CLASSIFICATION OF THE PELECYPOD FAMILY ARCIDAE,

by Philip W. Reinhart (Stanford, California).

Introduction.

The pelecypod family Arcidae is a large and important one, abundant and widely distributed during the Cenozoic and later Mesozoic eras. Inasmuch as more than 1300 species (1) are included within the family, its definition is obviously not a simple problem, but one on which wide differences of opinion have existed up to the present time. Classifications of the Arcidae have appeared previously, but none has attained completeness nor been entirely satisfactory in other respects. Mistakes in these earlier classifications have been found from time to time, new genera and subgenera have been described subsequently by many workers throughout the world; and, especially within recent years, nomenclatural changes have been so numerous as to cause confusion. In view of the unsatisfactory condition outlined above, my present purpose is to bring together the described subgroups of the Arcidae, make the necessary revisions in them, and attempt to arrange them in a logical sequence.

(1) This estimate is reached by a count of the specific and varietal names listed in my card catalogue, described under the generic name Arca or under the other genera here included in the Arcidae. This count makes no provision for homonyms, synonyms, or for species incorrectly described as « Arca ». Furthermore the catalogue cannot claim completeness. Therefore the estimate of 1300 species and varieties is not a close one, but may furnish some idea as to the abundance of the family.
This paper is the outgrowth of a study of the species of Arcidae represented on the Pacific Slope of North America. Before attempting to understand the relationships of these species with others throughout the world or to assign them to their proper taxonomic groups, it was first necessary to study these groups with the purpose of determining their validity, the relations existing between them, and their correct nomenclature. One result of this study is the classification proposed in this paper (2).

Acknowledgments.

I wish to acknowledge the cooperation of a large number of people who have aided substantially in the preparation of this paper. This work was done under the direction of Professor H. G. Schenck of Stanford University, to whom I am greatly indebted. In addition, Dr. S. W. Müller, of the same institution, assisted in many ways.

For criticism of the manuscript, as well as for other assistance, thanks are extended to Professor U. S. Grant IV, of the University of California at Los Angeles, and to Dr. John B. Reeside Jr., of the U. S. National Museum. For the loan of specimens and of necessary publications I am indebted especially to the following persons: Mrs. I. S. Oldroyd and Mr. D. L. Frizzell, of Stanford University; Dr. C. L. Camp, Dr. C. W. Merriam, Mr. W. L. Effinger, and Mr. F. Earl Turner, of the University of California; Drs. G. Dallas Hanna and Leo G. Hertlein, of the California Academy of Sciences; Mr. Clinton G. Abbott and Mr. and Mrs. Frank Stephens, of the San Diego Society of Natural History; Mr. F. B. Plummer, of the Bureau of Economic Geology of Texas; Dr. E. M. Kindle, of the Canadian Geological Survey; Mr. L. R. Cox, of the British Museum of Natural History; Mlle. H. Alimen, of the Sorbonne; Dr. M. Gilbert, of the Musée royal d'Histoire naturelle at Brussels; Messrs. A. R. May and Alex Clark, of the Shell Oil Company. Finally, I am indebted to my wife, Marion E. Reinhart, for her critical assistance during the preparation of the manuscript for publication.

(2) The detailed discussion of the Pacific Slope species is as yet unpublished. It was read in part before the Pacific Coast Branch of the Paleontological Society of America, April 8, 1933, at Los Angeles, California. The abstract appears in the Proceedings of the Geological Society of America for 1933, p. 388, June, 1934.
Notwithstanding the abundant help that I have received from these many sources, I accept responsibility for the taxonomic arrangement set forth in this paper.

Relation of the Arcidae to the class Pelecypoda.

Only a few characteristics have been used as a primary basis of classification of the Pelecypoda, in the various arrangements of this class of mollusks which have been proposed. The most important of these characteristics are the following: the number and relative size of the adductor muscles, the presence or absence of siphons, the hinge, the gills, and the texture of the shell.

The two adductor muscles in the Arcidae are nearly equal in size; siphons are absent; and the pallial line, which is usually present, is entire; the hinge consists of a dorsal hinge plate provided with numerous transverse teeth—taxodont dentition of Neumayr (3); and, finally, the texture of the shell is porcelanous, though in some cases so highly polished as to seem nacreous.

The following table is a synopsis of the place occupied by the Arcidae in some of the more important classifications of the Pelecypoda.

Reference to classification.  

Position occupied by Arcidae.

Mollusca bivalvia.  
Division Asiphonida.

Order 1. Conchifères dimyaires.  
Section 3. Conchifères lamel-lipèdes.

II. Dimya.  
B. Homomya.

Section A, Asiphonida.


Order 3, Taxodonta.

Order Asiphonida.
Suborder Homomyaria.

Order Tetrabranchia.
Suborder Inappendiculata.

Order Filibranchia.

3. Ambonodonta.
(1) Eutaxodonta.

Order Prionodesmacea.
A. Taxodonta.

Taxodentes.

Order Eleutherorhabda.
Suborder, Mytilacea.
The classification of Lamarck (1818, 1835) was based primarily upon the adductor muscles, whereas that of Tryon (1884) was based upon a combination of siphons and adductor muscles. The arrangement of the hinge was the basis for the classifications of Neumayr (1884), Dall (1895 and 1913, also 1889 [4]), Bernard (1896, etc.), and Grobben (1894). The presence or absence of siphons was made the primary basis of classification by Fleming (1828) and Woodward (1851). The structure of the gills was used by P. Fischer (1887), Pelseneer (1892, etc.), Ridewood (1903), and E. L. Rice (5). H. Douvillé (1912) placed the strongest emphasis on shell texture and the arrangement of the hinge. Comparing Douvillé’s classification with those of Dall and of Pelseneer, Davies (6) concluded that Douvillé’s was the only one of the three which can be considered a phylogenetic arrangement.

The classifications of Dall and Pelseneer are the most commonly used at the present time, that of Dall being used especially by American paleontologists. Pelseneer’s classification, though adopted by most zoologists, is not without modern critics. An arrangement paying little heed to fossils cannot be accepted as even an approximation of a phylogenetic classification.

Family, generic, and specific characteristics of the Arcidae.

Characteristics of family importance.

My basis for assigning a certain number of genera to the family Arcidae, while excluding others and allocating them to different families, can be outlined by the following enumeration of important characteristics possessed by all the genera here allocated to the Arcidae and not possessed by those of other families:

1. An ark-like (boat-shaped) form, which, although varying greatly, can be traced in all of the genera here assigned to the family.
2. A straight or moderately-arched hinge with numerous taxodont teeth, arranged either vertically or obliquely (not parallel) to the hinge-line.
3. An external ligament, occupying all or only part of a well-defined ligamental (or cardinal) area.
4. Two subequal adductor muscle scars.
5. A simple pallial line, without siphonal indentation.
6. Porcellanous shell material.

The following comparison of the Arcidae with other taxodont families with which they might be and have been confused will bring out the importance of these characteristics.

Comparison of the Arcidae with related families.

Parallelodontidae: This family, including Parallelodon and its allies, Cucullaria, etc., may be distinguished from the Arcidae by the fact that the teeth are arranged mainly parallel with the hinge, not transverse to it as in the Arcidae. The Parallelodontidae have been grouped with the Arcidae by many workers in the past, and by some at the present time. That the two families are genetically allied can hardly be questioned. However, the morphologic difference mentioned above, as well as differences in geologic history (the Parallelodontidae originated in the Paleozoic, the Arcidae in the Mesozoic era), make the separation of the two families advisable. It must be admitted that in a few cases it is difficult to draw a line between the two. For example, Pseudogrammatodon Arkell (Geol. Mag., London, vol. 67, n° 793, 1930, p. 307), based upon the Eocene Arca adversidentata Deshayes, combines the hinge structure of Parallelodon with the form of Barbatia. Arkell considered his genus to be an off-shoot from Barbatia, which it may indeed be. However, at present, because of its hinge structure, I prefer to place Pseudogrammatodon in the Parallelodontidae, as it seems equally possible that it
developed from some such Cretaceous paralleloodontid genus as *Nemodon* Conrad, 1869. Incidentally, the similarity between *Pseudogrammatodon* and *Porterius* Clark (Univ. Calif. Pub. Bull. Dept. Geol. Sci., vol. 15, no 4, 1925, p. 79) should be mentioned. *Porterius* is based upon an Oligocene species from Grays Harbor County, Washington, « *Barbatia* » *andersoni* VanWinkle, which has the same general features as « *Arca* » *adversidentata*. Careful comparison may show that *Pseudogrammatodon* is to be considered a synonym of *Porterius*.

**Limopsidae**: The Limopsidae are distinguished from the Arcidae by the possession of a deep ligamental pit. Even those genera of Arcidae which possess a shallow ligamental pit (*Trigonodesma*, *Arcopsis*) differ from the Limopsidae by retaining a distinct, *Arca*-like ligamental area, even though the ligament occupies but a small part of this. Such an area is entirely lacking in the Limopsidae. On this criterion, *Trigonodesma* is here retained in the Arcidae, whereas *Trinacria* is referred, as has been done in the past, to the Limopsidae, although aside from this difference in the ligamental area, these two genera are fairly similar.

**Glycymeridae**: The rounded outline and strongly-arched hinge of this family are the main criteria, based upon the shell, for separating this family from the Arcidae. That differences of the soft parts also exist is shown by Pelseneer (in E. Ray Lankester, « A Treatise on Zoology », Part 5, Mollusca, p. 258, London, 1906), who states that in *Arca* the heart is situated above the rectum, whereas in « *Pectunculus* » (= *Glycymeris*) the heart is traversed by the rectum.

Stewart (Acad. Nat. Sci. Philadelphia, Special Pub. 3, 1930, p. 80) placed the subfamily Noetiinae (consisting of *Noetia*, *Trigonarca*, *Halonanus* = *Trigonodesma*) in the family Glycymeridae, in which he also included the subfamily Cucullaeinae, the basis for this arrangement being shown by the following quotation: « It [*Noetia*] has only vertical striations on the ligamental area which is usually restricted posterior to the beaks. The posterior adductor muscle scar is bounded ventrally by a ridge or flange which sometimes ascends into the umbo. The posterior restriction of the ligament and the internal flange suggest relationship with *Cucullacea* which has the flange much enlarged, while *Arca*, *Barbatia*, *Anadara* and its numerous allies, *Argina*, *Senilia*, and *Trisidos*, all lack the flange. It seems that *Noetia* is more closely related to *Cucullacea* and *Glycymeris* than to the Arcidae.»

In view of the difference of hinge structure between *Cucullacea*
and *Glycymeris*, the above inclusion of the Cucullaeinae in the family Glycymeridae seems questionable. *Cucullaea* and related genera seem more appropriately allocated to the Parallelodonidae, where they have usually been placed in the past.

The posterior restriction of the ligament (mentioned by Stewart as suggesting a relationship between the Noetiinae and Glycymeridae) is not generally present in *Glycymeris*, nor is it very prominent in *Cucullaea*, although it is noticeable. In the Noetiinae the ligamental area is usually shorter posterior than anterior to the beaks, but this shortening is quite variable in *Noetia*, as has been outlined by Sheldon (Palaeont. Amer., vol. 1, n° 1, 1917, p. 29). This criterion does not present a strong argument for allying the Noetiinae to the Glycymeridae.

The flange or ridge bounding the posterior adductor muscle scar may indicate that the Noetiinae are related to *Cucullaea*, but it does not necessarily indicate a relationship with *Glycymeris* because such a flange is not consistently present in *Glycymeris*, and when present, is sometimes only feebly developed. Moreover, the question arises as to whether or not this flange is a character of family or subfamily rank, as in addition to its occurrence on the Noetiinae and Cucullaeinae, similar or analogous flanges are present on some genera of the Arcinae; namely *Striarca* (7), occasionally *Arca s. s.* (8), and *Microcucullaea* (9). Further, a flange bordering the anterior adductor muscle scar is present in the type species of *Parallelodon, P. rugosum* (Buckman), although it is not present on all species of *Parallelodon s. s.*, nor is it found on any species of the closely related subgenus *Grammatodon* (Arkell, Geol. Mag., London, vol. 67, n° 793, 1930, p. 302). This flange, in conclusion, is not a character of family or subfamily value.

The Noetiinae, therefore, are here retained in the Arcidae not only because the criteria cited by Stewart to justify placing this

(7) In *Striarca* a raised flange borders the inner side of both anterior and posterior adductor muscle scars.

(8) On a specimen of an undescribed species of *Arca s. s.* from Pliocene beds at Fugler Point, near Santa Maria, Santa Barbara County, California, a raised flange borders the inner side of each muscle scar. This species will be described in a later paper. Likewise, a similar raised flange borders only the posterior muscle scar of Recent specimens of *Arca tetragona* Poli (No. 341, Oldroyd Collection, Stanford University).

(9) A raised flange is present bordering each adductor muscle scar in the type species of this group.
subfamily in the Glycymeridae are not convincing, but also because of the general resemblance of Noetia to Anadara on the one hand and to Area s. s. on the other.

Nuculidae: This family is distinguished from the Arcidae by having a chondrophore, no external ligament, a nacreous interior, and a different kind of taxodont dentition.

Ctenodontidae: There seems to be little possibility of confusing this family, with its oval shape, and arched hinge lacking a ligamental area, with the Arcidae.

Nuculanidae and Cyrtodontidae: The taxodont families Nuculanidae (« Ledidae ») and Cyrtodontidae are too far removed to warrant comparison with the Arcidae.

Characteristics of generic and specific importance.

