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MIOCENE FOSSILS OF MARYLAND

By Harold E. Vokes

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CONTENTS

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INTRODUCTION

In 1685 Martin Lister, a famous European scientist, published a work on mollusca in which he illustrated a fossil shell, now known as *Ecphora quadricostata* (Say) (Pl. 25, fig. 1). This was the first American fossil figured in a scientific work. The original specimen came from the Miocene deposits of Maryland, probably from the vicinity of St. Marys City where it is relatively common. From this early beginning the Miocene deposits of Maryland and their rich faunas of fossil shells have attracted much attention from scientific and non-scientific students and collectors. Interest has greatly increased during recent years with the development of the Chesapeake Bay area as a summer home region for residents of Baltimore and Washington and with the establishment of summer camps along its shores by the Boy and Girl Scouts of America, the Young Mens' Christian Association, and others.

The scientific study of the Maryland faunas was begun by Thomas Say in 1824 when he described a number of new species from collections made in the area by Professor John Finch of England. The most prolific student was, however, Timothy Abbott Conrad who began publishing descriptions of Maryland fossils in 1830 and continued to do so until 1869. Others who were interested in the faunas included Isaac and Henry Lea, William Wagner, and William Healey Dall. Their studies were published in short papers in various scientific journals. There was no comprehensive study available to the non-scientific collector until 1904, when the Maryland Geological Survey published a large work consisting of a volume of text and a volume of illustrations describing and illustrating all of the known fossils from the Maryland Miocene. This work, which became the "bible" of collectors in the area is now out of print and unavailable except in scientific libraries. There has been an increasing demand for a guide to the faunas that will be available for, and intelligible to, non-scientific students and amateur collectors. This abbreviated discussion is designed to meet this demand.

This report does not include all of the species known to occur in Maryland Miocene faunas. It does include illustrations of all of the common species of the larger fossils and at least one representative of the genera that occur less abundantly. Groups whose fossil remains are of microscopic size, or whose study and identification requires microscopic techniques, are not included.

The species are referred to by their scientific names. These consist of a

minimum of three words: the first is the name of the genus or group to which the species belongs, the second is the name of the species, and the third is the name of the man who first recognized the species as constituting a distinctive unit and who described it scientifically. When the name of the author of the species is enclosed in parentheses it means that at the time that he described the species he referred it to a genus different from that to which it is now referred. Thus, in the case of *Macrocallista marylandica* (Conrad) (Pl. 16, fig. 1, 2), the species was originally described by Conrad as *Cytherea marylandica*, but the species *marylandica* is no longer considered as being referable to the genus *Cytherea*, so that Conrad's name is placed in parentheses. The generic and the specific names are always printed in a different type-face from that of the author as well as of that of the main body of the text.

A number of the generic names here used differ from those used in the Maryland Geological Survey's Miocene report. Those here used represent the concensus of present opinion as to the correct names to be applied to the species concerned. While some may mourn the demise of familiar names, this discussion is designed for students and beginners in the field of fossil study, and it seems most desirable that they begin at the level of our present knowledge.

MIOCENE DEPOSITS OF MARYLAND

Miocene deposits underlie much of the Coastal Plain of Maryland. On the Eastern Shore they are found in southernmost Kent, in most of Queen Annes, all of Talbot and Caroline, and all but the extreme southeastern portion of Dorchester Counties. Throughout most of this area they are overlain by, and buried under, later terrace deposits, so that fossiliferous outcrops are few and are found only in the valleys of the larger rivers. On the Western Shore, the Miocene strata underlie the southern portion of Anne Arundel, all but the northwestern part of Prince Georges, the greater part of Charles, and all of Calvert and St. Marys Counties. Here too they are partly buried under later terrace deposits, but the more rugged topography of the region and the lesser thicknesses of the terrace beds have resulted in outcrops being relatively abundant, especially along the western shore of Chesapeake Bay in Calvert County, along the banks of the Patuxent River in Calvert and St. Marys Counties, and on the shores of the St. Marys River in St. Marys County (Pl. 2). The most famous collecting area is the Calvert Cliffs which extend from Herring Bay in southern Anne Arundel County to Drum Point near the southern end of Calvert County. The exposures in these cliffs, which rise to a height of 100 feet or more above the waters of Chesapeake Bay, reveal an almost continuous series of outcrops of the three geological formations that are recognized in the record of the marine deposits of the Maryland Miocene. A fourth, essentially unfossiliferous, formation of non-marine origin may be represented at the extreme southern end of the cliffs.

The three marine formations of the Miocene make up the Chesapeake group. They are, from oldest to youngest, the Calvert, Choptank and St. Marys formations. Each differs from the others in the nature of the sediments that enter into its composition, and each may be recognized by distinctions in the contained fossil faunas. All of the strata have a gentle south-southeast dip, so that the oldest formation, the Calvert, is exposed to the northwestward and the younger Choptank and St. Marys formations crop out successively toward the southeast.

CALVERT FORMATION

The Calvert formation consists of a basal portion, known as the Fairhaven diatomaceous earth member, and an overlying series of dark sandy clays known as the Plum Point marl member.

Fairhaven Diatomaceous Earth Member

The Fairhaven member is composed largely of the microscopically small tests of diatoms, an aquatic plant that secretes a pill-box like covering of silica. The lower twenty feet of the member above a thin basal sandstone zone consists of an almost pure accumulation of these siliceous coverings, or tests, and is light gray to white in color. This was formerly mined for use in filters, as a base for cleansers and polishing powders, and as a heat resistant insulator for boilers. The higher strata of the Fairhaven member consist of a mixture of diatoms and clay. The thickness of the Fairhaven member is about 55 feet. It was named from Fairhaven in southern Anne Arundel County at the northern end of the Calvert cliffs.

Plum Point Marl Member

The Plum Point marl member consists of greenish-blue and bluish-green to light brown sandy clays that contain large numbers of fossils. The fossils are particularly abundant in two beds ranging from 4½ to 13 feet thick that are about 30 to 35 feet apart in the section. The beds are easily traced from Chesapeake Beach southward to a point about two miles south of Kenwood Beach at Governor Run. Since they share in the regional dip of the formation, these beds are high on the cliff at Chesapeake Beach and pass gradually below the surface of the Bay near Kenwood Beach. This member, named from Plum Point on the Calvert Cliffs, is about 135 feet thick in the cliffs.

CHOPTANK FORMATION

The Choptank formation overlies the Calvert and is easily distinguished by its yellowish sands that contrast sharply with the dark sandy clays of the Calvert formation. The lower beds of the Choptank vary, however, from a yellowish sand to a greenish sandy clay, so that it is difficult in places to be

certain as to the absolute contact between the two formations. The Choptank is named for its exposures on the Choptank River, where it crops out on the northern bank a short distance below Dover Bridge. The best development of the formation is in the Calvert Cliffs, where it is exposed from the vicinity of Parker Creek southward almost to Cove Point. Excellent exposures also occur to the northwest and southeast of Jones Wharf on the Patuxent River in St. Marys County. Two fossiliferous beds occur within the formation. The lower, about 6 to 10 feet thick in the Calvert Cliffs and over 30 feet thick at Drum Cliff near Jones Wharf, is separated from the upper by about 20 feet of unfossiliferous sand in the Calvert Cliffs and by about 8 feet of similar sand at Jones Wharf. The upper fossiliferous zone is about 12 to 15 feet thick in the Calvert Cliffs. Both beds consist almost wholly of fossil mollusk shells. The Choptank formation ranges from 50 to 100 feet in thickness.

ST. MARYS FORMATION

The St. Marys formation is named from St. Marys County where it is well developed, especially along the St. Marys River in the vicinity of St. Marys City. On the Eastern Shore it is buried beneath a mantle of later deposits and no outcrops are known. On the Western Shore it is exposed only in southern Calvert and St. Marys Counties. Perhaps the best exposure is that at Little Cove Point in Calvert County (Pl. 2). Here the formation consists of bluish sandy clays and fine sandstones, some of which are abundantly fossiliferous and contain a fauna that is notably rich in fossil gastropods (snails). The strata exposed near St. Marys City are believed to be higher in the geologic section than are those at Little Cove Point, but they are lithologically similar and carry a very similar fauna. The break makes it difficult to determine the true thickness of the St. Marys formation, but it is in excess of 150 feet.

YORKTOWN(?) FORMATION

Overlying the St. Marys formation in the vicinity of Little Cove Point, and in wells drilled on the Eastern Shore, is a series of unfossiliferous yellowish sands and gravels that may represent a non-marine shoreline equivalent of the fossiliferous upper Miocene Yorktown formation of Virginia, which rests upon the St. Marys formation.

ZONES IN MIOCENE DEPOSITS OF MARYLAND

In the Miocene report of the Maryland Geological Survey, G. B. Shattuck divided the Calvert, Choptank and St. Marys formations into zones. The zones are not true paleontologic zones as that term is used today, but are mainly individual strata in the formations. A number of the zones cannot be certainly recognized in the outcrops. Shattuck was misled in places by the presence or absence or by the relative abundance of fossils, so that he based

more than one of his zones on what was actually a variable horizon. For these reasons Shattuck's zone numbers are not used in this report. For those who attempt to utilize the zones, the following equivalences are noted:

1. *Ostrea percrassa* bed (Pl. 6, fig. 3), the basal bed of the Plum Point marl member of the Calvert formation, is zone 4. Shattuck divided the Fairhaven member into 3 zones.

2. The lower richly fossiliferous bed of the Calvert formation is zone 10. Zones 5 to 9 cannot be certainly differentiated from each other.

3. The upper richly fossiliferous bed of the Calvert is zone 14. Zones 11 and 13 are essentially unfossiliferous clays. Zone 12 contains a considerable number of poorly preserved fossils that are usually too soft to be collected. It has, however, yielded more vertebrate fossils than any other zone. North of Parker Creek zone 14 is located so high in the cliffs as to be practically inaccessible, but south of Parker Creek it has yielded a fauna that is composed primarily of *Isocardia fraterna* Say variety *marylandica* Schoonover (Pl. 13, fig. 1, 2).

4. The lower abundantly fossiliferous bed in the Choptank formation is zone 17. It is difficult, if not impossible, to distinguish zones 15 and 16 from each other. Shattuck was probably misled by the varying amounts of clay and yellow sand in the transitional strata between the Calvert and Choptank formations into assigning the strata at times to the top of the Calvert as zone 15 and at times to the base of the Choptank as zone 16.

5. The upper abundantly fossiliferous bed of the Choptank formation is zone 19. The relatively unfossiliferous strata between the two abundantly fossiliferous beds in the Choptank formation are zone 18.

6. The lower fossiliferous horizon in the St. Marys formation which yields most of the fossils found at Little Cove Point is zone 22. Zone 20 is an unfossiliferous bed at the top of the Choptank formation, and zone 21 is an unfossiliferous clay and sand sequence at the base of the St. Marys formation. Zone 23 is a series of clays and fine sands that overlies zone 22 in the Calvert Cliffs section. It is sparsely fossiliferous but does yield casts of pelecypods and of *Turritella plebia* Say (Pl. 22, fig. 5, 6, 8). A thin band in this zone contains small concretions, some of which have yielded poorly preserved crab claws.

7. The fossiliferous strata on the shores of the southern part of St. Marys County, and especially along both sides of the St. Marys River, are zone 24.

COMPOSITION OF THE MIOCENE FAUNAS

The faunas of the Miocene formations in Maryland include representatives of all of the known animal phyla that have hard parts capable of fossilization. There are 624 species discussed in the Maryland Geological Survey's Miocene volume; of these 408 are referrable to the phylum mollusca, which is overwhelmingly dominant among the larger fossils, both in the number of species and in the number of individuals. In this phylum the Class Gastropoda (snails)

predominates with 214 species, followed by the Pelecypoda (clams) with 187 species; there are 5 Scaphopoda (tooth shells), 1 Amphineura (chiton) and 1 Cephalopoda (*Nautilus*).

The following groups are composed of specimens of microscopic size or of species that require microscopic techniques for their identification: foraminifera, radiolaria, ostracoda, and bryozoa among the animals, and the diatomaceae among the plants. Since the publication of the Maryland Miocene volume, the foraminifera of the Chesapeake group have been intensively studied by Ann Dorsey (Mrs. Arthur W. Clapp) and the results, with excellent illustrations of the species identified, have been published in Bulletin 2, "Cretaceous Tertiary Subsurface Geology", Maryland Department of Geology, Mines and Water Resources. Bulletin 2 contains also a well illustrated report on the Miocene diatoms by Kenneth E. Lohman.

PHYLUM BRACHIOPODA

Only a single species of brachiopod, *Discinisca lugubris* (Conrad) (Pl. 4, fig. 1, 2) has been found. It is relatively common in the Calvert formation and especially common in the Choptank formation, but only a few specimens occur in the St. Marys formation. It is readily recognized by its subcircular to oval, cap-shaped outline and by its dark-brown to black corneous or horny-appearing shell. The apex of the shell varies in position from marginal to subcentral, and the exterior is usually roughened by prominent growth lines and often with irregular fine ribbing. The interior of the shell shows well-developed muscle scars (Pl. 4, fig. 2). Large specimens may be as much as one inch in diameter.

PHYLLUM MOLLUSCA

Class Pelecypoda

The pelecypod shell consists of two halves or *valves* that are attached to each other by an elastic *ligament* which is usually seated on valve margin immediately behind the tips of the valves or *umbos*. In some forms the major part of the ligament is located in a pit between the *teeth* on the *hinge plate*. In addition to the ligament, the valves are attached to each other by muscles which pass from the inner surface of one valve to that of the opposite valve. The largest of these muscles are the *adductor muscles*, and the scars of their areas of attachment to the surface of the valve are usually visible inside the shell. The contraction of the muscles serves to close the valves. The elasticity of the ligament acting on the principle of a "C-spring" tends to separate or open them when the adductor muscles are relaxed. A thin layer of flesh, the *mantle*, lines the inside of the shell of the living clam. It serves in part for the aeration of the blood of the animal and in part for the deposition of the shell. The mantle is attached to the inside of the shell along a line a short distance above the ventral border. The line of attachment is usually visible on the shell

and is called the *pallial line*. Most clams have a pair of more or less extensible tubes called *siphons* that project from the posterior part of the body. One draws a current of water into the mantle cavity where it bathes the gills and carries the microscopic food of the animal into a position where it can be captured, the other expells the water from the cavity and with it the waste products of the body. In order that these siphons may be retracted into the shell when the valves are closed, there is an angulation in the pallial line called the *pallial sinus*. If the siphons are very short and do not project from the shell the pallial sinus is not developed. Some burrowing forms have developed excessively large siphons that could not possibly fit into the shell at any time; the posterior end of the valves then becomes opened, having a *gape*, so that the valve margins are not in contact in that area at any time.

The valves are generally articulated below the umbos by a *hinge* that usually consists of a *hinge-plate* on which are located *hinge teeth* with corresponding pits or *sockets* on the other valve for their reception. The teeth immediately below the umbo, and more or less directed toward it, are the *cardinal teeth*. The teeth which, if present, are located on either side of the cardinal teeth and are more or less parallel to the valve margins are the *lateral teeth*. The hinge teeth do not serve as the center of movement as does the hinge of a door, but their function, through their interlocking mechanism, is to prevent the valves from sliding anteriorly or posteriorly with respect to each other, thus ensuring that the margins will be in contact with each other when the valves are closed.

The many variations in the types of hinge tooth arrangement developed by the various genera of the pelecypoda are of major importance in their classification. The following types are important in the faunas in the Maryland Miocene:

1. *Taxodont:* in this type the hinge consists of alternating teeth and sockets, not divided into cardinal or lateral series, but in some cases broken into an anterior and posterior series by a ligamental pit (Pl. 4, figs. 5, 6, 8, 13). In the family Arcidae (Pl. 5, fig. 2, 4, 6) it is not interrupted.

2. *Cyclodont:* the hinge plate has been reduced, with the cardinals, usually two, and the laterals reduced and located on the margins of the valve. This is the hinge found in *Cerastoderma* (Pl. 12, fig. 5–7) and other genera of the Cardiidae.

3. *Heterodont:* perfected hinges with lateral and cardinal teeth on a true hinge plate. In some forms the laterals are lost and only cardinals remain. Typical examples are shown on Pl. 9, fig. 2, 9, 10; Pl. 10, fig. 4, 8; Pl. 12, fig. 2, 3, 8, 11; Pl. 14, fig. 2, 5, 7; and Pl. 18, fig. 2, 5, 6, 9.

4. *Asthenodont:* borers and burrowers in which the teeth have become obsolete from disuse. Typical examples include *Mya* (Pl. 19, fig. 13) in which the ligament is situated on a small plate projecting from one valve into the other and the hinge teeth have been reduced to small ridges on the plate: *Corbula* (Pl. 19, fig. 6, 7, 8, 11) with the ligament on a projecting plate as in *Mya*, but

with one small cardinal yet present on the reduced hinge-plate; and *Panope*, with a base for an external ligament only.

Genus NUCULA

Four species of *Nucula* have been reported from the Miocene faunas. All are small and are characterized by a taxodont hinge with a central ligament pit (Pl. 4, fig. 5, 6) and by the fact that the interior of the shell has a pearly luster. *Nucula prunicola* Dall, distinguished by raised concentric ridges on the anterior part of the shell, is confined to the Plum Point marl member of the Calvert formation. *N. sinaria* Dall (Pl. 4, fig. 6, 7), on the other hand, is almost confined to the St. Marys formation, only a few doubtfully identified specimens having been reported from the Choptank. It is a smooth polished form with faint concentric and radial ornamentation, the concentric usually more strongly apparent on the anterior part of the valve and the radial on the posterior part. The other two species occur in all three formations. *N. taphria* Dall (Pl. 4, fig. 3) is distinguished by its small rather solid shell having a few strong concentric grooves that cross the entire valve. *N. proxima* Say (Pl. 4, fig. 4, 5), a species that is still living, may be distinguished from all except *N. sinaria* by the small high umbos and pronounced posterior "pouting" and from *sinaria* by the absence of the deep concentric grooves.

Genera NUCULANA and YOLDIA

These are two genera of elongate posteriorly pointed shells with taxodont hinges divided by a sub-umbonal ligamental pit (Pl. 4, fig. 8, 13). *Yoldia*, represented in all three formations by *Y. laevis* (Say) (Pl. 4, fig. 8, 9), is larger than the representatives of *Nuculana* and may be readily distinguished by the fact that the valves do not close at the posteriorly pointed edge. *Nuculana liciata* (Conrad) (Pl. 4, fig. 11–13) and its variety *amydra* (Dall) (Pl. 4, fig. 10) are essentially confined to the lower fossiliferous bed of the Calvert formation (zone 10). The typical form of the species is marked by fine concentric ridges that are usually more strongly developed over the body of the shell than at the posterior margin. The variety *amydra* has a smooth polished surface.

Genus GLYCYMERIS

The sub-rounded radiately ribbed shells of *Glycymeris parilis* (Conrad) (Pl. 4, fig. 15, 16) are very abundant in the lower fossiliferous bed of the Calvert formation, and have not been reliably reported from any other horizon. It is perhaps the best guide fossil for this horizon. Other than two specimens reported in the Maryland Miocene volume as *G. subovata* (Say), no other representatives of the genus have been collected in the Maryland Miocene geologic section.

Family ARCIDAE

Ten species were reported by Glenn as occurring in the Maryland Miocene. Only four, all referable to the genus *Anadara*, are at all common; the others are either rarely found, or have not been subsequently recovered and their occurrence is questionable. The four species of *Anadara* are:

A. subrostrata (Conrad) (Pl. 5, fig. 1, 2), confined to zone 10, is most easily distinguished by each of the radial ribs on the main body of the valve tending to have three grooves on its surface, a strong medial one with a weaker one on each side. The valves are elongate and about two-thirds as high as long.

A. staminea (Say) (Pl. 5, fig. 3, 4), known only from the Choptank formation, has a shell that is heavier in texture, almost as high as long, and with never more than a single groove in the radial ribs which are often ornamented by small nodes on their surfaces.

A. idonea (Conrad) (Pl. 5, fig. 5) of the St. Marys formation has a larger and heavier shell than *A. staminea* and is usually almost exactly as high as long. The radial ribs near the posterior angulation of the valve have several fine grooves on their surfaces, and those on the anterior and median surfaces usually bear but one groove or none.

A. arata (Say) (Pl. 5, fig. 6, 7), while quite rare in the St. Marys formation, is confined to it, and is of value in recognizing that formation. It is an elongate shell, almost twice as long as high, and the radial ribs lack all trace of grooving.

A fifth arcid species that is relatively rare is *Barbatia marylandica* (Conrad) (Pl. 4, fig. 14). This is known only from the lower fossiliferous horizon of the Calvert formation (zone 10) and may be at once recognized by its shape and very fine radial ribbing.

Genus ATRINA

Two species of *Atrina* have been reported from the Chesapeake group. *A. piscatoria* is known from only a single specimen from the Calvert formation. *A. harrisii* Dall (Pl. 5, fig. 8) is not rare in the Calvert and Choptank formations. The shell is very fragile, and specimens are difficult to collect and preserve.

Genus ISOGNOMON

Large specimens of *Isognomon maxillata* (Deshayes) (Pl. 6, fig. 1, 2) are common in the Calvert and Choptank formations. The shell, though thick, breaks up easily and is difficult to collect. In life the shells were highly nacreous with layers of organic material between those of lime; the organic layers have subsequently decayed causing the limy layers to separate easily. The species may be recognized by the heavy transversely grooved ligamental area.

Genus OSTREA

Four species of oysters have been found, two in the Calvert formation and two in the Choptank formation. *Ostrea percrassa* Conrad (Pl. 6, fig. 3) is abundant in the basal bed of the Plum Point marl member of the Calvert formation, and is relatively rare higher in the section, although it has been reported from the lower abundantly fossiliferous bed of the Calvert formation. It is a broad relatively unornamented species that is four to five inches in greatest length. *Ostrea sellaeformis* variety *thomasii* (Conrad), the other Calvert species, is readily separated from *O. percrassa* in having fifteen to twenty ribs on the convex lower valve. It is apparently found only in the lower fossiliferous bed of the Calvert formation.

Ostrea carolinensis Conrad (Pl. 7, fig. 1, 2) is often exceedingly abundant in the upper fossiliferous bed of the Choptank formation (zone 19). It may be confused with *O. sellaeformis thomasii* in that the convex lower valve of both is ornamented with irregular radial ribbing. Specimens of *O. carolinensis* are usually much higher in proportion to their total length and the ligamental groove in the hinge area is relatively straight, whereas that of the Calvert form tends to be distinctly twisted. The other Choptank oyster, *O. trigonalis* Conrad, is rarely found. It has only a few broad and relatively indistinct radial ribs on the convex valve.

Family PECTINIDAE

A number of Maryland Miocene species have in the past been referred to the genus *Pecten*, but only *Pecten* (*Pecten*) *humphreysii* Conrad (Pl. 7, fig. 3, 4) is accurately so identified. It occurs in the lower part of the Plum Point marl (zones 5 through 10 of Shattuck). It is characterized by having one flat and one convex valve. The convex valve has six to eight broad flat radiating ribs with the inter-rib areas about one-half the width of the ribs. The flat valve has ribbing that occupies the inter-rib interval of the other and wide interspaces equivalent to the ribs of the convex valve. This species is usually not common, but the writer once found a large number in a bed a few feet above the *Ostrea percrassa* zone a short distance west of Davidsonville in Anne Arundel County.

The common pectens in the Maryland Miocene belong to the genus *Chlamys*, subgenus *Lyropecten*. One of the most abundantly represented and characteristic species of the Calvert and Choptank formations is *Chlamys* (*Lyropecten*) *madisonius* (Say) (Pl. 7, fig. 6). It is characterized by 13 to 18, usually about 16, radial ribs, with the entire surface of the valve overlain by finer scaly riblets. Usually there are about three riblets on the tops of the major radial ribs, and they tend to be more strongly developed than are the riblets in the spaces between the major ribs. The species is very variable, however, particularly in the strength of the development of the riblets. One form, in which the middle

of the three riblets on each rib is much more strongly developed than the other two is the variety *bassleri* Tucker-Rowland, which occurs only in the Calvert formation. In a more extreme development, in *Chlamys* (*Lyropecten*) *coccymelus* (Dall), a rather rare species of the Calvert fauna, the finer riblets are all lost except for the strong central one on each major rib.

Typical specimens of *Chlamys* (*Lyropecten*) *madisonius* (Say) attain diameters up to six inches in the Choptank formation, especially near the top of the lower fossiliferous bed (zone 17) where they occur in vast numbers, often with large specimens of the barnacle *Balanus concavus* Bronn (Pl. 29, fig. 16–19) attached to them. The adult specimens in the Calvert formation are almost always of smaller size than those of the Choptank. The middle of the three strong riblets on the ribs appears first in the development of the individual. Small specimens, an inch or less in diameter, have a superficially very different appearance from the adults. The relationship is apparent on comparing them with the umbonal region of a well preserved adult specimen.

In the St. Marys formation *Chlamys* (*Lyropecten*) *santamaria* Tucker (Pl. 7, fig. 7) is the abundant pectinid species. It is characterized by 12 to 14 rather broad radial ribs that are usually slightly wider than the interspaces between them. The surface of the ribs and the interspaces are marked by many relatively fine scaly riblets. These are not as strong as the riblets in *C.* (*L.*) *madisonius* and are not more strongly developed on the surfaces of the ribs than they are in the interspaces, rather there is a tendency for the reverse to be true with a more prominent riblet often in the middle of an interspace. In the Maryland Miocene volume this species was identified and illustrated as "*Pecten*" *jeffersonius* Say, a species of the Yorktown formation that is characterized by the presence of about 9 strong flattened radial ribs. I have seen no undoubted specimens of *jeffersonius* from the St. Marys formation.

Another species of *Chlamys*, *C.* (*Placopecten*) *marylandicus* (Wagner) (Pl. 7, fig. 5), occurs in the Choptank formation and appears to be confined to the lower fossiliferous bed (zone 17). This species, having a diameter of about three inches, is smaller than the Choptank specimens of *C. madisonius*. The valves are ornamented by radial lines that tend to group themselves into major ribs of varying degrees of prominence. There is a fine concentric ornamentation in the spaces between the radial lines, but it does not cross them.

Genus PLICATULA

A small rather crudely radially ribbed oyster-like form, *Plicatula densata* Conrad (Pl. 8, fig. 1, 2), has been found in the Calvert formation at Church Hill in Queen Annes County. This genus, which is extremely abundant in the upper Miocene in Virginia and North Carolina, may be distinguished from *Ostrea* in the possession of small teeth on either side of the sub-umbonal ligament.

Genus ANOMIA

The thin irregularly rounded more or less transluscent shells of *Anomia* are occasionally found in the Calvert, Choptank and St. Marys formations. Most are so fragile as to be difficultly collected. They usually show a fine radial striation on the surface. The animals of *Anomia* attach themselves to other shells and surfaces, and the shape varies as the shape of the surface to which they are attached. The lower valve is flattened, the upper convex. Attachment is by means of a byssus which passes through the upper part of the flattened valve, and there are three byssal muscle scars on the inner side of the convex valve. The species in the Maryland Miocene deposits is identified as *Anomia aculeata* Gmelin (Pl. 8, fig. 3, 4, 5).

Genus MYTILUS

The "muscle shells", *Mytilus* and *Modiolus*, are not rare in the Maryland Miocene, but are usually not well preserved. *Mytilus*, in which the umbo is located at the anterior tip of the valve, is represented by two species, one of which, *M. conradinus* d'Orbigny (Pl. 8, fig. 6, 7), is much more common than the other, *M. (Mytiloconcha) incurvus* (Conrad), which has a more pointed, thicker shell with a heavy hinge plate area.

Genus MODIOLUS

Modiolus ducatelli Conrad (Pl. 8, fig. 8) of the Calvert, Choptank and St. Marys formations may be distinguished from *Mytilus conradinus* by its umbo which, although anterior in position, is not located at the extreme anterior tip of the valve but is raised slightly above the anterior end. In addition, *Modiolus* has a straight dorsal margin behind the umbo, forming a sort of posterior dorsal "wing" on the valve.

Genus THRACIA

The large thin-shelled species *Thracia conradi* Couthouy (Pl. 9, fig. 12) occurs mainly in the lowermost beds of the Calvert formation, casts having been obtained in the Fairhaven member and crushed shells in the beds beneath the lowermost abundantly fossiliferous horizon of that formation. I have also collected casts from the concretionary bed in the upper part of the section of the St. Marys formation at Little Cove Point (zone 23). The species is still living in the adjacent waters of the Atlantic Ocean.

Genus PANDORA

The small elongate pearly shells of *Pandora crassidens* Conrad (Pl. 9, fig. 13, 14) are fairly common in the St. Marys formation, especially in the beds along the St. Marys River. It has not been certainly found in the lower formations.

Genus ASTARTE

Species of this genus are exceedingly common and are diagnostic guide fossils in the Maryland Miocene formations. *Astarte cuneiformis* Conrad (Pl. 9, fig. 1, 2, 3) and its several varieties (Pl. 9. fig. 4), together with *A. thomasii* Conrad (Pl. 9, fig. 5), are markers of the Calvert fauna; *A. thisphila* Glenn (Pl. 9, fig. 6, 7, 9) and *A. obruta* Conrad (Pl. 9, fig. 8) distinguish the Choptank fauna; and *A. perplana* Conrad (Pl. 9, fig. 10, 11) is present in the St. Marys formation.

