

UNITED STATES DEPARTMENT OF THE INTERIOR

**THE MOLLUSCAN FAUNA OF THE
ALUM BLUFF GROUP OF FLORIDA**

**PART I. PRIONODESMACEA AND
ANOMALODESMACEA**

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THE MOLLUSCAN FAUNA OF THE ALUM BLUFF GROUP OF FLORIDA

BY

JULIA GARDNER

PART I. PRIONODESMACEA AND ANOMALODESMACEA



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JULIA GARDNER.

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PART I. PRIONODESMACEA AND ANOMALODESMACEA

INTRODUCTION

The Alum Bluff deposits consist of a series of sands and clays, for the most part unconsolidated, in many places highly calcareous, and carrying a varied and prolific fauna. Three distinct faunas are recognized in the deposits, and largely on the basis of these faunas the Alum Bluff is here elevated to the rank of a group and divided into three formations, each characterized by a distinctive fauna. These formations are here named, in descending order, Shoal River formation, Oak Grove sand, and Chipola formation.

The Mollusca of the Alum Bluff group include between 800 and 900 species. The detailed discussion of the stratigraphy will follow the systematic treatment of the fauna, for the stratigraphy is in large measure deduced from the fauna.

The section at Alum Bluff on Apalachicola River, Fla., was first cited by Langdon¹ in 1889. He recognized two fossiliferous horizons and referred them both to the Miocene, apparently without any appreciation of the time interval between them. The basal fossiliferous bed at Alum Bluff is now correlated with the "Chipola marl member" of Matson and others, and the upper beds are correlated with the Choctawhatchee marl. Johnson² mentions the "Alum Bluff or Chipola marl" at Rock Bluff, but Dall³ was the first to correctly interpret the Alum Bluff section. He⁴ was also the first to recognize the Oak Grove sand and to suspect the presence of the Alum Bluff in the vicinity of De Funiak Springs, about 10 miles southwest of the now classic Shoal River fossil localities in Walton County. Vaughan, however, established the "Shoal River marl member" as a distinct subdivision of the Alum Bluff. His type section of the Shoal River, at Shell Bluff, was first published by Matson and Clapp.⁵

Later work by the author has shown that the Shoal River fauna is present not only in the "Shoal River marl member," as defined by Matson and

others, but in underlying and overlying sands and clays and that, although the "Shoal River marl member" can not be identified by its lithology over great distances, the Shoal River fauna is readily distinguishable over a large area. In the type section at Shell Bluff, just cited, layers 3 to 7 are included in the Shoal River formation as here defined. A similar condition exists with regard to the Chipola fauna, which is not only present in the "Chipola marl member" as defined by Matson and others but in overlying sands and clays. Although there is no known section where the three faunas (Chipola, Oak Grove, and Shoal River) are present, there is no question that the Oak Grove fauna is intermediate between the Chipola fauna and the Shoal River fauna. In this report, therefore, the term Shoal River formation is applied to the marls, sands, and clays that occur stratigraphically between the top of the Oak Grove sand and the base of the Choctawhatchee marl, and the term Chipola formation is applied to the marls, sands, and clays that occur stratigraphically between the base of the Oak Grove sand and the top of the Chattahoochee formation. The definition of the Oak Grove sand is not herein modified, but its rank is changed from that of a member to that of a formation.

The name Alum Bluff is perhaps unfortunate, for only the lower part of the Alum Bluff group, as it is now understood, or the Chipola formation of this report, is present in the type section, where it is overlain by the Choctawhatchee marl. The obscure stratigraphic and lithologic relationships of the deposits probably account for the fact that their formational rank and the tripartite character of their fauna were not established until 1909.⁶

The study of the fauna and flora of the Alum Bluff deposits has, from the first, yielded gratifying results. The later paleontologists have been peculiarly fortunate in that they have been able to build upon Dall's "Tertiary fauna of Florida," a work extraordinarily comprehensive for a pioneer investigation, with descriptions and figures so adequate that there is rarely any question of the characters of a given species. Since that time Miss Maury⁷ has added a large number of species to the Chipola and

¹ Langdon, D. W., jr., Some Florida Miocene: *Am. Jour. Sci.*, 3d ser., vol. 38, p. 322, 1889.

² Johnson, L. C., The Chattahoochee embayment: *Geol. Soc. America Bull.*, vol. 3, p. 129, 1892.

³ Dall, W. H., Correlation papers; Neocene: *U. S. Geol. Survey Bull.* 84, p. 122, 1892.

⁴ Dall, W. H., and Stanley-Brown, Joseph, Cenozoic geology along the Apalachicola River: *Geol. Soc. America Bull.*, vol. 5, p. 166, 1894.

⁵ Matson, G. C., and Clapp, F. G., A preliminary report on the geology of Florida with special reference to the stratigraphy: *Florida Geol. Survey Second Ann. Rept.*, p. 105, 1909.

⁶ Matson, G. C., and Clapp, F. G., *op. cit.*, p. 91, 1909.

⁷ Maury, C. J., New Oligocene shells from Florida: *Bull. Am. Paleontology*, vol. 4, No. 21, 1910.

Oak Grove faunas, and Mr. Truman H. Aldrich, in a number of scattered papers, has greatly increased the knowledge of the rather neglected Shoal River fauna. Two relatively recent papers should be mentioned in even this cursory introduction—the short but significant discussion by Vaughan and Cooke⁸ of the Hawthorn formation and the comprehensive study by Berry⁹ of the flora of the Alum Bluff.

The interest of the present investigation lies not in the large number of 821 species considered but in the material which they furnish for comparison with other Tertiary faunas and for deductions upon the temperature, depth of the water, shore conditions, and all the factors that contributed to the early Miocene ecology.

The Alum Bluff is here raised to the rank of a group not merely because the faunal differences between its subdivisions are too great to be included within a single formational unit but because of the implied significance of the shifting in the strand line and ocean currents necessary to bring about so marked a change in the life. Perhaps the most surprising and the most obvious result of a critical examination of the Mollusca of the Alum Bluff is the marked individuality of each of the three faunas involved. The large number of peculiar species will doubtless be reduced by continued collecting, but there will remain a decided difference in the general make-up of the faunas coincident with certain changes in depth and temperature and the invasion of life from other areas.

The Chipola fauna is a subtropical assemblage, typical of a region decidedly warmer than that inhabited by either of the other two faunas; it is relatively richer in species and not so rich in individuals. Of the 439 species which have been recognized from this formation three out of four are peculiar to it. Among the outstanding features may be mentioned the predominance of the gastropods, particularly of the turritids, the abundance of the bizarre and consequently short-lived and diagnostic *Orthaulax gabbi*, the diversity of the Arcas and Cardiums, and the absence of any conspicuously dominant species of these genera, as in the Oak Grove and Shoal River. Apparently the Chipola was laid down in a period of unstable equilibrium. A number of new lines of development were being tried and this together with the favorable living conditions produced a much diversified fauna. However, in the "Sopchoppy limestone," which is nothing more than a very shallow-water phase of the Chipola, only about 50 species have been recognized, of which the only common forms are large *Ostreas* and *Pectens* and *Anomias*, an assemblage that is characteristic of oyster reefs.

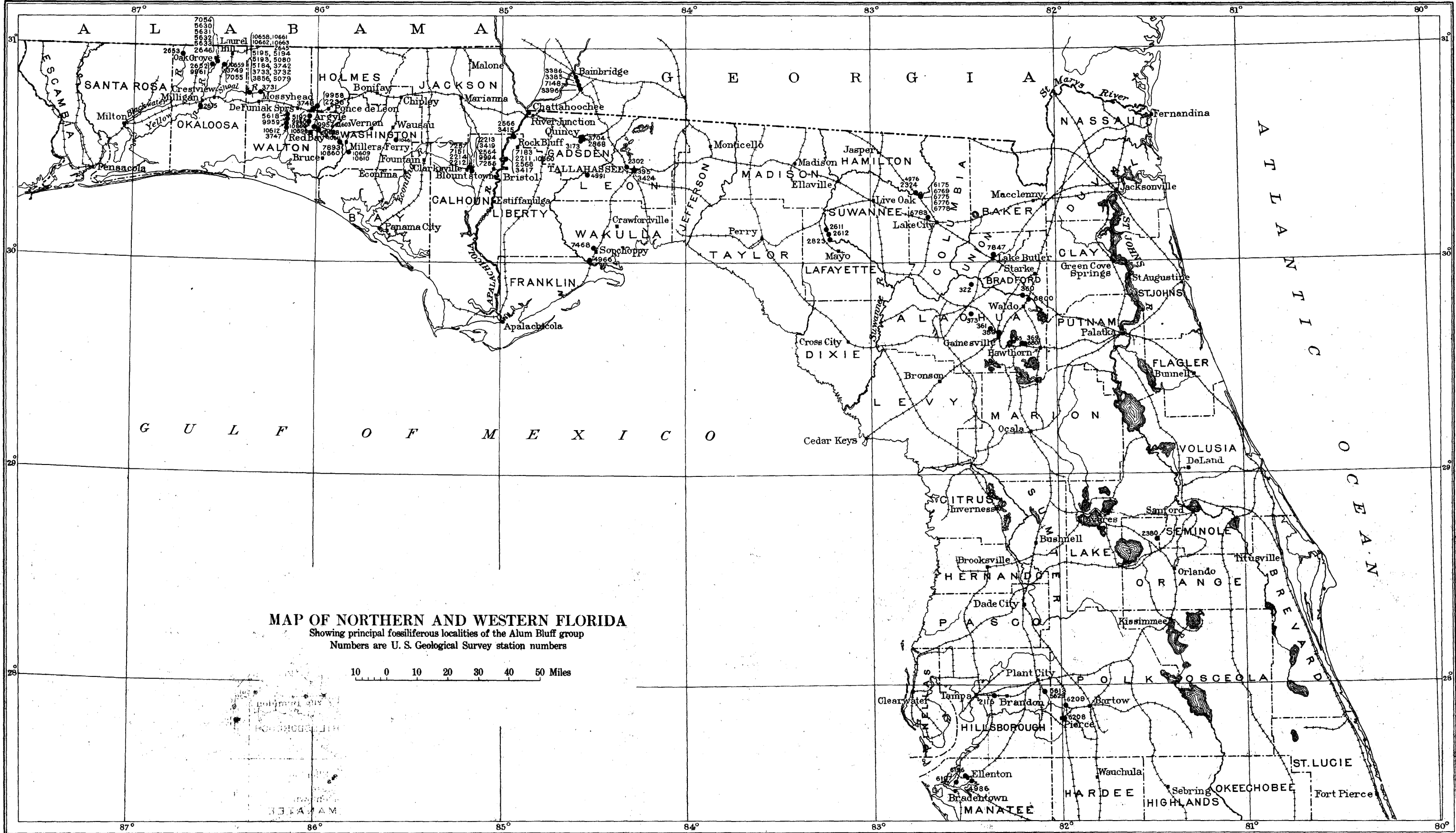
In the fauna of the grayish-green Oak Grove sand there is a foreshadowing of the radical fall in temperature at the close of the Alum Bluff epoch which permitted the Mollusca of the Maryland province to penetrate the Floridian waters and to continue to exist for a short time in this new environment. The number of species in the Oak Grove is less than half the number recognized in the Chipola, but the number of individuals is much greater. The large fulgoroïds were apparently quite common and also a *Pecten* (*Chlamys*) closely allied to *P. (Chlamys) madisonius* Conrad, of the Maryland Miocene. The conspicuously abundant and ubiquitous species, however, include a new *Strombus*, *Turritella alcida* Dall, *Glycymeris drymanos* Gardner, *Diluvarca dodona* (Dall), *Cardium taphrium* Dall, *Parvilucina piluliformis* Dall, *Chione glyptocyma* Dall, and *Spisula densa* Dall. Any one of these species might well be selected as characteristic of the Oak Grove fauna. They are all newcomers and, except *Cardium taphrium* (Dall), which is rare in the Shoal River, no trace of them has been detected in any later formation. They were extraordinarily well adapted to Oak Grove conditions but were too highly modified to change with the changing environment.

The Shoal River fauna is more complex than that of either the Chipola or the Oak Grove and shares some of the characters of both. The number of species is slightly increased, and several of them, such as *Conus waltonensis* Aldrich, a new *Cancellaria* and *Turritella*, and *Glycymeris waltonensis* Gardner are as prolific as the abundant species in the Oak Grove. Apparently the waters continued to be relatively cool, for *Astarte*, which occurs chiefly in northern and temperate waters, is represented by three species, whereas in the Oak Grove there is only one and in the Chipola none at all. On the other hand, the southern element did not submit without a struggle. The West Indian assemblage is suggested by such forms as *Spondylus* sp. cf. *S. bostrychites* Guppy and the diversity of the Cancellarias. Temperatures were not yet so unfavorable as to shut out entirely the vigorous southern fauna, but the northern invaders were becoming increasingly more numerous. It is probable that there was a gradual emergence of the land from the close of the Chipola to the close of the Shoal River. Although none of the Alum Bluff faunas are in any sense of the word deep-water faunas, the Shoal River includes a larger number of characteristic littoral and between-tide genera than either of the other two.

The most powerful factors in determining the evolution of the Alum Bluff faunas were probably the falling temperature of the sea water, the gradual subsidence of the sea, the probable shifting of the ocean currents and the consequent invasion of faunas from other provinces, and the time element, which permitted all these causes to become potent.

⁸ Vaughan, T. W., and Cooke, C. W., Correlation of the Hawthorn formation: Washington Acad. Sci. Jour., vol. 4, pp. 250-253, 1914.

⁹ Berry, E. W., The physical conditions and age indicated by the flora of the Alum Bluff formation: U. S. Geol. Survey Prof. Paper 98, 1916.



MAP OF NORTHERN AND WESTERN FLORIDA
 Showing principal fossiliferous localities of the Alum Bluff group
 Numbers are U. S. Geological Survey station numbers

10 0 10 20 30 40 50 Miles

DISTRIBUTION OF THE FAUNA

The following list shows the localities cited by number in the text and tables:

75. 6 miles west of Gainesville, Alachua County, Fla.
 322b. Nigger Sink, 8 miles north of Newmansville, Alachua County, Fla.
 323. Near Hawthorn, Alachua County, Fla.
 356. Sullivan's field, Levy County, Fla.
 359. Chimney Rock Quarry, half a mile north of Gainesville, Alachua County Fla.
 360. Preston's marl bed, 3½ miles north of Waldo, Alachua County, Fla.
 361. Hogtown Creek, at old mill 2 miles northwest of Gainesville, Alachua County, Fla.
 365. Johnsons Sink, 4 miles northwest of Hawthorn, Levy County, Fla.
 369. Hammock west of Magnesia Springs, near Hawthorn, Alachua County, Fla.
 373. Phosphate rock of the Devil's Mill Hopper, 5 miles northwest of Gainesville, Alachua County, Fla.
 395. 50-foot well in Tallahassee, Leon County, Fla.
 2116. Lapenotière's Hammock, on Sixmile Creek, 1½ miles south of Orient Station, Hillsborough County, Fla.
 2211. Lower bed, Alum Bluff, Liberty County, Fla.
 2212. Tenmile Creek, 1 mile west of Baileys Ferry, Calhoun County, Fla.
 2213. 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla.
 2214. Tenmile Creek, 1 mile west of Baileys Ferry, Calhoun County, Fla.
 2238. Flournoy's mill race, 2 miles east of Argyle, Walton County, Fla.
 2302. 2 miles west of Tallahassee, Leon County, Fla.
 2322. Sopchoppy Creek, Wakulla County, Fla.
 2324. White Sulphur Springs (White Springs), Suwannee River, Hamilton County, Fla.
 2380. Clay Springs, Orange County, Fla.
 2564. McClelland farm, 1 mile below Baileys Ferry, Calhoun County, Fla.
 2566. Upper bed at Rock Bluff, Apalachicola River, Liberty County, Fla.
 2568. Lower or "Chipola" bed at Alum Bluff, Apalachicola River, Liberty County, Fla.
 2611. West bank of Suwannee River, SW. ¼ NW. ¼ SE. ¼ sec. 8, T. 4 S., R. 11 E., near Dell, Lafayette County, and 15 miles south of Ellaville, Madison County, Fla.
 2612. West bank of Suwannee River just below a sulphur spring 2½ miles below 2611, Lafayette County, 17 miles south of Ellaville, Madison County, Fla.
 2645. McClellan farm, Shoal River, 5 miles west of Mossyhead, Walton County, Fla.
 2646. Oak Grove, Yellow River, Okaloosa County, Fla.
 2652. Horse Creek, 1½ miles south of Oak Grove, Okaloosa County, Fla.
 2653. "Otaheite beds," on east Blackwater Creek, 15 miles west of Oak Grove, Okaloosa County, Fla.
 2675. 1 mile south of railroad bridge at Milligan, Okaloosa County, Fla.
 2823. West bank of Suwannee River just below sulphur spring 2½ miles below 2612, 19½ miles south of Ellaville, Madison County, Fla.
 2868. Fuller's earth bed, Quincy, Gadsden County, Fla.
 3173. "Fuller's earth" mines of Chesebrough Co., Quincy, Gadsden County, Fla.
 3385. Gastropod Gulch, 4 miles southeast of Bainbridge, Decatur County, Ga.
 3386. Roseland Plantation, 3½ miles southeast of Bainbridge, Decatur County, Ga.
 3396. Sam Dickens's field, 7 miles southeast of Bainbridge, Decatur County, Ga.
 3415. "Rock Bluff," east bank of Apalachicola River, 12 miles below railroad, Liberty County, Fla.
 3417. Alum Bluff, 35 miles below railroad bridge over Apalachicola River, Liberty County, Fla.
 3419. McClelland farm 1 mile below Baileys Ferry, Calhoun County, Fla.
 3424. J. C. Henderson's well, western limits of Tallahassee, Leon County, Fla.
 3704. Quincy, Gadsden County, Fla.
 3731. Near Mosyhead, sec. 6, T. 3 N., R. 21 W., Walton County, Fla.
 3732. Dave Adams Mill Creek, sec. 2, T. 3 N., R. 21 W., Walton County, Fla.
 3733. Three-fourths mile west of Shell Bluff, Shoal River, Walton County, Fla.
 3742. Shell Bluff, Shoal River, Walton County, Fla.
 3747. 8 miles south of Lake De Funiak, Walton County, Fla.
 3748. Summerville mill race, 1 mile east of Argyle, Walton County, Fla.
 3749. Allen Senterfeit's mill, 3 or 4 miles north of Campton, Walton County, Fla.
 3856. 6 miles west-northwest of Mossyhead, Walton County, Fla.
 4966. 1,000 feet above Georgia, Florida & Alabama Railroad bridge over Ochlockonee River, Wakulla County, Fla.
 4976. White Springs, Hamilton County, Fla.
 4977. W. C. Rose's farm, West Sopchoppy, Wakulla County, Fla.
 4978. Rose's Mill Creek, 3 miles west of Sopchoppy, Wakulla County, Fla.
 4986. Miller's quarry, 1 mile from Ellenton, Manatee County, Fla.
 4991. Ochlockonee River, 1 mile north of Holland, Leon County, Fla.
 5079. One-half mile below Shell Bluff, Shoal River, Walton County, Fla.
 5080. First ravine below Shell Bluff, Shoal River, Walton County, Fla.
 5184. First ravine below Shell Bluff, Shoal River, Walton County, Fla.
 5192. Folk's Creek, 4 miles south of Argyle, Walton County, Fla.
 5193. Crowder's Crossing, 1½ miles below Shell Bluff, Shoal River, Walton County, Fla.
 5194. 1½ miles below Shell Bluff, Shoal River, Walton County, Fla.
 5195. First ravine below Shell Bluff, Shoal River, Walton County, Fla.
 5613. Coronet phosphate mine, 5 miles southeast of Plant City, Hillsborough County, Fla.
 5618. 3½ miles southwest of De Funiak Springs, Walton County, Fla.
 5629. Coronet phosphate mine, 5 miles southwest of Plant City, Hillsborough County, Fla.
 5630. 100 yards below Oak Grove Bridge, Yellow River, Okaloosa County, Fla.
 5631. Oak Grove Bridge, Yellow River, Okaloosa County, Fla.
 5632. Oak Grove, Yellow River, Okaloosa County, Fla.
 5633. Oak Grove, Yellow River, Okaloosa County, Fla.
 6175. Left bank of Suwannee River three-fourths mile above White Springs, Columbia County, Fla.
 6196. Rock stratum lying immediately above fuller's earth at Ellenton, Manatee County, Fla.

6197. Limestone underlying fuller's earth at Ellenton, Manatee County, Fla.
6208. Marl underlying phosphate of Pierce Phosphate Co., Pierce, Polk County, Fla.
6209. 2½ miles southwest of Phosphate Mining Co.'s pit No. 4, Mulberry, Polk County, Fla.
6769. East bank of Suwannee River at wagon bridge at White Springs, Hamilton County, Fla.
6775. Spring on left bank of Suwannee River about 100 yards above Rock Island and about half a mile above White Springs, Columbia County, Fla.
6776. Spring on left bank of Suwannee River about 100 yards above Rock Island and about half a mile above White Springs, Columbia County, Fla.
6778. Spring on left bank of Suwannee River about 100 yards above Rock Island and about half a mile above White Springs, Columbia County, Fla.
6783. Langston's Sink, about 4 miles northwest of Lake City, on road to White Springs, Columbia County, Fla.
6800. Preston Sink, 3 miles north of Waldo, Alachua County, Fla.
6801. Lochloosa Creek, near Magnesia Spring, about 3 miles west of Hawthorn, Alachua County, Fla.
7054. 400 feet below bridge, Oak Grove, Okaloosa County, Fla.
7055. Old Senterfeit mill, 4½ miles southwest of Laurel Hill, Walton County, Fla.
7148. Gastropod Gulch, 5½ miles southeast of Bainbridge, Decatur County, Ga.
7151. Tenmile Creek, Calhoun County, Fla.
7183. Alum Bluff (lower bed), Liberty County, Fla.
7256. Look and Tremble Shoals, Chipola River, Calhoun County, Fla.
7257. Sexton's marl bed, sec. 11, T. 1 N., R. 10 W., Tenmile Creek, Calhoun County, Fla.
7261. Upper Alaqua Lethu (?) Bluff, near De Funiak Springs, Walton County, Fla.
7264. De Funiak *Cardium* beds, Alaqua, Walton County, Fla.
7468. Sopchoppy, Wakulla County, Fla.
7847. Lake Butler, Bradford County, Fla.
7893. Boynton Landing, Choctawhatchee River, Washington County, Fla.
9957. Gully south of the road and east of the bridge over White's Creek, on road from Eucheeanna to Knox Hill, 6.7 miles south of Argyle, 1.7 miles southeast of Eucheeanna, Walton County, Fla.
9958. Site of Flournoy's old mill, about 1¼ miles northeast of Argyle, Walton County, Fla.
9959. One-fourth mile west by north of Pleasant Ridge Church, 5.2 miles southwest of De Funiak Springs, Walton County, Fla.
9960. Folk's Creek, sec. 21 or 22, T. 3 N., R. 18 W., 6 miles south of Argyle and 1.7 miles from Eucheeanna, Walton County, Fla.
9961. Horse Creek, 1½ miles south of Oak Grove, Okaloosa County, Fla.
9994. John M. P. McClelland's farm, Chipola River, Calhoun County, Fla.
10596. Waldon Bridge over Bruce Creek, 5 miles west of Red Bay, Walton County, Fla.
10603. Gully south of the road and east of the bridge over White's Creek, on road from Eucheeanna to Knox Hill, 6.7 miles south of Argyle, 1.7 miles southeast of Eucheeanna, Walton County, Fla.
10608. White's Creek, half a mile below bridge on Eucheeanna-Knox Hill road, Walton County, Fla.
10609. The Woodyard, three-fourths mile above Shell Landing, Holmes Creek, Washington County, Fla. (lower bed).
10610. The Woodyard, three-fourths mile above Shell Landing, Holmes Creek, Washington County, Fla. (upper limestone.)
10611. White's Creek near water's edge, half a mile below bridge over creek on road from Eucheeanna to Knox Hill, 6.7 miles south of Argyle, 1.7 miles southeast of Eucheeanna, Walton County, Fla.
10612. Chester Spence's farm, 5 miles southwest of De Funiak Springs, at head of Sconter's Mill Creek, Walton County, Fla.
10658. Shell Bluff, Shoal River, 6 miles west-northwest of Mossyhead, Walton County, Fla.
10659. Tanner's mill (Old Senterfeit mill), 4 miles southwest of Laurel Hill, Okaloosa County, Fla.
10660. Lower bed, Alum Bluff, Liberty County, Fla.
10661. Godwin Bridge over Shoal River, 5 to 6 miles northwest of Mossyhead, Walton County, Fla.
10662. Lower bed, Shoal River, between Godwin Bridge and Shell Bluff, 5 to 6 miles west-northwest of Mossyhead, Walton County, Fla.
10663. Crowder's Crossing, 1½ miles below Shell Bluff, Shoal River, Walton County, Fla.
10860. Boynton Landing, 4 miles east of Miller's Ferry, Washington County, Fla.
10869. Folk's Creek, 6 miles south of Argyle, Walton County, Fla.

SYSTEMATIC DESCRIPTIONS

Phylum MOLLUSCA

Class PELECYPODA

Order PRIONODESMACEA

Section TAXODONTA

Superfamily NUCULACEA

Family NUCULIDAE

Genus NUCULA Lamarck

1799. *Nucula* Lamarck, Prodrôme d'une nouvelle classification des coquilles: Soc. hist. nat. Paris Mém., p. 87.

Type: *Arca nucleus* Linnaeus. (Recent off the European coast from the Faroe Islands to the Aegean Sea; Pliocene of England and southern Europe.)

Shell nacreous, small, trigonal to subcircular or elliptical; umbones subcentral or posterior; two series of transverse, numerous and close-set hinge teeth, separated by a triangular chondrophore; surface generally smooth or concentrically striated; margins simple or crenulate; adductor impressions subequal, two in number; pallial line simple.

Nucula is represented in the Alum Bluff group of Florida, as at so many other horizons and areas, by a few common species. Each horizon has its own characteristic member of the group. There is but the single *Nucula* in the Oak Grove sand—*Nucula sinaria* Dall—a variable and prolific species that is restricted to the single horizon. *Nucula chipolana* Dall is almost equally abundant at the horizon which it characterizes. The subspecies which occurs in the Shoal River formation is less common and is replaced in the environs of De Funiak Springs by a larger form—*Nucula defuniak* Gardner, n. sp. The fifth species—*Nucula dasa* Gardner, n. sp.—has been found only at the type locality in the Chipola formation on Choctawhatchee River.

The distribution of the genus in the Alum Bluff bears much the same relationship to its occurrence in Miocene deposits to the north and south as does the distribution of *Nucula* in the Recent seas. In the early Miocene, as in Recent times along the Atlantic coast north of Hatteras, the individuals were large and increasingly abundant toward the north. The Florida species are very much smaller but still abundant, whereas *Nucula tenuisculpta* Gabb, which is characteristic of the Miocene West Indian faunas, is very small and never common.

The genus has survived from the middle Paleozoic, possibly because of its remarkable adaptability. It is found in both shallow and deep water and on both sandy and muddy bottoms. Though characteristic of the boreal and temperate oceans the group has also a meager representation in the tropical seas.

Shell conspicuously thin:

Altitude of adult shell rarely exceeding 3 millimeters.

Nucula chipolana Dall.

Altitude of adult shell usually exceeding 3 millimeters.

Nucula chipolana waltonia Gardner, n. subsp.

Shell heavy:

Escutcheon depressed, not radially striated:

Umbones low.....*Nucula sinaria* Dall.

Umbones moderately tumid and elevated.

Nucula dasa Gardner, n. sp.

Escutcheon not depressed, radially striate.

Nucula defuniak Gardner, n. sp.

***Nucula chipolana* Dall**

Plate II, Figure 1

1898. *Nucula chipolana* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 575, pl. 32, fig. 10.

Dall describes this species as follows:

Shell small, solid, polished, with faint radial striae more conspicuous ventrally, and more or less obvious incremental lines; beaks turgid, low; posterior end of shell obliquely truncate, flattish; base arcuate, anterior dorsal line sloping, anterior end attenuated and rounded; there is no defined lunule; the escutcheon is elongate-cordate, ill-defined, the margins in the middle line slightly pouting; internally polished, hardly pearly, with the basal margin finely sharply crenulate; the chondrophore small, narrow, and very oblique, anteriorly directed; anterior teeth narrow, slender, about thirteen; posterior teeth four or five. Longitude of shell, 4 millimeters; altitude, 2.75 millimeters; diameter, 2.0 millimeters.

The chief characteristics of this small species are its elongated form and fine radial striae.

Type: U. S. Nat. Mus. No. 136098.

Type locality: No. 2564, McClelland farm, 1 mile below Baileys Ferry, Calhoun County, Fla.

The species, broadly considered, is thinner shelled and more compressed than any of the other Alum Bluff forms, though this character is less marked at Alum Bluff than on Chipola River. The range of variation in outline is comparable to that of *Nucula sinaria* from Oak Grove, although the average individual from Oak Grove is larger and higher than that from Chipola River and Alum Bluff. The forms referred to the subspecies *waltonia* are also a little larger than *chipolana* s. s. and relatively higher, but the thinner shell and more delicate hinge are sufficient to separate them from *sinaria*. Then, too, the escutcheon of *sinaria* is slightly sunken and not merely flattened as in *chipolana* s. l. In *Nucula dasa* from the Chipola formation on Choctawhatchee River the shell is very heavy and rather inflated and the escutcheon is depressed.

Nucula chipolana Dall is abundant at the horizon which it characterizes.

Occurrence: Chipola formation, localities 10609^p, 10610^p, 7257^c, 2213^{pr}, 2564^c, 3419^a, 7151^a, 2211^a, 7183^c. Shoal River formation, locality 10661^p.¹⁰

***Nucula chipolana waltonia* Gardner, n. subsp.**

Plate II, Figures 2-3

Shell of moderate dimensions for the genus, thin and rather compressed. Umbones small, obtuse, opisthogyrate, posterior in position. Umbonal angle not far

¹⁰ pr, Prolific; a, abundant; c, common; p, present; r, rare (not more than half a dozen individuals).

from 90°. Anterior dorsal margin feebly convex, much more produced than the obliquely truncate posterior slope. Basal margin asymmetrically arcuate, more strongly upcurved behind than in front. Lunule not sharply delimited, indicated by the flattening of the shell. Escutcheon narrow, elongate, cordate, flattened but not depressed. A subcutaneous radial sculpture developed, usually obsolete in the umbonal region but fine and regular toward the base, where the sulci number about 12 to the millimeter and are separated by flat interradians that are more than double their own width. Basal margin finely serrate in harmony with the radials. Concentric sculpture restricted to grayish color bandings and obscure resting stages. Ligament entirely internal, lodged in a small cuneiform resilium rudely parallel to the anterior dorsal margin. Hinge rather delicate. Teeth taxodont, arranged in two discrete series, the posterior including six in the type, the anterior three times as many. The half dozen umbonal teeth in the anterior series exceedingly small and crowded, the medial teeth in both the anterior and posterior series slender but well elevated. Muscle impressions and pallial line very obscure because of the thinness of the shell.

Dimensions: Altitude, 3.2 millimeters; latitude, 4.0 millimeters; semidiameter, 1.2 millimeters.

Type: U. S. Nat. Mus. No. 352288.

Type locality: No. 3742, Shell Bluff, Shoal River, Walton County, Fla.

The Shoal River species is larger than that from the Chipola and relatively higher. The radial sculpture is commonly a little stronger and more persistent in the umbonal region, but this is not a constant character.

Occurrence: Shoal River formation, localities 3856^p, 2645^p, 3742^c, 10658^r, 2238^p, 9957^r.

Nucula sinaria Dall

Plate II, Figure 4

1898. *Nucula sinaria* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 575, pl. 32, fig. 7.

Dall describes this species as follows:

Shell small, solid, trigonal, polished, with fine radial striae, more distinct near the basal margins, and faint, concentric, rather irregular furrows, obsolete over most of the valve but tending to be stronger near the anterior and posterior slopes; here and there one crosses the whole shell like the indication of a resting stage; dorsal slopes nearly straight, base arcuate, ends rounded; lunule absent, escutcheon impressed; striated, the margins not putting in the middle; beaks prominent, obtuse; interior brilliantly pearly, muscular impressions deep; the basal margin finely crenulate; hinge strong, wide; the chondrophore oblique, heavy; anterior teeth wide, strong, about seventeen, posterior about seven. Longitude of shell, 4.75 millimeters; altitude, 4 millimeters; diameter, 2.5 millimeters.

This species differs from the preceding (*Nucula chipolana* Dall) by its more trigonal, heavy, and pearly shell, its wider and proportionately heavier hinge, and its impressed instead of merely flattened escutcheon.

Type: U. S. Nat. Mus. No. 135820.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County, Fla.

Nucula sinaria Dall exhibits a remarkable range of variation in dimensions and relative proportions. The type is larger, much higher, and more trigonal than the average individual from Oak Grove. The differences in the peripheral members are sufficiently great to be given subspecific rank, but as they are apparently of no stratigraphic or geographic significance there is little to be gained by splitting the series. The depressed escutcheon is a character shared by only one other Alum Bluff species, *Nucula dasa*, from the Chipola formation on Choctawhatchee River. The Chipola species is usually lower and heavier than *N. sinaria* and is more inflated in the umbonal region.

Occurrence: Oak Grove sand, localities 2646^p, 5632^a, 5631^c, 5633^c, 7054^c, 9961^c, 10659^c.

Nucula dasa Gardner n. sp.

Plate II, Figures 5-7

Shell highly polished, small, heavy, quite strongly inflated. Umbones quite prominent, obtuse, flattened upon their summits, opisthogyrate, set well within the posterior third. Umbonal angle not far from 90°. Posterior dorsal slope very steep. Anterior rather gentle and feebly arcuate. Basal margin more sharply upcurved in front than behind. Lunule narrow, elongated, not sharply delimited but defined by the flattening of the shell and by the darker coloring of the lunular area. Escutcheon rather narrow, cordate, feebly depressed, the depression emphasized by the slightly raised margins. Radial sculpture restricted to exceedingly fine lines, least faint near the base but commonly obscured even there by the surface glaze. Basal margin finely but sharply serrate. Concentric striae also very faint. Resting stages rarely developed. Ligament internal, lodged in a very small cuneiform resilium elongated parallel to the anterior dorsal margin. Hinge dentition strong and heavy. Teeth taxodont, arranged in two discrete series, the anterior series in the type including 15, the posterior 7, the half dozen nearest the umbones in the anterior series very fine and crowded, the posterior teeth and, more especially, the anterior teeth away from the umbones, elevated, compressed, curved slightly toward the dorsal margins but not hooked. Muscle impression and pallial line usually very obscure because of the highly polished inner surface. Anterior scar placed well down toward the base at the distal extremity of the hinge, larger, less rounded, and more ventral in position than the posterior scar. Pallial line simple, moderately near to the basal margin.

Dimensions: Altitude, 3.2 millimeters; latitude, 3.55 millimeters; semidiameter, 1.5 millimeters.

Type: U. S. Nat. Mus. No. 352289.

Type locality: No. 7893, Boynton Landing, Choctawhatchee River, Washington County, Fla.

Nucula dasa Gardner, n. sp., is the heaviest and most inflated species known from the Alum Bluff. In these characters it is contrasted sharply with the coexistent *N. chipolana* Dall, which is the thinnest and the most compressed. *N. dasa* shares with *N. sinaria* the sunken escutcheon, but the shell is less inflated in the Oak Grove species and the umbones less prominent.

Nucula dasa is known only from the type locality.

Occurrence: Chipola formation, locality 7893P.

***Nucula defuniak* Gardner, n. sp.**

Plate II, Figures 8-10

Shell of moderate dimensions for the group, not very strongly inflated in the umbonal region and compressed toward the ventral margins, rounded, trigonal in outline. Umbonal angle obtuse, not quite 90°. Umbones very small, opisthogyrate, posterior in position. Posterior dorsal slope consequently steeper than the anterior. Ventral margin asymmetrically arcuate, more strongly upcurved behind than in front. Lunule not defined, indicated by the flattening of the valves over a lenticular area, a slight darkening of the shell, and the closer radials. Escutcheon obscurely defined, cordate, flattened but not sunken, the shell substance darker as in the lunular area and the radials closer and stronger. Radial sculpture developed in the form of subcutaneous linear sulci, least faint toward the ventral margins, numbering 10 or 12 to the millimeter, and near the margin of the adult separated by flat interspaces of more than double their own width. Ventral margin finely crenate in harmony with the radials. Lunule sculptured with about 9 slightly wider radials separated by relatively narrow interspaces, the sculptured area cut off from the central portion of the shell and from the margin, which is microscopically serrated by the radials. Concentric sculpture restricted to an obscure color banding and a few ill-defined resting stages. Ligament internal, lodged in a narrow, cuneate, anteriorly directed resilium. Teeth arranged in two discrete series, 13 in number in the anterior series of the type, 7 in the posterior, the teeth shorter toward the umbones, especially in the anterior series, the medial teeth in each series very long and hooked, the hooks turned toward the dorsal margins. Muscle impressions placed at the extremities of the dental series, obscure, the anterior relatively higher and narrower than the posterior. Pallial line simple, distinct, distant from the basal margin. Inner margins in many specimens radially striate almost to the pallial line.

Dimensions: Altitude, 4.3 millimeters; latitude, 5.0 millimeters; semidiameter, 1.7 millimeters.

Type: U. S. Nat. Mus. No. 352290.

Type locality: No. 5618, 3½ miles southwest of De Funiak Springs, Walton County, Fla.

Nucula defuniak is very close to the type of *N. sinaria* in dimensions and outline but stands apart

from that species and from all the other Alum Bluff forms by reason of the radial sculpture upon the escutcheon.

The teeth in the anterior series of larger but less perfect individuals number as high as 18.

The species is best represented in the environs of its type locality.

Occurrence: Shoal River formation, localities 3856^r, 5079^p, 9958^r, 3748^c, 3747^c, 7261^p, 7264^p, 9960^c, 9957^r, 10603^c, 5618^c, 9959^p.

Family LEDIDAE

Genus LEDA Schumacher

1817. *Leda* Schumacher, Essai d'un nouveau système des habitations des vers testacés, pp. 55, 172.

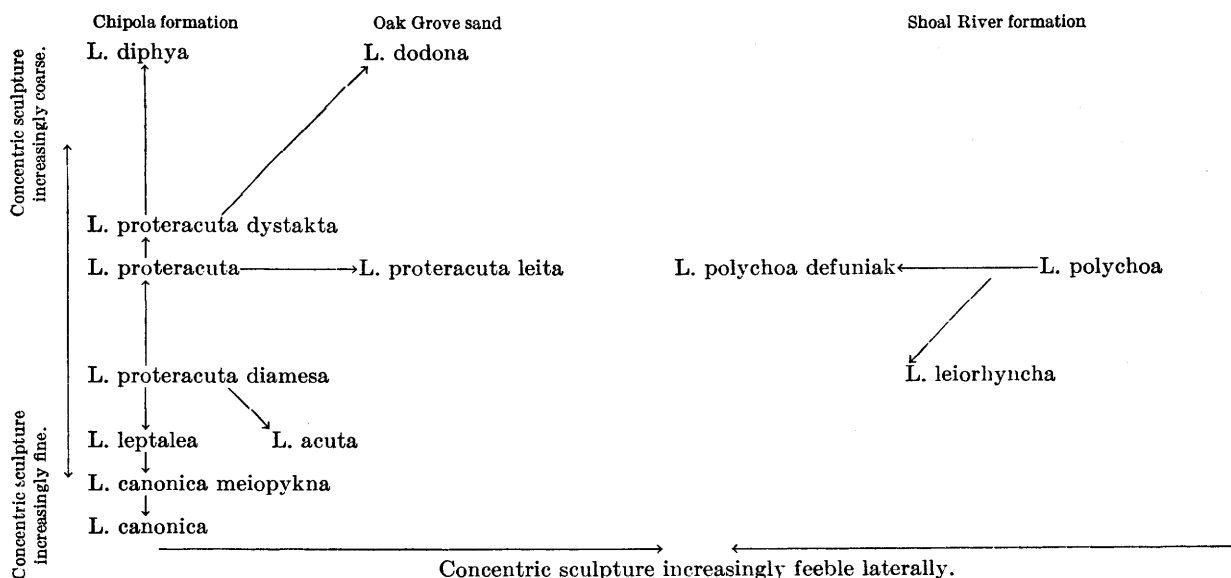
Type: *Arca rostrata* Gmelin=*Leda pernula* (Müller). (Recent in the North Atlantic.)

Shell solid, porcellaneous, transversely elongate, rounded anteriorly, more or less rostrate posteriorly; beaks proximate, commonly tumid, feebly opisthogyrate; exterior surface concentrically sculptured; hinge armature taxodont, the teeth arranged in an anterior and a posterior series; chondrophore subumbonal, trigonal; pallial line interrupted by a shallow sinus corresponding to the short siphons of the animal; inner ventral margins simple.

This genus also originated in the Paleozoic but in the Silurian, one period later than *Nucula*. The more than 80 living species have a wide geographic and bathymetric distribution, although the majority are boreal. *Leda* is conspicuously more abundant in the Miocene Floridian faunas than in those of the West Indies.

The smaller Alum Bluff Ledas, dissimilar as are the peripheral species, show an astonishing gradation, which relates even such unlike forms as *Leda canonica* Dall and *Leda diphya* Gardner, n. sp. The genus is abundant in the Chipola formation, being represented by eight species. In the Oak Grove sand *Leda* is remarkably rare. There is a single species peculiar to the formation and two other species, each of them represented by a single imperfect individual, one of which has been tentatively referred to a Chipola form and the other remains unnamed. A Shoal River *Leda* may be present at one locality. In the Shoal River formation the genus returns to prominence, though it is not quite so conspicuous at that horizon as it is in the Chipola. The three smaller Shoal River species are with one possible exception restricted in their range to the single horizon, though they have analogs in the Chipola faunas. The remarkable *Leda basilissa* Gardner, n. sp., recalls *Leda pharcida* Dall of the Wilcox fauna.

The relationship of the smaller Alum Bluff Ledas as indicated by the concentric sculpture may be expressed by the accompanying diagram.



The other characters—general outline, umbones, lunule, escutcheon, dentition, and muscle and mantle scars—vary but little. The Shoal River forms as a rule are larger than those from the Chipola and, on the whole, the more coarsely sculptured forms are more heavily built throughout.

Latitude of adult exceeding 15.0 millimeters.

Leda basilissa Gardner, n. sp.

Latitude of adult not exceeding 15.0 millimeters:

Latitude of adult rarely exceeding 7.0 millimeters; concentric sculpture as a rule not conspicuously coarse and distant toward the umbones:

Umbones broadly rounded:

Concentric ridges more or less obtuse, rarely exceeding 30 in number:

Concentric sculpture close and flattened over the entire surface. . . . *Leda? acuta* Conrad.
Concentric sculpture, if present, more or less elevated.

Leda proteracuta Gardner, n. sp., s. l.

Between 20 and 25 concentric ridges, most prominent medially, inclined to weaken and become obsolete laterally.

Leda proteracuta Gardner, n. sp., s. s.

Between 15 and 20 concentric ridges, relatively coarse and distant toward the umbones.

Leda proteracuta dystakta Gardner, n. subsp.

Concentric sculpture obsolete except near the tips of the umbones and the ventral margin.

Leda proteracuta leita Gardner, n. subsp.

From 25 to 30 concentric ridges, as a rule, in many specimens irregularly spaced.

Leda proteracuta diamesa Gardner, n. subsp.

Concentric ridges commonly acute, exceeding 30 in number in the adult:

From 30 to 40 acute concentric ridges.

Leda leptalea Gardner, n. sp.

More than 40 obtuse or subacute concentric ridges. *Leda canonica* Dall, s. l.

Concentric ridges exceedingly fine and closely crowded, 10 to 25 to the millimeter. . . . *Leda canonica* Dall, s. s.

Between 40 and 50 concentric ridges.

Leda canonica meiopykna Gardner, n. subsp.

Umbones obliquely flattened:

Concentric ridges rarely exceeding 40 and rarely altogether obsolete upon the rostrum:

Concentric sculpture persistent upon the rostrum. . . *Leda polychoa* Gardner, n. sp., s. l.

Concentric sculpture more or less obsolete upon the rostrum.

Leda polychoa defuniak Gardner, n. subsp.

Concentric ridges usually exceeding 40, altogether obsolete upon the rostrum.

Leda leiorhyncha Gardner, n. sp.

Latitude of adult usually exceeding 7.0 millimeters; concentric sculpture conspicuously coarse and distant toward the umbones:

Concentric sculpture on the medial portion of the shell becoming abruptly finer and closer; escutcheon finely and regularly laminated.

Leda diphya Gardner, n. sp.

Concentric sculpture uniform in character over the entire medial portion of the shell; escutcheon smooth or irregularly laminated. *Leda dodona* Dall.

Leda basilissa Gardner, n. sp.

Plate II, Figures 11-12

Shell very large, exceedingly brittle, compressed, transversely elongated, slightly produced and rostrate posteriorly. Umbonal angle very wide. Anterior dorsal margin gently declining, posterior feebly concave. Anterior lateral margin smoothly rounded but not bowed beyond the distal extremity of the dorsal margin. Posterior extremity probably obliquely truncate. Base line arcuate, more strongly upcurved in front than behind. Umbones swollen near their tips, slightly overtopping the dorsal margins, the tips proximate and feebly opisthogyrate. Lunule sublinear, depressed, extending almost but not quite to the lateral extremity, outer margin sharply elevated. Escutcheon narrow, lanceolate, concave, unequally divided by a sharply elevated line that cuts off an

inner lanceolate area. Incrementals of the inner area rudely parallel to the dorsal margin, of the outer area oblique to it. External surface finely and regularly sculptured concentrically, the sharply elevated, somewhat laminar threads of the umbonal area developing away from the umbones into crowded lamellae ventrally overlapping, raised slightly toward the anterior dorsal margin, abruptly disappearing at the edge of the lunule, bent abruptly outward and slightly downward at the keel, slightly flexuous across the keel, disappearing abruptly at the edge of the escutcheon; interspaces decidedly wider than the laminae upon the rostrum, not so wide upon the disk. Ligament internal, the pit wide, trigonal, sunk deep beneath the umbones. Dental series somewhat concavo-convex. The anterior series arched upward toward the dorsal margin, including 33 to 38 teeth, those at the extremities of the series short and straight, the medial teeth elevated and >-shaped, the apex of the angle directed toward the umbone. Number in posterior series probably a little higher. Adductor and pallial scars obscure.

Dimensions of left valve: Altitude, 14.3 millimeters; latitude, $32.0 \pm$ millimeters; semidiameter 4.5 millimeters. Dimensions of right valve of a larger specimen: Altitude, 17.0 millimeters; latitude $38.2 \pm$ millimeters; semidiameter 5.0 millimeters.

Cotypes: U. S. Nat. Mus. No. 352291.

Type locality: No. 3733, three-fourths of a mile west of Shell Bluff, Shoal River, Walton County, Fla.

Leda basilissa Gardner, n. sp., is a descendant of the group of *Leda pharcida* Dall of the Wilcox fauna, a shell of similar outline but not so large; it is more elongated transversely and the characters of lunule and escutcheon are similar, but the surface is more sharply sculptured.

The types are badly mutilated, but the shell is so unlike anything closely allied in time or space that it seems worth while to bring even the imperfect material to light.

Occurrence: Shoal River formation, locality 3733^r.

Leda acuta (Conrad)

Plate II, Figures 13-16

1832. *Nucula acuta* Conrad, American marine conchology, p. 32, pl. 6, fig. 3.
 Not *Nucula acuta* Sowerby, Geol. Soc. London Trans., 2d ser., vol. 5, pl. 39, fig. 5, 1837.
1845. *Nucula acuta* Conrad, Fossils of the medial Tertiary of the United States, p. 57, pl. 30, fig. 2.
1846. *Nucula carinata* H. C. Lea, Am. Philos. Soc. Trans., new ser., vol. 9, p. 244, pl. 24, fig. 28.
1846. *Nucula acutidens* H. C. Lea, idem, p. 244, pl. 34, fig. 29.
1857. *Nucula acuta* Say. Tuomey and Holmes, Pleiocene fossils of South Carolina, p. 53, pl. 17, figs. 10-12.
1858. *Leda acuta* Emmons, North Carolina Geol. Survey Rept., p. 287, fig. 208 A.
1860. ?*Nucula acuta* Holmes, Post-Pleiocene fossils of South Carolina, p. 16, pl. 3, fig. 7.

