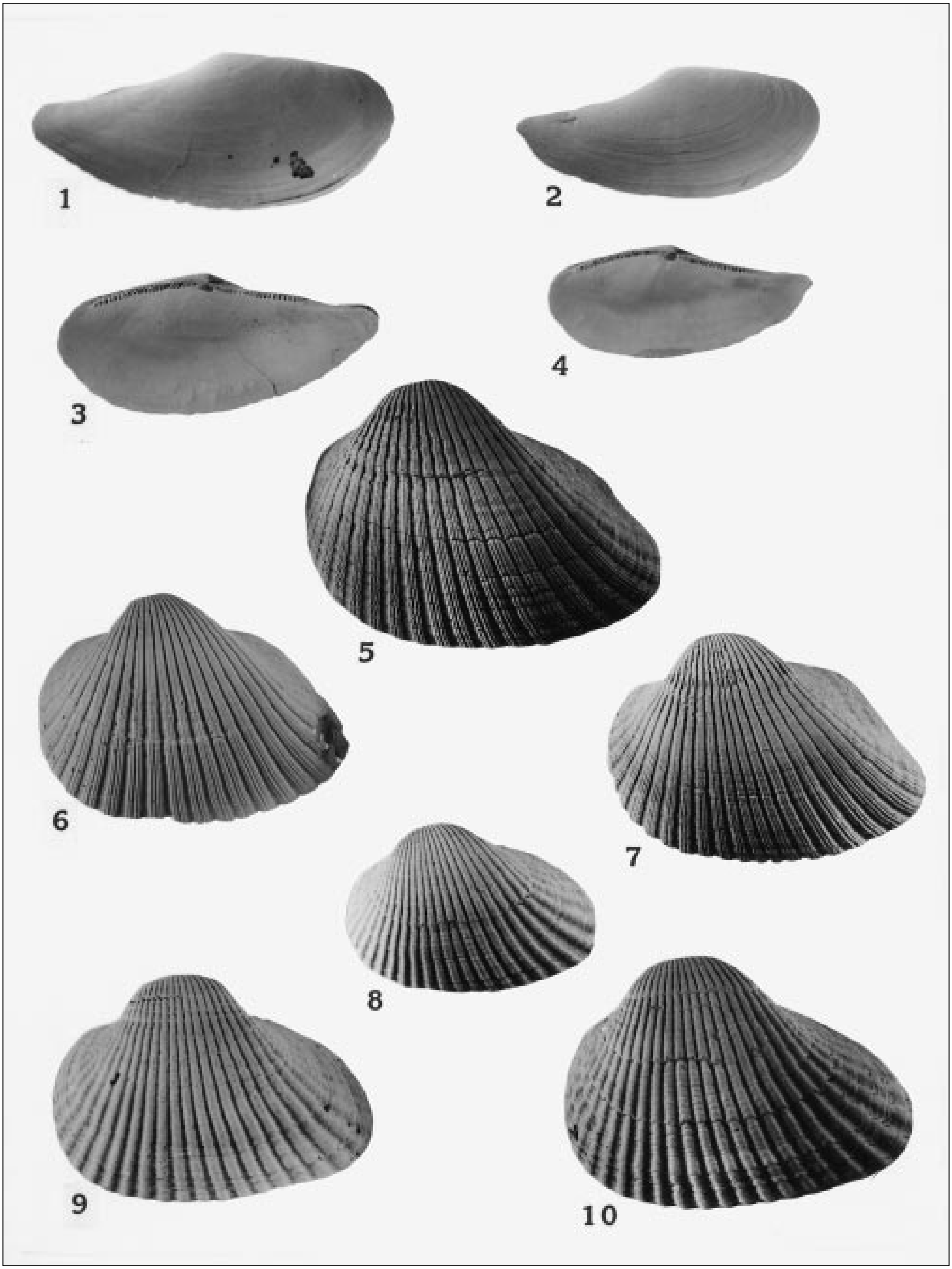
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PLATE 9

1, 3. *Glycymeris parilis* (Conrad)

1. Exterior view left valve; VMNH I 629; ht. 75.1 mm; l. 74.3 mm.
3. Interior view of the same specimen.

2. *Modiolus ducatellii* Conrad

Exterior view incomplete left valve; VMNH I 630; l. 52.9 mm. Specimen was photographed uncoated to show characteristic brown discoloration of the shell due to its periostracum.

4, 5. *Mytilus (Mytiloconcha) incurva* Conrad

4. Exterior view left valve of a nearly complete specimen; VMNH I 631; l. 155.0 mm.
5. Exterior view incomplete right valve; VMNH I 632; l. 84.0 mm.

6, 8. *Isognomon (Hippochaeta)* sp.

6. Exterior view of a worn beak; VMNH I 633; ht. 63.2 mm.
8. Interior view of the same specimen.

7, 9. *Glycymeris parilis* (Conrad)

7. Exterior view right valve; VMNH I 634; ht. 44.7 mm; l. 46.0 mm. This specimen has fewer ribs than average specimens but in all other respects appears typical.
9. Interior view of the same specimen.

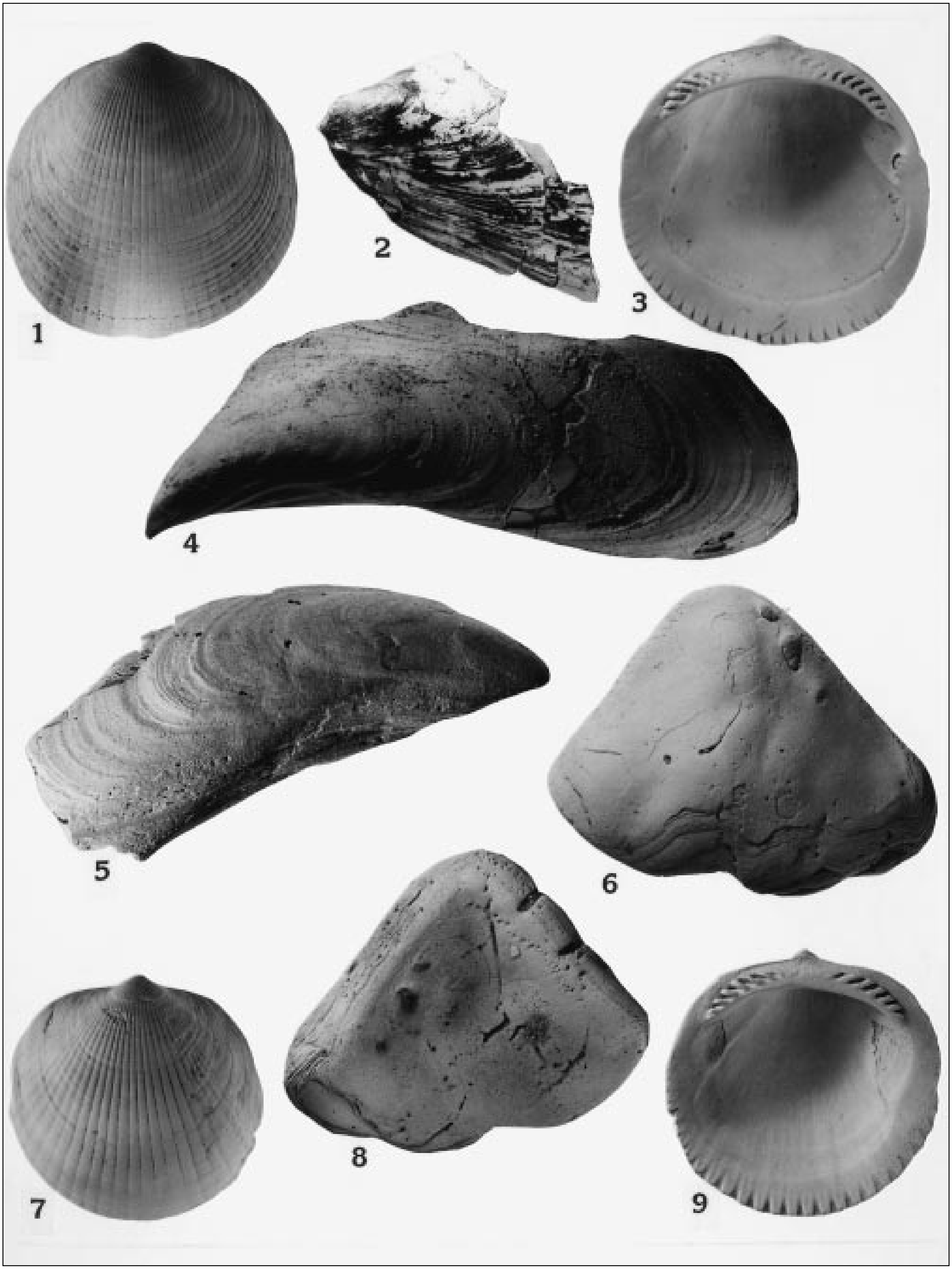
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PLATE 10