The characteristics that have been found to be the most important ones in differentiating genera and subgenera are the arrangement of the hinge and teeth, character of the ligamental area, external sculpture, presence or absence of a byssal gape and of crenulations on the inner margin of the shell, general form, equivalve or inequivalve character, location of beaks and the direction in which they point, and the presence or absence of a raised flange bordering the posterior (sometimes also the anterior) adductor muscle scar, present on a few genera, notably Trigonarca, Noetia, Trigonodesma, Striarca, and infrequently on Area s. s.

Specific characters include a totality of shell characters, the most important of these being outline, form, hinge and ligamental area, number of ribs and their ornamentation, shape of muscle scars, and denticulations on the inner margin of the shell.

Time of differentiation of the Arcidae.

The following is a list of the genera and subgenera of Arcidae, arranged in the order of their first appearance in the geologic column, so far as data available to me indicate:

Triassic: Barbatia, sensu lato?
Jurassic: Eonavicula, Barbatia, s. l., (definitely present).
Cretaceous: Cucullaearcia, Plagiarea, Arcopsis (Danian), Acar (Danian), Striarca, Nemoarca, Trigonarca.
Eocene: *Arca, sensu stricto, Barbatia, sensu stricto, Obliquarca, Scapularca, Trisidos, Argina, Noetia, Trigonodesma*.

Oligocene (10): *Bathyarca, Anadara, sensu stricto, Cuneearca, Scapharca*.

Miocene (11): *Calloarca, Granoarca, Larkinia*.

Pliocene: *Arcoptera, Soldania*.

Pleistocene: No first appearances recorded.

Recent: *Litharca, Pugilarca, Bentharca, Microcucullaea, Scaphula, Noetiella, Paranoetia*.

« Tertiary » (probably late Tertiary): *Senilia, Seldonella*.

This tabulation indicates that the family possibly originated in the Triassic, species of *Barbatia* having been reported from Triassic strata. Two groups of the family were definitely present during Jurassic time: *Eonavicula* and *Barbatia, s. l.* During the Cretaceous seven new groups, and in the Eocene, eight new groups appeared, these being followed by only four new ones in the Oligocene, three in the Miocene, and two in the Pliocene. No new groups are known to have originated during Pleistocene time, but in the Recent fauna there are seven which are not yet definitely reported as fossils.

**Classification of the Arcidae followed in this paper.**

The following classification is based upon both a study of the literature and an examination of specimens of hundreds of species, including the type species of the various groups dealt with except in the few cases where these were not available. Shell characters alone have been used in my arrangement of the arcids. Since there are many reasons for believing that the shell is at least as reliable as the soft parts for classificatory purposes, my failure to consider soft parts is not of overwhelming importance.

It will be noted that the following list does not include the Jurassic-Cretaceous genus *Isoarca* Münster, 1842 (type species: *Arca, sensu stricto*.

(10) The Tongrian stage of Belgium and its equivalents are taken as lower Oligocene.

(11) If some formations now synchronized with the Aquitanian stage are taken as upper Oligocene, then *Larkinia* appears first in the Oligocene.
I. decussata Münster), which, although it was listed as a subgenus of Arca by Dall (in Zittel, Textbook of Paleontology, Eastman Edition, 1927, p. 443), does not appear to have much in common with the Arcidae. The systematic position of this genus is somewhat uncertain. It was placed as a subgenus of Cucullaea by Fischer (Man. de Conch., 1887, p. 977); Stoliczka, although placing Isoarca in the Arcinae, pointed out its pearly shell and lack of a true ligamental area, suggesting that it might better be classed in the family Nuculidae (Pal. Indica, vol. 3, 1871, pp. 338-339). The resemblance of Isoarca and the upper Carboniferous genus Carbonarea Meek and Worthen, 1870 (monotypic species: C. gibbosa Meek and Worthen), has been pointed out by Arkell (Geol. Mag. London, vol. 67, n° 794, 1930, p. 350).

In conclusion, the following summary includes two new systematic names: the subgenus Larkinia and the subfamily Anadarinae.

Divisions of the family Arcidae as recognized in this paper.

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Perhaps some systematists will oppose this arrangement on the grounds that either too many or too few genera are recognized. Opinions as to the proper delimitation of genera and of subgenera are so varied that disagreement cannot be avoided. By many, though not by all, workers in the past the name *Arca* has been used in a much broader sense than here, one of the reasons often cited for this usage being that most of the groups of the arcids intergrade at their peripheries, and consequently cannot be separated generically. Intergradation unquestionably exists, but this condition has been overemphasized. Even in cases where intergradation between groups can be shown, this fact does not necessarily mean that these groups must therefore belong to the same genus; for if we accept the doctrine of evolution, it follows that any two closely related genera, broadly or narrowly defined, must be connected by intermediate forms. The delimitation of genera is therefore of necessity arbitrary. In the following classification only those categories are recognized as genera which seem sufficiently distinct to warrant this rank, while the lesser units are treated as subgenera, and unnecessary names
are suppressed as synonyms. In brief, I have attempted to recognize a sufficient number of genera so that precision of nomenclature is possible, but at the same time without retaining a confusingly large number of generic names.

Several groups are recognized here to which, so far as I know, only one or two species can be definitely assigned (especially Litharca, Arcoptera, Pugilarca, Nemoarca, Paranoetia, Sheldonella, Noetiella). Although evaluation of the taxonomic rank of such groups, naturally, is questionable, it is better to recognize them at present until more is known about them than to place them haphazardly in the synonymy of some other better-known group. When more species have been found which belong to these questionable groups, then it will be possible to reach some justifiable conclusion as to their relationships and taxonomic rank.

In the following part a thorough treatment of each taxonomic group has not been attempted, but sufficient information has been included to enable the reader, by referring to the works cited, to gain a fairly adequate knowledge of each group. Systematic names proposed before the year 1758, or proposed by authors who did not apply the principles of binary nomenclature, are not included in the following discussion because they are not accepted under the International Rules of Zoological Nomenclature (Articles 25B and 26), and their insertion would seem to cause more confusion than benefit.

Family ARCIDAE (Auctores, partim).

Shell consisting of two valves, equally inflated; equivalve or slightly inequivalve. Shell usually longer than high; umbones ordinarily placed anterior to center of shell. Sculpture consisting of radial ribs crossed by concentric lines or bands; radial sculpture absent in some groups. Texture of shell porcellaneous. Ventral margin gaping for the passage of a byssus in the subfamily Arcinæ; in the Anadarinae and usually in the Noetiinae, however, ventral margin is closed. Periostracum of horny material, usually covered with hairs, but in some cases smooth, lacking hairs. Ligament external, occupying a ligamental area which, in most genera, extends both anterior and posterior to the umbones, forming a notch, deeply entrenched between them. Hinge straight or gently arched; teeth numerous, usually either perpendicular to the hinge or set obliquely so as to converge ventrally. Two adductor muscle scars, subequal in size; pallial line
simple, lacking a sinus. Type genus: *Arca* Linné, based upon *A. noae* Linné.

Geologic range: Jurassic (possibly Triassic) to Recent.

**Subfamily ARCINAE (Auctores, partim).**

Ventral margin generally with opening for passage of byssus; sculpture consisting of radial ribs crossed by concentric growth lines; ribs sometimes noded, often irregular in size and spacing; surface of shell usually irregular; when viewed from anterior end, with both valves joined, ligamental area appears narrow and V-shaped (as in *Barbatia*) to very wide and quite flat (as in *Arca s. s.*); hinge straight or gently arched. Inner margin of shell usually smooth; beaks not opisthogyrate, but pointing forward, upward, or inward. Type genus: *Arca* Linné, based upon *A. noae* Linné.

Geologic range: Jurassic (possibly Triassic) to Recent.

**Genus ARCA Linné, 1758.**

**Subgenus ARCA s. s.**


*Byssarca* Swainson, *Zoological Illustrations*, ser. 2, vol. 3, 1832-1833, pl. 118; type species: *Arca noae* Linné, 1758; type by

(12) *Arcacites* Schlotheim (Die Petrefactenkunde auf ihrem jetzigen Standpunkte durch die Beschreibung seiner Sammlung versteineter und fossiler Ueberreste des Thier- und Pflanzenreichs der Vorwelt erlautert, 1820, p. 201) is a synonym of *Arca* in the broad, Linnean sense. The suffix *ites* was added by Schlotheim to the generic name of each genus dealt with by him.

Cibota (Browne) Mörch, Catalogus Conchylorum quae reliquit D. Alphonso d’Aguirra & Gadea Comes de Yoldi, Fasc. 2, 1853, p. 39.


Not Thyas J. Huehner, Samml. exotische Schmett. II, Tab.(203); exact date of publication unknown; between 1806-1834. Not Thyas Koch in Panzer, Deutschl. Crust. Ins., Heft 5, 1837, tab. 18.

Shifting of opinion as to what species should be accepted as the genotype of Arca has resulted in a great deal of confusion concerning the typical subgenus, as has been outlined by Stewart (Acad. Nat. Sci. Philadelphia, Special Pub. 3, 1930, pp. 83-86). As Stewart notes, since 1847 Arca noae Linne has been accepted almost universally as the type species, following the designation of Gray (Proc. Zool. Soc. London, 1847, p. 197). This same species had previously been designated the type of Arca by Schmidt (Versuch. Conch.-Samml., 1818, pp. 65, 178) but this designation seems to have been overlooked by most systematists before Stewart. At any rate, Gray's designation, as mentioned above, was almost universally accepted.

Within the last few years, however, there has been brought to light the fact that two other species had been designated the type of Arca previous to 1847, one of these even before Schmidt's designation of 1818: (1) Cox (Paleont. Zanzibar, 1927, p. 93) pointed out that Children had designated A. tortuosa Linne the type of Arca in 1823; and (2) in 1930, Stewart (Acad. Nat. Sci. Philadelphia, Special Pub. 3, p. 83) disclosed the fact that A. anti-

(13) Thyas is listed by Gray under the subclass Siphonophora ("Mantle leaves connected, with two siphonal openings behind"). Thyas radula is the only species cited; the reference to the illustration given is "pl. 358, fig. 4." The explanation of plates gives for pl. 358, fig. 4, the following: "Arca Gaimardi. Deshayes, Algeria, t. 123, f. 9." The illustration itself shows what is evidently an Arca s. s. The citation to the illustration of Thyas is therefore evidently a mistake, and one is left in doubt as to the correct interpretation of Thyas. Fortunately the name is preoccupied and can be dropped as a homonym.
quata Linné had been designated the type species by Schumacher in 1817 (Essai Nouv. Syst. Test., p. 172).

Inasmuch as Schumacher's designation of *A. antiquata* antedates Schmidt's of *A. noae* by one year, *A. antiquata* was accepted as the typical species of *Arca* by Stewart and by Grant and Gale (San Diego Soc. Nat. Hist., Mem. vol. 1, 1931, p. 137), although Stewart was reluctant at the change, suggesting that *A. noae* should be arbitrarily accepted as type by the International Commission on Zoological Nomenclature.

From this review, we see that lately three different groups have successively been called the typical subgenus of *Arca*:

1. the group accepted as *Arca s. s.* in this paper, having *Arca noae* Linné as type species;
2. *Trisidos*, the type species of which is *A. tortuosa* Linné; and
3. *Anadara*, with *Arca antiquata* Linné as type species.

In view of this complicated history, and of the reluctance of many workers to abandon *Arca noae* as the type of *Arca*, it is desirable to submit this case to the International Commission on Zoological Nomenclature so that an opinion from this body may definitely settle the question. I have therefore presented the case to Dr. C. W. Stiles, Chairman of the Commission, recommending that *Arca noae* be established as the type species, and he has assured me that the question will receive consideration as soon as possible.

Until an opinion from the Commission is available, the nomenclature used in this paper is subject to a possible change, as the Commission may vote in favor of retaining *Arca antiquata* as the type species. I do not, however, think this possibility very strong, for the following reasons: First, I have stated the case to a number of prominent paleontologists throughout the world, several of whom are on the International Commission, and with one exception these persons have expressed an opinion in favor of *Arca noae* as type species. Second, Schumacher's designation of *Arca antiquata* is questionable. Schumacher says (Essai Nouv. Syst. Test., 1817, p. 172): « Pour le type du genre j'ai donné la fig. 2, Pl. XIX, de la charnière de l'Arca antiquata Lin. qu'on trouve figurée dans Chemn. 7, pag. 201. Tab. 55, fig. 548. » It is a debatable question whether Schumacher was here designating a type species or merely illustrating a type of hinge structure.

For these reasons, probably *Arca noae* will be accepted by the International Commission as the type species of *Arca*, as has been done in this paper. However, in the event that *A. antiquata*
should be accepted as the type, the following changes in nomenclature will have to be made: (1) the group called *Anadara* in this paper will become *Arca* s. s.; and (2) the group here called *Arca* s. s. will be called *Navicula*, a name which appears to be preoccupied by a diatom genus (14), as stated by Hanna (Nautilus, vol. 45, no. 4, 1932, pp. 118-120).

*Arca* s. s., in the sense that *A. noae* is the type species, has been common in Europe and North America since the Eocene; and at least one European Cretaceous species may be definitely assigned to it — *Arca dupini ana* d'Orbigny from the Lower Greensand (Arkell, Geol. Mag., London, vol. 67, no. 793, 1930, pl. 16, fig. 2). My recognition of *Arca* s. s. in the type Tejon formation, Eocene, of California, is important in that it records the earliest occurrence of this genus in western North America; it had previously not been known here in beds older than Oligocene, where it is represented by *A. washingtoniana* Dickerson (Proc. Calif. Acad. Sci., 4 ser., vol. 7, no. 6, 1917, p. 166, pl. 27, figs. 2 a-b), from southwestern Washington.

