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Charles D. and Mary Vaux Walcott Research Fund

GENERA OF TERTIARY AND RECENT RHYNCHONELLOID BRACHIOPODS

(With 22 Plates)

By
G. ARTHUR COOPER
Head Curator, Department of Geology
United States National Museum
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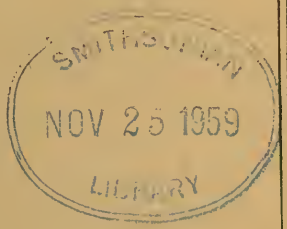
(Publication 4382)



CITY OF WASHINGTON
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INTRODUCTION

For several years the writer has been studying the few brachiopods known from the Tertiary formations in the eastern United States. Most of the species are terebratuloids but a few rhynchonelloids appear in the collection. The Palmer collection of Cretaceous and Tertiary brachiopods from Cuba was also made available. This collection, too, contains a few rhynchonelloids. This group of brachiopods seems to be unusual in Tertiary deposits and the same is true of the rhynchonelloids of modern seas. In the study of the Tertiary forms it proved necessary to compare them with modern representatives. In making these comparisons it became evident that modern rhynchonelloids have been well described in only a few instances and very few of them have ever been adequately illustrated. Inasmuch as the collection of Recent brachiopods in the National Museum contains a good representation of modern rhynchonelloids, the opportunity presented itself to correct the deficiencies outlined above.

In addition to the American Tertiary rhynchonelloids, some species from outside North America are also included. The National collections do not contain many representatives from foreign Tertiary deposits but some good specimens are available from the Mediterranean region and elsewhere. These made possible the figuring and description of some new or little-known genera.

Although this monograph adds considerably to our knowledge of Recent and Tertiary genera of rhynchonelloids it does not include all the known species or all the possible genera. A number of species are known from European deposits but the interior details have never been

described, nor were specimens available to use in this study. Consequently it is possible to assign to their proper genera only some of the known species. It is also known that the interior of a number of species differs from that of any of the genera discussed herein, but these species are represented by too few specimens to make generic description possible. Much therefore still remains to be done in the study of the Tertiary and Recent rhynchonelloids.

Possibly the biggest handicap in the study of modern and Tertiary rhynchonelloids is the fact that, except in a few instances, the specimens are quite rare. Several of the Recent species are known from one or two specimens only, yet their morphological details are unique or sufficiently different from known genera to make it impossible to include them in any of the established categories.

Some of the Tertiary species are sufficiently numerous for good descriptive work but their describers seldom made any effort to obtain interior details. Davidson (1870) did not describe the interior of any of the Italian Tertiary rhynchonelloids, probably because emphasis in his day was on description of the species. Later authors seemed to be content to assign many of the modern species to *Hemithyris* regardless of whether or not the interior or exterior details were in accordance with the generic characters of the type species. In present times emphasis is now placed on interior details because it is on them that the family and frequently the generic characters are based.

ACKNOWLEDGMENTS

In any study of this sort it is necessary to ask help of one's colleagues. I am grateful to all the scientists listed below for their help. Dr. Helen M. Muir-Wood, Deputy Keeper, Department of Palaeontology, in charge of the brachiopods in the British Museum (Natural History), furnished a specimen of *Compsothyris,* photographs of *Rhynchonella grayi* Woodward, photographs of serial sections of *R. polymorpha* (Massalongo) and *R. bipartita* (Brocchi), and casts of the specimens serially sectioned. Dr. A. Vandercammen, Subdirector of the Laboratory, Royal Institute of Natural Sciences, Belgium, furnished a specimen of *Mannia nysti* Davidson, a rare Belgian species.

Mrs. Ellen J. Trumbull of the U. S. Geological Survey made available specimens of west coast Tertiary species. Dr. J. H. Peck, Senior Museum Paleontologist of the Museum of Paleontology, University of California, made available a fine suite of topotypes of *Eohemithyris* which made possible preparations of the inner details of that interest-

ing genus described and illustrated herein. Dr. L. G. Hertlein, University of California at Los Angeles, lent paratypes of *Eohemithyris*. Dr. E. Montanaro Gallitelli, University of Modena, Italy, presented the National Museum with specimens of *Rhynchonella polymorpha* (Massalongo) that made it possible to prepare the interior details of the cardinalia described and figured in this monograph.