1, 2. *Crassostrea virginica* (Gmelin)
1. Exterior view right valve; VMNH I 635; ht. 142.0 mm; l. 53.0 mm.
2. Exterior view left valve; VMNH I 636; ht. 183.9 mm; l. 53.0 mm.

3, 4. *Pecten humphreysii woolmani* Heilprin
3. Exterior view incomplete right valve; VMNH I 637; ht. of fragment 53.8 mm. Collected by G. Simonson.
4. Exterior view incomplete left valve; VMNH I 638; ht. of fragment 58.0 mm. Collected by G. Simonson.

5–8. *Crassostrea virginica* (Gmelin)
5. Exterior view left valve; VMNH I 639; ht. 115.6 mm; l. 52.7 mm.
6. Exterior view left valve; VMNH I 640; ht. 149.0 mm; l. 69.0 mm.
7. Interior view right valve. The same specimen as figure 1.
8. Interior view left valve. The same specimen as figure 6.

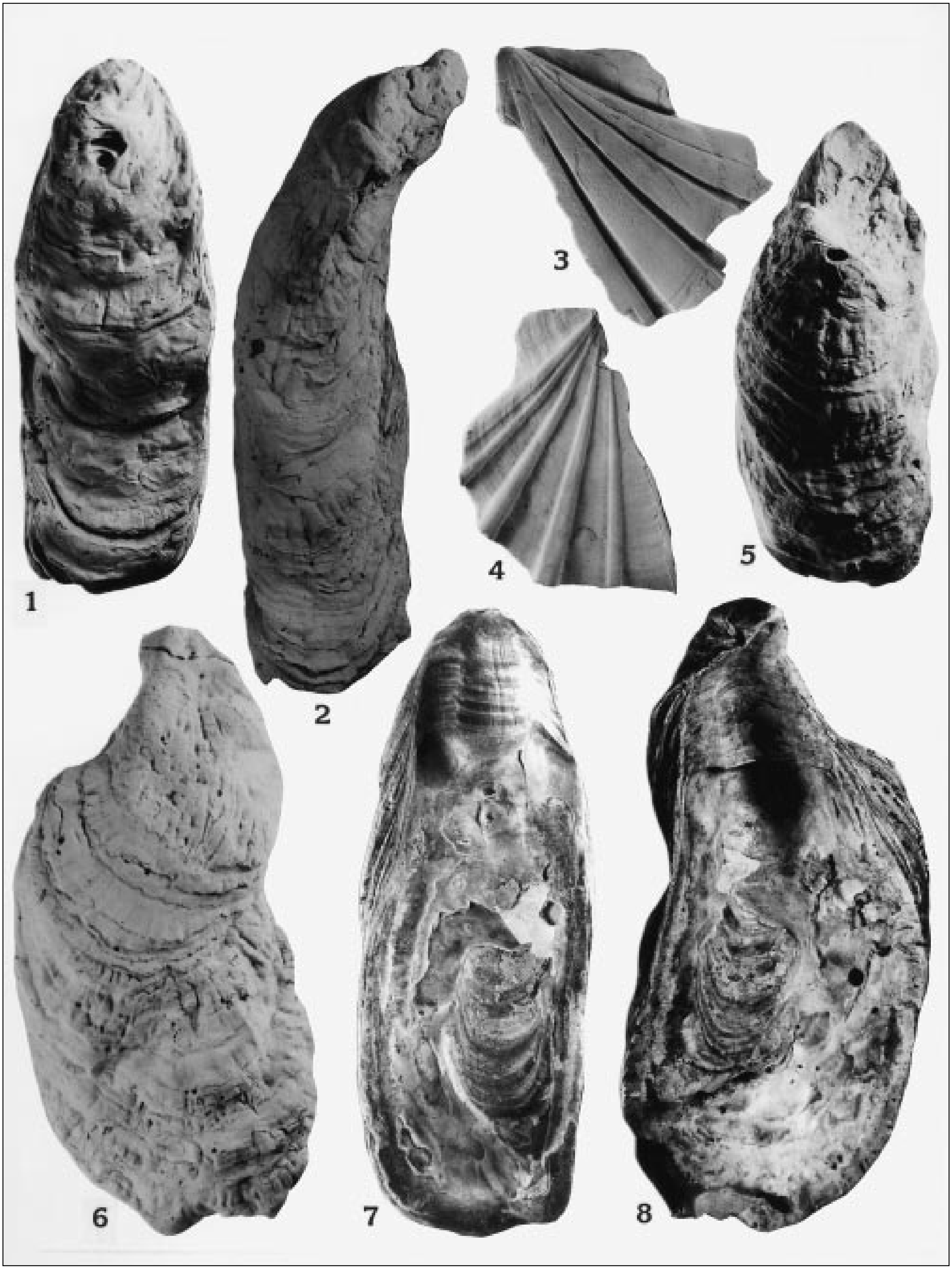
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PLATE 11

1, 2. *Chesapecten coccymelus* (Dall)
1. Exterior view left valve; VMNH I 641; ht. 43.4 mm; l. 41.0 mm.
2. Exterior view right valve; VMNH I 642; ht. 44.3 mm; l. 44.0 mm.

3, 4. *Chesapecten sayanus* (Dall)
3. Exterior view right valve; VMNH I 643; ht. 62.0 mm; l. 60.5 mm.
4. Exterior view right valve; VMNH I 644; ht. 85.3 mm; l. 84.2 mm.

5. *Chesapecten sayanus* (Dall)
Exterior view right valve; VMNH I 645; ht. 116.7 mm; approximate l. 119.5 mm. Pungo River Formation (lower Miocene) at the Texas Gulf Sulphur phosphate mine, Aurora, N. C.

6. *Chesapecten coccymelus* (Dall)
Exterior view right valve; VMNH I 646; ht. 67.1 mm; l. 68.7 mm. Pungo River Formation (lower Miocene) at the Texas Gulf Sulphur phosphate mine, Aurora, N. C.