It will be seen by careful examination of the illustrations that these species are distinguishable on the basis of their shape. *A. cuneiformis*, which is largely confined to the lower abundantly fossiliferous horizon of the Calvert formation, is characteristically elongate-trigonal in shape with sharply pointed umbos set off in part by a deeply excavated lunule. The surface of the valves is ornamented by a few concentric undulations or ripples near the beak which die out ventrally in the typical form, and the rest of the shell is smooth except for growth lines. In some of the varieties, however, the undulations may continue well down on the valve; and in the extreme form, the variety *calvertensis* Glenn (Pl. 9, fig. 4), the entire valve is marked by a fine evenly spaced concentric ribbing. The shell in this variety tends, also, to be somewhat higher in proportion to its length than it is in the typical *A. cuneiformis*. *A. thomasii* Conrad, also confined to the lower horizon of the Calvert formation, has a much more rounded outline than *A. cuneiformis* with which it occurs; and the concentric ribbing, which is present over the entire valve, is stronger and more widely spaced.

Astarte thisphila Glenn is the most abundant species of the genus in the Choptank formation. It appears to be confined to the lower part (zones 16 and 17) of that formation. The shell has conspicuously flattened umbos marked with strong and distant concentric undulations that extend well down and in some specimens entirely across the valve. The flattening of the umbonal area produces a hump-backed appearance to the posterior dorsal margin of the shell. *A. obruta* Conrad is very rare in the lower fossiliferous bed (zone 17) of the Choptank formation, but is common and characteristic of the upper horizons of the formation. It is almost an equilateral triangle in outline and may be easily separated from *A. thisphila* in that only a small area at the umbo is flattened and marked by concentric undulations while the rest of the valve is entirely smooth.

Astarte perplana Conrad, the only abundant representative of the genus in the St. Marys formation, has a much compressed shell that posteriorly has much the outline of *A. cuneiformis*, but has higher more anteriorly situated umbos, so that the anterior part of the shell is proportionately shorter and more broadly rounded. The surface of the valve is marked by low rather distant concentric undulations.

Genus EUCRASSATELLA

Three species, one in the Calvert and two in the Choptank faunas, represent this genus in the Maryland Miocene faunas. Mansfield and Schoonover each mention the finding of one specimen in the St. Marys fauna but do not mention the species represented. The genus is so rare in that formation that it can for all practical purposes be considered as being diagnostic of the lower formations. *E. melina* (Conrad) (Pl. 10, fig. 1) of the Calvert formation most closely resembles *E. turgidula* (Conrad) (Pl. 10, fig. 5) of the lower part of the Choptank formation, but typical specimens can be separated on the basis of the outline of the valves, particularly the almost straight ventral margin of *melina* in contrast to the well rounded margin of *turgidula*; this, combined with a somewhat greater dorsal slope to the latter results in a shell with narrower anterior and posterior ends. The umbonal areas of both species are flattened and bear *Astarte*-like concentric wrinkles, the width of the area so ornamented being greater in *turgidula* than in *melina*. The third species, *E. marylandica* (Conrad) (Pl. 10, fig. 6, 7), lacks the umbonal flattening, the beaks being rounded in profile, and the posterior end of the shell is compressed and much narrower than the anterior. This species occurs in the upper fossiliferous bed of the Choptank formation.

Family CARDITIDAE

Two species of Carditidae are common in the Maryland Miocene. They are distinctly different from each other and from other pelecypods in the faunas. *Cardita granulata* (Say) (Pl. 10, fig. 8,9) is an almost round species with 24 to 27 radial ribs on the surface of the valves. It is present in all three formations. *Carditamera protracta* Conrad (Pl. 10, fig. 2, 3, 4) is a trapezoidally elongate form with anteriorly located umbos. There are 19 to 21 radial ribs in the specimens from the lower part of the Calvert formation, and the number gradually liminishes to 15 to 17 in the specimens from the fossiliferous beds of the Choptank formation. The species has not been reported from the St. Marys formation.

Genus CHAMA

The irregularly rounded squamosely imbricate concentrically ribbed specimens of *Chama congregata* Conrad (Pl. 11, fig. 1, 2, 3) are said to be abundant at Church Hill in Queen Annes County, but rare at other localities. All known occurrences are in the Calvert formation.

Family LUCINIDAE

Six lucinid species are listed in the Maryland Miocene volume. Four are of common occurrence, and two are relatively rare. *Saxolucina* (*Megaxinus*)

anodonta (Say) (Pl. 11, fig. 4, 5) is the largest. Its flattened disc-like shell is found in all three formations. *Saxolucina* (*Megaxinus*) *foremani* (Conrad) (Pl. 11, fig. 6) is a smaller species with a straighter posterior end and much more inflated valves. It appears to be confined to the lower part of the Calvert formation, although Glenn has reported it from the Choptank at Governor Run, a record that has not been confirmed by subsequent collecting. The shells of both the above species are relatively smooth in contrast to the finely concentrically ribbed *Lucinoma contracta* (Say) (Pl. 11, fig. 7, 8), a species that is also proportionately much more elongate than are the representatives of *Saxolucina*. *L. contracta* is present in all three formations of the Maryland Miocene. It is most abundant in the beds that are otherwise not richly fossiliferous and is relatively rare in the abundantly fossiliferous beds.

The fourth common species is a small form, *Parvilucina crenulata* (Conrad) (Pl. 11, fig. 9, 10) with a lenticular shell ornamented with numerous fine concentric laminae. It occurs in all three Miocene formations. Two rarer species, *Parvilucina prunus* Dall and *P. trisulcata* (Conrad) are both small forms like *P. crenulata*, but differ in having a less rounded outline, both having more posteriorly located umbos and hence a more produced anterior margin of the valves.

Genus DIPLODONTA

Three species of *Diplodonta* occur. Two are relatively rare and the third is quite common in the Choptank sands and less abundant in the clayey silts of the Calvert and St. Marys formations. The latter species, *D. acclinis* (Conrad) (Pl. 12, fig. 1, 2), has an almost round outline, the length and height being approximately equal, and the diameter through a pair of valves is equal to about one-fourth of the length. *D. subvexa* (Conrad) (Pl. 11, fig. 11, 12), which is likewise circular but has a diameter between paired valves almost equal to half the length, is rarely found and is restricted to the upper part of the Calvert formation and the Choptank formation. The shell is very thin, much thinner than in *D. acclinis*, and the specimens are difficult to collect. *D. shilohensis* Dall has the shape and proportions of *D. subvexa*, but is only about one-third as large. It is known only from the Choptank formation and is seldom found.

If the sand and mud associated with the larger specimens is carefully washed through a screen, a number of small shells will be found. Many of these are immature individuals of species that attain larger sizes, but associated with them are forms that are small even when full grown. Many species of these types have been found in the Maryland Miocene faunas. Most are known from but a few specimens and from only one or two localities. A few typical examples are figured on Plate 12, figures 3, 4, and 8 to 12. The most abun-

dantly represented of these small forms is *Aligena aequata* (Conrad) (Pl. 12, fig. 3, 4) whose small rounded shell ornamented with rather distant raised concentric laminae is found at almost every locality in the fossiliferous horizons of the Choptank formation. Six species of *Erycina* have been reported, most of them confined to the Calvert formation. The illustrations of *E. rickardia* Glenn (Pl. 12, fig. 8, 9) show the characteristic features of this genus. Of the four species of *Bornia* known to be present in either the Calvert or the Choptank faunas, *B. mactroides* (Conrad) (Pl. 12, fig. 10, 11), known only from the Choptank, is the most abundantly occuring form. The almost triangular smooth little shell is quite easily recognized.

Family CARDIIDAE

Of the seven species of Cardiidae that have been reported from the Miocene faunas, only the large *Cerastoderma laqueatum* (Conrad) (Pl. 12, fig. 7) is at all of common occurrence, being present in all three formations but most common in the Choptank. The surface, which is ornamented by 33 to 36 radial ribs, usually breaks away from the inner part of the shell, and it is almost impossible to collect well preserved specimens. *C. leptopleurum* (Conrad) (Pl. 12, fig. 6), known only from the lower fossiliferous horizon of the Calvert formation, has a more rounded shell that is ornamented by 31 radial ribs that are narrower and more angulate with proportionately wider interspaces than are those on *C. laqueatum*. *C. craticuloide* (Conrad) (Pl. 12, fig. 5), also known only from the lower fossiliferous horizon of the Calvert formation, may be readily distinguished from the two preceding species in that the 29 to 32 radial ribs are almost triangular in section, their sides sloping obliquely from the narrow flattened crests to the equally narrow flattened interspaces. Two other rarely occurring species of *Cerastoderma* are known from the Calvert formation. They may be distinguished by the number of radial ribs on the surfaces of their valves. *C. patuxentium* Glenn has about 50 ribs, and *C. calvertensium* Glenn has but 17 to 22 ribs.

Genus ISOCARDIA

Four, possibly five, species of *Isocardia* occur in the Maryland Miocene deposits, but only *Isocardia fraterna* Say variety *marylandica* Schoonover (Pl. 13, fig. 1, 2) is common. It occurs in the upper fossiliferous horizon of the Calvert formation, throughout the Choptank formation, and is present, but very rare, in the St. Marys formation. The genus may be recognized by the relatively thin shell, the prominent strongly curved umbos, and the peculiarly twisted cardinal teeth that tend to parallel the margins of the hinge-plate rather than to point toward the umbos. Two species of the genus are rare in the lower fossiliferous stratum of the Calvert formation; both are proportionately much

shorter than *I. fraterna marylandica*, with their length approximately equal to their height. *I. markoëi* Conrad has spirally-twisted umbos that are so curved that their tips point away from the hinge line. *I. mazlea* Glenn has less strongly twisted umbos whose tips point almost ventrally. Another species, exceedingly rare in the upper fossiliferous horizon of the Calvert formation, is *I. ignolea* Glenn. This species is notably elongate, its length being almost one and one-half times as great as its height.

North of Chesapeake Beach a thin bed of *Isocardia* occurs a short distance above the *Ostrea percrassa* bed at the base of the Plum Point marls. The specimens from this bed are thin, fragile, and usually crushed. They seem however, to be different from any of the described species from the higher horizons and probably represent a new species.

The generic name *Glossus* should probably be used in place of *Isocardia*, but this change has not been accepted by all paleontologists.

Family VENERIDAE

The family Veneridae, the genus *Venus* of early authors, is one of the most flourishing of the pelecypod families in both the Tertiary and the Recent faunas. The illustrations on Plate 13, figures 3 and 4, and on Plates 14, 15 and 16 serve to emphasize the diversity of form in the Maryland Miocene species referred to this family. About fourteen species and varieties, referable to five genera, are sufficiently common and important to merit discussion. Some occur throughout all three formations, others are restricted in range and are diagnostic guide fossils.

Genus DOSINIA

The rounded solid shells of *Dosinia acetabulum* (Conrad) (Pl. 13, fig. 3, 4) occur in all three Maryland Miocene formations. They are perhaps most easily recognized by their rather polished surface which is, however, not smooth, but ornamented by concentric grooves or by very low flattened ribs that rise to sharper thin ribs toward the margins.

Genus MELOSIA

Melosia staminea (Conrad) (Pl. 14, fig. 6, 7), a species that has in the past been referred to the genus *Antigona*, or to *Artena*, is very common and abundant in the lower fossiliferous bed (zone 10) of the Calvert formation and is apparently confined to that zone. It is a relatively small species, so far as the veneridae are concerned, and is marked by 10 to 16 prominent acute and slightly reflected concentric ribs with fine concentric growth lamellae in the inter-rib areas. The hinge has three teeth, the anterior being very small in the left valve; the pallial sinus is also small for a member of this family.

Genus CHIONE

Three species of *Chione* occur. *C.* (*Lirophora*) *latilirata* (Conrad) (Pl. 15, fig. 4, 5, 7) occurs only in zone 10 in the lower part of the Calvert formation. *C. parkeria* Glenn (Pl. 14, fig. 4, 5) is known only from the upper part of the Calvert formation. *C.* (*Lirophora*) *alveata* (Conrad) (Pl. 15, fig. 6, 8) is known only from the St. Marys formation. *Chione latilirata* has been reported by Glenn from the Choptank formation at Greensboro, Caroline County; this is the only record of the genus from that formation. Its absence is apparently due to living conditions unsatisfactory for the genus during Choptank time.

Genus MERCENARIA

Three species and four varieties of *Mercenaria* make this the most diversely represented genus of Veneridae in the Maryland Miocene faunas. The genus may be recognized by a roughened area on the hinge plate below the ligament and just behind the posterior of the three cardinal teeth. *M. mercenaria* (Linnaeus) (Pl. 14, fig. 1, 2), the common "*Venus* clam" or "hard-shelled clam" of our present pelecypod fauna as well as of the sea-food stores, is present in all three formations, although rare in the St. Marys. It may be distinguished from the several varieties of *M. campechiensis* (Gmelin) primarily by its elongate shell that is relatively broad posteriorly and by its somewhat smoother surface with less strongly developed concentric rugae. The hinge, also, tends to be proportionately narrower and less heavy.

The true *M. campechiensis* (Gmelin) is not represented in the Maryland faunas, it being a more southern species. There are however four varieties of that species present; all have a notably roughened exterior due to a strong development of coarse concentric laminae, and all show a strong broad and heavy hinge area. The variety *capax* (Conrad) (Pl. 14, fig. 3; Pl. 15, fig. 2) of the Calvert and Choptank formations has a compact rounded outline with the umbos low and relatively anterior in position. The posterior end is almost squarely truncate, a feature that is in sharp contrast with the almost angular posterior extremity of the varieties *cuneata* (Conrad) of the Choptank and St. Marys formations and *tetrica* (Conrad) of the St. Marys. These varieties may be distinguished from each other by the exceedingly massive hinge and heavy almost centrally located umbos of the variety *cuneata*, which contrast with the relatively narrow hinge and anteriorly located umbos of the variety *tetrica*. The variety *mortoni* (Conrad) of the St. Marys formation has a more truncate posterior end than have either *cuneata* or *tetrica*, but it is not so strikingly short as that of the variety *capax*. It may also be distinguished from *capax* by its more prominent umbos and by the broadly rounded but produced anterior end.

Mercenaria rileyi (Conrad) (Pl. 15, fig. 1), a species that apparently occurs only in the lower fossiliferous horizon of the Calvert formation, is an elongate

relatively thin-shelled species with small non-inflated umbos that are quite anterior in position. The hinge-plate is narrower than that of any of the other species, especially the area posterior to the cardinal teeth.

Mercenaria plena (Conrad) (Pl. 15, fig. 3; Pl. 3) appears to be found only in the Choptank formation. It has much the outline of *M. campechiensis* variety *cuneata* but is not so sharply angulate posteriorly and the umbos are not as strongly inflated. It may best be separated, however, by its less roughened exterior and especially by its less heavy hinge-plate.

Genus MACROCALLISTA

Macrocallista marylandica (Conrad) (Pl. 16, fig. 1, 2) is one of the more easily recognized commonly occurring species in the faunas of the Calvert and Choptank formations. Its thick ponderous shell with smooth polished surface may be collected from almost every outcrop of the lower fossiliferous horizon (zone 10) of the Calvert formation and from the two fossiliferous beds (zones 17 and 19) of the Choptank formation. Part of the polished outer layer often breaks away when the shell is collected, revealing a chalky interior of the shell (Plate 16, fig. 1).

Genus CALLOCARDIA

Associated with the large Mercenarias are smaller smooth-shelled forms with outline somewhat like that of *Macrocallista marylandica*, but with a notably thinner shell. These forms may easily be distinguished from the latter by the possession of a small anterior lateral tooth and by the ascending rather tongue-shaped pallial sinus. They are referred to the genus *Callocardia*. Two species are recognized: *C. subnasuta* (Conrad) (Pl. 16, fig. 3, 4), present in all three formations, and *C. sayana* (Conrad) found only in the Choptank and St. Marys formations. *C. sayana* has a thicker more convex shell than *C. subnasuta*, its umbos are higher and more prominent, its hinge-plate broader and heavier, and its pallial sinus wider and less strikingly tongue-shaped.

Genus PETRICOLA

The irregular finely radiately ornamented shells of *Petricola harrisii* Dall (Pl. 17, fig. 1, 2), known only from the Choptank formation, and of *P.* (*Petricolaria*) *calvertensis* Dall (Pl. 17, fig. 3), reported from the Choptank and St. Marys formations, are always rare. Both species tend to live in holes in the sea floor or inside the valves of dead shells. Their shape is variable according to the degree of crowding and to the obstructions to their normal growth in their habitation. Specimens as little distorted as that shown in Plate 17, figure 3 are exceedingly uncommon, but *P. calvertensis* is always more elongate, the umbos more anterior in position, and the hinge-plate less strongly developed than that of *P. harrisii*. The only other form with which they might be con-

fused is *Asaphis centenaria* (Conrad) (Pl. 18, fig. 4, 5), which is a larger shell with somewhat the outline of some specimens of *P. calvertensis*, but which differs in the details of the hinge, especially in having but two cardinal teeth in each valve instead of the three found in *Petricola*.

Family TELLINIDAE

Three genera of Tellinidae are present in the fauna: *Tellina*, *Macoma*, and *Apolymetis*. Four species of *Tellina* have been reported, two of *Macoma*, and one of *Apolymetis*. Of the four species of *Tellina*, only two, *T.* (*Moerella*) *declivis* Conrad (Pl. 17, fig. 4) and *T.* (*Moerella*) *producta* Conrad (Pl. 17, fig. 5) may be classed as not being rare. The differences between these two small species are well shown in the illustrations. Internally, the hinge of both bears two small cardinal teeth under the umbo with moderately well developed anterior and posterior lateral teeth situated on the valve margins more or less remote from the cardinals. The presence of the lateral teeth distinguishes the species of *Tellina* from those of *Macoma*, which lack laterals. *Macoma lenis* (Conrad), the only species of the genus that is not exceedingly rare, occurs mainly in the Calvert formation, especially in the lowermost beds of the Plum Point marls. It is much larger than either of the two described species of *Tellina*, averaging about four times their length. *Macoma marylandica* Glenn, rare in the St. Marys formation, is approximately the same size as *Tellina declivis*, but has more central umbos and a less steeply sloping margin behind them.

Apolymetis biplicata (Conrad) (Pl. 17, fig. 14, 15) is the largest and most easily recognized species of the family in the Maryland faunas. It occurs in all three formations, but is most abundant in the Choptank formation where its thin-shelled valves with their characteristic waved posterior end with its abrupt truncation are commonly found as associated pairs.

Family SEMELIDAE

Related to *Tellina*, and similar in possessing a hinge with two small cardinal teeth and with anterior and posterior laterals, the genus *Semele* may be distinguished by possessing, in addition, an internal ligament that occupies an elongate pit posterior to the cardinal teeth but in front of the posterior lateral tooth (Pl. 17, fig. 10, 13). Two small species of the genus are quite common in all three formations. *S. carinata* (Conrad) (Pl. 17, fig. 11, 12, 13) is more common in the muddy silts of the Calvert and St. Marys formations, and *S. subovata* (Say) (Pl. 17, fig. 8, 9, 10) is more common in the sands of the Choptank formation. *S. carinata* may be distinguished from *S. subovata* by having distant raised concentric lamellae and a more steeply sloping posterior dorsal margin.

The genus *Abra* resembles a small smooth *Semele*, but has smaller cardinal

teeth and a larger pit for the internal ligament, the ventral margin of which projects below the hinge-plate into the body of the valve (Pl. 17, fig. 6). *A. longicalla* (Scacchi) (Pl. 17, fig. 6, 7) occurs in the lower part of the Choptank formation, including the lower abundantly fossiliferous stratum. In addition to its hinge characteristics, it may be distinguished by its broadly and regularly rounded ventral margin and its almost pointed posterior end.

Genus GARI

The elongate *Tellina*-like shells of the genus *Gari* may be distinguished from those of *Tellina* by the absence of lateral teeth, and from *Macoma*, which also lacks lateral teeth, by the possession of a raised plate-like projection of the valve in the area of ligamental attachment (Pl. 18, fig. 2). *G. gubernatoria* (Glenn) (Pl. 18, fig. 1, 2), the only species of the genus in the Maryland faunas, is rare in the Calvert formation, but moderately common in the Choptank.

Genus ASAPHIS

The irregularly radiately ornamented shells of *Asaphis centenaria* (Conrad) (Pl. 18, fig. 4, 5) occur in the Calvert and Choptank formations, but are much more common in the sands of the latter than in the more muddy strata of the former. It has not been reported from the St. Marys fauna, although it is present in the sands of the younger Yorktown formation in Virginia. This species has already been compared with *Petricola*, the only similar form in the Miocene faunas.

Genus ENSIS

Two species of the curved "razor-clams" occur in the Maryland Miocene faunas. The most abundant, *Ensis ensiformis* (Conrad) (Pl. 18, fig. 3), is present in the Calvert, Choptank and St. Marys formations. It may be distinguished from *E. directus* (Conrad), known only from fragments in the St. Marys formation, by its smaller size and more tapering posterior end. The anterior and ventral margins of *E. directus* are almost parallel and the posterior end almost squarely truncate.

Family MACTRIDAE

Nine species referred to three genera of Mactridae have been reported from the Maryland Miocene formations; three, however, are exceedingly rare. All members of the family are readily distinguished from other pelecypoda by the possession of a large pit on the hinge-plate for the reception of an internal ligament (Pl. 18, fig. 6; Pl. 19, fig. 1). The most abundant and widely distributed species is *Mactra clathrodon* Lea (Pl. 18, fig. 8, 9), present in all three formations. It may be distinguished from the other species of the family by its small size and especially by its relatively shallow and rounded pallial sinus.

In contrast with these small shells is the well-named *Spisula* (*Hemimactra*) *subponderosa* (d'Orbigny) (Pl. 18, fig. 6, 7; the figures are but ⅔ natural size), one of the most common pelecypods of the St. Marys formation. The thick heavy subtriangular shells of this species are also easily recognized by their peculiar almost pointed horizontal pallial sinus. Almost as large as *S. subponderosa* is *S.* (*Hemimactra*) *delumbis* (Conrad), and *S.* (*Hemimactra*) *marylandica* Dall (Pl. 19, fig. 1), both of which are present, but not common, in all three Maryland formations. They may readily be distinguished from *S. subponderosa* by their relatively thin shell and the different shape of their pallial sinus (compare Pl. 18, fig. 6 and Pl. 19, fig. 1). They may be distinguished from each other in that *S. delumbis* has but one elevated ridge-like line on the posterior dorsal slope of the valve and *S. marylandica* has three.

Genus MESODESMA

In the St. Marys formation are found the small *Mactra*-like shells of *Mesodesma mariana* Glenn (Pl. 19, fig. 2, 3, 4). They may be distinguished from young shells of *Mactra clathrodon*, which they resemble in their short rounded pallial sinus, by their more posteriorly located umbos which are very low and do not project above the hinge-plate and by the much greater anterior length of the shell.

Family MYACIDAE

The shells of the family Myacidae are characterized by a peculiar projecting spoon-like process in the right valve that carries the ligament under the umbo of the left valve to which it is attached on a thickened area of that shell. Thus the hinge areas of the two valves are strikingly dissimilar. Representatives of this family are rare in the Maryland Miocene faunas. The most striking form, *Mya* (*Arenomya*) *producta* Conrad (Pl. 19, fig. 13, 14), is known only from the Choptank formation at Jones Wharf. Its elongate shell is open or gaping at both extremities, indicating that it was a burrowing species.

Genus CORBULA

Species of the genus *Corbula* are of common occurrence throughout the Miocene formations. In the lower part of the Calvert formation, rare in the Fairhaven member but abundant in the lower Plum Point marls to the top of the lower abundantly fossiliferous horizon (zone 10), is found the relatively high *Corbula* (*Varicorbula*) *elevata* Conrad (Pl. 19, fig. 11, 12). Associated with it in the lower Plum Point marls and continuing upward throughout all three formations is the more elongate coarsely concentrically plicate *C.* (*Caryocorbula*) *inaequalis* Say (Pl. 19, fig. 8, 9, 10). Also in the Calvert and Choptank formations is *C.* (*Caryocorbula*) *cuneata* Say, a species similar in outline to *inaequalis* but differing in possessing much finer closer concentric ornamentation. A

fourth species of corbulid is the large *C.* (*Bicorbula*) *idonea* Conrad (Pl. 19, fig. 5, 6, 7) whose obscurely concentrically undulate shells, that are relatively smooth in comparison with the other species mentioned above, are found in the Calvert and Choptank formations. The left valve is rather strongly inflated, the right almost flat. The nearest relative of this species occurs in the much older Eocene deposits of France.

Genus HIATELLA

The normally distorted shells of *Hiatella arctica* (Linnaeus) (Pl. 20, fig. 4, 5), like *Petricola* a nestling species whose shape is influenced by the shape of the area in which it grows, occur in all three Maryland Miocene formations. It is still living in almost all of the ocean waters. As most frequently found the shell is quadrilateral in outline with the umbo nearly terminal, as shown in the illustrations. Occasionally the shell may be so short as to be almost square or may be greatly elongated and twisted sharply. The right valve is usually larger than and somewhat overlaps the left.

Genus PANOPE

The large shells of the genus *Panope*, the "gooeduck" of the Pacific coastal shell collectors, are relatively common in the Maryland Miocene formations, especially the Calvert and Choptank formations. Three species have been recognized on the basis of the shape of the valves. *Panope whitfieldi* Dall (Pl. 20, fig. 2) in the Plum Point marl and the lower part of the Choptank formation has a shell with centrally located umbos and with the anterior and posterior ends almost equally rounded. *P. americana* Conrad (Pl. 20, fig. 1) of the Plum Point marl and the Choptank formation has a noticeably obliquely truncate posterior extremity. *P. goldfussi* Wagner (Pl. 20, fig. 3) found throughout all three formations has umbos that are slightly anterior in position with the posterior end more elongate and noticeably tapering so that the posterior end is narrower than the anterior. All three species gape both anteriorly and posteriorly and like their modern descendants were animals that burrowed in the sands and muds of the sea floor.

Class Scaphopoda

The Scaphopods, or "tooth shells", occur throughout the Miocene deposits. Two genera are present. In *Dentalium* the shell is an elongate curved tube that is distinctly smaller at the posterior end than at the anterior. Three species are found: *D. attenuatum* Say (Pl. 21, fig. 2) which is ornamented by twelve to sixteen ribs that trend along the tube, and *D. caduloide* Dall (Pl. 21, fig. 1) and *D. danai* Martin, both of which are smooth. *D. danai* differs from *D. caduloide* in having a distinct notch in the smaller posterior end of the shell which is located on the convex or outer side of the curvature.

The other scaphopod genus is *Cadulus*, represented by small tubular shells that show a distinct median swelling. *C. thallus* (Conrad) (Pl. 21, fig. 3) is the most abundant representative of the class and careful search yields it at almost every locality. The shell is smooth and highly polished. A second species, *C. newtonensis* Meyer and Aldrich is more slender and at the narrower posterior end has two distinct notches on the convex side and two shallower notches on the concave side. If this end is broken, it cannot be readily distinguished from *C. thallus*.

Class Gastropoda

The gastropods, or snails, are in number of species the most abundantly represented group in the Maryland Miocene faunas. They are not, however, equally distributed throughout the three formations, but apparently preferred the more solid muddy silts and sands of the Calvert and St. Marys formations to the cleaner and presumably less stable sea floor represented by the Choptank sands.

The snail carries his shell with the apertural part forward and the spire pointed posteriorly, so that strictly speaking the tip of the *spire* is the posterior extremity of the shell and the "base" of the *aperture* is the anterior extremity. These terms are used only in the sense that the basal canal of the aperture, when present, is referred to as the *anterior canal* (Pl. 3, fig. 2), and any canal or notch near the "top" of the aperture is a *posterior canal* or *notch*. Most essential terms are indicated in the figure on Plate 3. The *outer lip* of the aperture is thickened in many species and may bear small teeth, or *denticles*, on its inner side (Pl. 28, fig. 7). Similarly there may be coarse teeth or *plications* on the inner lip (Pl. 27, fig. 4, 5) that are deposited along with the *callus* wash that often covers that lip and submerges the ornamentation so that its roughness does not wear upon the delicate membranes of the snail's body. The last turn of the shell comprises the *body whorl*, the earlier whorls being part of the spire. The line where one whorl comes into contact with an earlier whorl is the *suture*. In the form shown in Plate 3 the whorls simply abut against each other in a *linear suture*, but in some forms the suture may be *channeled* and in others the shell of the later whorl may ride up on and be *appressed* against the shell of the preceding whorl (Pl. 27, fig. 4, 5).

Genus FISSURIDEA

The genus *Fissuridea* includes the Maryland Miocene species that have a low conical shell with an ovate aperture and a small hole at the apex. At least four species are found: *F. marylandica* (Conrad) (Pl. 21, fig. 6, 7), relatively abundant in the Calvert formation and rare in the lower part of the Choptank; *F. griscomi* (Conrad) (Pl. 21, fig. 4, 5), which is rare in the Calvert and relatively common in the Choptank; *F. nassula* (Conrad), relatively rare and ap-

parently known only from the Choptank formation; and *F. alticosta* (Conrad) known in Maryland only from the St. Marys formation. Three of the species are ornamented by relatively strong primary ribs with finer, or secondary, ribs in the spaces between them. All of the ribs are relatively broad on *F. griscomi*, and there are usually but three secondary ribs between each pair of primaries. The ribbing in *F. marylandica* and *F. alticosta* is finer, with thinner primary ribs and with four to five secondaries between the primaries in *F. alticosta*. In *F. marylandica* there is a fairly strong secondary between each primary and a weaker, or tertiary rib, on each side of the secondary. Differences in shape between *F. marylandica* and *F. griscomi* are shown in the figures. *F. alticosta* is much shorter in proportion to its width, being oval in outline when viewed from above, and has a much higher apex than either of the other two species. *F. nassula* differs from all three in having all the ribbing of approximately the same strength.