RHYNCHONELLOID MORPHOLOGY

Throughout geological time the rhynchonelloids have been characterized by triangular to subpentagonal form, with prominent beak and a strong median fold on one valve, usually the brachial valve, and a deep sulcus on the other. Nearly all the genera are provided with a conspicuous beak having a foramen modified by deltidial plates. In some genera, especially a few of the Recent, Tertiary, or Mesozoic ones, the deltidial plates are elaborately auriculate, a feature unusual in other brachiopods. The rhynchonelloid shell is commonly costate; smooth forms are usual in Recent, Tertiary, and Mesozoic families but rare in Paleozoic representatives. The distinctive feature of the rhynchonelloid interior is the more or less long curved crura and hinge plates which characterize the cardinalia. Details of these latter features have long been neglected.

BEAK CHARACTERS

It is not here the intention to discuss these characters for all the rhynchonelloid brachiopods but to point out the significant features shown by the genera discussed herein. Of modern and Tertiary rhynchonelloids only *Cryptopora* and *Mannia* do not have a small round or elongate-oval foramen. In the two genera mentioned the foramen is elongate-triangular and is restricted only slightly by attenuated deltidial plates, which, unlike most other modern and Tertiary genera, form an elevated rim on the sides of the delthyrium.

The nature and completeness of the deltidial plates usually define the form of the foramen. In some genera the deltidial plates are *disjunct,* that is, they do not meet on the anterior side of the foramen. In such cases the foramen is said to be incomplete. An excellent example of this type is *Hemithyris*. When the deltidial plates meet on the anterior side of the foramen, they are spoken of as *conjunct* and the foramen is completely enclosed. Examples are *Basiliola, Aphelesia,* and *Aetheia*. These two conditions of the deltidial plates, disjunct or conjunct, are given considerable weight in genus making by some

workers. Yabe and Hatai (1934), for example, distinguished their genus *Neohemithyris* (=*Basiliola*) from *Hemithyris* chiefly on this basis.

Another feature given importance in the study of the rhynchonelloids is the position of the foramen in relation to the beak. A common condition is one in which the entire foramen is surrounded by the deltidial plates and is called a *hypothyrid* foramen. In other genera the foramen has migrated posteriorly because of pedicle pressure and has thus resorbed or worn away the portion of the deltidial plates on its posterior side. In this condition, which is called submesothyrid, the foramen is bounded posteriorly by the beak and anteriorly by the deltidial plates. A further condition is called *mesothyrid* and results from continued posterior migration of the foramen, which has resorbed part of the beak and is bounded posteriorly by part of the curving umbo and the deltidial plates anteriorly. This condition is rare in modern and Tertiary rhynchonelloids.

One of the most characteristic rhynchonelloid features is the rims or winglike extensions that adorn the deltidial plates of some genera. Perhaps the most exaggerated modern examples are those of *Grammetaria* and some species of *Cryptopora* in which the deltidial plates bear prominent lateral extensions. The more common condition is that of *Basiliola* in which the lateral and anterior margins of the deltidial plates in contact with the foramen are reflected dorsally in the direction of the brachial valve and form a conspicuous lip around the foramen. This may have helped, in conjunction with the pedicle collar, to form a tube which strengthened the hold of the valve on the pedicle.

INTERIOR CHARACTERS OF THE PEDICLE VALVE

Most of the Recent and Tertiary rhynchonelloids have the beak and pedicle regions strengthened by a pedicle collar. An elaborate collar is developed in *Basiliola.* The deltidial plates are conjunct and auriculate. Their inner margin grows laterally along the sides of the delthyrial cavity to meet on the floor of the valve. In *B. pompholyx* (U.S.N.M. 274135) the anterior margin of the collar protrudes anterior to the edge of the deltidial plates and is elevated above the valve floor (pl. 12, figs. 9, 10). In *B. beecheri* the anterior ends of the deltidial plates are thickened and expanded inward to form a flat area that rides over the umbo of the brachial valve when the valves are opened and closed (pl. 14, A, fig. 2).