1862. *Leda unca* Gould, Boston Soc. Nat. Hist. Proc., vol. 8, p. 282.
1863. *Nuculana acuta* Conrad, Acad. Nat. Sci. Philadelphia Proc. for 1862, p. 581.
1863. *Nuculana acutidens* H. C. Lea. Conrad, idem, p. 581.
1863. *Nuculana carinata* H. C. Lea. Conrad, idem, p. 581.
1864. *Nuculana acuta* Conrad. Meek, Check list of the invertebrate fossils of North America, Miocene, Smithsonian Misc. Coll., vol. 7, No. 183, p. 5. (Name only.)
1864. *Nuculana acutidens* (H. C. Lea). Meek, idem, p. 5. (Name only.)
1864. *Nuculana carinata* (H. C. Lea). Meek, idem, p. 5.
1881. *Leda jamaicensis* D'Orbigny. Dall, Harvard Coll. Mus. Comp. Zoology Bull., vol. 9, p. 124.
1882. *Leda unca* Gould. Verrill, Connecticut Acad. Arts and Sci. Trans., vol. 5, p. 572, pl. 58, fig. 41.
1884. *Leda acuta* (Conrad). Verrill, Connecticut Acad. Arts and Sci. Trans., vol. 6, p. 259, pl. 30, fig. 15.
1886. *Leda acuta* Conrad. Dall, Harvard Coll. Mus. Comp. Zoology Bull., vol. 12, p. 251; pl. 7, figs. 3a, 3b, 8.
1889. *Leda acuta* Conrad. Dall, Harvard Coll. Mus. Comp. Zoology Bull., vol. 18, p. 438.
1889. *Leda acuta* Conrad. Dall, U. S. Nat. Mus. Bull. 37, p. 44, pl. 7, figs. 3a, 3b, 8; pl. 45, fig. 15; pl. 64, fig. 140.
1898. *Leda acuta* Conrad. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, pp. 592, 593.
1904. *Leda concentrica* (Say). Glenn, Maryland Geol. Survey, Miocene, p. 397, pl. 108, figs. 1, 2 (part).
1906. *Leda acuta* (Conrad). Clark, Maryland Geol. Survey, Pliocene and Pleistocene, p. 208, pl. 65, figs. 5-8.

Conrad described this species in 1832, as follows:

Shell ovate elongated, convex, with numerous regular concentric striae; anterior side slightly recurved and very acute at the extremity, and with the dorsal margin sunk so as to form a lanceolate depression; beaks behind the center; fosset very small and hardly oblique.

Habitat: Tertiary of Virginia.

Type: Academy of Natural Sciences, Philadelphia.

The perplexing possibilities of variation in *Leda acuta* Conrad are due largely to its wide geographic distribution and to its great geologic range. The recent representatives present a comparative uniformity of development, whereas the Tertiary forms indicate a period of instability and evolution for the species. In the young the valves are higher, decidedly less convex, and the posterior dorsal margin straighter.

The great majority of the numerous Alum Bluff individuals commonly referred to *Leda acuta* have been distributed among *Leda proteracuta* and its subspecies, but there remain a few forms, most of them immature and badly worn, which probably represent a species distinct from both *acuta* and *proteracuta* but which have been tentatively included under the former. They are characterized by a relatively low, transversely ovate, trigonal outline and a concentric sculpture of very low, narrow, broadly rounded concentric ridges separated by little more than linear grooves, approximately uniform from the umbones to the ventral margin, slightly more compressed anteriorly, and not persistent across the rostrum. The normal sculpture of *Leda acuta* is a little more elevated and sharper, and there is no

subspecies of *proteracuta* which combines so fine and close a sculpture with one so much compressed.

Occurrence: Chipola formation, localities ?2213^p, ?2564^p, ?3419^p, ?7151^r.

Outside occurrence: Miocene: Calvert formation, Virginia; St. Marys formation, Virginia, North Carolina; Yorktown formation, Virginia, North Carolina; and Duplin formation, North Carolina, South Carolina, Georgia. Pliocene: Waccamaw formation, North Carolina, South Carolina; Caloosahatchie formation, Florida; and Croatan formation, Virginia, North Carolina. Pleistocene: Maryland, North Carolina, South Carolina, Florida. Recent: Rhode Island to Sombrero, in 7 to 225 fathoms.

Leda proteracuta Gardner, n. sp.

Plate II, Figures 17-18

1898. "*Leda acuta* Conrad." Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 592 (part).

Not *Nucula acuta* Conrad, American marine conchology, p. 32, pl. 6, fig. 1, 1832.

Shell rather small, delicate, polished, broadly and smoothly rounded in front of the umbones, narrow and cuneiform behind them. Umbones low, flattened upon their summits, the apices obtuse, incurved, and feebly opisthogyrate, submedial or slightly anterior in position. Lunule narrow, lenticular, defined by the obtuse angulation of the shell and by the abrupt change in the character of the concentric sculpture. Escutcheon broad, produced to the posterior extremity of the shell, very finely and sharply striated. Rostrum acutely rounded even to the tip, thrown into relief by the obscure depression in front of it and in the majority of forms by the absence of the concentric sculpture which ornaments the greater part of the disk. Concentric sculpture developed to a greater or less degree over the disk; umbones finely and sharply ridged, the ridges broadening and becoming more obtuse away from the umbones but persisting as a rule to the ventral margin, most elevated medially, usually obsolete upon the keel and more or less obsolete upon the depression in front of the keel and often upon the anterior portion of the disk as well; the ridges numbering normally from 15 to 20 if persistent to the base, separated on the medial portion of the shell by interspaces of about their own width but more crowded ventrally. Ligament internal, lodged in a minute chondrophore sunk deep beneath the umbones. Dentition normal for the group, the anterior series including approximately 17 teeth, the posterior approximately 12; teeth delicate, compressed, elevated in the medial portion of each series, especially of the posterior, fine and crowded near the chondrophore, slightly A-shaped, the angle directed toward the umbones. Muscle and mantle scars obscure because of the high polish of the interior. Anterior adductor moderately large,

irregular in outline, placed just within the distal extremity of the hinge; posterior adductor much smaller, narrow, elongated in the direction of the dorsal margin. Pallial sinus short, broad, ascending, obtusely truncate at the extremity. Pallial line moderately distant from the basal margin.

Dimensions: Altitude, 2.8 millimeters; latitude, 5.0 millimeters; semidiameter, 1.5 millimeters.

Type: U. S. Nat. Mus. No. 352292.

Type locality: No. 7257, Sexton's marl bed, Ten-mile Creek, Calhoun County, Fla.

Leda proteracuta is one of several species and subspecies included in the reference labels within the confines of that protean species *Leda acuta* Conrad. It is quite possibly the ancestor of Conrad's species and resembles its descendant in the range of variation. It is, however, constantly smaller than *Leda acuta*, more delicate, and as a rule relatively higher. The few individuals in the Chipola which it has not seemed advisable to separate specifically from *Leda acuta* have a lower, more compressed sculpture, uniformly close over the medial portion of the disk though weakening laterally.

Leda proteracuta, s. l. includes those forms that are characterized by a wide, finely striated escutcheon and a sculpture of more or less obtuse concentric ridges, rarely persistent across the rostrum, commonly obsolete toward both the anterior and the posterior lateral margins and in some specimens restricted to the tips of the umbones, the ridges usually of low or moderate elevation and fairly close and regular in spacing, some of them conspicuously coarse and distant toward the umbones and others narrow, subacute, and quite closely spaced. The individuals in which the sculpture is conspicuously coarse, conspicuously fine, or conspicuously absent are excluded from *Leda proteracuta* s. s. The coarsely sculptured individuals are segregated under the subspecies *dystakta*. As in the still more distantly sculptured *Leda diphyia*, the sculpture of *dystakta* becomes abruptly finer, closer, and commonly less regular upon the ventral portion of the shell. *Leda dodona* Dall is closely related to these coarser peripheral members, but it is more compressed toward the umbones and the ornamentation upon the escutcheon is irregular and more or less obsolete. The individuals in which the sculpture is restricted to the tips of the umbones and to crowded incrementals toward the ventral margin of the adults are segregated under the subspecies *leita*. These forms are for the most part more delicate and highly polished than is normal for the species. Those individuals that are characterized by a relatively fine, close, subacute sculpture have been segregated under *diamesa*. Through *diamesa* the species *Leda proteracuta* s. l. is related to the still more finely, sharply, and regularly sculptured *Leda leptalea* and through *Leda leptalea* in turn to *Leda canonica meioptykna* and

Leda canonica s. s., a shell so finely ornamented that under low magnification the ridges appear as a mere shagreen upon the surface. There is a less complete but roughly parallel series in the Shoal River fauna. *Leda polychoa* is the analog of *proteracuta* but runs a little larger and relatively higher and is more obliquely flattened upon the umbones than the Chipola species. The subspecies *defuniak* varies along lines similar to those followed by *leita*, but the sculpture is never so nearly obsolete. *Leda leiorhyncha* has no exact analog in the Chipola, for the concentric ridges are not only less persistent than in *polychoa* but they are also decidedly finer, suggesting in this variation *Leda proteracuta diamesa*.

Leda proteracuta is abundant not only in the wider but also in the restricted sense throughout the Chipola.

Occurrence: Chipola formation, localities 10609^p, 7257^p, 2213^a, 2564^a, 3419^a, 7151^p.

***Leda linifera chipolana* Dall**

1898. *Leda linifera* var. *chipolana* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 591.

Dall describes this variety as follows:

The Chipola beds have afforded another species of the same group (Nat. Mus. 114808) which in form and sculpture much resembles *Leda linifera*, but the shell is more inflated, the rostrum more pointed, with a marked inflection of the basal margin below it, and the anterior end is more attenuated. For the present this may take the provisional name of *Leda linifera* var. *chipolana*, though sufficient material would probably show it to be distinct. It is represented in the collection by only a single specimen 2.5 millimeters long.

Type: U. S. Nat. Mus. No. 114808.

The unique type is an extremely young form from which the entire outer surface has been removed by erosion. The few characters which were developed during the short life of the shell are so ill preserved that they do not furnish sufficient basis for identification with other individuals. The type, however, is apparently the young of *Leda proteracuta* Gardner, n. sp.

Occurrence: Chipola formation, locality 2213^r.

***Leda proteracuta dystakta* Gardner, n. subsp.**

Plate III, Figure 5

Shell similar in general aspect to *Leda proteracuta*, s. s., rather small and thin, moderately inflated. Anterior portion of shell broadly rounded or obscurely truncate at the lateral extremity, the posterior portion cuneate, sharply rounded at the tip of the rostrum. Umbones low, broad, obtuse at the tips, incurved, opisthogyrate, slightly anterior. Lunule very narrow, lenticular, slightly depressed, defined by the abrupt disappearance of the concentric sculpture. Escutcheon very wide, biconcave in the double valves, the space between the rostrum and the dorsal margin moderately excavated, persistent to the tip

of the rostrum, finely and closely striated independently of the sculpture upon the disk. Rostrum quite sharply angulated toward the beaks, rounded off toward the outer extremity, emphasized by the feeble depression and weakened or obsolete sculpture in front of it. Anterior ray usually distinct. Sculpture very coarse for the group, especially in the umbonal region: Concentric ridges at the extreme tips of the umbones fine, sharp, and closely spaced, the eight or nine succeeding ridges broad for the group, obtuse, quite prominently elevated, somewhat flexuous and inclined to arch upward toward the umbones, more or less compressed anteriorly, pinching out and disappearing toward the rostrum, separated by interspaces almost double their own width; ventral portion of shell much more finely and less regularly sculptured, a few of the ridges persistent across the rostrum. Ligament minute, trigonal, sunk deep beneath the umbones. Teeth laminar, acutely angulated, somewhat Λ -shaped, the angle dorsally directed, quite sharply elevated in the medial portion of each series, densely crowded toward the umbones, especially in the anterior series; anterior series consequently including 18 denticles, the posterior only 14. Adductor scars obscure, especially the rather large, roundish anterior scar; posterior impression much smaller, elongated parallel to the dorsal margin, slightly depressed. Pallial sinus short, broad, ascending, obliquely truncate at its extremity.

Dimensions: Altitude, 3.5 millimeters; latitude, 6.4 millimeters; semidiameter, 1.7 millimeters.

Type: U. S. Nat. Mus. No. 352294.

Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla.

Leda proteracuta dystakta differs from *proteracuta* s. s. in the coarser, more flexuous, and more distant concentric sculpture of the dorsal portion of the shell. The majority of the individuals preserved are juveniles which are sculptured with approximate regularity on the dorsal and ventral portions of the shell. The adults, however, exhibit a change in sculpture which both in degree and kind suggests *L. diphya*, though the umbonal sculpture is not so coarse in the species from Chipola River as in that from Choctawhatchee River, and the age variation is consequently less marked.

Occurrence: Chipola formation, localities 10609^p, 7893^r, 7257^r, 2213^p, 2564^p, 3419^p.

***Leda proteracuta leita* Gardner, n. subsp.**

Plate III, Figures 1-4

Shell rather small and delicate, moderately inflated, very highly polished, transversely ovate-trigonal in outline. Anterior portion of shell broadly and smoothly rounded, the gently inclined or feebly convex dorsal margin merging smoothly into the rounded, lateral margin and this in turn into the up-

curved base line. Posterior portion of shell narrow, produced, and rostrate, the dorsal margin very slightly excavated, rounding sharply at the tip of the beak into the upcurved base. Ventral margin asymmetrically arcuate, the maximum curvature in line with the umbones. Umbones low, broadly rounded, the apices incurved and feebly opisthogyrate. Lunule narrow, lenticular, defined by the obscure angulation of the valves and by the abrupt change in the character of the concentric sculpture if present. Escutcheon much wider, produced to the posterior extremity of the shell, very finely and sharply striated. Rostrum narrow and compressed in the umbonal region, a little broader and less acute toward the extremity, emphasized slightly by the obscure depression in front of it. Anterior ray quite distinct on the polished surface. External surface lustrous, sculptured only by a feeble corrugation in the umbonal region; the ridges fine and sharp at the apices but broadening as they disappear, more persistent, as a rule, on the medial portion of the disk than toward the margin, microscopically fine and crowded, concentric; scratches also commonly visible on the surface glaze, especially toward the ventral margin, which is in places roughened by resting stages, with equally fine, fortuitous radials locally developed on the anterior and medial portions of the shell. Ligament internal, lodged in an exceedingly small chondrophore sunk deep beneath the umbones. Teeth rather delicate, but acute and prominently elevated in the medial portion of each series; anterior series including approximately 18 teeth, the posterior 11 or 12—the larger number in the anterior series due to the larger number of fine, crowded, subumbonal teeth. Inner surface highly polished, obscuring the adductor and mantle scars. Anterior adductor scar moderately large, roundish, placed directly within the distal extremity of the hinge. Posterior adductor scar much smaller, extremely narrow, elongated parallel to the dorsal margin. Pallial sinus short, broad, angular, the margins rudely parallel, the extremity obliquely truncate. Pallial line at some little distance from the basal margin.

Dimensions: Altitude of right valve, 3.0 millimeters; left valve, 3.0 millimeters. Latitude of right valve, 6.0 millimeters; left valve, 5.5 millimeters. Semidiameter of right valve, 1.5 millimeters; left valve, 1.45 millimeters.

Cotypes: U. S. Nat. Mus. No. 352293.

Type locality: No. 7257, Sexton's marl bed, Tenmile Creek, Calhoun County, Fla.

Leda proteracuta leita is a small, delicate shell readily isolated from the other Alum Bluff Ledas by the smooth and highly lustrous surface. It is separated from *Leda proteracuta* s. s. by the restriction of the sculpture to the apical region and the growth lines toward the ventral margin.

Occurrence: Chipola formation, localities 10609^p, 7257^p, 2213^a, 2564^a, 3419^a, 9994^p, 7151^c. Oak Grove sand, locality ? 2646^r.

Leda proteracuta diamesa Gardner, n. subsp.

Plate III, Figure 6

Shell similar in dimensions and outline to others of the group, rather small, moderately inflated, transversely ovate-trigonal in outline, broadly rounded in front of the umbones, produced and rostrate behind them. Umbones low, rounded, feebly opisthogyrate, subcentral or slightly anterior. Lunule narrow, lenticular, feebly depressed, indicated chiefly by the abrupt weakening of the concentric sculpture. Escutcheon much wider, produced to the posterior extremity, concave between the rostrum and the dorsal margin, very finely and regularly striated; rostrum quite sharply angulated near the umbones, more obtuse away from the umbones, emphasized by the obscure depression in front of it. Anterior ray feeble or obsolete. External surface corrugated with narrow, acutely rounded concentric ridges, most elevated medially, somewhat flattened, as a rule, anteriorly and weakening toward the rostrum though usually persistent across it, numbering not far from 30, regularly spaced toward the umbones in the majority of forms but tending to become crowded and irregular near the basal margin. Ligament pit minute, trigonal, sunk deep beneath the umbones. Dentition vigorous, normal for the group. Teeth elevated and acutely pointed in the medial portion of each series, very fine and crowded toward the umbones, especially in the anterior series; the number of teeth consequently as many as 18 or 20 in the anterior series, though only about 14 in the posterior. Anterior muscle scar irregular and somewhat roundish in outline, the posterior a mere dent. Pallial sinus short, broad, ascending obliquely, truncated dorsally. Pallial line not very far from the basal margin.

Dimensions: Altitude, 3.7 millimeters; latitude, 6.5 millimeters; semidiameter, 1.8 millimeters.

Type: U. S. Nat. Mus. No. 352295.

Type locality: No. 7257, Sexton's marl bed, Tenmile Creek, Calhoun County, Fla.

Leda proteracuta diamesa includes those forms at the opposite end of the series from the coarsely sculptured forms that have been segregated under *Leda proteracuta dystakta*. *Leda proteracuta diamesa* is more closely sculptured than *Leda proteracuta* s. s., the spacing of the concentric ridges is usually less regular, and the tendency of the sculpture to become obsolete toward the rostrum and the anterior extremity is much less marked.

Many of the individuals approach very closely to *Leda leptalea*, though the concentric ridges are coarser, more obtuse, and usually more irregular and less persistent toward the rostrum.

Occurrence: Chipola formation, localities 7257^p, 2213^c, 2564^c, 3419^c, 7151^p.

Leda leptalea Gardner, n. sp.

Plate III, Figures 7-8

Shell rather small for the genus and delicate, moderately inflated, transversely ovate-trigonal in outline. Anterior dorsal margin gently declining, the posterior more steeply and slightly upturned at the extremity. Anterior lateral margin broadly rounded or obscurely truncate, the posterior extremity of the rostrum very sharply rounded. Base line strongly but somewhat asymmetrically rounded. Umbones rather low and broad, obtuse and feebly opisthogyrate at the tips, slightly anterior in position. Lunule very narrow, lenticular, feebly depressed, defined chiefly by the abrupt weakening of the concentric striae. Escutcheon much wider, persistent almost to the posterior extremity, concave between the rostrum and the dorsal margin, very finely and regularly striated in harmony with the concentric sculpture upon the disk. Rostrum acutely angulated toward the umbones, sharply rounded away from them. External surface corrugated with 30 to 40 fine, closely and regularly spaced, subacute, concentric ridges, approximately uniform in prominence from the lunule to the escutcheon, though flattened somewhat upon the anterior portion of the shell, continuous for the most part across the rostrum, though weakening upon it toward the ventral margin. Ligament pit minute, trigonal, entirely internal, sunk deep beneath the umbones. Dentition normal for the group. Denticles acute, prominently elevated in the medial portion of each series, slightly Λ -shaped, the apex of the angle directed toward the umbones, numbering approximately 16 in the anterior series and 13 in the posterior, the larger number in the anterior series due to the more numerous minute teeth crowded in front of the umbones. Anterior muscle scar rather large, irregular in outline, placed just within the distal extremity of the hinge teeth. Posterior adductor scar much smaller, slightly sunken, elongated parallel to the dorsal margin. Pallial sinus very short, rather broad, ascending. Pallial line at a moderate distance from the basal margin.

Dimensions: Altitude, 3.5 millimeters; latitude, 5.7 millimeters; semidiameter, 1.6 millimeters.

Type: U. S. Nat. Mus. No. 352296.

Type locality: No. 3419, McClelland farm, 1 mile below Baileys Ferry, Calhoun County, Fla.

Leda leptalea is a species intermediate between the dissimilar forms *Leda proteracuta* Gardner, n. sp., and *Leda canonica* Dall. It is more finely, sharply, and regularly sculptured than *Leda proteracuta* but more coarsely and distantly than *Leda canonica*. The gaps between are partly filled on the one side by *Leda proteracuta diamesa*, a form characterized by a sculpture not only coarser than that of *Leda leptalea* but usually less regular and less persistent toward the rostrum; on the other side by *Leda canonica meioptykna*,

a subspecies differing from *Leda canonica* only in the less fine concentric sculpture. *Leda leptalea* is well distributed through the Chipola, but it is not a common species at any of the known localities.

Occurrence: Chipola formation, localities 10609^p, 2213^p, 2564^p, 3419^p, 7151^r.

Leda canonica Dall

Plate III, Figures 15-17

1898. *Leda (linifera* Conrad, var. ?) *canonica* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 591.

Dall describes this species as follows:

The present form, represented by two small specimens about 2.5 millimeters long, is more elongate, less compressed, the rostrum has a rounded dorsal keel, and the surface is uniformly covered with fine, even, concentric sculpture. It is probably a distinct species, less robust than young *Leda acuta* Conrad of the same size but for which the material is hardly adequate to a full description and figure. The shell is near *Leda calatibianensis* Seguenza,¹¹ from the Astian of Italy.

Shell rather small and delicate for the genus, moderately inflated, transversely ovate-trigonal in outline, quite strongly and nearly symmetrically rounded in front of the umbones, produced into a subacute rostrum behind them. Umbones well rounded, not very prominent, feebly opisthogyrate, slightly anterior in position. Lunule very narrow, lenticular, defined only by the abrupt weakening of the concentric sculpture. Escutcheon much wider, depressed, persistent to the tip of the rostrum, very finely and evenly threaded in harmony with the sculpture upon the disk. Rostrum subacute, sharply rounded at the tip, emphasized by the obscure depression behind it. Anterior ray obscure or obsolete. Concentric sculpture exceedingly fine and regular over the entire shell, continuous across the rostrum, the ridges numbering from 10 to 25 to the millimeter. Ligament pit minute, sunk deep beneath the umbones. Dentition vigorous, the teeth acute and prominently elevated in the medial portion of each series, slightly Λ -shaped, the angle directed toward the umbones. Anterior series including approximately 15 to 18 teeth; the posterior teeth less fine, crowded toward the umbones, and only about 12 to 15. Anterior muscle scar moderately large, irregular in outline, placed just within the distal extremity of the hinge. Posterior scar smaller, somewhat depressed, elongated parallel to the dorsal margin. Pallial sinus short, broad, ascending, obtusely rounded at its extremity. Pallial line at some little distance from the basal margin.

Dimensions of right valve of an adult specimen: Altitude, 3.1 millimeters; latitude, 5.2 millimeters; semidiameter, 1.5 millimeters. Dimensions of left valve of another specimen: Altitude, 2.9 millimeters; latitude, 5.0 millimeters; semidiameter, 1.5 millimeters.

¹¹ Seguenza, Giuseppe, *Nuculidi terziarie rinvenute nelle provincie meridionali d'Italia*: R. Accad. Lincei Mem., vol. 1, pl. 2, fig. 9a, 1877.

Type: U. S. Nat. Mus. No. 114806; figured specimen, No. 352300.

Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla.

Unfortunately this not uncommon species was first described from juveniles of which one must serve as the type. *Leda canonica* includes the extreme end members in the Chipola of the *Leda proteracuta* group. The species is much more finely and more closely sculptured than any other of the Chipola species, though it approaches them through the subspecies *meiopykna* and *Leda leptalea*. The sculpture in *Leda canonica* (in a strict sense) is microscopically fine, and even under moderate magnification commonly appears as a shagreening rather than a true sculpture.

Occurrence: Chipola formation, localities 7257^p, 2213^p, 2564^c, 3419^c, 7151^p.

***Leda canonica meiopykna* Gardner, n. subsp.**

Plate III, Figure 18

Shell, small, rather thin, delicate, moderately inflated, transversely ovate-trigonal in outline, quite strongly rounded in front of the umbones, produced and obtusely rostrate behind them. Umbones rounded, obtuse, subcentral, feebly opisthogyrate. Lunule extremely narrow, lenticular, ill-defined. Escutcheon quite wide, persistent almost to the extremity of the rostrum, concave between the rostrum and the dorsal margin, very finely and evenly striated with a concentric sculpture closer than that upon the disk. Rostrum acutely angulated toward the umbones, sharply rounded toward the posterior extremity; surface covered with 40 to 50 fine, regular, subacute concentric ridges, approximately uniform in prominence throughout their extent though slightly lower and more obtuse on the anterior portion of the shell, persistent across the rostrum except toward the ventral margin. Ligament minute, sunk deep beneath the umbones, entirely interned. Dentition normal for the species; teeth laminar, elevated, acute, somewhat Λ -shaped, the angle directed toward the umbones, 10 or 11 in the posterior series, 12 or 13 in the anterior. Anterior adductor scar moderately large, irregular in outline, placed at the distal extremity of the hinge. Posterior scar much smaller, elongated parallel to the dorsal margin. Pallial sinus short, broad, ascending. Pallial line rather distant from the basal margin.

Dimensions of right valve: Altitude, 3.0 millimeters; latitude, 5.6 millimeters; semidiameter, 1.2 millimeters.

Type: U. S. Nat. Mus. No. 352301.

Type locality: No. 2564, McClelland farm, 1 mile below Baileys Ferry, Calhoun County, Fla.

Leda canonica meiopykna differs from *Leda canonica* s. s. only in the less crowded concentric sculpture. This character is so marked, however, that there seems to be reason for segregating the individuals that exhibit it. Through the subspecies *Leda canonica* approaches

Leda leptalea, although there is a distinct hiatus between the exceedingly fine sculpture of *canonica* and the less fine ornamentation of *leptalea*. The subspecies is rather less common than the restricted *canonica*.

Occurrence: Chipola formation, localities 2213^p, 2564^p, 3419^p.

***Leda polychoa* Gardner, n. sp.**

Plate III, Figures 9-10

Shell of moderate dimensions for the genus, quite solid, rather compressed in the immature forms, usually inflated in the adult, ovate-trigonal in outline, produced and acutely rostrate behind. Umbones submedial or anterior, very small but rather prominent because of their position at the apex of the triangle, flattened upon their summits, the tips incurved and feebly opisthogyrate. Lunule very narrow, lenticular, the margin sharply elevated toward the umbones, evanescent away from the umbones so that the lunule is indicated merely by the flattening of the shell and by the abrupt weakening of the concentric sculpture. Escutcheon also lenticular but much broader and more produced than the lunule; margins elevated along the entire length of the escutcheon, though more sharply pinched toward the umbones; concentric sculpture upon the escutcheon much sharper than upon the lunule. Shell in front of the umbones smoothly rounded, behind the umbones acutely angulated. Anterior dorsal margin oblique or feebly arched, merging smoothly into the rounded lateral margin and the lateral margin into the upcurved base line; posterior dorsal margin obliquely produced, little or not at all excavated except at the slightly upturned extremity, where it intersects the base line. Base asymmetrically arcuate, the maximum curvature in line with the umbones. Rostral angle acute and persistent to the posterior extremity. Anterior ray obscure or obsolete. Sculpture concentric, exceedingly variable, very fine, sharp, and regular in the umbonal region, less fine, more or less obtuse, and commonly irregular away from the umbones; the number of concentric ridges usually from 30 to 35 but in a few specimens as high as 45; the ridges flattening slightly toward the rostrum but not obsolete upon it, every other one, as a rule, persisting across the escutcheon. Ligament internal, lodged in a minute triangular pit directly beneath the umbones. Dentition vigorous, the anterior series feebly convex and including approximately 16 teeth, the posterior feebly concave and including approximately 15 teeth; teeth very fine and crowded beneath the umbones but prominently elevated in the medial portion of the series, acutely tapering but not hooked at their summits, compressed at the base and slightly Λ -shaped, the angle directed toward the umbones; distal teeth moderately prominent. Adductor scars small and obscure on the highly polished surface, the anterior irregular in

outline, placed at the distal extremity of the hinge, accentuated in the heavier shells by a slightly raised margin, the posterior much smaller than the anterior and quite deeply indented. Pallial sinus very short, linguiform, usually ascending slightly. Pallial line moderately distant from the base.

Dimensions: Altitude, 3.5 millimeters; latitude, 6.1 millimeters; diameter, 2.5 millimeters.

Type: U. S. Nat. Mus. 352297.

Type locality: No. 3742, Shell Bluff, Shoal River, Walton County, Fla.

Leda polychoa is the Shoal River representative of the *Leda proteracuta* group in the Chipola. Both species are exceedingly variable, and the end members very closely approximate one another. However, the ensemble in the two forms is distinct and constant through the horizon which each characterizes. *Leda polychoa* Gardner, n. sp., runs a trifle larger and heavier than *Leda proteracuta* and is typically more oblique posteriorly. The concentric ridges are as a rule narrower and less regularly spaced in the individual, though exhibiting a much lower range of specific variation than *Leda proteracuta*. The young are much compressed in both species, but the adults in *Leda polychoa* are more inclined to be inflated than in *Leda proteracuta*. In some individuals in the Shoal River species the flattening of the umbones is so pronounced and the inflation of the medial portion of the disk so high that the shell has a pathologic aspect. This is especially true of the short, high forms with submedial umbones. The concentric ridges as a rule are fine, sharp, and regular in the umbonal region, less fine and commonly less regular on the medial portion of the disk, and more crowded again toward the ventral margin, so that the change in sculpture with age combined with the change in outline gives a very marked age variation to the species. Those forms that are characterized by a more or less obtuse and irregular concentric sculpture, feeble or obsolete upon the rostrum, have been segregated under the subspecies *defuniak*, so named because of the prevalence of this type of sculpture in the environs of De Funiak Springs. The subspecies also occurs, however, together with *Leda polychoa* s. s. at the type locality at Shell Bluff.

Occurrence: Shoal River formation, localities 3856^c, 2645^r, 3732^r, 3742^a, 10658^p, 5195^p, 5079^r, 3748^p, 9960^p, 9957^c, 10603^c, 10608^c.

***Leda polychoa defuniak* Gardner, n. subsp.**

Plate III, Figures 11-12

Shell rather small, solid, trigonal, smoothly rounded in front of the umbones, rostrate and sharply cuneate behind them. Umbones small, not very prominent except for their position, incurved and feebly opisthogyrate, submedial or slightly anterior. Lunule very narrow and ill-defined. Escutcheon quite wide,

produced to the posterior extremity, biconcave in the double valves, the outer margins sharply elevated, the hinge margin also slightly raised. Concentric sculpture quite sharp and regular upon the escutcheon but more or less obsolete upon the lunule. Anterior dorsal margin not far from horizontal, merging smoothly into the broadly rounded lateral margin. Posterior dorsal margin oblique except at the slightly upturned extremity, produced until it intersects the upcurved base line. Basal margin asymmetrically arcuate, the maximum curvature directly beneath the umbones. Sculpture exhibiting a range of variation parallel to that of *Leda polychoa* s. s. but usually less sharp and regular and obsolete upon the rostrum; concentric ridges normally fine, sharp, and regular upon the umbones, becoming more obtuse, less regular, and more distant away from the umbones, feeble, or obsolete toward the rostrum, and less elevated and in some specimens obsolete toward the anterior extremity; ventral portion of shell more finely and sharply sculptured as a rule than the medial, the ridges persistent in some of the senile forms across the rostrum; concentric ridges normally between 35 and 40 as in *Leda polychoa* s. s. Ligament internal, lodged in a minute, trigonal chondrophore directly beneath the umbones. Dentition vigorous; anterior series feebly arcuate and including 18 to 20 teeth, the posterior feebly concave and including approximately 15 teeth; the teeth laminar, fine and crowded toward the umbones, prominently elevated in the medial portion of each series, acutely tapering, slightly Λ -shaped. Interior highly polished. Muscle scars and pallial line obscure. Anterior adductor scar irregular, rounded in outline, of moderate size and placed directly beneath the distal extremity of the hinge. Posterior scar much smaller, depressed dorsally, elongated parallel to the dorsal margin. Pallial line rather distant from the base. Pallial sinus short, linguiform, ascending.

Dimensions: Altitude, 4.0 millimeters; latitude, 7.5 millimeters; semidiameter, 2.0 millimeters.

Type: U. S. Nat. Mus. No. 352298.

Type locality: No. 5618, 3½ miles southwest of De Funiak Springs, Walton County, Fla.

The subspecies characterized by the feeble or obsolete sculpture upon the rostrum and usually by a less sharp and regular sculpture upon the disk is the common *Leda* in the environs of De Funiak Springs. The sculpture as a rule is sharper and more regular at the type locality of the subspecies than it is in the individuals that occur along Shoal River at the type locality of *Leda polychoa* in a strict sense. The range of variation in outline is lower than in the restricted species, and the short, highly inflated type is absent. The characters of the subspecies are commonly more marked in the young than in the adult, for in some of the adults the sculpture toward the ventral margin

persists across the rostrum. In a few forms the sculpture is obsolete over so wide an area both on the posterior and the anterior portion of the shell that the ornamentation suggests *Leda proteracuta leita*. A series of parallel variations is exhibited not only in the subspecies of *Leda proteracuta* from the Chipola but also in *Leda acuta*, which occurs in the Duplin Miocene of North Carolina.

Occurrence: Oak Grove sand, locality ?9961^p. Shoal River formation, localities 3742^p, 5079^r, 3733^r, 3748^r, 3747^p, 7261^r, 7264^p, 9960^p, 9957^c, 10603^c, 10608^c, 5618^c.

Leda leiorhyncha Gardner, n. sp.

Plate III, Figures 13-14

Shell rather small, solid, moderately inflated, transversely ovate-trigonal in outline, broadly and symmetrically rounded in front of the umbones, cuneate behind them, the obliquely produced posterior dorsal margin intersecting the upcurved base in a subacute angle. Umbones low, rounded upon their summits, incurved, opisthogyrate, slightly anterior. Lunule narrow, ill-defined, obscurely laminated. Escutcheon much wider, produced to the posterior extremity of the shell, well defined, quite sharply laminated in harmony with the sculpture upon the disk. Rostral angle acute toward the umbones, obtuse toward the outer margin. External surface sculptured with very fine, usually regular, quite sharply elevated or obtusely flattened concentric ridges, numbering about 40 to 45. Rostrum smooth, the unsculptured area becoming increasingly narrow toward the umbones. Sculpture less elevated upon the anterior portion of the shell than upon the medial but persistent to the lunule. Ligament internal, lodged in a minute, subumbonal chondrophore. Dentition vigorous; teeth compressed, somewhat Λ -shaped, the angle directed toward the umbones, arranged in two discrete series; anterior series feebly arched and including as a rule from 16 to 18 teeth; posterior series oblique or very slightly concave and including from 13 to 15 denticles; medial teeth in each series conspicuously elevated, less prominent toward the ventral extremities of the hinge and exceedingly small and crowded near the chondrophore. Anterior adductor scar obscure, irregular in outline, placed directly within the distal extremity of the hinge. Posterior scar smaller but much more distinct, elongated parallel to the hinge, impressed dorsally. Pallial sinus broad but rather short. Pallial line at some little distance from the basal margin.

Dimensions: Altitude, 3.5 millimeters; latitude, 6.0 millimeters; semidiameter, 1.6 millimeters.

Type: U. S. Nat. Mus. No. 352299.

Type locality: No. 3742, Shell Bluff, Shoal River, Walton County, Fla.

Leda leiorhyncha is a member of the group of *Leda polychoa* and closely resembles the more elongated, finely sculptured individuals of that species. Unlike

them, however, the rostrum is smooth, as if it had been planed and later polished. The absence of sculpture upon the rostrum suggests *Leda polychoa defuniak*, but the sculpture of the subspecies is more crowded and more regular and usually sharper. *Leda leiorhyncha* exhibits less variation than any other of the Shoal River Ledas, possibly because it is more restricted in its distribution.

Occurrence: Shoal River formation, localities 3742^c, ? 7264^r.

Leda diphya Gardner, n. sp.

Plate IV, Figures 13-15

Shell of moderate dimensions, quite heavy, highly inflated in the adult, ovate-trigonal, the anterior portion of the shell broadly and symmetrically rounded, the posterior portion narrow, rostrate, and cuneiform. Umbones gibbous except at the apices, which are flattened, incurved, opisthogyrate, and slightly anterior. Anterior dorsal margin merging smoothly into the broadly rounded lateral margin, which in turn merges into the upcurved base line. Posterior dorsal margin feebly convex, produced to meet the ventral margin. Base line asymmetrically arcuate, the maximum curvature in line with the umbones. Lunule extremely narrow, lenticular, defined by the abrupt weakening of the concentric laminae. Escutcheon conspicuously broad, concave, sharply differentiated, finely and regularly striated without regard to the sculpture upon the disk. Rostral angle acute toward the umbones, less sharp away from them but persistent to the outer extremity. Ornamentation remarkably discrepant in the young and the adult; juveniles and the umbonal region in the adults sculptured with 8 or 9 obtuse ridges, elevated, somewhat flexuous, and inclined to arch slightly upward toward the umbones, flattening near the margin of the lunule and obsolete upon the rostrum, separated from one another by wider interspaces, microscopically striated oblique to the ridges; change in character of sculpture very abrupt, the ventral two-thirds or more of the shell being finely and closely ribbed with about 25 narrow, rounded threads approximately uniform from the lunule to the rostrum which they override; interspaces little more than linear, not quite so narrow upon the medial portion of the disk where the shell is most inflated. Ligament internal, lodged in a minute pit sunk deep beneath the umbones. Teeth arranged in two discrete series approximately 18 in the posterior, 20 in the anterior, the anterior series very slightly concave, the posterior very slightly convex; teeth much compressed, acute, somewhat Λ -shaped, the angle directed toward the umbones, prominently elevated in the medial portion of each series, rather densely crowded. Anterior adductor scar quite large, obscurely quadrate, placed at the distal extremity of the hinge. Posterior adductor scar

little more than a deep dent oblique to the dorsal margin. Pallial sinus short, obtusely angulated, ascending. Pallial line at some little distance from the basal margin.

Dimensions: Altitude, 4.7 millimeters; latitude, 8.1 millimeters; semidiameter, 2.1 millimeters.

Type: U. S. Nat. Mus. No. 352302.

Type locality: No. 7893, Boynton Landing, Choc-tawhatchee River, Washington County, Fla.

There is no other post-Eocene *Leda* described from the east coast which exhibits an age variation so remarkable as that of *Leda diphya*, though it is suggested both in degree and kind by the Chipola River analog *Leda proteracuta dystakta*. The young suggest *Leda dodona* and an unnamed species from the Shoal River, though they are more heavily sculptured than either of the forms in question. The adult sculpture, on the other hand, suggests *Leda proteracuta diamesa* from the Chipola in its fineness, closeness, and regularity. This inconstancy of sculpture is a character exhibited by many of the Eocene species, and its persistence in the later fauna is noteworthy. Forms such as this should emphasize the inadvisability of describing juveniles.

Occurrence: Chipola formation, locality 7893P.

***Leda dodona* Dall**

Plate IV, Figure 6

1898. *Leda dodona* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 589, pl. 32, fig. 6.

Dall describes this species as follows:

Shell small, solid, slightly inequilateral, polished, strongly concentrically sculptured; sculpture of elegant, even, high, blunt-edged, slightly recurved lamellae, with deeply excavated, wider interspaces, which are striated by the lines of growth; the sculpture ends anteriorly at the margin of the lunule, and behind ceases on the rostral carina, about equally strong throughout; a radial depression extends from the beak to the anterior ventral margin, which it slightly emarginates; lunule narrow, transversely ribbed; escutcheon wider, extending to the end of the rostrum, bounded by a strong, rounded carina, on which the lamellae are conspicuous; within the carina the area is excavated and nearly smooth, except in the central part, where it is radially grooved; rostrum acute, slightly recurved near the tip, pallial sinus small; hinge with 19 anterior and 14 posterior rather solid teeth; chondrophore small, triangular. Longitude 9, altitude 5, diameter 4 millimeters.

Type: U. S. Nat. Mus. No. 135823.

Type locality: Oak Grove, Yellow River, Okaloosa County, Fla.

A single valve was found near De Funiak Springs which, though too imperfect to name, is interesting because it indicates the existence of the *dodona* group in the Shoal River. This valve is apparently adult but smaller than *Leda dodona* and not quite so high. The umbones are very much flattened and finely and sharply sculptured at the tips. Away from the tips there are four or five heavy, rounded ribs which increase rapidly in prominence. Between the most

conspicuous of these and the basal margin there are five additional ridges as broad but not so elevated as the medial rib, which by its prominence obscurely angulates the disk both externally and internally. The irregularity of the sculpture gives to the valve a pathologic aspect which may be normal for the species or may be merely an individual character.

Occurrence: Oak Grove sand, localities 2646P, 5632P, 9961P.

Genus YOLDIA Möller.

1842. *Yoldia* Möller, Index molluscorum Groenlandiae, p. 18.

Type: *Yoldia arctica* Möller. (Recent in the Arctic Ocean.)

The genus differs from *Leda* mainly in the posterior gape of the valves, the longer siphons and the consequently deeper pallial sinus.

Only two species have been recognized in the Alum Bluff. One of them, *Yoldia frater* Dall, is abundant in the Oak Grove and is present in the Shoal River and with modifications of doubtful taxonomic value in the Chipola; the other, *Yoldia soror*, is closely related to it and is restricted to the Shoal River. Both species are members of the very compact and closely related group represented in the east coast Miocene by *Yoldia laevis* Say and in the Pleistocene and Recent by *Yoldia limatula* Say. It is rather surprising to find this typically boreal genus so prominent in the warm-water faunas of the Alum Bluff.

Adult shell decidedly more than twice as long as it is broad.

Yoldia frater Dall.

Adult shell approximately twice as long as it is broad.

Yoldia soror Gardner, n. sp.

***Yoldia frater* Dall**

Plate IV, Figure 7

1898. *Yoldia frater* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 596, pl. 32, fig. 1.

Dall describes this species as follows:

Shell polished, thin, elongate, much resembling *Yoldia laevis*, from which it is distinguished by the less arcuate base, more attenuated anterior end, somewhat more compressed form, and, in the great majority of specimens, by having on the convexity of the beaks and the early part of their posterior slope a concentric sculpture of fine even riblets with about equal interspaces. There is also on the escutcheon an elevated radial line, absent on the corresponding part of *Yoldia laevis*, which also attains a nearly one-third larger size when full grown. There are about 26 teeth on each side of a small subumbonal chondrophore. Longitude 19, altitude 8, diameter 4 millimeters.

This shell is perhaps the ancestor of *Yoldia laevis*, from which it can usually be readily distinguished by its more rectangular form and sculptured umbones.

Type: U. S. Nat. Mus. No. 135821.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County, Fla.

There are, as a rule, only 21 to 23 teeth in each of the dental series. The pallial sinus is broad, linguiform,

with rudely parallel margins and a broadly rounded extremity. The pallial line runs very close to the basal margin.

The Chipola forms are generally thinner shelled and more compressed than those from Oak Grove, and the sculpture upon the umbones is more feeble and less persistent. However, these characters are so inconsistent in both the Chipola and the Oak Grove individuals that they are of very doubtful taxonomic value. The species is very prolific at the type locality and is abundant and widespread throughout the horizon. It is not an uncommon form in the Chipola fauna but nothing like so abundant as it is in the Oak Grove.

Occurrence: Chipola formation, localities 10611^a, 10596^c, 10609^c, 10610^p, 7893^p, 7257^p, 2213^c, 2564^p, 3419^p, 7151^p. Oak Grove sand, localities 2646^p, 5632^a, 5631^p, 5630^r, 5633^p, 7054^c, 9961^r. Shoal River formation, localities 5079^p, 5192^p, 9960^p.

Yoldia soror Gardner, n. sp.

Plate IV, Figures 8-12

Shell rather small for the genus, thin and very fragile, transversely ovate in outline, more attenuated and slightly gaping posteriorly, feebly inflated. Umbones small, well rounded, acutely pointed at their incurved, feebly opisthogyrate apices, slightly anterior. Lunule very narrow, lenticular, the margin sharply elevated toward the umbones but flattening distally. Escutcheon persisting the entire length of the posterior dorsal margin, narrow, delimited by a sharply incised groove, broken by a linear ridge running parallel to the groove and midway between it and the dorsal margin. Anterior dorsal margin very feebly convex, rounding abruptly into the broadly arcuate lateral margin. Posterior dorsal margin excavated, more produced than the anterior, the short lateral margin obtusely truncate. Base line horizontal medially, upcurved distally. External surface highly polished, retaining obscure traces of a concentric color banding, smooth except for incremental striae and a fine, faint concentric corrugation at the apices of the umbones. An anterior and a posterior area faintly indicated in some individuals by a change in the character of the color banding and of the incrementals. Ventral margins simple. Ligament entire, lodged in a short, rather wide, cuneate chondrophore directly beneath the umbones. Hinge teeth taxodont, slender, conic, acutely tapering but not hooked at their extremities, about 21 in the anterior series and 22 in the posterior, both series following parallel to the dorsal margin and thus forming a feebly concavo-convex hinge interrupted by the chondrophore. Muscle impressions and pallial sinus obscure because of the thin shell and highly polished interior. Anterior muscle scar rather large, rounded, placed well up under the distal extremity of the hinge. Posterior scar smaller and more angular, elongated parallel to the dorsal margin.

Pallial sinus broad, ascending, not persisting to the median horizontal. Pallial line running close to the basal margin.

Dimensions: Altitude, 5.6 millimeters; latitude, 11.5 millimeters; diameter, 4.0 millimeters.

Type: U. S. Nat. Mus. No. 352303.

Type locality: No. 3748, Summerville mill race, Walton County, Fla.

Yoldia soror Gardner, n. sp., is the closely related Shoal River analog of *Yoldia frater* of the Oak Grove and Chipola species. It differs in that it is relatively shorter and higher, the anterior and posterior portions of the shell are more nearly uniform in altitude, and the sculpture upon the umbones is more restricted or absent altogether.

Occurrence: Shoal River formation, localities 3856^a, 3742^c, 2238^r, 3748^p, 9957^p, 10603^c, 10608^p.

Superfamily ARCACEA

Family LIMOPSIDAE

Genus TRINACRIA C. Mayer

1868. *Trinacria* C. Mayer, Catalogue systématique et descriptif des fossiles des terrains tertiaires que se trouvent au Musée Fédéral de Zurich, vol. 3, pp. 59, 63.

Type: *Trigonocoelia crassa* Deshayes. (Eocene of the Paris Basin.)

Shell small, equivalved, inequilateral, not gaping. Outline transversely ovate to trigonal. Umbones small, subacute, opisthogyrate, submedial or slightly posterior. Anterior extremity broadly rounded. Posterior portion of shell more or less sharply rostrate, the rostral angle well defined toward the umbones but flattening toward the ventral margin. External surface usually smooth except for incrementals. Basal margin not serrate. Ligament area amphidetic. Ligament alivincular, seated on a small trigonal, depressed area directly beneath the umbones and persisting almost to the inner margin of the hinge, thus interrupting the dental series. Anterior and posterior series discrepant, the anterior usually including the larger number of teeth. Teeth very small, taxodont. Muscle impressions usually obscure, placed well up toward the dorsal margins. Pallial line simple.

Trinacria is a small group of restricted distribution. It has a moderate representation in the Eocene of continental Europe and is also present in the Eocene of the Gulf. It has not, however, been reported from strata younger than the Alum Bluff. One species and a subspecies occur in the Alum Bluff—*Trinacria meekii* Dall, a not uncommon little bivalve in the Oak Grove but rare in the Shoal River, and its subspecies *Trinacria parameekii* from the Chipola.

Altitude of adult approximately three-fifths the latitude.

Trinacria meekii Dall.

Altitude of adult less than three-fifths the latitude.

Trinacria meekii parameekii Gardner, n. subsp.

***Trinacria meekii* Dall**

Plate IV, Figure 1

1898. *Trinacria meekii* Dall, Wagner Free Inst. Sci. Trans. vol. 3, pt. 4, p. 604, pl. 32, fig. 17.