Genus TEINOSTOMA

The minute gastropods illustrated under the generic name *Teinostoma* in the Maryland Geological Survey's Miocene volume are now referred to several genera. True *Teinostoma* is represented by *T. nanum* (Lea) (Pl. 21, fig. 17, 18, 19) of the St. Marys formation. An even lower-spired and flatter species, *T. calvertense* Martin, occurs in the Calvert and lower Choptank formations. Both are distinguished by a large callus filling in the basal part of the shell.

Genus VITRINELLA

This minute form may be easily separated from *Teinostoma* by the open base of the shell with the earlier whorls visible inside the spire. *V. lipara* (Lea) (Pl. 21, fig. 20, 21, 22), present in all three formations, is the only species of the genus that is at all common in the Maryland faunas.

Genus CALLIOSTOMA

The turbinate or top-shaped shells of the genus *Calliostoma* are perhaps most easily recognized by the brilliant pearly luster of the inside of the aperture and of the inner layers of the shell when the outer layer is worn off. A considerable number of species (the Maryland Miocene volume describes thirteen) occur in the three fossiliferous formations. In the typical form of the genus the base of the whorl is solid with the central, or umbilical, opening filled with the callus of the inner lip of the shell. Perhaps the most abundantly represented species is *Calliostoma philanthropus* (Conrad) (Pl. 21, fig. 16), a relatively high spired form with moderately strong spiral ribs on the base and angle of the body whorl. The strength of the ribbing on the whorl slope varies from forms with about three strongly beaded spiral ribs, as shown in the illustration, to those with a strong subsutural beaded spiral but with the lower

pair weakly developed. A species of similar shape and with similar basal ornamentation is *C. virginicum* (Conrad) of the St. Marys formation. It usually has but two non-beaded spirals on the side of the whorl, the lower being much more strongly developed than the upper. Another similar species, *C. distans* (Conrad), also from the St. Marys formation, has five or six close-set spirals on the whorl slope.

Calliostoma aphelium Dall (Pl. 21, fig. 11, 12), an entirely smooth form with a color ornamentation of white spots just below the sutures that is often still observable on the fossils, is common in the lower fossil bed of the Choptank formation, but is present also, though rare, in the Calvert formation. The most abundant species of the genus in the St. Marys formation is *C.* (*Leiotrochus*) *humile* (Conrad) (Pl. 21, fig. 8, 9, 10). This finely ribbed species has an open umbilicus at the center of the shell base. Another related form is *C.* (*Leiotrochus*) *reclusa* (Conrad) also in the St. Marys fauna, which is distinguished by having shouldered whorls that have a beaded spiral at the outer edge of the shoulder.

Genus ARCHITECTONICA

Superficially similar to *Calliostoma* (*Leiotrochus*), but differing in lacking the pearly interior, is the so-called architect's shell, *Architectonica*, represented in the fauna of the lower fossiliferous horizon (zone 10) of the Calvert formation by *A. trilineata* (Conrad) (Pl. 21, fig. 13, 14, 15). The strong beaded spiral at the inner edge of the whorl which coils up into the open basal umbilicus is a distinctive characteristic.

Genus LEMINTINA

The worm-like tubes of the genus *Lemintina* are distinctly un-snail like in superficial appearance. Well preserved specimens show, however, that their early growth is marked by a high-spired coiled shell that closely resembles the early whorls of a *Turritella*. Two species occur in the Maryland Miocene, both in all three formations. *L. granifera* (Say) (Pl. 21, fig. 23) is ornamented by rows of small granular ribs, whereas *L. virginica* (Conrad) (Pl. 21, fig. 24) with less intricately coiled tubes lacks such ribbing.

Genus TURRITELLA

The genus *Turritella* is the most abundantly represented gastropod genus in the Maryland Miocene faunas. Representatives of eight species and varieties have been found in the lower fossiliferous zone of the Calvert formation. Five are varieties of the very variable species *T. variabilis* Conrad. The typical form (Pl. 22, fig. 2) is confined to the St. Marys fauna in Maryland. The variety *cumberlandia* Conrad (Pl. 22, fig. 3, 4) is wide-spread in both the Calvert and Choptank formations. The variety *exaltata* Conrad, confined to the Calvert

formation, has a single strong rib near the base of the whorls, and the side above it is concave to the suture. An unnamed variety has flat-sided whorls that lack ornamentation, and another has strongly convex whorls with the ornamentation very feeble. Both these last varieties are confined to the lower fossiliferous horizon of the Calvert formation. Perhaps most abundant in this lower Calvert horizon and apparently confined to it, is *T. indentata* Conrad (Pl. 22, fig. 1) with flat-sided whorls and deeply indented sutures on the latter part of the shell. There are two strong ribs on the base of the body whorl, the upper one forms the angulation immediately above the sutures and the lower is submerged on the upper whorls of the shell. *T. aequistriata* Conrad (Pl. 22, fig. 7) is confined to the Calvert formation, but is a relatively rare species. *Turritella plebia* Say (Pl. 22, fig. 5, 6, 8) is the most abundantly represented species of the genus in the faunas of all three formations. Typically it is a relatively small form with more or less convex whorls that are marked with fine uniform, or uniformly alternating, spiral ribs. This (Pl. 22, fig. 6) is the only form found in the St. Marys formation. There is, however, some variation in the forms found in the Choptank and Calvert faunas. One variety (Pl. 22, fig. 5) has flat-sided whorls with very uniform closely set ribbing; another (Pl. 22, fig. 8) has somewhat flat-sided whorls with deep sutures. This latter form is the most abundant representative of the species in the Calvert fauna, but occurs also in the Choptank formation.

Genus EPITONIUM

Specimens of the genus *Epitonium* are characterized by axial "varices" that are the outwardly reflexed lips of the aperture at earlier stages of the growth of the shell. They are relatively small in size. The species is never abundant in the Maryland Miocene, but is sufficiently common that careful collecting will usually yield one or more specimens at any locality in the richly fossiliferous horizons of the three formations. The form most usually found is *E.* (*Clathrus*) *sayanum* (Dall) (Pl. 22, fig. 9), present in all three formations. It is ornamented with 7 to 11, usually 9, varices that are continuous, one above the other, up the spire of the shell. A slightly smaller form, *E.* (*Clathrus*) *marylandica* Martin (Pl. 22, fig. 11) has 12 to 18, usually about 15, varices on the body whorl. It occurs in the Calvert and Choptank faunas, but seems to be more abundant in the Calvert. Both of these forms lack spiral ribbing on the whorls, but *E.* (*Opalia*) *reticulata* Martin has relatively slender small varices and about six revolving spiral ribs of almost equal strength that serve to give a reticulated appearance to the whole shell surface. It is rare in the Calvert formation. Two species occur that are much broader in proportion to the height of the whorl than are any of the preceding. *E.* (*Sthenorhytis*) *pachypleura* (Conrad) (Pl. 22, fig. 10), present in all formations, may be distinguished from the larger *E.* (*Sthenorhytis*) *expansa* (Conrad) of the St. Marys and Choptank

formations by the presence of a single rather strong spiral that extends from the upper (posterior) end of the aperture around the body whorl to the last varix.

Genera CERITHIOPSIS and SEILA

These are two genera of relatively small turrited shells that are marked by a distinct notch at the base of the aperture adjacent to the inner lip. *Cerithiopsis calvertensis* Martin (Pl. 22, fig. 12) is a species of the lower fossiliferous horizon of the Calvert formation that is ornamented by four relatively strong spiral ribs, the upper three exposed on the spire whorls, and by about thirty longitudinal or axial ribs that give the spirals a beaded appearance where the two kinds of ribs cross each other. *Seila adamsi* (H. C. Lea) (Pl. 22, fig. 13) has the same number of spiral ribs as the *Cerithiopsis* but lacks the axial ribbing, so that the spirals are regular and non-beaded in appearance. It is a rare species in the Calvert and Choptank faunas.

Genus CALYPTRAEA

Specimens of the genus *Calyptraea* are characterized by a broadly flattened conically spired shell with an exceedingly wide basal aperture and by a small diaphragm inside the shell above the base that covers about one-third of the area (Pl. 22, fig. 17). The animal lives inside the shell and uses its broad foot to hold itself to some surface, often that of a pelecypod valve, on which it browses on algae and other plant materials. *C. aperta* (Solander) (Pl. 22, fig. 16), though still living in the Atlantic Ocean, is found only in the Calvert fauna. Its rounded whorls are ornamented by small irregular spines. *C. centralis* (Conrad) (Pl. 22, fig. 14, 15, 17) of the St. Marys fauna has flat-sided whorls and lacks the spines.

Genus CRUCIBULUM

This genus, sometimes called the "cup and saucer" shell, has a flattened cone-shaped shell, widely open below, as in *Calyptraea*, but instead of a diaphragm inside the shell it has a smaller conical structure that is attached along one wall and has its apex immediately below the apex of the shell itself (Pl. 23, fig. 2, 4, 5). The largest species in the Maryland faunas is *C. pileolum* (H. C. Lea) (Pl. 23, fig. 1, 2) of the St. Marys formation, which is easily recognized by the strong ribbing radiating from the apex of the shell. *C. costatum* (Say) (Pl. 23, fig. 5, 6) is, despite its name, an obscurely ribbed form. It occurs in the Calvert and Choptank formations and is often considered to be the ancestor of *C. pileolum*. *C. multilineatum* (Conrad) (Pl. 23, fig. 3, 4), common in the Choptank but rare in the Calvert fauna, has numerous fine and irregular radial ribs.

Genus CREPIDULA

The "slipper shell," *Crepidula*, is represented in all three formations by two species that are yet living in the waters of Chesapeake Bay and the Atlantic Ocean. *C. plana* Say (Pl. 23, fig. 7, 8) is, as its name indicates, a very flat shell. The apex of the shell lies at the upper margin, and the apical half of the interior of the shell contains a platform-like diaphragm with a sinuous outer margin. The living animal is often attached to the inside of the dead shells of larger species of gastropods, obtaining living room by adapting its body to the convexity of the shell surface to which it is attached. *C. fornicata* (Linnaeus) (Pl. 23, figs. 9, 10) has a much more convex shell with a distinct apex separated from the actual margin of the aperture.

Genus XENOPHORA

The name of this genus means "strange bearer" and refers to the fact that the animal cements to the outside of its shell a camouflage of pieces of stone or of broken bits of shell. *X. conchyliophora* (Born) (Pl. 23, fig. 14, 15, 16) commonly uses pieces of broken shell. These give the form a very rough and unusual external appearance. It is most often found in the lower fossiliferous beds of the Calvert formation, but a few specimens have been found in the lower fossiliferous bed of the Choptank formation. The species is still living in the warmer waters of the Atlantic Ocean.

Family NATICIDAE

The species of the family Naticidae are carnivorous animals that prey upon other mollusks. They seek out another shell and, using a peculiar tooth ribbon that is common to almost all snails, drill a small round hole through it and suck out the juices of the animal inside. These holes, usually about one-eigth inch in diameter, are often seen in the shells of the pelecypods and gastropods in the Maryland Miocene faunas and are mute reminders of the unpleasant death suffered by the animal that formed the shell.

Three species, referred to two genera of this family, occur. *Polinices duplicatus* (Say) (Pl. 23, fig. 13) is relatively uncommon in the Calvert formation but is often found in the Choptank and St. Marys. It is distinguished by its relatively broad shell with a heavy callus on the inner lip, a tongue of which extends out to completely cover the basal umbilicus of the shell. *Lunatia heros* (Say) (Pl. 24, figs. 1, 2) has a larger shell with a thinner callus on the inner lip that lacks all trace of the tongue-shaped process that covers the umbilicus in *P. duplicatus*. The umbilicus in *L. heros* is open. *Lunatia hemicrypta* (Gabb) (Pl. 24, fig. 3) is a smaller shell that is higher than it is wide, differing in shape from both the other forms. It is found in the Calvert and Choptank formations only, whereas *L. heros* is a common species in all three formations. Both *Poli-*

nices duplicatus and *Lunatia heros* occur in the present faunas of the Atlantic Ocean.

Genus SINUM

Allied to the naticidae is the genus *Sinum* whose thin spirally ornamented shells are represented in all three formations by *S. fragile* (Conrad) (Pl. 23, fig. 11, 12). The animal of *Sinum* grew so large that it could not retreat into the shell which became partially submerged into the body and was only a remanent of a formerly useful structure.

Genus PHALIUM

The "helmet shells" are represented in the fauna of the St. Marys formation by the rare species *Phalium* (*Scmicassis*) *caelata* (Conrad) (Pl. 24, fig. 4), a very distinctive form that cannot be confused with any other species in the Miocene faunas.

Genus FICUS

The "fig shells" are represented in the fauna of the lower fossiliferous horizon of the Calvert formation by the rare species "*Ficus*" *harrisi* (Martin) (Pl. 24, fig. 5), a thin-shelled species with fine incised spiral lines ornamenting the rather bulbous body whorl.

Genus ECPHORA

The large shells of the genus *Ecphora* constitute one of the most unusual and diagnostic types of fossil in the Maryland Miocene fauna. One of these shells (Pl. 25, fig. 1) furnished the material for the first illustration of a fossil from North America by Martin Lister in 1685, and these shells are still the most sought for prizes by the collectors of Maryland fossils. The form figured by Lister appears to be that now known as *E. quadricostata* (Say) (Pl. 25, fig. 2), a species that is distinguished by the four strong "T"-shaped ribs. It is the common and characteristic species of the St. Marys fauna, but occasional specimens in the Choptank fauna cannot be distinguished from it. More typical of the Choptank fauna is *E. quadricostata* variety *umbilicata* (Wagner) (Pl. 25, fig. 3), in which the four ribs lack the "T"-shaped outer expansion of the typical St. Marys form and the umbilicus is rather widely flaring. This variety is present, though not common, in the Calvert formation where the genus is represented by *E. tricostata* Martin (Pl. 25, fig. 4) with three strong ribs and a weaker fourth one at the base of the series.

These three species appear to represent an evolutionary sequence in which the three strong ribs of *E. tricostata*, which is common in the Calvert and rare in the lower part of the Choptank formation, are retained and a fourth strong rib added by the increase in strength of the basal rib to form the typical

E. quadricostata umbilicata, rare in the Calvert and common in the Choptank fauna. The ribs assume a "T"-shaped form in the St. Marys fauna. The specimens found to the south in Virginia and North Carolina lack this type of ribbing even though they are otherwise typical of *E. quadricostata* and come from strata that are contemporaneous with those of the St. Marys formation.

A noteworthy feature of the specimens of the genus *Ecphora* is that the shells retain a brown color even when all other fossils in the fauna have assumed a chalky white tint.

Genus CORALLIOPHILA

A single species in the fauna of the St. Marys formation is doubtfully referred to the genus *Coralliophila*, a group whose present-day representatives live largely on and about coral reefs. This species, *C. cumberlandiana* (Gabb) (Pl. 24, fig. 11), has a short anterior canal and a thickened outer lip with 8 to 11 elongated denticles on its inner side. The surface of the shell has about eight thickened longitudinal ribs that are crossed by 18 to 20 spirals.

Genus UROSALPINX

Rather similar in appearance to *Coralliophila cumberlandiana*, but proportionately higher spired and less obese, is *Urosalpinx rusticus* (Conrad) (Pl. 24, fig. 12), also found in the St. Marys formation. The axial ribs are less heavy and slightly more numerous, and there are but five or six primary spirals crossing them.

Genus TROPHON

Trophon tetricus (Conrad) (Pl. 24, fig. 7, 8), a St. Marys species, is ornamented by numerous axial "ribs" that are actually varices from former outer lips of the aperture. They rise at the shoulder into short thin spines, and the surface of the whorl, including the varices, is ornamented by three or more rounded spiral ribs. The shell is seldom found perfect as the spines on the shoulder and the long anterior canal are very easily broken. Another small species, "*Trophon*" *chesapeakanus* Martin (Pl. 24, fig. 10), is abundant in the St. Marys formation at St. Marys River. It lacks the typical varices of the true *Trophon*, having about sixteen weak axial nodes on the center of the whorl and there is no spiral ornamentation. The correct generic assignment of this species has not been determined.

Genus TYPHIS

The genus *Typhis* includes species that have a superficial resemblance to those of *Trophon* but which differ in that the varices, instead of developing spines on the shoulder, fold over to form a small tube. The anterior canal likewise is closed to form a tube by the growing together of the inner and outer

lips of the basal part of the aperture. A single species of this genus, *Typhis acuticosta* (Conrad) (Pl. 24, fig. 6, 9), is rare, but present in all three formations.

Genus MITRELLA

The genus *Mitrella*, formerly called *Columbella*, consists of small relatively smooth high-spired shells with an aperture having a short anterior canal. Two species occur in the Maryland Miocene faunas: *Mitrella communis* (Conrad) (Pl. 24, fig. 15), present but relatively rare in the Calvert and Choptank formations and moderately common in the St. Marys, with 8 to 12 spiral lines on the body whorl that are so fine as to be visible only under magnification; and *M. calvertensis* (Martin), rare in the Calvert and Choptank formations, in which the body whorl is ornamented by about 24 narrow revolving grooves that are visible without magnification.

Genus BULLIOPSIS

Representatives of the genus *Bulliopsis* are moderately common in and wholly distinctive of the St. Marys formation. Three species have been described: *Bulliopsis quadrata* (Conrad) (Pl. 24, fig. 13); *B. marylandica* Conrad (Pl. 24, fig. 14); and *B. integra* (Conrad). The differences between the first two species are clear from the illustrations. *B. integra* most closely resembles *B. marylandica* in lacking the shoulder on the whorl but differs in having a shorter more inflated body whorl and a proportionately higher spire, and the callus on the inner lip is not as thickly developed.

Genus NASSARIUS

Species of the genus *Nassarius* are carrion feeders. They may be collected in the warmer seas of our present oceans by placing a piece of decaying fish or other bait in a tidal pool at low tide and gathering in the animals as they come from all directions for the food. The aperture (Pl. 24, fig. 16) is quite similar to that of *Bulliopsis*, from which the genus differs in possessing both axial and spiral ornamentation. Specimens of *N. peralta* (Conrad) (Pl. 24, fig. 17), common in the St. Marys formation, have 20 to 25 axial ribs that are constricted just below the suture to form a sort of sutural bead and which are crossed, near the base of the whorl, by an ornamentation of spiral lines. On the sides of the whorl the spirals appear only in the inter-axial areas. *Nassarius marylandica* (Conrad), also in the St. Marys fauna, is generally similar but has only 9 to 15 axial ribs on the body whorl and they lack the subsutural constriction, being continuous and uninterrupted to the suture. *N. peraltoides* (Conrad) (Pl. 24, fig. 16), present in the Calvert and Choptank faunas, is when full grown only about half the size of *N. peralta* which it resembles except that the spiral lines on the base of the whorl do not cross the axial ribs. *N. trivittatoides* (Whitfield),

rare in the Calvert and Choptank formations, has axial and spiral ribbing of approximately equal strength, giving the surface a reticulated or net-like appearance where the two types cross. It is a very small form.

Genus PTYCHOSALPINX

This genus of spirally ornamented shells that have a moderately short anterior canal and only a very thin, if any, callus wash on the inner lip is represented in the St. Marys formation by *Ptychosalpinx altilis* (Conrad) (Pl. 26, fig. 8) and in the Calvert formation by *P. lienosa* (Conrad). This latter is half again as large as *altilis* and has the primary spiral ribs more distant from each other with secondary and even tertiary spirals in the spaces between them.

Genus SIPHONALIA

The large shells of *Siphonalia* are among the more easily recognized fossils in the Miocene gastropod faunas. *S. devexa* (Conrad) (Pl. 25, figs. 5, 6), with abundant relatively fine spiral ribs and low distant swollen axial ribs, occurs in the Calvert and Choptank faunas. The more coarsely spirally ribbed *S. marylandica* Martin (Pl. 26, fig. 1), lacking axials on the body whorl, is a species of the St. Marys fauna.

Genus BUCCINOFUSUS

One of the largest gastropods in the fauna of the St. Marys formation, *Buccinofusus parilis* (Conrad) (Pl. 26, fig. 3), somewhat resembles *Siphonalia marylandica*. It differs in its proportionately shorter anterior canal, its distant sharp primary spiral ribs with three to four fine secondary spirals in the interspaces between adjacent primaries, and in the distant rounded axial ribs that are present on all whorls including the body whorl. This is a relatively common species in all localities along the St. Marys River.

Genus LIROSOMA

The biconic short-spired shell of *Lirosoma sulcosa* (Conrad) (Pl. 26, fig. 2) occurs in the St. Marys formation. It is a most distinctive species that is not readily mistaken for any other form in that fauna.

Genus BUSYCON

The large short-spired shells of *Busycon coronatum* (Conrad) (Pl. 27, fig. 1; also Pl. 3, fig. 2) are common in the St. Marys fauna associated with the variety *rugosum* (Conrad) (Pl. 27, fig. 2) which differs in having coarser spiral ornamentation and more numerous and heavier elongated nodes on the shoulder of the whorl. This variety occurs in both the Calvert and the Choptank formations, whereas the typical *coronatum* seems to be confined to the St. Marys formation.

Associated with these forms are species with more sloping shoulders and hence with a relatively higher spire. These are usually not as large as *B. coronatum* and the variety *rugosum*, but they seem to be equally as well referred to the genus *Busycon*. In the Calvert and Choptank faunas this group is represented by a form that seems to be but a variety of a species that is abundant in the Oligocene faunas of the Gulf Coastal area. This is, therefore, here referred to *Busycon spiniger* (Conrad) as an unnamed variety (Pl. 26, fig. 5). In the St. Marys fauna this form is succeeded by *Busycon fusiforme* (Conrad) (Pl. 26, fig. 4, 6) and by *B. tuberculatum* (Conrad) (Pl. 26, fig. 7). The latter most closely resembles *B. spiniger* variety, but differs in its more inflated body whorl, its more numerous elongated nodes on the whorl shoulder, and by the presence of incised spiral lines immediately below these nodes.

Family VOLUTIDAE

The family Volutidae is characterized by having shells with a moderately long aperture that is open anteriorly in an anterior canal and which have two or three folds or plications on the callus of the inner lip. Two genera are present in the Maryland Miocene, one has three plications on the inner lip and the other has two. *Scaphella solitaria* (Conrad) (Pl. 28, fig. 1) is the sole representative of the genus with three columellar plications. It occurs in all three formations, but is rarely found in the Choptank. The figured specimen is from the Calvert formation. It shows the maximum development of ornamentation in the species. Specimens from the St. Marys formation frequently lack the tuberculations on the shoulder of the whorl which consequently loses its angular appearance.

Two species of *Aurinia*, the genus with two columellar plications, occur. *Aurinia typus* (Conrad) (Pl. 27, fig. 4) is found in all three formations. *A. mutabilis* (Conrad) (Pl. 27, fig. 3, 5) is known in Maryland only from the St. Marys fauna. The differences between the two species are well shown in the figures. *Aurinia mutabilis* is unusual among the species in that the columellar plications are often not well developed at the aperture, often (Pl. 27, fig. 3) being apparently entirely absent. However, they are always present deeper within the whorls.

Genus OLIVA

Oliva litterata Lamarck (Pl. 28, fig. 2, 3), the common "olive shell" of the Florida and Gulf Coasts, is occasionally collected from the Maryland Miocene deposits. It has been reported from all three formations, but is always very rare.

Genus CANCELLARIA

Like the members of the family Volutidae, the genus *Cancellaria* is characterized by columellar plications on the inner lip of the aperture. These are

usually three in number, relatively sharp, and often quite low on the lip toward the base of the aperture which has an anterior notch rather than a canal as in the volutids. The outer lip is usually denticulate within. Thirteen species have been reported from the Maryland Miocene faunas; some are very rare and appear to have been based upon a single specimen. Five species are found often enough to merit mention. Most abundant is *Cancellaria alternata* Conrad (Pl. 28, fig. 6, 7), a species present in all three Maryland Miocene formations. This is a very variable species that may be best recognized by the presence of 5 to 7 spiral ribs on the spire whorls and by the relatively strong rounded axial ornamentation. Specimens from the Choptank formation at Jones Wharf are unusual in being shorter, thick-set, and less shouldered or constricted at the suture than are the typical forms shown in the figures. *Cancellaria prunicola* Martin (Pl. 28, fig. 4, 5), rare in the Calvert formation, is a strongly shouldered species with a distinct angulation at the outer edge of the shoulder and with narrower and more distant spiral ribs than has *C. alternata*. *Cancellaria engonata* Conrad of the Calvert fauna and *C. lunata* Conrad of the St. Marys formation have proportionately more elongated shells than either of the two previously mentioned species, and both have the whorls more constricted at the sutures. *C. lunata* has relatively strong and broad spiral ribs. Those of *engonata* are narrower and less prominent.

Cancellaria (*Trigonostoma*) *biplicifera* Conrad (Pl. 28, fig. 8) is the largest of the Cancellarias in the Maryland Miocene, and is also one of the most rare. It has been found in the Calvert and Choptank formations. It may be readily recognized by its large size and by having but two columellar plications on the inner lip of the aperture.

Genus CONUS

The single species of cone shell, *Conus diluvianus* Green (Pl. 28, fig. 13), occurs in the St. Marys formation. It has been found apparently only in St. Marys County (zone 24 of Shattuck), but there it is not a rare species.

Genus TEREBRA

The high-spired shells of the genus *Terebra* may be distinguished by a well-developed anterior notch on the aperture. This is often twisted to the left sufficiently to develop a distinct ridge, or fasciole, at the base of the columellar or inner lip (Pl. 28, fig. 9 to 12). A number of species and varieties have been reported from the three Maryland Miocene marine formations, but only in the fauna of the St. Marys formation are they sufficiently common that one may be certain of finding specimens. Here the most abundant species is *Terebra simplex* Conrad (Pl. 28, fig. 10) and its variety *sublirata* Dall (Pl. 28, fig. 9). Both are essentially unornamented species, although the variety may develop faint longitudinal swellings that extend from suture to suture and may have on the body whorl a suggestion of a constriction of the shell just below the

suture. Such sutural constrictions are often found in this genus, and are characteristically present in *T. curvilirata* Conrad (Pl. 28, fig. 12) which also occurs in the St. Marys formation. This form has about 12 axial ribs per whorl that are constricted below the suture to leave a row of bead-like nodes at their upper ends. It is always a smaller shell than *T. simplex* and its variety. A more strongly ornamented species, *T. curvilineata* Dall variety *whitfieldi* Martin (Pl. 28, fig. 11), occurs in the Calvert fauna. Its very small shell is marked by numerous fine axial ribs that usually extend from suture to suture without constriction. The surface of the shell between the axials is marked by submicroscopic spiral lines. Occasional specimens show a subsutural constriction of the axial ribs, but this is never as strong as in *T. curvilirata.*

The fauna of the Choptank and St. Marys formations contain occasional specimens of *Terebra inornata* Whitfield, a smooth species that may be readily distinguished from *T. simplex* by its smaller size and by the lesser diameter of the shell which has a more slender fragile appearance.

Family TURRIDAE

This is the most difficult and complex of all of the gastropod families, with a large number of genera present. All are characterized by the presence of a notch somewhere on the upper, or posterior, part of the aperture. The position and shape of this notch is shown by the growth lines on the shell even when the aperture itself is broken away. It may be near the suture of the whorl, as shown in the forms on Plate 28, figures 14 to 19, and on Plate 29, figure 1, or it may be lower, at the shoulder of the whorl, as shown on Plate 29, figures 2, 3, and 4.

In the earlier days broad generic assignments were made on the basis of shell form only. Thus in the Maryland Miocene volume, all of those species with a relatively long anterior canal and with the notch on the shoulder of the whorl were referred to "*Pleurotoma*", an invalid generic name; those with the shape of "*Pleurotoma*" but with the notch near the suture were identified as "*Surcula*". If the anterior canal was relatively short, the notch near the suture, and the moderately small shell had relatively strong axial and spiral ribbing, it was identified as a "*Mangilia*". The same type of shell, if the spire was relatively high and the spiral ribbing was reduced or absent, was called a "*Drillia*". More recently students have found that the characters of the initial whorls also were significant in showing the relationships of the species and many more generic names have come into use. No careful study of the Maryland Miocene species has been made, however, and the generic names used here must be considered as provisional and subject to change in the future.

The animals of this family are carnivores and, like all carnivorous types are rarer than are the plant-eating or herbivorous species. Hence, while twenty-six species and varieties of this family have been reported from the three Maryland

Miocene formations, all are rare. In general they are more commonly collected in the St. Marys formation than in the Calvert or Choptank formations.