*Arca* is represented also in the Oligocene of Europe, for example by *Arca sandbergeri* Deshayes, var. *crassistria* von Koenen (Abh. zur geol. Spezialkarte von Preuss. und den Thüringischen Staaten, Bd. 10, Heft 5. König. Preuss. geol. Landes., Berlin, 1893, pp. 1081-1084, pl. 72, figs. 1-4); also by *Arca conformis* von Koenen (*op. cit.*, pp. 1084-1086, pl. 72, figs. 5-7) from the lower and middle Oligocene of Germany. Miocene and later occurrences are wide-spread and abundant. At the present time *Arca* s. s. is world-wide in distribution, in tropical and warm seas.

(14) With regard to the diatom genus *Navicula*, Dr. G. D. Hanna has shown me a photographic reproduction of Saint-Vincent's original diagnosis of that genus, which is as follows (Dict. Hist. Nat. Paris, vol. 2, 1822, p. 128):

« III. Navicule, *Navicula*, N (V. pl. de ce Dict., Bacillariées, fig. 3). Ce nom est emprunté de la forme des Animalcules auxquelles nous l'appliquons, et dont le corps ressemble à une navette de tisserand; ce corps linéaire, comprimé, au moins sur un côté, est aminci aux deux extrémités. Le *Vibrio tripunctatus* de Müller est le type de ce genre, dans lequel rentre l'*Echinella acuta* de Lyngbye, et l'Animalcule que Gaillon, observateur exact de Dieppe, a reconnu être la cause de ce qu'il appelle Viridité des Huitres. V. ce mot. »

Whether the diatom *Navicula* was proposed in a zoological or botanical sense depends upon the use of the word « animalcule », which in the early 19th century was used in either sense. Whether the diatom genus preoccupies the molluscan one, therefore, is a question which would have to be decided by the International Commission.
Subgenus LITHARCA Gray, 1842.


Arca lithodomus, the only species allocated to this subgenus, was considered by Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 615) to be probably based upon a deformed specimen of « Arca » candida Gmelin. On this same assumption, Gardner (U. S. Geol. Survey Prof. Paper 142-A, 1926, p. 26) rejected Litharca as a synonym of Plagiarca Conrad, a subgenus of Barbatia. However, Maury (Science, vol. 54, n° 1404, 1921, pp. 516-517) had previously brought out the fact that Arca lithodomus is a valid species, and later (Palaeont. Amer., vol. 1, n° 4, 1922, pp. 7-8, pl. 1, figs. 1, 3) assigned it to Litharca, where it belongs.

Although known from only one species, Litharca probably should be retained as a separate subgenus, as it is distinct from Arca s. s., and indeed even resembles Noetia somewhat in general form, as Maury noted. However, Maury’s description and illustrations (1922) show that A. lithodomus belongs to Arca s. s. and not to Noetia.

Subgenus ARCOPTERA Heilprin, 1887.


Although *Arcoptera* does not differ greatly from *Arca s. s.*, I nevertheless consider it sufficiently distinct to retain it as a subgenus of *Arca* instead of reducing it to synonymy, as was done by Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 614). The attenuated extremities of *Arcoptera* are distinctive; and a further difference is that the ligamental area is not flat, as in *Arca s. s.*, but V-shaped when viewed from the anterior end of the shell, with both valves joined. *Arcoptera* is known only from the one species.

Subgenus EONAVICULA Arkell, 1929.


In addition to the type species, Arkell included in *Eonavicula* such Cretaceous species as *Arca carteroni* d’Orbigny, figured by Woods (Monograph of Cretaceous Lamellibranchia, pt. 1, Palaeont. Soc., vol. 53, 1899, pl. 6, figs. 4, 5), differentiating these species from *Navicula* (= *Arca s. s.*) by the greater inclination (and consequently smaller number) of the teeth of *Eonavicula*. The separation of these Mesozoic species is often a difficult one to make, as some Tertiary species that unquestionably belong to *Arca s. s.* also have inclined teeth (15), and, as Arkell noted, some Cretaceous species, as *A. carteroni* d’Orbigny, are gradational between *Eonavicula* and *Navicula*. Specimens of *Arca quadrisulcata* (N° 47526 and 23374, British Museum of Natural History), placed at my disposal by L. R. Cox, appear externally very similar to *Arca s. s.* The hinge is not exposed in these specimens. One difference, however, is noticeable: in *A. quadrisulcata* the ligamental area (unfortunately not well preserved in my specimens) is considerably narrower than in typical *Arca*. This distinction may be added to the criterion of highly inclined teeth in differentiating *Eonavicula* from *Arca s. s.*

(15) For example: *Arca washingtoniana* Dickerson (Proc. Calif. Acad. Sci., 4 ser., vol. 7, n° 6, p. 166, pl. 27, fig. 2) from the Oligocene of Washington and Oregon; *Arca tetragona* Poli, as figured by Woods (Crag Mollusca, pt. 2, Bivalves; Palaeont. Soc., vol. 4, 1850, pl. 10, figs. 1a-d), from the Pliocene of England. Other examples are mentioned by Arkell, op. cit., p. 344.
The development of *Arca* s. s. ("Navicula") from *Eonavicula* as well as the possible ancestry of *Eonavicula* have been ably discussed by Arkell (Geol. Mag., London, vol. 67, no 794, 1930, pp. 342-352). He suggests that three species figured by King (16) from the Permian Magnesian Limestone are closely related to *Eonavicula*, although the dentition of these species is not clearly known.

**Genus BARBATIA** Gray, 1842.

**Subgenus Barbatia s. s.**


*Savignyarca savignyarca* was placed by Lamy (Jour. de Conch., vol. 55, no 1, 1907, p. 71) as a synonym of *Arca obliquata* Gray. Judging from Reeve’s figure of this species (Conch. Icon., vol. 2, 1844, *Arca*, pl. 12, fig. 80), *obliquata* seems to be a *Barbatia*, and *Savignyarca* is therefore tentatively regarded as a synonym of *Barbatia* (17), as it was by Thiele (Handbuch der Systematischen Weichtierkunde, 3 Teil, Jena, 1934, p. 792).


(16a) By typographical error, spelled "*Savignyarca savignyarca*" by Jousseaume.

(17) Reeve’s figure, however, does not show the hinge. The hinge of a Tertiary species from Java called *Arca obliquata* Gray has been illustrated by Martin (Foss. von Java: Samml. Geol. Reichs Mus. Leiden, Bd. 1, 2 Abt., Heft 2, 1910, pl. 51, figs. 81 a-b). This species strongly suggests *Obliquarca*, and if correctly identified indicates the possibility that a study of authentic specimens of *Savignyarca savignyarca* may show that the name *Obliquarca* must be replaced by the earlier-named *Savignyarca*. Such specimens have not yet been available to me.
Barbatia, sensu lato, is present in Jurassic beds of Europe, from which several species have been described. Of these, Barbatia gracilicostata (Favre) (Mém. Soc. Physique et d’Hist. Nat. de Genève, vol. 37, fasc. 4, 1913, pp. 404-405, pl. 18, figs. 4-6), from the lower Portlandian of France, is at least closely related to Barbatia and probably should be classified in this genus, although it may belong to a distinct subgenus. Arkell (Geol. Mag., London, vol. 67, n° 794, 1930, p. 349) points out a species of Barbatia from the Lower Liassic, B. pulla (Terquem) (Mém. Soc. Géol. France, 2 sér., vol. 5, 1855, p. 307, pl. 21, figs. 1a-b). He also refers to Triassic occurrences of Barbatia but mentions no species. Although such species may be assigned to Barbatia, I have not seen any and am therefore unable to offer any opinion.

It is doubtful if any of the Cretaceous species of Barbatia belong to the typical subgenus, although they may be closely related. Barbatia fractura Wade (U. S. Geol. Survey Prof. Paper 137, 1926, p. 46, pl. 10, figs. 9-11), from the Upper Cretaceous of Tennessee, belongs to the subgenus Cucullaea arc Conrad.

In the Eocene, species appeared which are unhesitatingly assigned to Barbatia s. s.; for example, B. rigaulti (Deshayes) from the Bartonian, lower upper Eocene, of the Paris Basin (Cossmann and Pissarro, Icon. Compl. des Coq. Foss. de l’Éoc. des Env. de Paris, vol. 1, 1904-1906, pl. 36, fig. 110-37).

There appear to be few records of Barbatia from Oligocene beds, but the Miocene to Recent occurrences are plentiful; at present the genus is widely distributed in all of the warm and temperate seas, and in number of described species it is exceeded only by Anadara.

Lissarca Smith (Transit of Venus Exp., Zoology, Mollusca, 1877, p. 19), which was thought by Dall to be related to Barbatia, has been placed in the Limopsidae by Suter (Man. New Zealand Moll., 1913, p. 854), where it probably belongs. The type species of Lissarca is « Arca » (Lissarca) rubro-fusca Smith (op. cit., p. 19, pl. 9, fig. 17), a Recent species from Kerguelen Island. The original description of this genus has been inaccessible to me, and I have seen no specimens of the type species. Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 616) grouped Lissarca as a section of Barbatia; Lamy (Jour. de Conch., vol. 55, n° 1, 1907, p. 9) placed Lissarca as a subgenus of Arca, but followed Dall in recognizing its relation to Barbatia; Lamy observed that it is distinguished from Barbatia by the sub-
terminal position of the beaks and the absence of radial sculpture. Only a few species have been assigned to *Lissarca*. Recent species have been reported from the Shetland Islands, New Zealand, Kerguelen Islands, and Tasmania. *Lissarca* has also been reported from the Tertiary of Victoria (18) and of New Zealand (19).

**Subgenus SOLDANIA** de Stefani and Pantanelli, 1878.


This subgenus, characterized by its obsolete radial sculpture and by the extremely wide, edentulous gap in the hinge, has been reported, to my knowledge, only from the Pliocene of Europe. On a specimen in the Stanford University paleontological type collection (n° 5332) the posterior teeth are granular and quite irregular whereas the front teeth, although small, are fairly regular.

**Subgenus CALLOARCA** Gray, 1857.


« *Byssoarca* » *alternata* has been well figured in exterior view by Maury (Palaeont. Amer., vol. 1, n° 4, 1922, pl. 2, fig. 11). The hinge of this species is similar to that of *Barbatia* (*Calloarca* *leonensis* Mansfield (Florida State Geol. Survey, Bull. 8, 1932, pp. 42-43, pl. 5, figs. 1, 3, 5) from the Miocene of Florida. Examination of specimens of « *Byssoarca* » *alternata* has convinced me that *Calloarca* should be retained as a subgenus of

Barbatia and not reduced to a synonym of Acar as was done by Gardner (U. S. Geol. Survey Prof. Paper 142-A, 1926, p. 26), because, as Mansfield has pointed out (op. cit., p. 43), "B alternata has a different type of sculpture from Acar, and an edentulous gap in the hinge. It also lacks the elevated muscle scars of Acar.

In addition to "B alternata, the type species, and Barbatia leonensis Mansfield, Calloarca includes Barbatia «(Cucullaria)» taeniata Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 631, pl. 25, figs. 1, 1a) from the Pliocene of Florida, and Barbatia (Calloarca) phalacra Dall (op. cit., p. 626, pl. 33, fig. 3) from the Chipola formation, Miocene, of Florida. «Byssocoroc» lurida Sowerby (Proc. Zool. Soc. London, pt. 1, 1833, p. 19), a Recent species originally described from Ecuador, belongs to Calloarca, although it resembles the type less than the other species mentioned.

The name Calloarca was used incorrectly by Dall (1898) and by several subsequent workers to refer to species which actually belong to the subgenus Cucullaearea Conrad; some details of this usage are given under the discussion of Cucullaearea.

Calloarca resembles Acar Gray in that the ligamental area is wide in front and tapers to a point in the rear; a further resemblance is that the ligamental area is mainly, though not entirely, confined to the posterior of the beaks. However, Calloarca differs from Acar, as stated, by lacking reticulate sculpture and elevated muscle scars and by the edentulous gap in the hinge.

Subgenus ACAR Gray, 1857 (20).

Pl. II, figs. f, f'.


(20) Daphnoderma (Poli) Mörch (Catalogus Conchyliorum quae reliquit D. Alphonsa d'Aguiarra & Gadea Comes de Yoldi, Fasc. 2, 1853, p. 40) antedates Acar Gray, and may have to replace it. Inasmuch as I have not seen Poli's work, this question is here left open. Mörch includes two species in Daphnoderma: Area domingensis Lamarck and A. angulata Meusch, both of which belong to the group called Acar.
Bartsch (Proc. U. S. Nat. Mus., vol. 80, Art. 9, 1931, pl. 1, five top figures).

_Acar_ has existed from Danian (Upper Cretaceous or Paleocene) to the present time; today it is world-wide in distribution, in warm seas. Apparently the oldest reported species is _Barbatia (Acar) forchhammeri_ (Lundgren), which is listed from the Danian of Faxe, Denmark (Ravn, Mém. de l'Acad. Roy. des Sci. et des Lettres de Danemark, Sect. des Sci., 9 sér., t. 5, no 2, 1933, pp. 12-13). Another early species is « Arca » (Acar) _lamellosa_ Deshayes (Cossmann and Pissarro, Icon. Compl. des Coq. Foss. de l'Eoc. des Env. de Paris, vol. 1, 1904-1906, pl. 35, figs. 110-5), from the Thanetian, Lutetian, and Bartonian of the Paris Basin. _Acar_ was also living in southeastern United States during later Eocene, as Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 629) reports _Barbatia (Acar) reticulata_ (Gmelin) from the Jacksonian Eocene at Jackson, Mississippi. In the Oligocene _Acar_ is represented by « Arca » _lamellosa_ Deshayes, var.? (von Koenen, Abh. zur geol. Specialkarte von Preuss. und den Thuringischen Staaten, Bd. 10, Heft 5. König. Preuss. geol. Landes., Berlin, 1893, pp. 1086-1088, pl. 72, figs. 8-10) from Germany. This subgenus is also present in the so-called Oligocene of Washington, where an undescribed species is found in the Gries Ranch beds. The Miocene, Pliocene, and Pleistocene occurrences of this subgenus are fairly common, corresponding in general with its present distribution.