Dall describes this species as follows:

Shell small, solid, moderately convex, sculptured only with fine concentric lines; anterior end rounded, posterior somewhat shorter, more pointed; beaks low, with (in the adult) an almost linear depressed amphidetic area, interrupted by an oblique impressed subtriangular ligament pit which, though external, interrupts also the line of teeth; interior smooth, muscular impressions large, not bounded by an elevated line; pallial line slightly indented below the posterior adductor scar; there are about eight anterior and six posterior teeth, small and delicate; basal margin smooth and nearly straight. Longitude 5.5, altitude 3.2, diameter 2.2 millimeters.

Type: U. S. Nat. Mus. No. 135824.

Type locality: Oak Grove, Yellow River, Okaloosa County, Fla.

The Oak Grove forms run a little larger and a little heavier than the Chipola. The altitude is relatively higher, the umbones are more centrally placed, the posterior extremity is less nasute, and the base line not quite so straight as in the Chipola species. However, the end members at the two horizons distinctly overlap so that the differences can not be given full specific value.

Occurrence: Oak Grove sand, localities 2646^c, 5632^p, 5631^r, 5633^r, 7054^r. Shoal River formation, locality 3748^r.

***Trinacria meekii parameekii* Gardner, n. subsp.**

Plate IV, Figures 2-5

Shell small, thin, quite highly inflated, transversely ovate in outline. Umbones small, narrow, flattened upon their summits, acute at the tips, opisthogyrate, slightly posterior. Anterior dorsal margin approximately horizontal and parallel to the base, the posterior obliquely arcuate. Anterior extremity very broadly rounded, the posterior obtusely pointed. Base line approximately horizontal. Shell obscurely rostrate behind, the angle rather well defined toward the umbones but flattening toward the base. External surface sculptured only with fine incremental striae, emphasized here and there by a resting stage. Ventral margins smooth within. Ligament external. Ligament area exceedingly narrow, amphidetic. Ligament pit small, trigonal, depressed, subumbonal, elongated parallel to the anterior dorsal margin, produced almost to the inner margin of the hinge and thus interrupting the dental series. Teeth small, delicate, oblique to the margin, somewhat cuneate, the angle directed toward the umbones, 7 in the anterior series and 5 in the posterior, including the denticles at the extremities of each series. Muscle impressions and pallial line very obscure; scars moderately large for the size of the shell and placed

well up at the distal extremities of the teeth. Pallial line simple, parallel to the basal margin and not far distant from it.

Dimensions of right valve: Altitude, 2.6 millimeters; latitude, 4.5 millimeters; semidiameter, 1.4 millimeters. Dimensions of left valve: Altitude, 2.7 millimeters; latitude, 4.6 millimeters; semidiameter, 1.4 millimeters.

Cotypes: U. S. Nat. Mus. No. 352304.

Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla.

Trinacria meekii parameekii is smaller, thinner, relatively higher, and more angular than *Trinacria meekii* Dall from the Oak Grove. The umbones are more inclined to be posterior in the Chipola species, and the base line is usually straighter.

Occurrence: Chipola formation, localities 2213^p, 3419^r, 7151^p.

Family ARCIDAE**Genus ARCA (Linnaeus) Lamarck**

1758. Linnaeus, Systema naturae, 10th ed., p. 693.

1799. Lamarck, Prodrôme d'une nouvelle classification des coquilles: Soc. hist. nat. Paris Mém., p. 87.

Type: *Arca noae* Linnaeus. (Recent in the Mediterranean.)

Shell equivalve, oval or subquadrate. Valves closed or gaping ventrally. Sculpture generally heavy and radial. Hinge line long, straight, furnished with numerous transverse teeth. Umbones prominent, incurved, prosogyrate, separated by a rhomboidal ligamental area scarred with cartilage grooves. Margins smooth or crenulate. Pallial line simple. Adductor impressions subequal, strongly marked.

A genus represented by about 500 fossil species, which range from the Silurian onward, and by about 150 recent species which are widely distributed in the warmer seas from between tides to abyssal depths.

The abundance of the representatives of this genus, their wide range in time and place, together with their rather more than normal sensitiveness to environmental conditions, make them of peculiar importance in stratigraphic work.

The *Arca* fauna of the Alum Bluff includes 19 species. About two-thirds of this number occur in the Chipola, though only 8 of the 13 have not been reported from the Oak Grove as well. All three species of *Arca* s. s. are found in the Chipola, two in the Oak Grove, and none at all in the Shoal River. The two forms that occur in the Oak Grove—*Arca occidentalis* and *Arca umbonata*—reappear, however, in the later faunas and persist to the present day. All four *Barbatias*, too, are present in the Chipola, though three of them continue into the Oak Grove and one—*Arca adamsi*, which still persists in the living fauna—occurs also in the Shoal River. Neither is the fourth species—*Arca reticulata*—diagnostic, for

it is found in both the later Tertiary and the Recent faunas. *Diluvarca*, which is represented by 12 species, seems to be more sensitive and includes the more abundant and characteristic forms. Only a single species of *Diluvarca* occurs at more than one horizon and that form—*Arca hypomela*—is known in the Oak Grove from a single individual. The other six forms are all peculiar, though *Arca santarosana geraetera* has only subspecific value. *Arca staminata* seems to be restricted to the type locality at Alum Bluff. The diminutive *Arca mikkula* is the most abundant and widespread of the Chipola species. The four *Diluvarcas* from the Oak Grove are all allied to Chipola forms, though only *Arca hypomela* is specifically identical. *Arca dodona*, the most abundant of the four, is closely related to *Arca hypomela*. *Arca santarosana* is represented in the Chipola by a subspecies, whereas *Arca cardioides* is a very close analog of the Chipola *Arca initiator* and occupies a similar minor position in the fauna. The most prolific of the two Shoal River *Diluvarcas* is a probable analog of *Arca santarosana*, whereas the other finds its closest affinities among the *Arcas* of the upper bed at Alum Bluff.

Shell equivalve, transversely elongated, commonly rectangular; sculpture of crowded, irregular radials or, more rarely, evenly cancellated or granose:

Radials crowded and irregular:

Posterior keel well defined; umbones widely separated.....*Arca* s. s.

Altitude of adult exceeding 10 millimeters; radial sculpture not conspicuously delicate:

Posterior keel obtuse; concentric sculpture not strong enough to cancellate the surface.

Arca occidentalis Philippi.

Posterior keel acute; concentric sculpture strong enough to cancellate the surface.

Arca umbonata Lamarck.

Altitude of adult not exceeding 10 millimeters; radial sculpture conspicuously delicate.

Arca paratina Dall.

Posterior keel obscure or obsolete; umbones not widely separated.....*Barbatia (Plagiarca)*.

Shell compressed; latitude of adult exceeding 25.0 millimeters.

Barbatia (Plagiarca) marylandica Conrad.

Shell moderately inflated; latitude of adult not exceeding 25.0 millimeters.

Barbatia (Plagiarca) phalacra Dall.

Shell small, rudely rectangular; radials regular in size and spacing, evenly cancellated or granose...*Barbatia (Acar)*.

Radials evenly cancellated.

Barbatia (Acar) reticulata Gmelin.

Radials granose.

Barbatia (Fossularca) adamsi (Shuttleworth) Dall.

Shell commonly inequivalve, transversely elongated, rudely quadrate or ovate-trigonal in outline; radial sculpture regular.

Diluvarca.

Shell transversely elongated or ovate-trigonal; latitude, if ovate-trigonal, exceeding 10.0 millimeters:

Shell transversely elongated, the altitude in the adult forms rarely equaling three-fourths the latitude, the number of radials in such forms normally exceeding 32:

Radials normally not exceeding 32:

Latitude of adult shell exceeding 12.0 millimeters.....*Diluvarca latidentata* (Dall).

Latitude of adult shell not exceeding 12.0 millimeters.

Diluvarca mikkula Gardner, n. sp.

Radials normally exceeding 32:

Shell approximately twice as broad as it is high; radials on anterior and antero-medial portion of shell mesially sulcate:

Radials on postero-medial portion of shell mesially sulcate; latitude of adult exceeding 25.0 millimeters.

Diluvarca hypomela (Dall).

Radials on postero-medial portion of shell simple; latitude of adult not exceeding 25.0 millimeters.

Diluvarca acompsa (Dall).

Shell less than twice as broad as it is high:

Radials mesially sulcate; each half radial on the adult shell bisected by a shallow groove.....*Diluvarca dodona* (Dall).

Radials simple, not mesially sulcate.

Diluvarca strebla Gardner, n. sp.

Shell rudely quadrate or ovate-trigonal in outline, the altitude in the adult forms normally equaling or exceeding three-fourths the latitude; radials 27 to 33:

Radials usually 28 or 29, those on the anterior portion of the adult shell not mesially sulcate.

Diluvarca staminata (Dall).

Radials usually 30 to 32, those on the anterior portion of the shell mesially sulcate:

Shell not as high as it is broad:

Shell approximately three-fourths as high as it is broad.

Diluvarca santarosana (Dall).

Shell approximately seven-eighths as high as it is broad; umbones conspicuously narrow and elevated.

Diluvarca santarosana geraetera Gardner, n. subsp.

Shell approximately as high as it is broad.

Diluvarca waltonia Gardner, n. sp.

Shell ovate-trigonal; latitude not exceeding 10.0 millimeters; sculpture markedly discrepant in the two valves:

Latitude of adult rarely exceeding 5.5 millimeters.

Diluvarca (Cunearca) initiator (Dall).

Latitude of adult usually exceeding 5.5 millimeters.

Diluvarca (Cunearca) cardioides Gardner, n. sp.

Subgenus ARCA s.s.

Type: *Arca noae* Linnaeus. (Recent in the Mediterranean.)

The typical *Arcas* are transversely elongated, rudely quadrate, commonly irregular in outline, inequilateral, and gaping anteriorly. The beaks are prominent, placed well forward, and separated by a wide cardinal area scarred with oblique, discontinuous ligament grooves. The hinge line is straight; the teeth are numerous, subequal, and approximately at right angles to the margin.

Arca occidentalis Philippi

1847. *Arca occidentalis* Philippi, *Abbildungen und Beschreibungen Conchylien*, vol. 3, p. 29, pl. 4, fig. 4.

1917. *Arca occidentalis* Philippi. Sheldon, *Palaeontographica Americana*, vol. 1, No. 1, p. 8, pl. 1, figs. 8, 9, 10, 11.

1917. *Arca occidentalis* Philippi. Maury, Bull. Am. Paleontology, vol. 5, No. 29, p. 163, pl. 29, fig. 3.
Arca noae of many authors, not of Linnaeus.

Philippi described this species in 1847 as follows:

A. testa elongato-oblonga, subquadrangula; latere antico breviusculo, angulo fere recto terminato; postico emarginato; carina obtusa ab apice decurrente; costis regularibus, prominentibus, interstitia longitudinaliter striata subaequantibus; medianis parum minoribus; area dorsali mediocri; ligamento illam maxima ex parte occupante. Long. 22''; alt. 10''; crass. 11''.

Patria: Indiae Occidentales; ad Cubam legit cl. Pfeiffer.

Type locality: West Indies.

The typical recent specimens are large, transversely elongated shells covered with a heavy epidermis. The outline is conspicuously irregular. The umbones are rather small but acute, compressed, widely separated and placed well within the anterior third. The dorsal margin is straight and marks the maximum latitude of the shell. From the anterior extremity of the hinge the lateral margin slopes backward to the shallow byssal gape. The posterior portion of the ventral margin is broadly convex, the posterior lateral margin quite strongly concave. The rostrum is well defined from the umbones to the outer margin. The umbonal sulcus is feebly developed and broadens rapidly toward the ventral margin, coinciding at the base with the byssal gape. The radial sculpture is very irregular. As a rule there are 6 to 8 strong well-rounded cords on the anterior portion of the shell, with or without intercalated linear secondaries, and 12 or 15 finer and more closely spaced radials, usually with filamentous secondaries upon the median depression. Between the sulcus and the posterior keel the primaries are low, broad, in many specimens mesially furrowed, about 10 in number, and separated by interspaces of varying width in which from 1 to 5 secondaries are developed. The sculpture between the keel and the dorsal margin is the coarsest upon the shell. The number of primaries is about half a dozen, and they are so disposed that there is quite an area between the outer primary and the dorsal margin, which is either finely striated radially or sculptured only with the incrementals which are best developed upon this portion of the shell. The cardinal area is broad and somewhat kite-shaped, the ligament area more restricted than the cardinal, especially behind the umbones, and scarred with irregular furrows converging toward the umbones. The hinge margin is very finely and sharply serrate, the lateral and ventral margins obscurely crenulated in harmony with the external sculpture. The Oak Grove specimens are young but appear to be identical with the Recent species.

The date of publication of D'Orbigny's *Arca barbadensis* is uncertain, so that for the present it is unnecessary to supplant Philippi's well-known name.

Arca paratina Dall is similar in general characters to the young *occidentalis* but is a more delicate shell

and much more finely sculptured. *Arca umbonata* Lamarck is more inflated in the umbonal region, is more sharply rostrate, and develops a more imbricated ornamentation.

The occurrence of this tropical species in the Oak Grove is significant. Though present in the Bowden of Jamaica it has not been recognized in Florida in strata older than the Caloosahatchee.

The Recent representatives have a wide geographic distribution, though they are restricted to the shallow waters, usually less than 20 fathoms. The species has been reported from Hatteras to Santa Marta and Cartagena and east to Bermuda. The possession of a byssus by which they can attach themselves to foreign objects gives to this group a very effective means of dispersion.

Occurrence: Oak Grove sand, localities 2646^r (juveniles), 5632^r (juveniles). Shoal River formation, localities 10603^p, 10608^r.

Outside occurrence: Miocene: Moin Hill, Costa Rica; Bowden beds, Jamaica; Gurabo formation, Santo Domingo. Pliocene: Caloosahatchee beds, Florida. Pleistocene: Florida and the West Indies. Recent: Cape Hatteras to Cartagena and east to Bermuda in 1 to 20 fathoms.

Arca umbonata Lamarck

1819. *Arca umbonata* Lamarck, Histoire naturelle des animaux sans vertèbres, vol. 6, p. 37.
 1835. *Arca umbonata* Lamarck, idem, 2d ed., vol. 6, p. 462. (Synonymy in part excluded.)
 1847. *Arca umbonata* Lamarck. Philippi, Abbildungen und Beschreibungen Conchylien, vol. 3, p. 14, pl. 4, figs. 3a-c.
 1873. *Barbatia bonaczyi* Gabb, Geology of Santo Domingo, Am. Philos. Soc. Trans., vol. 15, p. 254.
 1887. *Arca imbricata* Bruguière. Heilprin, Wagner Free Inst. Sci. Trans., vol. 1, p. 118.
 1887. *Arca listeri?* Philippi. Heilprin, Wagner Free Inst. Sci. Trans., vol. 1, p. 118.
 1889. *Arca imbricata* Bruguière. Dall, U. S. Nat. Mus. Bull. 37, p. 40.
 1917. *Arca umbonata* Lamarck. Sheldon, Palaeontographica Americana, vol. 1, No. 1, p. 8, pl. 1, figs. 12-17.
 1917. *Arca umbonata* Lamarck. Maury, Bull. Am. Paleontology, vol. 5, No. 29, p. 163, pl. 30, fig. 11.

Lamarck described this species in 1819 as follows:

A. testâ transversim oblongâ, ventricosâ, angulato-sinuatâ decussatim substriatâ; umbonibus magnis, arcuatis; latere postico brevissimo.

Type locality: Jamaica. (Recent.)

Arca umbonata is a shell of moderately large size and very irregular outline. The umbones are prominent, widely separated, acute at their summits, feebly prosogyrate, and placed within the anterior third. The hinge line is straight and extends to the anterior extremity of the shell but not to the posterior. The anterior margin between the dorsal area and the byssal opening is smoothly rounded. The opening is rather wide and occupies one-third or more of the margin between the anterior extremity of the hinge and the posterior keel. There is a decided vertical

expansion of the shell behind the opening and the posterior keel, which is produced backward beyond the posterior extremity of the hinge. The posterior lateral margin is little or not at all constricted. The surface ornamentation is finely and rather evenly cancellate, the radials standing out more sharply anteriorly, whereas on the posterior area they do not number more than half a dozen and are much coarser than upon the medial or anterior portions of the shell. The cardinal area is wide and smoothly convex, and the ligament occupies the entire area. There are two deep grooves diverging beneath the umbones and forming a small, diamond-shaped area in the double valves. Other shorter grooves to the number of half a dozen are developed near the hinge line. The hinge is very finely serrate within the limits of the pallial line, which follows close to the outer margin. The inner margins are simple.

Arca umbonata is more irregular in outline and more regular in ornamentation than any of the other species of *Arca* s. s. reported from the Alum Bluff. The umbonal inflation is also higher and the rostral keel sharper than in either *Arca occidentalis* or *Arca paratina*.

The Alum Bluff material is very meager and not sufficient to prove without question the identity of the Tertiary and Recent species. The relationship is certainly close, and the apparently wider byssal gape of the Tertiary forms may easily be due to individual variation or to a slight immaturity.

The Recent representatives inhabit the shallow waters along the east coast from Hatteras to southern Brazil and east to Bermuda.

Occurrence: Chipola formation, localities 2212^r, 2213^r, 2564^r, 3419^r. Oak Grove sand, localities 2646^r, 5632^r.

Outside occurrence: Miocene: "Tampa silex beds," Florida; Moin Hill, Costa Rica, and the Gurabo formation, Dominican Republic. Pleistocene: Florida and the West Indies. Recent: Cape Hatteras to southern Brazil in less than 50 fathoms.

Arca paratina Dall

Plate V, Figure 5

1898. *Arca paratina* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 621, pl. 33, fig. 14.

1917. *Arca paratina* Dall. Sheldon, Palaeontographica Americana, vol. 1, No. 1, p. 7, pl. 1, figs. 5-7.

Dall describes this species as follows:

Shell elongated, not very thick or high, not much distorted but with a variable byssal gape, inequilateral, the beaks at or near the anterior fourth; moderately alate in front and behind; beaks low, pointed, not inflated, their apices slightly prosogyrate, cardinal area long, narrow, lozenge-shaped, flattish, with longitudinal striae, the site of the resilium marked on each valve by two grooves forming a small triangle, within which are traces of the inception of other grooves; sculpture chiefly of fine radial riblets overrunning and somewhat imbricated by

not prominent lines of growth; the radials which end on the margin of the byssal foramen are perceptibly finer than the rest, those on the posterior dorsal slope are more or less fasciculated, the ends of the fascicles dentating the posterior margin; on the dorsal anterior part the riblets increase somewhat in size but are not fasciculated; the dorsal border in front is anterior to the rest of the margin; between the dorsal posterior extreme and the ventral posterior angle there is often an irregular but not deep emargination; the borders of the byssal foramen are irregularly emarginate; interior smooth, the margin denticulated by the sculpture except at the foramen; hinge line straight, minutely denticulate; the teeth in the center smaller, those toward the ends inclined outward slightly, above, and a little larger; there are about 23 anterior and 40 posterior teeth, with no marked hiatus between the series. Longitude of shell, 28 millimeters; altitude of hinge line, 8.5 millimeters; of beaks, 10 millimeters; diameter at the umbonal part, 10 millimeters. It is quite possible that the shell grows to a considerably larger size.

This species is distinguishable at once from the *A. occidentalis* of the same size by its uniformly more delicate and much more numerous ribs and by its greater length in proportion to its height. It is also usually less alate behind and of more uniform, undistorted shape. Differences of form and proportion seem to separate it sufficiently from *A. subprotracta* Heilprin.

Type: U. S. Nat. Mus. No. 114786.

Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla.

The young of *Arca umbonata* Lamarck are more inflated and more sharply rostrate, and the sculpture is relatively coarser and more evenly fluted. The young of *Arca occidentalis* are even more similar in general characters but are less delicate and less finely sculptured. *Arca yaquensis* Maury, so common in the Cercado and Thomonde formations of the Dominican Republic is less elongated transversely.

Occurrence: Chipola formation, localities 10609^a, 2213^a, 3419^p, 2211^p.

Subgenus BARBATIA Gray.

1842. *Barbatia* J. E. Gray. Synopsis of the contents of the British Museum, p. 81.

Type: *Arca barbata* Linnaeus. (Recent in the Mediterranean.)

Gray describes this subgenus as follows:

The *Barbatia* are elongated shells, covered with a hairy periostraca; the teeth on the middle of the line are small, of the ends large and oblique.

Dall adds the following remarks:¹²

The type form of this group is tolerably regular and seldom deformed, like the typical Arks, from the anfractuositities of its station; the reticulated sculpture shows few irregularities; the cardinal area is narrow with numerous grooves for the resilium, which form a series of elongated concentric lozenges on the area; the shell is not conspicuously truncate or keeled; the teeth are small and vertical in the middle of the series and toward the end diverge distally and become larger and more distant. In some species these distal teeth are often broken up, like those of *Cucullaea*, but this feature is not constant in the species. Several groups or sections are recognizable, though they merge into one another through their peripheral species.

¹² Dall, W. H., Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 614, 1898.

Section **PLAGIARCA** Conrad

1875. *Plagiarca* Conrad. Kerr, Rept. Geol. Survey North Carolina, vol. 1, app. A, p. 4.
= *Calloarca* Dall and authors. (Type: *Arca candida* Gmelin.)
Not *Calloarca* Gray, 1857, Annals and Mag. Nat. Hist., 2d ser., vol. 19, p. 369. (Type: *Barbatia alternata* Reeve.)

Type: *Barbatia carolinensis* Conrad. (Cretaceous (Ripley formation) of North Carolina.)

The monotype of Gray's *Calloarca* is *Arca alternata* Reeve, a rare west coast species of the *Acar* group. As no other species can serve as the type, *Calloarca* must of necessity become a synonym of *Acar*. *Litharca* Gray, 1842, was founded with *Byssoarca lithodomus* Sowerby as the monotype, a form which is probably nothing more than an *Arca candida* much distorted by growth in a *Lithodomus* burrow. In view of the uncertainty and the misfortunes of employing such a type, *Litharca* may well be rejected in favor of Conrad's clearly defined *Plagiarca*.

Conrad defines this section as follows:

Shell with a straight hinge margin terminating in an angle, narrow cardinal area, having minute close angulated lines; cardinal teeth very oblique without angles toward the interior margin; short; anterior series with one or two teeth comparatively large, slightly angulated in the middle and very oblique.

Barbatia (Plagiarca) marylandica Conrad

1840. *Byssoarca marylandica* Conrad, Fossils of the medial Tertiary of the United States, p. 54, pl. 29, fig. 1.
1863. *Barbatia (Byssoarca) marylandica* Conrad, Acad. Nat. Sci. Philadelphia Proc. for 1862, p. 580.
1864. *Barbatia marylandica* Conrad. Meek, Check list of the invertebrate fossils of North America: Smithsonian Misc. Coll. No. 183, p. 6.
1894. *Barbatia marylandica* Conrad. Whitfield, U. S. Geol. Survey Mon. 24, p. 48, pl. 7, figs. 2-4.
1898. *Barbatia (Calloarca) marylandica* Conrad. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 623.
1898. *Barbatia (Calloarca) candida* Gmelin. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 626 (part).
Not *Arca candida* Gmelin, 1792, and authors.
1898. *Barbatia (Calloarca) marylandica* Conrad. Dall, U. S. Nat. Mus. Bull. 90, p. 119, pl. 4, fig. 3.
1904. *Arca (Barbatia) marylandica* Conrad. Glenn, Maryland Geol. Survey, Miocene, p. 392, pl. 106, fig. 7.
1917. *Arca marylandica* Conrad. Sheldon, Palaeontographica Americana, vol. 1, No. 1, p. 14, pl. 3, figs. 5-7.

Conrad described this species in 1840, as follows:

Shell oblong, compressed, thin, with very numerous radiating granulated striae; beaks not prominent; base much contracted or emarginate anterior to the middle; posterior side dilated, the superior margin very oblique and emarginate; extremity angulated, and situated nearer to the line of the hinge than to that of the base; cardinal teeth minute, except toward the extremities of the cardinal line, where they are comparatively very large and oblique; inner margin entire.

Type: Academy of Natural Sciences of Philadelphia.

Type locality: "Cliffs of Calvert," Md. (Calvert formation).

The Chipola individuals seem to be a little higher relatively, a little more regular in outline, and not

quite so finely sculptured as those from Maryland and New Jersey. The radials upon the anterior portion of the shell are quite sharply elevated and granulated and separated by interspaces of approximately their own width. On the medial portion of the shell the primaries are finer and less uniform in size and spacing and toward the posterior portion of the shell are often mesially sulcate. Secondaries are quite regularly intercalated, making a rather crowded ornamentation. Over the keel the radials are very low and irregular, but strengthen again behind the keel, are more sharply corrugated by the incrementals, and are, as a rule, mesially sulcate. The cardinal area is narrow and furrowed with four or five discontinuous, more or less undulatory grooves. The hinge is extremely narrow and finely serrate medially but widens distally, especially behind the umbones. There are about four relatively coarse anterior teeth and half a dozen posterior. The inner margins are simple.

Occurrence: Chipola formation, localities 2212^p, 2213^p, 2564^r, 3419^r, 2211^r. Oak Grove sand, localities 2646^r, 7054^r, 10659^r. Shoal River formation, locality 10603^r.

Outside occurrence: Miocene: "Tampa silex beds" at Ballast Point, Fla.; the marls of Jericho, Cumberland County, N. J., and beds at Plum Point, Calvert Cliffs, and Centerville, Md.

Juveniles referred by Dall to *Arca candida* Gmelin should be included under this species. The young *candida* are less finely and more sharply threaded than young *marylandica*. *Arca candida* is a denizen of the shallow waters along the east coast from Cape Hatteras to southern Brazil.

Barbatia (Plagiarca) phalacra Dall

Plate V, Figure 6

1898. *Barbatia (Calloarca) phalacra* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 626, pl. 33, fig. 3.
1917. *Arca phalacra* Dall. Sheldon, Palaeontographica Americana, vol. 1, No. 1, p. 16, pl. 3, fig. 10.

Dall describes this species as follows:

Shell thin, moderately convex, equivalve, inequilateral; the prosogyrate beaks within the anterior fourth low and somewhat compressed; sculpture of very numerous fine, even, mostly dichotomous riblets without nodules or reticulation over the whole shell, crossed only by feeble incremental lines; cardinal area very narrow with a few longitudinal grooves; hinge teeth small, short, and vertical mesially without any gap in the series, distally longer, larger, and more oblique; hinge line $\frac{1}{4}$ of the whole length; internal margin of the valves smooth, byssal gape inconspicuous. Longitude 23.5, altitude 11, diameter 9 millimeters.

This is a very modest and neat little species which does not seem identifiable with any of the others. It is perhaps nearest to *B. mississippiensis* Conrad but is smaller, less flattened, and more regular.

Type: U. S. Nat. Mus. No. 135831.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County, Fla.

There is a bewildering amount of age variation in this species. The young are very finely and evenly threaded radially. Later on the radials become less uniform in size and spacing and tend to bifurcate. Secondaries are commonly intercalated, and the resulting ornamentation is quite similar to that of the less inflated *Barbatia marylandica* Conrad. The juvenile uniformity of sculpture persists much longer in the two individuals from Oak Grove than in the Chipola individuals and may, with the acquisition of further material, prove a character of taxonomic value.

Occurrence: Chipola formation, locality 2213^p. Oak Grove sand, locality 2646^r.

Section ACAR Gray

1857. *Acar* J. E. Gray, *Annals and Mag. Nat. Hist.*, 2d ser., vol. 19, p. 369.

Type: *Arca gradata* Broderip and Sowerby. (Recent off the west coast of Mexico and Central America.)

Shell small, solid, inequilateral, transversely elongated, rectangular, rostrate behind; surface normally cancellate; ligament area rhomboidal and, for the most part, opisthodontic, more restricted anteriorly than the cardinal area.

Arca donaciformis, commonly cited as the type of this section and described by Reeve from Mozambique, is not included in Gray's original list of three species. *Arca gradata* was designated the type by Woodring.^{13a}

Barbatia (Acar) *reticulata* Gmelin

1784. *Arca reticulata* Chemnitz, *Conchylien-Cabinet*, vol. 7, p. 193, pl. 54, fig. 540.

1792. *Arca reticulata* Gmelin, *Systema naturae*, vol. 6, p. 3311.

1819. *Arca domingensis* Lamarck, *Histoire naturelle des animaux sans vertèbres*, vol. 6, p. 40.

1898. *Barbatia* (Acar) *reticulata* Gmelin. Dall, *Wagner Free Inst. Sci. Trans.*, vol. 3, pt. 4, p. 629.

1917. *Arca reticulata* Gmelin. Sheldon, *Palaeontographica Americana*, vol. 1, No. 1, p. 20, pl. 4, figs. 8-12.

1917. *Barbatia* (Acar) *reticulata* Gmelin. Maury, *Bull. Am. Paleontology*, vol. 5, No. 29, p. 166, pl. 30, fig. 16.

1919. *Arca* (Acar) *reticulata* Gmelin. Harris, *Bull. Am. Paleontology*, vol. 6, No. 31, p. 55, pl. 22, figs. 18, 19.

Gmelin described this species in 1792 as follows:

A. testa subrhomboidea decussatim striata alba: natibus approximatis, vulva cordata.

List. Conch., t. 233 f. 67.

Martini Besch., *Berl. Naturf.*, 3, t. 6, f. 9.

Chemn. Conch., 7 t. 54 f. 540.

Habitat * * * arcae Noae affinis; utrum hujus, an sequentis familiae?

Type locality: Not definitely known.

The shell is small, heavy, inflated, subrhomboidal, and acutely rostrate posteriorly, thus suggesting in outline and dimensions a very solid and overgrown *Barbatia adamsi*. The umbones are rather broad, an-

terior in position, strongly incurved, prosogyrate, and proximate. The external surface is sharply cancellated by conspicuously elevated radial cords separated by deep grooves of approximately their own width and crossed at regular intervals by numerous concentric ridges or laminae which tend to nodulate the radials at their intersection. Between the concentric ridges the interradial grooves appear as deep pits. Along the posterior keel the concentric sculpture is commonly conspicuously laminar or scabrous, and this character is maintained to a certain extent across the posterior area. The cardinal area is extremely narrow, expanding slightly beneath the umbones and scarred with a few irregular, commonly discontinuous grooves rudely parallel to the hinge line. The hinge is rather short and rather coarsely dentate distally, with irregular and in some specimens obsolete medial serrations. The inner margin of the valves is finely dentate.

Two individuals serve to establish the presence of a species unusually well characterized by outline and ornamentation.

Occurrence: Chipola formation, locality 2213^r. Shoal River formation, locality 10608^r.

Outside occurrence: Eocene: Claiborne group of Mississippi and Texas(?). Miocene: "Tampa silex beds" of Florida; Miocene of Santo Domingo and Jamaica. Pliocene: Caloosahatchee formation of Florida. Pleistocene: Florida and the West Indies. Recent: Cape Hatteras to the Gulf of Campeche and east to Bermuda.

The Recent members have a wide geographic and bathymetric range. Off Hatteras the form occurs both in shallow water and in deep water up to 287 fathoms. Elsewhere in its range along the east coast from Hatteras to the Gulf of Campeche and east to Bermuda it is restricted to the shallow waters. The species has also been reported from the west coast from San Diego to Ecuador, but this is probably a closely allied and not an identical form.

Section FOSSULARCA Cossmann

1887. Cossmann, *Catalogue illustré des coquilles fossiles de l'Éocène des environs de Paris*, vol. 2, p. 142.

Type: *Arca quadrilatera* Lamarck. (Eocene of the Paris Basin.)

Cossmann defines this section as follows:

Coquille mince, oblongue, subquadrangulaire, subéquilatérale, inéquivalve, à surface treillisée; crochets écartés; aire ligamentaire étroite, portant sous le crochet une petite fossette triangulaire bien limitée, au fond de laquelle se distinguent de petits sillons perpendiculaires au bord; dents presque égales, plus ou moins obliques.

Shell thin, oblong, subquadrate, subequilateral, inequivalve. Sculpture reticulate. Umbones separated by a narrow cardinal area grooved parallel to the hinge line. Ligament restricted to a minute vertically striated diamond-shaped area directly beneath the beaks. Teeth subequal, more or less oblique.

^{13a} This report was already in proof when Woodring's "Miocene mollusks from Bowden, Jamaica" (*Carnegie Inst. Washington Pub.* 366, 1925), was published. I have taken advantage of Woodring's work to the extent of making a number of changes in the nomenclature, but I have been unable to offer any discussion of these changes.

Barbatia (Fossularca) adamsi (Shuttleworth MS.) Dall

Plate V, Figures 1-4

1845. *Arca coelata* Conrad, Fossils of the medial Tertiary of the United States, p. 61, pl. 32, fig. 2.
Not *Arca coelata* Reeve, 1844.
1886. *Arca adamsi* Shuttleworth. Dall, Harvard Coll. Mus. Comp. Zoology Bull., vol. 12, p. 243.
1888. *Arca (Acar) adamsii* Shuttleworth MS.? Smith, E. A., Linnaean Soc. Jour. Zoology, vol. 20, p. 499, pl. 30, figs. 6, 6a.
1898. *Barbatia (Fossularca) adamsi* (Shuttleworth) Smith. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 629.
1917. *Arca adamsi* (Shuttleworth) Smith. Sheldon, Palaeontographica Americana, vol. 1, No. 1, p. 22, pl. 4, figs. 16-18, pl. 5, fig. 1.

Conrad described this form in 1845 as follows:

Trapezoidal, disk widely and not profoundly contracted; ribs numerous, alternated toward the base, tuberculated, aculeated anteriorly and posteriorly; posterior slope depressed; umbo acutely angulated behind; basal margin slightly arched; posterior margin obliquely truncated; beaks approximate. Locality, Wilmington, N. C.

Dall described this species in 1886 as follows:

This species is very common in shallow water throughout the West Indies and extends northward nearly or quite to Cape Hatteras. Its simulated ribs of trailing blisters give it a remarkably similar appearance to *Arca lactea*, which, however, has real ribs. There is a dwarf, very short squarish variety, which from its greater proportional diameter (though not otherwise different) would at first be separated as distinct and which may be called *Arca adamsi* var. *conradiana*.

Figured specimen: U. S. Nat. Mus. No. 325489 (Wilmington, N. C.).

Type locality: West Indies.

Though this species was named by Shuttleworth in the early fifties, and though it is widely distributed, no record of any published description or figure has yet been found. The name appears in several check lists by Beau, Krebs, and others, but Dall seems to have been the first to give any criteria for its identification. The formal Latin description of Smith was not published until two years later.

The shell is unusually distinctive and may be readily recognized by the trapezoidal outline, the contraction of the basal margin, the dainty cancellated sculpture with its riblets formed of hollow flutings, the transverse ligamental grooves confined within a small diamond-shaped area directly beneath the umbones, and the well-defined muscular impressions mounted on raised ridges which converge dorsally beneath umbones. The measurements given by Smith are: Longitude, 12 millimeters; altitude, 7.5 millimeters; diameter, 7.5 millimeters.

There are no characters by which the Alum Bluff forms may be separated from the Recent. In most of the individuals, however, the sculpture is more or less decorticated, leaving a roughened limy surface. The Recent members occur in considerable abundance from Hatteras to Fernando de Noronha, Brazil, in waters 35 fathoms in greatest depth. The species has also been reported from Bermuda.

Occurrence: Chipola formation, localities 2213^c, 9994^r, ?7468. Oak Grove sand, localities 2646^r, 5632^r. Shoal River formation, localities 9957^r, 5618^r.

Outside occurrence: Miocene: Bowden formation, Jamaica; Yorktown formation, Virginia; Duplin formation, North Carolina, South Carolina, Georgia. Pliocene: Waccamaw formation, South Carolina; Caloosahatchee formation, Florida; Croatan formation, North Carolina. Pleistocene: South Carolina, Florida. Recent: Cape Hatteras to Fernando de Noronha, Brazil, and east to Bermuda in 10 to 35 fathoms.

Subgenus DILUVARCA Woodring

1925. Woodring, W. P., Miocene mollusks from Bowden, Jamaica: Carnegie Inst. Washington Pub. 366, p. 40 = *Scapharca* of authors, not of Gray, Zool. Soc. London Proc., p. 198, 1847.

Type: *Arca diluvii* Lamarck. Miocene to Recent, Mediterranean Sea.

The following is a description of *Diluvarca*:

Shell heavy, medium-sized, moderately elongate, strongly inflated, inequilateral, equivalve, valves closed along ventral margin; umbos high and full; sculpture consisting of strong, narrow, flattened radial ribs separated by squarely channeled interspaces, ribs beaded by concentric threads; cardinal area relatively wide, on adult shells almost entire area occupied by ligament and bearing chevron-shaped ligament grooves diverging from under umbo at an obtuse angle; hinge uninterrupted but consisting of two series of teeth unequal in length; the shorter anterior series comprising teeth that are slightly oblique at anterior end and become vertical but not much reduced in size at posterior end; the longer posterior series comprising teeth that are strongly oblique at posterior end and become vertical and very small at anterior end; posterior muscle scar quadrangular, larger than the rounded anterior scar; margin of valve deeply fluted.

***Diluvarca (Diluvarca) latidentata* (Dall)**

Plate V, Figure 7

1898. *Scapharca (Scapharca) latidentata* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 638, pl. 32, fig. 15.
1915. *Scapharca latidentata* Dall, U. S. Nat. Mus. Bull. 90, p. 121, pl. 25, fig. 2 (part).
1917. *Arca latidentata* Dall. Sheldon, Palaeontographica Americana, vol. 1, No. 1, p. 33, pl. 7, figs. 17-20.

Dall described this species in 1898 as follows:

Shell small, ovate, moderately convex, with low, quite anterior, mesially sulcate, prosocoelous beaks; left valve with about 30 rounded, radiating, undivided ribs, separated by slightly wider interspaces and crossed by numerous smaller concentric ridges which become beadlike on the ribs and vary in prominence in different specimens; base evenly arcuate, ends rounded; cardinal area narrow, impressed, smooth, with one or two grooves behind the beaks but none elsewhere; valves slightly twisted, so that the basal margin is not in a single plane; line of teeth interrupted a little behind the beaks, the anterior series having the anterior and posterior teeth larger and the intervening teeth thinner and more closely

¹¹ Annals and Mag. Nat. Hist., 2d ser., vol. 19, p. 371, 1857.

¹² Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 618, 1898.

adjacent, all nearly vertical; posterior teeth vertical, shorter, the series longer, the teeth smallest proximally and regularly increasing in size toward the distal end of the series, equidistant and regular; inner margin of the valve deeply fluted. Longitude 18, height 11, diameter 9 millimeters.

This little shell looks a good deal like the young of *Anadara arista* Dall but has the beaks less central, less prominent, and distinctly impressed mesially, giving a somewhat bilobed aspect to the very young.

Type: U. S. Nat. Mus. No. 107720.

Type locality: No. 2564, McClelland farm, 1 mile below Baileys Ferry, Calhoun County, Fla.

There is no *Diluvarca* reported from the Alum Bluff which shares with *latidentata* the evenly arcuate base and the narrow, well-elevated radials separated from one another by interspaces of approximately their own width.

Occurrence: Chipola formation, localities 10609^r, 7893^r, 2212^p, 2214^r, 2213^c, 2564^r, 3419^r.

***Diluvarca (Diluvarca) mikkula* Gardner, n. sp.**

Plate V, Figures 8-9

Shell very small, slightly inequivalved, transversely elongated, subrectangular. Umbones rather full, moderately elevated, the apices turned inward and slightly forward and placed at some little distance in front of the median vertical. Length of dorsal margin approximating but not equaling the maximum latitude of the shell. Anterior margin intercepting the dorsal at nearly a right angle, expanding slightly in front of the dorsal margin. Base line broadly and feebly constricted at the terminus of the shallow umbonal depression, expanding posteriorly. Postero-ventral margin slightly produced and rounded. Posterior lateral margin oblique, intercepting the dorsal margin at an acute angle. Umbonal depression shallow but distinct. Posterior keel obscurely defined toward the umbones, obsolete away from the umbones. Radial sculpture of low, narrow bands widening laterally, especially upon the posterior slope, 23 in number, separated by angular, interradsial channels of approximately their own width. Concentric sculpture restricted to exceedingly fine laminae, visible for the most part only in the interspaces on the posterior half of the shell but in some specimens overriding the radials from the umbones to the postero-ventral margin. Margins crenate in harmony with the radial sculpture. Cardinal area narrow, produced posteriorly, expanding somewhat beneath the umbones. Area of ligament attachment rhomboidal, coincident anteriorly with the cardinal area but more restricted posteriorly; one or two grooves directed obliquely backward from the umbones, the more shallow of the two defining the posterior limit of the ligament. Inner margin of hinge broadly and feebly arcuate. Hinge teeth very fine, especially beneath the umbones, less fine and more obliquely distal. Adductor scars

obscure, placed well up toward the hinge. Anterior scar roundish, smaller and more regular in outline than the posterior.

Dimensions: Altitude, 3.5 millimeters; latitude, 6.0 millimeters; diameter, 3.2 millimeters.

Type: U. S. Nat. Mus. No. 352305.

Type locality: No. 2211, Alum Bluff (lower bed), Liberty County, Fla.

This small and prolific bivalve has been considered to be the young of *Diluvarca hypomela* (Dall), but it is much heavier than *hypomela* of the same size and more nearly rectangular. The umbonal depression is less pronounced, and the radials are broader and flatter and normally less than 30 in number, whereas those of *hypomela* commonly exceed 40.

Occurrence: Chipola formation, localities 2213^a, 2564^a, 3419^a, 2211^a, 7183^c, 10660^r.

***Diluvarca (Diluvarca) hypomela* (Dall)**

Plate V, Figure 12

1898. *Scapharca (Scapharca) hypomela* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 637, pl. 33, fig. 1.

1913. ?*Scapharca hypomela* Dall, U. S. Nat. Mus. Bull. 90, p. 121, pl. 17, fig. 7, pl. 21, figs. 17, 18.

1917. *Arca hypomela* Dall. Sheldon, Palaeontographica Americana, vol. 1, No. 1, p. 34, pl. 7, figs. 22-25.

Dall described this species as follows:

Shell of moderate size, long, inflated, with rather low, mesially compressed, prosogyrate beaks; left valve with about 43 deeply channeled, flat-topped ribs with fine, regular, concentric beading, except on the posterior slope, where the ribs are lower, flatter, and obsolete channeled; near the margin some of the ribs have a second set of finer grooves; hinge line straight, anterior end descending vertically, then obliquely rounded into the base, which is nearly parallel with the hinge line; the posterior end descends more obliquely and the basal angle is prolonged a little and rounded; the interspaces between the ribs in both valves are very narrow, and on the right valve the beading is less conspicuous; the cardinal area is somewhat concave, flattish, with three or four concentric grooves in lozenge form; teeth of the hinge similar, numerous, not interrupted, short, vertical, the distal teeth a little longer and more oblique; margin of the valves fluted, the right valve slightly smaller than the other. Longitude 50, altitude 25, diameter 20 millimeters.

This species has the appearance of being the Oligocene ancestor of the Miocene *A. lienosa*, from which it differs by its smaller size, closer and rather narrower ribbing.

Type: U. S. Nat. Mus. No. 114800.

Type locality: No. 2212, Tenmile Creek, 1 mile west of Baileys Ferry, Calhoun County, Fla.

The Ballast Point individuals are smaller, heavier, and more inflated than those from the Chipola and present differences of at least subspecific value. The casts from Sopchoppy indicate a more evenly inflated shell and an earlier and more constant bifurcation of the radials. The rather ornate sculpture of the adult *hypomela* together with its transversely elongated outline is sufficient to separate it from the coexistent members of the genus. The Oak Grove *Diluvarca*

dodona is higher relatively and has higher, more inflated umbones, a less obtuse rostrum, and more finely divided radials. *Arca henikeni* Maury from the Cercado and Gurabo formations of the Dominican Republic is intermediate in outline between *Diluvarca hypomela* Dall and *D. dodona* from the Oak Grove. The details of the sculpture, however, are more simple than in either of the Alum Bluff species. *Diluvarca acompsa* from the Chipola suggests an adolescent *hypomela* but is more uniform in altitude in the anterior and posterior portions of the shell, the base line running approximately parallel to the dorsal margin throughout its extent. The very young *hypomela* may be separated from *D. mikkula* by their thinner shells, more irregular, somewhat bilobate outline, and more numerous radials.

Occurrence: Chipola formation, localities 10609^p, 7893^r, 2212^p, 7257^r, 2213^c, 2564^p, 3419^c, ?7468^r. Oak Grove formation, locality 5630^r. Shoal River formation, locality 10603^p.

***Diluvarca (Diluvarca) acompsa* (Dall)**

Plate V, Figure 11

1898. *Scapharca (Scapharca) acompsa* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 648, pl. 33, fig. 15.
1917. *Arca acompsa* Dall. Sheldon, Palaeontographica Americana, vol. 1, No. 1, p. 34, pl. 7, fig. 21.

Dall described this species in 1898 as follows:

Shell rectangular, elongate, rather compressed, with low prosocoelous beaks, situated at about the anterior fourth of the whole length; right valve with about 36 flattened radial ribs, with much narrower interspaces; the anterior (22) ribs are mesially divided by a sharp groove and feebly rippled above; the posterior ribs are flat, smooth, and increase in width backward; the anterior end of the shell is evenly rounded, the base straight and parallel with the hinge line, the posterior end wider, a little produced below and with a conspicuous angle above; cardinal area long, very narrow, with one or two grooves, and bordered behind with an elevated margin; hinge line straight, long, with numerous small, uninterrupted teeth, very short mesially, longer and somewhat more oblique distally; inner margin of the valves fluted, shell thin and delicate. Longitude 20, altitude 10.5, semidiameter 4.5 millimeters.

Only two right valves of this little species have been examined. It resembles the young of *A. hypomela* but is immediately distinguishable by its more compressed and rectangular form and smooth, flat posterior ribs.

Type: U. S. Nat. Mus. No. 114794.

Type locality: No. 2212, Tenmile Creek, 1 mile west of Baileys Ferry, Calhoun County, Fla.

In the young *hypomela*, especially those too young to have developed the sculptural details, the posterior portion of the shell is decidedly broader than the anterior, so that the base line is not parallel to the hinge as in *acompsa* but oblique to it.

No further valves referable to this species have been found.

Occurrence: Chipola formation, localities 2212^r, 2213^r.

***Diluvarca (Diluvarca) dodona* (Dall)**

Plate V, Figures 14-15a

1898. *Scapharca (Scapharca) dodona* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 640, pl. 31, figs. 1, 8, 8a.
1917. *Arca dodona* Dall. Sheldon, Palaeontographica Americana, vol. 1, No. 1, p. 37, pl. 8, figs. 6-10.

Dall described this species in 1898 as follows:

Shell small, solid, inequilateral, inflated, and rounded in front, pointed and attenuated behind; with mesially impressed, prosocoelous beaks; left valve with 36 squarish radial ribs, each with a deep central groove longitudinally, the portions on each side with a shallower longitudinal sulcus, so that each rib, except in young shells, is composed of four threads set in two pairs; the ribs separated from each other by channeled interspaces about half as wide as the ribs; concentric sculpture of numerous rather close set, regular, blunt, elevated lines, which appear on the riblets as fine undulations; beaks at the anterior third; cardinal area, with a raised margin, lozenge-shaped, rather wide, slightly narrower behind the beaks, with about four rather wavy sets of concentric grooves; hinge line short, solid, the teeth not interrupted, larger distally, the most anterior tending to break up into granulations, about 50 in all, subvertical, shorter in the middle of the hinge; margins of the valve deeply fluted; right valve with wider interspaces and narrower, often tripartite, ribs. Longitude 40, altitude 28, diameter 30 millimeters.

This fine shell has a neat and elegant surface sculpture, and is one of several which the Oak Grove marl contains and which appear to be new.

Type: U. S. Nat. Mus. No. 107385.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County, Fla.

Diluvarca dodona is the most ornate of all the *Diluvarcas* reported from the Alum Bluff. *Diluvarca hypomela* from the Chipola presents the same general type of sculpture but is relatively lower and more elongated transversely and the ribs are more numerous and cut by only a single longitudinal sulcus.

The species is prolific and widely distributed throughout the Oak Grove.

Occurrence: Oak Grove sand, localities 2646^{pr}, 5632^c, 5631^p, 5630^p, 5633^p, 7054^c.