Hemithyris possesses a pedicle collar but it is not complete because the deltidial plates are disjunct. The inner edges of the deltidial plates

are extended ventrally to the valve floor where they join to form the collar, but this is never closed at the anterior end. In genera with disjunct deltidial plates the collar is seldom prominently developed. In some instances as in *Frieleia* it forms a callosity at the posterior apex against which the pedicle rests. It is suggestive of the pedicle callist of the Orthoidea in the Paleozoic. In *Cryptopora* no pedicle collar is developed, but a small apical plate elevated above the valve floor serves the same purpose, the pedicle evidently lying against it.

The dental plates are another part of the apical region of the rhynchonelloid of importance in classification and generic definition. Dental plates are generally present in rhynchonelloids from the time of their origin. They are present in all but two of the Recent and Tertiary members discussed herein. Usually they are strong and erect plates which define narrow but distinct umbonal cavities. In a few genera such as *Rhytirhynchia, Aetheia,* and *Patagorhynchia* the dental plates are reduced to mere vestiges or are absent. The only specimen of *Patagorhynchia* available for dissection, that figured on plate 6, A, failed to show any trace of dental plates. *Aetheia* which is usually described as lacking these structures seems to have vestiges of them. *Rhytirhynchia* has fairly distinct dental plates in the Okinawa Pliocene species but they are mere vestiges in the Recent *R. sladeni* (Dall) from the Indian Ocean.

INTERIOR CHARACTERS OF THE BRACHIAL VALVE

The definitive family characters of the brachiopods are in the brachial valve. This is the more conservative of the two valves and thus retains its diagnostic features while parts of the pedicle valve which is fixed to some solid object may be evolving. The most important characters of this valve are the cardinalia which embrace the cardinal process, the hinge plates, crura, and septa. Except for Thomson's (1927) work, no attempt has been made to apply the features of the cardinalia to the classification of Recent and Tertiary rhynchonelloids. Parts of the cardinalia have been used in defining families and subfamilies of the Paleozoic rhynchonelloid genera. These attempts have been based on the presence or absence of a cardinal process. The type of crura and hinge plates, however, have not been used even though they offer the greatest possibilities.

Cardinal process.—In the modern and Tertiary brachiopods this structure does not attain a high state of development and makes little impress on the classification. In some Paleozoic genera the cardinal process is a simple vertical blade, suggesting inheritance from an

orthoid ancestor. In the Devonian the cardinal process of some genera, especially the robust forms that have passed under the name *Uncinulus* (=*Sphaerirhynchia*), have elaborate cardinal processes. Some of these appear to be secondary characters and difficult to evaluate in the present meager state of our knowledge. The cardinal process is not highly developed in the few Mesozoic forms, the interiors of which have been described. In modern and Tertiary forms the most prominent cardinal process is that of *Plicirhynchia,* a robust and thick shell.

The cardinal process of several genera such as *Notosaria* (pl. 6, B, fig. 16) and *Hemithyris* (pl. 4, E, fig. 9) appears as a triangular roughened area at the apex. In the younger shells it is scarcely visible but it is fairly prominent in old or obese specimens. The majority of the modern and Tertiary forms have no cardinal process, the diductor muscles being inserted in a pit under the apex. The presence of a cardinal process in rhynchonelloids of this age is thus a ready means of distinction.

Hinge plates.—These structures are an important part of the cardinalia and the combination of them with various kinds of crura makes recognizable patterns. The sockets, which are corrugated in nearly all of the genera discussed herein, are defined by a prominent ridge that curves anterolaterally from the apex or the cardinal process to form a narrow cup defining the socket. This ridge may be high or low, thick or thin, and to its inner side is attached the outer hinge plate or the crus, depending on the genus. The outer hinge plate may not exist in some genera or it may be a fairly broad plate between the socket ridge and the crus. To it are attached the muscles that rotate the animal on its pedicle. The outer hinge plates are especially well developed in *Basiliola* (pl. 12, fig. 15) and *Neorhynchia,* but not present in *Aphelesia.*

The inner hinge plates are seldom well developed but appear in several genera. These are extensions medially from the inside edge of the crura. They are best developed in *Frieleia* (pl. 15, A, fig. 10) where they are so strong that they unite in the middle of the valve to create a small apical chamber somewhat reminiscent of the septalium (or cruralium?) of certain Paleozoic and Mesozoic genera. The inner hinge plates are also developed in exaggerated form in *Aetheia* but in a way different from *Frieleia.* In *Aetheia* they are not flat or slightly concave plates but are great swellings that extend medially from the crura and plug the whole apical region. The degree of development of either of these hinge plates may play a role in genus definition.