Bartsch may be correct in his proposal (Proc. U. S. Nat. Mus., vol. 80, Art. 9, 1931, p. 1) to elevate _Acar_ to generic rank; but for the present, in order to emphasize its similarity to _Barbatia_, it is retained here as a subgenus of _Barbatia_.

_Acar_ is distinguished by its reticulate sculpture, compact, quadrilateral form, raised muscle scars, and by its ligament being mainly restricted to the posterior of the umbones, resembling _Obliquarca_ in this last respect.

Subgenus _OBLIQUARCA_ Sacco, 1898.

Pl. II, figs. d, d'.

_Obliquarca_ Sacco, I Molluschi dei Terreni Terziarii del Piemonte e della Liguria, pt. 26, 1898, p. 16; type species (by original designation) : _Arca modioliformis_ Deshayes (Descrip. des Coq. Foss. de Paris, vol. 1, 1831, p. 214, pl. 32, figs. 5, 6) from the Eocene of the Paris Basin.
"Arca" modioliformis was figured by Cossmann and Pissarro (Icon. Compl. des Coq. Foss. de l'Éoc. des Env. de Paris, vol. 1, 1904-1906, pl. 36, figs. 110-38). These figures, together with the description of Deshayes (Anim. sans Vert., Bas. Paris, vol. 1, 1860, pp. 896-897), show that the most striking feature about the species is that the ligamental area is restricted to the part of the dorsal margin posterior to the umbo. This feature has been observed also on specimens of this species in the Schenck Collection, Stanford University (n° 857). The ligamental grooves, which are clearly visible on the posterior part of the dorsal margin, stop on reaching the umbo, and the anterior dorsal margin is perfectly smooth and flat. In this respect Obliquarca is similar to Porterius Clark (Univ. Calif. Pub. Bull. Dept. Geol. Sci., vol. 15, n° 4, 1925, p. 79) which differs, however, in that the posterior teeth of Porterius are arranged horizontally, whereas those of Obliquarca are set obliquely, as in Barbatia.

Obliquarca is well represented in the Eocene by several species in addition to the type; for example, the following: Barbatia marceauxi (Deshayes), B. striatularis (Deshayes), B. distans (Deshayes) (21) from the Paris Basin, and by B. morsei Gabb from the Domengine formation, Eocene, of California. Obliquarca is also probably represented in the Oligocene of north Germany, as "Arca" decussata Nyst (von Koenen, Abh. zur geol. Specialkarte von Preuss. und den Thüringischen Staaten, Bd. 10, Heft 5. König. Preuss. geol. Landes., Berlin, 1893, pp. 1104-1107, pl. 70, figs. 11-14) appears to be close to Obliquarca, although it may belong to Porterius. Von Koenen's fig. 14b, showing a small specimen, especially resembles Porterius.

Obliquarca was recognized in the Miocene of Jamaica by Woodring (Carn. Inst. Washington, Pub. 366, 1925, pp. 38-40), who described three species from Bowden. Although these species belong to Obliquarca, they differ from the type by lacking the central nearly edentulous gap in the hinge.

That Obliquarca or at least a closely related group is present in the Recent fauna is shown by specimens in the Oldroyd Collection, Stanford University (n° 360, labelled "Arca barbata Linné"), from Key West, Florida. The hinge on these Recent specimens is similar to that of Barbatia modioliformis (Deshayes), and the ligament is present only posterior to the umbones. B. modioliformis differs mainly by having its umbones

(21) These species are figured by Cossmann and Pissarro, op. cit., pl. 36.
placed slightly more anteriorly than are those of the Recent species. Sheldon (Palaeont. Amer., vol. 1, n° 1, 1917, pl. 2, figs. 5-7) has figured the same species as « Arca barbata Linné », her figure 7 showing the arrangement of the ligament. Although I do not know the name of this species, it is clearly not Barbatia barbata (Linné). It is probably a variety of Barbatia fusca (Bruguière) (Dict. Ency. Méth., 1, 1792, p. 102, n° 10).

In addition, Barbatia alfredensis Bartsch (U. S. Nat. Mus. Bull. 91, 1915, p. 182, pl. 46, figs. 9, 10), a Recent species from South Africa, seems to be related to Obliquarca. Judging from Bartsch’s fig. 10, the ligament is confined to the posterior of the beaks, and this species resembles Obliquarca in other respects, except that the beaks are not placed so far anteriorly as in the type species.

Subgenus CUCULLAEARCA Conrad, 1865.

Pl. II, fig. e.


« Lithoarca Gray ». Mörch, Catalogus Conchyliorum quae reliquit D. Alphonso d’Aguirra & Gadea, Comes de Yoldi. Fasc. 2, 1853, p. 40; several species listed, including Arca velata Sowerby. (Not Lithoarca Gray, 1842.)


Dall (1898, p. 624) considered « Byssarrowa » lima Conrad, the type species of Cucullaearea, to be a synonym of the Eocene « Arca » cuculloides Conrad, which has been figured by Sheldon (Palaeont. Amer., vol. 1, n° 1, 1917, pl. 2, figs. 8-12); I have compared Sheldon's figures with the original figure of « Arca » lima, and whether the two are conspecific or not, they are very similar.

Stoliczka (Palaeont. Indica, vol. 3, 1871, p. 340) pointed out the similarity of Cucullaearea to Barbatia of the B. velata type, but did not see the distinction from true Barbatia. Cucullaearea, however, comprises a clearly recognizable group, characterized by a large byssal gape, a wide, grooved ligamental area which usually separates the anterior teeth widely from the posterior ones, a widened posterior end, and a fairly heavy shell. Although Dall recognized this group as distinct from Barbatia s. s., he incorrectly referred to it under the name « Calloarca — the group of Arca candida Gmelin ». Actually, however, « Arca » candida belongs to Cucullaearea, not to Calloarca, the type species of which is Byssarrowa alternata Sowerby, 1833. This misconception as to the type species of Calloarca has been the cause of the erroneous suppression of Cucullaearea and the incorrect use of the name Calloarca. It is thus seen that Cucullaearea includes most of the species called Calloarca by Dall (1898) and Maury (Palaeont. Amer., vol. 1, n° 4, 1922, pp. 13-18).

Polynema Conrad is based upon Barbatia lintea Conrad, which has been well figured by Stephenson (North Carolina Geol. and Econ. Survey, vol. 5, pt. 1, 1923, pl. 21, figs. 6-10). His figs. 7 and 8 show a mature specimen which does not differ in important respects from the type species of Cucullaearea, and I consequently see no basis for recognizing Polynema as distinct. Furthermore, the name Polynema is preoccupied.

Cucullaearea is represented in the upper Cretaceous by several species, including Barbatia fractura Wade (U. S. Geol. Survey Prof. Paper 137, 1926, p. 46, pl. 10, figs. 9-11) from the Ripley formation of Coon Creek, Tennessee. It is represented in the Eocene by numerous species, such as Barbatia cliffensis Hanna (Univ. Calif. Pub. Bull. Dept. Geol. Sci., vol. 16, n° 8, 1927, p. 272, pl. 26, figs. 1-6) from the upper middle Eocene of California; and Barbatia morlieri (Deshayes) (Cossmann and Pissarro, Icon. Compl. des Coq. Foss. de l'Éoc. des Env. de Paris, vol. 1, 1904-1906, pl. 35, fig. 110-8) from the upper Eocene of the Paris Basin. Cucullaearea occurs in the Oligocene, as in addition
to the type species, « Byssocra » lima from the Vicksburgian Oligocene, it includes « Arca » rustica von Koenen (Abh. zur geol. Speciaalkarte von Preuss, und den Thüringischen Staaten, Bd. 10, Heft 5. König. Preuss. geol. Landes., Berlin, 1893, pp. 1088-1090, pl. 71, figs. 1-3) from the lower Oligocene of Lattorf, Germany. This species was renamed Arca kokeni by von Koenen (op. cit., Bd. 10, Heft 7, 1894, pp. 1416-1417).

At the present time Cucullarca is widely distributed in warm seas, a characteristic example being Barbatia velata (Sowerby) (Proc. Zool. Soc. London, pt. 1, 1833, p. 18), a Recent species originally described from the Lord Hood and Chain Islands, north of Australia.

Subgenus GRANOARCA Conrad, 1862.


Pectinarca Sacco, I Molluschi dei Terreni Terziarii del Piemonte e della Liguria, pt. 26, 1898, p. 26; type species (by original designation): Arca pectinata Brocchi (Conchologia Fossile Subapennina, vol. 2, 1811, pp. 176-177, pl. 10, figs. 15 a-b) from the Pliocene of Italy; also figured by Sacco, op. cit., pl. 5, figs. 22-25.

Because of its Barbatia-like form and byssal gape — which, although slight, is nevertheless present — Granoarca has in the past always been grouped as a subdivision of Barbatia (22) where it appears to belong, although in dentition, external sculpture, and thickness of shell it is similar to Anadara, as shown by plesiotypes 5354-5356 in the Stanford University paleontological type collection. No matter with which group it is classified, Granoarca seems to represent, as stated by Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 628), an intermediate form between Barbatia and Anadara.

Mansfield includes in *Granoarca, Barbatia (Granoarca) propatula*, var. *busana* Harris (Mansfield, Florida State Geol. Survey, Bull. 8, 1932, p. 44, pl. 3, figs. 2, 4, 6) from the upper Miocene of Florida, and *Arca campyla* Dall (op. cit., pp. 644-645, pl. 31, figs. 3-4; pl. 32, fig. 22) from the Pliocene of Florida, but the last species does not seem very close to the type.

*Pectinatarca* Sacco has for its type species *Arca* *pectinata* Brocchi from the Pliocene of Italy. Through the courtesy of L. R. Cox a specimen of this species has been available to me. Judging from this specimen as well as from the figures of Sacco and Brocchi, there can be little doubt that *Arca* *pectinata* belongs to the same group as *Barbatia (Granoarca) propatula*; the Italian species is similar in form and ornamentation, and has the small byssal gape characteristic of *Granoarca*, although Cossmann and Peyrot (Conch. néogénique de l'Aquitaine, vol. 2, 1912, p. 141) state, in regard to this last point: "vraisemblablement pas de byssus à cause de la régularité de la coquille". However, the byssal gape of *Barbatia propatula* is also difficult to detect, and the shell likewise appears fairly regular. A careful examination leaves little doubt as to the presence of a byssal gape on both *B. propatula* and *B. pectinata*.

**Subgenus PUGILARCA Marwick, 1928.**


Although proposed as a subgenus of *Barbatia*, *Pugilarca* appears to be closer to *Acar*, resembling it in general form, sculpture, and character of ligamental area. The hinge of *Pugilarca* differs in lacking central teeth, whereas in *Acar* there is usually little, if any, interruption in the dentition. Marwick's mention (p. 441) of the smooth valve-margins of *Pugilarca* carries very little weight, however, because in some specimens of *Barbatia (Acar) gradata* (Broderip and Sowerby) the valve-margins are also smooth, not crenulated. One point of uncertainty is the adductor muscle scars. Marwick does not state whether or not *Barbatia barneaformis* has the raised muscle scars which characterize *Acar*, and his figures do not settle this question.
Subgenus PLAGIARCA Conrad, 1875.


The type species of this subgenus has been well illustrated by Stephenson (North Carolina Geol. and Econ. Survey, vol. 5, pt. 1, 1923, pl. 22, figs. 1-6). *Plagiarea* seems to be close to *Barbatia s. s.* but has heavier radial ribs, in this respect approaching *Anadara*. « *Arca* » rhomboidea Lea (23) and « *A. » vaughani Casey, as figured by Sheldon (Palaeont. Amer., vol. 1, no 1, 1917, pl. 7, figs. 7, 8, 11), from the Claiborne Eocene of Alabama, somewhat resemble *Plagiarea* and appear to belong to this subgenus, as does the upper Cretaceous species *Arca menairyensis* Wade (U. S. Geol. Survey Prof. Paper 137, 1926, p. 46, pl. 10, figs. 3, 6). *Plagiarea* thus appears to range from Upper Cretaceous to Upper Eocene.

Gardner (U. S. Geol. Survey Prof. Paper 142-A, 1926, p. 26), due to a misconception, regarded *Plagiarea* as being equivalent to *Litharca* Gray, as I have stated under the discussion of *Litharca*. *Barbatia marylandica* Conrad and *B. phalacra* Dall, of the Floridan Miocene, cannot be included in *Plagiarea* as was done by Gardner (*loc. cit.*). *B. marylandica* belongs to *Cucullaea* *Arca* Conrad, and *B. phalacra* to *Calloarca* Gray.

Genus ARCOPSIS von Koenen, 1885.

Subgenus ARCOPSIS s. s.

*Pl. III., figs. g, g'.


(24) Von Koenen evidently proposed *Arcopsis* for his new species, *Arca limopsis*, but he did not designate a type. His inclusion of *Arca lactea* Linné in *Arcopsis* makes the present type designation necessary.
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pp. 85-86, pl. 4, figs. 12 a-e) from the Paleocene of Copenhagen.


It is unfortunate that the well-known name _Fossularca_ must be replaced by _Arcopsis_ which, due probably to the obscure way in which it was proposed, has been almost entirely overlooked. Vincent, however (Mém. du Mus. Roy. d’Hist. Nat. de Belgique, Mém. 46, 1930, p. 71), has shown _Arcopsis_ to have priority. A comparison of the type species of _Arcopsis_ with that of _Fossularca_ leaves no doubt that this conclusion is correct.