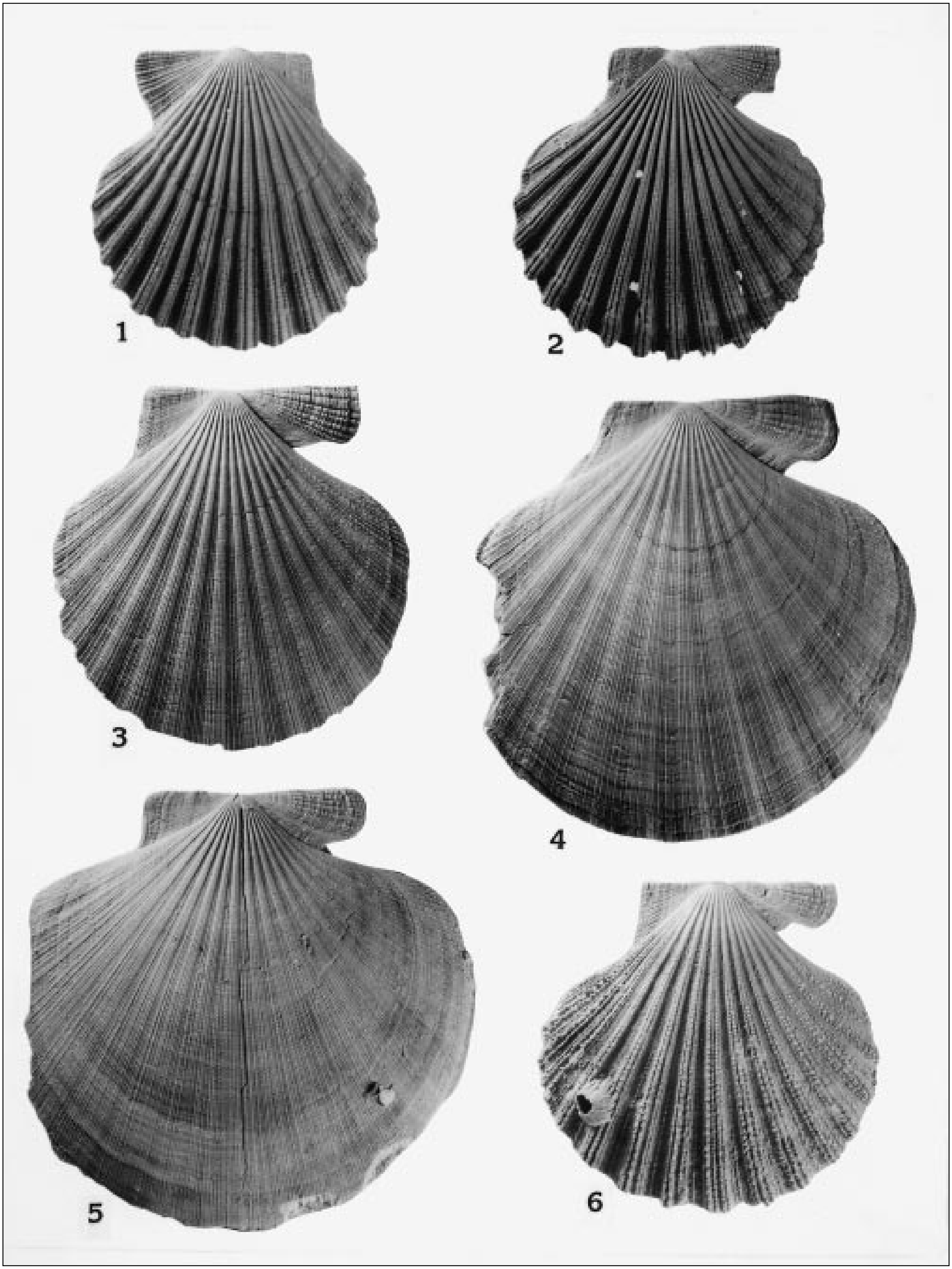

PLATE 12

1–3. *Stewartia anodonta* (Say)
- 1. Exterior view right valve; VMNH I 647; ht. 45.0 mm; l. 46.1 mm.
- 2. Interior view left valve; VMNH I 648; ht. 44.8 mm; l. 47.2 mm.
- 3. Exterior view of the same specimen.

4, 8, 9. *Carditamera aculeata* Conrad
- 4. Exterior view left valve; VMNH I 649; ht. 27.9 mm; l. 51.0 mm.
- 8. Interior view of the same specimen.
- 9. Exterior view right valve; VMNH I 650; ht. 31.1 mm; l. 53.9 mm.

5–7. *Parvalucina crenulata* (Conrad)
- 5. Exterior view right valve; VMNH I 651; ht. 5.1 mm; l. 5.1 mm.
- 6. Exterior view right valve; VMNH I 652; ht. 4.7 mm; l. 4.8 mm.
- 7. Exterior view left valve; VMNH I 653; ht. 4.2 mm; l. 4.6 mm.

10, 12. *Cyclocardia castrana* (Glenn)
- 10. Exterior view left valve; VMNH I 654; ht. 19.5 mm; l. 20.1 mm.
- 12. Interior view right valve; VMNH I 655; ht. 21.5 mm; l. 22.1 mm.

11, 13, 14. *Marvacrassatella melinus* (Conrad)
- 11. Exterior view right valve; VMNH I 656; ht. 40.1 mm; l. 61.2 mm.
- 13. Exterior view left valve; VMNH I 657; ht. 48.8 mm; l. 76.0 mm.
- 14. Interior view of the same specimen.