Six species and varieties were referred to "*Pleurotoma*" in the Maryland Miocene volume. The most common is that here referred to *Hemipleurotoma communis* (Conrad) (Pl. 29, fig. 3, 4), perhaps the most abundant species of the family in the St. Marys fauna. *Gemmula bellacrenata* (Conrad) (Pl. 29, fig. 2), a relatively large form, occurs in the Calvert and the lower part of the Choptank formations. Also in the Calvert formation is *Hemipleurotoma communis* variety *protocommunis* Martin, similar to *communis*, but with much finer spiral ribs and with numerous secondary spirals between the primary ones. "*Pleurotoma*" *choptankensis* Martin, relatively abundant in the Choptank deposits at Jones Wharf, is a slender almost wholly smooth species that is about three-quarters of an inch in length when fully grown.

Six species were referred to "*Surcula*" in the Maryland Miocene volume. One of them is known only from a single imperfect specimen. Two have spiral ornamentation only and three have spiral and axial ribbing. Those with spiral ornamentation include "*Surcula*" *biscatenaria* (Conrad) (Pl. 28, fig. 19), rare in the Choptank and St. Marys formations, that superficially resembles in its ornamentation *Hemipleurotoma communis* (Conrad) (Pl. 29, fig. 3, 4), but which may be separated from that species in that the notch is near the suture rather than on the shoulder and by the longer somewhat twisted anterior canal. *Ancistrosyrinx* (*?*) *rotifera* (Conrad) (Pl. 29, fig. 1), the other spirally ornamented species, can be easily recognized by its striking row of beaded nodes along the angulation of the whorl at the outer edge of the well-developed shoulder. It has been found in the Calvert and the St. Marys faunas. *Leucosyrinx* (*?*) *marylandica* (Conrad) (Pl. 28, fig. 18) of the St. Marys formation is representative of the species with spiral and axial ribbing. "*Surcula*" *rugata* Conrad, reported from the Calvert and Choptank formations, has a shorter anterior canal with about ten relatively strong axial ribs on the upper portion of the body whorl. It is a large species, attaining almost two inches in height. A very similarly appearing form, "*Surcula*" *engonata* Conrad, of the St. Marys formation attains lengths of only about one-half inch and may be distinguished on size alone.

Only one of the five small species that were referred to "*Mangilia*" in the Maryland Miocene volume is at all commonly found. This is "*Mangilia*" *parva* (Conrad) (Pl. 28, fig. 16) which occurs in all three formations but is most often collected from the St. Marys formation.

Nine species and varieties were referred to "*Drillia*". Five have both axial and spiral ribbing and four have axial ribbing or none. Of those with axial and spiral ribbing, "*Drillia*" *incilifera* (Conrad) (Pl. 28, fig. 17) of the St. Marys formation is most abundant, along with a variety *distans* (Conrad) that lacks spiral ornamentation on the upper half of the whorl. The other forms are ex-

ceedingly rare. The species lacking spiral ornamentation are typified by *Cymatosyrinx limatula* (Conrad) (Pl. 28, fig. 14, 15) which is reported from all three Maryland Miocene formations. A variety of this species, *C. limatula* variety *dissimilis* (Conrad), found only in the St. Marys fauna, differs in having the axial ribs almost to wholly obsolete on the later whorls, and the shell is essentially smooth. "*Drillia*" *pseudeburnea* (Whitfield) of the Calvert fauna resembles *Cymatosyrinx limatula*, but differs in having a shorter anterior canal, a more slender shell, and the axial ribs on the spire whorls tending to run from suture to suture, the smooth subsutural band of *limatula* being but little developed.

Family PYRAMIDELLIDAE

Careful washing and screening of the sands and muddy silts of the Miocene formations will often yield a considerable number of minute shells of gastropods. Chief among these are representatives of the several genera of the family Pyramidellidae. The peculiarly ornamented genus *Turbonilla* in which the axial ribs do not extend to the base of the body whorl is most abundantly represented by *T.* (*Pyrigiscus*) *interrupta* (Totten) (Pl. 29, fig. 5, 6), present in all three formations, *T. nivea* (Stimpson), which lacks the spiral lines between the axial ribs, occurs in the Choptank and St. Marys formations. *Odostomia conoidea* (Brocchi) (Pl. 29, fig. 7, 8), representative of a smooth-shelled genus of this family, has been reported from all three formations.

Family EULIMIDAE

Also present among the fine siftings will be representatives of the family Eulimidae, a group composed of high-spired smooth shells. The typical genus *Eulima* is represented by *E. migrans* Conrad (Pl. 29, fig. 9) and by *E. eborea* Conrad (Pl. 29, fig. 10), both of which have been found in all three formations. A third species, *E. laevigata* (H. C. Lea) found only in the St. Marys fauna has a body whorl that is somewhat angulate at the base, approaching the condition found in *Niso lineata* (Conrad) (Pl. 29, fig. 11) of the Calvert fauna, but lacking the characteristic basal perforation of the latter form.

Family TORNATINIDAE

The small "bubble-shells" of *Volvula*, *Cylichna*, and *Cylichnina* will also occur among the siftings. The genus *Volvula* has an aperture, longer than the rest of the shell, that curves over the apex which it covers by its callus. Four varieties of *Volvula iota* (Conrad) have been described. *V. iota* variety *patuxentia* Martin (Pl. 29, fig. 13) has the lowest upper limit to the aperture. It occurs in the Calvert and Choptank formations. The variety *marylandica* Martin, present in all three formations, has the aperture extending well above the apex of the shell. *Cylichna* has a small cylindrical shell in which the aperture does not cover

the apex. The only species that is at all common is *C. calvertensis* Martin (Pl. 29, fig. 12) of the Calvert formation. *Cylichnina conulus* (Deshayes) (Pl. 29, fig. 14) is representative of the genus *Cylichnina*. It is known only from the Calvert formation in Maryland, but is rather widely distributed in the Tertiary formations of Europe. *Cylichnina marylandica* Martin of the St. Marys formation is similar in form but lacks all trace of spiral ornamentation.

Genus ACTAEON

Actaeon shilohensis Whitfield (Pl. 29, fig. 15) is representative of a genus of small shells that is marked by the presence of a single columellar plication near the base of the inner lip of the aperture. It has been reported from the St. Marys and Calvert faunas, but not from the Choptank formation. *A. ovoides* Conrad, present in all three formations, differs mainly in having the revolving ornamentation extending over all parts of the whorl, lacking the smooth subsutural area of *A. shilohensis*.

PHYLUM ECHINODERMATA

Class Echinoidea

The spiny-skinned echinoderms are represented by two species of the class Echinoidea. *Echinocardium orthonotum* (Conrad) (Pl. 30, fig. 1, 2, 3), one of the so-called "heart urchins", is normally an exceedingly rare species in the Choptank formation. A few years ago, however, a colony containing a large number of individuals was found in the lower part of that formation (zone 16) near Scientists Cliffs. It is now in the United States National Museum in Washington, D. C. Subsequently a smaller group was found nearby and the specimens are in the collection of The Johns Hopkins University.

The flat "sand dollars" of *Abertella aberti* (Conrad) (Pl. 30, fig. 4, 5) are common, although usually broken, in thin bands in the Choptank formation, particularly near Jones Wharf on the Patuxent River and just north of Governor Run in the Calvert Cliffs. The layer is hard and perfect specimens are exceedingly difficult to secure and to clean.

In addition to these echinoids, isolated plates of "brittle stars" are occasionally found, but apparently no complete specimen has ever been recovered.

PHYLUM ARTHROPODA

Class Crustacea

Fragmentary crab claws are often found in all three Maryland Miocene formations, but only one or two perfect specimens have been obtained; and they have apparently come from the St. Marys formation.

More common than the fragmentary claws are the shells of *Balanus concavus* Bronn (Pl. 29, fig. 16 to 19), an exceedingly large barnacle, which often occurs in large numbers, especially when attached to the shells of *Chlamys* (*Lyropecten*)

madisonius (Say). An unusually large specimen showing the lateral plates is shown in figure 18, and a view of the interior of one of these in figure 16. The apex of the shell can be closed by smaller plates that are usually separated from the main mass of the shell and are found as isolated plates in the matrix. Examples of two of these apical plates are shown in figures 17 and 19.

PHYLUM COELENTERATA

Class Anthozoa

A number of genera and species of corals are described and illustrated in the Maryland Miocene volume, but most of the specimens came from the Miocene deposits of Virginia. Only one species, *Astrhelia palmata* (Goldfuss) (Pl. 31, fig. 2), is at all common and, except for one specimen of *Septastrea marylandica* (Conrad) from the St. Marys River, is the only species of coral known to occur in the Maryland faunas. It is most abundant in the Choptank formation, but has also been reported from a number of localities within the Calvert formation.

Class Hydrozoa

The encrusting hydrozoans are represented by *Hydractinia multispinosa* Ulrich (Pl. 31, fig. 1) whose finely noded growths are most commonly found covering gastropod shells, especially those of *Polinices*. It is extremely abundant at some localities within the lower fossiliferous horizon of the Calvert formation.

PHYLUM VERMES

Although zoologists recognize several phyla of worm-like animals, the paleontologist who has to work upon their rare hard parts usually lumps them together under the broad phylum name of Vermes. The minute spirally coiled tubes of *Spirorbis calvertensis* Martin (Pl. 31, fig. 3) are occasionally found attached to the shells of various species of mollusks. They seem to be most common in the lower fossiliferous bed of the Calvert formation.

PHYLUM CHORDATA

Subphylum Vertebrata

Vertebrate fossil remains are not rare in the Maryland Miocene. Most commonly found are the teeth of sharks (Pl. 31, fig. 8 to 12). A great variety of sizes and shapes occur in the deposits of all three formations, but they are especially abundant and varied in the Calvert fauna. Only a few of the characteristic shapes have been illustrated. Associated with these are the plate-like pavement teeth of the skates and rays, fishes that feed upon mollusks and use their flat teeth to crush the shells in order to get at the flesh of the animal.

These teeth are usually coal black in color. Plate 31, figures 6 and 7 show a side and a top view of a broken specimen. Other fish remains include rounded biconcave vertebrae (Pl. 31, fig. 4, 5). The specimen figured, from the Calvert formation at Plum Point, has been identified as belonging to the giant shark *Carcharodon*.

Plates of sea turtles have occasionally been found in the Calvert formation, as have also a few isolated teeth of a crocodile. The crocodile-type teeth may be recognized by their lack of the typical root-like structure of the shark teeth. They are usually almost round in section and often are longitudinally striated.

The remains of whales and porpoises are not rare, especially in the Calvert formation, and a few rather complete skeletons have been recovered. Isolated whale vertebrae are often found and may be recognized by their rather porous structure, by the presence of spinal processes upon them, and, usually, by their relatively large size. The terminal disks of the vertebrae are sometimes found separated from the rest of the structure, and because of the radiating ridges on one side may be mistaken for corals by the amateur collector. Their large size, two inches or more in diameter, and their bony composition and structure will serve at once to reveal their true nature.

The complete remains of vertebrate animals in the Maryland Miocene deposits are sufficiently rare and of such scientific importance that anyone finding a skeleton that gives evidence of being at all complete is urged to notify the United States National Museum, in Washington, D. C., in order that it may supervise the collection, preparation and study of the material. The original discoverer will receive full credit from the Museum and will reap much pleasure from the results of his thoughtfulness.

DESCRIPTION OF PLATES

(*A line adjacent to the figure of a fossil indicates the actual size of the specimen*)

PLATE 1

View of Calvert Cliffs on Chesapeake Bay in Calvert County. (*Photo by A. Aubrey Bodine*)

PLATE 2

Geologic Map of Miocene Formations in Southern Maryland (with names of well-known fossil collecting localities along the Calvert Cliffs in Calvert County)

PLATE 3

1. Interior of *Mercenaria plena* (Conrad) (Pl. 15, fig. 3) showing the more common descriptive terms used in the study of the pelecypoda and the usual measurements and orientation of the shell.
2. Apertural view of *Buscyon coronatum* (Conrad) (Pl. 27, fig. 1) showing some of the more important parts of the shell and the usual measurements made in its study.

PLATE 4

Figure

1, 2. *Discinisca lugubris* (Conrad). Choptank formation, Jones Wharf (p. 6).
3. *Nucula taphria* Dall. Duplin formation, Natural Well, North Carolina (p. 8).
4, 5. *Nucula proxima* Say. Choptank formation, Dover Bridge (p. 8).
6, 7. *Nucula sinaria* Dall. St. Marys formation, Little Cove Point (p. 8).
8, 9. *Yoldia laevis* (Say). Choptank formation, Jones Wharf (p. 8).
10. *Nuculana liciata* (Conrad) variety *amydra* (Dall). Calvert formation, Plum Point (p. 8).
11–13. *Nuculana liciata* (Conrad). Calvert formation, Plum Point (p. 8).
14. *Barbatia marylandica* (Conrad). Calvert formation, Plum Point (p. 9).
15, 16. *Glycymeris parilis* (Conrad). Calvert formation, 3 miles south of Fishing Creek (p. 8).

PLATE 5

1, 2. *Anadara subrostrata* (Conrad). Calvert formation, Plum Point (p. 9).
3, 4. *Anadara staminea* (Say). Choptank formation, Flag Pond (p. 9).
5. *Anadara idonea* (Conrad). St. Marys formation, St. Marys River (p. 9).
6, 7. *Anadara arata* (Say). St. Marys formation, St. Marys River (p. 9).
8. *Atrina harrisii* Dall. Choptank formation, Pawpaw Point (p. 9).

PLATE 6

1, 2. *Isognomon maxillata* (Deshayes). (1) Choptank formation, Jones Wharf, (2) Calvert formation, Plum Point (p. 9).
3. *Ostrea percrassa* Conrad. Calvert formation, Magruder Ferry (p. 5, 10).

PLATE 7

1, 2. *Ostrea carolinensis* Conrad. Choptank formation, Governor Run (p. 10).
3, 4. *Pecten* (*Pecten*) *humphreysii* Conrad. Calvert formation, Plum Point (p. 10).
5. *Chlamys* (*Placopecten*) *marylandicus* (Wagner). Choptank formation, Jones Wharf (p. 11).
6. *Chlamys* (*Lyropecten*) *madisonius* (Say). Choptank formation, Flag Pond (p. 10).
7. *Chlamys* (*Lyropecten*) *santamaria* Tucker. St. Marys formation, St. Marys River (p. 11).

PLATE 8

1, 2. *Plicatula densata* Conrad. Calvert formation, Church Hill (p. 11).
3–5. *Anomia aculeata* Gmelin. (3) Calvert formation, Plum Point; (4, 5) Choptank formation, Jones Wharf (p. 12).
6, 7. *Mytilus conradinus* d'Orbigny. Calvert formation, Plum Point (p. 12).
8. *Modiolus ducatelli* Conrad. Choptank formation, Dover Bridge (p. 12).

PLATE 9

1–3. *Astarte cuneiformis* Conrad. Calvert formation, Plum Point (p. 13).
4. *Astarte cuneiformis* Conrad variety *calvertensis* Glenn. Calvert formation, Plum Point (p. 13).
5. *Astarte thomasii* Conrad. Calvert formation, Plum Point (p. 13).
6, 7, 9. *Astarte thisphila* Glenn. Choptank formation, Jones Wharf (p. 13).
8. *Astarte obruta* Conrad. Choptank formation, Dover Bridge (p. 13).
10, 11. *Astarte perplana* Conrad. St. Marys formation, St. Marys River (p. 13).
12. *Thracia conradi* Couthouy. Calvert formation, Plum Point (p. 12).
13, 14. *Pandora crassidens* Conrad. St. Marys formation, St. Marys River (p. 12).

PLATE 10

1. *Eucrassatella melina* (Conrad). Calvert formation, Plum Point (p. 14).
2–4. *Carditamera protracta* (Conrad). Choptank formation, Governor Run (p. 14).
5. *Eucrassatella turgidula* (Conrad). Choptank formation, Jones Wharf (p. 14).
6, 7. *Eucrassatella marylandica* (Conrad). Choptank formation, Jones Wharf (p. 14).
8, 9. *Cardita granulata* (Say). St. Marys formation, St. Marys River (p. 14).

PLATE 11

1–3. *Chama congregata Conrad.* Calvert formation, Church Hill (p. 14).
4, 5. *Saxolucina (Megaxinus) anodonta* (Say). Choptank formation, Jones Wharf (p. 15).
6. *Saxolucina (Megaxinus) foremani* (Conrad). Calvert formation, Plum Point (p. 15).
7, 8. *Lucinoma contracta* (Say). Choptank formation, Pawpaw Point (p. 15).
9, 10. *Parvilucina crenulata* (Conrad). St. Marys formation, Little Cove Point (p. 15).
11, 12. *Diplodonta subvexa* (Conrad). Choptank formation, Flag Pond (p. 15).

PLATE 12

1, 2. *Diplodonta acclinis* (Conrad). Pliocene, Caloosahatchie River, Florida (p. 15).
3, 4. *Aligena aequata* (Conrad). Choptank formation, Jones Wharf (p. 15, 16).
5. *Cerastoderma craticuloide* (Conrad). Calvert formation, Plum Point (p. 16).
6. *Cerastoderma leptopleurum* (Conrad). Calvert formation, Plum Point (p. 16).
7. *Cerastoderma laqueatum* (Conrad). Choptank formation, Jones Wharf (p. 16).
8, 9. *Erycina rickardia* Glenn. Calvert formation, Plum Point (p. 15, 16).
10, 11. *Bornia mactroides* (Conrad). Choptank formation, Dover Bridge (p. 15, 16).
12. *Dicranodesma calvertensis* Glenn. Calvert formation, Plum Point (p. 15).

PLATE 13

1, 2. *Isocardia fraterna* Say variety *marylandica* Schoonover. Choptank formation, Jones Wharf (p. 5, 16).
3, 4. *Dosinia acetabulum* (Conrad). St. Marys formation, St. Marys River (p. 17).

PLATE 14

1, 2. *Mercenaria mercenaria* (Linnaeus). Calvert formation, Plum Point (p. 18).
3. *Mercenaria campechiensis* (Gmelin) variety *capax* (Conrad). St. Marys formation, St. Marys River (p. 18).
4, 5. *Chione parkeria* Glenn. Calvert formation, 2 miles south of Parkers Creek (p. 18).
6, 7. *Melosia staminea* (Conrad). Calvert formation, Plum Point (p. 17).

PLATE 15

1. *Mercenaria rileyi* (Conrad). Calvert formation, Plum Point (p. 18).
2. *Mercenaria campechiensis* (Gmelin) variety *capax* (Conrad). Choptank formation, Cordova (p. 18).
3. *Mercenaria plena* (Conrad). Choptank formation, Governor Run (p. 19).
4, 5, 7. *Chione* (*Lirophora*) *latilirata* (Conrad). (4, 7) Calvert formation, Plum Point; (5) Pliocene, South Carolina (p. 18).
6, 8. *Chione* (*Lirophora*) *alveata* (Conrad). St. Marys formation, St. Marys River (p 18.)

PLATE 16

1, 2. *Macrocallista marylandica* (Conrad). Choptank formation, Jones Wharf (p. 19).
3, 4. *Callocardia subnasuta* (Conrad). St. Marys formation, St. Marys River (p. 19).

PLATE 17

1, 2. *Petricola harrisii* Dall. Choptank formation, Jones Wharf (p. 19).
3. *Petricola* (*Petricolaria*) *calvertensis* Dall. Miocene, Maryland (p. 19).
4. *Tellina* (*Moerella*) *declivis* Conrad. Calvert formation, Plum Point (p. 20).
5. *Tellina* (*Moerella*) *producta* Conrad. St. Marys formation, Little Cove Point (p. 20).
6, 7. *Abra longicalla* (Scacchi). Choptank formation, Jones Wharf (p. 21).
8–10. *Semele subovata* (Say). Choptank formation, Jones Wharf (p. 20).
11–13. *Semele carinata* (Conrad). St. Marys formation, St. Marys River (p. 20).
14, 15. *Apolymetis biplicata* (Conrad). Choptank formation, Jones Wharf (p. 20).

PLATE 18

1, 2. *Gari gubernatoria* (Glenn). Choptank formation, Jones Wharf (p. 21).
3. *Ensis ensiformis* (Conrad). St. Marys formation, St. Marys River (p. 21).
4, 5. *Asaphis centenaria* (Conrad). Choptank formation, Jones Wharf (p. 20, 21)
6, 7. *Spisula* (*Hemimactra*) *subponderosa* (d'Orbigny). St. Marys formation, St. Marys River (× ⅔) (p. 21, 22).
8, 9. *Mactra clathrodon* Lea. St. Marys formation, Little Cove Point (p. 21).

PLATE 19

1. *Spisula* (*Hemimactra*) *marylandica* Dall. Miocene, Maryland (× ¾) (p. 22).
2–4. *Mesodesma mariana* Glenn. St. Marys formation, Little Cove Point (p. 22).
5–7. *Corbula* (*Bicorbula*) *idonea* Conrad. Choptank formation, Jones Wharf (p. 23).
8–10. *Corbula* (*Coryocorbula*) *inaequalis* Say. (8) Calvert formation, Plum Point; (9) Choptank formation, Jones Wharf; (00) Calvert formation, Church Hill (p. 22).
11, 12. *Corbula* (*Varicorbula*) *elevata* Conrad. Calvert formation, Plum Point (p. 22).
13, 14. *Mya* (*Arenomya*) *producta* Conrad. Choptank formation, Jones Wharf (p. 22).

PLATE 20

1. *Panope americana* Conrad. Calvert formation, Plum Point (?) (p. 23).
2. *Panope whitfieldi* Dall. Calvert formation, Plum Point (p. 23).

3. *Panope goldfussii* Wagner. Calvert formation, Plum Point (p. 23).
4, 5. *Hiatella arctica* (Linnaeus). Choptank formation, Jones Wharf (p. 23).

PLATE 21

1. *Dentalium caduloide* Dall. St. Marys formation, St. Marys River (p. 23).
2. *Dentalium attenuatum* Say. St. Marys formation, St. Marys River (p. 23).
3. *Cadulus thallus* (Conrad). Calvert formation, Plum Point (p. 24).
4, 5. *Fissuridea griscomi* (Conrad). Calvert formation, Church Hill (p. 24).
6, 7. *Fissuridea marylandica* (Conrad). Calvert formation, Plum Point (p. 24).
8–10. *Calliostoma (Leiotrochus) humile* (Conrad). St. Marys formation, St. Marys River (p. 26).
11, 12. *Calliostoma aphelium* Dall. Choptank formation, Jones Wharf (p. 26).
13–15. *Architectonica trilineata* (Conrad). Calvert formation, Plum Point (p. 26).
16. *Calliostoma philanthropus* (Conrad). Choptank formation, 2 miles south of Governor Run (p. 25).
17–19. *Teinostoma nanum* (Lea). St. Marys formation, St. Marys River (p. 25).
20–22. *Vitrinella lipara* (Lea). St. Marys formation, St. Marys River (p. 25).
23. *Lemintina granifera* (Say). Calvert formation, Church Hill (p. 26).
24. *Lemintina virginica* (Conrad). Calvert formation, Plum Point (p. 26).

PLATE 22

1. *Turritella indentata* Conrad. Calvert formation, 3 miles south of Chesapeake Beach (p. 27).
2. *Turritella variabilis* Conrad. St. Marys formation, St. Marys River (p. 26).
3, 4. *Turritella variabilis* Conrad variety *cumberlandia* Conrad. Calvert formation, Plum Point (p. 26).
5, 6, 8. *Turritella plebia* Say. (5) Choptank formation, Jones Wharf; (6) St. Marys formation, St. Marys River; (8) Calvert formation, Plum Point (p. 5, 27).
7. *Turritella aequistriata* Conrad. Calvert formation, Church Hill (p. 27).
9. *Epitonium (Clathrus) sayanum* (Dall). St. Marys formation, St. Marys River (p. 27).
10. *Epitonium (Sthenorhytis) pachypleura* (Conrad). Calvert formation, Plum Point (p. 27).
11. *Epitonium (Clathrus) marylandica* (Martin). Choptank formation, Jones Wharf (p. 27).
12. *Cerithiopsis calvertensis* Martin. Calvert formation, Plum Point (p. 28).
13. *Seila adamsi* (H. C. Lea). Calvert formation, Plum Point (p. 28).
14, 15, 17. *Calyptraea centralis* (Conrad). St. Marys formation, St. Marys River (p. 28).
16. *Calyptraea aperta* (Solander). Calvert formation, Plum Point (p. 28).

PLATE 23

1, 2. *Crucibulum pileolum* (H. C. Lea). St. Marys formation, St. Marys River (p. 28).
3, 4. *Crucibulum multilineatum* (Conrad). Choptank formation, Jones Wharf (p. 28).
5, 6. *Crucibulum costatum* (Say). Calvert formation, Plum Point (p. 28).
7, 8. *Crepidula plana* Say. Calvert formation, Plum Point (p. 29).
9, 10. *Crepidula fornicata* (Linnaeus). St. Marys formation, Little Cove Point (p. 29).
11, 12. *Sinum fragile* (Conrad). Calvert formation, Plum Point (p. 30).
13. *Polinices duplicatus* (Say). St. Marys formation, St. Marys River (p. 29).
14–16. *Xenophora conchyliophora* (Born). Calvert formation, Plum Point (p. 29).

PLATE 24

1, 2. *Lunatia heros* (Say). (1) Choptank formation, Jones Wharf; (2) St. Marys formation, St. Marys River (p. 29).
3. *Lunatia hemicrypta* (Gabb). Choptank formation, Jones Wharf (p. 29).
4. *Phalium (Semicassis) caelata* (Conrad). St. Marys formation, St. Marys River (p. 30).

5. *"Ficus" harrisi* (Martin). Calvert formation, Plum Point (p. 30).
6, 9. *Typhis acuticosta* (Conrad). St. Marys Formation, Little Cove Point (p. 32).
7, 8. *Trophon tetricus* (Conrad). St. Marys formation, St. Marys River (p. 31).
10. *"Trophon" chesapeakanus* Martin. St. Marys formation, St. Marys River (p. 31).
11. *Coralliophila cumberlandiana* (Gabb). St. Marys formation, St. Marys River (p. 31).
12. *Urosalpinx rusticus* (Conrad). St. Marys formation, St. Marys River (p. 31).
13. *Bulliopsis quadrata* (Conrad). St. Marys formation, St. Marys River (p. 32).
14. *Bulliopsis marylandica* Conrad. St. Marys formation, St. Marys River (p. 32).
15. *Mitrella communis* (Conrad). St. Marys formation, St. Marys River (p. 32).
16. *Nassarius peraltoides* (Conrad). Choptank formation, Jones Wharf (p. 32).
17. *Nassarius peralta* (Conrad). St. Marys formation, St. Marys River (p. 32).

PLATE 25

1. *Ecphora quadricostata* (Say). Reproduction of figure by Lister (p. 30).
2. *Ecphora quadricostata* (Say). St. Marys formation, St. Marys River (p. 30).
3. *Ecphora quadricostata* (Say) variety *umbilicata* (Wagner). Choptank formation, Jones Wharf (p. 30).
4. *Ecphora quadricostata* (Say) variety *tricostata* Martin. Calvert formation, Plum Point (p. 30).
5, 6. *Siphonalia devexa* (Conrad). Calvert formation, Plum Point (p. 33).

PLATE 26

1. *Siphonalia marylandica* Martin. St. Marys formation, St. Marys River (p. 33).
2. *Lirosoma sulcosa* (Conrad). St. Marys formation, St. Marys River (p. 33).
3. *Buccinofusus parilis* (Conrad). St. Marys formation, St. Marys River (p. 33).
4, 6. *Busycon fusiforme* (Conrad). St. Marys formation, Little Cove Point (p. 34).
5. *Busycon spiniger* (Conrad) variety ?. Choptank formation, Jones Wharf (p. 34).
7. *Busycon tuberculatum* (Conrad). St. Marys formation, St. Marys River (p. 34).
8. *Ptychosalpinx altilis* (Conrad). St. Marys formation, St. Marys River (p. 33).

PLATE 27

1. *Busycon coronatum* (Conrad). St. Marys formation, St. Marys River (p. 33).
2. *Busycon coronatum* (Conrad) variety *rugosum* (Conrad). St. Marys formation, St. Marys River (p. 33).
3, 5. *Aurinia mutabilis* (Conrad). St. Marys formation, St. Marys River (p. 34).
4. *Aurinia typus* (Conrad). Choptank formation, Jones Wharf (p. 34).

PLATE 28

1. *Scaphella solitaria* (Conrad). Calvert formation, Plum Point (p. 34).
2, 3. *Oliva litterata* Lamarck. Calvert formation, Church Hill (p. 34).
4, 5. *Cancellaria prunicola* Martin. Calvert formation, Plum Point (p. 35).
6, 7. *Cancellaria alternata* Conrad. St. Marys formation, St. Marys River (p. 35).
8. *Cancellaria (Trigonostoma) biplicifera* Conrad. Choptank formation, Jones Wharf (p. 35).
9. *Terebra simplex* Conrad, var. *sublirata* Dall. St. Marys formation, St. Marys River (p. 35).
10. *Terebra simplex* Conrad. St. Marys formation, St. Marys River (p. 35).
11. *Terebra curvilineata* Whitfield, variety *whitfieldi* Martin. Calvert formation, Plum Point (p. 36).
12. *Terebra curvilirata* Conrad. St. Marys formation, St. Marys River (p. 36).
13. *Conus diluvianus* Green. St. Marys formation, St. Marys River (p. 35).