Stephenson (North Carolina Geol. and Econ. Survey, vol. 5, pt. 1, 1923, p. 109) suggested that _Fossularca_ was probably to be considered a synonym of _Striarcia_ Conrad, this suggestion being based upon a certain similarity between the type species of _Striarcia_ and « _Fossularca_ » _adamsi_ (Smith), which he mistakenly regarded as the type of _Fossularca_. However, « _Fossularca_ » _adamsi_ (which has been well figured by Gardner, U. S. Geol. Survey Prof. Paper 142-A, 1926, pl. 5, figs. 1-4), although superficially similar, nevertheless appears to me distinct from the type species of _Striarcia_. « _F. » adamsi_ possesses the small, triangular ligamental pit and the dentition interrupted in the center, characteristic of _Arcopsis_ (= « _Fossularca_ »), and should therefore be retained in the genus _Arcopsis_. In _Striarcia_ the ligamental area is comparatively large and transversely striated.

The oldest occurrence of _Arcopsis_ seems to be that reported by Ravn who described two species from the Danian of Faxe, Denmark; at least one of these species, « _Barbatia_ » (Arcopsis) _brünnichi_ Ravn, is a true _Arcopsis_ (Ravn, Mém. de l’Acad. des Sci. et des Lettres de Danemark, Sect. des Sci., 9 sér., t. 5, n° 2, 1933, pp. 13-14, pl. 1, figs. 3 a-b, 4 a-b). For reasons given in an earlier paper this author assigns the Danian to the Upper Cretaceous, rather than to the Eocene (Ravn, Mus. de Minéral. et Géol. de l’Univ. de Copenhague, Communications géol., n° 5.

(25) The explanation of plate 19 appears on p. 238, incorrectly labelled « Dix-septième planche ».
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1925). If this assignment proves to be correct, the geologic range of *Arcopsis* is Upper Cretaceous to Recent.

*Arcopsis* is known most abundantly from the Eocene, being recognized in the United States, France, and New Zealand (26); it is also present in the Oligocene of Germany (27). The later species of *Arcopsis* include *Arcopsis adamsi* (Smith) which has existed in the West Indies and southeastern United States from Miocene to Recent, and *Arcopsis solida* (Sowerby) (Proc. Zool. Soc. London, pt. 1, 1833, p. 18) from tropical western America.

*Ovalarca* Woodring (Carn. Inst. Washington, Pub. 366, 1925, p. 52), the type species of which is "*Arca* ovalina" Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 630., pl. 32, fig. 18), from the Miocene of Bowden, Jamaica, was proposed as a subgenus of *Fossularca*; *Ovalarca*, however, seems more properly to belong to the family Limopsidae.

Subgenus SCAPULARCA Cossmann and Peyrot, 1912.


This subgenus includes several species from the Eocene of France, but I have not seen it reported from elsewhere. *Scapularca* resembles *Arcopsis* in dentition and ligamental area, but differs in being more inequilateral in shape and in possessing stronger radial ribs. Specimens of *Arcopsis* (*Scapularca*) globosa (Deshayes), nos 854 and 862 in the Schenck collection at Stanford University, show, on both valves, a small raised flange bordering each muscle scar, just behind the anterior scar and in front of the posterior scar. Similar flanges are likewise present

(26) "*Fossularca* januvaria" Marwick (Trans. Proc. New Zealand Inst., vol. 56, 1926, pp. 310-311, pl. 72, figs. 1, 5) from the Waiarekan stage of the Oamaru Series, the age of which is stated to be either upper Eocene or Oligocene.


(28) The explanation of plate 18 appears on pp. 237-238, incorrectly labelled "Seizième planche".
on three species of *Arcopsis s. s.* in the Stanford University collections, but do not seem to be developed on the type species. *Scapularca* was considered a subgenus of *Trigonodesma* (one of the Noetiinae) by Gilibert (Mus. Roy. d’Hist. Nat. de Belgique, Mém. 53, 1933, p. 123). Because of its closer resemblance to *Arcopsis* in many respects, however, *Scapularca* is here retained under *Arcopsis*.

*Arcopsis scapulina* and other species of *Scapularca* were called *Anadara* by Cossmann and Pissarro (Icon. Compl. des Coq. Foss. de l’Èoc. des Env. de Paris, vol. 1, 1904-1906, pl. 36, figs. 110-45 to 110-48).

Genus STRIARCA Conrad, 1862.


*Galactella* Cossmann and Peyrot, Conch. néogénique de l’Aquitaine, Tome 2, 1912, p. 192; type species (by original designation): *Arca lactea* Linné (Syst. Nat., ed. 10, 1758, p. 694), a Recent species, the type locality of which is the Mediterranean Sea. Figured by Bucquoy, Dautzenberg, and Dollfus (Mollusques Marins du Roussillon, tome 2, Pelecypoda, Fascicule 5, 1891, pl. 37, figs. 1-5).

The type species of *Breviarca* has been well figured by Wade (U. S. Geol. Survey Prof. Paper 137, 1926, pl. 10, fig. 14, pl. 11, figs. 1, 2). The similarity between *Striarca* and *Breviarca* was pointed out by Gardner in Stephenson (North Carolina Geol. and Econ. Survey, vol. 5, pt. 1, 1923, p.109). A comparison of « *Arca* centenaria » and « *Trigonarca* saffordi » leads me also to the conclusion that these two species are congeneric, as they were considered by Stephenson.
A comparison of « Fossularca (Galactella) lactea (Linné) (29) (the type species of Galactella) with Striarca centenaria shows such a striking similarity between the two that Galactella, which had been proposed as a subgenus of Fossularca, is here regarded as a synonym of Striarca, which it more closely resembles.

In addition to its distinctive form, Striarca is characterized by a raised flange bordering the inner side of both the anterior and posterior adductor muscle scars. Its geologic range seems to be Upper Cretaceous to Recent.

Genus BATHYARCA Kobelt, 1891.

Subgenus BATHYARCA s. s.

Pl. III, fig. h.


The synonymy and distribution of Bathyarca pectunculoides (Scacchi) are given by Lamy (Jour. de Conch., vol. 55, n° 3, 1907, pp. 278-281). This species has been reported from European waters, from the Mediterranean to as far north as Norway, often living in deep water. Other species which have been referred to Bathyarca are given by Verrill and Bush (Proc. U. S. Nat. Mus., vol. 20, n° 1139, 1898, pp. 842-843); these increase the distribution of this genus to world-wide extent, but a critical study of these species would be necessary in order to determine how many actually should be grouped as Bathyarca. For example, « Arca » glacialis Gray (Parry's First Voyage, Supp. to App., 1824, p. 244), though related, can hardly be a typical Bathyarca as it differs in important respects from B. pectunculoides.

Although Dall reported this genus from the Eocene (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 619) he did not mention any species, and I have not found a definite record of Bathyarca from strata older than Oligocene. Bathyarca is repre-

(29) Syst. Nat., ed. 10, 1758, p. 694. Specimens of this species are in the Oldroyd Collection, Stanford University, n° 355.
sent in the lower Oligocene of Germany by « Arca » saxonica von Koenen (Abh. zur geol. Spezialkarte von Preuss. und den Thüringischen Staaten, Bd. 10, Heft 5. König. Preuss. geol. Landes., Berlin, 1893, pp. 1107-1109, pl. 73, figs. 9-12). In addition, Bathyarca hendersoni (Dall) (op. cit., p. 653, pl. 33, fig. 9), which was also figured by Woodring (Carn. Inst. Washington, Pub. 366, 1925, pl. 6, figs. 1-3), from the Miocene of Bowden, Jamaica, appears to be a true Bathyarca.

Subgenus BENTHARCA Verrill and Bush, 1898.

Bentharca Verrill and Bush, Proc. U. S. Nat. Mus., vol. 20, n° 1139, 1898, p. 842, footnote; type species (by original designation) : Macrodon asperula Dall (Bull. Mus. Comp. Zool., Harvard College, vol. 9, 1881, pp. 120-121; op. cit., vol. 12, 1885-1886, pp. 244-245, pl. 8, figs. 4, 4a), a Recent species from the Gulf of Mexico.


Bentharca appears clearly to be related to Bathyarca, differing in being more inequilateral, and in having horizontal posterior teeth and short, transverse anterior ones. The type species is from the Gulf of Mexico and the West Indies, living in deep water (1000 to 1500 fathoms). « Arca (Macrodon) » dalli Smith (Rep. H. M. S. Challenger, Zool., vol. 13, 1885, p. 269, pl. 17, figs. 10-10h), from a depth of 50 fathoms, off Kobe, Japan, may belong to Bentharca (30), but it is not very similar to the type species. I have not seen Bentharca reported as a fossil.

(30) This species was recently assigned to Pseudogrammatodon Arkell (Geol. Mag., London, vol. 67, n° 793, 1930, p. 307), the type species of which is the Eocene Arca adversidentata Deshayes. This assignment, however, appears questionable.
Subgenus MICROCUCCULAEA Iredale, 1929.


Topotypes n° 1505, Oldroyd Collection at Stanford University, show the small flanges, one just in front of the posterior muscle scar and one behind the anterior scar, which separate this group from Bathyarca and which probably are the basis for Iredale’s conjecture (loc. cit.) that Microcucullaea is a dwarfed relative of Cucullaea. This conjecture is extremely interesting, but for the present, due to its close resemblance to Bathyarca, Microcucullaea is placed as a subgenus of Bathyarca.

Only two species of Microcucullaea are definitely known to me: the type and B. (M.) adelaidiana (Iredale) (loc. cit.), both from southern Australia. Depths reported for these species range from 40 to 100 fathoms. Marwick (Geol. Survey New Zealand, Pal. Bull. 13, 1931, pp. 56-57, pl. 3, figs. 36-37) describes two species (Microcucullaea pectinata and M. crenulifera) from the Tertiary of New Zealand, but inasmuch as the hinge and interior of his specimens are not preserved, it appears impossible to refer them with any certainty to Microcucullaea, although they seem to belong to the genus Bathyarca.

Genus TRISIDOS Bolten, 1798.


Parallelepipedum (Klein) Mörch, Catalogus Conchylidorum quae reliquit D. Alphonso d’Aguirra & Gadea Comes de Yoldi, Fasc. 2, 1853, p. 40. Several species listed, including Arca semitorta Lamarck.
Arca tortuosa was designated the type species of Arca by Children in 1823 (Lamarck's Genera of Shells, p. 46), as was noticed by Cox (Paleont. Zanzibar, 1927, p. 93). This peculiarly twisted species of Arca was accordingly considered the type of the genus until 1930 when Stewart (Acad. Nat. Sci. Philadelphia, Special Pub. 3, p. 83) pointed out that in 1817 Arca antiquata Linné had been designated the type of Arca by Schumacher (Essai Nouv. Syst. Test., 1817, p. 172), and that in 1818 Arca noae had been so designated by Schmidt (Versuch. Conch.-Samml., 1818, pp. 65, 178), both of these designations antedating that of Children.

Trisidos has been reported from the upper Eocene of Egypt (31) and from the « Nummulitic group » of India (32). It has also been reported from the Oligocene of Italy (33) and Hungary (34), and from the Miocene of southern France (35) and Burma (36).

An outline of some of the fossil species of Trisidos is given by Sacco (1898, p. 27; see footnote 33 for reference). The Recent species of Trisidos are restricted to the Red Sea, the Indian Ocean, and the China Sea.

A useful paper on Trisidos is the recent one by Makiyama (Venus, vol. 2, n° 6, 1931, pp. 269-277), in which he describes a new species, « Arca » kiyonoi, and summarizes a good deal of information on Trisidos. Examination of Stanford University paratype n° 5548 of this new species shows it to be fairly close to the type of the genus Trisidos. It should be mentioned that Makiyama followed Children’s designation of Arca tortuosa as

(33) Arca (Parallelepipedum) isseli Rov., Stefanini, Atti dell'Accademia Scientifica Veneto-Trentino-Istriana, anno VIII (1915), p. 9, pl. 5, fig. 3 (an inadequate illustration of a poorly-preserved specimen).
Parallelepipedum kurracheense, var. italica Sacco (I Molluschi dei Terreni Terziarii del Piemonte e della Liguria, pt. 26, 1898, p. 27, pl. 6, fig. 6), from the Tongrian, is a true Trisidos.
(34) Parallelepipedum schafurziki Ferenc and Horusitzky, Földrazi Közlemények, Budapest, 57, 1927, pp. 63, 144.
(35) Davies reports (Proc. Geologists’ Assn., vol. 40, 1929, p. 322) that a « Parallelepipedum » was described by Myer-Eymar from the Vindobonian (middle Miocene) of southern France.
type of *Area*, and therefore incorrectly considered *Trisidos* a synonym of *Area s. s.*

**Genus SCAPHULA Benson, 1834.**


The few known species of this unusual littic genus inhabit the rivers of Burma, Siam, and India. *Scaphula* seems not to be restricted to fresh water, however, as Stoliczka (Palaeont. Indica, vol. 3, 1871, p. 333) says: «Scaphula, which is generally quoted as a mere fresh-water inhabitant, seems quite as common, if not more common, in the brackish waters of the delta of the Irawadi, as where it occurs in the Ganges near Monghyr, (see Blanford, Jour. As. Soc., Bengal, XXXVI, pt. II, p. 70). »

Apparently no *Scaphula* has ever been identified with certainty as a fossil, although a few fossil species such as the two mentioned below have been assigned to this genus.

« *Barbatia (Scaphula?)* » austeni (Forbes) (Woods, Monograph of Cretaceous Lamellibranchia, pt. 1, Palaeont. Soc., vol. 53, 1899, pp. 37-38, pl. 7, figs. 1-3), from the Cretaceous of England, has radial striations and a well-developed ligamental area which distinguish it from *Scaphula*, although it somewhat resembles this genus in form. Judging from a specimen of this species from Atherfield, England (No. L. 16283, British Museum of Natural History), loaned by L. R. Cox, it appears to be an unusually high, strongly carinated species of *Eonavicula*.