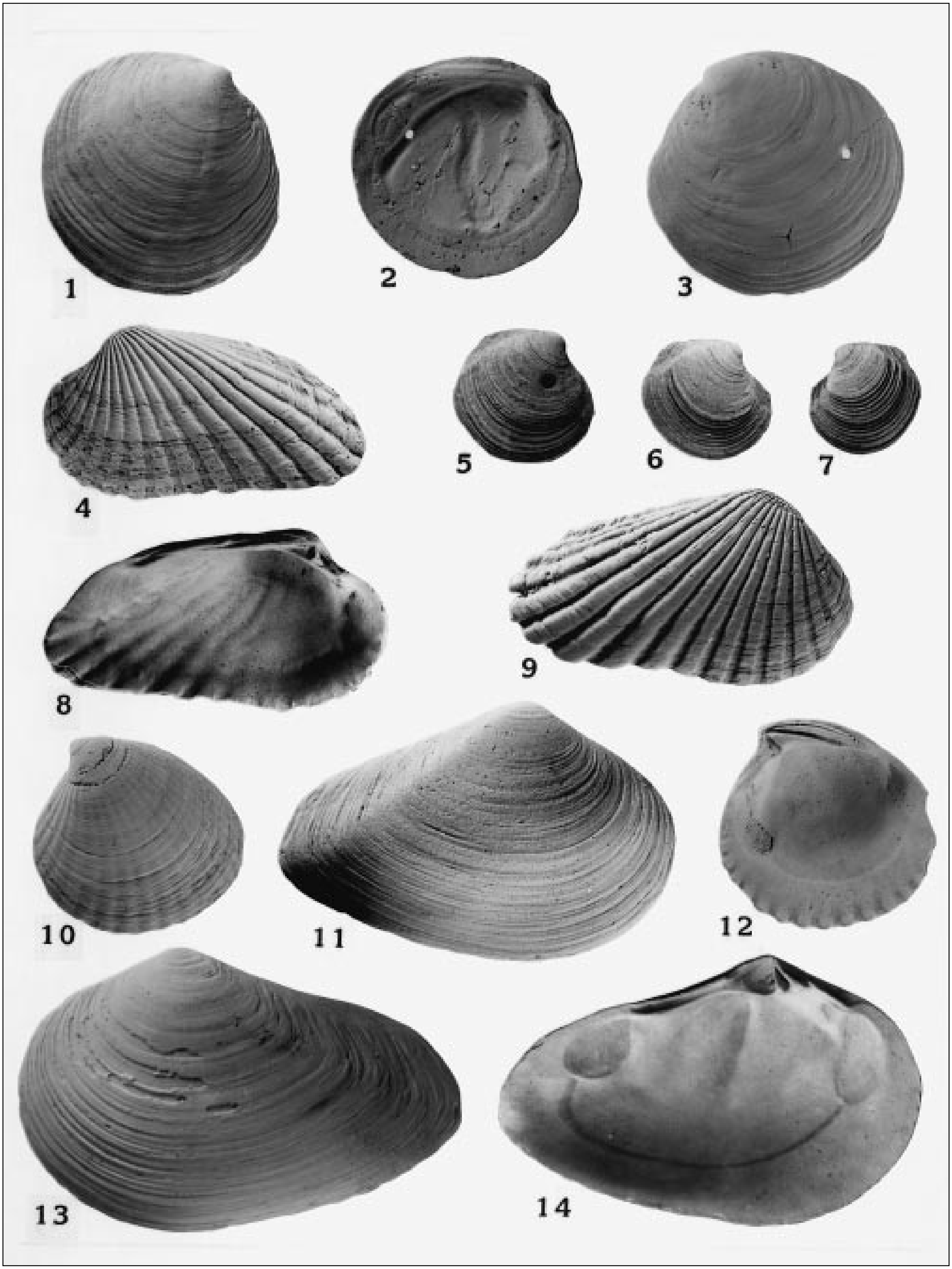

PLATE 13

1, 2. *Astarte distans* Conrad

1. Exterior view left valve; VMNH I 658; ht. 24.0 mm; l. 29.6 mm. Specimen shows well-developed concentric undulations on exterior associated with higher energy, sandy matrix.
2. Exterior view right valve; VMNH I 659; ht. 24.2 mm; l. 28.9 mm. Specimen with rugose sculpture as in figure 1.

3, 6. *Astarte* sp.

3. Exterior view right valve; VMNH I 660; ht. 18.9 mm; l. 20.0 mm.
6. Exterior view left valve; VMNH I 661; ht. 18.6 mm; l. 20.8 mm.

4, 5. *Astarte distans* Conrad

4. Exterior view right valve; VMNH I 662; ht. 23.4 mm; l. 28.0 mm. Specimen shows the lower, more rounded, less rugose concentric sculpture associated with finer, more silty sands. Martin (1904) named this morphotype *Astarte castrana*. This specimen came from Bed a at the Pollack Farm Site.
5. Exterior view left valve; VMNH I 663; ht. 27.0 mm; l. 30.8 mm. Specimen with subdued sculpture as in figure 4.

7, 8. *Dinocardium* sp.

7. Exterior view left valve; VMNH I 664; ht. 63.0 mm; l. 65.3 mm. Collected by J. Beard.
8. Interior view of the same specimen.

9, 11. *“Cardium” calvertensium* Glenn

9. Exterior view left valve; VMNH I 665; ht. 20.4 mm; l. 21.5 mm.
11. Exterior view left valve; VMNH I 666; ht. 17.0 mm; l. 18.8 mm.

10. *Chesacardium craticuloides* (Conrad)
Exterior view right valve; VMNH I 667; ht. 32.1 mm; l. 37.1 mm.

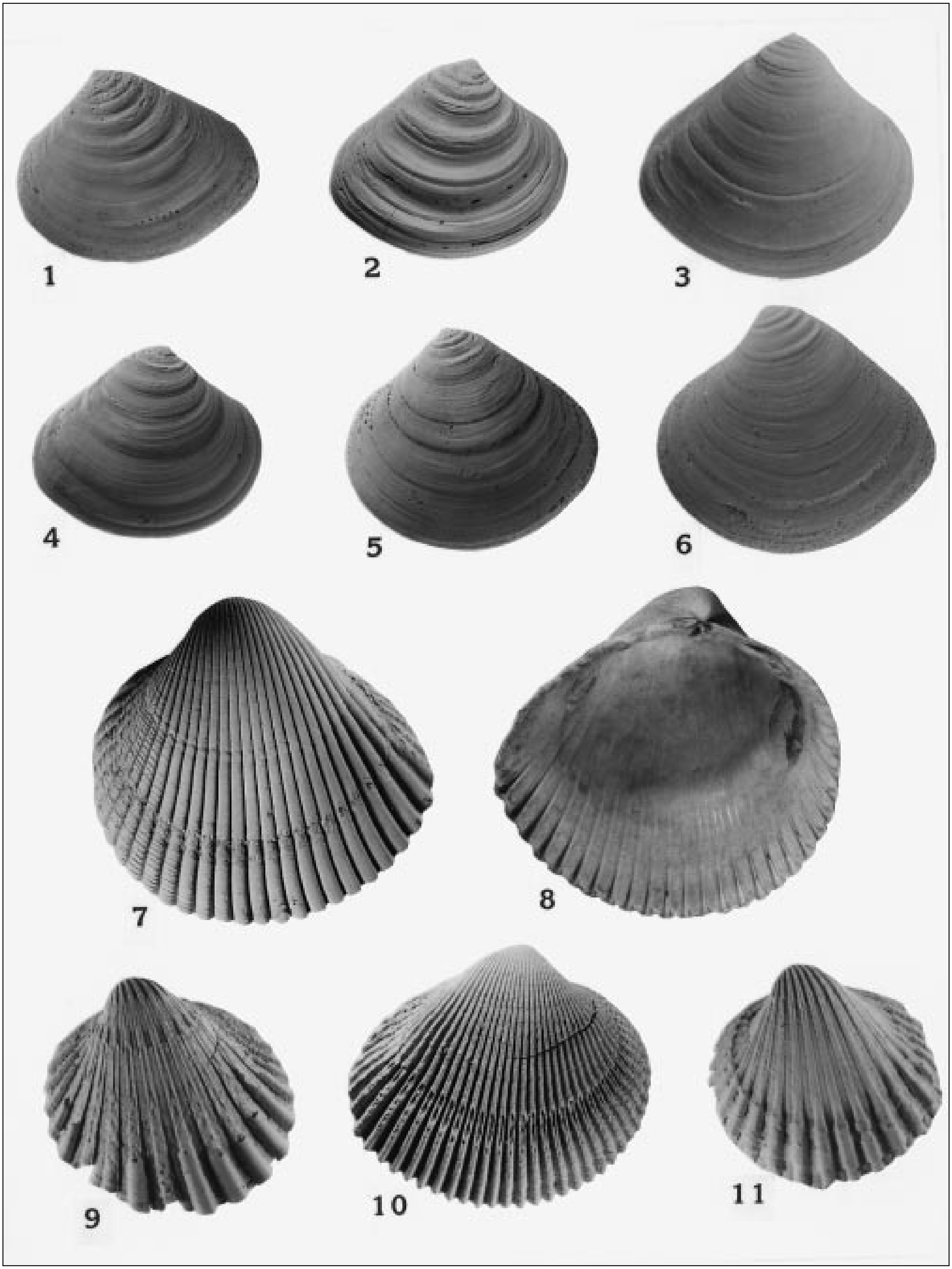
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PLATE 14

1, 2. *Leptomactra marylandica* (Dall)
1. Exterior view left valve; VMNH I 668; ht. 51.4 mm; l. 75.8 mm. Collected by G. Simonson.
2. Interior view of the same specimen.

3–6. *“Mactra”* sp.
3. Exterior view right valve; VMNH I 669; ht. 47.1 mm; l. 63.2 mm.
4. Interior view of the same specimen.
5. Exterior view left valve; VMNH I 670; ht. 40.4 mm; l. 63.1 mm.
6. Interior view of the same specimen.