Crura.—The crura are the most distinctive part of the rhynchonel-

loid shell and are usually moderately long, somewhat curved plates extending into the body cavity. To them the body wall is attached and the brachia are attached to the anterior body wall at their extremity. Among the Mesozoic rhynchonelloids several distinctive types of crura have been named. The five types distinguished do not cover the possibilities among the Rhynchonelloidea because the crura of many of the Paleozoic genera have not yet been described and illustrated. Furthermore all these types are not recognizable in the Recent and Tertiary forms.

Rothpletz (1886, p. 86) was the first to name types of crura. He distinguished the following (translated from the German):

1. Radulifer type.—Generally consisting of two dental plates in the larger [pedicle] valve, a median septum in the small [brachial] valve, two hinge plates joined at the beak of the small [brachial] valve, and two narrow crura curved toward the large [pedicle] valve, which at their free lower ends are provided with barbs. One can compare these crura with the radula [Schabeisen] of the Greek athletes and I therefore name rhynchonellas with such crura *radulifer*. (Rothpletz, pl. 11, figs. 20 and 21.)

2. Falcifer type.—The crura, with otherwise like structures, rarely have the form, as with *lacunosa* according to Quenstedt's researches, the form of broad, sharp septa which are extended parallel with the plane of symmetry of the shell and possess a sickle shape (*Rhynchonellae falciferae*). (Rothpeltz, pl. 11, fig. 19.)

3. Septifer type.—There can be, however, such sickle-shaped crura so broad they make contact with the edge directed toward the small [brachial] valve, are grown with it and consequently appear like actual septa extending from the shell (*Rhynchonellae septiferae*). (Pl. 8, figs. 46-48.)

Thirty-four groups or "Sippe" of rhynchonelloids were recognized by Rothpletz but the interior details of 19 of them were unknown at this time. Of the remaining 15 Sippe, 3 belong to the falcifer group (Trilobita, Lacunosa, and Varians), 2 belong to the septifer type (Inversa and Trigona), and 10 are placed in the radulifer group (Amalthei, Variabilis, Concinna, Plicatissima, Tetraëdra, Inconstans, Difformis, Plicatella, Psittacea, and Spinosa). Some of these Sippe have been made into genera but generally little relationship exists between the interior details of many of the species placed in each group.

Wisniewska (1932, p. 6), in her fine work on rhynchonelloids from

the Jurassic of Poland, more clearly defines these types and adds a fourth, as follows:

1. Radulifer type.—Crura narrow, recurved toward the ventral valve, widening gradually toward their extremity. This type, characterizing the genera *Septaliphoria, Rhynchonella,* and *Cyclothyris,* was given the name "radulifer" by Rothpletz.

2. Falcifer type.—Crura with a large suspended crural plate, touching the bottom of the valve only near its summit. This is the "falcifer" type of Rothpletz characterizing the genus *Lacunosella.*

3. Septifer type.—Crura short with the crural plates supported at the bottom of the valve and extending for about one-third the valve length. This is the "septifer" type of Rothpletz affirmed by us only in the genus *Septocrurella.*

4. Arcuifer type.—Crura with large bases separated from each other and curved so as to turn their concave sides toward the middle, the extremity turned toward the ventral valve and terminated by a sort of small crural plate in the form of a hammer. This type of crura, seen in the genus *Monticlarella,* may be called "arcuifer."

Muir-Wood (1934, p. 526; 1936, p. 14) added a fifth type as a result of her work on Mesozoic brachiopods:

Calcarifer crura.—". . . The crura consist of two flattened, curved, posteriorly concave laminae which project from the hinge-plate into the cavity of the pedicle valve. These laminae each unite with a second curved lamina which appears to be suspended from it and projects dorsally like a spur. A ventral extension of the second lamina terminates in a hook-shaped process, the apex of which is directed medianly." *Kallirhynchia* and *Rhynchonelloidella* possess this type.