14, 15. *Cymatosyrinx limatula* (Conrad). (14) St. Marys formation, St. Marys River; (15) Calvert formation, Plum Point (p. 38).
16. *"Mangilia" parva* (Conrad). St. Marys formation, Little Cove Point (p. 37).
17. *"Drillia" incilifera* (Conrad). St. Marys formation, Little Cove Point (p. 37).
18. *Leucosyrinx* (?) *marylandica* (Conrad). Calvert formation, Plum Point (p. 37).
19. *"Surcula" biscatenaria* (Conrad). St. Marys formation, St. Marys River (p. 37).

PLATE 29

1. *Ancistrosyrinx* (?) *rotifera* (Conrad). St. Marys formation, St. Marys River (p. 37).
2. *Gemmula bellacrenata* (Conrad). Calvert formation, Plum Point (p. 37).
3, 4. *Hemipleurotoma communis* (Conrad). St. Marys formation, Little Cove Point (p. 37).
5, 6. *Turbonilla (Pyrgiscus) interrupta* (Totten). (5) Choptank formation, Greensboro; (6) St. Marys formation, St. Marys River (p. 38).
7, 8. *Odostomia conoidea* (Brocchi). (7) Choptank formation, Jones Wharf; (8) St. Marys formation, St. Marys River (p. 38).
9. *Eulima migrans* Conrad. St. Marys formation, Little Cove Point (p. 38).
10. *Eulima eborea* Conrad. St. Marys formation, St. Marys River (p. 38).
11. *Niso lineata* (Conrad). Calvert formation, Plum Point (p. 38).
12. *Cylichna calvertensis* Martin. Calvert formation, Plum Point (p. 39).
13. *Volvula iota* (Conrad) variety *patuxentia* Martin. Choptank formation, Jones Wharf (p. 38).
14. *Cylichnina conulus* (Deshayes). Calvert formation, Plum Point (p. 39).
15. *Actaeon shilohensis* Whitfield. St. Marys formation, Little Cove Point (p. 39).
16–19. *Balanus concavus* Bronn. Choptank formation, Jones Wharf (p. 11, 39).

PLATE 30

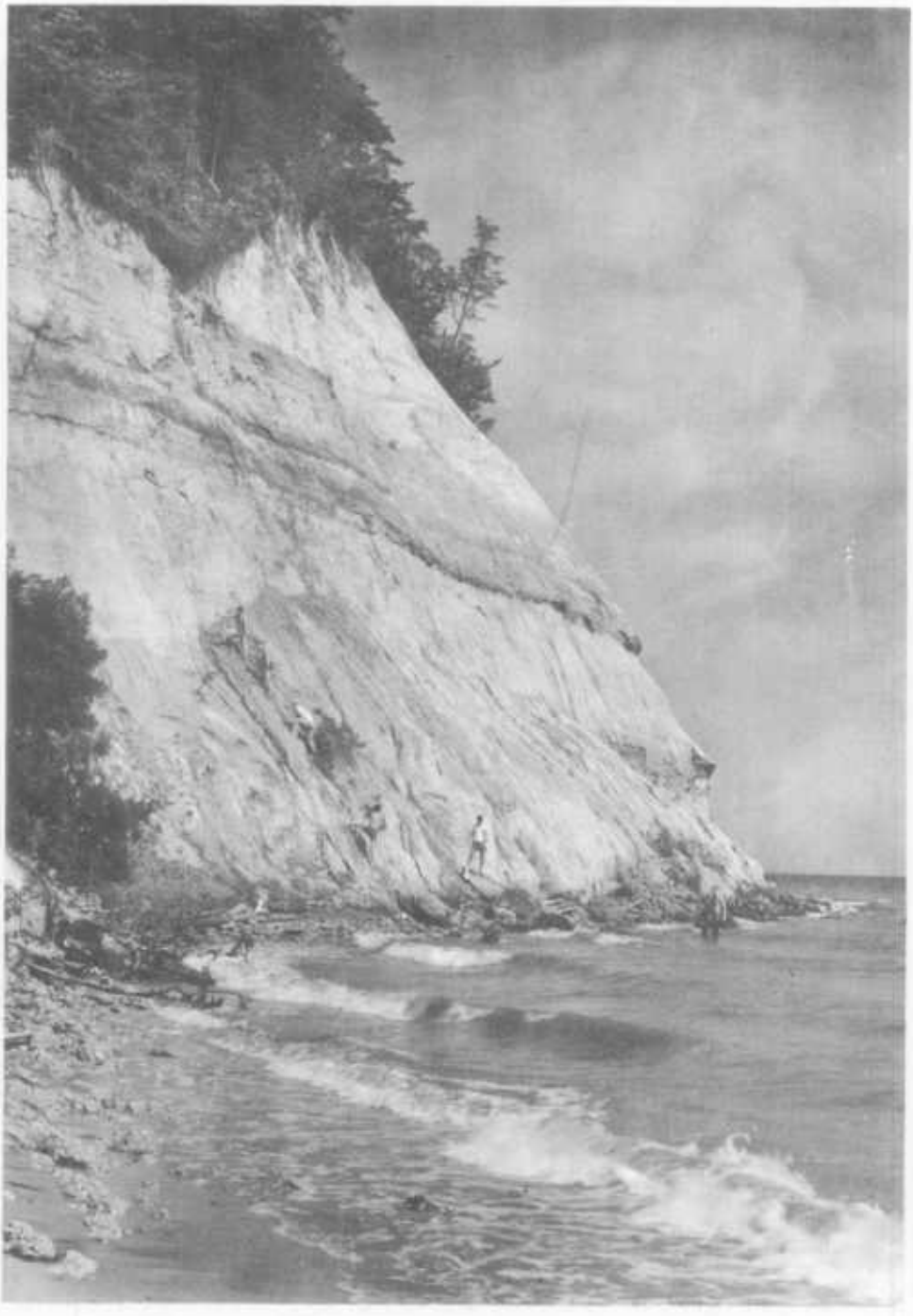
1–3. *Echinocardium orthonotum* (Conrad). Choptank formation, Jones Wharf (p. 39).
4. 5. *Abertella aberti* (Conrad). Choptank formation, Jones Wharf (p. 39).

PLATE 31

1. *Hydractinia multispinosa* Ulrich. Calvert formation, Plum Point (p. 40).
2. *Astrhelia palmata* (Goldfuss). Choptank formation, Talbot County (p. 40).
3. *Spirorbis calvertensis* Martin. Calvert formation, Plum Point (p. 40).
4, 5. Vertebral centrum of *Carcharodon* species. Calvert formation, Plum Point (p. 41).
6, 7. Dental pavement of *Myliobatis pachyodon* Cope. Calvert formation, Charles County near the Patuxent River (p. 41).
8–12. Shark teeth. (8) *Otodus obliquus* Agassiz. Calvert formation, Charles County near the Patuxent River; (9) *Odontaspis cuspidata* (Agassiz). St. Marys formation, St. Marys River; (10) *Galeocerdo aduncus* Agassiz. Calvert formation, Plum Point; (11) *Hemipristis serra* Agassiz. Calvert formation, Popes Creek; (12) *Oxyrhina desori* Agassiz. Calvert formation, Charles County near the Patuxent River (p. 40).

PLATES

PLATE 1



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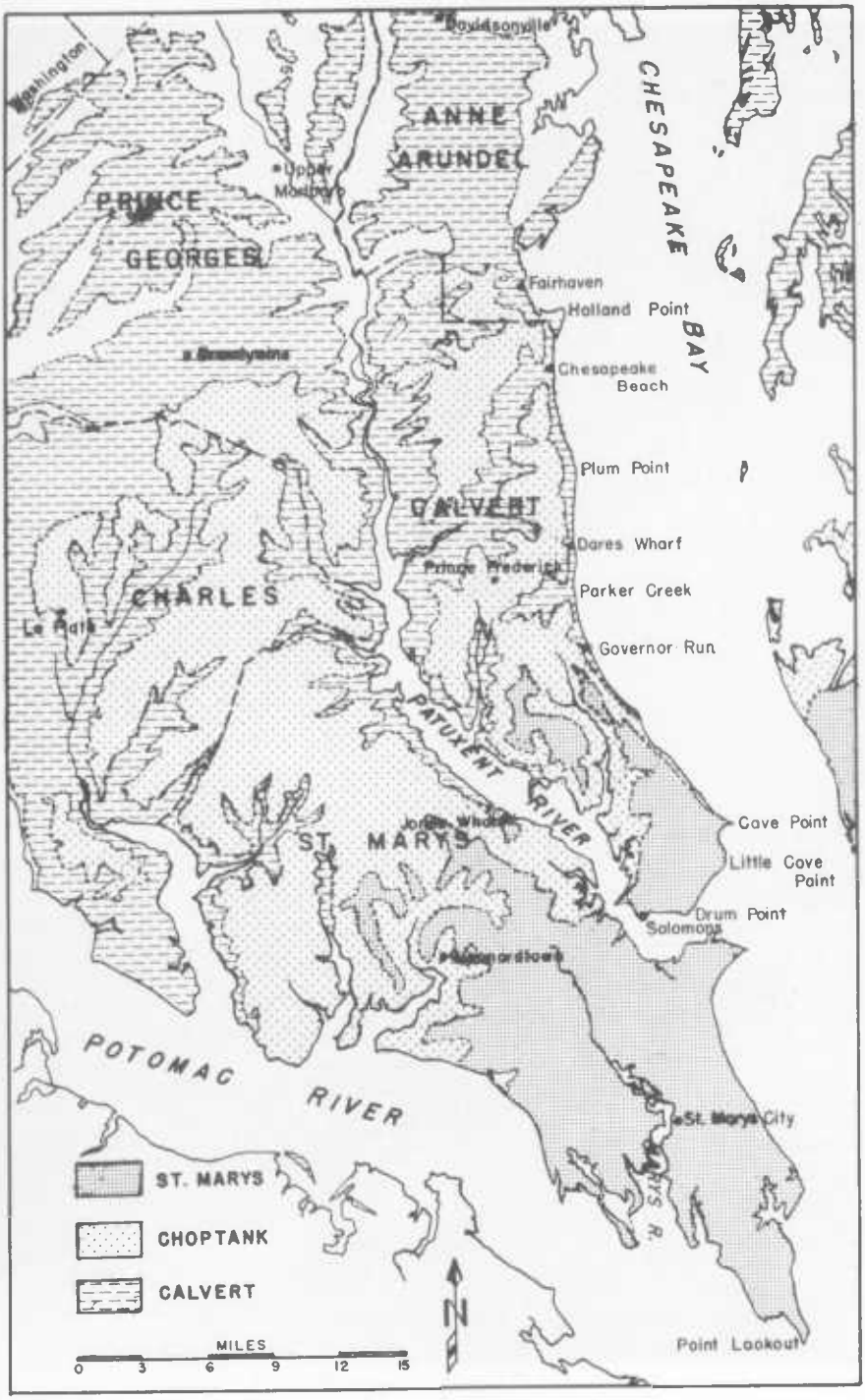
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CALVERT
Dares Wharf
Prince Frederick
Parker Creek
CHARLES
La Plata
Governor Run
PATUXENT RIVER
Jordan Wharf
ST. MARYS
Cave Point
Little Cove Point
Drum Point
Solomons
POTOMAC RIVER
St. Marys City
ST. MARYS
CHOPTANK
CALVERT
MILES
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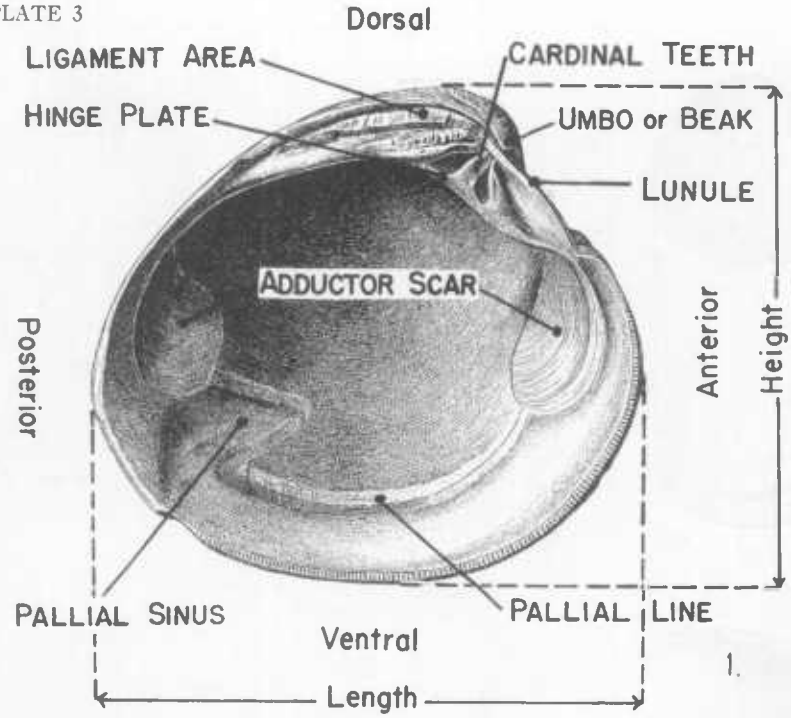
Point Lookout

PLATE 3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CARDINAL TEETH
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Posterior
Anterior
Height
PALLIAL SINUS
PALLIAL LINE
Ventral
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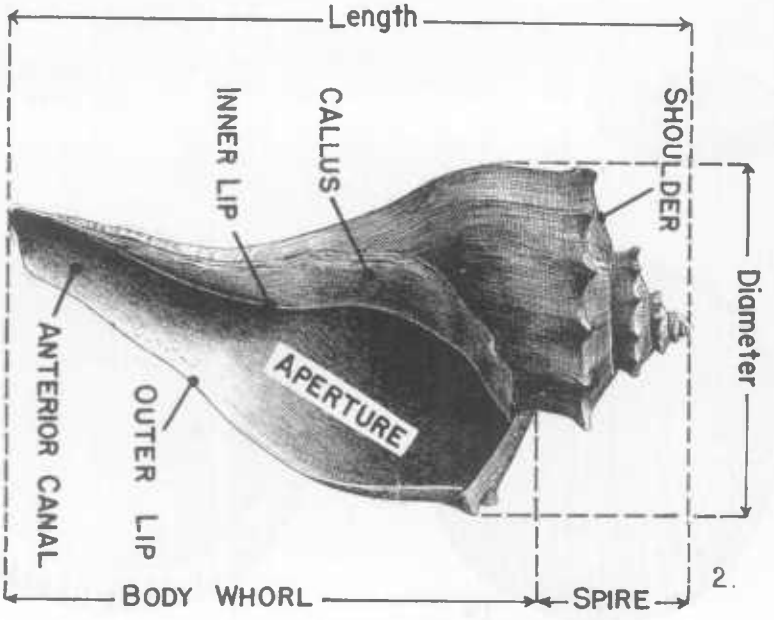
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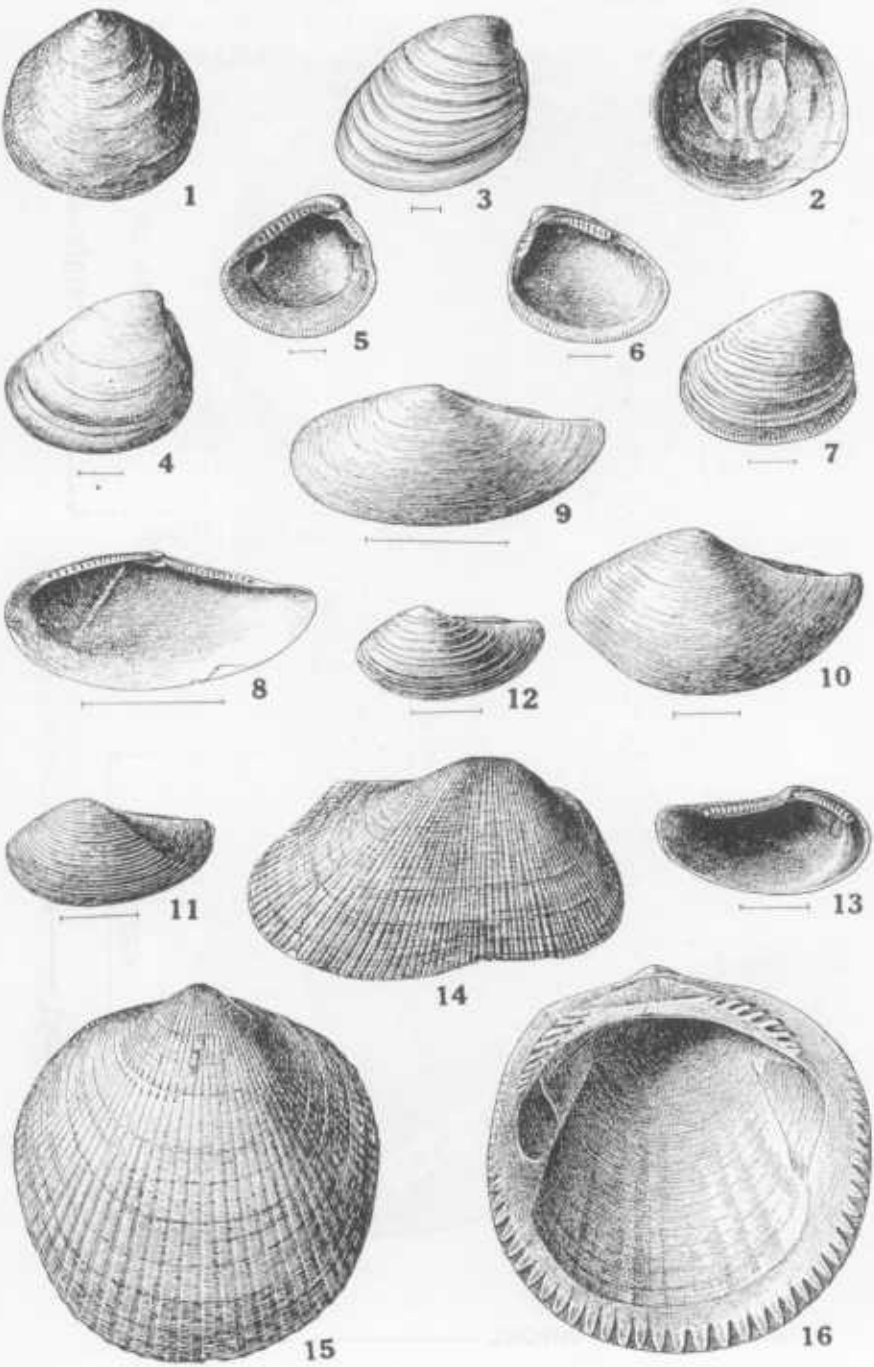
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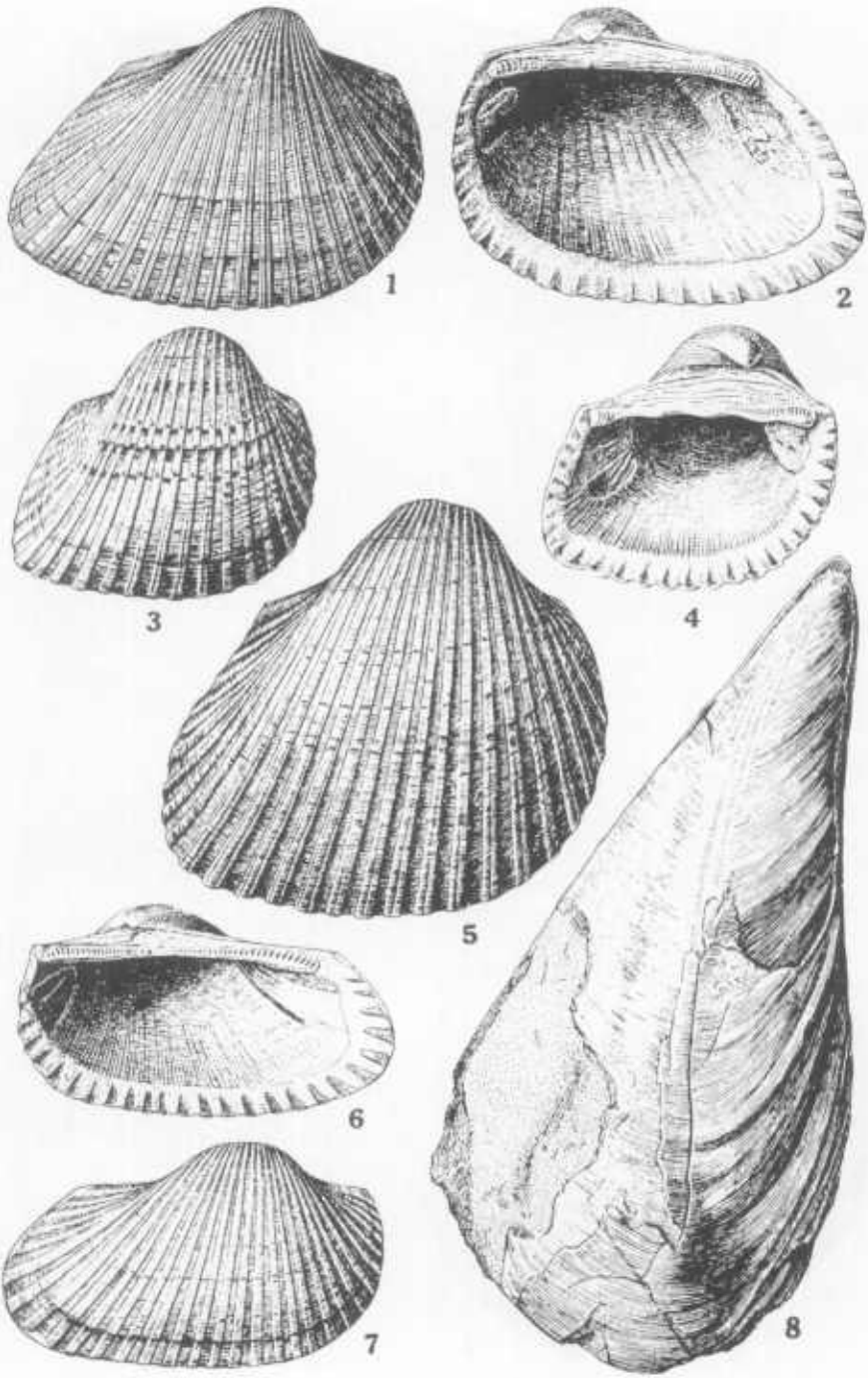
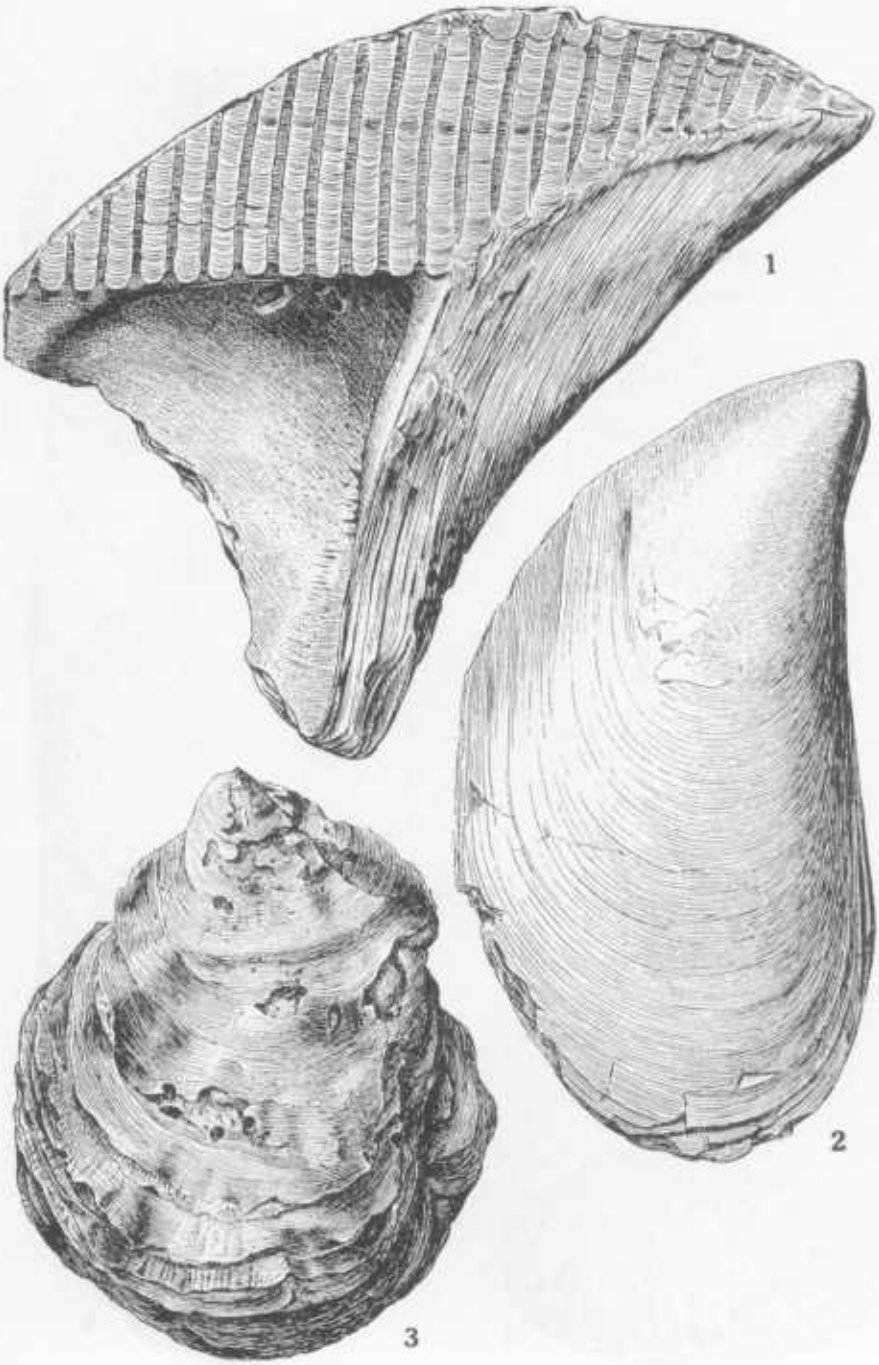
PLATE 5

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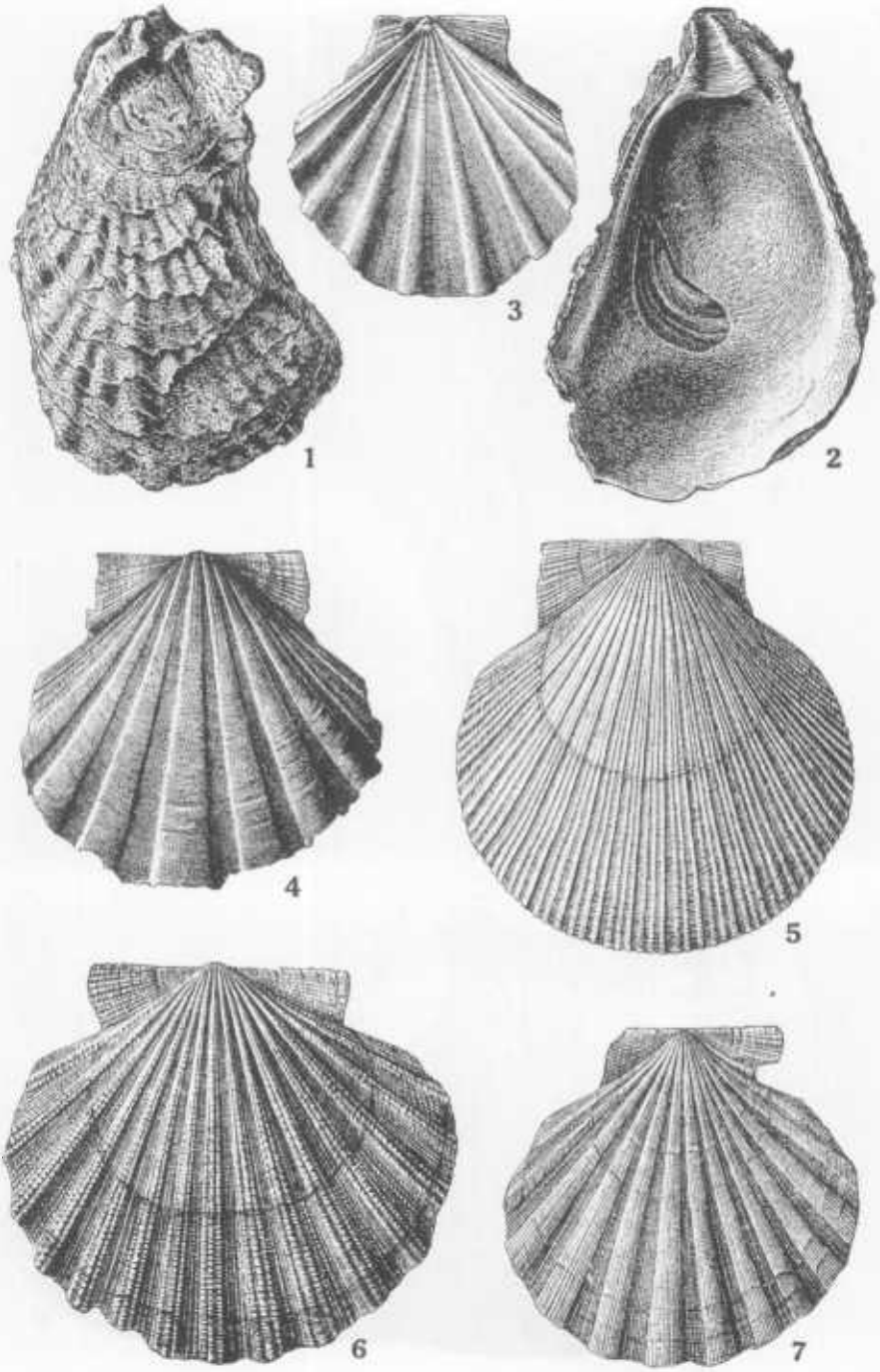