« *Arca (Scaphula)* » convergidens Gerhardt (Neues Jahrb. für Min., B. Bd., vol. 11, 1897, p. 98, pl. 2, figs. 5 a-c) from the Cretaceous of northern South America, appears to resemble *Cucullacea*, rather than *Scaphula*.

**Subfamily ANADARINAE Reinhart, n. subfam.**

Ventral margin closed, byssal gape lacking; sculpture consisting of large, regular radial ribs, sculptured with grooves or nodes in most species; surface of shell regularly rounded; liga-
mental area narrow to moderately wide, flat to widely V-shaped when viewed in cross section (with both valves joined); hinge straight or gently arched; teeth regularly diminishing in size from extremities to center, but usually not completely lacking in the center. Inner margin of shell crenulated; beaks never opisthogyrate, pointing either inward or forward. Type genus: Anadara Gray, based upon Arca antiquata Linné.

Geologic range: Cretaceous to Recent.

Genus ANADARA Gray, 1847.

Subgenus Anadara s. s.

Pl. III, figs. 1, 1'.


Anomalocardia (Klein, 1753) H. & A. Adams, Genera of Recent Moll., vol. 2, 1858, pp. 535-536; type species not designated; Arca antiquata Linné cited as an example.


Anomalocardia Mörch is not subgenerically distinguishable from Anadara. Rasia was noticed by Stewart (Acad. Nat. Sci. Philadelphia, Special Pub. 3, 1930, p. 86) for the first time, apparently, since it was proposed. It may later prove desirable to recognize this group, but at present it seems to differ from Anadara by specific — not by subgeneric — distinctions.

Diluvarca has been discussed at length by Grant and Gale (San Diego Soc. Nat. Hist., Mem. vol. 1, 1931, pp. 137-138) who correctly considered it a synonym of Anadara, not a subgenus of Barbatia as it was first used by Woodring (1925). In 1928 Woodring (Carn. Inst. Washington, Pub. 385, p. 18, footnote) had arrived at the same conclusion later reached by Grant and Gale regarding Diluvarca, recognizing that it should be suppressed as a synonym of Anadara. Arca diluvii Lamarck, the type species of Diluvarca, has been figured by Bucquoy, Dautzenberg, and Dollfus (Mollusques Marins du Roussillon, vol. 2, Pelecypoda, Fascicule 5, 1891, pl. 31, figs. 13-17).

The range of Anadara s. s. is Oligocene to Recent. This group has been, since the Miocene, one of the most abundant of the Arcidae, occurring in all the warm seas of the world. Its detailed record in the Oligocene is not clear, due to the uncertainty of the Oligocene-Miocene boundary in most parts of the world, but it is represented in the Oligocene of Europe (38) and in the so-called Oligocene of North and South America. «Arca»

(37) Von Ihering has described a species of Anadara (« Arca » camaronensis) from Patagonia, occurring in beds which he assigned to the lower Eocene (Ann. Museo Nacional de Buenos Aires, ser. 3, vol. 7, 1907, p. 238, text figs. 9 a-b). The age of the «Patagonian formation» has long been in dispute, but it is now generally regarded as Oligocene or Miocene (Davies, «Tertiary Faunas», 1934, pp. 184-185).

(38) «Arca » sulcicosta Nyst (von Koenen, Abh. zur geol. Spezialkarte von Preuss. und den Thüringischen Staaten, Bd. 10, Heft 5. König. Preuss. geol. Landesa., Berlin, 1893, pp. 1097-1100, pl. 70, figs. 1 a-b, 2 a-c) from the Oligocene of Lattorf, Germany, is a true Anadara; also «Arca » sulcicosta, var. camerata von Koenen (op. cit., pp. 1097-1100, pl. 70, figs. 3 a-c, 4 a-c) from the same locality. A topotype of «A. » sulcicosta is in the Schenck collection at Stanford University (n° 856).

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granulosa Deshayes was referred to Anadara by Cossmann and Pissarro (Icon. Compl. des Coq. Foss. de l’Èoc. des Env. de Paris, vol. 1, 1904-1906, pl. 36, figs. 110-45). This species, from the Lutetian, Eocene, of the Paris Basin, is represented by specimens in the Schenck collection at Stanford University (nº 865). Examination of these specimens shows that « Arca » granulosa is a small, somewhat elongate species of Argina, shown both by the arrangement of the teeth, and by the ligament, which is narrow and confined to the posterior of the beaks.

My reasons for not accepting Arca antiquata as the type species of Arca s. s., as has recently been done (40), are given under the discussion of Arca s. s. See Addendum, p. 54.

Subgenus LARKINIA Reinhart, n. subgen.

Pl. IV, fig. 1.

Type species: Anadara larkinii (Nelson) (Olsson, Bull. Amer. Paleo., vol. 19, 1932, pp. 75-76, pl. 2, figs. 1, 4, 5) from the Tumbes formation, Miocene, of Peru.

This subgenus is proposed as a substitute for the incorrect use of the name Senilia as recently applied to several South American species (41), and as applied previously to Anadara grandis (Broderip and Sowerby). A. grandis was placed in Senilia by Lamy (Jour. de Conch., vol. 55, nº 3, 1907, p. 262) as well as by some subsequent workers; and indeed this species does somewhat resemble « Arca » senilis Linné, the type of Senilia, although it lacks the extremely prosogyrate beaks of Senilia and differs in other respects. However, if A. grandis were considered a Senilia, it would be necessary also to include the closely related species A. multicostata (Sowerby) and its variety camuloensis (Osmont) (Univ. Calif. Pub. Bull. Dept. Geol., vol. 4, nº 4, 1905, p. 98).

(40) Thiele, J., Handbuch der Systematischen Weichtierkunde, 3 Teil, Jena, 1934, p. 793.


pl. 10, figs. 6, 6a; pl. 11, figs. 6 b-c), both of which are more closely related to Anadara s. s. than to Senilia.

It is seen, then, that Larkinia is intermediate between Anadara s. s. and Senilia. However, it is separated more sharply from Senilia than from Anadara s. s., into which it merges gradually.

In addition to the species mentioned, Larkinia includes Anadara santana and its variety weddlei, both of Loel and Corey (Univ. Calif. Pub. Bull. Dept. Geol. Sci., vol. 22, n° 3, 1932, p. 185, pl. 8, figs. 1-4), from the Vaqueros formation, lower Miocene of California.

Larkinia differs from Anadara s. s. in having a somewhat high, trigonal form; prominent, highly-elevated umbones; exceptionally long crenulations on the inner margin of the shell; and a wide hinge, bearing long teeth which have a tendency to diverge at the center of the hinge, whereas in Anadara s. s. the central teeth are usually either vertical or convergent ventrally. Senilia differs from Larkinia by possessing extremely prosogyrate beaks, an abnormally small number of very wide radial ribs, and a more trigonal form.

Anadara larkinii is represented in the Schenck Collection, Stanford University (n° 680), as are most of the other species here referred to Larkinia.

Subgenus SENILIA Gray, 1842.


In addition to the type species, Senilia includes « Arca » subnitens Recluz (Jour. de Conch., vol. 2, 1851, p. 363, pl. 10,

(42) Although Linné cites Jamaica as the type locality of A. senilis, its presence in the West Indies has not been confirmed (Lamy, Jour. de Conch., vol. 55, n° 3, 1907, p. 282). So far as known, A. senilis lives only in western Africa. It has been reported from the Tertiary by Dreger (« Vorkommen der Senilia senilis Linn. als Fossil », Verh. geol. Reichsanst., 1895, pp. 129-130).
of the pelecypod family arcidae

figs. 3, 4), Recent, from the west coast of Africa. This species is similar to A. senilis but seems to be a distinct species.

Olsson (Bull. Amer. Paleo., vol. 19, 1932, pp. 71-76, pls. 1 and 2) has included in Senilia several species from the Peruvian Miocene which are distinct from this subgenus, as has been stated above. The type of Senilia is characterized by its high, trigonal form, extremely prosogyrate beaks, small number of ribs, and by an oblique break in the dentition just under the umbo (43). Although these Peruvian Miocene species resemble Senilia in shape, they lack the other characteristics, and it is therefore necessary to keep them separate; they are accordingly included in the new subgenus Larkinia Reinhart.

Subgenus ARGINA Gray, 1842 (44).

Pl. IV, fig. m.


Gray's description of Lunarca shows that it was known only from the single type specimen of L. costata. Due to this scarcity of material Gray was suspicious of the validity of his new group and suggested that L. costata might be « only a monstrosity of Argina pexata ». In regard to this point, the illustrations of L. costata given by Adams (Genera of Recent Moll., vol. 3, 1858, pl. 125, figs. 8, 8a) so strongly resemble Argina in all details ex-

(43) This last feature is not shown in Reeve's figure of A. senilis (Conch. Icon., 1844, Arca, pl. 7, fig. 45) but is present in every specimen of a large collection of this species in the Oldroyd Collection, n° 373, Stanford University.

(44) Argina was more fully described by Gray in 1857 (Ann. Mag. Nat. Hist. ser. 2, vol. 19, p. 372). In this publication several species are mentioned: Arca pexata, A. campechensis, etc.
cept the anterior teeth that Gray's suggestion appears to be highly probable, and *Lunarca* is accordingly here questionably placed as a synonym of *Argina*.

*Argina* is known from Eocene to Recent; it has been described from the Eocene of Peru by Olsson (45) and Woods (46), and is also represented in the Eocene of the Paris Basin by *Arca* *granulosa* Deshayes, as previously stated. *Argina* is also apparently represented in the so-called Oligocene of Peru by *Arca* (*Argina*) *puntabraoensis* Olsson (Bull. Amer. Paleo., vol. 17, no 63, 1931, pp. 134-135, pl. 2, figs. 1, 4) although inasmuch as the hinge is unknown its subgeneric assignment is uncertain. At the present time *Argina* is for the most part confined to tropical America, in both the Atlantic and Pacific Oceans, although one species, *Arca* (*Argina*) *canaticostata* Lamy (Jour. de Conch., vol. 55, no 3, 1907, p. 297, pl. 3, figs. 1-3), lives off the coast of eastern Africa, and another, *Arca* (*Argina*) *indica* Gmelin (in Linné, Syst. Nat., ed. 13, t. 1, pt. 6, 1790, p. 3312), was originally reported from the Indian Ocean, but its occurrence there is questioned by Lamy (*op. cit.*, p. 296).

**Subgenus CUNEARCA Dall, 1898.**

Pl. III, figs. j, j'.


(45) *Arca* (*Argina*) *samanensis* Olsson, Bull. Amer. Paleo., vol. 15, no 57, 1929, p. 71, pl. 1, figs. 4, 5.


(47) Although Dall obviously intended this species as type of *Cunearca*, he did not so designate it. However, *Arca incongrua* was named as type species in 1907 by Lamy (Jour. Conch., vol. 55, no 1, p. 6).
Iredale's description and figures of *Imparilarca* show it to be a synonym of *Cunearea*. *Imparilarca hubbardii* is described as inequivalve and with discrepant sculpture, the ribs on the left valve being nodose while those on the right are mostly smooth. These features are characteristic of *Cunearea* and show, together with Iredale's illustrations, which unfortunately do not show the hinge, that *Imparilarca hubbardii* is a *Cunearea*. The same conclusion was reached by Thiele (Handbuch der Systematischen Weichtierkunde, 3 Teil, Jena, 1934, p. 793).

The earliest occurrence of this subgenus of which I have a record is in the Vicksburgian Oligocene of Mississippi, where it is represented by *Scapharca* *lesueuri* Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 643; Sheldon, Palaeont. Amer., vol. 1, n° 1, 1917, pp. 32-33, pl. 7, figs. 12-16). This species unquestionably belongs to *Cunearea*, as it is inequivalve, and has the discrepant sculpture, elevated beaks, and somewhat trigonal form which characterize this subgenus.

« *Arca* *filicata* Guppy (Quart. Jour. Geol. Soc. London, vol. 22, 1866, p. 583, pl. 26, fig. 5) has been correctly assigned by Sheldon to *Cunearea*. This species is found in the Manzanillo beds of Trinidad which were correlated by Maury (Jour. Acad. Nat. Sci. Philadelphia, 2 ser., vol. 15, pt. 2, 1912, pp. 35, 45) with the Oligocene Vicksburg group. Woodring, however (Carn. Inst. Washington, Pub. 385, 1928, table opp. p. 41), later placed the Manzanillo beds in the lower middle Miocene.

Other Miocene and Oligocene occurrences of *Cunearea* in North and South America and Europe are fairly common (48), but records of its Pliocene and especially of its Pleistocene occurrences are rare. At the present time *Cunearea* is widely distributed in warm seas.

Under the discussion of *Scapharca* is mentioned the close relationship of *Scapharca* with *Cunearea* and *Anadara*; the criteria for distinguishing these three groups are there pointed out.

Subgenus SCAPHARCA Gray, 1847.

Pl. IV, fig. k.


In the description of Arca inaequivalvis, Bruguière refers to « Martini, Conchyl. tom. 7, pag. 210, tab. 156, fig. 552 ». (« Tab. 156 » is an error for tab. 56). The specimen figured by Martini (Martini and Chemnitz, Conch. Cab.), from Tranquebar, Indian Ocean, is therefore the type of this species. Martini’s illustration is poor; the species has been somewhat better figured by Reeve (Conch. Icon., vol. 2, Arca, 1844, pl. 8, fig. 54).