Among the Tertiary rhynchonelloids considered herein five types of crura are distinguishable, three of which have been identified among Mesozoic genera and have been named. Two types have not been named or described among the Mesozoic genera.

Of the three named types *Hemithyris* belongs to the group having radulifer crura. These are long, slender, and curved but have a horizontally flattened, bluntly pointed distal extremity. The *Hemithyris* crus is strengthened by a narrow ridge on the anterior side. The radulifer type of crus is not common among Recent and modern genera.

The second type of crus known in the Mesozoic and present among modern and Tertiary genera is that characteristic of the Basiliolidae and named falcifer type. The Basiliolidae are all characterized by

having broad-bladed, gently curved crura that are convex outward and gently concave inward. This crus is generally attached to the hinge plate by its convex side and may or may not be separated from the socket ridge by outer hinge plates.

The third type of named crus is that characterizing the Erymnariidae and called septifer type. This is an extremely rare type of crura known in a few genera only.

A fourth type of crus is recognized in the Cryptoporidae. The crura are long and slender and appear to be continuous with the distal end of the socket ridge. The distal extremity of the crus is commonly flattened, expanded, and serrate or digitate, some examples suggesting a tiny hand with outspread fingers. The name *"manicu-lifer"* is proposed for this type.

The fifth type of crus in the modern and Tertiary genera is generally shorter than the others, laterally compressed, somewhat flat in section and attached to the hinge plate or socket ridge so that the short direction is nearly vertical or slightly oblique. This type is best seen in *Frieleia,* but *Grammetaria, Hispanirhynchia,* and *Compsothyris* have similar crura. This type is here designated as *"spinulifer."*

Median ridges, median septa and camerae.—A conspicuous feature of many rhynchonelloid stocks is the median septum. Some groups however, such as the Basiliolinae, are devoid of septa in the brachial valve. The most conspicuous septum in any modern rhynchonelloid is that of *Cryptopora* in which, although short, it is so elevated that it almost touches the inner surface of the opposite valve. The septum of *Frieleia* is also considerably elevated.

In the descriptions below a distinction is made between median septa and median ridges. The term septum is reserved for the thin blades, like those of *Cryptopora* or *Frieleia* that stand boldly and abruptly above the inner valve surface. These are in contrast to the ridges such as that of *Aetheia,* which is low, short, and stout, and that of *Aphelesia* which is low, long, and slender. Dorsally aseptate rhynchonelloids are commonly provided with low and inconspicuous median ridges, some in the form of a myophragm but others buttressing the cardinalia.

In a few genera of Recent and Tertiary, *Frieleia* for example, the median septum joins folds from the inside of the crural bases to form a small chamber at the posterior. In some instances the chamber remains open but it is frequently closed by deposit of shell material on its inner walls to form a thick apical callosity. All degrees occur in *Frieleia* from the open chamber to the solid callosity between the

hinge plates. These do not seem to constitute a *septalium* in the true sense of the word as defined by Leidhold (1928, p. 11) who says that the median septum divides to produce the chamber. Wisniewska (1932, p. 6), on the other hand, states that the septalium of the Mesozoic rhynchonelloids is formed by internal inflection of the hinge plate to meet the median septum. This seems to be the method of formation of this structure in *Frieleia* rather than division of the median septum.

The method suggested by Wisniewska seems certainly to be the case in *Septaliphoria* in which it is possible in some specimens to see the median septum between the lateral walls of the apical chamber. The specimen illustrated (pl. 21, C, fig. 6) shows the plates converging to the median septum and bounding a small chamber. In other specimens the plates bounding the chamber meet the floor of the valve rather than the median septum (see Wisniewska, 1932, p. 26, fig. 6).

In *Camarotoechia* (pl. 4, D, figs. 6-8) the entire structure seems to be different from the Jurassic forms and strongly reminiscent of the orthoids. The sides of the chamber buttress the crura which can be seen buried in excess shell tissue surrounding the plates (Kozlowski, 1929, p. 146, fig. 43, A). Division into hinge plates is difficult. The structures of the modern and Tertiary forms with camera seem more like the Mesozoic species than like the Paleozoic.