***Diluvarca (Diluvarca) staminata* (Dall)**

Plate V, Figure 13

1898. *Scapharca (Scapharca) staminata* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 641, pl. 31, fig. 11 (fig. 13 excluded).
1917. *Arca staminata* Dall. Sheldon, Palaeontographica Americana, vol. 1, No. 1, p. 39 (part), pl. 9, figs. 4, 5 (fig. 6 excluded).

Dall described this species in 1898 as follows:

Shell of moderate size, plump, rhombic, with well-elevated hardly sulcate, slightly prosocoelous beaks, situated in the anterior third of the length; left valve with 28 or 29 radial ribs, the posterior of which are smooth and almost rounded; those on the middle of the valve are squarish, with wider channeled interspaces, and rippled or furnished with transverse nodulation above, which grows stronger and more crowded anteriorly; the ribs are not sulcate or dichotomous, and hardly differ on the two valves; hinge line straight, rather long, and with conspicuous angles at the ends; anterior end of the valve rounded,

base nearly parallel with the hinge line, posterior end somewhat produced; beaks narrow, cardinal area with from three to five sets of lozenge-shaped groovings; hinge strong, the teeth in two adjacent series, somewhat oblique, smaller mesially, at the anterior end of the hinge sometimes more or less broken into granules; inner margin of the valves fluted, interior radially striate. Longitude of a large valve 47, altitude 37 millimeters, longitude of figured shell 39, altitude 30, diameter 28 millimeters.

This species differs from *A. santarosana*, which occurs in the same beds, by its more rhombic form, proportionately longer hinge line, and unsculpted ribs. It is also a larger and less elegantly sculptured shell. *A. staminea* Say, of which *staminata* may prove to be an Oligocene race, has a proportionately longer hinge line, is more sharply truncate behind and more obliquely rounded in front, the beaks are less elevated and wider, the ribs anteriorly are only sparsely and feebly nodular, while the aspect of the whole shell is less elegant.

Type: U. S. Nat. Mus. No. 149025.

Type locality: No. 2211, Alum Bluff (lower bed), Liberty County, Fla.

Diluvarca staminata is another of the surprisingly numerous species peculiar to the coarse sands of Alum Bluff. Though contemporaneous forms, *Diluvarca staminata* and *Diluvarca santarosana geraetera* seem to be mutually exclusive, as the one is known only from Alum Bluff, the other from the Chipola. The specimens from Escambia County, Ala., tentatively referred to *D. staminata* are more closely allied to *D. santarosana geraetera*. *Diluvarca chiriquiensis* (Gabb) from the Thomonde formation of Haiti differs from all of the Alum Bluff members of the *staminata* group in the equal valves, the more obtuse posterior keel, the much broader, more closely scored cardinal area, and consequently more widely separated umbones.

By a curious error an individual of a quite distinct species—*Diluvarca waltonia* Gardner—from Walton County was figured by Dall.

Occurrence: Chipola formation, localities 2211^c, 7183^c, 10660^c, ? 7468^c.

Diluvarca (Diluvarca) santarosana (Dall)

Plate VI, Figures 1-2

1898. *Scapharca (Scapharca) santarosana* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 641, pl. 31, figs. 2, 10.

1917. *Arca santarosana* Dall. Sheldon, Palaeontographica Americana, vol. 1, No. 1, p. 38, pl. 9, figs. 1-3.

Dall described this species in 1898 as follows:

Shell small, short, plump, rostrate, with moderately elevated, mesially sulcate prosocoelous beaks; left valve with 30 elevated, squarish, radial ribs, separated by slightly narrower channeled interspaces; the ribs on the posterior slope are low, smaller, and nearly smooth; those on the middle of the shell have mostly near the margin a shallow mesial sulcus; in those still more anterior the sulcus is deeper and wider, dividing each rib over most of its length into two more or less rounded riblets; concentric sculpture of regularly spaced elevated lines, which on the ribs appear as prominent ripples; right valve having the ribs narrower and less strongly sculptured, and the sulci less distinct; cardinal area short, with about three concentric grooves; beaks within the anterior fourth; hinge line short, with about 57 rather irregular, closely adjacent, nearly

vertical teeth, longer and more oblique distally; margins strongly fluted; base flexuous, posterior end narrow, pointed, without any marked angle at the end of the hinge line. Longitude 36.5, altitude 28, diameter 28 millimeters.

This species is most nearly related to *A. staminata* Dall, from which it can be distinguished especially by its lower beaks, more oblique posterior slope, more flexuous base, and attenuated posterior end.

Type: U. S. Nat. Mus. No. 107386.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County (formerly Santa Rosa County), Fla.

The Chipola specimens have been segregated under the subspecies *geraetera* because of their relatively higher altitude consequent upon the more elevated and narrower umbones. The two forms occupy about the same relative position in the faunas which they characterize.

The species that occurs abundantly in the vicinity of Bainbridge, Decatur County, Ga., is for the most part the typical *santarosana*, though there is a tendency toward variation along the lines of *geraetera*. Apparently a second species or subspecies is present at this locality, though represented only by immature forms. These individuals differ from the young *santarosana* in their much lower, broader outline. The ornamentation and cardinal area, however, offer no distinguishing characters, and the forms in question are left nameless for the time being.

Occurrence: Oak Grove sand, localities 3386^c, 3385^c, 7148^c, 3396^c, 2646^a, 5632^p, 5631^r, 5630^p, 5633^r, 7054^p, 9961^r, 7055^p, 10659^a. Shoal River formation, locality ?5192^r.

Diluvarca (Diluvarca) santarosana geraetera Gardner, n. subsp.

Plate VII, Figures 1-2

1917. "*Arca staminata*" Sheldon, Palaeontographica Americana, vol. 1, No. 1, pl. 9, fig. 6. (Figs. 4 and 5 excluded.) Not *Scapharca (Scapharca) staminata* Dall, 1898.

Shell of moderate dimensions, heavy, the left valve a little larger than the right. Trigonal in the exterior view, the interior, excluding the cardinal area and the prominent umbones, subrhomboidal. Umbones rather narrow but full, conspicuously elevated, incurved and prosogyrate, the apices within the anterior third. Dorsal margin straight, a little shorter than the greatest width of the shell. Anterior margin slightly constricted at the hinge, broadly and feebly rounded, merging smoothly into the base line, which is somewhat compressed in the adults directly in front of the posterior keel. Rostrum subacute and well defined from the umbones to the ventral margin. Posterior area obliquely flattened, the posterior margin intercepting the dorsal at an angle of more than 90°. Ribs of right valve normally 31 or 32, including the 10 or 11 upon the posterior slope; costals on anterior part of shell corrugated by the incrementals and mesially sulcate, the groove being deepest, the wrinkles heaviest, and the spacing widest along the

curve from the anterior to the medial portion of the shell; depression in front of posterior keel emphasized by the disappearance of all ornamentation upon the costae; posterior ribs relatively narrow, rounded, and feebly corrugated. One more rib in left valve than in right; ribs of left valve corrugated or nodose and feebly sulcate upon the antero-medial arch, narrower and less closely spaced posteriorly than upon the medial portion of the shell. Inner margins fluted in harmony with the external sculpture. Cardinal area broad, rudely kite-shaped in the double valves, scored with sinuous ligament grooves, which are rudely concentric and tend to arch up toward the umbones. Hinge very narrow, feebly arcuate along its inner margin, finely serrate; the teeth not far from 50, arranged in two series and tending to break up and become irregular at the extremities of each series. Muscle impressions rather large, well defined, the posterior larger, less regular, and more remote from the hinge than the anterior and, in the adult, feebly buttressed. Pallial line running parallel and rather close to the outer margins.

Dimensions: Altitude of right valve, 35.0 millimeters; left valve, 36.5 millimeters. Latitude of right valve, 37.5 millimeters; left valve, 39.0 millimeters; diameter, 37.0 millimeters.

Cotypes: U. S. Nat. Mus. No. 352308.

Type locality: No. 2212, Tenmile Creek, 1 mile west of Baileys Ferry, Calhoun County, Fla.

The subspecies *geraetera* differs from *santarosana* s. s. in the narrower and more elevated umbones. This dimensional difference is so constant in the great majority of the specimens from Chipola River and appears so early in the shell that it is worthy to be recognized in the nomenclature. There are a number of young forms apparently unrepresented in the adult which differ from the normal *geraetera* in the more produced and angulated posterior keel. In the normal young of *geraetera* the base line is approximately parallel to the dorsal margin, whereas in the adult they converge slightly posteriorly. In the abnormal young forms mentioned, however, the base line is pulled down at the keel, so that it diverges from the dorsal margin and simulates in external aspect some of the coexistent *Cardium* (*Fragum*). In the absence of adults these juveniles are included under *geraetera*.

Occurrence: Chipola formation, localities 10609^c, 7893^p, 2212^c, 7257^p, 2213^a, 2564^a, 3419^c, 9994^p, 7151^c, 3704^p, ?7468^p, 5613^c, 5629^a.

***Diluvarca (Diluvarca) waltonia* Gardner, n. sp.**

Plate VI, Figures 3-6

1898. *Scapharca (Scapharca) staminata* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, pl. 31, fig. 13 (description excluded).

1898. *Scapharca (Scapharca) staminea* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 642 (part).

Not *Arca staminea* Say, American marine conchology, pl. 36, fig. 2 and text, 1832.

1898. *Scapharca (Anadara) clisea* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 657 (part).

Shell rather large, heavy; the left valve a little the larger of the two, ovate-trigonal in outline when viewed from the exterior. Umbones broad and well rounded, elevated high above the hinge line, incurved and feebly prosogyrate, set a little in advance of the median vertical. Anterior area rounding smoothly into the medial. Posterior area obliquely flattened and delimited by a subacute keel which persists from the umbones to the outer margin. Dorsal margin approximately the greatest width of the shell but a little less produced posteriorly. Anterior lateral margin approximately at right angles to the dorsal for a short distance then merging smoothly into the up-curved base. Ventral margin nearly parallel to the dorsal, though inclined to diverge slightly behind. Postero-ventral margin produced beyond the dorsal, the posterior lateral margin consequently oblique. Right and left valve discrepantly sculptured, each, however, with approximately 30 ribs; anterior costals of right valve corrugated or obtusely nodulated by the modified incremental sculpture, the costal ornamentation becoming reduced on the medial portion of the shell and nearly obsolete on the half dozen ribs directly in front of the keel; the half dozen ribs directly behind the keel also simple and more rounded than on any other portion of the shell; the four or five radials nearest the posterior margin relatively very narrow and finely nodulated; all the costals upon the left valve nodose in the young forms, those upon the posterior area, however, becoming simple in the adults; interradials relatively wider and more angular in the right valve than in the left. Inner margin sharply fluted in harmony with the external sculpture. Cardinal area wide in the adults, rising quite steeply from the hinge to the umbones, little or not at all concave, rhomboidal in the double valves, scored with irregular grooves, commonly discontinuous but arranged roughly in concentric rhomboids, about eight in the adult. Hinge narrow but rather heavy, reinforced distally, very finely and closely serrate. Teeth arranged in two series which meet with a barely perceptible interruption directly behind the umbones; anterior series including about 20 denticles, the posterior from 25 to 30; teeth in the medial portion of the hinge normal to the margin, those near the distal extremities more oblique and irregular. Adductor scars very large and distinct, the anterior more regular in outline and placed nearer to the dorsal margin than the posterior. Pallial line distinct, running parallel and quite close to the ventral margin.

Dimensions: Altitude, 32.5 millimeters; latitude, 33.0 millimeters; diameter, 36.0 millimeters.

Type: U. S. Nat. Mus. No. 352306; figured specimen, U. S. Nat. Mus. No. 113827.

Type locality: No. 3856, 6 miles west-northwest of Mossyhead, Walton County, Fla.

Diluvarca waltonia is the close analog of *Diluvarca santarosana* from the Oak Grove and its Chipola subspecies *geraetera*. It is the heaviest of the three forms and relatively the highest. The umbones are more tumid than those in either of the older forms, the depression in front of the posterior keel is obscure or obsolete, and the base line is consequently straighter. The cardinal area is higher as a rule than that of the Oak Grove species, and the hinge is less delicate. The only differences in sculpture are those concomitant with the thicker, ruder shell of *waltonia*. Though the adults of these forms can be readily separated, many of the immature individuals are indistinguishable.

Diluvarca clisea (Dall), to which the specimens from Walton County have occasionally been referred, is a larger, more oblique form with the postero-ventral extremity of the shell pulled downward and backward. The two valves of *clisea* are similarly sculptured, and the number of ribs in some specimens runs as low as 26. *Diluvarca staminata* is a broader species with a higher, more concave, and more nearly symmetrical cardinal area. *Diluvarca staminea* Say is much closer to *D. waltonia* than either *clisea* or *staminata* and its possible descendant, a hypothesis strengthened by the closer similarity of the Shoal River forms to the specimens from the Calvert than to those from the St. Marys. The Maryland species offers a wide range of variation in outline, but those individuals in which the relative altitude is as great as in *waltonia* develop a higher cardinal area. The average number of ribs is lower in the Maryland form, and those directly in front of the posterior keel are normally bisulcate or trisulcate, a character not observed in any *waltonia*.

Occurrence: Shoal River formation, localities 3856^{pr}, 3732^p, 3742^a, 3731^c, 10658^p, 5080^r, 5184^p, 5195^r, ?5079^a, 10661^c, 5193^r, 5194^r, 3733^p, 2238^r, 9958^p, 3748^c, 3747^r, 7264^r, 9960^p, ?10603^c, 5618^c, ?9959^c.

***Diluvarca (Diluvarca) strebla* Gardner, n. sp.**

Plate VIII, Figures 1-2

Shell of moderate dimensions, rather thick, the left valve a little the larger, transversely elongated, broadly and quite strongly inflated from the umbones to the ventral margin, somewhat constricted toward the posterior extremity, especially in the right valve, thus giving to the shell a slightly warped appearance. Umbones broad, very full, incurved and prosogyrate, the apices compressed and feebly sulcated medially, placed a little in front of the median vertical and rather close together. Posterior keel obsolete, the posterior slope of the umbones more sharply rounded, however, than the anterior. Dorsal margin straight, a little more than three-fourths as long as the maximum

width of the shell. Anterior lateral margin retreating from the dorsal, which it intercepts approximately at right angles, and merging into the upcurved base. Ventral margin expanded anteriorly so that the greatest altitude is in plumb with the umbones, constricted posteriorly in the adults but not in the young. Posterior extremity in the adults narrow and quite sharply rounded, the lateral margin intercepting the dorsal at an angle not far from 135°. Sculpture very similar in the two valves, the costals of the left valve being a little more elevated and more wrinkled by the concentric sculpture than those of the right. Radials simple, the same in number in the two valves—approximately 34—narrower and more closely spaced medially and less modified by the incremental sculpture than toward the extremities. Concentric lamination very fine, close, and even, corrugating the anterior costals, especially in the younger forms, but on the posterior portion of the shell almost obsolete, except in the channels. Interradials a little narrower as a rule than the radials, though commonly a trifle wider upon the medial ventral portion of the adult left valve. Inner margins fluted in harmony with the external sculpture. Cardinal area rather narrow, concave, rhomboidal, the portion behind the umbones more produced and attenuated than that in front of it. Ligament grooves in the double valves arranged in about half a dozen more or less regular, concentric rhomboids. Hinge narrow but rather heavy, reinforced distally, very finely and closely serrate. Teeth arranged in two series, their interior extremities adjoining one another with a barely perceptible break, the number in the anterior series running as high as 35, in the posterior series up to 45; serrations in the medial portion of the hinge very fine, close, and at right angles to the margin, coarser and somewhat oblique toward the outer extremities. Adductor scars large and prominent, the anterior a little more rounded, not quite so large and placed a little higher than the posterior, which is rudely quadrate in outline and elongated parallel to the posterior margin of the cardinal area. Pallial line distinct, parallel to the outer margin and not far distant from it.

Dimensions: Altitude, 27.0 millimeters; latitude, 41.0 millimeters; diameter, 26.0 millimeters.

Type: U. S. Nat. Mus. No. 352309.

Type locality: No. 3856, 6 miles west-northwest of Mossyhead, Walton County, Fla.

No similar species has been collected from the Alum Bluff group. The upper bed at Alum Bluff, the Choctawhatchee marl, contains a possible descendant—“*Scapharca (Anadara) aresta* Dall. The younger form is smaller, a little lower relatively, and less tumid, but it exhibits the same peculiarities of outline and the same type of sculpture. The closest affinities of *strebla*, however, are with a probably synchronous species of the *Diluvarca* section, *Diluvarca actinophora*

(Dall), from Monkey Hill. The Floridian form differs in being a little more inflated than the Panaman and more compressed posteriorly.

Occurrence: Shoal River formation, localities 3856^a, 3742^b, 3731^c, 5184^r, 19960^r, 10603^p, 5618^p, 10612^p.

Section CUNEARCA Dall

1898. *Cunearca* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 618.

Type: *Arca incongrua* Say. (Recent on the east coast from Hatteras to the West Indies.)

Dall describes this section as follows:

Thin, trigonal, inflated, with erect beaks; the cardinal area short, amphidetic, equilateral, set off by deep grooves from the rest of the sculpture, smooth or transversely striated, without furrows; hinge teeth divisible into two series, smaller proximally, larger and more oblique distally, often more or less Λ-shaped; the right valve smaller; sculpture of the two valves obviously discrepant; the epidermis smooth or not pilose.

Diluvarca (Cunearca) initiator Dall

Plate V, Figure 10

1898. *Scapharca (Cunearca) initiator* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 634, pl. 32, fig. 11.

1917. *Arca initiator* Dall. Sheldon, Palaeontographica Americana, vol. 1, No. 1, p. 56, (?) pl. 13, figs. 7-9.

Dall described this species in 1898 as follows:

Shell small, solid, oblique, with prosogyrate beaks, somewhat impressed mesially near the apices of the valves; right valve ovate-rhombic with 20 strong, rounded, nodulous, radial ribs, separated by wider interspaces; left valve decidedly smaller, with the ribs smooth, squarish, and without nodules, except a few on some of the shorter anterior ribs; cardinal area wider in front of the beaks, narrower behind them; margins of the valves internally fluted; hinge line short, with about 22 subequal vertical teeth. Longitude (of left valve) 5, altitude 4.7, diameter 5 millimeters.

This little shell was at first thought to be the young of a larger species, but nothing allied to it of a larger size has turned up at any locality in the formation, while its solidity gives it a mature appearance. The cardinal area differs in form from any of the known species in the adult state.

Type: U. S. Nat. Mus. No. 107717.

Type locality: No. 2564, McClelland farm, 1 mile below Baileys Ferry, Calhoun County, Fla.

This small form suggests the young of *Diluvarca santarosana geraetera* Gardner, n. subsp., though it is heavier and more nearly equilateral; the sculpture is much more discrepant in the two valves, the radials are normally only 20 or 21 instead of 30 as in *santarosana*, and those of the right valve are coarser and more nodose. *Diluvarca cardioides*, from the Oak Grove, is a very close analog of *initiator*, but it is a little larger and relatively broader and less globose. The number of ribs is approximately the same in both species, from 20 to 22, and may in both run up to 25, but those of *initiator* are not so broad as those of *cardioides*.

The relative abundance of the two forms is about the same. Neither species is uncommon at the horizon which it characterizes.

Diluvarca initiator (Dall) suggests a miniature *Diluvarca cor-cupidonis* (Maury) from the Thomonde of Haiti and the Cercado of the Dominican Republic. The West Indian shell is larger and coarser, with more inflated umbones.

Occurrence: Chipola formation, localities 2213^b, 2564^p, 3419^r, 7151^r, 7183^r.

Miss Sheldon reports and figures the species from the Oligocene of Sour Lake, Tex.

Diluvarca (Cunearca) cardioides Gardner, n. sp.

Plate VI, Figures 7-10

Shell small, solid, inequivalve, inequilateral, cor-date-trigonal when viewed from the exterior, the interior rudely quadrate. Umbones well rounded, prominently elevated medially, sulcate only toward the apices, which are incurved, prosogyrate, placed a little in front of the median vertical and at a moderate distance from one another. Anterior area rounding smoothly into the medial, the posterior obliquely flattened and defined in the left valve by an obtuse keel, which in the right valve is obscure or obsolete. Dorsal margin straight, not quite equaling the maximum width of the shell. Anterior margin very feebly expanded, merging smoothly into the upcurved base. Ventral margin diverging slightly from the dorsal toward the posterior extremity. Postero-ventral margin obtusely angulated. Posterior lateral margin oblique, intercepting the dorsal at an angle of a little more than 90°. Sculpture markedly discrepant in the two valves; ribs approximately 21 in number in each, the 7 or 8 anterior ribs of the right valve and the 5 posterior feebly nodose, the 8 or 9 intermediate costals smooth and flattened upon their summits and separated by intercostal channels of approximately their own width; radials upon the anterior and medial portions of the left valve heavy, obtusely nodose, separated by deep and narrow intercostal channels; radial outlining the posterior keel the broadest upon the valve, nodulated in the young, smooth in the fully adult; posterior ribs relatively narrow and widely separated, feebly nodose in the young, nearly smooth in the adult. Inner margins crenate in harmony with the external sculpture, the flutings persisting into the interior of the shell almost to the umbones. Cardinal area rhombic in the double valves, narrower and more produced behind the umbones than in front of them. Area of ligament attachment more symmetric than the cardinal area, for the most part opisthodontic and outlined by two deep grooves diverging from a point a little behind the apices of the umbones. Hinge narrow, the ventral margin feebly arcuate; hinge teeth about 30, very fine and approximately vertical medially, a little coarser distally and somewhat oblique. Anterior adductor rather small, roundish, placed just within the extremity of the hinge. Posterior adductor larger, more irregular in

outline, less dorsal in position than the anterior. Pallial line simple, parallel to the outer margin, and at some little distance from it.

Dimensions: Right valve, altitude, 5.0 millimeters; latitude, 5.8 millimeters; semidiameter, 2.0 millimeters. Left valve of another individual, altitude, 7.7 millimeters; latitude, 9.0 millimeters; semidiameter, 3.6 millimeters.

Cotypes: U. S. Nat. Mus. No. 352307.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County, Fla.

This small species, which suggests *Cardium (Fragum)* in its general appearance, is the analog of the Chipola *D. initiator*. The Oak Grove form is the larger of the two, is less globose, and is relatively broader. The costals number approximately the same in the two species, but those of *D. cardioides* are a little heavier. In both species there is considerable variation in the number of ribs, which may be as high as 25.

Occurrence: Oak Grove sand, localities 2646^p, 5632^p, ? 5631^r, 7054^r, 9961^r.

Genus GLYCYMERIS Da Costa

1778. *Glycymeris* Da Costa, British conchology, p. 168.

Type: *Glycymeris orbicularis* Da Costa = *Arca glycymeris* Linnaeus. (Recent off the British Isles and the coast of Europe.)

Shell heavy, equivalve, equilateral or subequilateral, suborbicular. Beaks almost straight, only very slightly incurved. Hinge margin arcuate, set with two series of strong transverse teeth which are progressively obliterated during growth by the subsidence of the cardinal area. Exterior surface of valves concentrically or radially striate. Margins crenulate within. Adductor scars subequal. Pallial line simple or very slightly sinuous.

The genus originated in the Cretaceous, culminated in the Miocene, and is represented to-day by about 80 species, widely distributed in the shallower waters of the warm and temperate seas.

Glycymeris is represented in the Alum Bluff group by few species, but by a wealth of individuals. Four out of five species and subspecies are referable to the group of *Glycymeris subovata* Say, so prominent in the later Tertiary. Each horizon has its characteristic member of the group, and in the Oak Grove there is also a subspecific form developed. The diagnostic members of the group, *Glycymeris drymanos* and its subspecies *grapta* in the Oak Grove and *G. waltonensis* in the Shoal River, are exceedingly abundant. The true *G. subovata*, which occurs in the Chipola and rarely in the Shoal River, is much less prolific. It is also interesting to note the backward extension of the range of *G. pectinata* Gmelin, which is so common in the later Tertiary and so abundant in the shallow waters of the Recent seas from Cape Fear south through the West Indies. Another species, *Glycymeris americana* De France, which is prominent in the

Recent faunas of the east coast, is possibly present in the Shoal River. If the worn valve from Whites Creek is not identical with the Recent form it is certainly a close forerunner.

Radial sculpture of impressed sulci; altitude of adult exceeding 20 millimeters:

Radials persistent to the lateral margins and in the majority of the adults to the base; outline approximately symmetrical bilaterally:

Shell not very heavy, relatively compressed; inter-radial spaces arched.-----*Glycymeris subovata* Say.

Shell heavy, relatively inflated; interradial spaces flattened. *Glycymeris drymanos* Gardner, n. sp., s. l. Secondary radial sulcations not developed.

Glycymeris drymanos Gardner, n. sp., s. s.

Secondary radial sulcations developed.

Glycymeris drymanos grapta Gardner, n. subsp.

Radials evanescent toward the lateral and in the adults toward the ventral margins; shell often obliquely produced posteriorly; interradial spaces flattened.

Glycymeris waltonensis Gardner, n. sp.

Radial sculpture of elevated costae; altitude of adult not exceeding 20 millimeters.-----*Glycymeris pectinata* Gmelin.

Glycymeris subovata (Say)

Plate VIII, Figures 3-8

1824. *Pectunculus subovatus* Say, Acad. Nat. Sci. Philadelphia Jour., 1st ser., vol. 4, p. 140, pl. 10, fig. 4.
 1832. *Pectunculus subovatus* Say. Conrad, Fossil shells of the Tertiary formations of North America, p. 17, pl. 2, fig. 3.
 1845. *Pectunculus subovatus* Say. Conrad, Fossils of the medial Tertiary of the United States, p. 62, pl. 34, fig. 1.
 1858. *Pectunculus subovatus* Conrad. Emmons, North Carolina Geol. Survey Rept., p. 286, fig. 207.
 1863. *Azinaea (Pectunculus) subovata* Say. Conrad, Acad. Nat. Sci. Philadelphia Proc. for 1862, p. 581.
 1864. *Azinaea subovata* (Say) Conrad. Meek, Check list of the invertebrate fossils of North America, Miocene: Smithsonian Misc. Coll., No. 183, p. 5. (Name only.)
 1898. *Glycymeris subovata* Say. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 611.
 1904. *Glycymeris subovata* (Say). Glenn, Maryland Geol. Survey, Miocene, p. 394, pl. 107, figs. 3, 4.

Say described this species in 1824 as follows:

Longitudinally short ovate, with about 30 longitudinal impressed acute lines, the intervals a little convex.

Shell increasing in width by a slightly curved line from the apex to beyond the middle; lateral curvatures equal; apices separate, small, central; intervening space with but little obliquity to the plane of the shell, with obsolete angulated lines; teeth forming a regularly and much arcuated series, which is rectilinearly truncated above so as to leave in that part a mere edentulous elevated line; within destitute of striae; margin with elevated angular lines; exterior surface with about thirty longitudinal, impressed, acute lines, the intervals a little convex.

Length from the apex to the base $1\frac{1}{8}$ inches; breadth $1\frac{1}{2}$ inches nearly.

Type locality: Maryland.

Figured specimens: U. S. Nat. Mus. Nos. 325484 (right valve; Suffolk, Va.), 325485 (left valve; Colerain Landing, N. C.)

Glycymeris subovata Say differs narrowly in the outline and degree of convexity of the valves and rather

widely in the character of the sculpture. The normal form is ornamented with 25 to 35 low, gently arched radials separated by deeply impressed linear grooves which are more closely approximated laterally and in the young shells. In the young, too, the ribs are much more strongly arcuate, but they broaden and flatten in the adults and, in senile individuals, evanesce toward the basal margin. The subspecies results from the tendency toward an asymmetric outline, the obliteration of the lateral sculpture, and the widening of the impressed grooves.

The species is one of the most widely distributed and one of the most conspicuous of the east coast Tertiary molluscan fauna.

The Chipola representatives are smaller than the later Tertiary individuals but differ in no other constant character from typical members of the species. *Glycymeris drymanos* is heavier and more inflated, with more flattened interradial areas and a somewhat coarser dental armature. *Glycymeris waltonensis* is also more inflated, as a rule, more or less produced posteriorly, much less strongly sulcated radially, especially toward the margins, and more compressed in the dorsal region. The Chipola representatives of the group do not begin to approximate in relative abundance either those of the Oak Grove or of the Shoal River.

Occurrence: Chipola formation, localities 10609^p, 7893^p, 2212^p, 2213^c, 2564^c, 3419^c, 9994^r, ?7151^r, 2211^r. Shoal River formation, localities 9958^r, 9959^c.

Outside occurrence: Miocene, Choctawhatchee marl, Alum Bluff (upper bed), Calhoun County, Fla.; Jacksonville formation, Middleburg, Black Creek, Clay County, Fla.; Calvert formation, Maryland, Virginia; St. Marys formation, Virginia, North Carolina; Yorktown formation, Virginia, North Carolina; Duplin formation, North Carolina, Georgia.

***Glycymeris drymanos* Gardner, n. sp.**

Plate IX, Figures 1-2

Shell of moderate size for the genus, thick, heavy, rather tumid, subcircular to subovate in outline, in many specimens slightly produced obliquely. Posterior dorsal margin usually sloping a little more steeply than the anterior. Lateral margins broad and merging gradually into the arcuate base. Umbones subcentral or a little anterior, incurved, orthogyrate, acute at the tips, rounded, not very prominent. Normal external sculpture consisting of radiating sulci, 18 or 19 in number upon the medial portion of the types but ranging from 16 to 22 in other individuals, usually more closely spaced upon the posterior half of the shell than upon the anterior. Four additional sulci on each of the submargins of the types, but as many as 6 or 7 in other individuals, all of them, both upon the disk and the margins, persistent as a rule to the outer edge. Interlinear

spaces usually flat upon the disk, occasionally rounded, the interspaces upon the submargins in many specimens raised and commonly rather steeply inclined toward the dorsal margin. Concentric sculpture restricted to incrementals, most prominent, as a rule, toward the ventral margin. Ligament area of moderate size, rather high, approximately symmetrical; sulci deep, 8 on each side in the type. Dental arch high, interrupted in all but the very young by the submergence of the ligament area. Teeth strong, 12 anterior and 12 posterior in the right valve, 14 anterior and 12 posterior in the left valve of the type; the number in the complete series about 15 to the side. Muscle scars conspicuous, the anterior slightly larger than the posterior, semi-elliptical or rounded conical in outline, the posterior rudely quadrilateral and feebly buttressed. Pallial line simple, distinct, rather distant from the margin. Interior of valve finely striated radially, especially just inside of the pallial line. Inner margins ornamented with a series of elevations, quadrate medially, trigonal distally.

Dimensions of right valve: Altitude, 38.5 millimeters; latitude, 38.5 millimeters; diameter, 15.0 millimeters. Dimensions of left valve of another specimen: Altitude, 38.2 millimeters; latitude, 37.5 millimeters; diameter, 13.0 millimeters.

Cotypes: U. S. Nat. Mus. No. 352310.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County, Fla.

The young are stocky little square-shouldered shells.

Glycymeris drymanos Gardner, n. sp., is smaller than *G. subovata* Say with which it has been confused, relatively heavier and more inflated. The dorsal margins are not quite so wide, and the hinge area is consequently higher and the dental arch more compressed. Then, too, the submargins are as a rule better differentiated than they are in *G. subovata* and the lineations upon the disk relatively more distant. The sulci are similar in character to those of *subovata*, but the interradial spaces are for the most part flattened and not rounded. *G. waltonensis* runs a little smaller and is not quite so heavy. Many specimens are obliquely produced posteriorly and are generally more or less compressed in the dorsal region. The radial sulcation in the adult is more feeble than in *G. drymanos*, more or less obsolete toward the margins, and very commonly more distinct upon the posterior half of the shell than upon the anterior. The young and adolescent forms are, however, very difficult to separate, for the diagnostic features of *G. waltonensis* do not usually appear until the adult stage. Both *Glycymeris drymanos* and its subspecies *grapta* are exceedingly prolific at the type locality and its environs.

Occurrence: Oak Grove sand, localities 2646^{pr}, 5632^c, 5631^r, 5630^c, 5633^c, 7054^a, 2652^p, 9961^p, 7055^c, ?3749^c.

***Glycymeris drymanos grapta* Gardner, n. subsp.**

Plate IX, Figures 3-4

Outline and general dimensions similar to those of *G. drymanos*, of moderate size, heavy, rather tumid, subcircular to subovate, the umbones subcentral, the dorsal margins more or less oblique, the posterior in many specimens slightly more produced than the anterior, the lateral margins broadly rounded or obscurely truncate, the base line arcuate. Primary radial sculpture similar to that of *G. drymanos* s. s. and running through a similar series of variations, 16 on the disk of the right valve of the type, 17 on the left in another individual, and 4 additional sulci on each of the submargins of each valve. A further and exceedingly variable secondary sculpture developed in the shape of fortuitous sulci, for the most part less deeply impressed than the primaries, rather more commonly developed upon the medial and anterior portions of the shell than upon the posterior; faint secondary lineations suggesting those of *G. americana* developed near the base of the primaries, more commonly with one or rarely two sulci running up from the basal margin halfway or more to the beaks. Submarginal ribs in many specimens strongly dissected. Characters of ligament and hinge areas and the interior similar to those of *G. drymanos* Gardner, n. sp.; the ligament area rather small and moderately high, with six or seven sulci diverging beneath the umbones; the rather high dental arch with about a dozen teeth on either side; the anterior muscle scars rounded, trigonal; the posterior smaller, rudely quadrate, and feebly buttressed; the interior of the disk faintly striated radially; the pallial line simple, distinct, the inner basal margin crenulated.

Dimensions of right valve: Altitude, 37.0 millimeters; latitude, 37.6 millimeters; diameter, 13.0 millimeters. Dimensions of left valve of another individual: Altitude, 36.5 millimeters; latitude, 36.5 millimeters; diameter, 13.5 millimeters.

Cotypes: U. S. Nat. Mus. No. 352311.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County, Fla.

The secondary radial sculpture, the diagnostic character of the subspecies, does not develop until the form is about half grown, so that the young can not be separated from the young of *G. drymanos* s. s.

Occurrence: Oak Grove sand, localities 2646^{pr}, 5632^r, 5630^r, 5633^r, 7054^p.

***Glycymeris waltonensis* Gardner, n. sp.**

Plate IX, Figures 5-8

Shell of moderate size for the group, moderately thick and heavy, and moderately inflated. Outline subcircular and approximately symmetric bilaterally in the young and adolescent, in many specimens quite strongly and obliquely produced posteriorly in

the adults. Umbones rather low, rounded, acute at their apices, orthogyrate, and in the adults more or less anterior in position. Dorsal margins converging at an angle of 45° to 60°, the posterior margin generally more produced than the anterior. Anterior lateral margin very broadly rounded or obscurely truncate. Posterior lateral margin obscurely differentiated, as a rule, very short, rounded or obtusely truncate, the dorsal margin usually produced beyond the median horizontal. Base line arcuate, more strongly and more abruptly upcurved in front than behind. External surface radially sulcate, the sulci linear and varying in number, as a rule between 20 and 30, inclined to become obsolete toward the margins, both the lateral and the ventral, most distinct upon the medial portion of the disk, usually more distinct and more closely spaced posteriorly than anteriorly. Concentric sculpture developed only in the shape of incrementals, most pronounced toward the ventral margins. Ligament area usually quite high and trigonal. Dental armature heavy. Dental arch high. Teeth strong, numerous, normally about 12 on either side, the anterior a little more elevated as a rule and more strongly arched than the posterior. Muscle scars very distinct, the anterior rounded, trigonal, the posterior rudely quadrate. Posterior buttress exceedingly feeble. Pallial line simple. Interior of disk faintly striated radially. Inner edge evenly crenate along the lateral and basal margins.

Dimensions: Altitude, 33.9 millimeters; latitude, 35.1 millimeters; maximum diameter, 20.6 millimeters.

Type: U. S. Nat. Mus. No. 352312; figured specimen, No. 352313.

Type locality: No. 3732, Shell Bluff, Shoal River, Walton County, Fla.

Glycymeris waltonensis is the Shoal River representative of the group of *G. subovata* Say and was included by Dall under his variety *plagia*. It is, however, distinct from *plagia* by reason of its smaller average size, more inflated umbones, and more flattened interradials. In many individuals of *waltonensis* the posterior end is quite strongly produced obliquely and in some of them it is obtusely pointed. The radial lineation is commonly, as in the type, very much sharper on the posterior half of the shell than upon the anterior, although this differentiation is developed only in the adults and is not constant even in them. There is rather a wide age and individual variation in the outline of the ligament area and in the dental armature, but the area is inclined to be narrow and rather high and the dentition strong and regular.

The characteristic Oak Grove species—*Glycymeris drymanos* Gardner, n. sp.—is a slightly larger, heavier, and more inflated shell. Its outline as a rule is more nearly symmetrical and the dorsal arch usually

broader. The radial sulci are generally deeper and persist to the margins. The striations upon the sub-margins are not inclined to be obsolete, as in *G. waltonensis*, and there is usually some trace of the secondary or fortuitous sulcation, which is best developed in the subspecies *grapta*. It is difficult to separate the young of the two species, for the characteristic features of *waltonensis* are not acquired until maturity, but the stronger sculpture of the Oak Grove forms may serve as a reliable diagnostic in any considerable series.

Glycymeris waltonensis is exceedingly prolific; in fact, in the collections under investigation it is the most prolific of the Shoal River bivalves.

Occurrence: Shoal River formation, localities 3856^p, 2645^c, 3732^a, 3742^{pr}, 5080^c, 5184^a, 5195^a, 5079^c, 5193^p, 5194^r, 3733^r, 22238^r, 3748^r, 9957^a, 10603^{pr}, 10608^p.

***Glycymeris* sp. cf. *G. americana* DeFrance**

A single valve of a species possibly closely allied to or possibly identical with *Glycymeris americana* was found at Whites Creek, 6.7 miles south of Argyle, Walton County, Fla. The genus *Glycymeris*, as we know it on the east coast, seems to have undergone remarkably few changes between the early Tertiary and the Recent times. The presence of even the single valve marks the introduction of another modern species or of a closely allied precursor in the uppermost of the Alum Bluff faunas.

Occurrence: Shoal River formation, locality 9957^r.

***Glycymeris pectinata* (Gmelin)**

Plate IX, Figures 9-12

1792. *Arca pectinata* Gmelin, Systema naturae, vol. 6, p. 3313.
 1841. *Pectunculus aratus* Conrad, Am. Jour. Sci., 1st ser., vol. 41, p. 346.
 1845. *Pectunculus aratus* Conrad, Fossils of the medial Tertiary of the United States, p. 62, pl. 34, fig. 2.
 1853. *Pectunculus pectiniformis* D'Orbigny, in De la Sagra, Histoire physique, politique et naturelle de l'île de Cuba, Mollusques de Cuba, vol. 2, p. 313.
 1856. *Pectunculus aratus* Conrad. Tuomey and Holmes, Pleiocene fossils of South Carolina, p. 50, pl. 17, figs. 6, 6a, 6b.
 1858. *Pectunculus charlestonensis* Holmes, Post-Pleiocene fossils of South Carolina, p. 16, pl. 3, fig. 5.
 1886. *Pectunculus pectinatus* Gmelin. Dall, Harvard Coll. Mus. Comp. Zoology Bull., vol. 12, p. 239.
 1898. *Glycymeris pectinata* Gmelin. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 612.
 Not *Pectunculus pectiniformis* Lamareck, 1819, Histoire naturelle des animaux sans vertèbres, vol. 6, p. 53.

Gmelin described this species in 1792 as follows:

A. testa lenticulari inaurita longitudinaliter striata: striis aevibus. * * *

Habitat in Oceano Americano, pectunculo affinis, at testa minore magis convexa, fusca, spadicea, aut lutea punctata, maculata, nebulosa, aut undulata, intus subfusca aut alba.

Conrad in 1845 added the following details:

Ovate, with about 28 rounded ribs, about as wide as the interstices and crossed by wrinkled lines; anterior margin ob-

liquely truncated; extremity with a slightly prominent obtuse angle, beneath which the margin is obliquely truncated inward; posterior margin obliquely truncated above; cardinal teeth prominent, closely arranged, angulated; basal margin with about 15 wide remote crenae.

Locality, Wilmington, N. C.

Allied to *P. pectinatus* Lamareck, but the ribs are narrower, more remote and prominent.

Figured specimen: U. S. Nat. Mus. No. 325491 (Neills Eddy Landing, N. C.).

The Shoal River representatives are rather large, heavy, medially inflated, and angular in outline. The umbones are small but full, orthogyrate, acute, and proximate at their tips, subcentral in position. The dorsal margins are short and form as a rule a continuous straight line. Their angle of union with the posterior lateral margin is rather sharper than with the anterior. The anterior lateral margin merges gradually into the upcurved base, whereas the posterior obliquely truncates the posterior end of the shell for about two-thirds the distance from the umbones to the base line. The base line is almost straight medially and more strongly upcurved in front than behind. The radials are prominently elevated, somewhat flattened upon their summits, running wider than the interradials, generally 20 or 21 in number, narrower and a little more crowded laterally, especially upon the posterior margin. The concentric lamination upon fresh specimens is very fine. The ligament area is small and rather high, the grooves generally 3 or 4 in number. The teeth are strong, obtusely Λ -shaped, and arranged in two series of about 11 each which converge at an angle not far from 90°. The muscle impressions are small but distinct and very feebly buttressed. The pallial line is also distinct, and there is the usual fine radial striation upon the interior. The basal and lateral margins are coarsely crenate in harmony with the external ribbing, the crenulations dying out as they approach the dorsal margins. The altitude of the largest of the Shoal River individuals is 15 millimeters, its latitude 14.5 millimeters.

This small *Glycymeris*, so abundant in the later Tertiary deposits and in the Recent seas, has not been previously reported from the lower Miocene. It is represented at the single locality by about half a dozen valves.

Occurrence: Shoal River formation, locality 3742^p.

Outside occurrence: Miocene, Yorktown formation, Virginia, North Carolina. Duplin formation, North Carolina. Pliocene, Waccamaw formation, North Carolina, South Carolina. Caloosahatchee formation, Florida. Croatan marl, North Carolina. Pleistocene, South Carolina. Recent, Cape Hatteras to Greytown, Nicaragua, and Barbados, in 2 to 175 fathoms; occurs in both deep and shallow water in the West Indies, elsewhere in shallow water only.

Section SCHIZODONTA

Superfamily PTERIACEA

Family PINNIDAE

Genus ATRINA Gray

1840. *Atrina* J. E. Gray, Synopsis of the contents of the British Museum, p. 151, nomina nuda.
 1842. *Atrina* J. E. Gray, idem, p. 83.

Type: *Pinna nigra* Chemnitz. (Recent in the Indo-Pacific.)

Gray characterized the genus in 1842 as follows:

The *Pinna* have an elongated shell with a longitudinal crack filled with a cartilage in the middle of each valve, and *Atrina* are shorter shells without any such crack.

Shell thin, fragile, inequivalve, gaping posteriorly, cuneate. Umbones sharp, pointed, terminal, anterior. Ligament lodged in a long narrow groove. Hinge edentulous. Byssal notch small, situated beneath the umbones.

Atrina is separated from *Pinna*, to which it has been frequently assigned as a subgenus, by the absence of the medial longitudinal sulcation. It is confined to the warmer waters and is never abundantly represented.

The genus apparently began as early as the late Paleozoic. The Recent species bury themselves in the sand and mud along tropical and subtropical shores. Only a single species has been reported from the Alum Bluff, but this ranges with some variation through both the Chipola and the Oak Grove. Fragments of an indeterminate form occur also in the Shoal River.

Atrina chipolana Dall

1898. *Atrina* (*argentea* var. ?) *chipolana* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 662.

Dall describes this species as follows:

This form is only represented by fragments. It would appear to attain about the size of *A. argentea*, but to be somewhat more convex and arcuate. The chief distinction is in the sculpture; the dorsal areas of the valves of both have about five equidistant radial riblets; the ventral areas in *argentea* have a few radial ribs near the middle of the valve, below which the sculpture becomes obsolete; in *chipolana* the ventral areas are sculptured with distinct oblique, concentric waves, with about equal interspaces; the upper ends of these waves terminate abruptly where they meet the longitudinal riblets, so that the sculpture of the ventral is strongly contrasted with that of the dorsal areas. This form also appears to increase in width more rapidly than the *argentea*. On the whole, the two appear specifically distinct, but a complete description must be deferred until better material enables the characters to be fully elucidated.

Type: U. S. Nat. Mus. No. 114778.

Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla.

Conrad's original description of *Atrina argentea* is as follows:¹⁶

¹⁶ Conrad, T. A., Observations on the Eocene formation and description of one hundred and five new fossils of that period from the vicinity of Vicksburg, Miss.: Acad. Nat. Sci. Philadelphia Proc., vol. 3, pp. 295-296, 1847.

Triangular, with straight margins and acute summit; compressed; substance highly polished and silvery; valves with longitudinal radii on more than half the disc, about thirteen in number; anterior side with rugose, obtuse, oblique, finer and more approximate lines. Length $2\frac{3}{4}$. Rare.

There are no fragments worth figuring, and the original description can not be amplified from any material furnished by the later collections. It is possible that there may be more than an individual variation between the Oak Grove and the Chipola forms, as the Oak Grove fragments seem to indicate a broader, less convex species.

Occurrence: Chipola formation, locality 2213^p. Oak Grove sand, locality 2646^p.

Family PEDALIONIDAE

Genus PEDALION (Solander MSS.) Huddesford

1770. *Pedalion* Huddesford, Duo indices ad synopsis methodicam conchyliorum Martini Lister, Index II, p. 23.
 = *Melina* Retzius, 1788.
 = *Perna* Lamarck, 1799.

Type: *Ostrea isognomum* Linnaeus. (Recent in the East Indies.)

Shell without well-defined auricles, subquadrangular to subcuneate, compressed. Exterior surface lamellar. Interior nacreous. Umbones sharp, anterior, terminal. Hinge edentulous. Area wide, furnished with a series of elongated cartilage pits set normal to the margin. Pallial line simple. Muscular impression large, slightly eccentric.

The genus is sparsely represented in the Mesozoic and Cenozoic faunas.

The reported occurrence at Oak Grove is the only record of the presence of this genus in the Alum Bluff.

Pedalion solereperta (Maury)

1910. *Perna solereperta* Maury, Bull. Am. Paleontology, vol. 4, No. 21, p. 33, pl. 8, fig. 8.

Maury describes this species as follows:

Shell very inequilateral, small, compressed, with the general outline of *P. ephippium* Linnaeus. Unfortunately the only valve found is broken, but the portion of the cardinal area that remains shows distinctly two of the series of cartilage pits. Exterior of the shell with numerous fine radiating riblets not appearing over the earlier 5 millimeters of the shell.

Length of shell 12, width 8 millimeters.

This appears to be the first true *Perna* found in the Florida Tertiaries.

Oak Grove, Santa Rosa [now Okaloosa] County, Fla. Cornell University collection.

Both the description and the figure are inadequate, but there is nothing to supplement them in any of the later collections.

Occurrence: Oak Grove sand (Cornell University).

Family PTERIIDAE

Genus PTERIA Scopoli

1777. *Pteria* Scopoli, Introductio ad historiam naturalem, p. 397.

Type: *Mytilus hirundo* Linnaeus. (Recent off the coast of England and southward through the Mediterranean.)

Shell inequivalve, inequilateral, auriculate. Anterior ear comparatively small, posterior aliform. Byssal sinus under anterior auricle of right valve. Exterior surface almost smooth, lamellar or striated. Interior nacreous. Umbones low but sharp. Hinge line elongated, straight. A single cardinal tooth placed under the umbone of each valve, commonly supplemented by a laminar lateral tooth. Ligament marginal, partly internal, partly external. Pallial line entire. Adductor impression subcentral.

The genus has a vast stratigraphic range—from the Silurian onward. The Recent species number about 120 and live chiefly in tropical and subtropical waters. Among them may be mentioned the Antillean pearl oyster, *Pteria radiata* Leach.

The picturesque name of the type species was doubtless suggested by the outline of the shell, which is not unlike that of a swallow on the wing.

Only a single species has been found sufficiently well preserved to receive a name, and even this occurs in so fragmentary a state that it has not been figured. Aside from *P. chipolana*, which is apparently quite common at the single horizon at which it occurs, there is another rather closely related Chipola species and also an Oak Grove form of the group of the *P. multangula* H. C. Lea from the Chesapeake Miocene. No trace of the genus has been observed in the Shoal River material.