Scapharca is intermediate between Anadara s. s. and Cunearia, but is more closely allied to the latter. All three groups intergrade considerably, and for correct subgeneric allocation, well preserved specimens are often necessary. Anadara is equivalved, with the two valves similarly sculptured, comparatively heavy-shelled, and typically elongate. Cuneeria and Scapharca, in contrast, are inequivalved, discrepantly sculptured, usually (although not always) thin-shelled, typically rather high in outline, with prominent beaks. The distinction between Scapharca and Cunearia lies in the degree of discrepancy of sculpture. In Cunearia, the left valve usually bears prominent nodes which are not conspicuously developed on the right. Other discrepancies in sculpture also sometimes exist. In Scapharca, on the other hand, the sculpture is nearly, sometimes entirely, similar on the two valves. A slight discrepancy in sculpture exists in the type species, judging from specimens in the Oldroyd Collection (n° 1948), Stanford University. Finally, Cunearia is generally higher and more trigonal in outline than Scapharca.

The geologic range of Scapharca is Oligocene to Recent. In Oligocene deposits it is represented by a few species, among them

The Miocene occurrences are numerous and world-wide, a few examples being the following: *Arca dariensis* Brown and Pilsbry (Proc. Acad. Nat. Sci. Philadelphia, vol. 63, 1911, pp. 362-363, pl. 22, fig. 11), from the Gatun formation of Panama; *Scapharca hypomela* Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 648, pl. 33, fig. 1), from the Miocene of Florida; *Arca daneyi* Cossmann and Pissarro (Bordeaux Actes Soc. Linn., vol. 66, 1912, pp. 280-282), originally described from the Aquitanian of France. Specimens of this species from the lower Burdigalian, Miocene, are in the Schenck collection (n° 458), Stanford University.

Pliocene to Recent occurrences of *Scapharca* are likewise very common and widely distributed. Included among the Recent species are several from the Pacific coast of North and Central America, among them *Arca labiosa* Sowerby, *A. cepoides* Reeve, *A. obesa* Sowerby. These species are illustrated and discussed by Maury (Palaeont. Amer., vol. 1, n° 4, 1922, pp. 23-31, pl. 3).

Genus *NEMOARCA* Conrad, 1869.

*Nemoarca* Conrad, Amer. Jour. Conch., vol. 5, pt. 2, 1869, p. 97; type species (by monotypy): *Nemoarca cretacea* Conrad (op. cit., p. 97, pl. 9, fig. 21) from the Cretaceous of Haddonfield, New Jersey. Conrad's figure is poor; this species has been figured more clearly by Whitfield (Geol. Survey New Jersey, Palaeontology, vol. 1, 1886, pl. 12, figs. 8-10).

*Nemoarca* has been recognized only in the Cretaceous, being represented so far as I am aware solely by the type species. It appears to belong to the Anadarinae, but is quite distinct from any of the Cenozoic members of that subfamily.

Subfamily NOETINAE Stewart, 1930.

Ventral margin closed, byssal gape usually lacking; sculpture consisting either of radial ribs, or concentric bands, or both; surface of shell regularly rounded; ligamental area narrow to moderately wide, flat to V-shaped in cross-section (with both valves joined); hinge gently to strongly arched; teeth regular,
converging ventrally, in most cases not dying out completely in the center. Inner margin either crenulated or smooth; beaks opisthogyrate; outline of shell trigonal. Posterior muscle scar typically bordered in front by a raised flange. Type genus: Noetia Gray, based upon Noetia triangularis Gray (= Arca reversa (Gray MS) Sowerby).

Geologic range: Cretaceous to Recent.

Genus NOETIA Gray, 1857.

Subgenus Noetia s. s.

Pl. V, fig. n.


L. R. Cox very kindly compared the holotype of Noetia triangularis, in the British Museum of Natural History, with specimens of N. reversa (Gray MS) (Sowerby) (Proc. Zool. Soc. London, 1833, pt. 1, p. 20). This comparison showed triangularis to be a synonym of N. reversa. Photographs of triangularis furnished me by Mr. Cox lead to the same conclusion. Stewart was therefore incorrect (Acad. Nat. Sci. Philadelphia, Special Pub. 3, 1930, p. 80) in assuming that N. triangularis is a synonym of « Arca » ponderosa Say. Noetia reversa has been figured by Maury (Palaeont. Amer., vol. 1, n° 4, 1922, pl. 1, figs. 7, 11).

As Stewart observed (op. cit., p. 81), Noetia s. s. seems to be restricted to American waters in the Recent fauna, although at least one of the foreign species mentioned by Lamy (Jour. de Conch., vol. 55, n° 3, 1907, pp. 300-305) belongs to the subgenus Paranoetia Thiele: for example, « Arca » lateralis Reeve (Conch. Icon., vol. 2, 1844, Arca, pl. 17, fig. 115) from the Philippines. In addition, « Barbatia » cafria Bartsch (U. S. Nat. Mus. Bull. 91, 1915, p. 183, pl. 38, figs. 1, 5) from South Africa is close to Noetia, and it may likewise belong to the subgenus Paranoetia.

The distribution of the fossil species of Noetia has been discussed by Stewart (op. cit., p. 81) and Woodring (Carn. Inst. Washington, Pub. 385, 1928, p. 101). As these authors state, Noetia is not known in Europe in beds older than Aquitanian (Miocene?). Beginning with the Miocene, it is fairly common in
OF THE PELECYPOD FAMILY ARCIDAE

America, but, as stated, is represented in Europe by only one species, *Noetia okeni* (Mayer) (Jour. de Conch., vol. 6, 1857, p. 185, pl. 14, figs. 7, 8) from the Aquitanian. Topotypes of this species in the Schenck collection, Stanford University (n° 859), show it to be a true *Noetia*. *Noetia* is represented in the Eocene of the East Indies (49) and of the Indian region (50); and in addition a variety has been described from upper Eocene beds of Kyushû, Japan, as *Arca (Noetia) pondaungensis* Cotter, var. *transversa* Nagao (51) (Sci. Rep. Tôhoku Imp. Univ., geol. ser. 2, vol. 12, n° 1, 1928, pp. 26-27, pl. 6, figs. 8-10), which appears to be a *Noetia*.

**Subgenus NOETIELLA** Thiele and Jaeckel, 1931.

*Noetiella* Thiele and Jaeckel, Muscheln der deutschen Tiefsee-Expedition : Wissenschaftlich Ergebnisse der Deutschen Tiefsee-Expedition, Bd. 21, Heft 1, 1931, Jena, p. 173; type species (by original designation) : *Barbatia pectunculiformis* Dunker (Novitates Conchologicae, 1870, pp. 88-89, pl. 28, figs. 4-6), Recent, from Borneo.

I have not had the opportunity of seeing the type species of *Noetiella*. The suggestion was made by Stewart that it might be related to *Halonanus* (Acad. Nat. Sci. Philadelphia, Special Pub. 3, 1930, p. 79). In addition to the type, the following species is assigned to *Noetiella* by its authors: *Arca (Noetiella) congoensis* Thiele and Jaeckel (op. cit., p. 176, pl. 1, fig. 11) from the mouth of the Congo.

**Subgenus PARANOETIA** Thiele, 1934.

*Paranoetia* Thiele, Handbuch der Systematischen Weichtierkunde, 3 Teil, Jena, 1934, p. 793; type species (by mono-

(49) « *Arca (Anadara) molengraaffii* Martin (Samml. Geol. Reichs-Mus. Leiden, n. ser., vol. 2, n° 5, 1916, p. 184, pl. 7, figs. 191, a, 192, a) from the upper Eocene of Java.


(51) Inasmuch as the specific name *transversa* has been preoccupied in the genus *Arca* since 1822 (*Arca transversa* Say, Jour. Acad. Nat. Sci. Philadelphia, vol. 2, pt. 2, pp. 269-270), Nagao's varietal name is a homonym. I have notified Professor Nagao of this fact, and he will soon rename his variety.
Arca lateralis, the type species of Paranoetia, is similar in general form to the type of Sheldonella, mentioned below, but apparently lacks a byssal notch.

Subgenus SHELDONELLA Maury, 1917.


The type species of Sheldonella differs from typical Noetia by lacking the usual sharp umbonal ridge, and notably by the presence of the well-developed byssal notch described by Maury and shown in her illustrations. In true Noetia no byssal notch is present. Because of this notch the relation of Sheldonella to Noetia seems uncertain, but inasmuch as the two are similar in most other respects, Sheldonella seems best placed as a subgenus of Noetia. I know of no species other than the type which can be confidently assigned to Sheldonella.

Genus TRIGONARCA Conrad, 1862.


A good description of Trigonarca and illustrations of the type species are given by Stephenson (North Carolina Geol. and Econ. Survey, vol. 5, pt. 1, 1923, pp. 96-98, pl. 15, figs. 1-3). Trigonarca forms a distinctive, widely-distributed group limited to the Cretaceous (52), appearing to be most abundant in the Upper

(52) Gillet (Mém. Soc. Géol. de France, n. sér., Mém. no 3, 1924, p. 18) mentions an unnamed species of Trigonarca in the Lias, but sufficient information is not given concerning it; I must therefore question its occurrence for the time being.
Cretaceous. This genus has been reported from the Cretaceous of North America (Stephenson, 1923; Packard, Univ. Calif. Pub. Bull. Dept. Geol. Sci., vol. 13, no 10, 1922, pp. 418-419); from southern India (Stoliczka, Palaeont. Indica, Cretaceous Fauna of S. India, vol. 3, 1871, pp. 352-355); from England (Woods, Monograph of Cretaceous Lamellibranchia, pt. 1, Palaeont. Soc., vol. 53, 1899, p. 47); from South Africa (Rennie, Ann. S. African Mus., vol. 28, pt. 2, 1930, p. 169 (53)); and from Italy (Greco, Palaeont. Italica, vol. 24, 1918, pp. 28-30). Several of the other occurrences reported are either incorrect or uncertain; for example, "Arca (Trigonarca) ferlinii" Greco (Palaeont. Italica, vol. 23, 1917, pp. 128-129, pl. 16, fig. 7) and "A. (T.)" rosellinii Greco (op. cit., pp. 150-151, pl. 17, fig. 13) from the Cretaceous of Egypt do not belong to Trigonarca. And the status of Trigonarca obsoleta Yabe and Nagao (Sci. Rep. Tôhoku Imp. Univ., 2 ser., vol. 9, no 2, 1926, pp. 43-44, pl. 12, fig. 24), from the Cretaceous of Japan, is very doubtful, as it is based upon a poorly-preserved specimen.

Protarca Stephenson (North Carolina Geol. and Econ. Survey, vol. 5, pt. 1, 1923, pp. 103-104) was considered by Stephenson to be intermediate between Trigonarca and Glycymeris. This seems to be the case, but I believe Protarca to be more nearly related to Glycymeris. The type species of Protarca, designated by Stephenson, is P. obliqua Stephenson (op. cit., pp. 104-105, pl. 19, figs. 1-3), from the Upper Cretaceous of Snow Hill, North Carolina. A plastotype is in the Stanford University paleontological type collection.

Genus TRIGONODESMA Wood, 1864.

Pl. V, figs. p, p'.


The type species of Trigonodesma was figured, as Arca laevigata Caillat, by Wood (op. cit., pl. 15, figs. 8 a-c). Wood noted that this species is slightly inequivalved, with the right valve larger than the left; he also observed that the ligament occupies a small, triangular pit beneath the umbones. According to Gilbert (Mus. Roy. d’Hist. Nat. de Belgique, Mém. 53, 1933, p. 122) the ornamentation of the two valves is somewhat dissimilar, the left valve being ornamented only with concentric growth lines, while the right has radial striations as well. This observation has been partly verified by an examination made by me of a series of eleven well-preserved specimens of this species from Barton, England (No 72521 in the Geological Department of the British Museum of Natural History). This discrepancy of ornamentation, however, does not seem to be a constant character, as two left valves were noted in which the radial striations are more prominent than the concentric ones. My observations on this point may be summarized as follows: radial and concentric striations are present on both valves; in most cases, though not in all, the radial sculpture predominates on the right valve and concentric sculpture on the left. The posterior muscle scar is bordered on its anterior side by a slightly-elevated flange, but no flange could be detected bordering the anterior scar.

Halonanus Stewart, based upon « Noetia » pulchra Gabb, differs slightly from Trigonodesma and is therefore only questionably considered a synonym of that genus. The hinge of « Noetia » pulchra is definitely arched, and the central interruption in the teeth is not so pronounced as in Trigonodesma. Trigonodesma has only a slightly arched hinge; it also has a more prominent anterior dorsal margin than « N. » pulchra. However, an attempt to separate Halonanus from Trigonodesma has failed to disclose any satisfactory criteria for a generic separation, as in other respects, including the elevated posterior flange, the two are similar. The differences therefore appear to be specific rather than generic, although this point is debatable.
Trigonodesma includes *« Arca » hornii* Gabb (54) (Pal. Calif., vol. 1, 1864, p. 194, pl. 30, fig. 263) and *« A. » hornii*, subsp. *elusa* Clark and Woodford (Univ. Calif. Pub. Bull. Dept. Geol. Sci., vol. 17, no 2, 1927, p. 87, pl. 14, fig. 6) from the Eocene of California, and a number of other Eocene species from the eastern United States, which are listed by Stewart: *« Noetia » pulchra* Gabb (type of *Halonanus*), *« Trinacria » decisa* (Conrad), *« T. » perplana* (Conrad), *« T. » declivis* (Conrad), and *« T. » ellipsis* Lea (55). To these may be added *« Trigonocoelia » ledoides* Meyer (Alabama Geol. Survey, Bull. 1, 1886, p. 79, pl. 1, fig. 20) from the Eocene of Claiborne, Alabama. Stewart also questionably included (in *Halonanus*) *« Trinacria » baudoni* Meyer (Cossmann and Pissarro, Icon. Comp. des Coq. Foss. de l’Eocène des Env. de Paris, vol. 1, 1904-1906, pl. 34, fig. 107-9) from the Eocene of the Paris Basin.