EXTERIOR CHARACTERS

It is usually difficult to evaluate the generic characters of the exterior of brachiopods and all workers are not agreed on this evaluation. It is, however, quite clear that ornamentation and folding patterns are generic in character.

Ornamentation.—Buckman (1917) and Rothpletz (1886), who made attempts at the classification of rhynchonelloid brachiopods, mostly used the exterior to make genera or species groups which might ultimately become genera. Both of these classifications fail because ornamentation and folding are repetitious in many unrelated stocks. Buckman attempted to make his genera on the basis of a scheme of ornamentation development: those that are smooth and then develop costae, those that are capillate and develop costae and ornate or spinose forms. These characters were combined with shell outline and anterior folding. Buckman, however, failed to determine the characters of the cardinalia.

Rothpletz (1886) arranged many rhynchonelloid species into groups or "Sippe" having similar external characters. Although he determined the nature of the crura of some species he did not reveal the details

of all of them. Consequently he placed many species together which are utterly unlike internally.

In modern and Tertiary rhynchonelloids a smooth exterior is common, a capillate or costellate exterior is also fairly common, but a strongly plicate exterior is unusual, occurring in only a few genera. *Rhytirhynchia* is similar to *Basiliola* but differs exteriorly by its anterior costation. *Notosaria* and *Tegulorhynchia* are the only completely strongly costate modern rhynchonelloids. *Rhynchonella grayi* Woodward, the true generic affinities of which are with the Eocene genus *Eohemithyris,* is partially costate but not so strongly costate as the Patagonian genus *Plicirhynchia.*

Folding.—The anterior commissure of most rhynchonelloids is uniplicate but some of them are sulcate or even more complicated. The production of a fold is thought to be related to the feeding habits of the brachiopod, the median fold helping to channel the excurrent stream at midvalve.

Sulcation, brachial valve with sulcus, pedicle valve with fold, is not a common feature of the brachiopods but crops up again and again in many unrelated stocks, producing confusing heterochronous and isochronus homeomorphs. *Neorhynchia* is the only known Recent sulcate rhynchonelloid, but another modern deep-sea form, *Abyssothyris,* is a terebratuloid having a shape identical to that of *Neorhynchia.* If it were not for the punctae of *Abyssothyris* it would be almost impossible to tell the two genera apart on exterior characters alone. Rhynchonelloids of almost identical form to *Neorhynchia* are known from all the periods of the Mesozoic era and from the Paleozoic back at least as far as the Devonian. It is difficult to suggest any reason for the reversal of folding from the usual uniplicate condition because the two types must have functioned in the same manner. It is a common feature of the young brachiopod to have a more robust pedicle valve more or less prominently folded in the ventral direction and with a somewhat sulcate brachial valve. Perhaps sulcation is merely a retention of youthful shell characters into the adult stages.

Several of the modern and Tertiary brachiopods have rectimarginate anterior commissures. This, too, is a youthful character. Buckman emphasized the folding of brachiopods and used this feature as a major part of his classification. It is evident, however, from the above remarks and known brachiopod history that folding is of value only as a generic character. When combined with ornamentation features as Buckman advocated, valid genera have been established. These however can only be placed in their proper families by determination of their beak and cardinalia characters.

RHYNCHONELLOID CLASSIFICATION

Very few comprehensive works have ever been written on the rhynchonelloids. The first to have attempted a detailed classification of these difficult shells was Rothpletz (1886), who divided them into seven species groups and numerous subdivisions of these groups based on exterior details. Although Rothpletz carefully defined the interior of some of the Jurassic rhynchonelloids, using strictly modern methods, he did not bring the information into his classification. Some of Rothpletz's groups and subdivisions bring together species now known to have nothing in common except exterior form. Besides overlooking details of anatomy in his classification, Rothpletz also composed unlikely assemblages from various parts of the geological column.