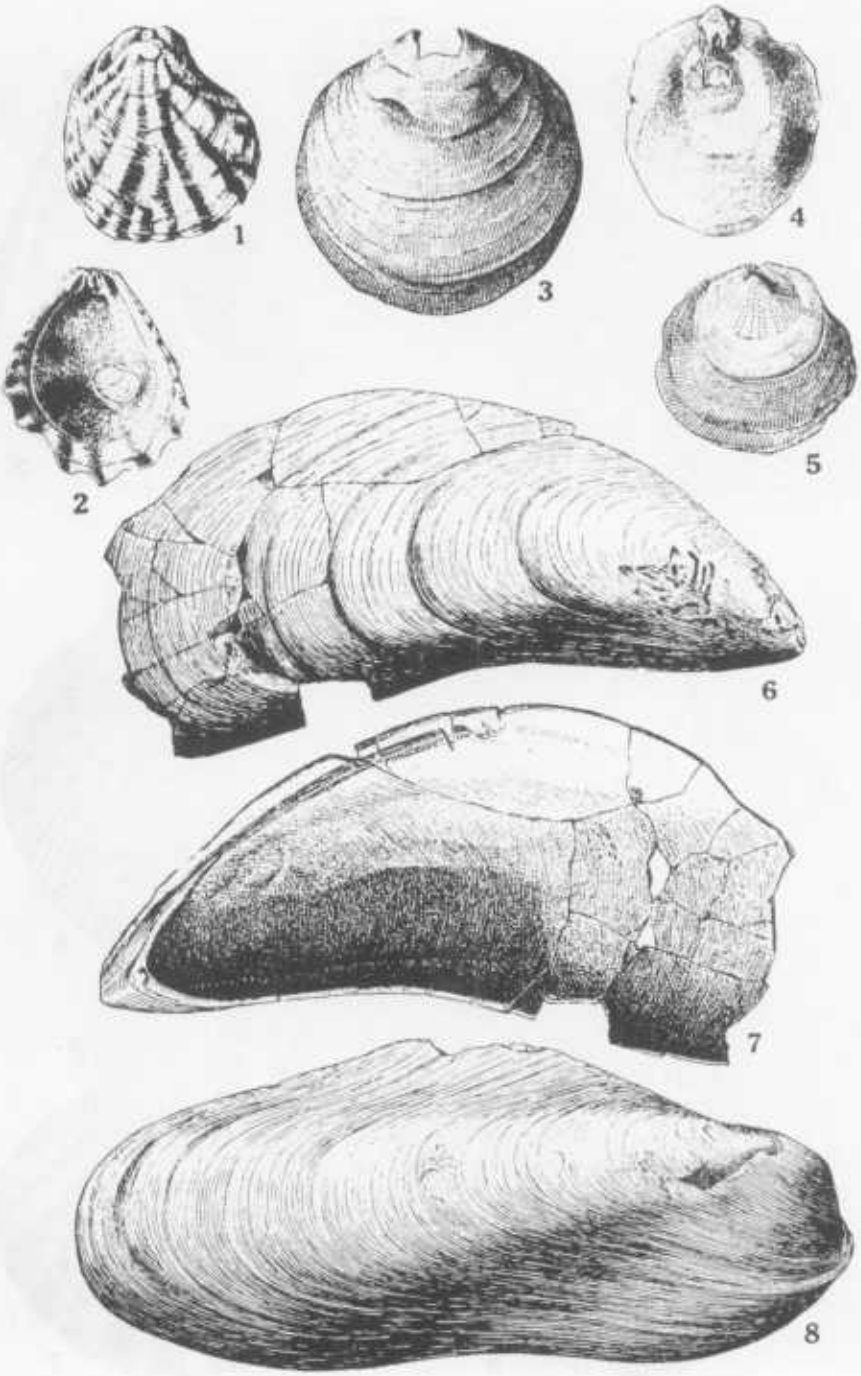
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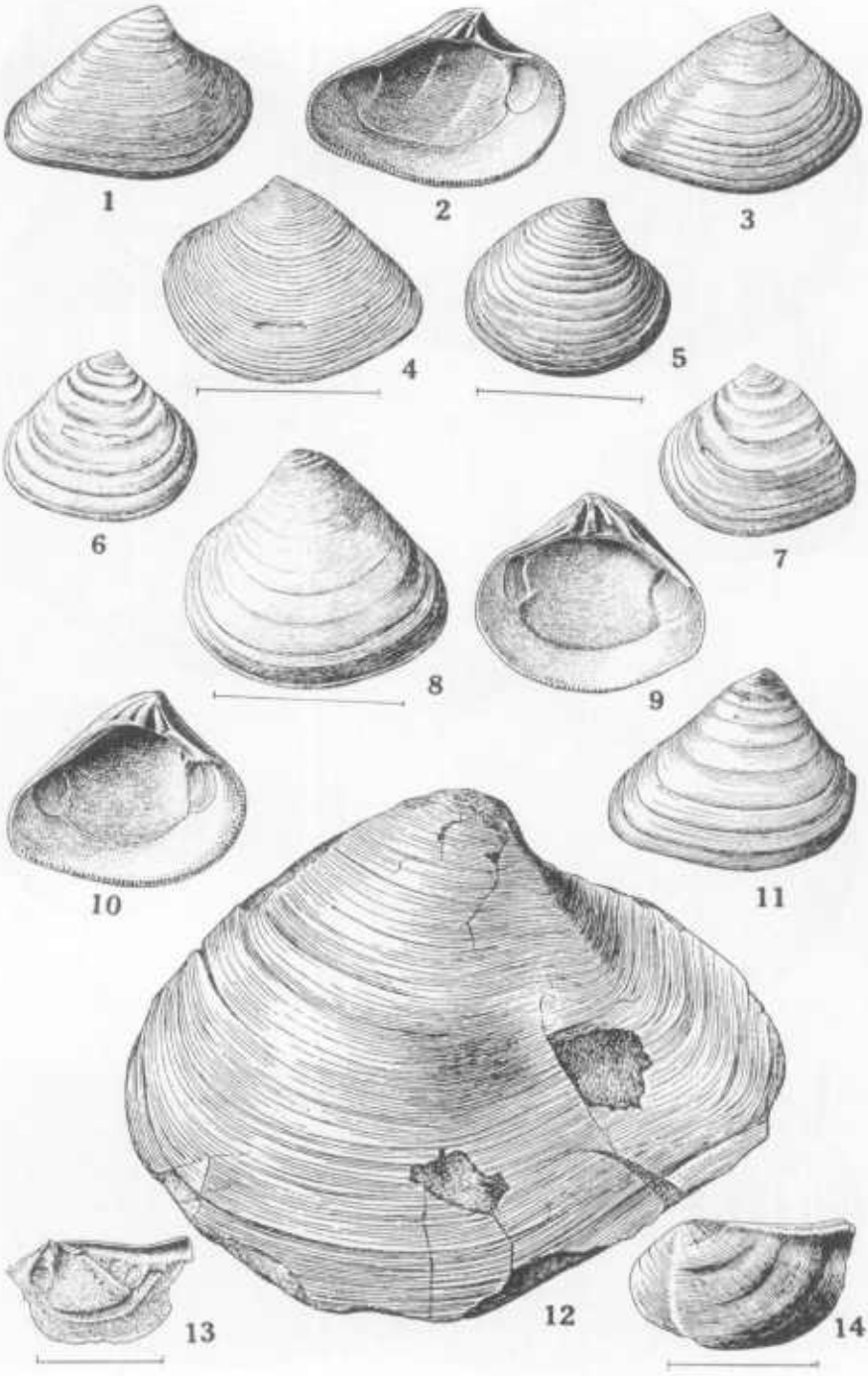

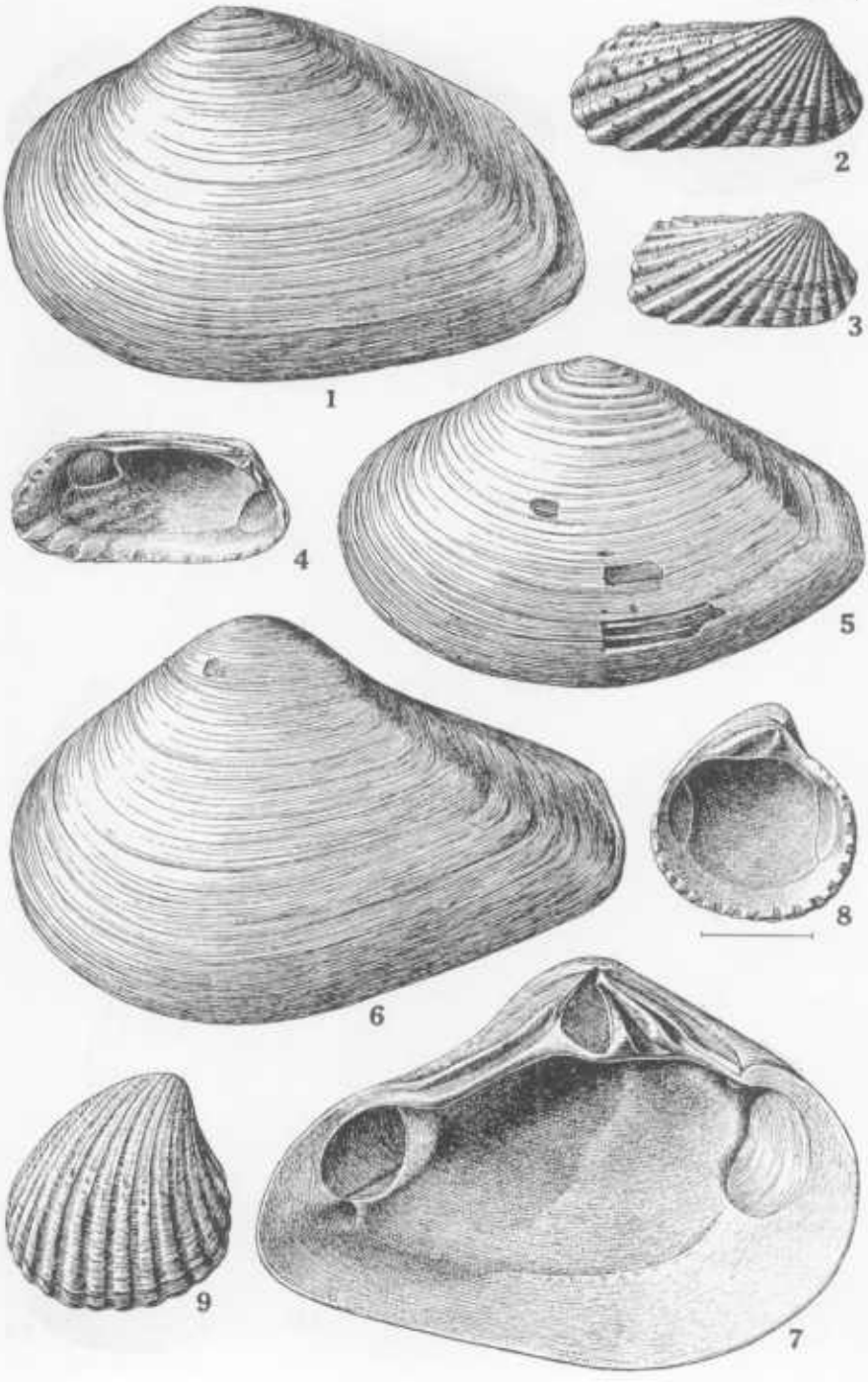
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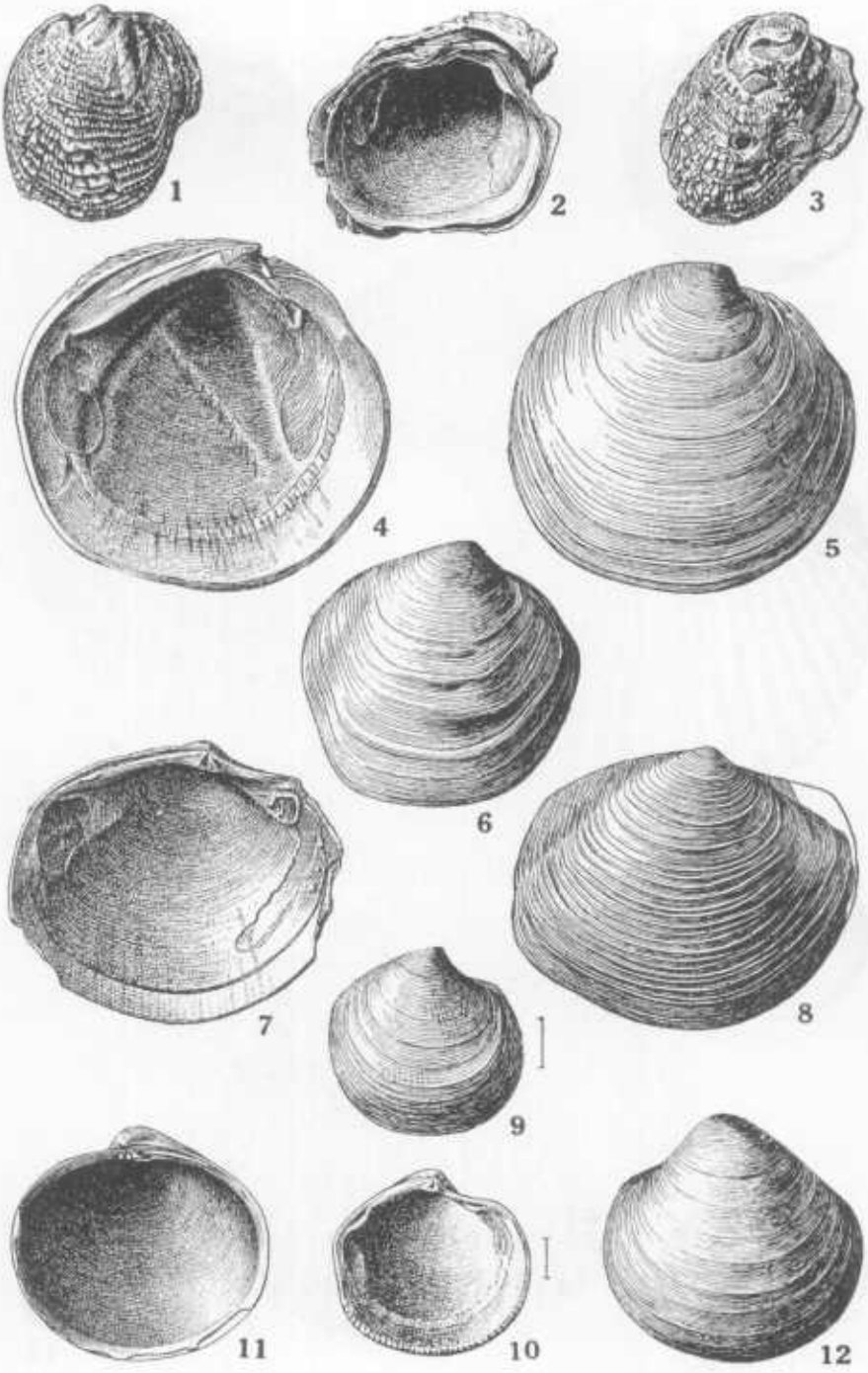

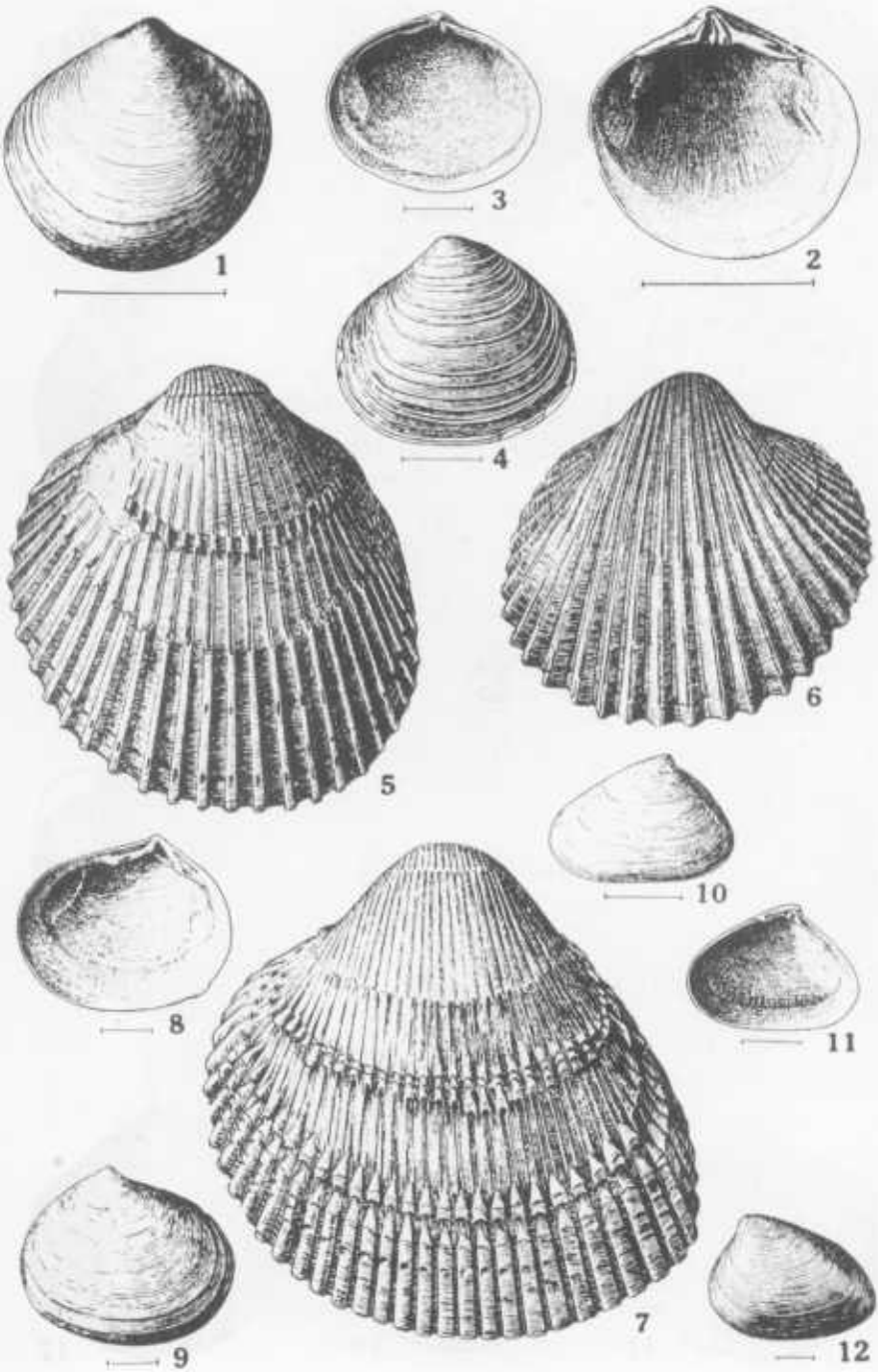
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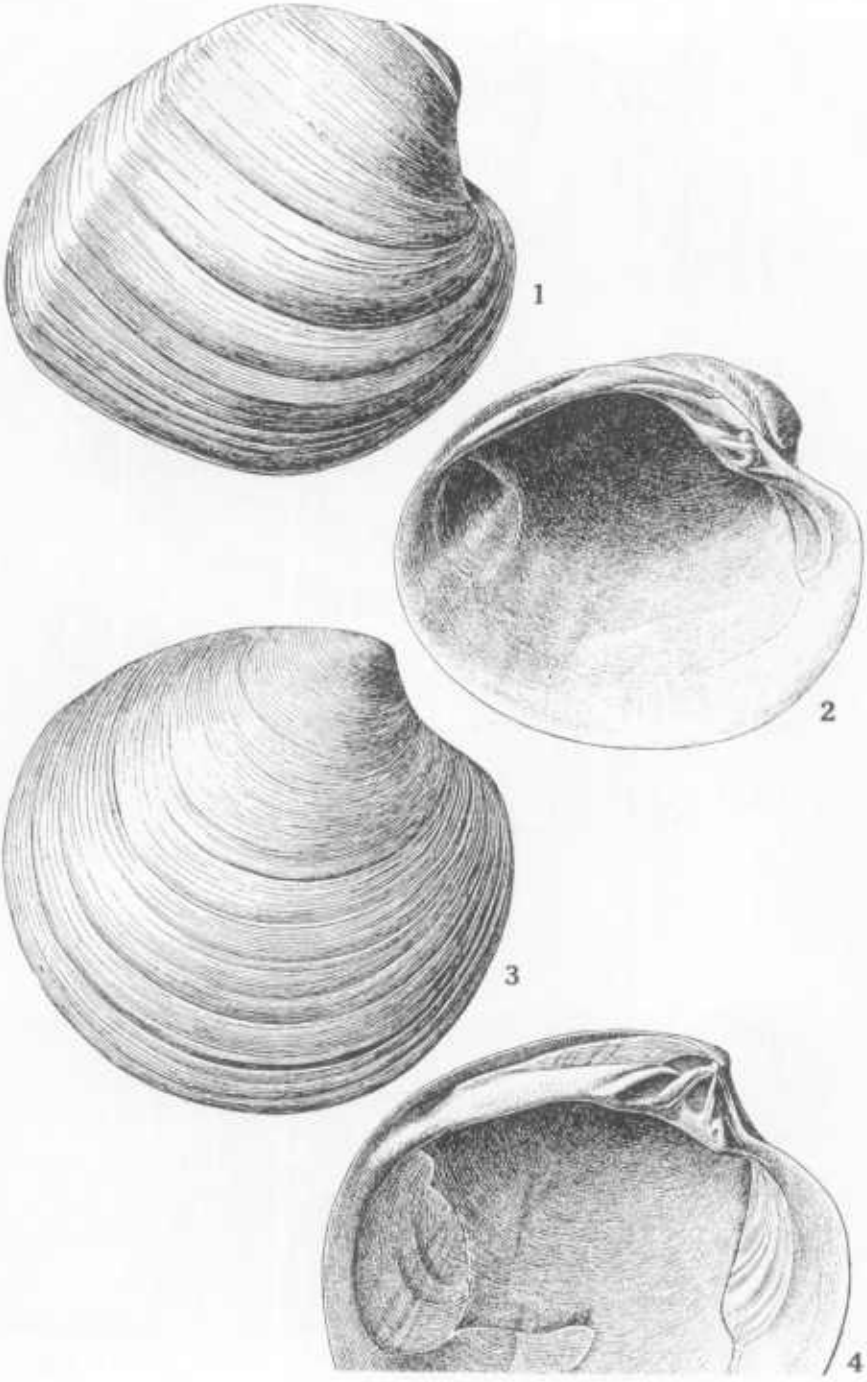

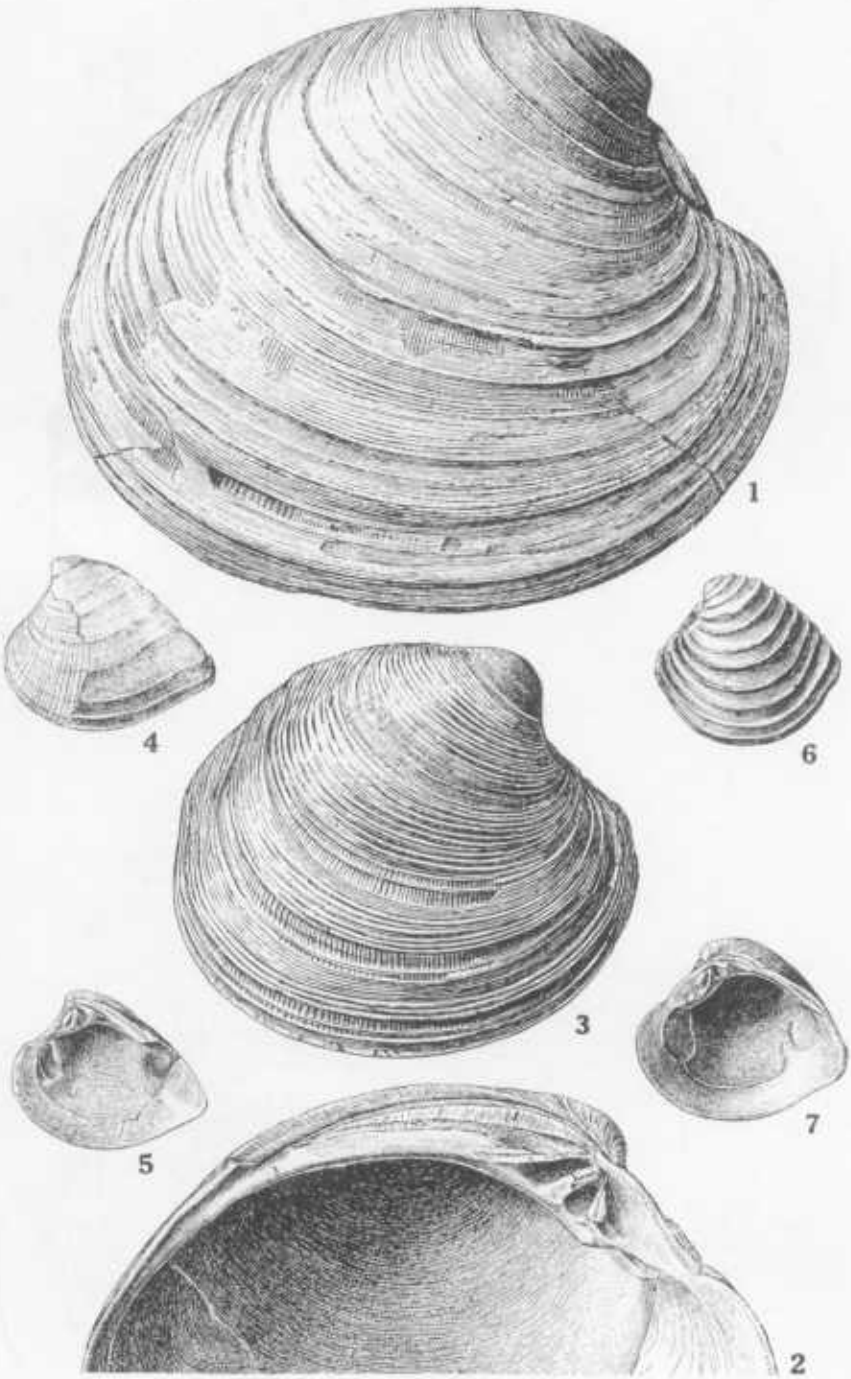
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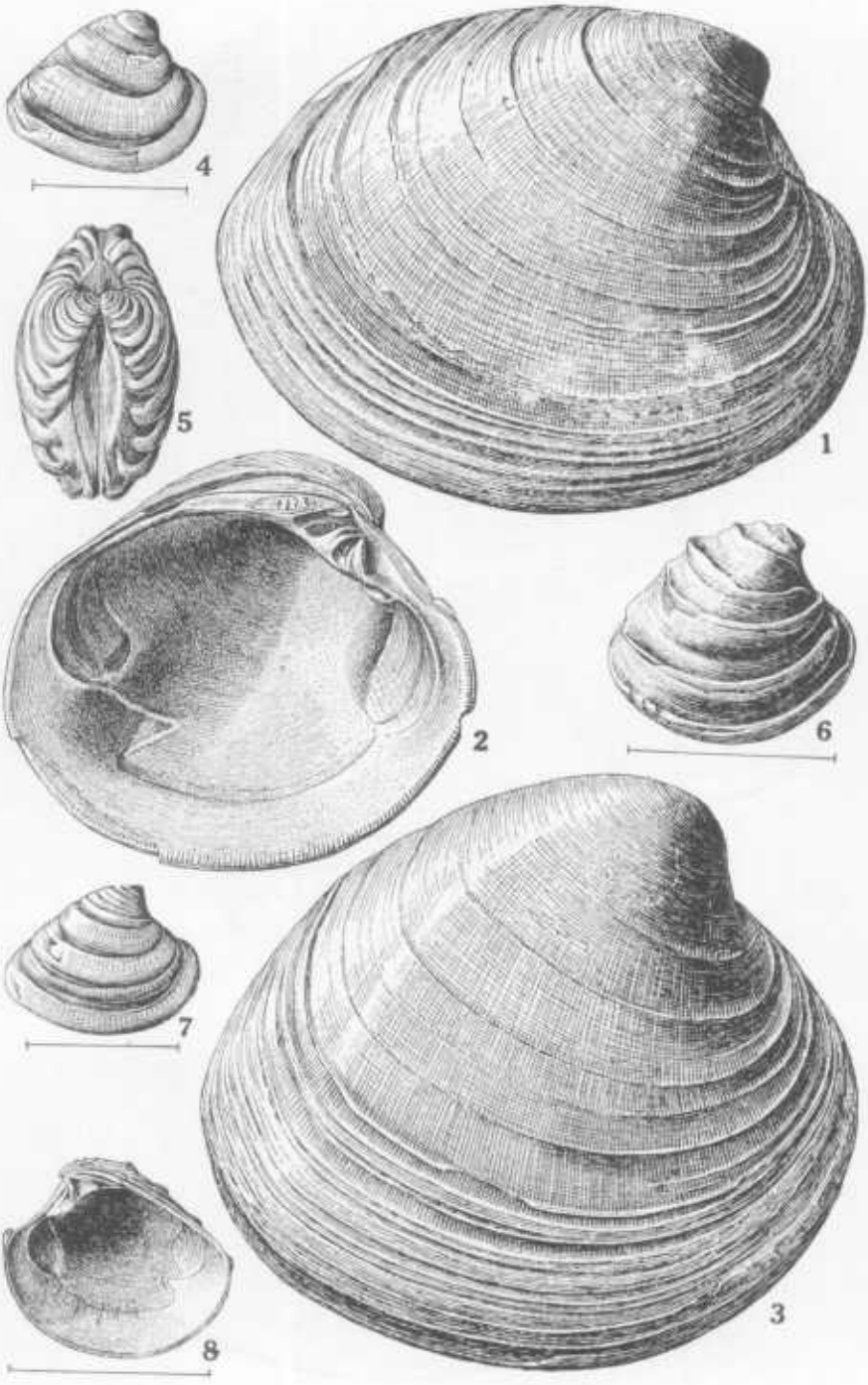