7, 8. *Ensis directus* Conrad
7. Exterior view incomplete left valve; VMNH I 671; approximate ht. 8.0 mm; l. of fragment 32.6 mm.
8. Interior view of the same specimen.

9–11. *Strigilla* sp.
9. Exterior view left valve; VMNH I 672; ht. 16.6 mm; l. 17.0 mm.
10. Interior view of the same specimen.
11. Interior view right valve; VMNH I 673; ht. 17.0 mm; l. 17.5 mm.

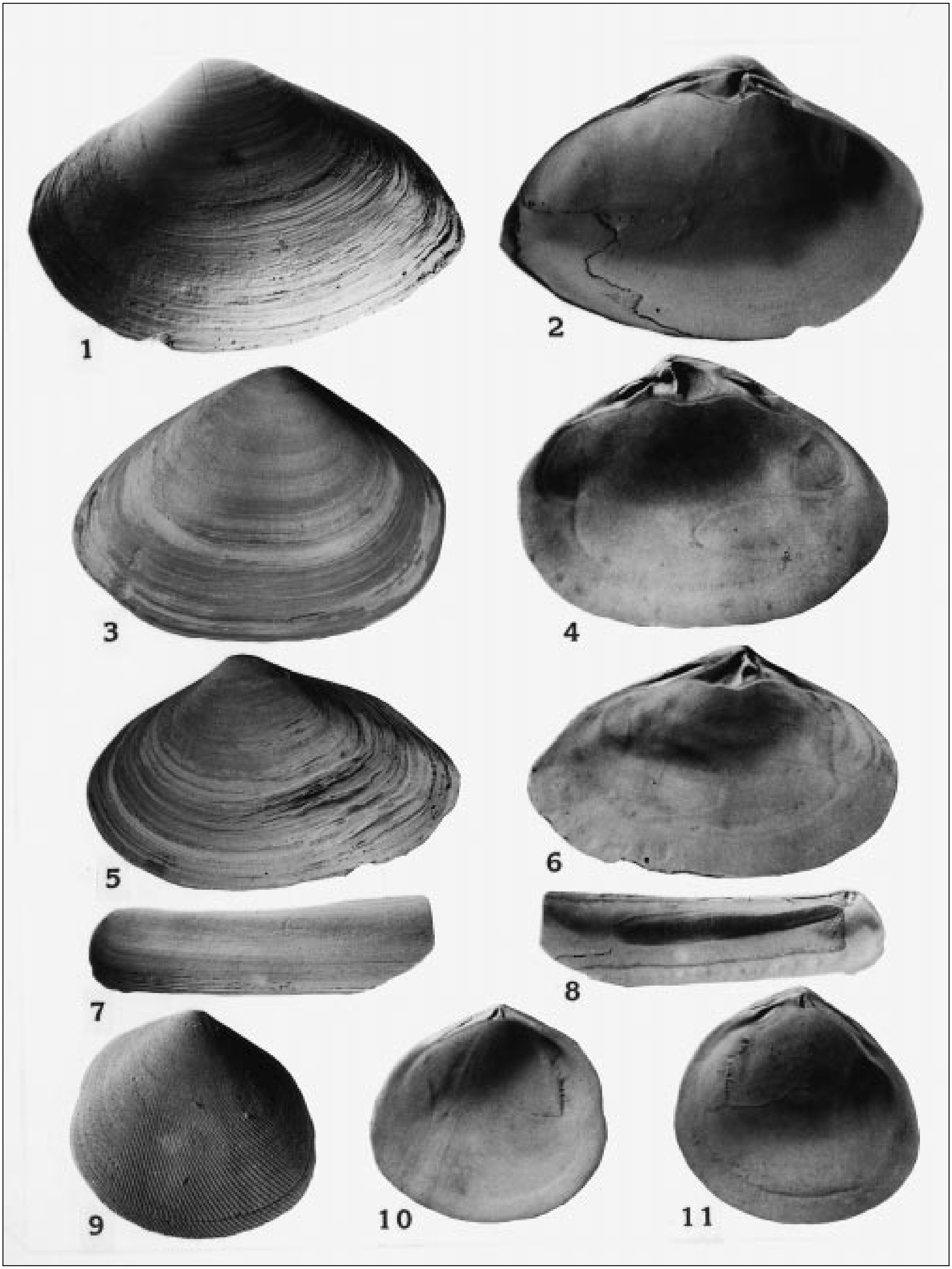
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PLATE 15

1. *Florimetis biplicata* (Conrad)
   Exterior view left valve; VMNH I 674; ht. 47.3 mm; l. 59.4 mm.

2. *Semele subovata* (Say)
   Exterior view right valve; VMNH I 675; ht. 16.1 mm; l. 21.0 mm.

3, 5. *Tagelus plebeius* ssp.
   3. Exterior view left valve; VMNH I 676; ht. 22.1 mm; l. 66.7 mm.
   5. Interior view of the same specimen.

4, 6, 9. *Donax idoneus* ssp.
   4. Exterior view left valve; VMNH I 677; ht. 17.5 mm; l. 29.9 mm.
   6. Exterior view right valve; VMNH I 678; ht. 25.5 mm; l. 43.9 mm.
   9. Exterior view right valve; VMNH I 679; ht. 26.8 mm; l. 43.1 mm.

7, 8, 10. *Iphigenia* sp.
   7 .Exterior view left valve; VMNH I 680; ht. 26.7 mm; l. 41.0 mm.
   8. Interior view right valve; VMNH I 681; ht. 21.5 mm; l. 36.1 mm.
   10. Exterior view of the same specimen.

11–14. *Donax* sp.
   11. Interior view right valve; VMNH I 682; ht. 9.0 mm; l. 16.1 mm.
   12. Exterior view left valve; VMNH I 683; ht. 10.2 mm; l. 18.5 mm.
   13. Interior view left valve. The same specimen as figure 12.
   14. Exterior view right valve. The same specimen as figure 11.