Bittner's (1890, 1892) great works on the Triassic brachiopods defined in exquisite detail some of the rare and unusual spiriferoids but neglected interior features of the rhynchonelloids except for a few forms. The Triassic rhynchonelloids are a prolific lot and will amply repay in new information a modern, detailed study. Bittner added only a few genera but left many for the future. He, too, was content to work chiefly on exterior details even though the method of serial sectioning was well known and even used by him in some cases.

Hall and Clarke (1894) described many rhynchonelloid genera but never made a serious attempt at classification. They did, however, show the importance of internal characters and described these details in many Paleozoic genera.

Weller (1910) used the serial-section method to make known the details of many rhynchonelloid genera, but he did not go beyond genus making. His work was important for showing that a combination of interior and exterior details is necessary for the correct elucidation of rhynchonelloid descent. He indicated several genera that had interior details like those of *Camarotoechia* but were quite unlike that genus in exterior details. He had, therefore, no other choice than to create new genera for them.

The greatest strides in the understanding of the rhynchonelloids came in Buckman's classic work on the Jurassic brachiopods of Burma and Great Britain. Buckman also proliferated genera more than anyone before him. In his work he relied almost wholly on exterior characters, first on the kind of ornamentation and then on the type of folding of the anterior commissure. These features were supplemented by some details of the interior such as the septa and the muscle scars which were exhibited by a process of calcining the shells.

Unfortunately most of the interior characters developed by Buckman are of secondary importance compared with the cardinalia, which he did not develop. He made no effort to learn the details of these features by serial sectioning as since used by many British authors.

A necessary task of the future is to determine the cardinalia characters of the Buckman genera and then to sort these genera into families based on these characters. It seems likely that most of Buckman's genera will prove useful because the exterior features of most of them are distinctive. It will probably be found that some of these ornamentation patterns will be repeated in combination with various cardinalia patterns. The result will be a further, but necessary, proliferation of genera, but a considerably better understanding of Jurassic genera will be forthcoming. In this connection the writer has determined the interior features of a number of Jurassic rhynchonelloids by etching the shell from limestone. These show the cardinalia of *Septaliphoria* in combination with exterior characters indicating more than one genus. Another interesting feature is variations of the septaliphore interior that promise to be of great interest. Silicified Mesozoic rhynchonelloids occur in South America, Israel, Africa, and elsewhere, and should be sought and prepared because they offer the best opportunity for understanding interior details.

Leidhold (1921, 1922) wrote several papers elucidating the interior of the rhynchonelloid shell. His work in 1921 defined the interior of *Septaliphoria* and two other genera, but he did not make any strides in classification of these brachiopods.

Schuchert, in Schuchert and LeVene (1929), took a stride forward in rhynchonelloid classification when he separated the Camarotoechiidae from the Rhynchonellidae. Unfortunately, however, he did not define the characters of the family. Even with this family divided into three subfamilies Schuchert has many forms of unlike structure classified together. He states that the "Classification into families [of the Rhynchonellacea=Rhynchonelloidea] is not yet satisfactory." No attempt was made to subdivide the Mesozoic and later forms except to group them according to geological periods, and to recognize the Dimerellidae of Buckman.

Thomson (1927, pp. 145-164) discussed Recent and Tertiary rhynchonelloids in detail and made many interesting observations on them. He also assigned the genera to two families. The peculiar and primitive *Cryptopora* was assigned to the Dimerellidae where it seems very unhappy and the rest of the genera were put in the Rhynchonellidae where they are likewise out of place.

Pettit (1950, 1954), in revising the Cretaceous rhynchonelloids of Great Britain, described some details of their interior but his work is disappointing in this respect. In some instances the interior was described by serial sections when direct preparations should have been less time consuming, easier to make, and far better understood. Owen (1955, p. 369) recently described a method for making serial sections of brachiopods preserved in chalk. In the writer's opinion the serial-section method should be a last resort when all others fail. Chalk brachiopods are easy to prepare directly. The serial-section method is destructive of material and the interior characters may be obscured by old age growth and inner injury. Sectioning is far less satisfactory than direct observation unless it is the only course that can be taken.