Pteria chipolana Dall

1898. *Pteria* (*argentea* var.?) *chipolana* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 669.

Dall describes this species as follows:

Small, with a straight hinge line and narrow, deep ligamentary sulcus, the right valve with a small, well-marked cardinal tooth fitting into a small pit in the opposite valve; anterior wing short, small, with a narrow byssal sinus marked on the auricle by a short groove, external surface smooth, the posterior wing feebly set off; valves rather compressed, none of the valves exceeding 25 millimeters in length.

It is probable that this represents a species distinct from that of Vicksburg, but the material in my possession is insufficient to determine the question, but the type of *P. argentea* shows little trace of a byssal sinus and is more inequilateral than our shell.

Type: U. S. Nat. Mus. No. 114881.

Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla.

No specimens worthy of figuring are contained in any of the available collections. The Chipola species is certainly distinct from the Vicksburg, though no additional characters have been observed except the close, sharp lamination upon the anterior auricle of the right valve. There is a second *Pteria* present in the Chipola beds, a form more oblique than *chipolana* and more delicate but known only from a fragment of a right valve. The hinge in this fragment is long and straight, the umbone narrow and obliquely acute, the anterior auricle rather produced and attenuated

and crowded with laminae sinuated by the shallow byssus, the posterior auricle relatively large and quite well defined. The entire known surface with the exception of the anterior auricle is microscopically crackled and chased with regularly disposed incised lines. The surface is mottled with a reddish brown, which seems to be a remnant of the original color pattern. The ligament sulcus is very shallow and the cardinal tooth rude.

Fragments of a third species occur in the Oak Grove beds. This form was apparently much thicker and heavier and had a shell structure similar to that of *P. multangula* H. C. Lea. The nacre is pearl-gray and highly iridescent, as in the Miocene species, and there are traces of similar undulatory growth lines and radiating threadlets. The ligament area is wide and the armature well developed for the group.

Occurrence: Chipola formation, localities 2213^r, 2564^c, 3419^r, 2211^p.

Superfamily OSTRACEA

Family OSTREIDAE

Genus OSTREA (Linnaeus) Lamarck

1758. Linnaeus, *Systema naturae*, 10th ed., p. 696.

1799. Lamarck, *Prodrome d'une nouvelle classification des coquilles*: Soc. hist. nat. Paris Mém., p. 81.

Type: *Ostrea edulis* Linnaeus. (Recent off the European shores from Iceland to the Adriatic.)

Ostrea, the common oyster, is doubtless by reason of its great economic value the most widely known of the molluscan genera. The shell is inequivalve, generally irregular and more or less inequilateral. Except in the larval stages it is attached by the convex left valve. The right valve, which is flattened or slightly concave, serves as a cover. The hinge is edentulous. There is a single muscle scar, the posterior, and this is subcentral. The pallial line is simple but not well defined.

The genus has been prominent in all the molluscan faunas from the Mesozoic onward. Two hundred and forty species have been recognized in the Cretaceous alone, and throughout the Tertiary *Ostrea* forms one of the most conspicuous elements of nearly every fauna. Nevertheless, the later Tertiary species are of little value as horizon markers because of their wide stratigraphic range. As in all attached forms the limits of variation are wide.

The distribution of the oysters in the Alum Bluff group is surprisingly local. Only one or possibly two of the six species which occur has been found in more than one formation. *Ostrea haitensis*, the most widely distributed representative of the genus, is abundant in both the Oak Grove and Chipola and is present in the Shoal River. *Ostrea rugifera* Dall is the most characteristic member of the group at Chipola and may possibly be represented in the fuller's earth beds near Tallahassee. *Ostrea pauciplicata* is

apparently restricted to the Oak Grove, whereas *O. trigonalis*, *O. podagrina*, and the prolific *O. normalis* Dall (*O. mauricensis* of authors) are restricted in the Alum Bluff section to that portion formerly known as the "Hawthorn beds." There is no conspicuous development of the genus at any horizon, and during the Shoal River epoch conditions must have been decidedly unfavorable.

Adult shell rarely exceeding 7 centimeters in altitude; radial sculpture strongly developed on the left valve:

Radials on the left valve rarely exceeding 15 in number, regularly imbricated by the incrementals.

Ostrea pauciplicata Dall.

Radials on the left valve usually exceeding 15 in number; concentric sculpture usually feeble and irregular.

Ostrea rugifera Dall.

Adult shell generally exceeding 7 centimeters in altitude:

Left valve strongly plicated radially:

Shell rather thin..... *Ostrea haitensis* Sowerby.

Shell very heavy..... *Ostrea podagrina* Dall.

Left valve nonplicate or feebly and irregularly undulated:

Outline broadly ovate, irregularly plicate, as a rule; ligament area usually low, broad, and flattened.

Ostrea trigonalis Conrad.

Outline narrowly ovate, usually elongated, not radially plicate; ligament area usually high, narrow, and medially excavated..... *Ostrea normalis* Dall.

***Ostrea pauciplicata* Dall**

Plate X, Figures 3-4

1898. *Ostrea sellaeformis* var. *pauciplicata* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 678.

Dall says:

Shell fan-shaped with acute beaks, thin, with few (7 to 15) rather large, loosely imbricated radial but not divaricating ribs, the scales more or less fluted, thin, and elevated; upper valve falcate, with concentric laminae; structure flattish and thin.

Dimensions: Right valve, altitude, 47.0 millimeters; latitude, 28.0 millimeters. Left valve of another individual, altitude, 55.0 millimeters; latitude, 37.0 millimeters.

Cotypes: U. S. Nat. Mus. No. 153874.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County, Fla.

The right valve as well as the left is usually quite strongly falcate. Radial sculpture is absent upon the upper valve. The external surface of the lower valve is very prettily frilled by the free-edged and unusually regular concentric laminae. The beaks are compressed, the ligament area is narrow and trigonal, and the medial depression is deep. The submargins are commonly punctate or minutely nodulated, and the single muscle scar is pyriform and rather high.

The species is well characterized by its thin shell, falcate outline, fanlike radials, and uniform concentric lamination. It is more coarsely sculptured than *O. rugifera* and more regularly sculptured than *O. haitensis*. It seems to be sufficiently distinct from *O. sellaeformis* to deserve generic rank.

The form is apparently peculiar to the Oak Grove horizon.

Occurrence: Oak Grove sand, localities 2646^a, 5632^c, 5630^p, 7054^c, 9961^c.

***Ostrea rugifera* Dall**

Plate X, Figures 1-2

1898. *Ostrea sellaeformis* var. *rugifera* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 678.

Dall describes this species as follows:

Shell rather thin, irregular, coarsely ribbed, more or less imbricated, margin plicate, form tending to ovate or rounded.

Dimensions: Right valve, altitude, 61.5 millimeters; latitude, 37.0 millimeters. Left valve of another individual, altitude, 58.0 millimeters; latitude, 38.0 millimeters.

Cotypes: Right valve, U. S. Nat. Mus. No. 114570; left valve, U. S. Nat. Mus. No. 114571.

Type locality: No. 2211, lower bed, Alum Bluff, Liberty County, Fla.

Shell rather small, rudely ovate or ovate-trigonal in outline, the lower valve slightly convex and overreaching the flattened upper valve along all but the dorsal margins. External surface of left valve normally sculptured with 20 to 25 cordate riblets which show a slight tendency to diastomose but are for the most part continuous from the umbones to the ventral margins. Concentric sculpture manifested in irregular nodulations of the costae and more rarely in imbricating lamellae. Surface of right valve sculptured with very thin, closely appressed, concentric lamellae, about 30 in number in perfect individuals. Ligament area short and narrow, usually a little twisted; hinge edentulous. Submargins finely punctate or dentate. Single muscle scar pyriform in outline in fresh individuals, posterior in position, a little below the median horizontal. Inner margin of left valve finely crenulated.

Ostrea rugifera Dall is most abundantly developed at Alum Bluff and is consistently more regular in outline, relatively broader and more finely ribbed at that locality than it is along the Chipola. The Chipola River individuals are elongated and are as a rule more sparsely ribbed and more conspicuously laminated. Some of the end members are separable with difficulty from *O. pauciplicata* of the Oak Grove. The radials of *O. pauciplicata* are, however, more undulatory, usually broader, and less numerous and the concentric laminae more regularly fluted.

Occurrence: Chipola formation, localities, 2212^a, 2213^a, 2564^c, 3419^c, 9994^p, 2211^{pr}, 2568^r, 7183^c, 3424^p, 7468^c, 4976^r, 4977^r, 4986^p.

***Ostrea trigonalis* Conrad**

1829. *Ostrea* sp., Lesueur, Walnut Hills fossils, pl. 4, fig. 17; pl. 5, fig. 1.

1854. *Ostrea trigonalis* Conrad. Wailes, Report on the agriculture and geology of Mississippi, pl. 14, fig. 10.

1855. *Ostrea trigonalis* Conrad, Acad. Nat. Sci. Philadelphia Proc., vol. 7, p. 259.
 1898. *Ostrea trigonalis* Conrad. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 681.
 1904. *Ostrea trigonalis* Conrad. Glenn, Maryland Geol. Survey, Miocene, p. 381, pl. 101, figs. 1a, 1b.
 1909. *Ostrea trigonalis* Conrad. Grabau and Shimer, North American index fossils, vol. 1, p. 465, figs. 621, a, b. (After Glenn.)

Conrad described this species in 1855 as follows:

Triangular, flat, surface irregular, with some indistinct radiating lines; muscular impression obliquely suboval, situated nearer the summit than the base; margin somewhat ascending, submargin carinated. A single imperfect upper valve is all that I have seen of this shell but it is widely different from any other Eocene species known to me.

Type locality: Jackson, Miss.

A few of the excellent plates of Lesueur, a French engraver, were distributed privately but never properly published, so that his name would have no standing even if he had given one.

Ostrea trigonalis Conrad is heavy, commonly irregular, and varies widely in outline. The umbones are generally subcentral and fairly straight, the hinge area rather broad and flat, with a shallow central channel. The strong vermicular sculpturing of the submargins in front of the hinge area, particularly in the right valve, forms one of the best diagnostics of the species. The outer surface of the heavy upper valve is coarsely wrinkled, that of the lower valve in some specimens is smooth, in others sculptured with coarse growth lines, and in still others rudely plicated. The muscle scar is semioval, and in many specimens deeply impressed.

The species has been reported from the fuller's earth beds at Rock Bluff and from Sopchoppy. It is a poorly characterized form, not sufficiently well preserved to be identified with assurance.

It is quite possible that the few valves in question may be more properly referable to the less ponderous *Ostrea haitensis* Sowerby.

Occurrence: Chipola formation, localities ?2566^r, ?7468^r, ?6175^r, ?6769^r, ?6209^r.

Ostrea haitensis Sowerby

1850. *Ostrea haitensis* Sowerby, Quart. Jour. Geol. Soc. London, vol. 6, p. 53.
 1873. *Ostrea haytensis* Sowerby. Gabb, Am. Philos. Soc. Trans., vol. 15, p. 257.
 1866. *Ostrea virginica* Guppy, Quart. Jour. Geol. Soc. London, vol. 22, pp. 576, 577.
 Not *Ostrea virginica* Gmelin, 1792.
 1898. *Ostrea haitensis* Sowerby. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 685 (part).
 1917. *Ostrea haitensis* Sowerby. Maury, Bull. Am. Paleontology, vol. 5, No. 29, p. 182, pl. 31, figs. 1, 2.

Sowerby described this species in 1850 as follows:

Testa oblonga, crassa, plicata, plicis paucis (senis ad septenis), magnis, undulatis, subsquamosis, squamis nonnunquam sub-tubulosis; limbo interno omnino glabro.

This species appears to be related to *O. imbricata* Lamarck; it differs, however, in its general form, which is oblong and not orbicular, and in the number of external radiating folds, which are only six or seven in our shell.

Type locality: Near San Jago, Santo Domingo, West Indies.

Shell large, commonly 10 or 12 centimeters across, solid but not greatly thickened. Both valves flattened and subcircular to broadly ovate in outline, the left a little more convex as a rule than the right and a little broader. Left valve strongly plicate, the right variable, in some individuals similar in sculpture to the left, in others almost smooth; plications taking the form of sharp, V-shaped ridges, generally six or seven in number upon the medial portion of the disk, originating at the umbones and growing increasingly prominent toward the ventral margin; two to four finer costals usually developed near the dorsal margins and fortuitous secondaries introduced near the ventral margin, either intercalated between the primaries or diastomosing from them. Concentric laminae overriding the costals and commonly subspinose upon their crests. Ligament area varying from high and rather narrow to low and broad but generally small and rather flattened submargins, in many specimens finely corrugated. Single muscle scar large, transversely elliptical to subcircular, slightly posterior to ventral in position. Margins simple in the heavy shells, more or less fluted in the lighter.

Ostrea haitensis Sowerby is characterized by its rather large but relatively thin shell and the strong and, for an oyster, quite regular radial plications. The young are separated from *O. rugifera* of the same size by the coarser ribbing in the right valve and the less closely appressed lamellae in the left. *O. pauciplicata* is more falcate and more regularly laminated concentrically.

Occurrence: Chipola formation, localities 10611^c, 10609^c, 10610^p, 2212^c, 2213^a, 2564^p, 3419^p, 9994^r, 6775^p. Oak Grove sand, localities 2646^{pr}, 5630^p, 7054^a. Shoal River formation, localities 3742^p, 5618^p, 10612^r.

Ostrea podagrina Dall

Plate X, Figures 5-6

1896. *Ostrea podagrina* Dall, U. S. Nat. Mus. Proc., vol. 18, p. 22.
 1898. *Ostrea podagrina* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 682, pl. 30, figs. 5, 6.

Dall described this species in 1896 as follows:

Shell compact, thick and heavy, wider than high, with very short wide beaks, coarsely imbricated surface, inflated shell, with three or four strong, wide, rather irregular radial plications; interior smooth, distinctly margined, with a large sub-central adductor scar; hinge and beak flat, the ligamentary area in the flat valve hardly excavated, the edges of the flat valve near the cardinal border with two obscurely wrinkled projecting crura, which fit into shallow depressions in the opposite valve; elsewhere there are no striae or pustules on the edge of the valves. Height, 110; width, 100; diameter, 50 millimeters.

Type: U. S. Nat. Mus. No. 135127.

Type locality: No. 2612, west bank Suwannee River near Sulphur Springs Station, Lafayette County, Fla.

The altitude of the type is 100.0 millimeters; the latitude 110.0 millimeters.

This species suggests a massive *O. haitensis*.

Occurrence: Chipola formation, localities 2611^p, 2612^p, 2823^p.

***Ostrea normalis* Dall**

Plate XI, Figures 3-4

1898. *Ostrea georgiana*, forma normalis Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 684.

1915. *Ostrea mauricensis* Gabb? Dall, U. S. Nat. Mus. Bull. 90, p. 123.

Not *Ostrea mauricensis* Gabb, 1860.

Dall described this species in 1898 as follows:

The typical *O. georgiana* are the enormous senile specimens with shells ranging to 2 feet long and 3 or 4 inches thick. The young and really more normal specimens have been overlooked, though much more abundant, or referred to other species, chiefly *O. virginica*, from which they differ by their more elongated, usually straight, deeply excavated cardinal area and the absence of ribbing on the lower valve in most specimens.

Dimensions: Right valve, altitude, 95.0 millimeters; latitude, 55.0 millimeters. Left valve of another individual, altitude, 100.0 millimeters; latitude, 50.0 millimeters.

Cotypes: U. S. Nat. Mus. No. 153848.

Type locality: No. 323, Devil's Mill Hopper near Hawthorn, Arredonda County, Fla.

Shell solid, usually thick, elongated ovate-trigonal in outline, sometimes very narrow and rudely cylindrical. Right valve flattened. Left valve feebly convex. Umbones narrow and compressed, erect or slightly inclined. Component concentric layers usually visible both on the disk and along the lateral margin, most expanded, as a rule, a little more than half way down from the dorsal to the ventral margin, thus giving to the exterior a pseudoconvexity which the interior does not possess; concentric laminae probably frilled much as in *O. compressirostra* Say but with the free edges usually broken away. Ligament area usually high and narrow, strongly depressed medially in the left valve, conspicuously elevated in the right, especially toward its ventral extremity. Lateral margins well differentiated both by the change in the plane of the hinge and in the direction of the incrementals; vermicular sculpture rarely developed upon the submargins. Single muscle scar semielliptical, deeply excavated in the heavier individuals, slightly posterior and ventral in position.

Ostrea mauricensis Gabb, the species to which these forms have been commonly assigned, was described from a shell 1½ inches long from New Jersey. The outline is similar to that of many of the individuals from Florida, but unlike the vast majority of them the ligament area is low, broad, and flattened. The abun-

dant species in Cumberland County, N. J., the environs of Gabb's type locality, is *O. percrassa* Conrad, a species characterized by just such a hinge as that exhibited by *O. mauricensis*. Although it is difficult to prove anything by a young oyster, yet the chances are favorable that Gabb's type is the young of the species abundant in that vicinity rather than the young of a form which has not been reported in the adult state from the area north of Hatteras and which probably does not occur north of Georgia. Furthermore, the contour, habit of growth, and general hinge characters are strikingly similar to those of *O. georgiana* of the earlier Tertiary of the Gulf region, and there is quite probably a genetic relation between the forms. They have been kept apart, however, because they are so readily separable and because of the difference in stratigraphic occurrence. The species is very abundant at many localities in north-west and central Florida, notably in Leon, Levy, and Alachua counties. It is restricted, apparently, to those beds formerly grouped under the name of the "Hawthorn formation" and now considered as Alum Bluff, and to the so-called "Grand Gulf beds" overlying the Alum Bluff in the type section.

Occurrence: Chipola formation ("Hawthorn beds"), localities 2566^p, 3415^r, 2302^r, 6175^p, 6769^e, 6776^r, 6778^r, 2324^p, 6783^r, 361^r, 5^p, 322^p, 6801^p, 323^r, 369^{pr}, 365^a, 356^a, 2116^r, 5629^p.

ISODONTA

Superfamily PECTINACEA

Family PECTINIDAE

Genus PECTEN Müller

1776. *Pecten* Müller, Zoologiae danicae, prodromus seu animalium, p. 248.

Type: *Ostrea maxima* Linnaeus. (Recent off the coast of Europe from Norway to the Straits of Gibraltar).

Shell approximately equilateral, inequivalve, usually suborbicular, auriculate; right valve, as a rule, the more convex, not adherent but attached by a byssus. Hinge line straight. Resilium central, internal, triangular. Interlocking grooves and ridges diverging from the apex of the resilial pit. Pallial line simple. Monomyarian; adductor impression rounded, posterior.

The earliest true *Pecten* known is from the Cretaceous. The Recent species number more than 200, and their distribution is world-wide.

Pecten does not constitute the conspicuous element in most of the Alum Bluff faunas that it does in many of the formations of the later Tertiary. The abundance of the large *Chlamys* (*Lyropecten*) *sayanus* gives to the Oak Grove fauna the general aspect of that of the Chesapeake, and the Chipola faunas represented in the "Sopchoppy limestone" and in the fuller's earth beds at Quincy have much the same general make-up. In

the Chipola along Chipola River, however, and in the Shoal River the genus is known only by species of small or only moderate dimensions and is not conspicuously abundant. *Pecten* (*Pecten*) is represented by a single species from the Chipola and fragments of an indeterminate species from the Shoal River and *Chlamys* (*Lyropecten*) by a characteristic species in the Chipola and another in the Oak Grove. The Oak Grove species is probably more closely allied to the Chesapeake *Pecten* than to any in the other formations of the Alum Bluff. The section *Nodipecten* with one species and possibly *Chlamys* (*Chlamys*) with three are, like *Pecten* (*Pecten*), most common in the Chipola. *Chlamys* includes *chipolanus*, the commonest member of the genus along Chipola River. In *Plagioctenium nicholsi* from the Shoal River, there is a possible precursor of the *P. gibbus* group. *Pseudamussium* is present in both the Oak Grove and the Shoal River but not in the Chipola. The representatives are very closely allied to the common *Pseudamussium* of the Bowden. *Amusium*, however, occurs only in the Chipola. The single species which establishes the presence of the group at this horizon is the probable precursor of the later Tertiary *mortoni*.

External surface radially costate:

Right valve very strongly convex, broader than high; left valve flattened; byssal notch and ctenolium not developed.....*Pecten* s. s., *Pecten burnsii* Dall.
 Right valve not very strongly convex, usually higher than it is broad; byssal notch and ctenolium developed.
Chlamys s. l.

Costals not nodose nor undulated longitudinally, normally exceeding 13 in number:

Primary costals longitudinally threaded even in the adolescents:

Costals not persisting to the ventral margin of the adult; secondary lirae not subspinose...*Chlamys* (*Lyropecten*) *sayanus* Dall.
 Costals persisting to the ventral margin of the adult; secondary lirae subspinose.

Chlamys (*Lyropecten*) *acanikos* Gardner, n. sp.

Primary costals not longitudinally threaded in the adolescents:

Costals subspinose, normally exceeding 18 in number.....*Chlamys* (*Chlamys*) sp.
 Costals not subspinose, rarely exceeding 18 in number:

Costals feeble, obsolete in the umbonal region.

Chlamys (*Chlamys*) *alumensis* Dall.

Costals vigorous, persistent almost to the tips of the umbones:

Concentric lamination equally prominent upon the costal and intercostal areas.

Chlamys (*Chlamys*) *chipolanus* Dall.

Concentric lamination feeble or obsolete upon the summits of the costals.

Chlamys (*Plagioctenium*) *nicholsi* Gardner, n. sp.

Costals nodose or undulated longitudinally, rarely exceeding 13 in number.

Chlamys (*Nodipecten*) *condylomatus* Dall.

External surface not macroscopically radially costate:

Inner surface smooth:

External surface smooth.

Pseudamussium defuniak Gardner, n. sp.

External surface microscopically threaded.

Pseudamussium diktuotum Gardner, n. sp.

Inner surface lirate.....*Amusium precursor* Dall.

Subgenus **PECTEN** s. s.

Type: *Ostrea maxima* Linnaeus. (Recent off the coast of Europe from Norway to the Straits of Gibraltar.)

The true *Pectens* are characterized by the strongly inflated right valve, the flat left valve, and the absence of a well-defined byssal notch and ctenolium at the base of the anterior auricle of the right valve. The radial sculpture is usually vigorous and the concentric lamination more or less obvious.

Pecten (**Pecten**) **burnsii** Dall

Plate XII, Figure 1

1898. *Pecten* (*Pecten*) *burnsii* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 720, pl. 34, fig. 8.

Dall describes this species as follows:

Shell resembling *P. poulsoni* Morton, but smaller, less inflated and with larger ears; ribs 14, on the right valve strong, each divided by two grooves so as to be tricarinate, the minor keels scabrous, the interspaces narrower, with fine concentric sculpture; ears and submargins radially threaded, the ears large, subequal, the notch shallow; left valve flat, the ribs angular, simple, strong, with fine concentric sculpture; ears large, radially finely threaded; interior fluted. Altitude 18, latitude 19, diameter 6 millimeters.

In specimens of *P. poulsoni* of the size of this species the scabrous tricarination of the ribs has not yet appeared; they are quite simple, and number 17 to 20. This is probably one of those cases where a lineal descendant takes on the adult character of the ancestor at an earlier period in its life than the ancestor did, a character often indicating senility in the life of the species. *P. burnsii* appears to be rare, and the type disappears entirely from the succeeding horizons, as far as known, being replaced in the Miocene by large species such as *P. hemicyclius*.

Type: U. S. Nat. Mus. No. 114781.

Type locality: No. 2213, 1 mile below Baileys Ferry, Calhoun County, Fla.

The marked convexity of the right valve and the flatness of the left are sufficient to separate this small form from its congeners. The right valves of *Pecten chipolanus* are rather close, but they are not so broad, they carry one or two more ribs, and they are much more strongly imbricated. The costal grooves in *P. burnsii* become obsolete at some little distance from the umbones and are consequently absent in the young forms. The auricles upon the left valve are relatively large, subequal, finely striate, and merge without any decided break in outline or sculpture into the submargins. The posterior auricle of the right valve is similar in outline to that of the left, though more strongly sculptured radially, but the anterior auricle is decidedly narrower and more produced,

threaded with four or five coarse lirae, and cut off from the submargin by a deep and narrow byssal notch. The anterior auricle in the type is broken, though this is indicated neither in the figure nor in the description.

Occurrence: Chipola formation, localities 10609^r, 2212^p, 2213^p, 2564^p, 3419^p.

Pecten (Pecten) sp. indet.

Indeterminate fragments of the left valve of a true *Pecten* have been found in sufficient abundance in Walton County to establish the subgenus in the Shoal River. They indicate a species with an average altitude of about 30.0 millimeters and an approximately equal latitude. The flatness of the left valve leaves no doubt about the subgeneric affinities of the species, but the radial fluting is not unlike that of *Chlamys* (*Lyropecten*).

Occurrence: Shoal River formation, localities 9960^r, 9957^r, 10603^r, 10608^r.

Subgenus CHLAMYS Bolten

1798. *Chlamys* Bolten, Museum Boltenianum, pt. 2, p. 161.

Type: *Pecten islandicus* Müller. (Pleistocene of the boulder clays of the northeast coast and Recent from the Arctic to Chesapeake Bay.)

Chlamys s. l. includes those species with both valves more or less convex and a well-developed byssus. The anterior auricle of the right valve is modified to permit the extrusion of the byssus and the ctenolium developed to prevent the byssal threads from becoming massed and tangled.

Cossmann is possibly right in giving full generic rank to this group, though there are so many forms, such as *Lyropecten*, on the border that it does not seem wise to disturb the established arrangement without a monographic study of the entire *Pecten* race.

Chlamys is first recognized in the early Mesozoic and includes the large majority of Tertiary and Recent forms assigned to *Pecten* in a broad sense.

Section LYROPECTEN Conrad¹³

1863. *Lyropecten* Conrad, Acad. Nat. Sci. Philadelphia Proc. for 1862, p. 291.

Type: *Lyropecten estrellanus* Conrad. (Miocene of the Pacific Coast.)

Conrad described this species as follows:

Inequivalve, radiately costate; hinge with a triangular pit as in *Pecten* and diverging prominent teeth on each side the ligament cavity.

The valves are generally large and coarse and both of them convex. The costals, unlike those of *Chlamys* s. s., are relatively few in number but very heavy and not dichotomous.

Lyropecten is the dominant group in the Chesapeake Miocene, conspicuous both by reason of its abundance and the large size of the individuals. The beginnings in the lower Miocene are very modest, possibly because the group had not reached the peak of its development, possibly because the cooler climate of the Chesapeake was more favorable. The heavy Pectens of the Miocene of south Europe, the *Gigantopecten* Roverto and its synonym *Macrochlamys* Sacco, are referable to *Pecten* rather than *Chlamys* because of the absence of a byssus. They differ from *Pecten* s. s. only in the slight convexity of the left valve.

Chlamys (Lyropecten) sayanus Dall

Plate XII, Figure 7

1898. *Pecten madisonius sayanus*, n. var., Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 725, pl. 26, fig. 6.

Dall describes this species as follows:

This form is the precursor in the Upper Oligocene¹⁷ of the typical *madisonius* of the Miocene. It differs from the latter in its extreme compression, the ribs, except in the umbonal region, being almost obsolete. Altitude 120, latitude 135, diameter about 16 millimeters.

Type: U. S. Nat. Mus. No. 135838.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County, Fla.

Chlamys sayanus is larger than any other *Pecten* reported from the Alum Bluff. The umbonal angle is relatively broad, and the arc included between the dorsal margins of the adults approaches 270°. The young are higher relatively, a change in proportions which is reflected in the slight concavity of the dorsal margins. The ribs in the umbonal region are very sharp and narrow but broader and flatter away from the umbones and toward the base of the fully adult are reduced to feeble undulations. The normal number for the adult is 15. As a rule there is a narrow medial sulcus, most clearly defined a little less than halfway from the umbones to the base, and on each side of the sulcus two and toward the base three or four fine, subequal threadlets. The threads upon the sides of the ribs are finer and sharper than those on the summits. The interradials are of approximately the same width toward the base as the radials and are similarly threaded; the medial lira tends to be a little more prominent than the others, thus suggesting *C. jeffersonius edgecombensis*. The auricles are low and broad, the posterior very finely and closely liriate, the anterior on the left valve less finely and on the right valve quite coarsely threaded with 6 to 9 unequal lirae. The concentric lamination is sharpest and most elevated toward the outer margins and upon the auricles. The byssal notch is very deep, as in *C. madisonius*, and the ctenolium well defined by a few prominent serrations.

¹³ *Lyropecten* and the closely related *Nodipecten* precede *Chlamys* s. s., because of their closer relationship to *Pecten* s. s.

¹⁷ Lower Miocene of the later correlations.

In *Chlamys acanikos* from the Chipola the ribs are more numerous by two or three and do not flatten away from the umbones. The secondary threads are fewer, more even, and more spinose, and the intercostal areas more angular.

P. sayanus is very common and widespread at the horizon which it characterizes.

Occurrence: Oak Grove sand, localities 2646^a, 5632^c, 5631^p, 5630^c, 5633^p, 7054^a, 9961^p, 10659^p.

***Chlamys (Lyropecten) acanikos* Gardner, n. sp.**

Plate XI, Figures 1-2

Shell rather thin and very easily broken, large and quite compressed. Umbonal angle acute and approximating 90°, the arc included between the dorsal margins slightly exceeding 180°. Radials narrow, abruptly elevated, rounded upon their summits, persistent to the outer margin, normally 17 in number, each of them, as a rule, cut by two linear sulci which divide the summit into three subequal lirae. Sides of ribs and intercostal areas also closely lirated, each thread bearing a series of small spinose processes, those upon the medial thread on the costal and upon the medial thread of the intercostal areas the most produced. Intercostal areas deep, concave, usually narrower than the costals. Inner margins sharply fluted. Auricles of moderate size, the anterior in the right valve angular, produced, cut off from the submargin by a deep byssal notch threaded with 6 or 7 scabrous lirations. Anterior submargin very narrow and free from ornamentation. Posterior auricle of right valve trigonal, cut off from the narrow unsculptured submargin by an acute angle; left auricles larger than the right, finely threaded, not sharply separated from the similarly sculptured submargins. Ctenolium including 4 or 5 rather prominent denticles. Ligament area very narrow. Resilial pit small, trigonal, the lateral margins well elevated. Cardinal margin of right valve bent over the left. Cardinal crura obscure. Adductor scar large, subcircular, slightly posterior, placed well up toward the umbones.

Dimensions: Altitude, 36.0 millimeters; latitude, 35.0 millimeters; semidiameter, 7.0 millimeters.

Type: U. S. Nat. Mus. No. 352450.

Type locality: No. 7893, Boynton Landing, Choctawhatchee River, Washington County, Fla.

Larger but less perfect individuals attain an altitude of 63.0 millimeters. The species, however, does not seem to reach the dimensions of its nearest relative *Chlamys madisonius*. The costals are usually more numerous by two than in *sayanus*, much more persistent, and less finely sculptured, both longitudinally and concentrically. *Pecten pleurinominis* Woodring (= *P. thetidis* Dall) is quite closely allied, though the costals of the Bowden species are more numerous and the secondary liration usually coarser.

The individuals collected along Chipola River are all immature and badly worn. It is the common *Chlamys*, however, at Boynton Landing on the Choctawhatchee and in the environs of White Springs on Suwannee River, Columbia County, and packs the fuller's earth beds at Quincy in Gadsden County.

Occurrence: Chipola formation, localities 10609^p, 10610^c, 7893^p, 2212^p, 2213^p, 2566^p, 3704^a, 3173^c, 2302^p, 7468^r, 6175^c, 6769^c, 4976^c, 6775^c, 6776^c, 360^p, 6800^c, 5613^c, 6208^r, 6209^p, 5629^a, 6196^c, 6197^c, 4986^c, 2380^p, 7847^a.

Section NODIPECTEN Dall

1898. *Nodipecten* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 695.

Type: *Ostrea nodosa* Linnaeus. (Pliocene of Florida; Pleistocene and Recent of the Gulf of Mexico and the Antilles.)

Dall defines this section as follows:

Shell like *Lyropecten*, but the ribs intermittently nodose, with more or less prominent hollow nodes or bullae; radial striation pronounced; ears unequal, the posterior smaller, the valves often more or less oblique; imbricate surface layer sometimes very marked.

***Chlamys (Nodipecten) condylomatus* Dall**

Plate XII, Figures 3-4

1898. *Pecten (Nodipecten) condylomatus* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 729, pl. 34, figs. 14, 15.

Dall described this species as follows:

Shell small for the group, subequilateral, slightly inequivalve, the right valve more convex, with 9 to 13 strong, undulated, rounded, more or less nodulous, finely radially striated ribs, the undulations affecting the whole of the disk, sudden and very pronounced, giving a side view of the valve somewhat the aspect of a clenched fist; interspaces narrower radially, finely threaded, the whole valve with fine concentric lamellation somewhat prickly or laminose at the intersections; submargins rather wide, radially finely striate; ears small, subequal, the surface coarsely radially threaded, the byssal ear produced with a conspicuous sinus and fasciole; ctenolium well marked; inner basal margin fluted by the ribs; cardinal margin with two or three strong crural ridges. Altitude 40, latitude 45, diameter about 22 millimeters.

This is an interesting species, peculiar from its small size and the abruptness of its knuckle-like undulations. Some specimens, however, are but little undulated, and the mutations are much the same as occur in other species of the section.

Type: U. S. Nat. Mus. No. 114776.

Type locality: No. 2212, Tenmile Creek, 1 mile west of Baileys Ferry, Calhoun County, Fla.

The difference in the convexity of the valves is marked even in the young. The secondary threading is very fine and even and closer upon the costals than in the intercostal areas. As a rule there are from 6 to 8 such threads upon the summits of each of the costals in the adults and only 3 or 4 in the intercostals, which run about the same width. The concentric lamination is very fine and even, but not so close nor so elevated as in *C. chipolanus*. The young

may be known before the first knuckling by the relatively low number of ribs and by their comparatively abrupt increase in width a short distance away from the umbones. The individual from White Beach at Osprey is too much compressed and too evenly costate to be referred to this species. The specimen from Hawkinsville, Ga., was also incorrectly determined.

The species is characteristic of the Chipola formation, but it occurs in greatly diminished numbers in both the Oak Grove and the Shoal River.

Occurrence: Chipola formation, localities 2212^p, 2213^c, 2564^c, 3419^c, 9994^p. Oak Grove sand, locality 9961^r. Shoal River formation, locality 9957^r.

Section CHLAMYS s. s.

Type: *Pecten islandicus* Müller. (Pleistocene of the boulder clays of the northeast coast and Recent from the Arctic to Chesapeake Bay.)

Chlamys s. s. is characterized by the subequal, feebly convex, high, and commonly oblique valves sculptured with numerous imbricated or spinose radials, dichotomous, as a rule, toward the ventral margin. The byssal notch is very defined and the pectenidial teeth are strong.

Chlamys (*Chlamys*) sp. indet.

1898. *Pecten* (*Chlamys*) *kneiskerni* Conrad. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 735 (part).

Dall described this species as follows:

In Professor Whitfield's attempt to identify the cast of an immature shell named as above by Conrad, the former has evidently brought together the young, uncharacteristic shells of several species of *Chlamys*. Conrad's shell was described as having 13 ribs and none on the submargins; Whitfield gives the species 15 to 50 ribs and radiated submargins. This is a range altogether too great for a single species. Probably some of Professor Whitfield's specimens were young *choctavensis*, which has an unusually large number of ribs. I have supposed a shell from the Jacksonian might represent the unidentifiable species of Conrad. This has 25 ribs, divaricating near the base with rather sparse concentric imbrications; ribs wider than the interspaces, entire in the young; valves rounded; ears rather small with concentric imbricated radii and rather deep byssal sulcus.

The Chipola individuals tentatively referred to this species are certainly distinct from the Eocene species described and seem to be the young of an unknown form. They are relatively high and angular little valves, sculptured with 19 or 20 narrow, elevated, well-rounded ribs, separated by narrower interspaces. A single row of short spinose processes is borne upon the summit of each costal and upon each of the coarse threads which ornament the auricles. There are 4 or 5 of these threads upon the right valve and about half a dozen upon the left. The ornamentation upon them and upon the submargins is sharper than upon the disk.

Occurrence: Chipola formation, locality 2213^p.

Chlamys (*Chlamys*) *chipolanus* Dall

Plate XII, Figure 2

1898. *Pecten* (*Aequipecten*) *chipolanus* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 733, pl. 29, fig. 9.

Dall described this species as follows:

Shell solid, rounded, plump, with 15 to 17 strong, rounded ribs with narrower interspaces which are almost channeled, both ribs and channels with continuous fluctuated, sometimes crowded, low concentric lamellae; the ribs faintly grooved distally on top; the concentric sculpture sometimes strong on three or more ribs and almost absent on the intervening ones; hinge line wide, ears large, with conspicuous but not deep notch, with six or seven coarsely imbricated, close-set radial threads on the byssal ear and more numerous threads on the others; submargins nearly smooth; cardinal crura strong; inner basal margin with strong, short flutings, obsolete above. Altitude 25, latitude 25, length of hinge line 18 millimeters.

Type: U. S. Nat. Mus. No. 114784.

Type locality: No. 2212, Tenmile Creek, 1 mile west of Baileys Ferry, Calhoun County, Fla.

Chlamys chipolanus offers perhaps a wider range of variation than any other of the Alum Bluff Pectens. There is a curious tendency in the young forms toward the development of the concentric sculpture upon every third rib only. None of its congeners are very closely allied and *Pecten burnsii* is decidedly broader; the right valve is more convex than that of *chipolanus*, and the left valve is approximately flat. The costals even in the young of *acanikos* are acutely scabrous and in *Chlamys* sp. indet. they are more numerous and minutely spinose distally. The sculpture of *C. alumensis*, on the other hand, both the concentric and the radial, is less sharply defined and in the umbonal region obsolete. *Chlamys inaequalis acutipictus* Woodring from the Bowden beds is possibly an analog, though the concentric laminae in this species do not override the costals as in well-preserved specimens of *chipolanus*. The group as a whole is very much better represented in the earlier Tertiary than in the later. It is rather surprising that much the most common species of the Chipola should be of so early a type. The species seems to be more closely allied to *Chlamys* than to *Aequipecten*, under which it was first placed.

Occurrence: Chipola formation localities 7893^r, 2212^c, 7257^r, 2213^a, 2564^a, 3419^c, 7151^r, 2211^p, 7183^r, ?7468^p, ?4966^r, ?2302^p, ?3424^r, ?6175^p, ?6776^r.

Chlamys (*Chlamys*) *alumensis* Dall

Plate XII, Figures 8-9

1898. *Pecten* (*Chlamys*) *alumensis* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 740, pl. 34, figs. 10, 11.

Dall described this species as follows:

Shell small, thin, with compressed, flattish umbones and 14 or 15 feeble, obsolete ribs on the lower part of the disk separated by equal shallow interspaces; the whole surface marked with fine concentric lines; ears subequal, concentrically striate, not radiated, except the byssal ear, which has five

scabrous riblets and a well-marked notch; interior fluted to correspond with the external ribs; the cardinal crura developed. Altitude reaching 15-18 millimeters in fully adult shells; figured specimen 8, latitude 7.5 millimeters.

This small shell is sufficiently distinct in its characters to indicate its specific rank, though it may be that it attains a larger size when adult than any of the specimens obtained.

Cotypes: U. S. Nat. Mus. No. 114580.

Type locality: No. 2211, Alum Bluff (lower bed), Liberty County, Fla.

In so strongly individualized a group this species is well characterized by its lack of character. The sculpture is obsolete in the umbonal region and even at best has a much worn and subdued aspect.

Occurrence: Chipola formation, localities 2213^r, 3419^p, 2211^c.

Section PLAGIOCTENIUM Dall

1898. *Plagioctenium* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 696.

Type: *Pecten ventricosus* Sowerby = *Pecten circularis* Sowerby (Pleistocene of California; Recent from Monterey, Calif., to the Gulf of California and Payta, Peru).

Dall described this group as follows:

Resembling *Aequipecten* but without radial striation; the concentric sculpture in looped lamellae; the ribs strong, frequently smooth above; the submargins impressed below the subequal auricles; the valves well inflated, with a tendency to oblique growth in the adult.

To this very natural group belong nearly all the shallow-water Pectens of our own coasts, such as *P. irradians* Lamarck, *P. gibbus* Linnaeus, *P. dislocatus* Say, *P. ventricosus* Sowerby, *P. nucleus* Linnaeus, *P. purpuratus* Lamarck, *P. eboreus* Conrad, *P. comparilis* Tuomey and Holmes, and numerous other fossil species.

The section is readily separable from *Chlamys* s. s. by the simple, usually less numerous radials, which do not diastomose toward the ventral margin.

It is interesting to find in the youngest of the Alum Bluff group an ancestral type allied to *P. gibbus*, one of the most prolific of the east coast Pectens.

Chlamys (*Plagioctenium*) *nicholsi* Gardner, n. sp.

Plate XII, Figures 5-6

Shell rather small, thin but tough, slightly inequivalve, the left valve quite compressed, the right feebly inflated. Umbonal angle a little more than 90°. Dorsal margins rather short, the posterior slightly more produced than the anterior. Ventral arc including more than 180°. Radials 17 in number in each valve of the type, though commonly not exceeding 15, beginning almost at the very tips of the umbones and gradually increasing in width and elevation; adult ribbing strong and even, the summits of the costals broadly rounded or somewhat flattened and forming obtuse angles with the sides, the intercostals broadly concave and of approximately the same width as the costals; secondary threading ordinarily not developed, but both costal and intercostal areas exhibiting a close and microscopically fine radial lineation. Incre-

mental sculpture very obscure in the right valve and on the costals of the left, the intercostal areas of the left valve evenly but not very closely laminated. Ventral margin scalloped in harmony with the radial sculpture. Interior fluted almost to the umbones. Submargins narrow, steeply sloping, free from ornamentation. Auricles of left valve and the posterior auricle of the right subequal, well differentiated from the submargins, and threaded with six or seven lirae, which become increasingly coarse toward the hinge line and which are rendered more or less scabrous by the overriding concentric lamellae; byssal ear narrower than the others and more coarsely sculptured both radially and concentrically. Byssal notch quite deep. Ctenolium including four or five denticles of moderate prominence; length of hinge line more than half the maximum width of the shell. Right valve flexed sharply over the left. Ligament area very narrow, persisting almost to the extremities of the hinge. Resilial pit very small, trigonal, subumbonal. Cardinal crura quite well developed, the surface shagreened in order that they may hold more firmly. Monomyarian, the single adductor scar rather small, slightly posterior, and placed a little above the median horizontal. Pallial line simple, commonly obscure, distant from the base.

Dimensions: Altitude of right valve, 20.6 millimeters; left valve of another specimen 25.0 millimeters. Latitude of right valve, 21.2 millimeters; left valve, 25.5 millimeters.

Cotypes: U. S. Nat. Mus. No. 352453.

Type locality: No. 3856, 6 miles west-northwest of Mossyhead, Walton County, Fla.

A larger valve from the type locality shows a rather fine threading toward the ventral margin most distinct in the intercostal areas. There is a moderate range of variation in relative dimensions, but the costals may number as few as 15 and as many as 19. In *Chlamys sayanus* the secondary sculpture is introduced very early in the life of the shell. *Chlamys chipolanus* is relatively higher as a rule, and the concentric laminae are more crowded and more elevated and equally prominent upon the costal and intercostal areas. *Chlamys nicholsi* Gardner, n. sp., is probably an ancestral type of the *gibbus* group, so abundant and diversified in the later Tertiary and Recent faunas.

The species is by far the most abundant and widespread member of the genus in the Shoal River fauna.

Occurrence: Shoal River formation, localities 3856^a, 2645^r, 3742^a, ?5079^a, ?5193^p, 9958^p, 3748^p, 7261^r, ?7264^r, ?5192^r, 9960^r, 9957^c, 10603^a, 5618^c, 9959^c.

Subgenus PSEUDAMUSSIUM H. and A. Adams

1858. *Pseudamussium* H. and A. Adams, Genera of Recent Mollusca, vol. 2, p. 553.

Type: *Pecten exoticus* Chemnitz = *Pecten pseudamussium* Sowerby (Recent off Gambia, West Africa).

The shells are small, very thin, and more or less translucent. The auricles are low and in the right valve unequal, for the anterior is cut by the byssal notch. The radial sculpture is feeble or absent altogether, but the surface is in many specimens concentrically imbricated. The inner face of the disk is smooth.

Pseudamussium differs from the other Pectens in the absence of a well-defined external sculpture, from *Amusium* in the absence of strong internal lirae.

The subgenus has been reported from the mid-Mesozoic and is still existent. Though never abundant, *Pseudamussium* is probably better represented during the Eocene, both in this country and in Europe, than during any other period.

There is a lamentable lack of uniformity in the spelling of the name of this subgenus and the name of the genus to which it bears so strong a superficial resemblance. With the continentals, as a rule, we have *Amussium* and *Pseudamussium*; in this country, *Amusium* and *Pseudamusium*. I have followed the original spelling of the authors, though Bolten was doubtless incorrect when he wrote the name of the "compass shell" with only one s. The name is derived from the Latin *amussium*, a horizontal wheel for denoting the direction of the wind.

***Pseudamussium defuniak* Gardner, n. sp.**

Plate XII, Figures 10-12

Shell very small, rather thick, porcellanous, the disk a rude sector of about 90°. Right valve moderately inflated, obliquely flattened toward the umbones. Left valve flattened. Umbones acute, rising a little above the hinge line. Anterior dorsal margins acutely angulated, slightly more produced than the obtusely angulated posterior margins. Surface of disk smooth except for exceedingly faint traces of a striation like that of *Camptonectes*, visible only under high magnification on a single individual. Traces of a blotchy color pattern also discernible. Auricles rather small, those of the left valve subequal, the anterior auricle of the right valve higher and more produced than the posterior; anterior auricle cut off from the disk by a narrow but well-defined byssal groove. Margin sharply elevated along the groove and outlined by an obscure thread; traces of one or two more threadlets and a feeble concentric lamination commonly visible near the notch; right posterior auricle not sharply differentiated from the disk and apparently free from sculpture; left anterior auricle and submargin shagreened with an exceedingly fine concentric lamination and radial threading, which becomes obsolete toward the hinge; left posterior auricle and submargin merging smoothly into one another and into the disk, faintly lineated away from the hinge line but showing no trace of a concentric imbrication. No trace of a ligament area along the hinge margin. Resilial pit minute; provinculum still retained on all

the individuals in the shape of fine ridges normal to the hinge margin, the ventral margin of the provinculum expanding slightly about halfway between the ligament pit and the distal extremities of the hinge. Adductor scar very obscure, apparently rather small, quite strongly posterior, and about midway between the dorsal and ventral margins. Pallial line also obscure. Inner surface of valve smooth.

Dimensions: Altitude of right valve, 3.8 millimeters; left valve of another individual, 4.6 millimeters. Latitude of right valve, 3.75 millimeters; left valve, 4.6 ± millimeters.

Cotypes: U. S. Nat. Mus. No. 352453.

Type locality: No. 5618, 3½ miles southwest of De Funiak Springs, Walton County, Fla.

The relationship of this small form to *P. guppyi* Dall is certainly very close, but it is smaller, the right valve is less convex and the left valve more flattened than in *guppyi*. The dorsal margins are also less sharply defined as a rule. The *Camptonectes* sculpture has been observed on only a single individual of *defuniak* and very obscurely on that, and the ventral expansion of the provinculum is not so marked as in *guppyi*. The single valve from Oak Grove, which was referred by Dall to *guppyi*, is possibly specifically identical. The threading upon the auricles is less fine, however, and not so restricted as in *defuniak*.

Occurrence: Shoal River formation, localities 7264^r, 10608^r, 5618^p.