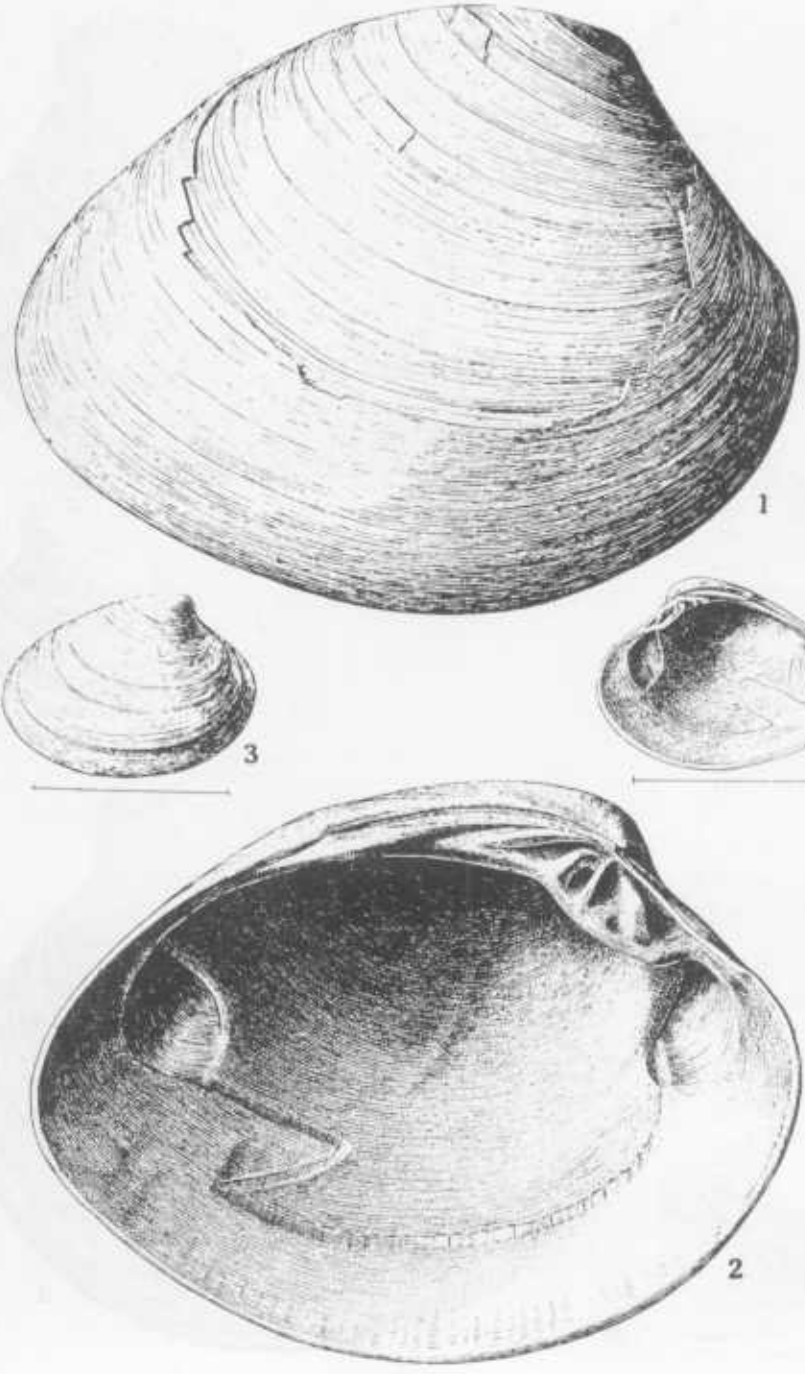
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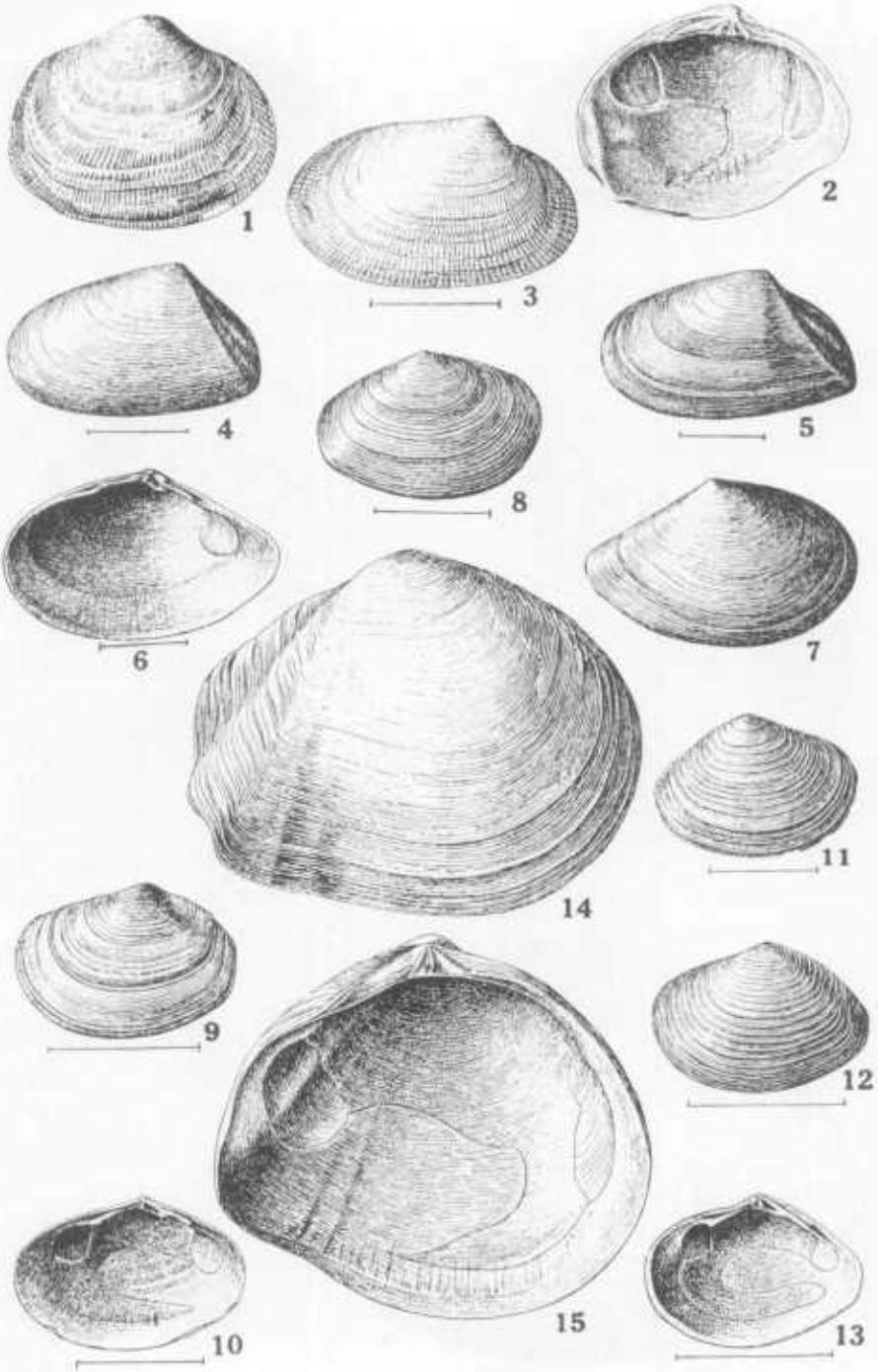

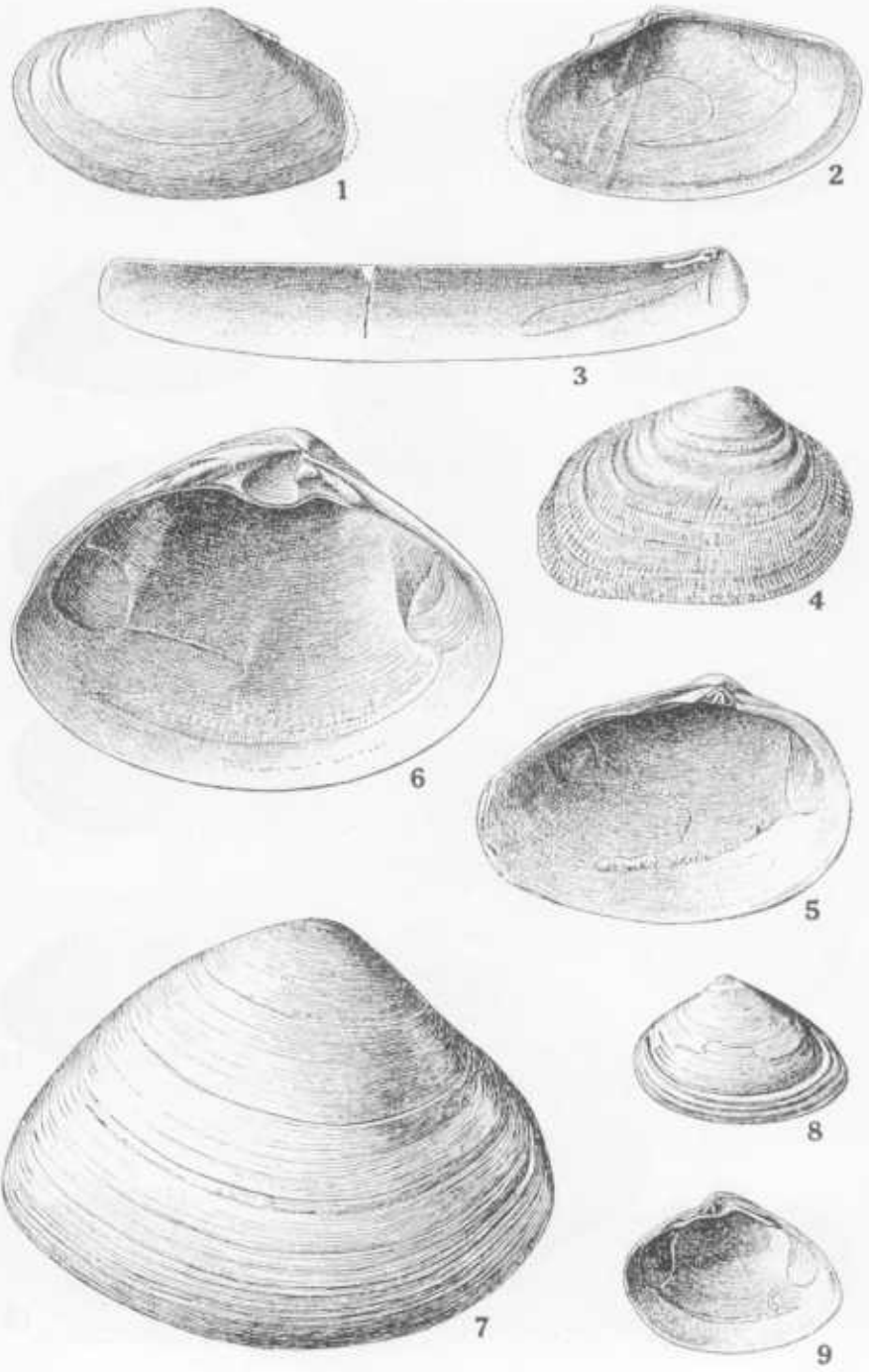
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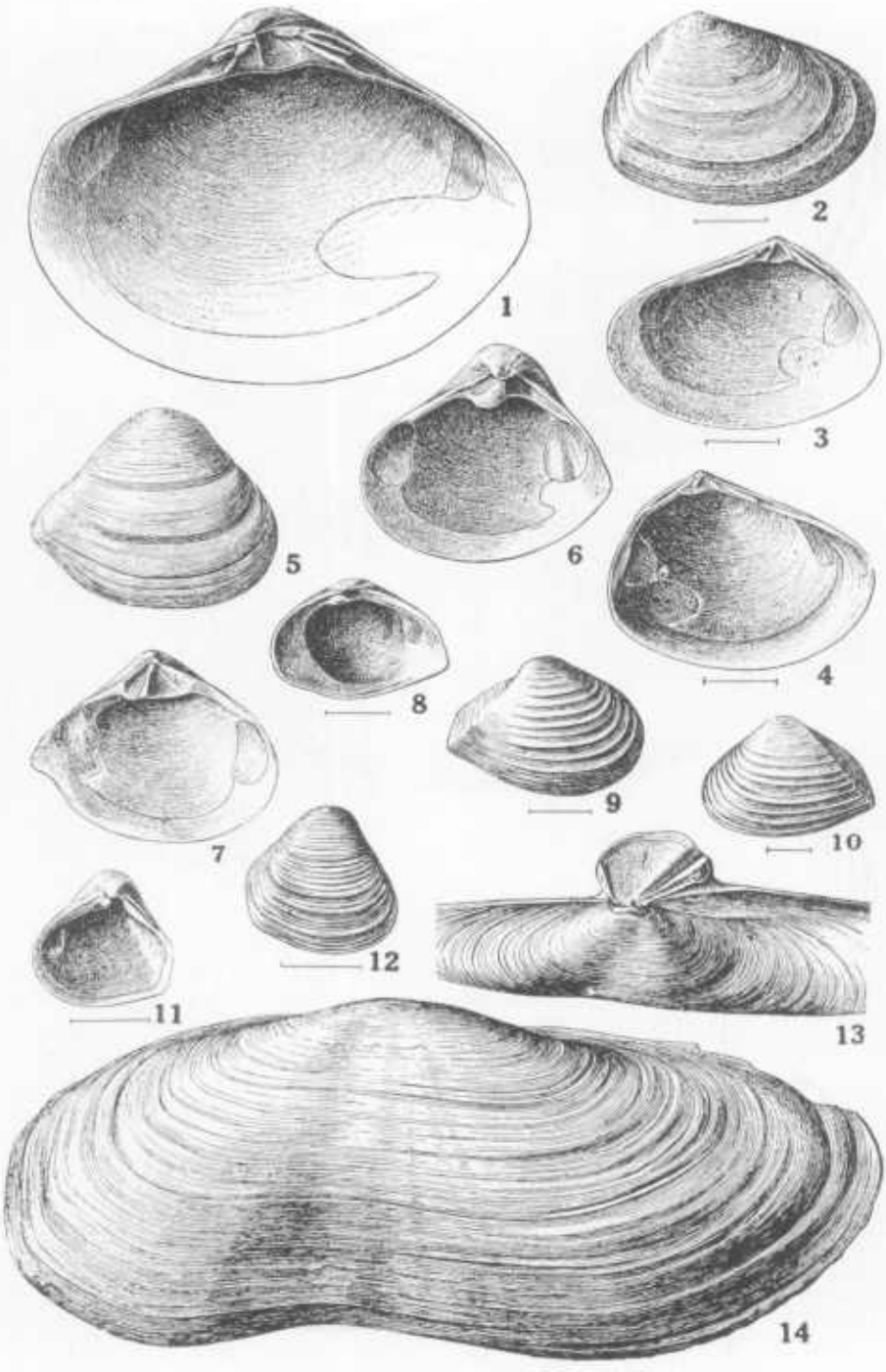

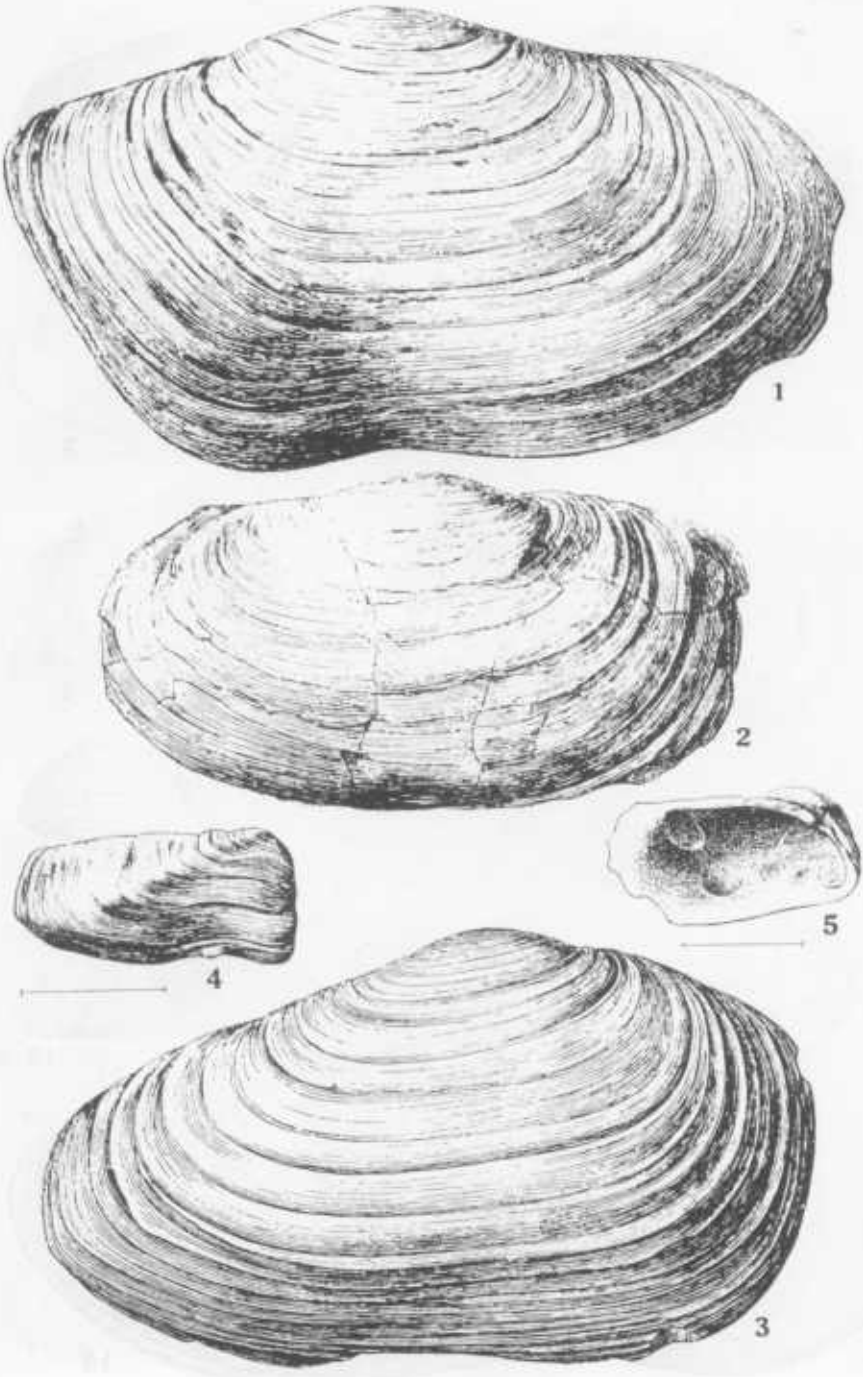
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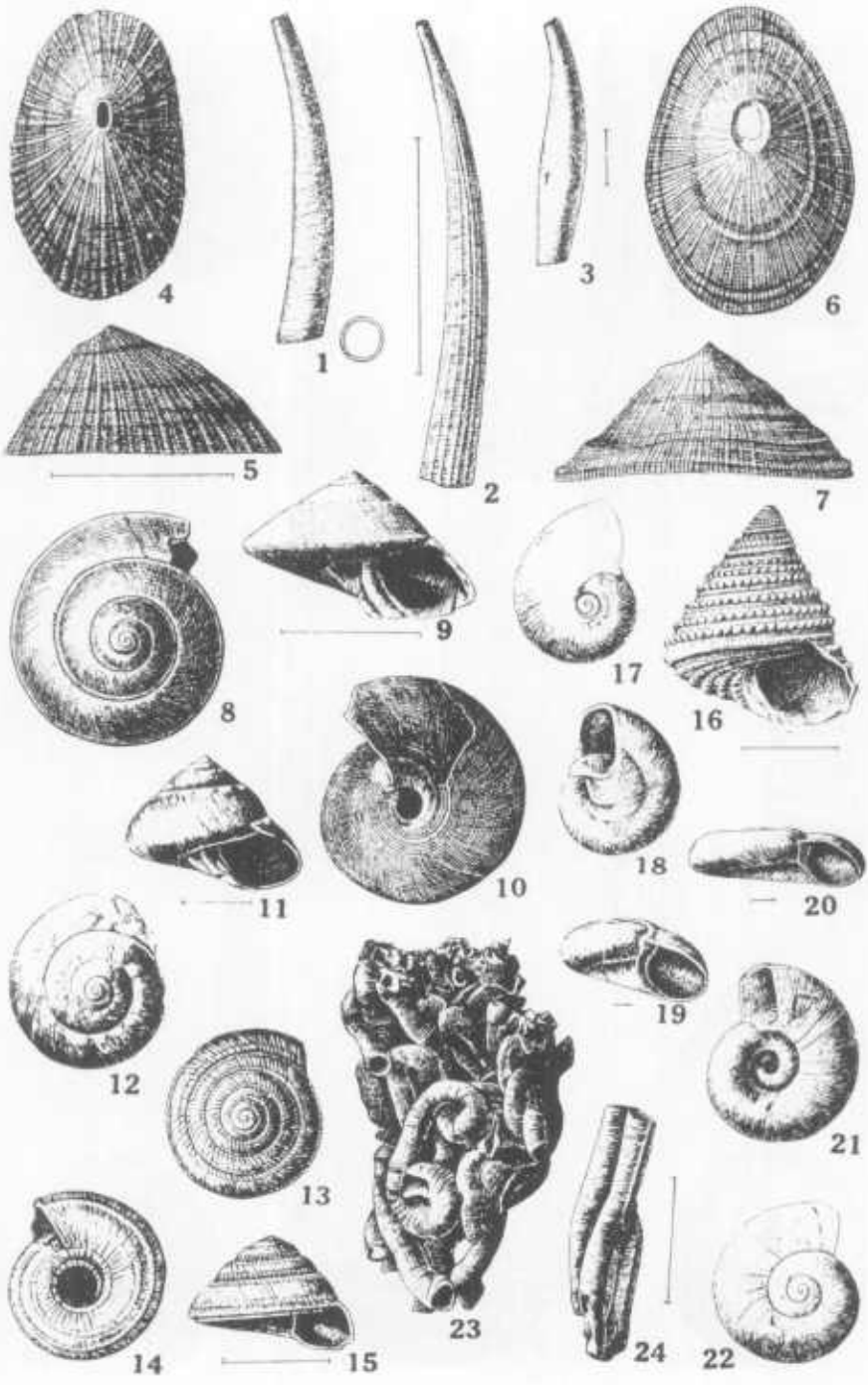

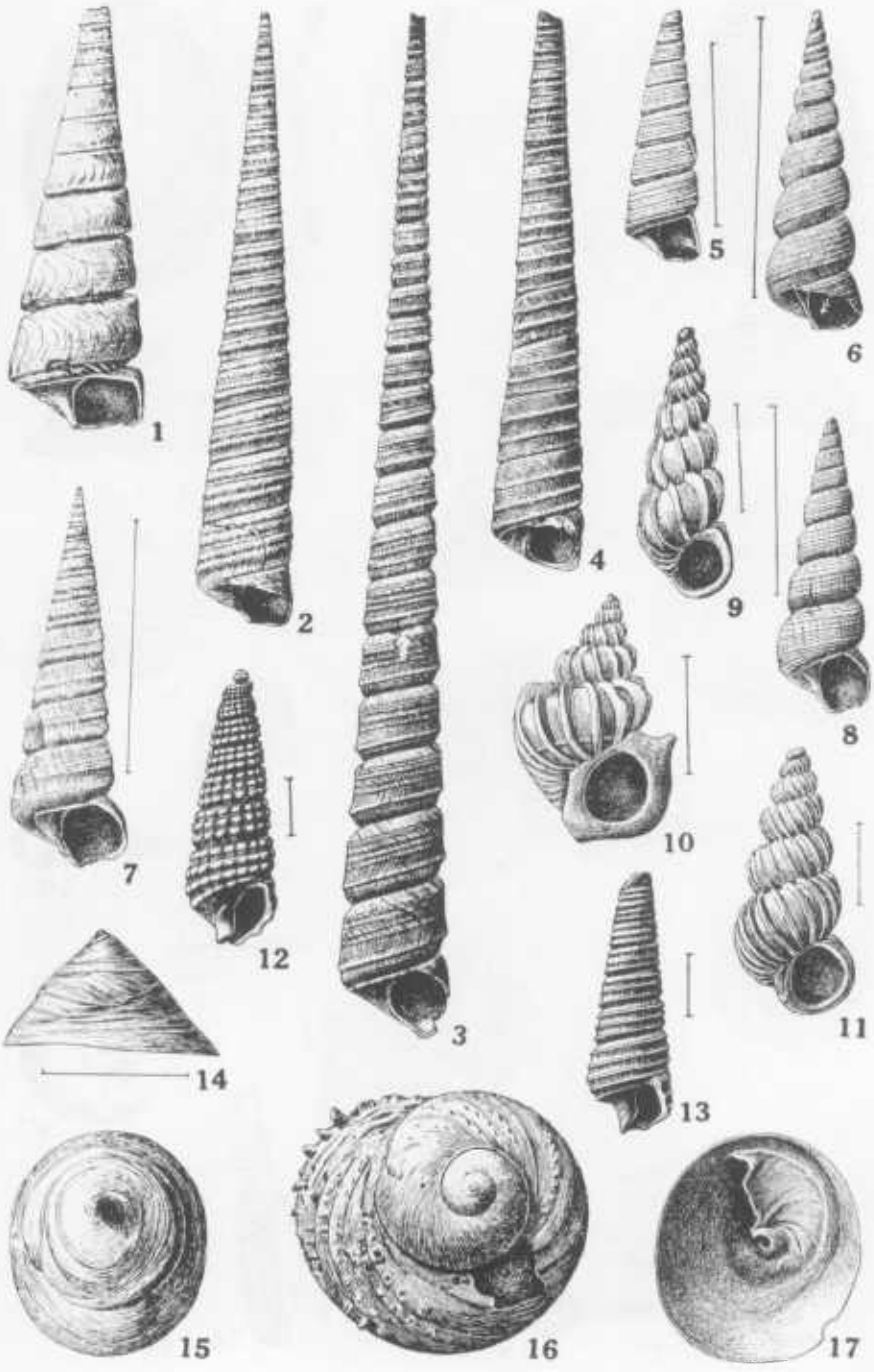
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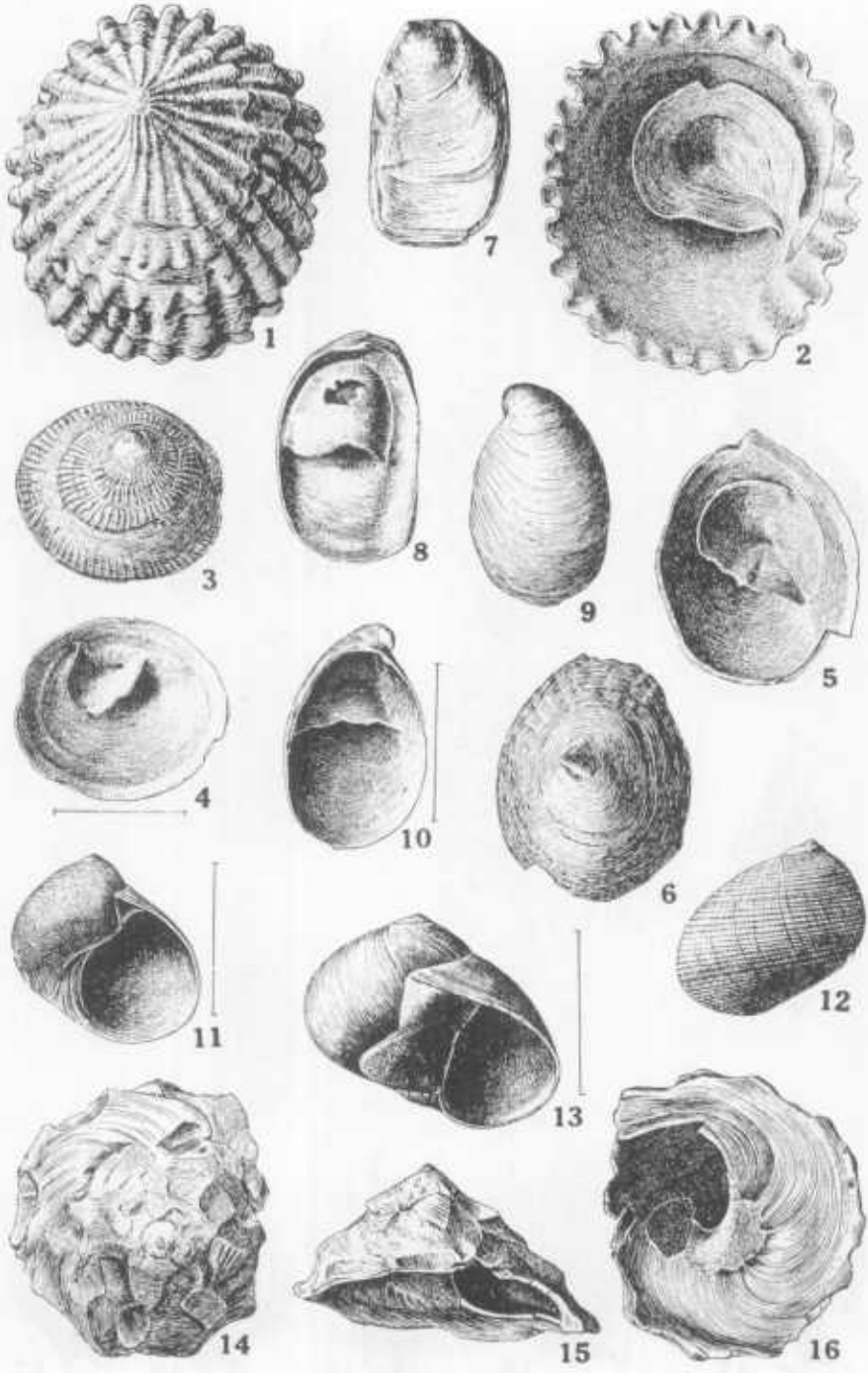