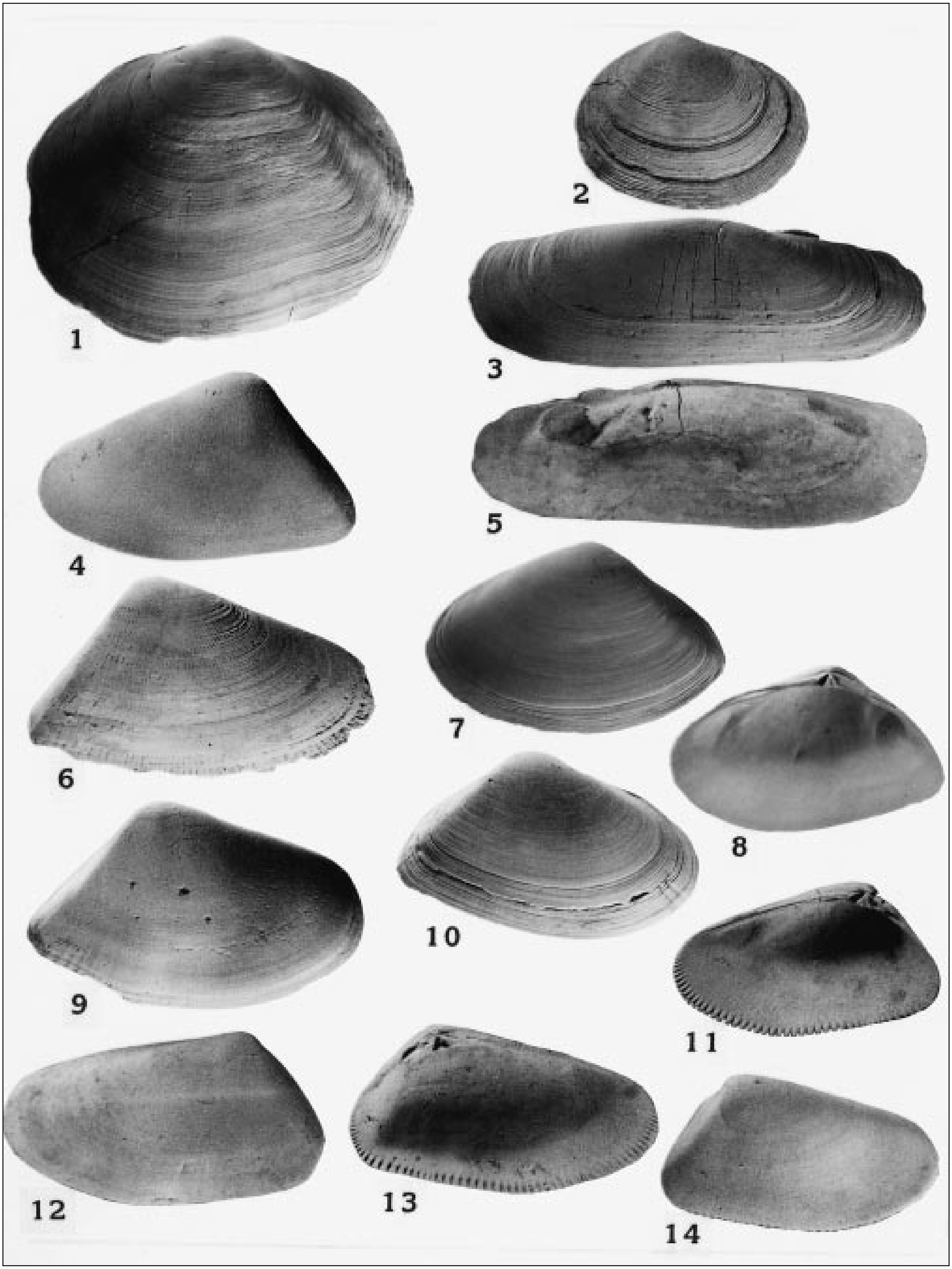
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PLATE 16

1–3. *Mytilopsis erimiocenicus* Vokes
1. Exterior view right valve; VMNH I 684; approximate ht. 10.5 mm; l. 26.1 mm.
2. Interior view right valve; VMNH I 685; ht. 9.3 mm; l. 18.9 mm.
3. Exterior view left valve; VMNH I 686; ht. 9.0 mm; l. 21.1 mm.

4. *Glossus* sp.
Exterior view right valve; VMNH I 687; ht. 34.9 mm; l. 45.0 mm.

5, 6. *Lirophora latilirata* (Conrad)
5. Exterior view right valve; VMNH I 688; ht. 16.0 mm; l. 18.0 mm.
6. Exterior view left valve; VMNH I 689; ht. 16.2 mm; l. 18.9 mm.

7, 8. *Mercenaria ducatellii* (Conrad)
7. Exterior view right valve; VMNH I 690; ht. 65.0 mm; l. 81.0 mm.
8. Exterior view left valve; VMNH I 691; ht. 78.0 mm; l. 96.7 mm.

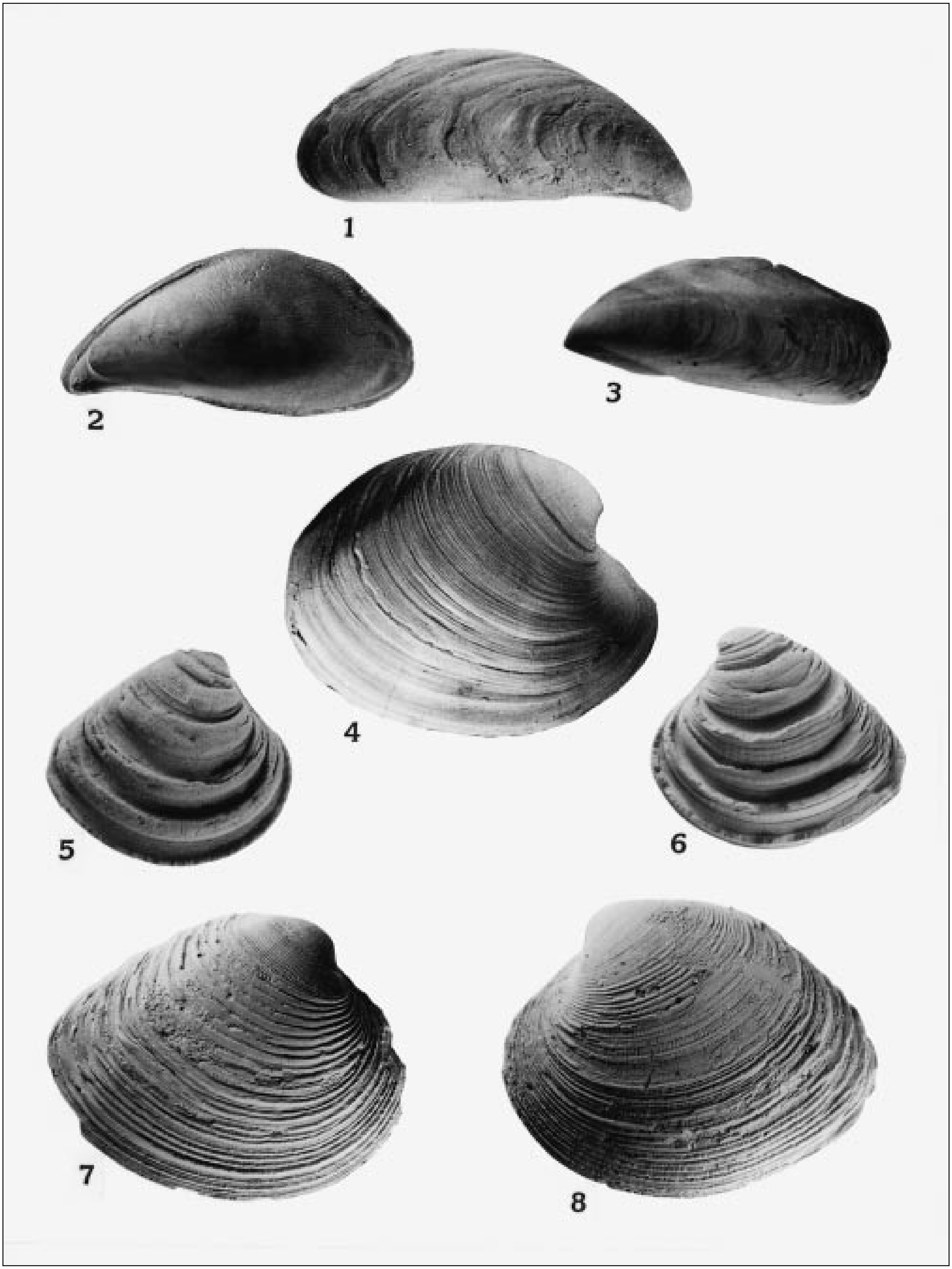
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PLATE 17

1–3. *Mercenaria ducatellii* (Conrad)

1. Exterior view right valve; VMNH I 692; ht. 76.6 mm; l. 93.5 mm. *Martesia* are visible in several of the holes bored into the shell.
2. Interior view right valve; VMNH I 690; ht. 65.0 mm; l. 81.0 mm.
3. Exterior view right valve; VMNH I 693; ht. 44.1 mm; l. 52.9 mm.

4. *Dosinia acetabulum blackwelderi* Ward

Exterior view right valve; VMNH I 694; ht. 58.1 mm; l. 57.8 mm.