Trigonodesma resembles Noetia and Trigonarca in having a trigonal form and opisthogyrate beaks, but differs from both in having the ligament placed in a small shallow pit between the umbones, resembling *Arcopsis* in this respect. However, because of its trigonal form and generally opisthogyrate beaks, *Trigonodesma* is here placed in the Noetiinae. It is apparently confined to the Eocene.

As stated under the discussion of « Family, generic, and specific characteristics of the Arcidae », *Trigonodesma* is similar in form to the type species of *Trinacria* Mayer, 1868, of the family Limopsidae (*« Trigonocoelia » crassa* Deshayes, Anim. sans vert. bas. Paris, vol. 1, 1860, p. 841, pl. 65, figs. 1-4; upper Eocene — « Sables moyens » — of the Paris Basin). The difference of hinge structure which distinguishes *Trinacria* from *Trigonodesma* has already been discussed earlier in this paper, and will not be repeated. The general similarity in form between *Trigonodesma* and *Trinacria*, and the relatively small differences which separate them, indicate that these two genera are on the border line of the families Arcidae and Limopsidae, respectively.

(54) It should be mentioned that *« Arca » hornii* and its subspecies *elusa* are more closely related to the type species of *Trigonodesma* from Europe than to the type species of *Halonanus* from southeastern United States.

(55) These species are discussed and figured by Harris, Bull. Amer. Paleo., vol. 6, no 31, 1919, pp. 41-44, pls. 18-19.
ADDENDUM.

Although *Senilia* and *Argina* were named earlier than *Anadara*, they are treated in this paper as subgenera of *Anadara*. Even though it is not customary for subgeneric names to antedate generic ones, there is nothing in the International Rules of Zoological Nomenclature to prevent such an action. On the other hand, this action is made advisable in this case because of the following considerations: (1) the wide-spread use of the name *Anadara* as a genus, in contrast to the much less common use of *Senilia* and *Argina*; (2) the unsatisfactory manner in which *Senilia* and *Argina* (as well as all other genera in Gray's 1842 Synopsis) were proposed, causing Iredale to favor rejecting all of the names proposed in this work (Iredale, Proc. Mal. Soc. London, vol. 10, 1913, p. 301). Should some later ruling by the International Commission make it necessary for generic names to antedate subgeneric names, it would be preferable to elevate *Argina* and *Senilia* to generic rank, in order to avoid reducing *Anadara* to a subgenus of either.
SELECTED BIBLIOGRAPHY

A complete list of the papers cited in the foregoing text would be desirable here, but inasmuch as its length would make its publication prohibitive, the list has been shortened so as to include only those works referred to most frequently.

Bibliographic citations in the text are abbreviated, in most cases, in accordance with the form suggested by Wood (Suggestions to Authors: U. S. Geological Survey Admin. Pub., 3 ed., 1916, pp. 24-28), and in citing publications not listed by Wood I have attempted to make the references as clear as possible.


Tryon, G. W., 1884. *Structural and Systematic Conchology*, vol. 3.


EXPLANATION OF PLATES

a, a’. *Arca (Arca) noae* Linné (type of *Arca*). Plesiotype n° 5297, Stanford University paleo. type coll., Recent, from Mediterranean Sea. a, interior of right valve; a’, anterior view, outline, showing wide, flat ligamental area. Length 69 mm.

b, b’. *Barbatia (Barbatia) barbata* (Linné) (type of *Barbatia s. s.*). Plesiotype n° 1115, Oldroyd Collection, Stanford University, Recent from Roussillon, Mediterranean Sea. b, interior of left valve; b’ anterior view, outline. Length 63 mm.

c, c’. *Barbatia (Calloarca) alternata* (Sowerby) (type of *Calloarca*). Plesiotype n° 3483, University of California at Los Angeles type coll., Recent, from western Mexico. c, interior of right valve; c’, dorsal view of the same. Length, ca. 38 mm.

d, d’. *Barbatia (Obliquarca) marceauxi* (Deshayes). Plesiotype n° 5299, Stanford University paleo. type coll., upper Eocene of Hermonville, Paris Basin. d, interior of right valve; d’ oblique dorsal view, showing ligament to be restricted to the posterior of the umbo. Length 18 mm. This is not the type species of *Obliquarca*, but is is a closely related species, having the same general characteristics.

e. *Barbatia (Cucullaeorca) cuculloides* (Conrad). Sketched from Aldrich, Alabama Mus. Nat. Hist., Mus. Paper 12, 1931, pl. 6, fig. 1A. Upper Eocene of Claiborne, Alabama. Interior of right valve. Length 61 mm. *B. lima* (Conrad), the type species of *Cucullaeorca*, is usually considered a synonym of *cuculloides*.

f, f’. *Barbatia (Acar) gradata* (Broderip and Sowerby) (type of *Acar*). Sketched from Bartsch, Proc. U. S. Nat. Mus., vol. 80, Art. 9, 1931, pl. 1, top figures. Recent, from Mazatlan, western Mexico. f, interior of left valve showing prominent muscle scars; f’, dorsal view of both valves together showing shape of ligamental area and its location mainly posterior to umbones. Length 41 mm.

g, g’. *Arcopsis (Arcopsis) quadrilaterea* (Lamarck) (type of *Fossularca*, here placed in the synonymy of *Arcopsis*). Plesiotype n° 5295, Stanford University paleo. type coll., Bartonian, Eocene, of Le Fayel, Oise, Paris Basin. g, interior of left valve; g’, dorsal view showing location of shallow ligamental pit. Length 7 mm.
h. *Bathyarca* (*Bathyarca*) *pectunculoides* (Scacchi) (type of *Bathyarca*). Sketched from Sheldon, *Palaeont. Amer.*, vol. 1, no. 1, 1917, pl. 16, fig. 11. Recent, from Finmark, Sweden. Interior of left valve. Length ca. 11 mm.

i, i'. *Anadara* (*Anadara*) *antiquata* (Linne) (type of *Anadara* s. s.). Plesiotype no. 5298, Stanford University paleo. type coll., Recent, from Philippine Islands. i, interior of left valve; i', anterior view, outline. Length 58.5 mm.

j, j'. *Anadara* (*Cuneearca*) *incongrua* (Say) (type of *Cuneearca*). Plesiotype no. 5296, Stanford University paleo. type coll., Recent, from Florida. j, interior of left valve; j', anterior view, outline, showing posterior extension of shell. Length 57 mm.

k. *Anadara* (*Scapharca*) *inaequivalvis* (Bruguière) (type of *Scapharca*). Plesiotype no. 1948, Oldroyd Collection, Stanford University. Recent, from Awaji, Japan. Left valve. Length 76 mm.

l. *Anadara* (*Larkinia*) *larkinii* (Nelson) (type species of *Larkinia*). Sketched from Olsson, *Bull. Amer. Paleo.*, vol. 19, no. 68, 1932, pl. 2, fig. 4. Tumbes formation, Miocene, of Que. Tucillal, Zorritos district, Peru.


n. *Noetia* (*Noetia*) *triangularis* Gray (type of *Noetia*). Holotype, British Mus. Nat. Hist. Recent, locality unknown. Interior of right valve. Length, ca. 35 mm. This species is a synonym of *N. reversa* (Gray MS) (Sowerby), a tropical American species living in both the Atlantic and Pacific Oceans.


### Genera and subgenera of Arcidae

**ARCA s. s.**
- **Surface ornamentation:** numerous radial ribs, resembling those of *Barbatia*. Surface of shell irregular.
- **Ligamental area:** extremely wide and almost flat.
- **Teeth:** numerous fine, regular teeth, perpendicular to hinge or converging ventrally; hinge very long, narrow, and straight.
- **Inner margin of shell:** smooth. Large byssal gape.

**BARBATIA s. s.**
- **Surface ornamentation:** many fine, narrow, radial ribs; irregular concentric lines; surface of shell irregular.
- **Ligamental area:** narrow; V-shaped in cross section, with both valves joined.
- **Teeth:** converging ventrally; reduced to very small size at center of hinge.
- **Inner margin of shell:** smooth. Small byssal gape.

**CALLOARCA**
- **Surface ornamentation:** radial ribs, very large on posterior slope and only slightly less so at anterior end; less prominent medially.
- **Ligamental area:** as in *Acar*; narrow, ligament present posterior to beaks.
- **Teeth:** small, converging strongly at extremities.
- **Inner margin of shell:** smooth. Small byssal gape.

Differs from *Acar* by lacking the reticulate sculpture and prominently elevated muscle scars of that subgenus.
### OBLIQUARCA
- **Surface ornamentation:** fine radial ribs.
- **Ligamental area:** narrow, present only posterior to umbones.
- **Teeth:** converging ventrally; small at center of hinge.
- **Inner margin of shell:** smooth.
- Distinguished from *Barbatia s. s.* by the arrangement of its ligamental area.

### CUCULLAEARCA
- **Surface ornamentation:** same as *Barbatia s. s.* — fine radial ribs.
- **Ligamental area:** wide; V-shaped in cross section, with both valves joined.
- **Teeth:** Large at extremities of hinge, converging ventrally; small and granular at center.
- **Inner margin of shell:** smooth. Large byssal gape.
- Distinguished from *Barbatia s. s.* by large ligamental area, large byssal gape, and posterior enlargement in outline.

### ACAR
- **Surface ornamentation:** reticulate sculpture; surface of shell irregular, deformed in appearance.
- **Ligamental area:** narrow; present only posterior to umbones.
- **Teeth:** converging ventrally; small and granular, especially at center of hinge.
- **Inner margin of shell:** smooth or crenulated. Small byssal gape.
- **Muscle scars:** elevated, conspicuous.
Plate III.

AARCOPSIS

Surface ornamentation: fine radial ribs.
Ligamental area: narrow; ligament confined to small, shallow pit between umbones.
Teeth: regular, converging ventrally; edentulous gap at center of hinge.
Inner margin of shell: smooth.

BATHYARCA

Surface ornamentation: fine radial and concentric lines.
Ligamental area: very narrow.
Teeth: converging ventrally, with an edentulous gap at center of hinge.
Inner margin of shell: smooth; small byssal gape.
Shell very small and fragile; right valve smaller than the left.

ANADARA s. s.

Surface ornamentation: large radial ribs, grooved or noded on most species. Both valves equally sculptured.
Ligamental area: moderately wide, usually V-shaped in cross section, with both valves joined. Commonly sculptured with chevron-shaped grooves.
Teeth: regular, arranged perpendicular to hinge line; in most cases converging ventrally at extremities of hinge.
Inner margin of shell: crenulated; no byssal gape. Shell commonly heavy, equivalved.

CUNEARCA

Similar to Anadara s. s. except for the following points:
Left valve always larger than right; left valve with noded ribs; right valve with ribs plain or only slightly noded; other discrepancies in sculpture between the two valves sometimes present. Shell high and short in outline, with elevated beaks. Valves typically thin-shelled.
Intermediate between *Cunearca* and *Anadara s. s.* Inequivalved, with the left valve larger than the right. Sculpture either similar on the two valves or slightly discrepant (never strongly discrepant as in *Cunearca*). Valves typically thin-shelled.

**Surface ornamentation:** large radial ribs, noded or smooth.

**Shape:** high and somewhat trigonal, with strongly elevated beaks.

**Ligamental area:** large, with ligamental grooves tending to be chevron-shaped.

**Teeth:** very long; converging ventrally at extremities of hinge, but diverging near the center.

**Inner margin of shell:** deeply grooved with long crenulations. No byssal gape. Shell equivalved.

Shell very thick and heavy.

**Surface ornamentation:** large radial ribs.

**Ligamental area:** narrow; confined to posterior of beaks.

**Teeth:** anterior teeth few in number and irregular; posterior teeth numerous.

**Inner margin of shell:** crenulated. No byssal gape.

Differs from *Anadara s. s.* only in the arrangement of the teeth and ligamental area.
**NOETIA**

*Surface ornamentation:* fairly prominent radial ribs.  
*Shape:* trigonal in outline. Beaks opisthogyrate.  
*Ligamental area:* moderately wide; located chiefly (in the type species entirely) anterior to the beaks.  
*Teeth:* converging ventrally; hinge somewhat arched.  
*Inner margin of shell:* crenulated; no byssal gape.  
*Muscle scars:* posterior scar bordered, on its anterior side, by an elevated flange.

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**TRIGONARCA**

*Surface ornamentation:* concentric lines only.  
*Shape:* trigonal in outline. Beaks opisthogyrate.  
*Ligamental area:* wide; longer in front of beaks than behind.  
*Teeth:* strong and regular; converging at extremities.  
*Hinge:* arched.  
*Inner margin of shell:* smooth. No byssal gape.  
*Muscle scars:* prominent; posterior scar bordered, on its anterior side, by an elevated flange.

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**TRIGONODESMA**

*Surface ornamentation:* concentric lines, and (particularly on right valve) radial striations.  
*Shape:* trigonal in outline; beaks opisthogyrate; shell very small.  
*Ligamental area:* small; ligament restricted to small shallow pit beneath umbones, in type species.  
*Teeth:* small and fairly regular; hinge straight to slightly arched.  
*Inner margin of shell:* smooth; no byssal gape.  
*Muscle scars:* posterior scar bordered by elevated flange.
INDEX

Listed below are the generic, subgeneric, specific, and subspecific names mentioned in the text. Subspecific and varietal names are listed with the specific name omitted: for example, *Anadara santana*, var. *weddei* appears in the index as « *weddei, Anadara* ». Numbers in italics indicate the page or pages on which the principal discussion of each genus and subgenus is to be found (thus, 23-24). In many cases, names occur several times on one page, as well as in footnotes.

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