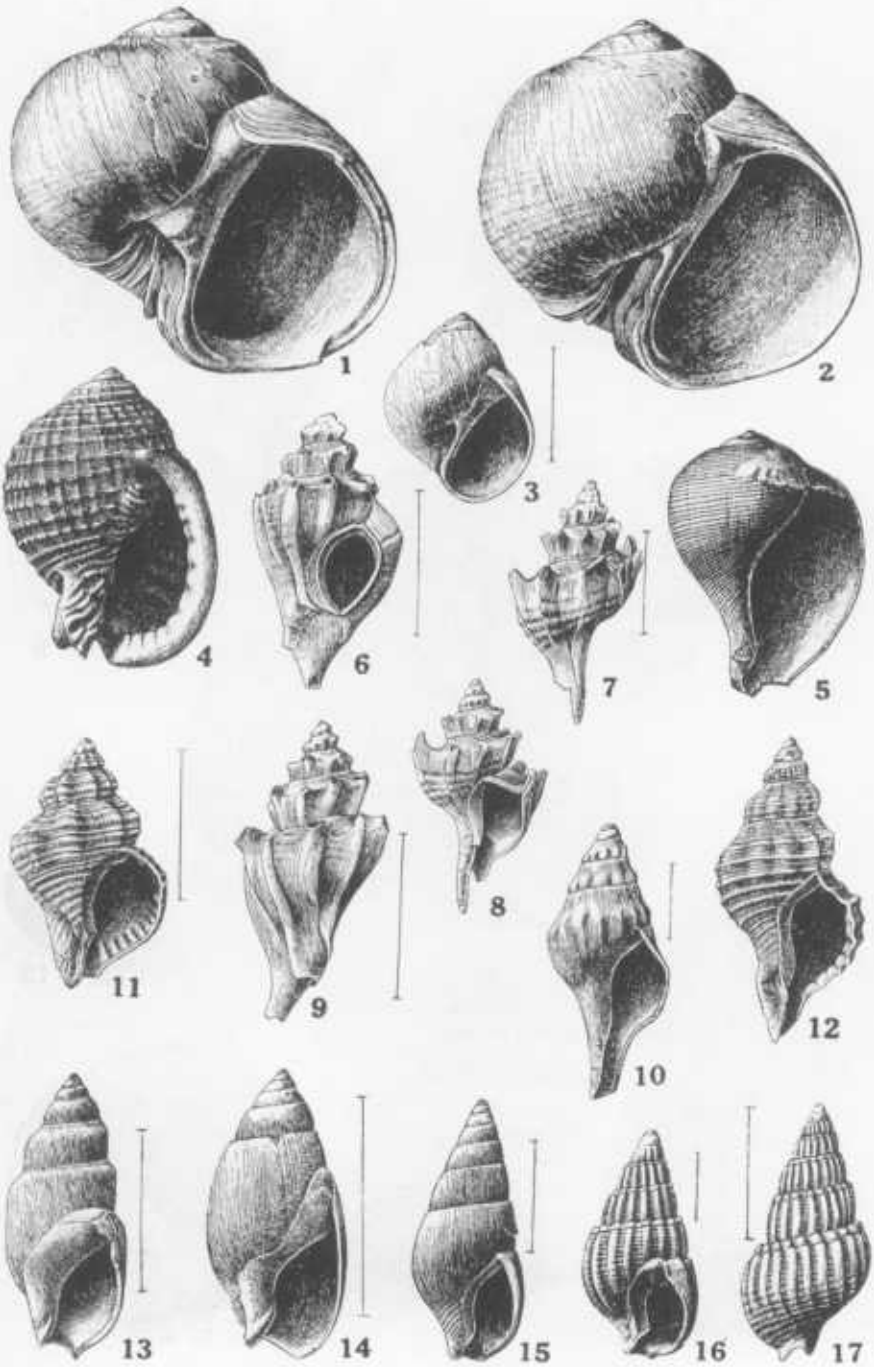
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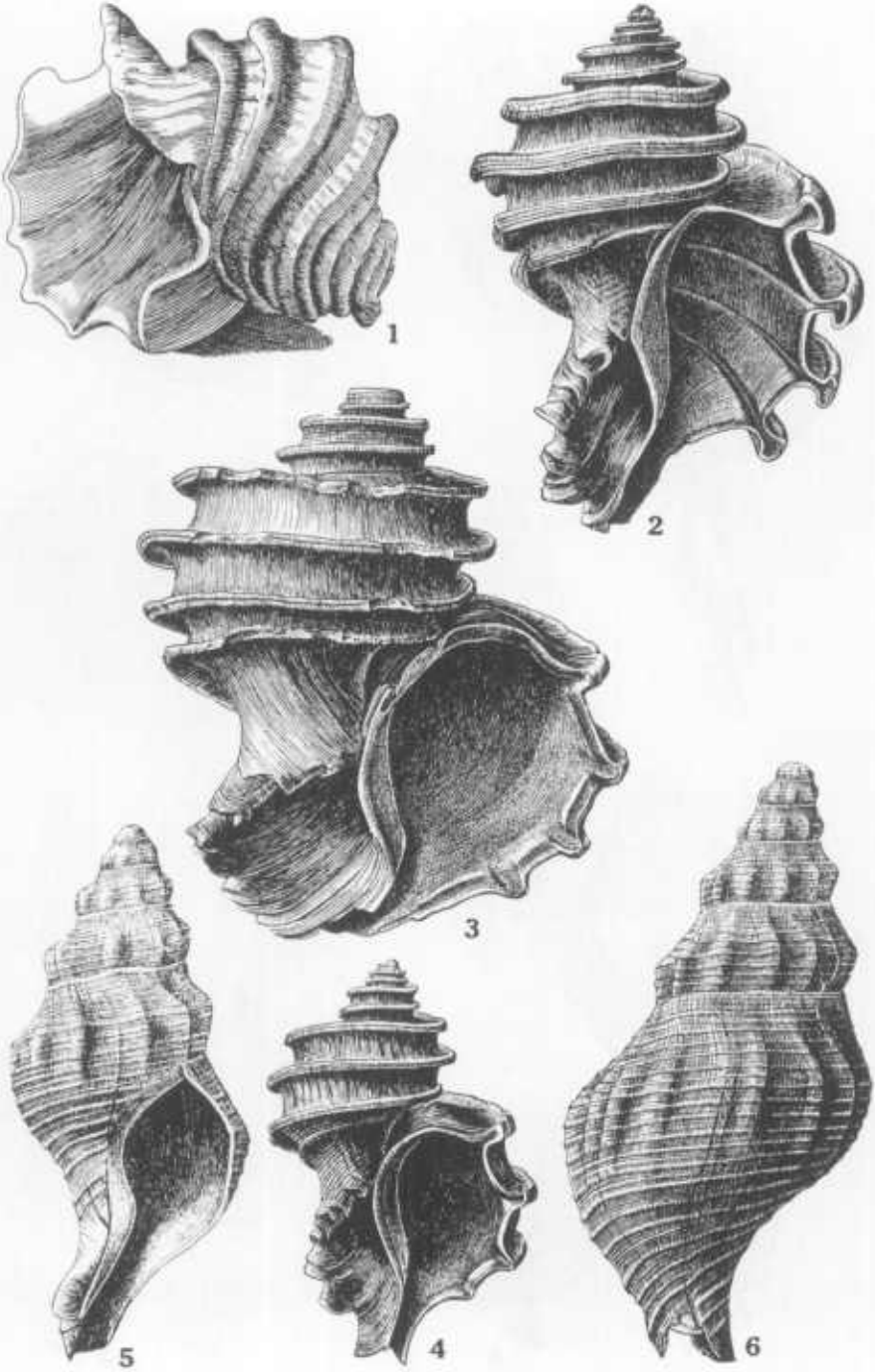

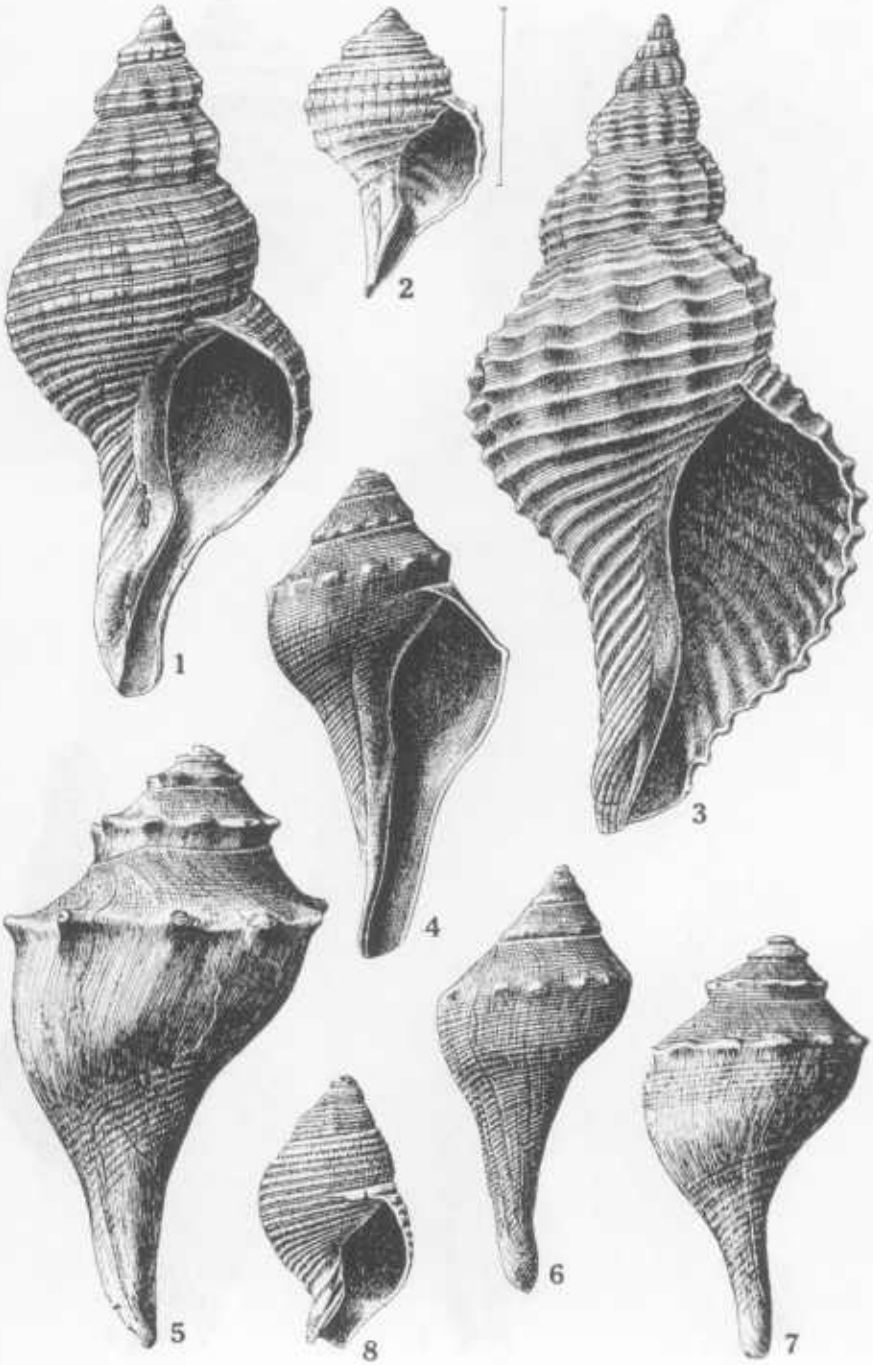
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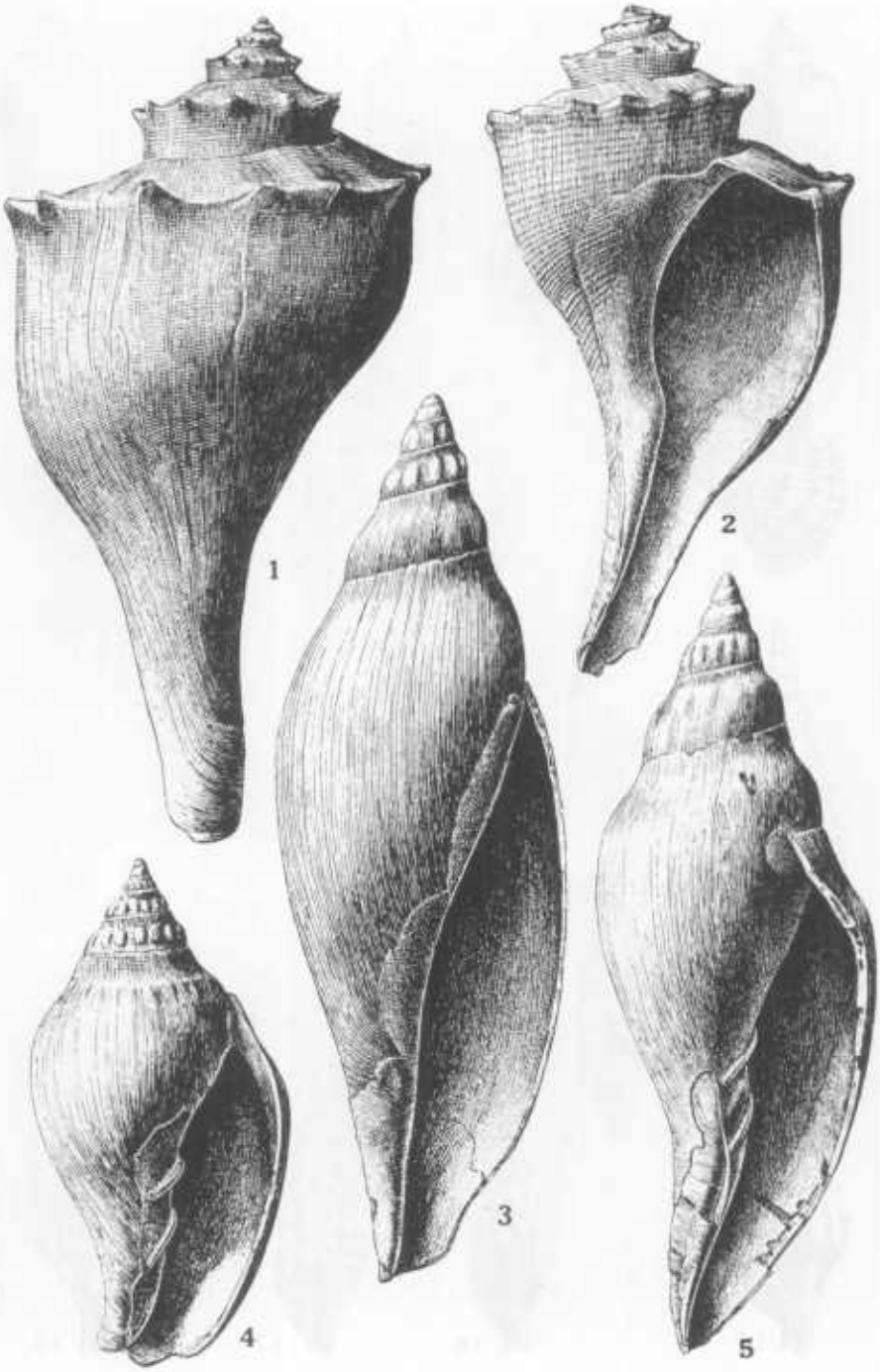

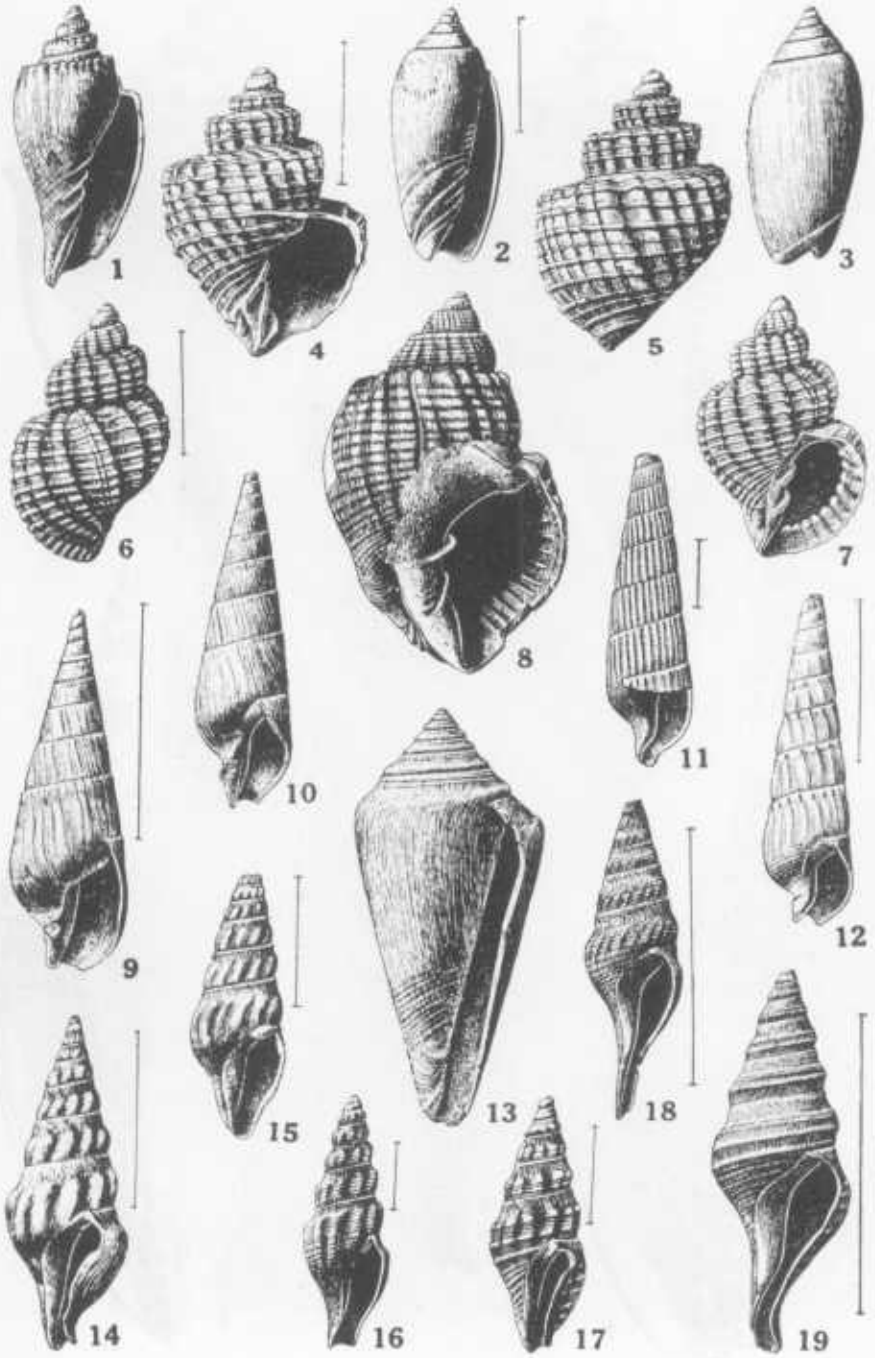
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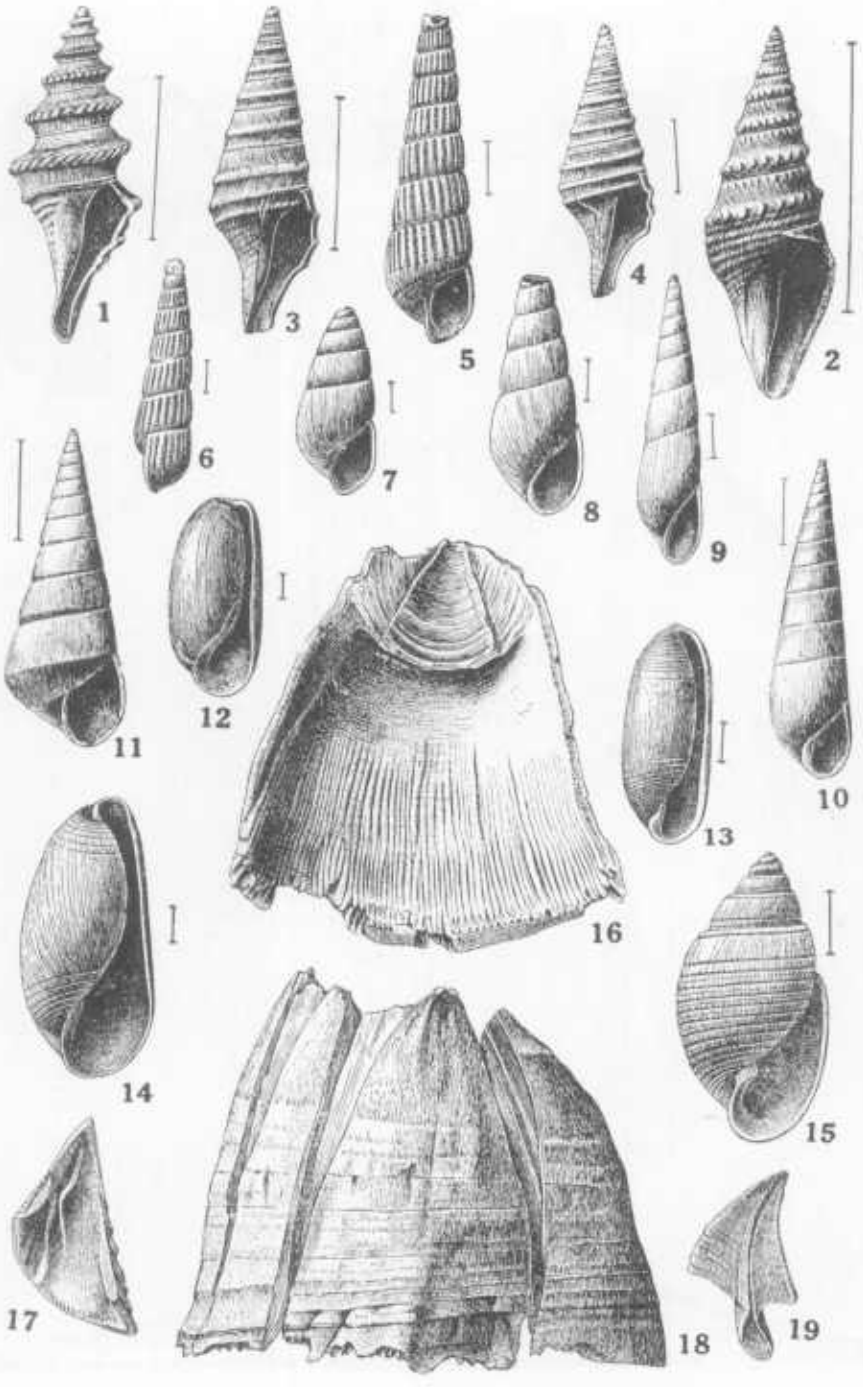

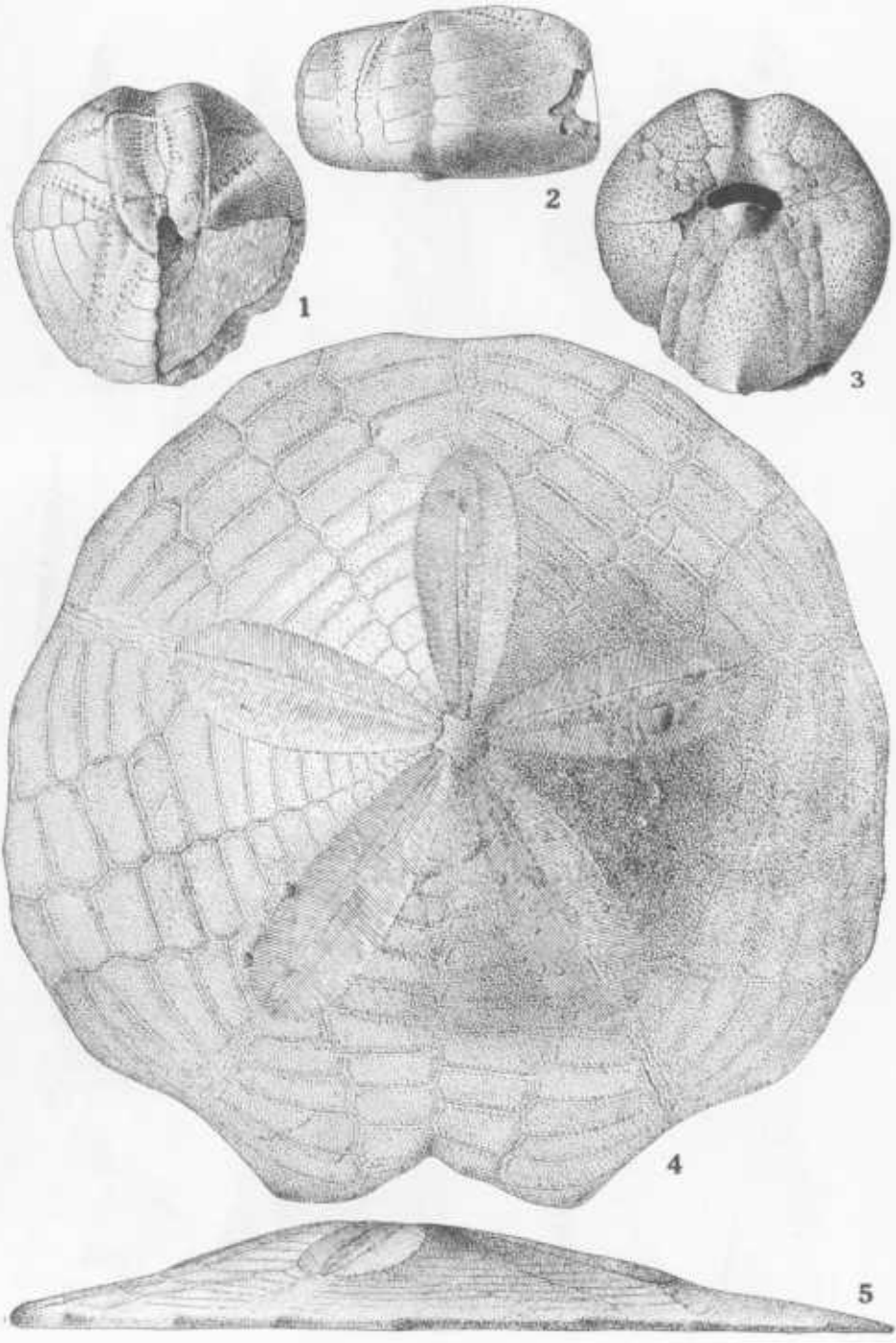
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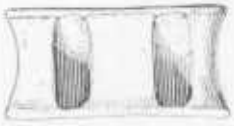
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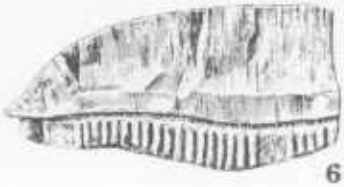
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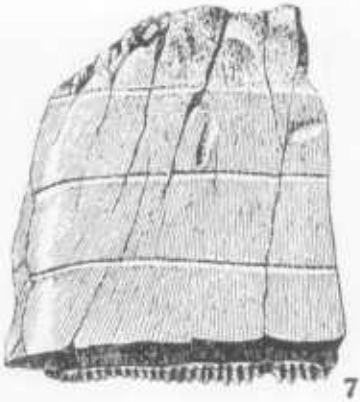
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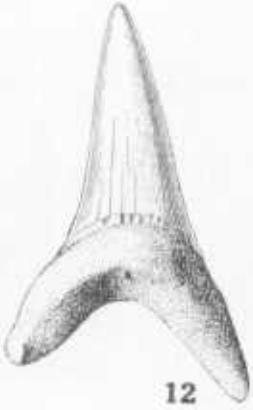
12

INDEX