***Pseudamussium diktuotum* Gardner, n. sp.**

Plate XII, Figures 13-14

Shell small, relatively thick, porcellanous; the disk a rude sector of about 90°. Right valve moderately inflated, obliquely flattened toward the umbones; left valve compressed. Umbones acute, projecting a little beyond the hinge line. Anterior extremity slightly more produced than the posterior. External surface covered with a crowded, microscopically fine threading crossed by sharp and regular incrementals, thus forming a rather regular reticulate sculpture. Auricles small, those of the left valve not so small as those of the right; anterior auricle of left valve more sharply differentiated from the disk than the posterior auricle; anterior auricle of the right valve larger than the posterior and more sharply threaded, cut off from the disk by a shallow but distinct byssal notch; Resilial pit minute. Provinculum still retained in the form of fine ridges normal to the hinge margin, expanding slightly midway between the resilial pit and the distal extremities of the hinge. Adductor scar obscure, posterior in position. Pallial line ill defined. Inner margins smooth.

Dimensions: Altitude of right valve, 3.8 millimeters; left valve of another specimen, 4.2 millimeters. Latitude of right valve, 4.0 millimeters; left valve of another specimen, 4.5 millimeters.

Cotypes: U. S. Nat. Mus. No. 352454.

Type locality: No. 9961, Horse Creek, 1½ miles south of Oak Grove, Okaloosa County, Fla.

There is a considerable degree of variation in the strength of the sculpture upon this remarkable little species. On some specimens the sculpture is almost obsolete, on others it is very sharply and evenly reticulate. However, the development of any sculpture other than the *Camptonectes* striation upon the disk is sufficient to distinguish this species from all the other east coast Tertiary forms.

Occurrence: Oak Grove sand, locality 9961P.

Pecten (Pseudamussium) sp.

1898. *Pecten (Pseudamussium) guppyi* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, pp. 718, 755 (part).

Type locality: No. 2580, Bowden, Jamaica.

The single left valve from Oak Grove which has been included under this species differs from the Bowden forms in its lower, broader outline, the less fine and more even threading of the auricles, and the apparent absence of the *Camptonectes* striation upon the disk. It is smaller, too, than the Bowden individuals and quite possibly immature. Further material must be collected before the species is sufficiently well known to determine. It may quite possibly prove to be identical with the valves of similar dimensions and outline collected from the Shoal River in the environs of De Funiak Springs. The threading upon the auricles of the Shoal River individuals is even finer than that on the Oak Grove valve and becomes obsolete altogether near the hinge line.

Occurrence: Oak Grove sand, locality 2646P.

Genus AMUSIUM Bolten

1798. *Amusium* Bolten, Museum Boltinianum, 1st ed., pt. 2, p. 165.

Type: *Ostrea pleuronectes* Linnaeus. (Recent in the Indo-Pacific.)

The valves are commonly large, thin, and feebly convex and like those of the true *Pecten*s are not attached by a byssus. Radial sculpture is sometimes suggested by the color pattern but is rarely developed and is never strong. A concentric imbrication may be observed in some species, particularly toward the ventral margin. The discrepancy in ornamentation so common in *Pseudamussium* is reflected in the discrepant coloring in *Amusium* s. s. In *Amusium papyraceum*, the Recent Antillean shell, the right valve is white or bordered with pale yellow, but the left is a deep reddish or purplish brown. This general type of color holds throughout *Amusium* s. s. The lirae developed upon the inner surface of the disk are perhaps the most constant diagnostic of the genus.

Like *Pecten*, *Amusium* may be traced back to the Mesozoic. The thin, internally lirated shells of

Amusium require a much more specialized habitat than the heavy, externally ribbed shells of most of the *Pecten* group, and perhaps for this reason the genus is relatively rare.

Subgenus AMUSIUM s. s.

Type: *Ostrea pleuronectes* Linnaeus. (Recent in the Indo-Pacific.)

Amusium s. s. is characterized by the rather large, feebly convex valves, similar in sculpture or in the absence of it, the right valve white or pale, the left dark and commonly showing a color pattern.

Amusium (Amusium) precursor Dall

1898. *Pecten (Amusium) precursor* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 755.

Dall described this species as follows:

Nepionic left valve with obsolete radii and often feeble concentric undulations. * * *

P. precursor is nearly as large as *P. mortoni*, but slightly rougher and more convex when adult, the young are nearly orbicular; a distinct trace of *Camptonectes* striation, near the beak and submargins, may be discerned with a magnifier in a good light. Altitude 110, latitude 123, diameter 20 millimeters. The right valve is much flatter than the other. As the material is much broken up, it seemed hardly worth while to figure it.

Type: U. S. Nat. Mus. No. 114773.

Type locality: No. 2212, Tenmile Creek, 1 mile west of Baileys Ferry, Calhoun County, Fla.

Fragments are common at the localities on Chipola River, but no perfect adult has yet been brought back. A faint radial lineation may be discerned upon the auricles as well as upon the umbone, but this character as well as most of the others' is shared by *P. mortoni*.

Occurrence: Chipola formation, localities 2212C, 2213C, 2564P.

Family SPONDYLIDAE

Genus SPONDYLUS Linnaeus

1758. *Spondylus* Linnaeus, Systema naturae, 10th ed., p. 690.

Type: *Spondylus gaederopus* Linnaeus. (Recent in the Mediterranean.)

Shell inequivalve, subequilateral, ovate or ovate-trigonal in outline, auriculate, normally attached by the right valve, which is, as a rule, more inflated than the left. Surface radially sculptured, the costals commonly unequal and irregular and bearing foliaceous or spinose processes. Auricles smaller and less sharply defined than those of *Pecten*. Cardinal area higher in the right valve than in the left. Ligament alivincular, lodged in a trigonal slit beneath the umbones. Dentition typically isodont, the teeth two in number in each valve, diverging and interlocking with the teeth of the opposite valve. Only a single adductor scar retained in the adult. Pallial line simple.

Spondylus has been found in strata as old as the Jurassic and still persists in the tropical and sub-

tropical waters. Though never a prolific group, the thorny oysters are conspicuous for their rather large size, elaborate ornamentation, and gorgeous coloring.

Only a single species is definitely recognized in the Alum Bluff, a form closely allied to the *Spondylus bostrychites* of Guppy from Santo Domingo and the Bowden beds.

Spondylus chipolanus Dall

1898. *Spondylus bostrychites* var. *chipolanus* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 758.

1915. *Spondylus chipolanus* Dall, U. S. Nat. Mus. Bull. 90, p. 125, pl. 19, fig. 1 (part).

Dall described this species in 1898 as follows:

The type form of this species has a relatively small number of spinose ribs, the intervening ones being free from spines, longitudinally finely striate, and show when very perfect minute scales. The adult shell is rather short and rounded and less inflated than usual in the genus. The species is remarkable for its small hinge area.

In the variety *chipolanus* Dall there is no radial striation on the interspatial ribs, but rather a concentric sculpture; there are many more spinose ribs, the shell is more oval and more inflated, and, as far as the material goes, seems to attain a larger size. It may prove distinct with more perfect specimens, in which case the varietal name may be taken as specific.

Type: U. S. Nat. Mus. No. 114817.

Type locality: No. 2213, 1 mile below Baileys Ferry, Calhoun County, Fla.

The Chipola species attains considerable dimensions, imperfect double valves showing an altitude of $110.0 \pm$ millimeters, a latitude of 85.0 millimeters, and a maximum diameter of 65.0 millimeters. The right valve is quite strongly rounded, the left valve inflated or flattened. The sculpture is exceedingly variable in detail but invariably ornate. The surface is crowded with unequal radial threads, all of them more or less spiny and every third or fourth thread heavier than the others and bearing long, slender spinose processes. The concentric imbrication is very close and for the most part microscopically fine. The cardinal area is higher in the right valve than in the left and slit medially by the ligament, which extends from the tip of the umbones to the ventral margin of the hinge, expanding slightly ventrally. The teeth are short, very thick and heavy, and slightly hooked at their extremities. The teeth of the right valve are inclosed in sockets formed by the elevated margins of the ligament pit of the left valve and the inner surface of the teeth. The muscle scar is very large, roundish, and placed a little behind and ventral to the middle.

The species that occurs at Ballast Point is apparently the true *bostrychites* of the West Indies. The specimen figured in Bulletin 90 is from Chipola River and is the type of *S. chipolanus*. The very young right valves are sculptured with overlapping concentric laminae, quite unlike anything exhibited by the adult.

Occurrence: Chipola formation, localities 2212^r, 2213^p, ?2211^r. Oak Grove sand, locality ?2646^r.

Spondylus sp. cf. *S. bostrychites* Guppy

Fragments of a *Spondylus* collected at a single locality in the Shoal River, indicate a species more closely allied than the Chipola specimens to *S. bostrychites* Guppy and possibly identical with it.

Occurrence: Shoal River formation, localities. 9957^r, 10603^r.

Genus *PLICATULA* Lamarck

1801. *Plicatula* Lamarck, Système des animaux sans vertèbres, p. 132.

Type: *Plicatula gibbosa* Lamarck = *P. ramosa* Lamarck. (Recent on the east coast from Hatteras to Bahia, Brazil.)

Shell inequivalve, flattened or slightly convex, trigonal to subcircular, commonly irregular, attached by the umbone of the right valve, which is the larger. Exterior surface generally plicate. Ligament internal, lodged in a central cartilage pit between the two heavy, divergent, transversely striated cardinal teeth. Pallial line entire. Muscular impression simple, excentric.

The genus originated in the early Mesozoic, culminated in the late Mesozoic, and is represented by less than a dozen recent species, living for the most part in the Pacific and Indian oceans.

Plicatula is separated from its near relative, *Spondylus*, by the absence of auricles.

Plicatula is not uncommon in the Chipola, rare in the Oak Grove, and unknown in the Shoal River. *P. lepidota* is known from a single individual. The other of the two Alum Bluff species, *P. densata* Conrad, can not be separated from the specimens included under that name from the older "silex beds" nor from those occurring in the younger Chesapeake of New Jersey, Maryland, and Virginia.

Surface strongly and regularly plicated radially.

Plicatula densata Conrad.

Surface irregularly sculptured both radially and concentrically, not regularly plicate-----*Plicatula lepidota* Gardner, n. sp.

Plicatula densata Conrad

Plate XIII, Figures 1-3

1843. *Plicatula densata* Conrad, Acad. Nat. Sci. Philadelphia Proc., vol. 1, p. 311.

1845. *Plicatula densata* Conrad, Fossils of the Tertiary formations of the United States, p. 75, pl. 43, fig. 6.

1863. *Plicatula densata* Conrad, Acad. Nat. Sci. Philadelphia Proc. for 1862, p. 582.

1895. ?*Spondylus inornatus* Whitfield, U. S. Geol. Survey Mon., vol. 24, p. 34, pl. 5, figs. 1, 2.

1895. *Plicatula densata* Conrad. Whitfield, U. S. Geol. Survey Mon., vol. 24, p. 35, pl. 5, figs. 3-8.

1898. *Plicatula densata* Conrad. Dall, Wagner Free Inst. Philadelphia Trans., vol. 3, pt. 4, p. 763.

1904. *Plicatula densata* Conrad. Glenn, Maryland Geol. Survey, Miocene, p. 371, pl. 98, figs. 7-9.

Conrad described this species in 1843 as follows:

Ovate, thick, profoundly and irregularly plicated; inferior valve ventricose, its ribs acute, with arched spiniform scales;

cardinal teeth large, curved, laterally striated, crenulated on the margins; larger cardinal tooth in each valve slightly bifid, broad; muscular impression prominent. Length $1\frac{1}{8}$ inches.

Locality: Cumberland County, N. J.

The valves have about ten folds, and the lower valve resembles a variety of *Ostrea virginiana*.

The animal may be attached by either the right or the left valve, and over the area of attachment the sculpture is of course obsolete. The form consequently differs greatly, not only in outline but in the character of the sculpture, according to the size and shape of the object to which it is fastened. In the free valves the plications are produced almost to the umbones, but in those fixed valves that are attached over a large area the radial plications are commonly reduced to a narrow frill around the outer margin. The inner surface included within the pallial line is chalky white, except for the vitreous muscle scar.

Plicatula densata is the common member of the genus in the Alum Bluff fauna. Its nearest relative is the even more strongly plicated species *Plicatula marginata* Say, so abundant throughout the Miocene of Virginia and the Carolinas. In that form the radial plications range from 3 to 8 and are less prone to ramify and become spinose than in *densata*. In *P. lepidota* Gardner, n. sp., known only from a single individual, there is no well-defined radial plication of the valve but only a fine and very irregular surface ornamentation.

Occurrence: Chipola formation, localities 7893^p, 2212^p, 2213^c, 9994^p, 4986^r; Oak Grove sand, localities 2646^p, 7054^r, 9961^p.

Outside occurrence: Miocene, "Tampa silex beds," Florida. Calvert formation, New Jersey and Maryland. St. Marys formation, Virginia and North Carolina. Yorktown formation, Virginia and North Carolina.

***Plicatula lepidota* Gardner, n. sp.**

Plate XIII, Figure 11

Shell of moderate dimensions for the genus, rather thin, warped, compressed and angular toward the hinge, broadly expanded ventrally. Only the left valve and the cardinal area of the right known. Cardinal area high and trigonal in the right valve, extremely narrow in the left. Anterior margin of left valve finely serrate just below the hinge line. Surface sculptured with finely crinkled lamellae fluted at more or less regular intervals but not with sufficient regularity to form a well-defined radial sculpture. Only the ventral row of flutings regular in the type and these partly closed and produced into about 15 somewhat spinose processes. Inner margins crenulate. Ligament internal, lodged in a small pit sunk deep beneath the umbones. Dentition vigorous, the teeth of the right valve included between those of the left, the anterior tooth a little heavier than the posterior; sides of all the teeth transversely ridged. Monomyarian,

the single muscle scar very sharply defined, roundish, posterior, and a little below the median horizontal. Pallial line simple, distinct. Surface within the pallial line chalky white except for the vitreous muscle scar.

Dimensions: Altitude, 29.5 millimeters; latitude, 30.0 millimeters.

Type: U. S. Nat. Mus. No. 352446.

Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla.

Unlike that of the common, coexistent *P. densata*, the surface of *P. lepidota* is not radially plicate but is ornamented with a curiously irregular sculpture not unlike that of some of the oysters. The concentric lamellae are irregular in width and spacing and are roughened by a microscopically fine, irregular grooving, not continuous as a rule, across the free edge. At irregular intervals the edges are sharply fluted, though upon the outermost laminae the flutings are approximately equisized and equispaced. The peculiar roughened, more or less prickly surface of this species is unlike that of any known member of the genus. The type is unique.

Occurrence: Chipola formation, locality 2213^r.

Family LIMIDAE

Genus LIMA (Bruguère) Cuvier

1798. *Lima* Cuvier, Tableau élémentaire de l'histoire naturelle des animaux, p. 421.

Type: *Ostrea lima* Linnaeus. (Type probably a recent shell from the Mediterranean; widely distributed in nearly all the tropical and south temperate seas; reported fossil in the Pliocene and Pleistocene.)

Shell auriculate, auricles unequal. Outline usually ovate, scoop-shaped and obliquely truncated laterally. Valves closed inferiorly but gaping anteriorly and sometimes posteriorly. Exterior surface rarely smooth, generally sculptured with simple or imbricated radial striae. Umbones rather prominent and distant. Hinge edentulous. Ligament internal, lodged in a subumbonal pit. Pallial line simple. Single muscle scar excentric, nearer to the posterior than the anterior margin.

The genus is indicated in the Carboniferous, culminates in the Cretaceous, and is sparsely represented in nearly all the recent seas by white or colorless shells, which may be attached by a byssus or may swim freely with a motion similar to that of *Pecten*.

Fragments sufficiently well preserved to establish the presence of the genus in the Alum Bluff have been collected, but their specific identity is uncertain.

Subgenus LIMA s. s.

Type: *Ostrea lima* Linnaeus. (Recent in nearly all the tropical and south temperate seas; reported fossil in the Pliocene and Pleistocene.)

Lima s. s. is characterized by the gaping, inequilateral valves and the edentulous hinge.

Section MANTELLUM Bolten

1798. *Mantellum* Bolten, Museum Boltinianum, pt. 2, p. 160.

Type: *Ostrea inflata* Gmelin. (Recent in the Mediterranean Sea; reported from the Pliocene of Italy by Sacco.)

Mantellum is characterized by the widely gaping anterior margins and the submargins which are not impressed like those of the typical section.

Lima hians (Gmelin), which is commonly cited as the type of *Mantellum*, is not included in Bolten's list of 1798.

Lima (Mantellum) carolinensis Dall

Plate XIII, Figure 4

1898. *Lima (Mantellum) carolinensis* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 767, pl. 35, fig. 21.

Dall described this species as follows:

Shell small, thin, inflated, oblique, with a moderate gape, sculptured with concentric lines of growth and rather sharp, fine, numerous, somewhat irregular radial threads, obsolete on the beaks, absent from the posterior submargin and the anterior ears; submargins not impressed. beak prominent, ears small, the margin of the gape forming a concave sinuosity in front of and below the anterior beak; hinge line short, with a very wide pit, its lower margin projecting from the cardinal plate; interior radially striate, the basal margin slightly crenulate. Altitude 16, latitude 12, diameter 7 millimeters.

This differs from *L. papyria* Conrad, from the Maryland Miocene, in the absence of the angle which in the latter species modifies the margin just below the anterior ear and in the presence of dense radial striation on the anterior submargin, while in *L. papyria* this region is smooth.

Type: U. S. Nat. Mus. No. 107801.

Type locality: No. 2025, Darlington, S. C. (Miocene: Duplin formation.)

The Oak Grove individuals are all imperfect, and most of them are immature. Though it is possible that perfect adults might exhibit characters which would be of systematic value in separating them from the Carolina specimens, there are none preserved in the available material.

Occurrence: Oak Grove sand, locality ?2646^p.

Outside occurrence: Miocene: Duplin formation, Natural Well, Duplin, N. C., and Darlington, S. C.

Superfamily ANOMIACEA

Family ANOMIIDAE

Genus ANOMIA (Linnaeus) Müller

1758. *Anomia* Linnaeus, Systema naturae, 10th ed., p. 700 (part).

1776. *Anomia* Müller, Zoologiae danicae, prodromus seu animalium, p. 248.

Type: *Anomia ephippium* Linnaeus. (Recent from the Arctic Ocean, off the European shores, to the Aegean archipelago; fossil in the Pliocene of England and Italy and the Pleistocene of Scandinavia.)

Shell inequivalve, adherent, generally subcircular or oblong. Left valve more or less convex, right valve

flattened. Hinge margin of left valve commonly incurved and slightly thickened. Ligament scar found directly beneath left umbone. Interior of disk of left valve scarred with an adductor and a major and minor byssal impression, the major byssal scar being the largest of the three and dorsal to the adductor and minor byssal scars, which are usually subequal; interior of right valve containing foraminal opening and, ventral to it, the impression of the adductor muscle; posterior dorsal margin of right valve carrying an inconspicuous ligamental process. Pallial line simple.

Ancestral forms of this genus have been recognized in rocks as ancient as the Devonian. The recent species number about forty and are widely distributed along the shores from low water mark to 100 fathoms.

Anomia has four representatives in the Alum Bluff—three of them restricted to the Chipola and the fourth, *A. floridana*, common to the Oak Grove and the Shoal River. Only a single species, however, has been recorded from Chipola River, the *A. microgrammata* of Dall, a form separated only varieties from a not uncommon Bowden species. *A. glypta*, from Boynton Landing on the Choctawhatchee, is closely allied to *microgrammata*. The Suwannee River species, however, has much the aspect of *Carolia*, though it seems to differ in the characters diagnostic of that genus.

External surface very finely and closely lirated or sulcate:

Altitude normally exceeding 25.0 millimeters.

Anomia glypta Gardner, n. sp.

Altitude not normally exceeding 25.0 millimeters.

Anomia microgrammata Dall.

External surface smooth or more or less irregularly lirated or plicate:

Altitude not normally exceeding 40.0 millimeters; color greenish.....

Anomia floridana Dall.

Altitude normally exceeding 40.0 millimeters; color chalky white.....

Anomia suwanneensis Gardner, n. sp.

Anomia glypta Gardner, n. sp.

Plate XIII, Figures 6-7

Shell of moderate dimensions for the genus, thin, subcircular in outline, the left valve warped into a feeble convexity. Umbones distinct but not conspicuous, the tips placed just within the cardinal border and slightly opisthodontic. Surface crowded with a very fine and somewhat irregular radial lineation or grooving similar in a way to that of *A. microgrammata* Dall but more crowded and less uniform, equally developed, however, on all parts of the disk. Ligament internal, mounted on a low shelly process somewhat reniform in outline, the convex surface parallel to the dorsal margin, the distal extremities more elevated than the medial portion. Hinge edentulous, the cardinal border slightly thickened and arching over the ligament pit. Scarred area elongated dorsoventrally, widening toward its ventral margin, which falls a little below the median horizontal; major byssal scar of approximately the same size and almost directly above the single adductor impression; the minor

byssal scar, the smallest of the three, placed a little in front of the other two and a little below the intermediate line between them.

Dimensions: Altitude, 41.0 millimeters; latitude, $46.0 \pm$ millimeters; diameter of left valve, 5.5 millimeters.

Type: U. S. Nat. Mus. No. 352449.

Type locality: No. 7893, Boynton Landing, Choc-tawhatchee River, Washington County, Fla.

Anomia glypta suggests a much overgrown *A. microgrammata* but runs about double the size of that species and has a surface ornamentation differing slightly in character though almost equally fine. The relative dimensions and the arrangement of the scars also differs in the two species, the adductor scar running smaller relatively in *A. microgrammata* and more posterior with reference to the major byssal scar. The species is known only from the type locality.

Occurrence: Chipola formation, locality 7893^p.

Anomia microgrammata Dall

Plate XIII, Figure 8

1898. *Anomia microgrammata* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 783, pl. 35, fig. 11.

Dall described this species as follows:

Shell small, irregular, characterized by a fine, almost microscopic, close-set radial striation covering the whole surface and flaring away from the medial line of the valve in a somewhat wavy manner; the two lower scars on the left valve are subequal and side by side, the major byssal scar larger, opposite the medial line between them; the beak of the left valve is some distance within the margin, and the surface where worn appears smooth; the striation is only visible under a lens in most cases. Altitude 17, latitude 25 millimeters.

This species is recognizable by its fine, almost divaricate striation, which does not break into pustules near the beaks, as in the larger and more coarsely sculptured *A. ephippioides*.

Type: U. S. Nat. Mus. No. 114824.

Type locality: No. 2212, Tenmile Creek, 1 mile west of Baileys Ferry, Calhoun County, Fla.

Anomia microgrammata Dall from the Chipola and *A. floridana* from the later Alum Bluff formations bear much the same relationship to one another as *A. aculeata* (Gmelin) and *A. simplex* D'Orbigny of the later Tertiary and Recent faunas. The regularly sculptured Miocene and Recent species run about the same dimensions, but the ornamentation of the *A. microgrammata* is more delicate and more uniformly developed than that of *A. aculeata*. *A. glypta*, which occurs also in the Chipola but is not known from Chipola River, is much larger, probably less convex, less regularly sculptured, and has an adductor scar almost as large as the major byssal scar and almost directly below it.

Occurrence: Chipola formation, localities 2213^p, 2564^p, 3419^p, 2211^r.

Anomia floridana Dall

Plate XIII, Figure 10

1898. *Anomia floridana* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 783, pl. 35, fig. 7.

Dall described this species as follows:

Shell of moderate size, usually rather convex, the surface irregular, obsolete microscopically radially striated, more or less irregularly feebly pustular and with obsolete, broken, feeble radial plications; the minor byssal scar is above and slightly further back (about half its own width) than the adductor scar of the same size; the major byssal scar is rounded and much larger, situated directly above the minor one, so that the three scars are nearly in one dorsoventral line; the beak of the left valve is at the cardinal margin. Altitude of largest specimen 35 millimeters, latitude 39 millimeters.

This species is intermediate in size and character between *A. microgrammata* Dall and *A. ruffini* Conrad. It is smaller and less sculptured than the latter, which also wants the microscopic striation; it is larger, less sharply striated, and has the beak and scars situated differently from the former. Many of the specimens still retain some of the original greenish coloration.

Type: U. S. Nat. Mus. No. 135845.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County, Fla.

The sculpture of *A. floridana* seems to be of much the same fortuitous character as that of *A. simplex* D'Orbigny. No difference can be detected between the Oak Grove and Shoal River species. The greenish color is very characteristic of this species and very unlike anything observed in any of its congeners.

Occurrence: Oak Grove sand, localities 2646^a, 5632^p, 5631^r, 5633^p, 7054^p, 3749^r. Shoal River formation, localities 5079^c, 3733^p, 9958^r, 5192^p, 9960^c, 9957^c, 10603^a, 10608^r.

Anomia suwanneensis Gardner, n. sp.

Plate XIII, Figure 5

Shell nacreous, chalky white or talcose, very large for the group, the left valve warped into a moderate convexity, suborbicular in outline. Umbones inconspicuous, scarcely interrupting the normal curvature of the valve; the tips of the umbones set just within the margin. External surface smooth except for concentric lamination, most distinct toward the ventral margin. Ligament mounted on very low, shelly crests, most elevated distally; ligament scar broadly conic or horseshoe-shaped, the apex of the cone directly beneath the umbones, the cardinal margin arching over it; ventral margin of scar concave; lateral margins not elevated. Hinge edentulous; cardinal area indicated by a thickening of the margin, the component layers showing up in cross section. Scarred area ovate to spatulate, widening ventrally, the outer layer retaining the impressions broken away in all available material.

Dimensions: Altitude, $45.0 \pm$ millimeters; latitude, 52.0 millimeters; diameter (left valve), 14.0 millimeters.

Type: U. S. Nat. Mus. No. 352448.

Type locality: No. 4976, White Springs, Suwannee River, Hamilton County, Fla.

This large form suggests *Carolia*. Unfortunately the best diagnostic generic characters have not been preserved. Only the left valve has been collected, which indicates that the right valve is thin and delicate, like that of *Anomia* rather than that of *Carolia*. The ligament attachment of the right valve and the foraminiferal characters are consequently unknown. The area that incloses the adductor and byssal scars is elongated dorsoventrally, the characteristic outline in *Anomia*, though the individual scars have not been observed. In *Carolia* there is a single subcircular adductor scar nearly central in position. The species is much the largest of the genus that has been reported from the Alum Bluff. One individual from the type locality exhibits a fortuitous radial threading in the umbonal region.

Occurrence: Chipola formation, localities 3424^r, 6175^c, 6769^c, 4976^p, 6775^p, 6778^p, 6776^r. ? Oak Grove sand, locality ?3385^r.

Genus *PODODESMUS* Philippi

1837. *Pododesmus* Philippi, Wiegmann, Archiv Naturgeschichte, vol. 1, p. 385.

Type: *Pododesmus decipiens* Philippi = *Pododesmus rudis* Broderip. (Recent in the West Indies.)

The genus resembles *Placunanomia* in the possession of a simple conspicuous byssal scar but differs from it in the single hinge line, the small open foramen, and the coarsely wrinkled but not plicated external surface.

Paranomina Conrad from the eastern Cretaceous is very close to *Pododesmus*, but there is no definite proof of the presence of the genus in strata earlier than the Tertiary. The Recent representatives, like the fossil, have a meager distribution.

Only a single species has been established from the Alum Bluff, and that is restricted in its known distribution to the type locality at Rock Bluff on Chattahoochee River.

Pododesmus rudis (Broderip) Gray

Plate XIII, Figure 12

1834. *Placunanomia rudis* Broderip, Zool. Soc. London Proc. for 1834, p. 2.

1837. *Pododesmus decipiens* Philippi. Wiegmann, Archiv Naturgeschichte, vol. 1, p. 386, pl. 9, figs. 1a-d.

1849. *Placunanomia rudis* Broderip. Gray, Zool. Soc. London Proc. for 1849, p. 120.

1849. *Placunanomia abnormalis* Gray, idem, p. 121.

1859. *Placunanomia rudis* Broderip. Reeve, Conchologia Iconica, vol. 11, *Placunanomia*, pl. 1, fig. 2.

1859. *Placunanomia echinata* Broderip. Reeve, idem, pl. 1, fig. 1.

1859. *Placunanomia abnormalis* Gray. Reeve, idem, pl. 3, figs. 14a, 14b.

1859. *Placunanomia harfordi* Reeve, idem, pl. 2, figs. 8a, 8b.

1898. *Pododesmus rudis* Broderip. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 779.

Broderip described this species in 1834 as follows:

Plac. testa sordide alba, crassa, concentric irregulariter corrugata, intus nitide polita; alt. 1 $\frac{7}{8}$, long. 1 $\frac{6}{8}$, lat. $\frac{5}{8}$ poll.

Hab. in India Occidentali.

Dall in 1898 gives the following details:

This shell resembles *Anomia aculeata* externally, from which it is distinguished by its small, often obsolete, byssal foramen, and by having only two muscular impressions—one large and conspicuous, which is the mark of the modified byssal muscle, and another below it, smaller and hardly distinguishable on a fresh polished specimen, which is due to the adductor.

The external sculpture of *Pododesmus* is more strongly rugose than that of the average *Anomia aculeata* Gmelin. The single valve dubitably referred to *P. rudis* does not retain enough of its diagnostic characters to make the determination convincing.

The two valves from the Chipola formation referred to this species in former check lists are imperfectly preserved specimens of an indeterminate species of *Anomia*. The figured specimen is a Recent valve from the Antilles.

Outside occurrence: Pliocene, Waccamaw formation, North Carolina. Recent: Cedar Keys to Guadeloupe and Santa Catarina, Brazil, in less than 50 fathoms.

Pododesmus scopelus Dall

Plate XIII, Figure 9

1898. *Pododesmus scopelus* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 779, pl. 30, fig. 8.

Dall described this species as follows:

Shell large, irregular, taking the form of the object to which it adheres, the upper valve convex, with rude, irregular radial threads or unequal riblets, close-set and frequently broken up so as to appear vermicular; interior smooth, with two muscular impressions rather feebly impressed, the site of the resilium deeply impressed and extending behind the cardinal margin; attached valve concave, irregular, the foramen small and elongate, probably eventually closed, the chondrophore projecting partly over it in our specimens; space between the valves very small. Altitude 44, latitude 58, diameter 7 millimeters.

This species is one of the few characteristic fossils which are preserved at Rock Bluff and has not occurred at Oak Grove or Alum Bluff in the same horizon, which may be explained by the fact that the bed at Rock Bluff is an old oyster reef, in which only *Ostrea*, *Turritella*, the present species, and fragments of *Pecten* and *Balanus* are preserved. The matrix is ill adapted to conserve fossils in their perfections, and the specimens of *Pododesmus* are very irregular and mostly shattered by internal movements of the marl.

Type: U. S. Nat. Mus. No. 115732.

Type locality: No. 2566, Rock Bluff, Chattahoochee River, Liberty County, Fla.

No new material referable to this species has been collected since the description was first published.

Occurrence: Chipola formation, locality 2566^c.

Genus *CAROLIA* Cantraine

1838. *Carolia* Cantraine, Acad. roy. sci. Bruxelles Bull., vol. 5, p. 111.

Type: *Carolia placunoides* Cantraine. (Eocene of Egypt.)

The dedication of the genus to Charles Bonaparte is rather interesting:

Je dédie ce genre à Charles Bonaparte, prince de Musignano, tant comme un hommage rendu à ses talents, que comme un gage de ma reconnaissance pour la bienveillance dont il daigne m'honorer.

Dall describes the genus as follows:¹⁹

Shell thin, nacreous, with radiating striae, the right valve flattened; resilium rounded-triangular, internal, large, attached in the right valve to a pedunculate chondrophore seated on the anal side of the umbo and extended adorally so as to bring the middle of the resilium in the median line of the valve; in the left valve the resilium is attached in the cavity of the umbo, leaving a broad fan-shaped, thickened scar of attachment, of which the anterior and posterior margins are elevated into diverging lamellae. In the young stage the right valve is perforated for the passage of a byssus or byssal plug, which gradually atrophies, so that in the full-grown shell the sinus and perforation are closed with shelly matter and so overshadowed by the heavy chondrophore as to be hardly perceptible even as a scar. It should be observed that the attachment of the resilium is wholly posterior and not the result of the merging of an anterior and posterior chondrophore. The scar of the adductor in each valve is single, orbicular, and nearly central, with two very minute accessory pedal or byssal muscular scars above it in the left valve.

This genus has been discussed by Gray and Fisher, the latter giving some instructive figures of the gradual obliteration of the sinus and of the analogous early sinus in *Ephippium papyraceum*.

For a fine specimen of the *Carolia* figured by Rozière in Savigny's Égypte I am indebted to Lieut. S. M. Ackley, U. S. N., who obtained it from the Eocene Tertiary bed underlying the desert, about 5 miles west from the bed of the ancient Lake Moeris, in the Fayoum. It measures 13 by 15 centimeters, being somewhat wider than high. The chondrophore is almost sessile, so short is the peduncle; the scar of the byssal foramen is very distinct, about 2 millimeters in diameter and 10 millimeters below the base of the chondrophore. So small is the play of the valves that the cardinal border, sensu stricto, has ceased to exist, and the convex valve has that margin flattened and produced dorsally, taking on a patelliform character. The elevated lateral margins of the ligamentary scar are clearly of dynamic origin and not developed crura.

A singular fact is that the convex valve retains several of the sessile plugs of a large *Anomia* and adherent portions of their valves.

This species has no cardinal area, the surface is radiately striate and of that talcose aspect proper to *Placenta* and *Ephippium*; the distal portion of the chondrophore bears traces of a reflexed lamina like that we figure for our Floridian form. This character again is obviously dynamic and is probably absent in young and perhaps some adult specimens.

The group has been recognized only in the Eocene of Egypt and in the Tertiary of the southeastern United States and West Indies.

Subgenus *WAKULLINA* Dall

1895. *Wakullina* Dall, U. S. Nat. Mus. Proc., vol. 18, p. 21.

1898. *Wakullina* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 772.

Type: *Carolia (Wakullina) floridana* Dall. (Lower Miocene [Chipola formation], Florida.)

Dall described this group in 1895 as follows:

Shell with the single chondrophore of *Monia*, the obsolescent byssal notch and plug and simple adductor scar of *Ephippium*. The sensible but narrow cardinal area of *Ephippium* is here represented by a broad and conspicuous margin; the lateral edges of the ligamentary scar in the left valve form narrow, elevated crura, and the exterior is destitute of the radiating sculpture common to all the other forms of the group, and resembles that of the smooth *Anomias*.

Only the type species has been described, and that is apparently restricted to the single horizon.

Carolia (Wakullina) floridana Dall

Plate XIV, Figures 1-5

1895. *Carolia (Wakullina) floridana* Dall, U. S. Nat. Mus. Proc., vol. 18, p. 21.

1898. *Carolia (Wakullina) floridana* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 777, pl. 24, figs. 5, 6, 6b, 7, 7b.

Dall described this species in 1895 as follows:

Shell thin, smooth, nacreous, adherent to other bodies, sub-orbicular, more or less irregular; right valve flattened or concave, especially at the umbo; left valve convex, with a moderately prominent umbo near the cardinal margin; hinge margin variable, but always with a transverse flattish area arched in the middle over the attachment of the internal ligament; exterior irregularly imbricated by the scaly nacreous layers; interior smooth, with a large subcentral, nearly orbicular adductor scar; the minute scaled byssal foramen, under the middle of the chondrophore, connected by a soldered linear suture with the upper anterior margin of the valve; chondrophore rounded, triangular, broad, radiately rugose above, recurved as a thin lamina from the umbo in fully adult specimens, rather closely sessile, and fitting into the umbonal cavity of the left valve; left valve, with the ligamentary attachment broadly triangular, marginated by a thin shelly lamina on each side, and arched over by the elevated portion of the cardinal area; there is no trace of a byssal muscle scar in adult examples. Breadth in either direction about 110; maximum diameter of the closed valves, 9 millimeters.

"Sopchoppy limestone" [Chipola formation] on the banks of Deep Creek, near the Sopchoppy River, Wakulla County, Fla. [No collection number.]

In 1898 he adds:

This fine shell, curiously enough, is, so far as known, the only species in the Sopchoppy limestone which retains its shell structure, all the other mollusks, so far as observed, being represented only by their impressions in the soft limestone. It is interesting to find an Egyptian type in our southern fauna, though the only relation between them is, in the writer's opinion, that which both bear to the Anomiidae which preceded them, and the analogous recent forms which have succeeded to them. The characters upon which *Carolia* is based are purely dynamic and might be expected to occur in a long succession of Anomiidae of any region, the several *Carolias* having no genetic connection with each other, as such, any more than the Oregonian *Batissa* has with those of other continents now living.

¹⁹ Dall, W. H., Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 775, 1898.

Cotypes: U. S. Nat. Mus. Acc. No. 154336.

There is no form with which well-preserved specimens of *C. floridana* can be confused.

Occurrence: Chipola formation, localities 2868^p, 4991^c, 2322^p, 7468^c, 4977^p.

DYSODONTA

Superfamily MYTILACEA

Family MYTILIDAE

Genus MYTILUS Linnaeus

1758. *Mytilus* Linnaeus, *Systema naturae*, 10th ed., p. 704.

Type: *Mytilus edulis* Linnaeus. (Recent in the Arctic Ocean and the North Atlantic.)

Shell thin, equivalve, cuneiform; posterior margin rounded, gaping slightly for the strong, coarse byssus; beaks anterior, terminal and pointed; valves covered with a conspicuous epidermis, in some specimens subnacreous within; surface smooth or sculptured; hinge teeth small or obsolete; anterior adductor muscle impression very small; posterior adductor muscle very large; pallial line simple.

Triassic to Recent. The recent forms are gregarious and usually attached and comprise about 70 species, which occur most commonly in cooler waters.

The representation of the genus in the Alum Bluff is exceedingly meager. Each of the two species observed is known only from casts.

Apical region not produced and thickened.

Mytilus s. s., *Mytilus pandionis* Dall.

Apical region produced and thickened.

Mytiloconcha Conrad, *Mytilus (Mytiloconcha) incurvus* Conrad.

Section MYTILUS s. s.

Type: *Mytilus edulis* Linnaeus. (Recent in the Arctic Ocean and the North Atlantic.)

Shell smooth or concentrically sculptured; apical region not produced and thickened.

Mytilus pandionis Dall

Plate XIV, Figures 6-7

1898. *Mytilus pandionis* Dall, *Wagner Free Inst. Sci. Trans.*, vol. 3, pt. 4, p. 787, pl. 30, figs. 9, 10.

Shell large, somewhat compressed behind, wide, with the posterior cardinal angle in the anterior third; cardinal line short, an impressed narrow area in front of the beaks nearly half as long as the shell; surface apparently smooth (the type is an internal cast), umbones acute. Altitude 122, latitude 60, diameter 36 millimeters.

Type: U. S. Nat. Mus. No. 154344.

Type locality: White Beach near Osprey, Little Sarasota Bay, Fla.

The material from White Beach has proved to be of Pliocene rather than lower Miocene age.

Subgenus MYTILOCONCHA Conrad

1863. *Mytiloconcha* Conrad, *Acad. Nat. Sci. Philadelphia Proc.* for 1862, pp. 290, 579.

Type: *Myoconcha incurva* Conrad. Miocene (Calvert formation) of Calvert County, Md.

Conrad described this group as follows:

Subfalcate, thick; perlaceous, laminated; hinge thick, elongated; pointed at the apex; an oblique tooth or ridge and parallel furrow throughout the entire length of hinge area.

Mytilus (Mytiloconcha) incurvus Conrad

1839. *Myoconcha incurva* Conrad, *Fossils of the medial Tertiary of the United States*, No. 1, p. 3 of cover.

1840. *Myoconcha incurva* Conrad, *idem*, No. 2, p. 52, pl. 28, fig. 1.

1854. *Mytilus incurvus* Conrad, *Acad. Nat. Sci. Philadelphia Proc.*, vol. 7, p. 29.

1863. *Mytiloconcha (Myoconcha) incurva* Conrad, *Acad. Nat. Sci. Philadelphia Proc.* for 1862, p. 291.

1863. *Mytiloconcha (Myoconcha) incurva* Conrad, *idem*, p. 579.

1894. *Mytiloconcha incrassata* Whitfield, *U. S. Geol. Survey Mon.* 24, p. 38, pl. 5, figs. 10, 11.

Not *Mytiloconcha incrassata* Conrad, 1863.

1898. *Mytilus (Mytiloconcha) incurvus* Conrad. *Dall, Wagner Free Inst. Sci. Trans.*, vol. 3, pt. 4, p. 789.

Conrad described this species in 1839 as follows:

Shell incurved, thick, narrowed toward the apex; posterior side with a submarginal furrow; ninge with a narrow straight groove for the cartilage, and a broad furrow on the posterior side. Length about 4½ inches. Locality, Calvert County, Md.

Dall, in 1898, said:

The specimens found in New Jersey are very badly worn and young, hence Professor Whitfield's identification of them, which I believe erroneous. I have never seen a perfect specimen of this singular shell, but the external casts from the Upper Oligocene of Florida show its characters admirably. The *M. incrassata* Conrad is only a rather heavy *Mytilus*. The hinge of the present species has two strong teeth in the left and one in the right valve, which are obsolete in senile specimens. These teeth are produced over the cardinal area as ridges, extending to the apex of the valve, with a furrow on each side of each ridge, a single furrow between the two ridges of the left valve. Apart from the furrows and ridges the area is flattened. Close to the posterior margin the groove of the ligament is continued along the edge of the area to the apex. In a specimen 120 millimeters long the area is 20 millimeters long and about the same in greatest width. The characters are those of ordinary *Mytilus* but curiously exaggerated. *Mytilus hesperianus* Lamarck, of the Red Crag of Britain, would seem to belong in this group.

The determination of the casts referred to this species has not been verified. The characters preserved are not sufficient to make the identification with assurance.

Occurrence: Chipola formation ("Sopchoppy limestone," Dall), locality ?7468^r.

Genus MODIOLUS Lamarck

1799. *Modiolus* Lamarck, *Prodrome d'une nouvelle classification des coquilles*: *Soc. hist. nat. Paris Mém.*, p. 87.

Type: *Mytilus modiolus* Linnaeus. (Recent in the Arctic Ocean and the North Atlantic.)

Shell equivalve, inequilateral, transversely or obliquely ovate in outline; ligament external, opisthodontic; hinge edentulous; anterior muscle impression atrophied; pallial line simple.

The genus is separated from *Mytilus* by the character of the beaks, which are nonterminal, wider, and rounded anteriorly. It has a long geologic range, at least from the beginning of the Mesozoic and possibly from the Devonian. The recent species are about 70 in number and are most abundant in the tropical seas. Unlike *Mytilus*, the representatives of *Modiolus* are nestbuilders and burrow or spin a woven structure from stones and fragments of shells.

The genus is well diversified in the Alum Bluff, though its representation is very meager. Three sections have been recognized, each represented by a single species. The Oak Grove form is known only from fragments, but these indicate so fine a species that it seems wise to wait for a worthy type. The other two sections—*Brachidontes* and *Botula*—have been observed only in the Chipola.

Shell smooth; altitude normally exceeding 40.0 millimeters.

Modiolus (Modiolus) sp. indet.

Shell radially sulcate—*Modiolus (Brachidontes) curtulus* Dall.

Shell smooth or concentrically sulcate; altitude rarely exceeding 30.0 millimeters—?*Modiolus (Botula) cinnamomeus* Lamarck.

Section MODIOLUS s. s.

Type: *Mytilus modiolus* Linnaeus. (Recent in the Arctic Ocean and the North Atlantic.)

The section is characterized by the smooth surface and hirsute epidermis.

Modiolus sp.

1898. *Modiolus cretaceus* Conrad. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 792 (part).

Not *Modiola cretacea* Conrad, Geol. Soc. Pennsylvania Trans., vol. 1, p. 340, pl. 13, fig. 2, 1835.

Fragments of an unusually fine species, which must attain an altitude at least of 10 centimeters, occur not uncommonly at Oak Grove. None of them are sufficiently complete, however, for illustration. The form is moderately inflated apparently, flaring widely posteriorly and obscurely alate. The umbones are sharply rounded but probably not so acute as in *M. cretacea*. The ridge from the umbones to the posterior margin seems to be less clearly defined. The surface is incrementally sculptured and along the posterior wing the laminar ridges stand out quite sharply. The genus is also represented in the "Sopchoppy limestone" and at Boynton Landing, but probably by distinct though allied species.

Occurrence: Oak Grove sand, locality 2652^p.

Section BRACHIDONTES Swainson

1840. *Brachidontes* Swainson, Treatise on malacology, p. 384.

Type: *Modiola sulcata* Lamarck. (Recent in the Indian Ocean.)

Brachidontes is characterized by the radially sulcate surface and the nonhirsute epidermis.

The name is most commonly spelled *Brachydontes*, but in Swainson's Treatise it is spelled *Brachidontes*.

Modiolus (Brachidontes) curtulus Dall

Plate XV, Figure 4

1898. *Modiolus (Brachydontes) grammatus* var. *curtuus* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 794.

Dall described this species as follows:

The variety, which more abundant material might show to be a distinct species, is stouter, more triangular, with coarser and more nodulous ribs and stronger crenulations of the margin. Altitude 12, maximum latitude 7, diameter 6 millimeters.

Shell small but quite solid, cuneate in outline, attenuated toward the umbones; flaring and obtusely angulated along the posterior margin, the anterior margin straight or feebly concave, the base line broadly rounded. Umbones very small, subacute, almost but not quite terminal. Radials along the posterior and ventral margins coarse, heavily corrugated by the incrementals, tending to bifurcate toward the outer margin, not far from 15 in number, those upon the anterior slope almost twice that number and consequently much finer and more crowded and not dichotomous. Ligament groove moderately deep. Hinge edentulous. Adductor scar obscure. Inner margins crenate in harmony with the external sculpture, nearly obsolete toward the umbones.

Type: U. S. Nat. Mus. No. 114578.

Type locality: No. 2211, Alum Bluff (lower bed), Liberty County, Fla.

This form is certainly distinct from the Ballast Point species which is almost sub-cylindrical in outline and ornamented with a fine and delicate radial threading. The lirae in *grammatus* are double the number of those ornamenting *M. curtulus*, and the fluting of the inner margins is consequently much finer and more feeble.

Occurrence: Chipola formation, locality 2211^r.

Section BOTULA Mörch

1853. *Botula* Mörch, Catalogus Conchyliorum Comes de Yoldi, pt. 2, p. 55.

Type: *Modiola cinnamomea* Lamarck. (Recent in the Indian Ocean.)

Botula may be known by the concentrically sulcate surface and the polished epidermis.

?*Modiolus (Botula) cinnamomeus* Lamarck

1785. *Mytilus cinnamominus* Chemnitz, Conchylien Cabinet, vol. 8, p. 152, pl. 82, fig. 731.

1819. *Modiola cinnamomea* Lamarck, Histoire naturelle des animaux sans vertèbres, vol. 6, p. 114.

1898. ?*Modiolus (Botula) cinnamomeus* Lamarck. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 797.

1901. ?*Modiolus cinnamomeus* Lamarck. Dall and Simpson, Mollusca of Porto Rico, U. S. Fish Commission Bull., vol. 1, p. 470.

1915. *Modiolus (Botula) cinnamomeus* Lamarck. Dall, U. S. Nat. Mus. Pull. 90, p. 128.

Lamarck described this species in 1819 as follows:

M. testa subcylindrica, ventricosa, arcuata, utraque extremitate retusa; natibus subprominulis.

Type locality: Off Nicobar, East Indies.

Dall and Simpson described this species in 1901 as follows:

Shell small, nearly smooth, subrhomboidal and somewhat elongated, slightly arcuate, inflated, with a thick, dark chestnut epidermis, which shows distinct, often dark, rest periods, and is darker colored at the posterior end and anterior base; beaks full and high, placed at the upper anterior extremity of the shell and projecting in front of the anterior end; hinge line curved, the line extending around to the anterior base in an unbroken curve.

In 1898 Dall said:

I am not able to determine whether the East Indian shell usually called *M. fuscus* Gmelin is the same or distinct specifically. The distribution of boring species is often very wide. It is certain, however, that Chemnitz's specimens, on which Lamarck founded the species, were West Indian. It seems remarkable that this species should be found in the Oligocene, but I am not, from my present material, able to find any differential characters whatever from recent specimens of the same size.

This form differs from *Lithophaga* especially by the presence of a row of small but well-defined scars, extending in a radial manner toward the lower posterior basal angle of the shell, within the pallial line. These almost give the impression, when observed casually, of the presence of a pallial sinus. In the absence of fresh specimens of the animal I am unable to determine the function of these scars.