5–7. *Macrocallista marylandica* (Conrad)

5. Interior view right valve; VMNH I 695; ht. 54.0 mm; l. 78.5 mm.
6. Exterior view left valve; VMNH I 696; ht. 40.0 mm; l. 51.2 mm.
7. Exterior view right valve; VMNH I 697; ht. 57.1 mm; l. 82.5 mm.

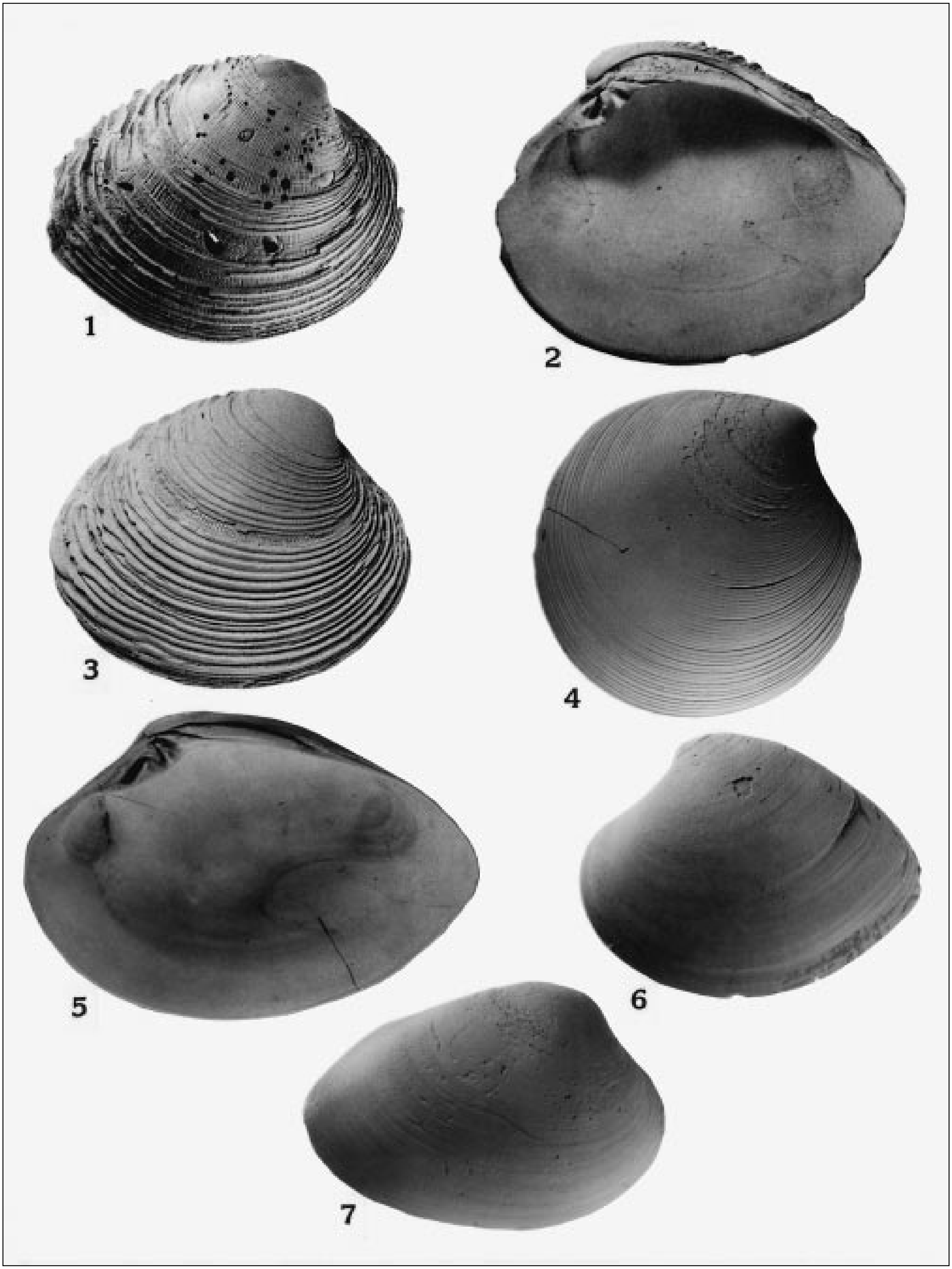
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PLATE 18

1, 4. *Clementia grayi* Dall
1. Exterior view left valve of a paired individual; VMNH I 698; ht. 56.5 mm; l. 62.9 mm.
4. Exterior view of beak of a left valve; VMNH I 699; l. of fragment 42.0 mm. Most of the specimens from the Pollack Farm Site are fragmentary, consisting mainly of the hinge area. They look very similar to one found at Shiloh, New Jersey and illustrated by Richards and Harbison (1942, p. 175, fig. 4).

2, 5. *Mya producta* Conrad
2. Exterior view right valve; VMNH I 700; ht. 52.5 mm; l. 102.0 mm.
5. Exterior view left valve; VMNH I 701; ht. 36.1 mm; l. 76.0 mm. Collected by G. Simonson.

3, 6. *Caryocorbula subcontracta* (Whitfield)
3. Exterior view right valve; VMNH I 702; ht. 4.9 mm; l. 6.1 mm.
6. Interior view right valve; VMNH I 703; ht. 4.7 mm; l. 6.0 mm.

7, 8, 10, 11. *Bicorbula idonea* (Conrad)
7. Exterior view right valve; VMNH I 704; ht. 25.8 mm; l. 30.0 mm.
8. Exterior view left valve; VMNH I 705; ht. 17.9 mm; l. 23.8 mm.
10. Interior view right valve. The same specimen as figure 7.
11. Interior view left valve. The same specimen as figure 8.

9, 12. *Varicorbula elevata* (Conrad)
9. Exterior view right valve; VMNH I 706; ht. 8.9 mm; l. 8.8 mm.
12. Interior view of the same specimen.

13, 14. *Caryocorbula cuneata* (Say)
13. Exterior view left valve; VMNH I 707; ht. 5.5 mm; l. 9.5 mm.
14. Interior view left valve; VMNH I 708; ht. 5.7 mm; l. 9.5 mm.

15. *Panopea whitfieldi* Dall
Exterior view right valve of a paired individual; VMNH I 709; ht. 53.1 mm; l. 95.5 mm. This specimen was found in living position in Bed a. Collected by J. Beard.

16. *Panopea americana* Conrad
Exterior view incomplete right valve; VMNH I 710; ht. 77.5 mm; l. of fragment 115.0 mm.