Dall's authority for his assurance that *cinnamomeus* was described from a West Indian shell is not given. Chemnitz states in his original description that the shell which he figured and to which Lamarck referred came from Nicobar in the East Indies. Boring forms have an abnormally wide distribution, and this may be one of those exceedingly rare species common to the warm waters of the Eastern and Western Hemispheres. Additional evidence of their specific identity is, however, necessary to conviction. In view of the doubtful identity of the Recent West Indian form with the East Indian and of the fossil Floridian and West Indian species with the Recent West Indian the presence of a single battered valve in the Alum Bluff material does not establish beyond question the presence of Lamarck's *cinnamomeus* in the Alum Bluff of Florida.

Occurrence: Chipola formation, locality 2213^r.

Genus MODIOLARIA Beck

1840. *Modiolaria* Beck, in Robert, E., Zoologie d'un voyage de recherche en Islande et en Grönlande, p. xxviii, pl. 17, figs. 1-4.

Type: *Mytilus discors* Linnaeus. (Recent off the coast of Greenland and northern Europe.)

A genus very closely related to *Crenella*. The distinguishing features are the unsculptured area on the medial portion of the disk and the more sinuous pallial line concomitant with the longer siphons.

This group of small forms has been found in strata as early as the Mesozoic. Although the recent species have been reported from nearly all the seas, the group is essentially characteristic of the cooler waters.

The evidence of the presence of this genus in the Alum Bluff rests upon a single characteristic fragment from Chipola River.

Modiolaria sp.

1898. *Modiolaria* sp. indet. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 806.

Dall described this form as follows:

A single broken valve belonging to this genus was obtained from the Chipola marl. It is a species similar to *M. lateralis* Say, but marked especially by well-developed latticed sculpture in the interspaces of the radii.

No further material has been collected which might serve to identify this species.

Occurrence: Chipola formation, locality 2564^r.

Genus CRENELLA Brown

1827. *Crenella* Brown, Illustrations of the conchology of Great Britain and Ireland, pl. 31, figs. 12-14.

1844. *Crenella* Brown, Illustrations of the Recent conchology of Great Britain and Ireland, 2d ed., p. 75, pl. 23, figs. 12-14.

Not *Crenella* Sowerby, 1842.

Type: *Mytilus decussatus* Montagu. (Recent off the coast of Greenland and in north Atlantic waters.)

Brown described this group in 1827 as follows:

Shell oblong-oval, equilateral, ventricose; beaks obtuse, slightly turned to one side; hinge destitute of teeth but with a flattened, horizontal, slightly crenated plate on one side of the hinge in each valve; right valve with a triangular, horizontal, projecting, reflexed plate, and the left one with an oblique plait, both of which are a little crenated externally.

Dall in 1898 gave the following details:²⁰

This interesting little group extends through the Tertiary and, owing to the little study given to its characters, has received many names. The shell is usually convex and ovoid, with more or less incurved beaks, a nacreous inner layer, thin epidermis which adheres closely to the shell, and a fine radial, often crossed by a concentric striation. In young shells the provinculum is exceptionally well developed, sometimes recalling the hinge of *Nucula* by its strong and projecting denticulations. If the shell is thin these become obsolete with growth, but in some species are replaced by a series of denticulations directly consequent on the impingement of the external sculpture on the cardinal margin, thus repeating a second time in the same individual the process by which the provinculum was originally initiated in its ancestors. At least that is the way in which the writer interprets the facts. When the shell is thick, or when the external sculpture is very delicate, no secondary denticulations appear in the adult, which is then left with a practically unarmed hinge line. The appearance of the provinculum is not dependent on the existence of the external sculpture, but the secondary denticulations are so dependent. The exterior may be almost perfectly smooth and polished with only microscopic striation; finely radially striate without decussation (like *C. sericea*), decussate, or with the radial sculpture

²⁰ Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 802, 1898.

strong and divaricate. Usually the sculpture is uniformly distributed over the surface, but occasionally there will be an area of unstriated separating two of striated surface, as in *Modiolaria*, but without the impressed boundaries of the latter genus.

The genus ranges from the Cretaceous to the Recent. Like the rest of the family it is characteristic of the cooler waters. For that reason, doubtless, its distribution in the warm waters of the Alum Bluff is exceedingly meager.

***Crenella minuscula* Dall**

Plate XV, Figure 9

1898. *Crenella minuscula* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 803, pl. 35, fig. 22.

Dall described this species as follows:

Shell minute, thin, inflated, elongate ovate, feebly radially striated, the striations apparently diverging from a medial line on the disk; not dichotomous; the beaks smooth; inner margins crenulate; valves nearly equilateral. Altitude 1.75, latitude 1.25, diameter 1 millimeter.

This little shell is rare in the marl and resembles in a general way *C. divaricata* Orbigny, of which it is the precursor, but has fainter sculpture and smooth beaks, besides being constantly of smaller size, and is more narrow in form than the young of *C. divaricata* of the same length.

Type: U. S. Nat. Mus. No. 114624.

Type locality: No. 2211, Alum Bluff (lower bed), Liberty County, Fla.

The smooth prodissoconch can be plainly observed in these minute forms. The affinities of the species are obviously with the later Tertiary or Recent members rather than with the Eocene.

Occurrence: Chipola formation, 3419^r, 7151^p, 2211^p, 10660^r.

Genus LITHOPHAGA Bolten

1798. *Lithophaga* Bolten, Museum Boltenianum, pt. 2, p. 156.

Type: *Mytilus lithophagus* Linnaeus. (Recent in the Mediterranean.)

Shell thin, nacreous, equivalve, strongly inequilateral, transversely elongated, more or less cylindrical in outline. Umbones strongly anterior, but not terminal. Anterior extremity rounded. Posterior extremity rostrate or cuneiform. External surface smooth or feebly sculptured concentrically. Ligament submarginal. Hinge edentulous. Muscle impressions unequal, indistinct.

The genus has been reported from strata as far back as the Carboniferous. The recent species number less than 50 and are confined to tropical and subtropical waters.

The young are attached by a byssus but in the later stages usually perforate coral colonies, the shells of larger bivalves, or even the solid rock. Two of the five subgenera into which the group has been divided are incrustated with a dense calcareous covering in the adult stages. The cavities which they excavate are characteristically flask-shaped in outline. The perforations in the columns of the temple of Serapis,

which served Lyell for his classic illustration of changes in the level of the sea, were made by *Lithophagae*.

Lithophaga is known in the Alum Bluff by a single species, which is represented in the available collections by double valves from the Oak Grove and by a single valve from the Chipola at Boynton Landing.

***Lithophaga oryzoides* Gardner, n. sp.**

Plate XV, Figure 10

Shell very small and very thin, inflated, subcylindrical in outline, tapering slightly toward the extremities so that in outline and dimensions it is not unlike a grain of rice. Umbones very low and inconspicuous, following the curvature of the umbonal extremity and scarcely interrupting it. Posterior margin expanded slightly medially. Anterior margin approximately straight. Ventral extremity a little more narrow than the dorsal and less broadly rounded. Maximum inflation of valves slightly ventral to the umbones, gradually dying out posteriorly. Anterior slope steeper than the posterior. Surface smooth excepting for incremental and more or less exaggerated resting stages. Ligament groove submarginal, very obscure. Hinge edentulous. Scars of soft parts not discernible; interior highly polished. Shell so thin that the surface is faintly rippled by the growth stages which corrugate the exterior.

Dimensions: Altitude, 5.7 millimeters; latitude, 2.6 millimeters; diameter, 3.1 millimeters.

Type: U. S. Nat. Mus. No. 352447.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County, Fla.

This small species is less elongated than the young of *L. niger* D'Orbigny and shows no trace of the characteristic grooving upon the anterior slope. There is no other form in the Alum Bluff which approaches it.

Occurrence: Chipola formation, locality 7893^r; Oak Grove sand, locality 2646^r.

Family JULIIDAE Dall

Genus JULIA Gould

1862. *Julia* Gould, Boston Soc. Nat. Hist. Proc., vol. 8, p. 233.

Type: *Julia exquisita* Gould. (Recent in the Hawaiian Islands.)

Shell small, porcellanous, transversely ovate, inflated. Umbones quite prominent, prosodetic, strongly anterior in position. Lunule deeply impressed. Escutcheon obsolete. Surface smooth or feebly striated radially. Ligament marginal or partly internal. Hinge edentulous except for laminar extensions of the ventral margins of the lunule. Posterior adductor scar subcentral; anterior adductor probably obsolete.

Since the publication of *Julia floridana* Dall, heralded as the first member of the genus to be found in the fossil state and the first to be found in America, a second species has been isolated in the Bowden of Jamaica by Wendell P. Woodring. The known Recent representatives are Indo-Pacific in distribution.

Julia floridana Dall

Plate XV, Figures 1-3

1898. *Julia floridana* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 811, pl. 35, figs. 1, 2, 3.

Dall says:

Shell small, inflated, smooth, arched above, rounded behind, the base nearly straight; the beaks prominent, with a small impressed lunule immediately under them; below this lunule the valve projects forward to a rather acute point; with the exception of the groove for the ligament the hinge line is perfectly simple, without teeth or crenulations of any kind; the edge of the impressed lunule in the right valve is produced into a lamella, which fits behind a less prominent extension of the corresponding margin in the opposite valve; interior of the valves smooth, with no trace of muscular or other scars; exterior sculptured only by faint incremental lines; inner margin of the valves simple, not crenulated; shell substance showing no traces of nacreous structure, but rather porcellanous. Altitude 4.5, latitude 6.5, diameter 2 millimeters.

This species evidently belongs to the same restricted group as the original *Prasina borbonica* of Deshayes. The chief difference is that the impressed lunule is smaller and not so deep and that its margin in the left valve is not elevated into so evident a tubercle. Careful scrutiny of more than 20 valves collected failed to show any satisfactory muscular or pallial scars.

Cotypes: U. S. Nat. Mus. No. 114674.

Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla.

This small and unusually well characterized little species is not uncommon in the environs of the type locality.

Occurrence: Chipola formation, localities 2213^P, 3419^P.

Order ANOMALODESMACEA Dall

Dall gives the following description of this order:²¹

Pelecypods having the mantle lobes more or less completely united, leaving two siphonal, a pedal, and sometimes a fourth opening between them; siphons well developed, always at the posterior end of the body; two subequal adductor muscles; the shell structure nacreous and cellulo-crystalline, rarely with a prismatic layer; the area amphidetic or obscure, rarely distinctly divided; the ligament usually opisthodetic, generally associated with an internal resilium, chondrophores and lithodesma; valves generally unequal, the dorsal margin without a distinct hinge plate, the armature of the hinge feeble, often obsolete or absent; rarely with lateral laminae or well-developed dental processes; the animals usually sedentary burrowers, hermaphrodite and marine. * * *

Although this group in the general classification has usually been placed after the forms here included in the Teleodesmacea, no linear arrangement can properly express their natural relations. This and the preceding order (Prionodesmacea) represent for us lines of parallel development of the most ancient origin, while the Teleodesmacea probably took their rise chiefly from forms which, genetically, would be included in the present order. The modern Anomalodesmacea are nearly all much specialized and their archaic characters veiled by later adaptations. That any have come down to us retaining indications of their archaic character is probably due to the burrowing habit, which has shielded them from many vicissitudes and checked in this way the perfecting processes of selection.

The student will understand, therefore, that the present group is here regarded as having one general origin with the Teleodesmacea, the two being contrasted with the Prionodesmacea, the latter differing more from either than the former differ from each other. Part of the original stock has produced the perfected types of pelecypods, which have lost all their archaic characters and become the Teleodesmacea, while another part, sheltered by peculiarities of station and developing adaptive modifications, has lagged behind the others and still indicates in some degree the ancient types from which it sprang.

Superfamily ANATINACEA

Dall characterizes this superfamily as follows:²²

Anomalodesmacea having V-shaped reticulate gills; not secreting a calcareous tube external to the shell.

Section EUSIPHONIA

Siphons elongate, the lithodesma, when present, at the anterior end of the internal resilium, and external to the mass of the resilium.²²

Family PERIPLOMATIDAE**Genus PERIPLOMA Schumacher**

1817. *Periploma* Schumacher, Essai d'un nouveau système des habitations des vers testacés, p. 115.

Type: *Periploma inaequivalvis* Schumacher. (Recent in the West Indies.)

Shell subnacreous, inequivalve, nearly closed, oval or rounded; umbones opisthogyrate; ligament internal, supported by two vertically or anteriorly directed chondrophores; hinge edentulous; muscle impressions unequal; pallial sinus broad and shallow.

Dall says:²³

The genus and its subdivisions show a gradual modification of the hinge characters. In *Periploma* there is a strong, prominent clavicular rib supporting the chondrophore, and in front of the latter is a small lunate lithodesma; in *Cochlodesma* the clavicle is obsolescent and in front of the chondrophores there is a cartilaginous mass of dark-brown color, uniting the valves and occupying the place of the lithodesma, but uncalcified.

The genus is rare in the Tertiary, whereas the Recent forms are for the most part confined to the eastern coast of the Americas.

The group is represented in the Alum Bluff by a single abundant but ill-preserved species restricted to a single horizon.

Periploma discus Gardner, n. sp.

Plate XV, Figures 11-13

Shell large for the genus, thick, nacreous, and so exceedingly fragile that the species is known only from abundant fragments. Valves rather compressed apparently, rudely discoidal in outline. Umbones subcentral, opisthogyrate, quite tumid and acutely pointed at their apices. An acute ridge apparently developed near the apex. Surface incrementally wrinkled, commonly with microscopically fine striae that cut obliquely across the wrinkles toward the ventral margin. Concentric sculpture giving way

²¹ Dall, W. H., op. cit., p. 530.

²² Dall, W. H., Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci. Trans., vol. 3, pt. 3, pp. 512, 529-530, 1895.

²³ Dall, W. H., Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1528, 1903.

near the lateral margins to a fine granulation suggestive of *Thracia*. Ligament internal but obsolete ventrally, supported by two prominent spoon-shaped chondrophores, produced obliquely backward from beneath the tips of the umbones, reinforced by a clavate lithodesma. Chondrophores strengthened by a rib-like thickening of the shell ventral to the chondrophore and at a low angle to the posterior dorsal margin. Hinge edentulous. Muscle impressions and pallial sinus unknown.

Dimensions: Altitude $67.0 \pm$ millimeters; latitude $70.0 \pm$ millimeters.

Type: U. S. Nat. Mus. No. 352445.

Type locality: No. 3856, 6 miles west-northwest of Mossyhead, Walton County, Fla.

A new species that occurs abundantly in a fragmentary state is most annoying. If it is named a permanent type must be selected and it must be figured, but in the possible event of the discovery of perfect material there may be a permanent cause for regret. On the other hand, a species that constitutes a considerable factor in a fauna can not be entirely disregarded in a monograph of that fauna. The collections from the Shoal River are extensive and were carefully made, and the chances for finding perfect individuals were probably as good as they will be later.

There is no trace of the genus at any other horizon nor of any but the one species in the Shoal River. It is possibly the precursor of *Periploma peralta* Conrad, though it is relatively higher, less compressed, and very much thicker shelled.

Occurrence: Shoal River formation, localities 3856^a, 3733^r, 3748^r, 9957^r, 10603^p, 10608^p.

Family THRACIIDAE

Genus THRACIA (Leach MS.) De Blainville

1824. *Thracia* De Blainville, Dictionnaire des sciences naturelles, vol. 32, p. 347.

1839. *Thracia* Couthouy, Boston Jour. Nat. Hist., vol. 2, p. 129.

Type: *Thracia corbuloides* De Blainville. (Recent in the Mediterranean.)

Couthouy describes this genus as follows:

Shell thin, transversely oval, inequivalve, corbuliform, right valve the more convex, inequilateral, slightly gaping at both extremities; beaks well marked, and inclined a little backward; hinge having upon each valve a more or less prominent, horizontal spoon-shaped apophysis, receiving the internal portion of a ligament, visible also externally; this internal ligament is (sometimes) posteriorly attached to and strongly supports a cylindrical ossiculum, in the form of a semicircle. Anterior muscular impression narrow and elongated, united to the posterior, which is small and rounded, by a pallial impression strongly excavated posteriorly.

Thracia has had a rather meager representation since the Triassic. The shells are usually very fragile and ill adapted to preservation. The Recent forms have been collected from the American and European coasts and from the China Sea.

A single valve attests the existence of the genus during Alum Bluff time.

Thracia sp. indet.

A single left valve apparently allied to the small *Thracia transversa* H. C. Lea from the Miocene of Virginia but differing from it in the more elongate outline and the more coarsely sculptured umbones was collected from a locality near Shell Bluff on Shoal River. Though too imperfect to describe, it is quite sufficient to establish the presence of the genus in the Alum Bluff fauna.

Occurrence: Shoal River formation, locality 5079^r.

Section ADELOSIPHONIA

Dall characterizes this section as follows:²⁵

Siphons short, the lithodesma dividing the mass of the cartilage mesially.

Family PANDORIDAE Gray

Genus PANDORA (Bruguière) Lamarck

1798. *Pandora* Bruguière, Tableau encyclopédique et méthodique, vol. 1, pl. 250 (no desc.), figs. a-c.

1799. *Pandora* Lamarck, Prodrôme d'une nouvelle classification des coquilles: Soc. hist. nat. Paris Mém., p. 88. Sole sp. *Tellina inaequivalvis* Linnaeus.

Monotype: *Tellina inaequivalvis* Linnaeus. (Recent in the Mediterranean.)

Dall described this genus as follows:²⁶

The beaks of *Pandora* are erect and in the adult always more or less eroded. The ligament and resilium lie initially beneath them. The latter is usually longer, wholly submerged, and separate from the ligament except at its starting point. It is set in a groove, oblique or nearly vertical, and the edges of the groove are usually a little raised. On the anterior side of the ligament, when present, is to be found a long, straplike lithodesma. In *Pandora* s. s. and *Coelodon* there is no lithodesma developed. The normal number of teeth or laminae in each valve would appear to be three, but they may be merged in the cardinal border or the raised edge of the chondrophore, so that in *Pandora* s. s., when adult, the left valve appears to be without teeth and the right valve has only two. The teeth are formed, as in other cases, of a shank or lamina and a hook. Usually these become separated at an early age, forming two separate teeth, but in *Coelodon* the anterior left cardinal not only retains its connection with its "hook," but as the shell grows the entering angle between the hook and shank, by the fusing of the distal edges of the laminae, is, as it were, partially roofed over, a feature of which the most conspicuous examples in other groups occur in the Mactridae. The formulae are as follows:

Clidiophora, $\frac{L. \text{iorioio}}{R. \text{oioioi}}$; *Coelodon*, $\frac{L. \text{ioioio}}{R. \text{oioioi}}$; *Pandora*, $\frac{L. \text{oroio}}{R. \text{irio}}$.

The anterior left cardinal in the latter is represented only by a callosity on the anterior dorsal border of the valve in front of the umbonal notch. In all the groups the laminae have a tendency to pedunculation, the bases being narrower than the distal portion. They are therefore very liable to be broken off in opening the valves and are sometimes so interlocked that the animal itself can open the valves but to a trifling extent. The ligament is short and black; it usually appears to extend over the upper ends of the laminae in a horizontal direction or it may dip obliquely into the valves. In one case observed the ends of the ligament descended one in front and the other behind the upper end of the resilium, but

²⁵ Dall, W. H., Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci. Trans., vol. 3, pt. 3, p. 532, 1895.

²⁶ Idem, pt. 6, pp. 1516-1517, 1903.

the normal position is in front of the resilium. The lunule and escutcheon when present are compressed and almost linear, the dorsal margin of the flat valve usually slightly overlies that of the convex valve. The pallial line is in this genus largely a misnomer, for the mantle is attached to the shell by a succession of rounded spots which are not continuous; the visceral area of the disk may be smooth but is often punctate or radially striate and brilliantly pearly. The left valve is the convex one, and the ventral margin of the right valve is generally more or less flexible, so that the solid portions of the valves come together. The pearly layer is overlaid by a conspicuous, often partly eroded, prismatic layer, and that by a periostracum which in the northern species is often rather profuse and papery. The margin is practically entire, but they often have a few radiating threads on the posterior slope of the left valve, while on the right valve, especially in *Kennerleyia*, there are usually radial, impressed, somewhat dendritic brown lines.

The species are usually found in sandy or muddy situations, and the group is represented as early as the Cretaceous in Europe.

The genus, though including only about 20 Recent species, is universally distributed from the Arctic to the Indian Ocean.

Only the single species has been recorded from the Alum Bluff, but this occurs rather abundantly both in the Oak Grove and in the Shoal River. No trace of the genus has yet been found in the Chipola.

Subgenus *KENNERLEYIA* Carpenter

1864. *Kennerleyia* Carpenter, Zool. Soc. London Proc., p. 602.

Type: *Kennerleyia filosa* Carpenter. (Recent from Nunivak Island, Bering Sea to San Pedro, Calif.)

The subgenus is characterized by the radial ornamentation of the right valve and the development of a lithodesma.

Pandora (*Kennerleyia*) *dodona* Dall

Plate XV, Figure 8

1903. *Pandora* (*Kennerleyia*) *dodona* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1518, pl. 57, fig. 25.

Dall described this species as follows:

Shell small; left valve very convex, when adult somewhat twisted, attenuated distally, with a slender, blunt rostrum; anterior area defined by an obsolete sulcus and with the central area smooth; posterior dorsal area bounded below by a single radial thread and somewhat concentrically wrinkled, hinge plate normal, disk with the muscular impressions strongly marked; right valve slightly concave, with a strong posterior dorsal keel, concentrically striated and with a few radial incised lines. Length 12.5 (to 15.0), height 5.2, diameter 2.0 millimeters.

This species is somewhat like *P. carolinensis* Bush, but more slender and more enrolled; in fact, in the latter respect our other species, recent or fossil, approach it closely only exceptionally.

Type: U. S. Nat. Mus. No. 135848a.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County, Fla.

The Shoal River forms run a little larger and a little heavier, as a rule, but the differences are so slight and the exceptions in both faunas so numerous that even a subspecific distinction is too fine.

Occurrence: Oak Grovesand, localities 2646^a, 5632^p, 5631^p, 7054^p. Shoal River formation, localities 3856^p, 3742^a, 5195^r, 5079^c, 7264^r, 10603^r, 9959^r.

Superfamily POROMYACEA Dall

Dall²⁷ characterized this superfamily as follows:

Anomalodesmacea having modified foliobranch or lamellar gills, slightly or not at all reticulated, and frequently degenerate or even absent; * * * the mantle lobes united, with siphons and a pedal, but no opisthopodial foramen; the resilium reinforced below by a lithodesma.

Family VERTICORDIIDAE

Genus *VERTICORDIA* (Searles Wood MS.) Sowerby

1844. *Verticordia* Sowerby, Mineral conchology, vol. 7, pl. 639.

Type: *Verticordia cardiformis* Sowerby. (Pliocene (Coraline Crag) of Suffolk, England.)

Sowerby uses the name *Verticordia* on the plate, though in the description he refers to it as *Hippagus*?

Shell nacreous, equivalve, generally though not invariably small, and suborbicular. Umbones subcentral, or anterior, prominent; prosogyrate, often strongly involute. Lunule false, more or less depressed. External sculpture strongly radial. Ligament submarginal, continued to apices of umbones. Internal cartilage supported by lithodesma. Strong subumbonal cardinal generally present in the right valve; posterior lateral developed in one group; left valve commonly devoid of true teeth, in some specimens developing a posterior lateral, more rarely a subumbonal cardinal. Valvular margins more or less modified to function as laterals. Adductor impressions small, commonly obscure. Pallial line simple or feebly sinuous. Inner margins frequently denticulated by the radiating costae.

Verticordia has, as might be inferred, a very meager representation in the Tertiary of the east coast. The genus is characteristically a deep-water form, one species occurring at a depth of almost 1,700 fathoms, whereas the Alum Bluff sands and marls are essentially shallow-water deposits.

Only the single species has been reported from the Alum Bluff, and this is restricted to the Chipola formation.

Subgenus *TRIGONULINA* D'Orbigny

1845. *Trigonulina* D'Orbigny, in De la Sagra, Histoire physique, politique et naturelle de l'île de Cuba, Mollusques de Cuba, vol. 2, p. 327.

Type: *Trigonulina ornata* D'Orbigny. (Recent from Rhode Island to the Barbados.)

Dall²⁸ characterized this group as follows:

Shell compressed laterally; ossicle long, narrow, rectangular, flat; right valve as in *Verticordia*, with a long lateral tooth; left valve as in *Verticordia*.

²⁷ Dall, W. H., op. cit., pt. 3, p. 534.

²⁸ Dall, W. H., Reports on the results of dredging under the supervision of Alexander Agassiz in the Gulf of Mexico (1877-78) and in the Caribbean Sea (1879-80): Harvard Coll. Mus. Comp. Zoology Bull., vol. 12, No. 6, p. 286, 1886.

Verticordia (Trigonulina) dalli Gardner, n. sp.

Plate XV, Figures 6-7

1903. *Verticordia (Trigonulina) cossmanni* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1512 (part).

Shell highly nacreous, small, compressed, subcircular to rudely elliptical in outline, inequilateral. Umbones slightly anterior, the apices moderately inflated, strongly prosogyrate. Margin directly in front of umbones deeply excavated by false lunule. Escutcheon absent. Anterior extremity broadly arcuate; posterior dorsal and lateral margins a parabolic curve from the umbones to the base line, which is approximately vertical. Surface heavily corded with eight subequal, abruptly elevated ribs, radiating from the umbones in gentle curves, convex posteriorly, the six anterior radials well within the anterior half of the shell, the posterior radial very close to the posterior margin and parallel to it, the remaining radial halfway between the posterior and the hindmost of the anterior series; interspaces deeply concave anteriorly and of approximately the same width as the radials, very much wider and more shallow posteriorly; entire external surface microgranular. Outer margins sharply dentate. Ligament deeply inset, continued to the apices of the umbones, doubtless reinforced by a lithodesma. A single rather stout, subumbonal cardinal developed in the right valve, received in the left valve between the dorsal margin and the thickened margin of the lunule, which functions as a denticle. Posterior margin of right valve grooved almost from the umbones to the base to receive the beveled margin of the left valve. Muscle impressions and pallial line obscure. Interior pearly and fluted almost to the umbones, in harmony with the radial sculpture.

Dimensions: Altitude, 2.6 millimeters; latitude, 3.3 millimeters.

Type: U. S. Nat. Mus. No. 114673.

Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla.

The Jackson shell, with which this has been confounded, has much the same outline but differs in the larger number of radials. In the *Verticordias* the range in this character is very slight, too slight to permit the specific identity of a form with 8 or 9 ribs and one with 12 to 15. The ninth rib when present is introduced directly behind the anterior of the two isolated ribs and is usually a little less prominent than the others.

Occurrence: Chipola formation, localities 7257^r, 2213^p, 2564^p.

Family CUSPIDARIIDAE Dall**Genus CUSPIDARIA Nardo**1840. *Cuspidaria* Nardo, Revue zoologique, p. 30.

Type: *Tellina cuspidata* Olivi. (Recent in the Mediterranean.)

Shell minutely pyriform in outline, feebly inequivalve, strongly inequilateral, the anterior portion of

the shell inflated, the posterior abruptly constricted and compressed, squarely truncate, gaping.

The genus originated in the Mesozoic and persists in the recent seas as one of the characteristic deep-water forms. One species, *C. lucifuga* Fischer, has been reported from over 2,500 fathoms.

The single valve that establishes the presence of the genus in the Alum Bluff is very closely related to a form now living in the West Indies.

Subgenus PLECTODON Carpenter1864. *Plectodon* Carpenter, British Assoc. Adv. Sci. Rept. for 1863, p. 638.

Type: *Plectodon scaber* Carpenter. (Recent off the coast of California.)

The group is characterized by the granular surface, the nearly obsolete external ligament inserted behind and under the beaks, and the twisting of the dorsal margins under the umbones to form a dental process.

Cuspidaria (Plectodon) cf. C. granulata Dall1881. *Neaera granulata* Dall, Harvard Coll. Mus. Comp. Zoology Bull., vol. 9, No. 2, p. 111.1886. *Leiomya (Plectodon) granulata* Dall, Harvard Coll. Mus. Comp. Zoology Bull., vol. 12, No. 6, p. 300, pl. 3, fig. 8.1889. *Leiomya (Plectodon) granulata* Dall, U. S. Nat. Mus., Bull. 37, p. 66, pl. 3, fig. 8.1903. *Cuspidaria (Plectodon) granulata* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1507.

Dall described *C. granulata* in 1881 as follows:

Shell in form somewhat like G. O. Sars's figure of *N. glacialis* Sars, but more elongated. Sculpture of an indefinite, hardly perceptible, rounded ridge extending from the beak toward the lower angle of the rostrum, with a more definite one extending toward the anterior margin, which it slightly angulates, forming the boundary of a sort of lunule or impressed space in front of the beaks; beside these there are fainter or stronger concentric striae or slight ridges, extending toward the margin; lastly, the entire surface is more or less densely covered with minute opaque white granules, such as in *Poromya*; the granulations are obscurely radiately and concentrically arranged. Color dead white, beaks little prominent. Teeth small, subobsolete; ventral margin rounded, anterior about the same; general appearance of the shell superficially much like *Leda minuta* Fabricius. Interior very polished. Longitude, 11.0; altitude, 8.0; latitude, 4.0; longitude of rostrum, which is not smooth, 3.3 millimeters.

Off Sombrero, 54 and 72 fathoms; Barbados, 100 fathoms.

The single valve from the Shoal River is apparently young and is less inflated than the Pliocene and Recent species. No differences can be detected in marginal outline, surface sculpture, or dentition. However, it is to be expected that the more stable deeper water forms should range for longer periods than the members of the inshore faunas. The Recent *C. granulata* has been reported from 54 fathoms to 118 fathoms, a depth sufficient to protect the fauna from many of the abrupt environmental changes to which the littoral faunas are subjected. The valve in question probably drifted inshore and does not indicate an unusual depth for the fauna with which it is associated.

Occurrence: Shoal River formation, locality 5618^r.

PLATES II-XV

PLATE II

[The specimen figured is the type unless otherwise stated.]

FIGURE 1. *Nucula chipolana* Dall (p. 8). Exterior of right valve; altitude, 2.75 millimeters; latitude, 4.0 millimeters. (After Dall.)

FIGURES 2-3. *Nucula chipolana* subsp. *waltonia* Gardner, n. subsp. (pp. 8-9).

2. Exterior of right valve; altitude, 3.2 millimeters; latitude, 4.0 millimeters.

3. Interior of right valve; altitude, 3.2 millimeters; latitude, 4.0 millimeters.

FIGURE 4. *Nucula sinaria* Dall (p. 9). Interior of left valve; altitude, 4.0 millimeters; latitude, 4.75 millimeters.

FIGURES 5-7. *Nucula dasa* Gardner, n. sp. (pp. 9-10).

5. Exterior of right valve; altitude, 3.2 millimeters; latitude, 3.55 millimeters.

6. Interior of right valve; altitude, 3.2 millimeters; latitude, 3.55 millimeters.

7. Hinge of right valve; altitude, 3.2 millimeters; latitude, 3.55 millimeters; semidiameter, 1.5 millimeters.

FIGURES 8-10. *Nucula defuniak* Gardner, n. sp. (p. 10).

8. Exterior of right valve; altitude, 4.3 millimeters; latitude, 5.0 millimeters.

9. Interior of right valve; altitude, 4.3 millimeters; latitude, 5.0 millimeters.

10. Hinge of right valve; altitude, 4.3 millimeters; latitude, 5.0 millimeters; semidiameter, 1.7 millimeters.

FIGURES 11-12. *Leda basilissa* Gardner, n. sp. (pp. 11-12).

11. Exterior of left valve (cotype); altitude, 14.3 millimeters; latitude, $32.0 \pm$ millimeters.

12. Exterior of right valve (cotype); altitude, 17.0 millimeters; latitude, $38.2 \pm$ millimeters.

FIGURES 13-16. *Leda acuta* (Conrad) (pp. 12-13).

13. Exterior of right valve (not the type); altitude, 3.8 millimeters; latitude, 6.8 millimeters. (After Clark.)

14. Interior of right valve (not the type); altitude, 3.8 millimeters; latitude, 6.8 millimeters. (After Clark.)

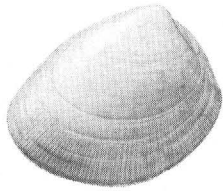
15. Exterior of left valve (not the type); altitude, 4 millimeters; latitude, 7 millimeters. (After Clark.)

16. Interior of left valve (not the type); altitude, 4 millimeters; latitude, 7 millimeters. (After Clark.)

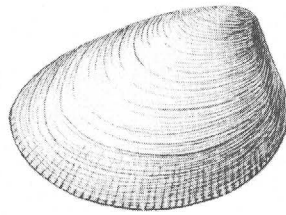
FIGURES 17-18. *Leda proteracuta* Gardner, n. sp. (pp. 13-14).

17. Exterior of right valve; altitude, 2.8 millimeters; latitude, 5.0 millimeters.

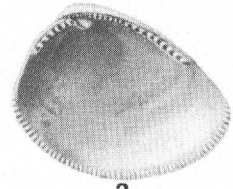
18. Interior of right valve; altitude, 2.8 millimeters; latitude, 5.0 millimeters.



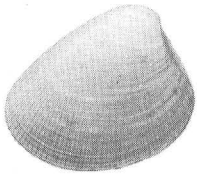
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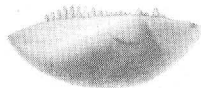
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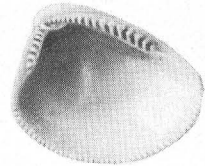
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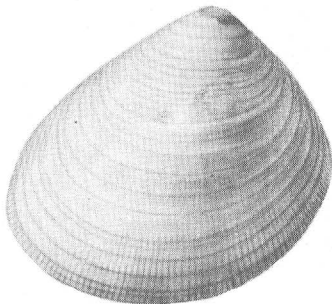
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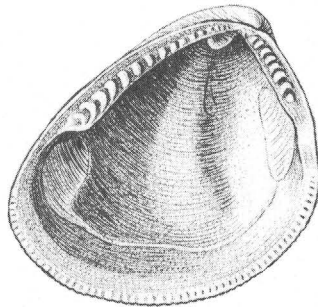
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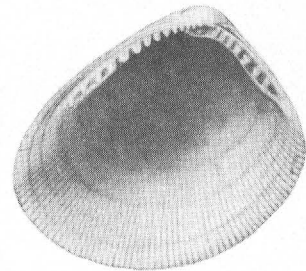
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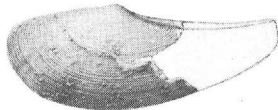
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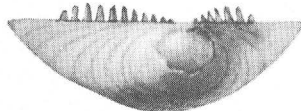
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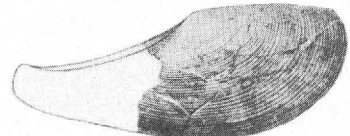
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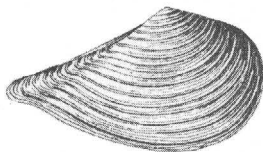
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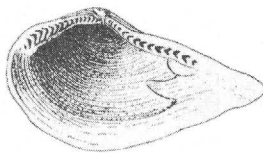
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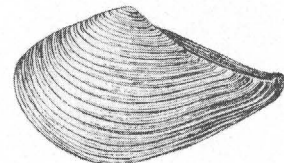
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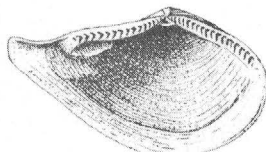
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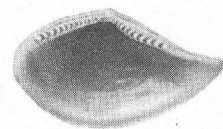
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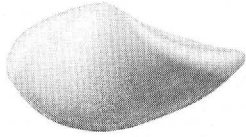


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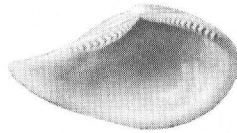


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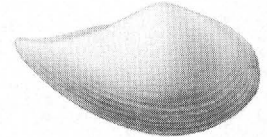
PRIONODESMACEA OF THE ALUM BLUFF GROUP



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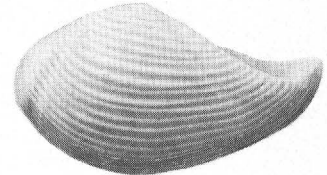
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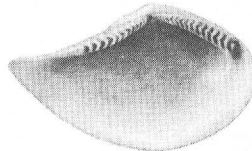
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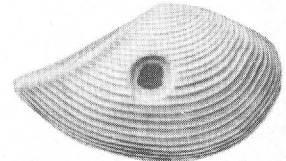
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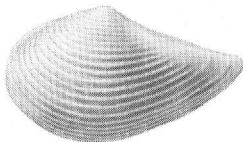
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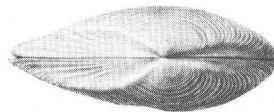
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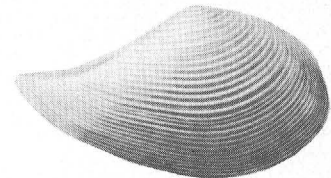
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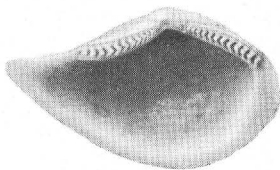
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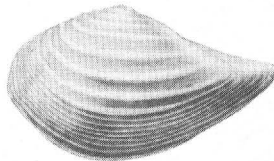
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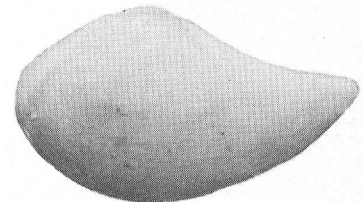
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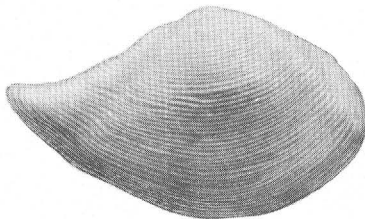
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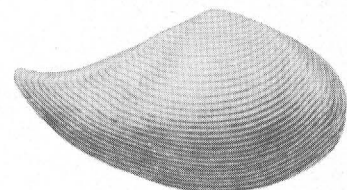
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18

PLATE III

FIGURES 1-4. *Leda proteracuta* subsp. *leita* Gardner (pp. 14-15).

1. Exterior of left valve (cotype); altitude 3.0 millimeters; latitude, 5.5 millimeters.
2. Interior of left valve (cotype); altitude, 3.0 millimeters; latitude, 5.5 millimeters.
3. Exterior of right valve (cotype); altitude, 3.0 millimeters; latitude, 6.0 millimeters.
4. Hinge of left valve (cotype; altitude, 3.0 millimeters; latitude, 5.5 millimeters; semidiameter, 1.45 millimeters.

FIGURE 5. *Leda proteracuta* subsp. *dystakta* (p. 14). Exterior of left valve; altitude, 3.5 millimeters; latitude, 6.4 millimeters.

FIGURE 6. *Leda proteracuta* subsp. *diamesa* Gardner (p. 15). Exterior of left valve; altitude, 3.7 millimeters; latitude, 6.5 millimeters.

FIGURES 7-8. *Leda leptalea* Gardner, n. sp. (p. 16).

7. Exterior of left valve; altitude, 3.5 millimeters; latitude, 5.7 millimeters.
8. Interior of left valve; altitude, 3.5 millimeters; latitude, 5.7 millimeters.

FIGURES 9-10. *Leda polychoa* Gardner, n. sp. (pp. 17-18).

9. Exterior of right valve; altitude, 3.5 millimeters; latitude, 6.1 millimeters.
10. Dorsal view of double valves; altitude, 3.5 millimeters; latitude, 6.1 millimeters; diameter, 2.5 millimeters.

FIGURES 11-12. *Leda polychoa* subsp. *defuniak* Gardner, n. subsp. (pp. 18-19).

11. Exterior of left valve (not the type); altitude, 3.4 millimeters; latitude, 5.5 millimeters.
12. Exterior of right valve; altitude, 4.0 millimeters; latitude, 7.5 millimeters.

FIGURES 13-14. *Leda leiorhyncha* Gardner, n. sp. (p. 19).

13. Exterior of left valve; altitude, 3.5 millimeters; latitude, 6.0 millimeters.
14. Interior of left valve; altitude, 3.5 millimeters; latitude, 6.0 millimeters.

FIGURES 15-17. *Leda canonica* Dall (pp. 16-17).

15. Exterior of left valve (not the type); altitude, 2.9 millimeters; latitude, 5.0 millimeters.
16. Exterior of right valve; altitude, 1.4 millimeters; latitude, 2.5 millimeters.
17. Exterior of right valve (not the type); altitude, 3.1 millimeters; latitude, 5.2 millimeters.

FIGURE 18. *Leda canonica* subsp. *meiopykna* Gardner, n. subsp. (p. 17). Exterior of right valve; altitude, 3.0 millimeters; latitude, 5.6 millimeters.

PLATE IV

FIGURE 1. *Trinacria meekii* Dall (p. 22). Interior of right valve; altitude, 3.2 millimeters; latitude, 5.5 millimeters. (After Dall.)

FIGURES 2-5. *Trinacria meekii* subsp. *parameekii* Gardner, n. subsp. (p. 22).

2. Exterior of left valve (cotype); altitude, 2.7 millimeters; latitude, 4.6 millimeters.

3. Interior of left valve (cotype); altitude, 2.7 millimeters; latitude, 4.6 millimeters.

4. Interior of right valve (cotype); altitude, 2.6 millimeters; latitude, 4.5 millimeters.

5. Exterior of right valve (cotype); altitude, 2.6 millimeters; latitude, 4.5 millimeters.

FIGURE 6. *Leda dodona* Dall (p. 20). Exterior of left valve; altitude, 5.0 millimeters; latitude, 9.0 millimeters. (After Dall.)

FIGURE 7. *Yoldia frater* Dall (pp. 20-21). Exterior of left valve; altitude, 8.0 millimeters; latitude, 19.0 millimeters. (After Dall.)

FIGURES 8-12. *Yoldia soror* Gardner, n. sp. (p. 21).

8. Exterior of left valve; altitude, 5.6 millimeters; latitude, 11.5 millimeters.

9. Exterior of right valve; altitude, 5.6 millimeters; latitude, 11.5 millimeters.

10. Interior of left valve; altitude, 5.6 millimeters; latitude, 11.5 millimeters.

11. Interior of right valve; altitude, 5.6 millimeters; latitude, 11.5 millimeters.

12. Hinge of left valve; altitude, 5.6 millimeters; latitude, 11.5 millimeters; diameter, 4.0 millimeters.

FIGURES 13-15. *Leda diphya* Gardner, n. sp. (pp. 19-20).

13. Exterior of left valve; altitude, 4.7 millimeters; latitude, 8.1 millimeters.

14. Interior of left valve; altitude, 4.7 millimeters; latitude, 8.1 millimeters.

15. Exterior of juvenile left valve (not the type).



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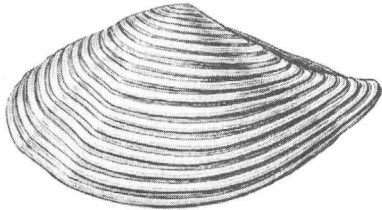
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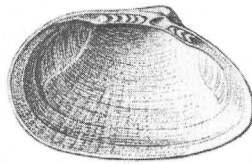
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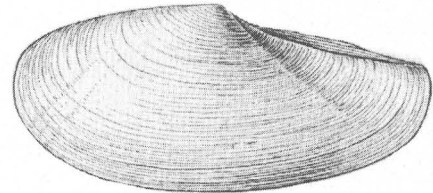
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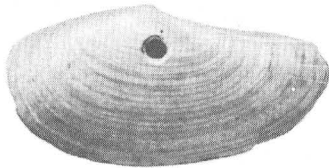
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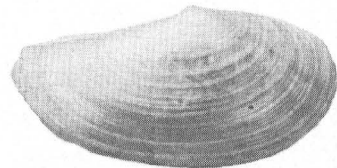
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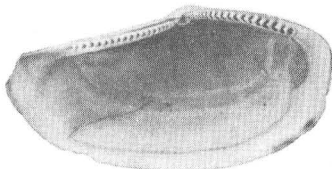
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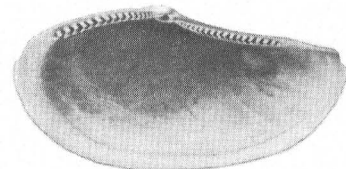
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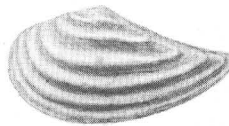
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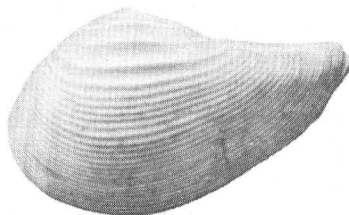
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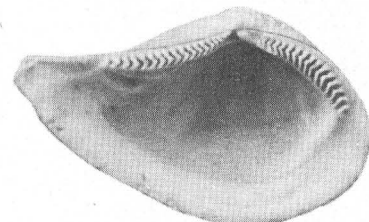
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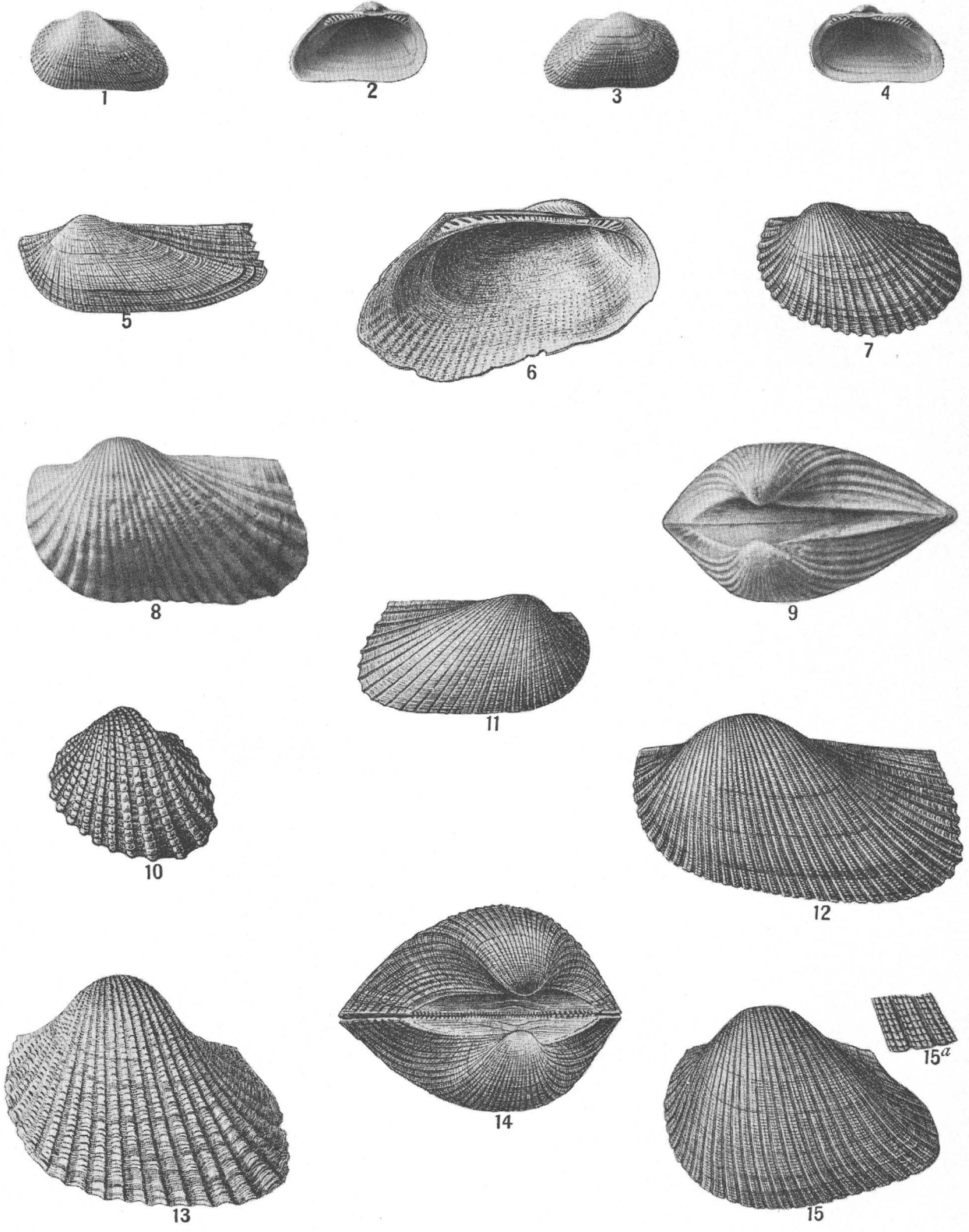
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PRIONODESMACEA OF THE ALUM BLUFF GROUP

PLATE V

FIGURES 1-4. *Barbatia adamsi* (Shuttleworth) Dall (p. 28).