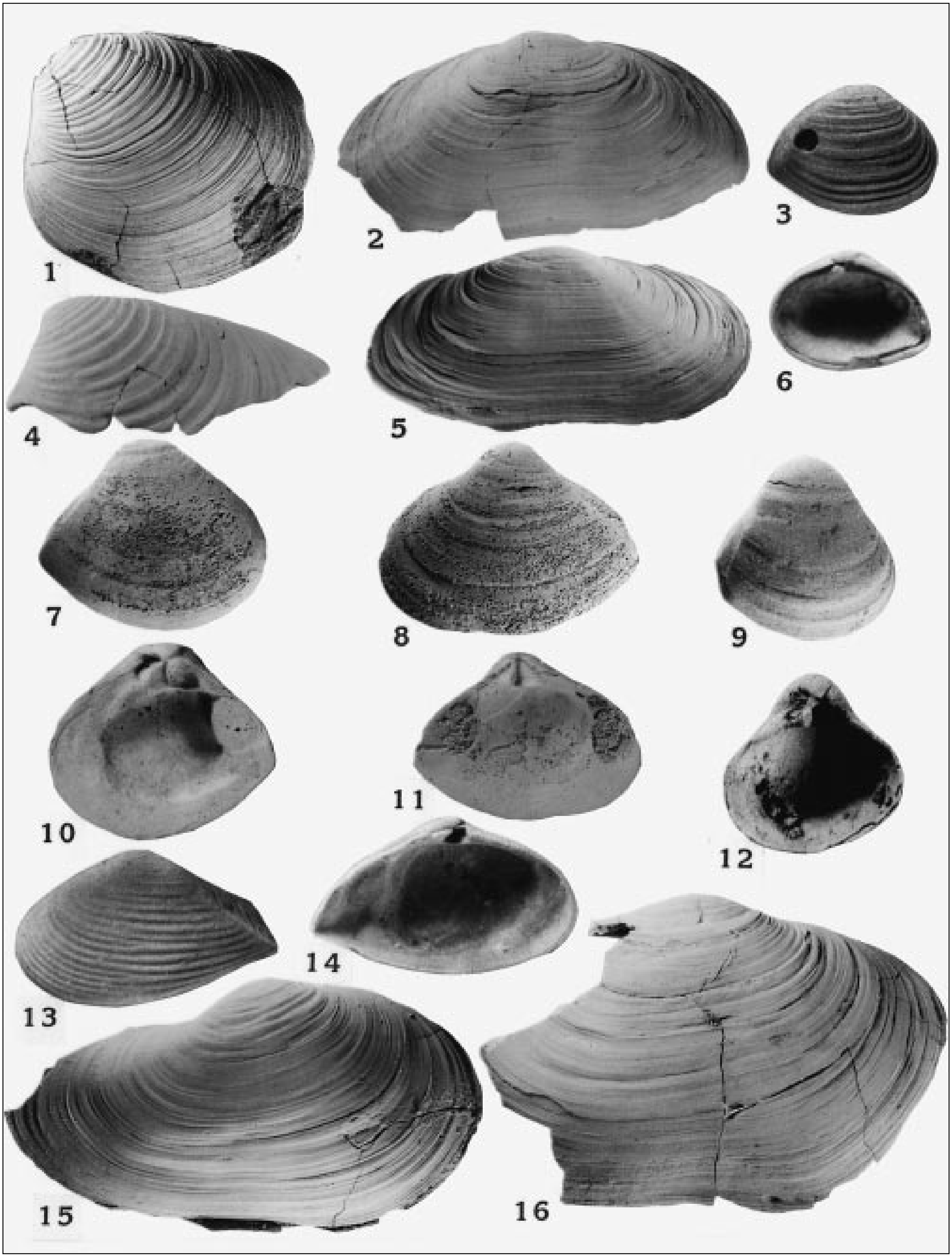
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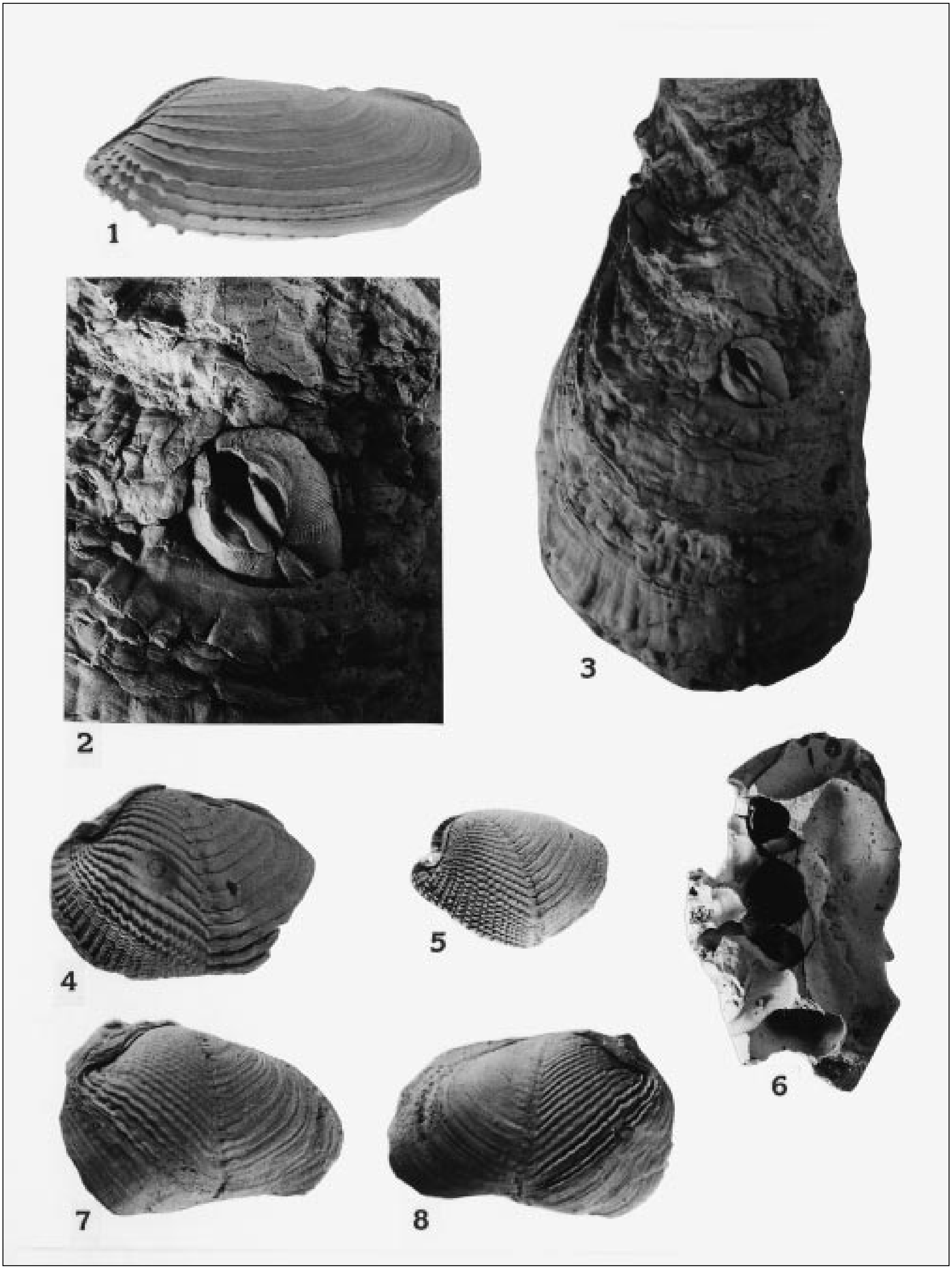
PLATE 19

1. *Thovana* sp.
   Exterior view left valve; VMNH I 711; ht. 10.7 mm; l. 25.9 mm.

2–8. *Martesia ovalis* (Say)
   2. Exposed hinge of a complete specimen in place in a boring into *Crassostrea virginica*; VMNH I 712. Length of specimen as exposed in boring 22.7 mm.
   3. Close-up view of same specimen in figure 2.
   4. Exterior view incomplete left valve; VMNH I 713; ht. 13.0 mm; l. 18.0 mm.
   5. Exterior view left valve; VMNH I 714; ht. 7.4 mm; l. 9.5 mm.
   6. *Martesia ovalis* borings into a broken *Mercenaria* shell; VMNH I 715. Some valves still remain in place. The heavy infestation probably contributed to the destruction of the host shell. Length of shell fragment 53 mm.
   7. Exterior view left valve; VMNH I 716; ht. 9.5 mm; l. 13.7 mm.
   8. Exterior view right valve; VMNH I 716; ht. 10.0 mm; l. 14.6 mm.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