1. Exterior of left valve (not the type); altitude, 6.5 millimeters; latitude, 11.5 millimeters.
2. Interior of left valve (not the type); altitude, 6.5 millimeters; latitude, 11.5 millimeters.
3. Exterior of right valve (not the type); altitude, 6.5 millimeters; latitude, 11.5 millimeters.
4. Interior of right valve (not the type); altitude, 6.5 millimeters; latitude, 11.5 millimeters.

FIGURE 5. *Arca paratina* Dall (p. 25). Exterior of left valve; altitude, 10.0 millimeters; latitude, 28.0 millimeters. (After Dall.)

FIGURE 6. *Barbatia phalacra* Dall (pp. 26-27). Interior of left valve; altitude, 11.0 millimeters; latitude, 23.5 millimeters. (After Dall.)

FIGURE 7. *Diluvarca latidentata* (Dall) (pp. 28-29). Exterior of left valve; altitude, 11.0 millimeters; latitude, 18.0 millimeters. (After Dall.)

FIGURES 8-9. *Diluvarca mikkula* Gardner, n. sp. (p. 29).

8. Exterior of left valve; altitude, 3.5 millimeters; latitude, 6.0 millimeters.
9. Dorsal view of double valves; altitude, 3.5 millimeters; latitude, 6.0 millimeters; diameter, 3.2 millimeters.

FIGURE 10. *Diluvarca initiator* (Dall) (p. 34). Exterior of left valve; altitude, 4.7 millimeters; latitude, 5.0 millimeters. (After Dall.)

FIGURE 11. *Diluvarca accompasa* (Dall) (p. 30). Exterior of right valve; altitude, 10.5 millimeters; latitude, 20.0 millimeters. (After Dall.)

FIGURE 12. *Diluvarca hypomela* (Dall) (pp. 29-30). Exterior of left valve; altitude, 25.0 millimeters; latitude, 50.0 millimeters. (After Dall.)

FIGURE 13. *Diluvarca staminata* (Dall) (pp. 30-31). Exterior of left valve; altitude, 37.0 millimeters; latitude, 47.0 millimeters. (After Dall.)

FIGURES 14-15a. *Diluvarca dodona* (Dall) (p. 30).

14. Dorsal view of double valves; altitude, 28.0 millimeters; latitude, 40.0 millimeters; diameter, 30.0 millimeters. (After Dall.)
15. Exterior of left valve; altitude, 28.0 millimeters; latitude, 40.0 millimeters. (After Dall.)
- 15a. Detail of sculpture. (After Dall.)

PLATE VI

FIGURES 1-2. *Diluwarca santarosana* (Dall) (p. 31).

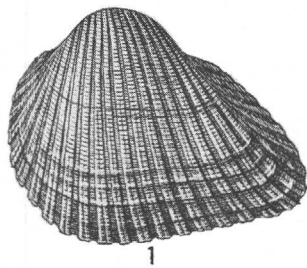
1. Exterior of left valve; altitude, 28.0 millimeters; latitude, 36.5 millimeters. (After Dall.)
2. Dorsal view of double valves; altitude, 28.0 millimeters; latitude, 36.5 millimeters; diameter, 28.0 millimeters. (After Dall.)

FIGURES 3-6. *Diluwarca waltonia* Gardner, n. sp. (pp. 32-33).

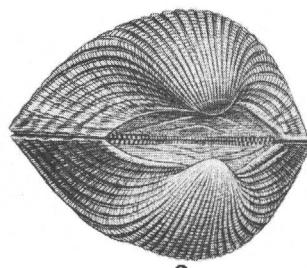
3. Interior of right valve (not the type); altitude, 33.0 millimeters; latitude, 35.0 millimeters. (After Dall.)
4. Anterior view of double valves; altitude, 32.5 millimeters; latitude, 33.0 millimeters; diameter, 36.0 millimeters.
5. Exterior of left valve; altitude, 32.5 millimeters; latitude, 33.0 millimeters.
6. Exterior of right valve; altitude, 32.5 millimeters; latitude, 33.0 millimeters.

FIGURES 7-10. *Diluwarca cardioides* Gardner, n. sp. (pp. 34-35).

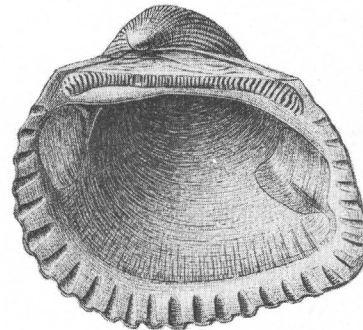
7. Exterior of right valve (cotype); altitude, 5.0 millimeters; latitude, 5.8 millimeters.
8. Interior of right valve (cotype); altitude, 5.0 millimeters; latitude, 5.8 millimeters.
9. Exterior of left valve (cotype); altitude, 7.7 millimeters; latitude, 9.0 millimeters.
10. Interior of left valve (cotype); altitude, 7.7 millimeters; latitude, 9.0 millimeters.



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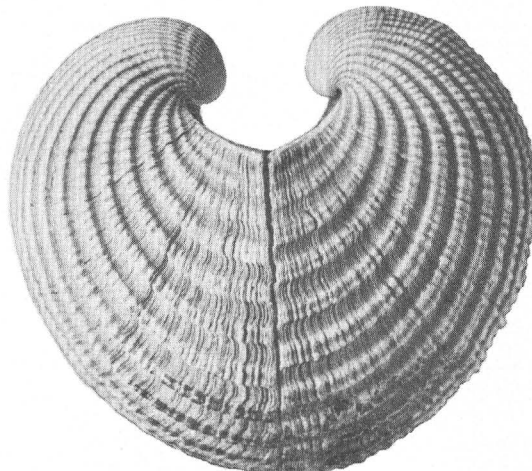
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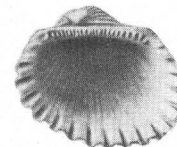
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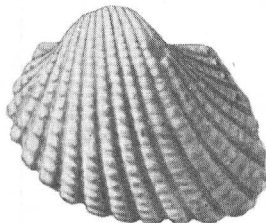
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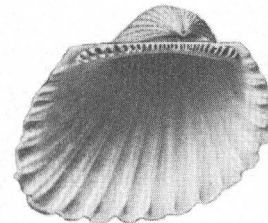
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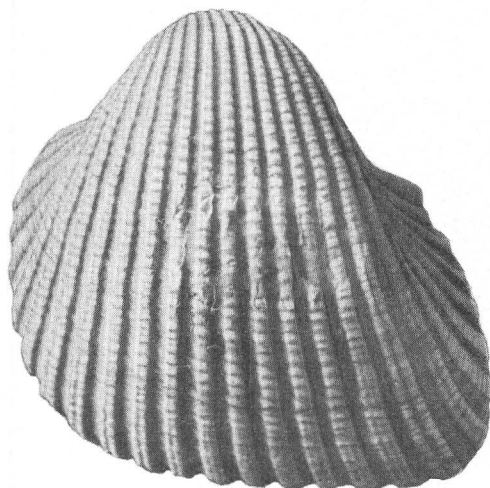
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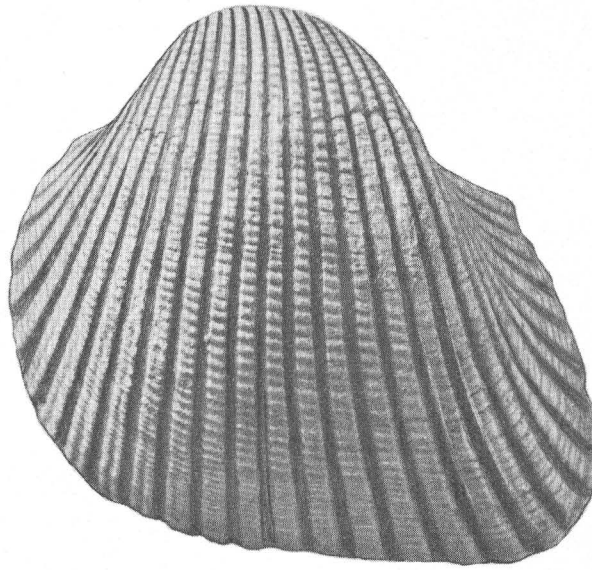


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PLATE VII

FIGURES 1-2. *Diluvarca santarosana* subsp. *geraetera* Gardner (pp. 31-32).

1. Exterior of left valve (cotype); altitude, 36.5 millimeters; latitude, 39.0 millimeters.
2. Exterior of right valve (cotype); altitude, 35.0 millimeters; latitude, 37.5 millimeters.

PLATE VIII

FIGURES 1-2. *Diluvarča strebla* Gardner, n. sp. (pp. 33-34).

1. Exterior of right valve; altitude, 27.0 millimeters; latitude, 41.0 millimeters.

2. Dorsal view of double valves; altitude, 27.0 millimeters; latitude, 41.0 millimeters; diameter, 26.0 millimeters.

FIGURES 3-8. *Glycymeris subovata* (Say) (pp. 35-36).

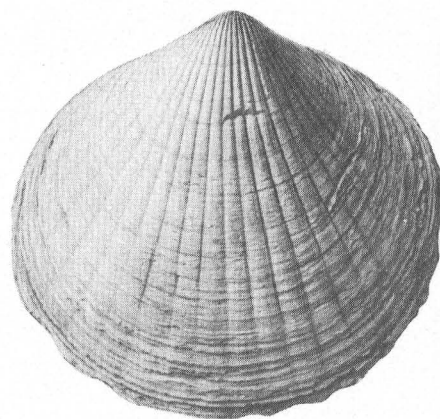
3. Exterior of right valve (not the type); altitude, 55.0 millimeters; latitude, 58.0 millimeters.

4. Interior of left valve (not the type); altitude, 55.0 millimeters; latitude, 59.0 millimeters.

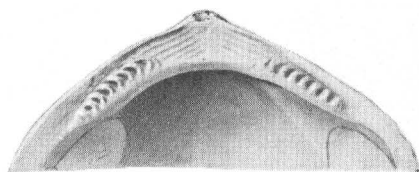
5-8. Hinges showing progressive encroachment of the cardinal area upon the dental arch (not the type).



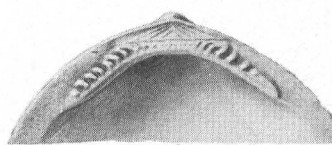
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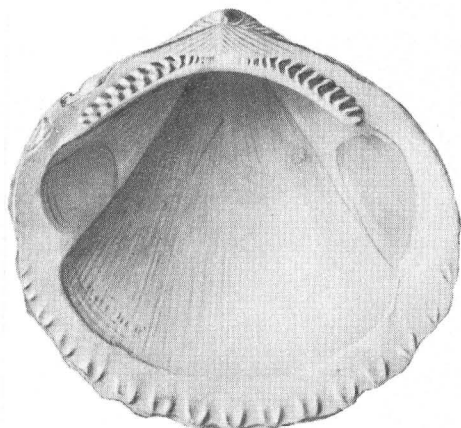
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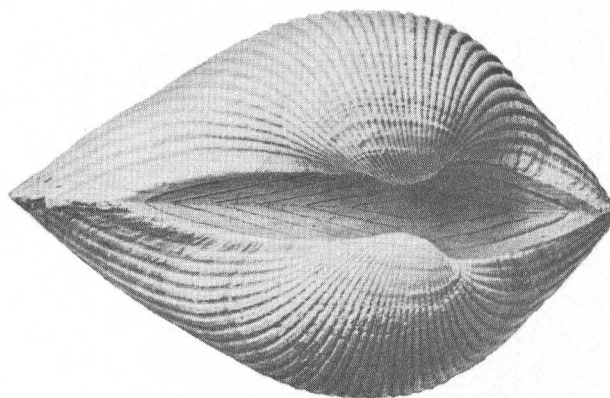
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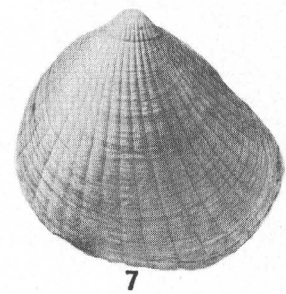
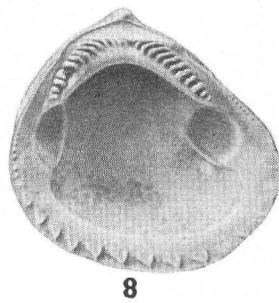
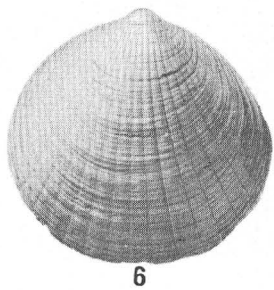
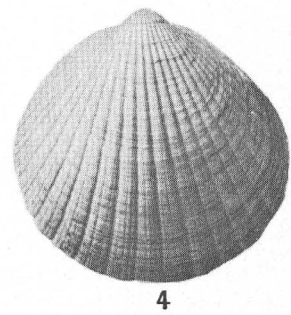
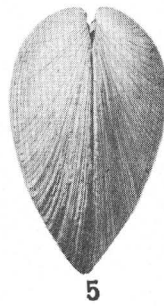
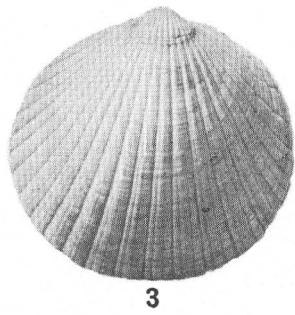
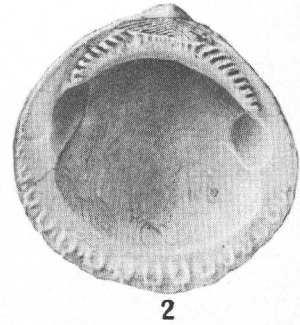
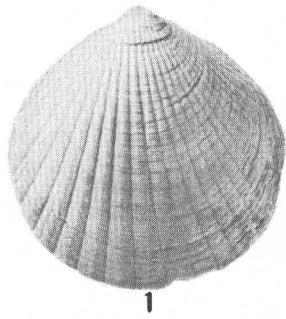


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PLATE IX

FIGURES 1-2. *Glycymeris drymanos* Gardner, n. sp. (p. 36).

1. Exterior of left valve (cotype); altitude, 38.2 millimeters; latitude, 37.5 millimeters.
2. Interior of right valve (cotype); altitude, 38.5 millimeters; latitude, 38.5 millimeters.

FIGURES 3-4. *Glycymeris drymanos* subsp. *grapta* Gardner, n. subsp. (p. 37).

3. Exterior of right valve (cotype); altitude, 37.0 millimeters; latitude, 37.6 millimeters.
4. Exterior of left valve (cotype); altitude, 36.5 millimeters; latitude, 36.5 millimeters.

FIGURES 5-8. *Glycymeris waltonensis* Gardner, n. sp. (pp. 37-38).

5. Anterior view of double valves; altitude, 33.9 millimeters; latitude, 35.1 millimeters; diameter, 20.6 millimeters.
6. Exterior of left valve; altitude, 33.9 millimeters; latitude, 35.1 millimeters.
7. Exterior of left valve (not the type); altitude, 33.0 millimeters; latitude, 35.5 millimeters.
8. Interior of right valve (not the type); altitude, 33.0 millimeters; latitude, 35.5 millimeters.

FIGURES 9-12. *Glycymeris pectinata* (Gmelin) (p. 38).

9. Exterior of right valve (not the type); altitude, 12.5 millimeters; latitude, 12.5 millimeters.
10. Interior of right valve (not the type); altitude, 12.5 millimeters; latitude, 12.5 millimeters.
11. Exterior of left valve (not the type); altitude, 15.5 millimeters; latitude, 15.5 millimeters.
12. Interior of left valve (not the type); altitude, 15.5 millimeters; latitude, 15.5 millimeters.

PLATE X

FIGURES 1-2. *Ostrea rugifera* Dall (p. 41).

1. Interior of left valve (cotype); altitude, 58.0 millimeters; latitude, 38.0 millimeters.
2. Exterior of right valve of another individual (cotype); altitude, 61.5 millimeters; latitude, 37.0 millimeters.

FIGURES 3-4. *Ostrea pauciplicata* Dall (p. 41).

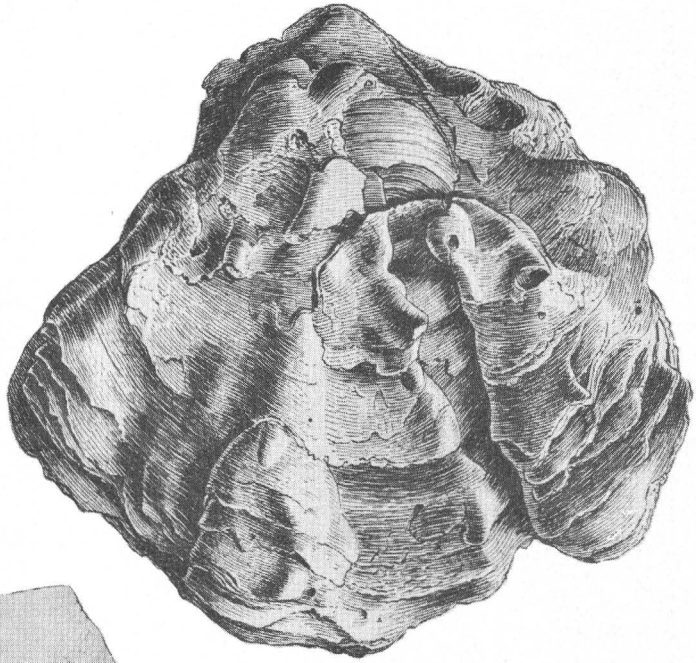
3. Exterior of left valve (cotype); altitude, 55.0 millimeters; latitude, 37.0 millimeters.
4. Exterior of right valve of another individual (cotype); altitude, 47.0 millimeters; latitude, 28.0 millimeters.

FIGURES 5-6. *Ostrea podagrina* Dall (pp. 42-43).

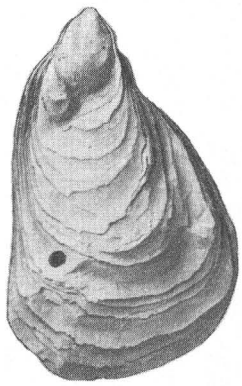
5. Exterior of left valve; altitude, 100.0 millimeters; latitude, 110.0 millimeters. (After Dall.)
6. Interior of left valve; altitude, 100.0 millimeters; latitude, 110.0 millimeters. (After Dall.)



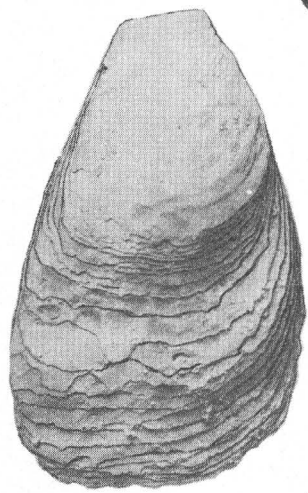
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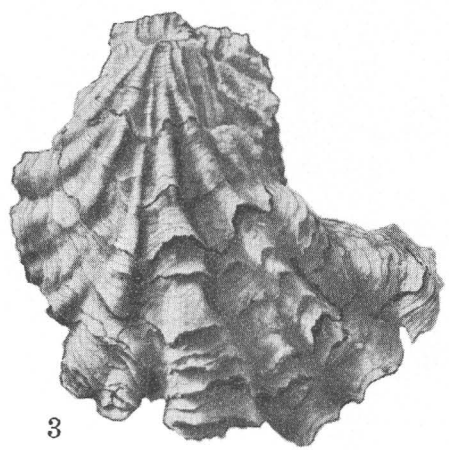
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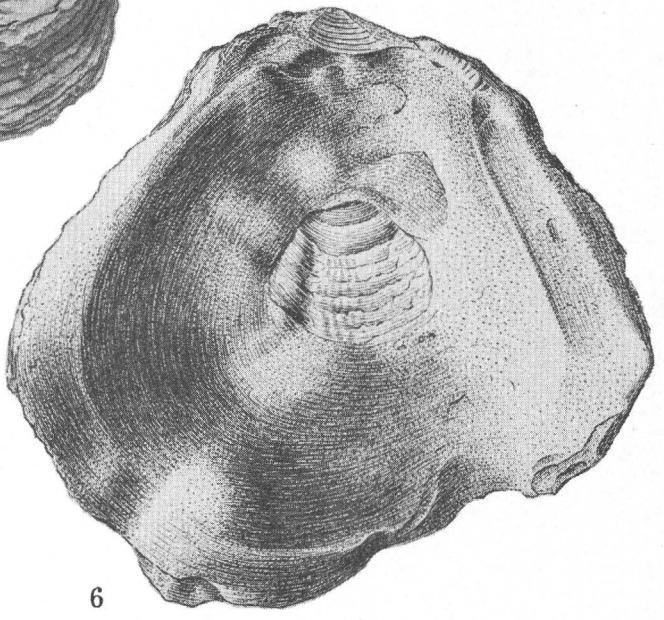
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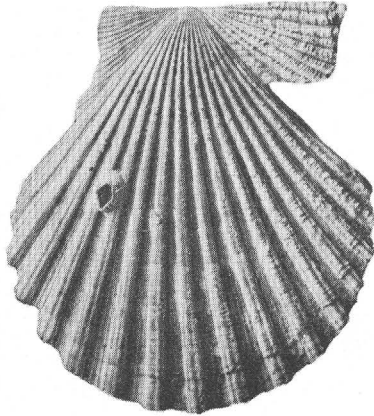


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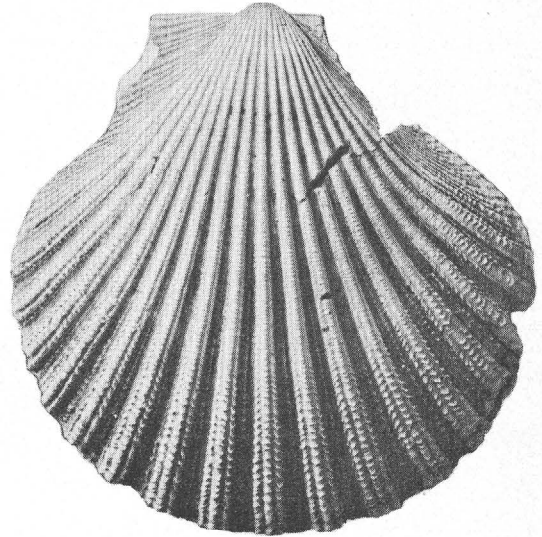


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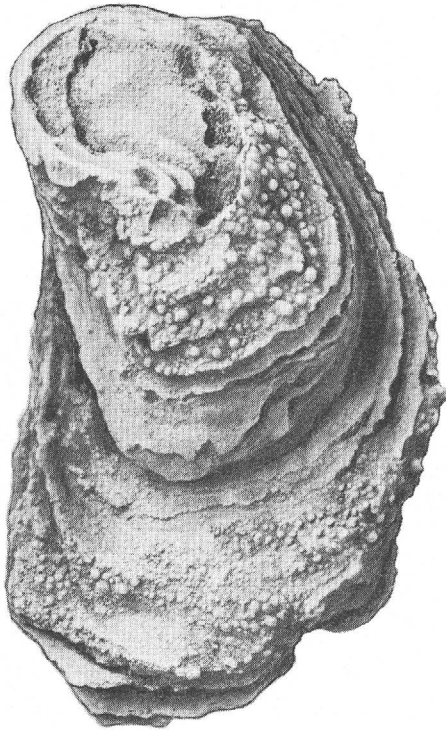
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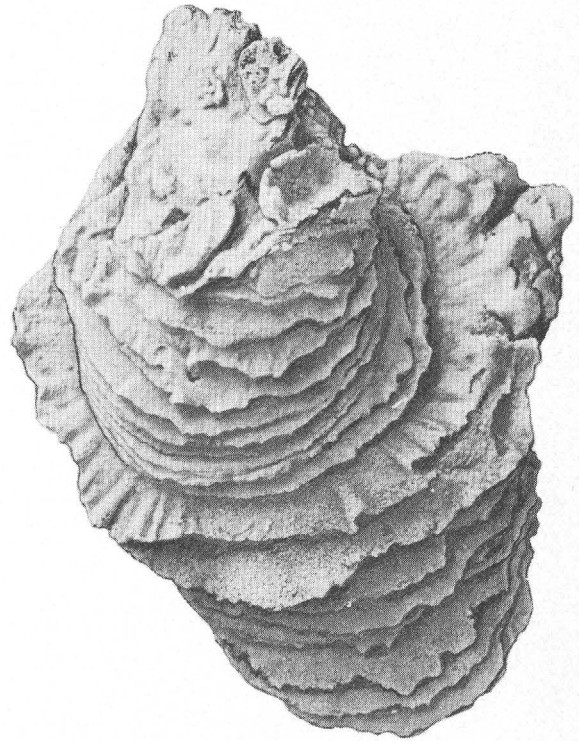
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PLATE XI

FIGURES 1-2. *Chlamys (Lyropecten) acanikos* Gardner, n. sp. (p. 46).

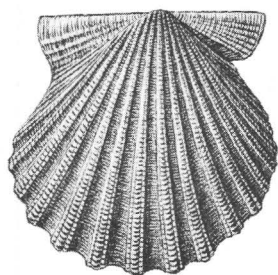
1. Exterior of right valve (not the type); altitude, 26.0 millimeters; latitude, 23.0 millimeters.
2. Exterior of left valve; altitude, 36.0 millimeters; latitude, 35.0 millimeters.

FIGURES 3-4. *Ostrea normalis* Dall (p. 43).

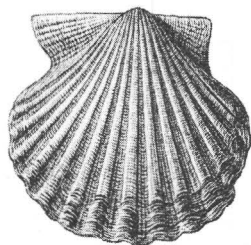
3. Exterior of right valve (cotype); altitude, 95.0 millimeters; latitude, 55.0 millimeters.
4. Exterior of left valve (cotype); altitude, 100.0 millimeters; latitude (exclusive of projecting lamellae) 50.0 millimeters.

PLATE XII

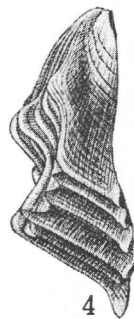
- FIGURE 1. *Pecten (Pecten) burnsii* Dall (pp. 44-45). Exterior of right valve; altitude, 18.0 millimeters; latitude, 19.0 millimeters; diameter, 6.0 millimeters. (After Dall.)
- FIGURE 2. *Chlamys (Chlamys) chipolanus* Dall (p. 47). Exterior of left valve; altitude, 25.0 millimeters; latitude, 25.0 millimeters. (After Dall.)
- FIGURES 3-4. *Chlamys (Nodipecten) condylomatus* Dall (pp. 46-47).
3. Exterior of left valve; altitude, 24.0 millimeters; latitude, 23.0 millimeters. (After Dall.)
4. Profile of same. (After Dall.)
- FIGURES 5-6. *Chlamys (Plagioctenium) nicholsi* Gardner, n. sp. (p. 48).
5. Exterior of right valve (cotype); altitude, 20.6 millimeters; latitude, 21.2 millimeters.
6. Exterior of left valve of another individual (cotype); altitude, 25.0 millimeters; latitude, 25.5 millimeters.
- FIGURE 7. *Chlamys (Lyropecten) sayanus* Dall (pp. 45-46). Exterior of right valve; altitude, 120.0 millimeters; latitude, 135.0 millimeters.
- FIGURES 8-9. *Chlamys (Chlamys) alumensis* Dall (pp. 47-48).
8. Exterior of left valve (cotype); altitude, 8.5 millimeters; latitude, 7.8 millimeters. (After Dall.)
9. Exterior of right valve of another individual (cotype); altitude, 8.0 millimeters; latitude, 7.5 millimeters. (After Dall.)
- FIGURES 10-12. *Pseudamussium defuniak* Gardner, n. sp. (p. 49).
10. Exterior of left valve (cotype); altitude, 4.6 millimeters; latitude, 4.6 ± millimeters.
11. Exterior of right valve of another individual (cotype); altitude, 3.8 millimeters; latitude, 3.75 millimeters.
12. Hinge area of left valve, ×10.
- FIGURES 13-14. *Pseudamussium diktuotum* Gardner, n. sp. (pp. 49-50).
13. Exterior of right valve (cotype); altitude, 3.8 millimeters; latitude, 4.0 millimeters.
14. Exterior of left valve of another individual (cotype); altitude, 4.2 millimeters; latitude, 4.5 millimeters.



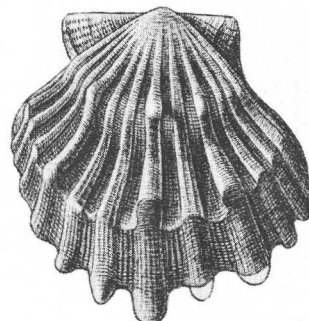
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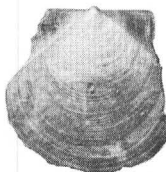
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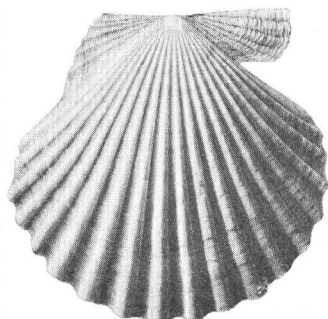
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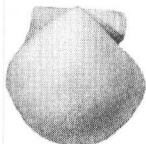
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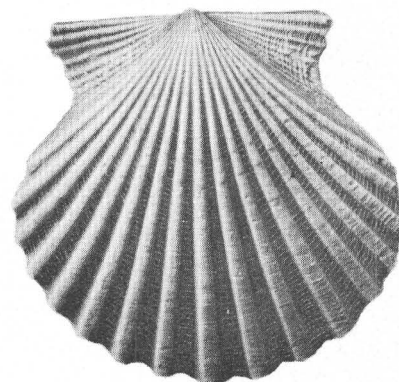
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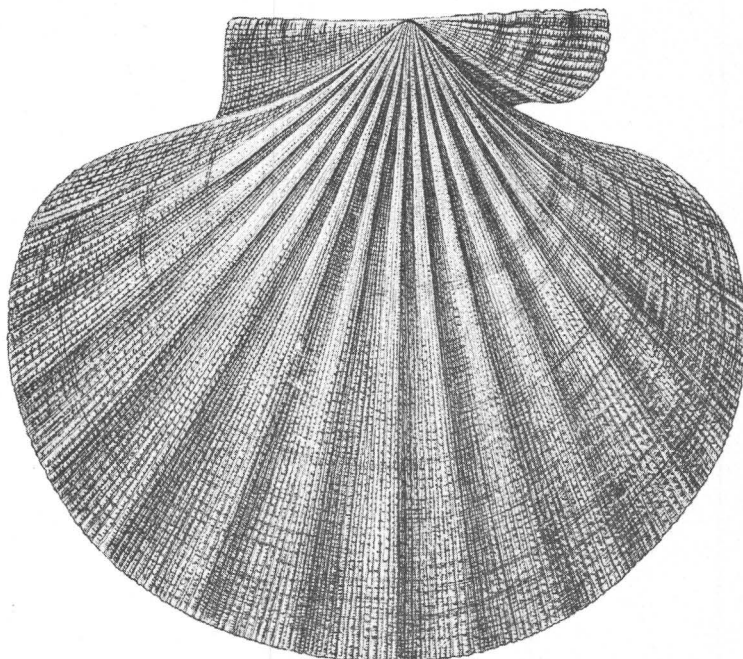
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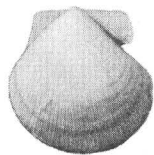
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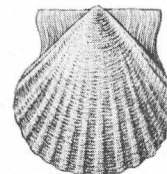
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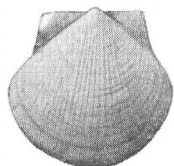
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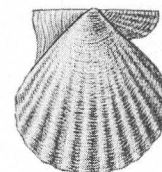
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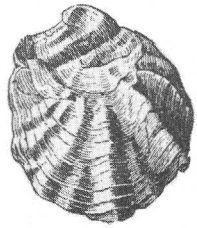


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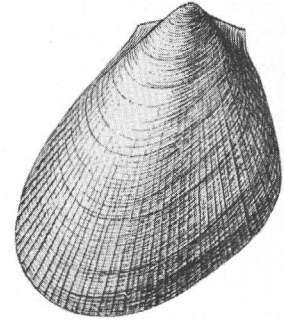
PRIONODESMACEA OF THE ALUM BLUFF GROUP



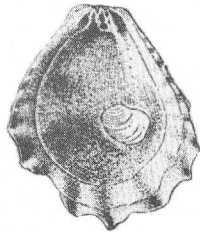
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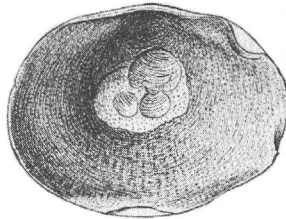
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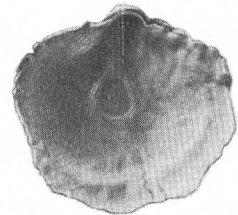
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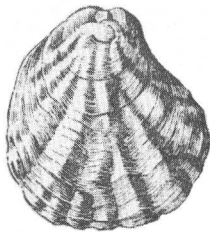
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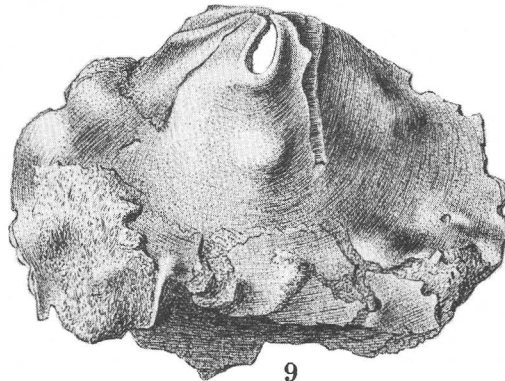
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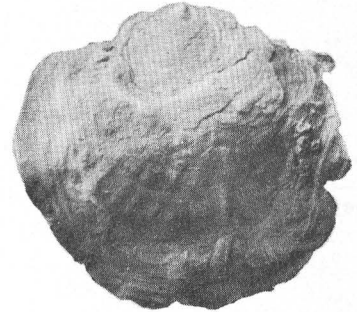
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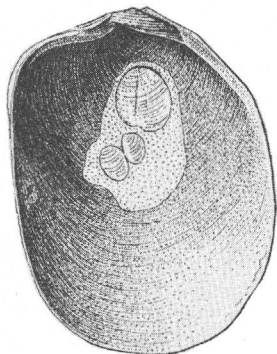
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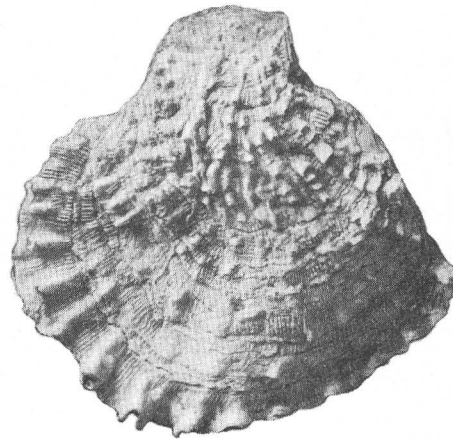
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PRIONODESMACEA OF THE ALUM BLUFF GROUP

PLATE XIII

FIGURES 1-3. *Plicatula densata* Conrad (pp. 51-52).

1. Exterior of right valve (not the type); altitude, 28.0 millimeters; latitude, 24.0 millimeters. (After Glenn.)
2. Interior of right valve (not the type); altitude, 28.0 millimeters; latitude, 24.0 millimeters. (After Glenn.)
3. Exterior of left valve (not the type); altitude, 30.0 millimeters; latitude, 26.0 millimeters. (After Glenn.)

FIGURE 4. *Lima carolinensis* Dall (p. 53). Exterior of right valve; altitude, 16.0 millimeters; latitude, 12.0 millimeters. (After Dall.)

FIGURE 5. *Anomia suwanneensis* Gardner, n. sp. (pp. 54-55). Exterior of left valve; altitude, 45.0± millimeters; latitude, 52.0 millimeters.

FIGURES 6-7. *Anomia glypta* Gardner, n. sp. (pp. 53-54).

6. Interior of left valve (not the type); altitude, 27.0 millimeters; latitude, 29.0 millimeters.
7. Exterior of left valve; altitude, 41.0 millimeters; latitude, 46.0± millimeters.

FIGURE 8. *Anomia microgrammata* Dall (p. 54). Interior of left valve; altitude, 17.0 millimeters; latitude, 25.0 millimeters. (After Dall.)

FIGURE 9. *Pododesmus scopelus* Dall (p. 55). Interior of right valve; altitude, 44.0 millimeters; latitude, 58.0 millimeters. (After Dall.)

FIGURE 10. *Anomia floridana* Dall (p. 54). Interior of left valve; altitude, 29.0 millimeters; latitude, 21.0 millimeters. (After Dall.)

FIGURE 11. *Plicatula lepidota* Gardner, n. sp. (p. 52). Exterior of left valve; altitude, 29.5 millimeters; latitude, 30.0 millimeters.

FIGURE 12. *Pododesmus rudis* Broderip (p. 55). Exterior of left valve (not the type); altitude, 40.0 millimeters; latitude, 36.0 millimeters.

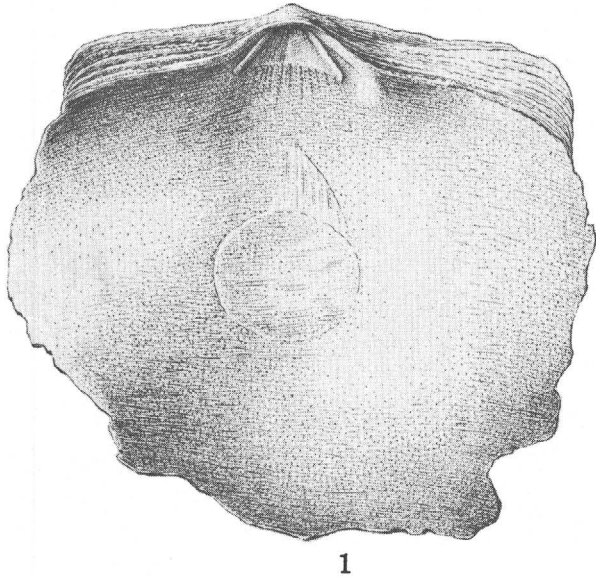
PLATE XIV

FIGURES 1-5. *Carolia (Wakullina) floridana* Dall (pp. 56-57).

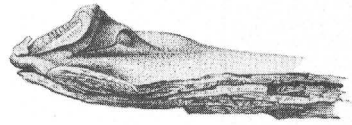
1. Interior of left valve (cotype); altitude, $130.0 \pm$ millimeters; latitude, $122.0 \pm$ millimeters. (After Dall.)
2. Profile of hinge of right valve showing scar of foramen and profile of chondrophore (cotype); natural size. (After Dall.)
3. View of same specimen from above (cotype); natural size. (After Dall.)
4. Cardinal area of double valves (cotype). (After Dall. p. 57)
5. Exterior of left valve of the same individual (cotype); altitude, 110.0 millimeters; latitude, 110.0 millimeters. (After Dall.)

FIGURES 6-7. *Mytilus pandionis* Dall (p. 57).

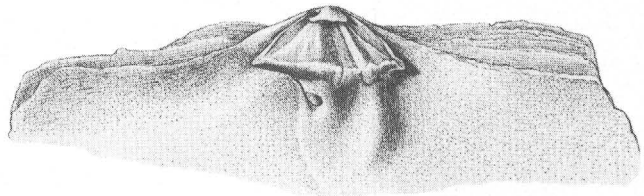
6. Internal cast of right valve; altitude, 122.0 millimeters; latitude, 60.0 millimeters; diameter 36.0 millimeters. (After Dall.)
7. Profile of same cast. (After Dall.)



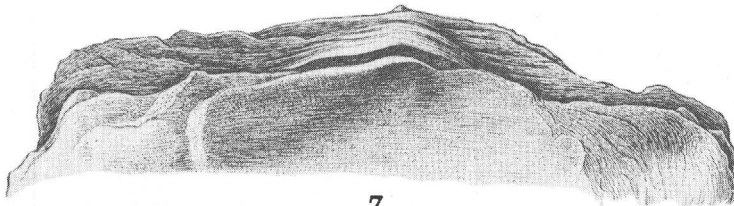
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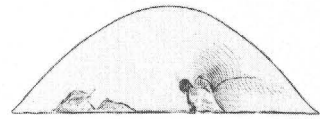
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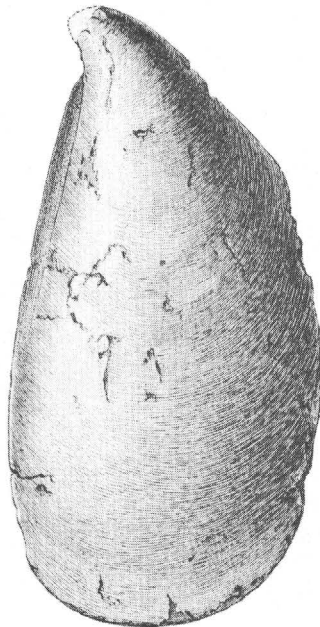
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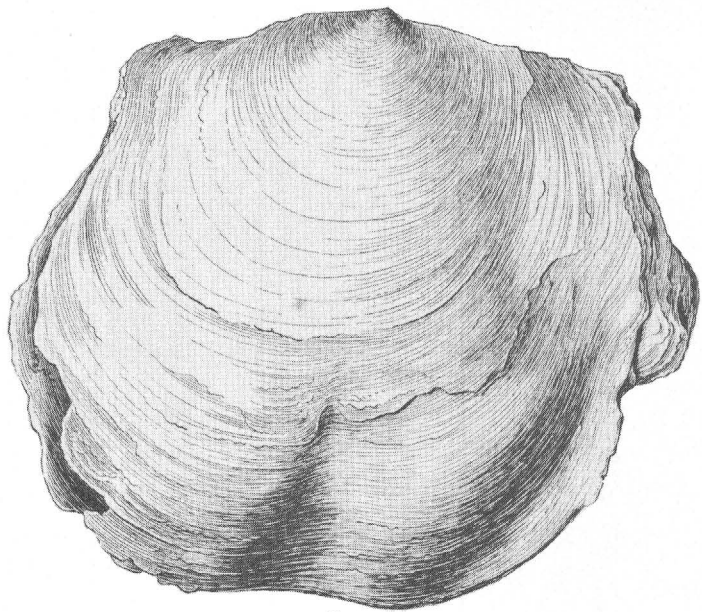
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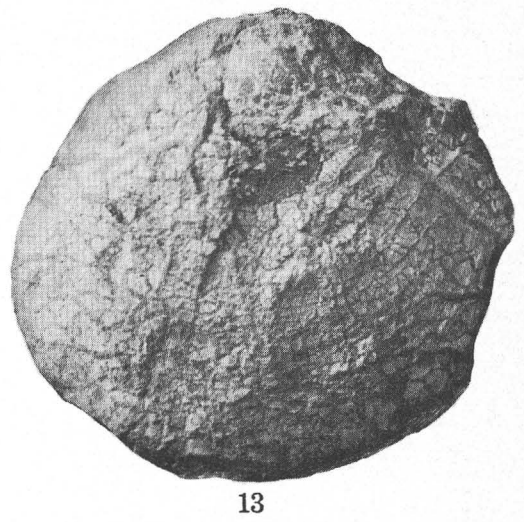
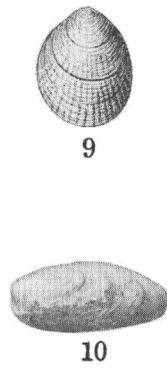
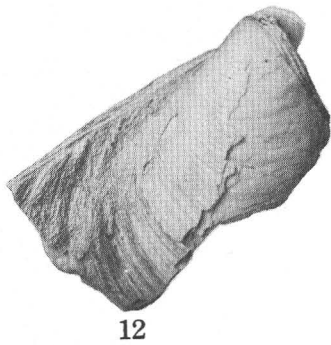
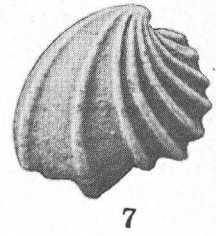
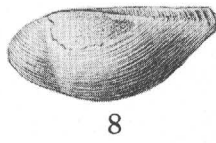
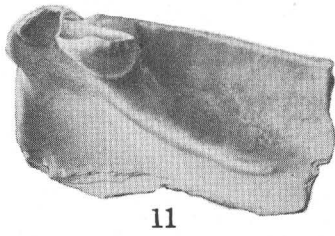
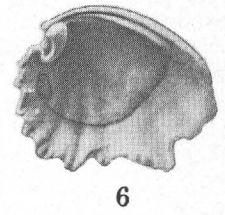
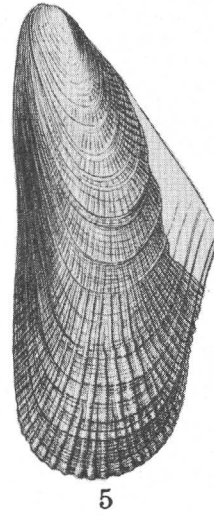
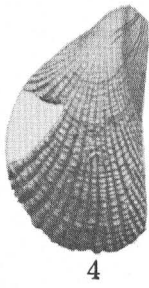
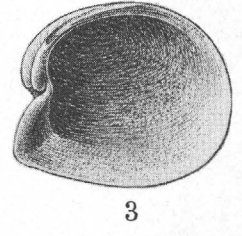
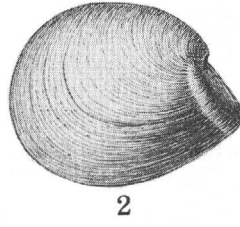
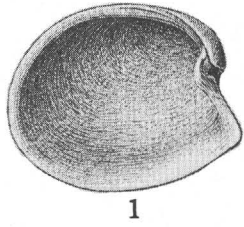


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5

PRIONODESMACEA OF THE ALUM BLUFF GROUP



PRIONODESMACEA AND ANOMALODESMACEA OF THE ALUM BLUFF GROUP

PLATE XV

FIGURES 1-3. *Julia floridana* Dall (p. 61).

1. Interior of left valve (cotype); altitude, 2.7 millimeters; latitude, 3.5 millimeters. (After Dall.)
2. Exterior of right valve (cotype); altitude, 2.7 millimeters; latitude, 3.7 millimeters. (After Dall.)
3. Interior of right valve (cotype); altitude, 2.7 millimeters; latitude, 3.5 millimeters. (After Dall.)

FIGURE 4. *Modiolus (Brachidontes) curtulus* Dall (p. 58). Exterior of right valve; altitude, 12.0 millimeters; latitude, 7.0 millimeters.

FIGURE 5. *Modiolus (Brachidontes) grammatus* Dall (p. 58). Exterior of left valve; altitude, 20.0 millimeters. (After Dall.)

FIGURES 6-7. *Verticordia dalli* Gardner, n. sp. (p. 64).

6. Interior of right valve; altitude, 2.6 millimeters; latitude, 3.3 millimeters.
7. Exterior of right valve; altitude, 2.6 millimeters; latitude, 3.3 millimeters.

FIGURE 8. *Pandora (Kennerleyia) dodona* Dall (p. 63). Exterior of left valve; altitude, 5.2 millimeters; latitude, 12.5 millimeters. (After Dall.)

FIGURE 9. *Crenella minuscula* Dall (p. 60). Exterior of left valve; altitude, 1.75 millimeters; latitude, 1.25 millimeters. (After Dall.)

FIGURE 10. *Lithophaga oryzoides* Gardner, n. sp. (p. 60). Exterior of left valve; altitude, 5.7 millimeters; latitude, 2.6 millimeters.

FIGURES 11-13. *Periploma discus* Gardner, n. sp. (pp. 61-62).

11. Portion of hinge of right valve showing chondrophore (paratype); $\times 2$.
12. Exterior of same specimen (paratype); $\times 2$.
13. Cast of interior with adhering fragments of nacre; altitude, $67.0 \pm$ millimeters; latitude, $70.0 \pm$ millimeters.

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