Rzhonsnitzkaia (1956, p. 125) presented an abstract and outline of a new classification of the order Rhynchonellida of Moore 1952. This classification is more elaborate and complete than any hitherto published but the families are not defined and the characters on which they are based are not stated. Family splitting of the rhynchonelloids has been so long needed that the characters of some of Rzhonsnitskaia's new families and subfamilies are quite obvious. For a few, however, they are not so clear. Among the younger rhynchonelloids the only new category introduced is the Hemithyrinae, which will probably receive general acceptance, and is here elevated to family status.

FAMILY AND GENERIC ARRANGEMENT AND CHARACTERS

This brief survey of rhynchonelloid classification indicates that fundamental work is still to be done on the group. These shells are difficult, but they can be made to yield good interiors by simple methods of manual preparation or by serial sectioning. The writer attempts below to group into families the Recent and Tertiary rhynchonelloids on the basis of their interior details combined with features of the exterior. The cardinalia characters in their over-all pattern are, in accordance with his work on the orthoids, triplesioids, pentameroids, and several other groups, regarded as of family rank. Some details of the cardinalia are generic but mostly they help to define families. The generic characters are found in minor interior details combined with ornamentation features and beak characters of the pedicle valve. This is well shown by the number of genera in the Paleozoic that have the internal characters of *Camarotoechia* but vary in external form and ornamentation: *Paraphorynchus, Camarotoechia,* and *Pugnoides* are examples. The principle is well exemplified by the families described below.

Family CRYPTOPORIDAE Muir-Wood, 1955.—Primitive rhynchonelloidea having a large deltoid foramen slightly restricted by elongate, triangular, elevated deltidial plates; crura long, maniculifer, continuous with the socket ridges; median septum strongly elevated; cardinal process a lobate thickening between the socket ridges; one pair of nephridia.

Genera: *Cryptopora* and *Mannia.*

Cryptopora.—Triangular in outline, exterior smooth.

Mannia.—Exterior spinose, with spoon-shaped expansion of median septum of brachial valve (validity of genus in question, see text, p. 22).

BASILIOLIDAE Cooper, new family.—Smooth or semicostate rhynchonelloids having conjunct deltidial plates and small auriculate foramen; pedicle valve with dental plates varying from nearly obsolete to strong, pedicle collar well developed; brachial valve with broad falcifer crura supported by outer hinge plates or the socket ridge; no median septum but a median ridge may be present.

Subfamilies: BASILIOLINAE, APHELESIINAE, and AETHEIINAE.

BASILIOLINAE Cooper, new subfamily.—Basiliolidae with crura attached to broad outer hinge plates; no median septum.

Genera: *Basiliola, Eohemithyris, Neorhynchia, Rhytirhynchia, Probolarina,* and *Streptaria.*

Basiliola.—Brachial valve much deeper than the pedicle valve; pedicle collar elaborate; exterior smooth; anterior commissure strongly uniplicate.

Eohemithyris.—Valves subequal in depth, smooth to semicostate; anterior commissure uniplicate.

Neorhynchia.—Deltidial plates disjunct; exterior smooth but anterior commissure sulcate; incipient inner hinge plates.

Rhytirhynchia.—Outline like that of *Basiliola* but anteriorly costate; anterior commissure sulciplicate.

Probolarina.—Beak elongated; deltidial plates well exposed; anterior half strongly costate; elaborate pedicle collar; anterior commissure uniplicate.

Streptaria.—Exterior smooth to semicostate; anterior with sides twisted; foramen with reflected rim; dental plates reduced; pedicle collar poorly developed.

APHELESIINAE Cooper, new subfamily.—Basiliolidae with crura attached directly to side of socket ridge; thick median ridge present in brachial valve.

Genus: *Aphelesia.*

Aphelesia.—Smooth to anteriorly costate; anterior commissure uniplicate.

AETHEIINAE Cooper, new subfamily.—Basiliolidae having a minute

foramen, concave deltidial plates, reduced to obsolete dental plates and thick inner hinge plates.

Genera: *Aethcia* and *Patagorhynchia.*

Aethcia.—Elongate triangular in outline and exterior smooth.

Patagorhynchia.—Costellate and anteriorly imbricate.

Family Hemithyridae Rzhonsnitzkaia, 1956 [proposed as a subfamily].—Rhynchonelloidea with strong, slender, curved radulifer crura attached to small outer hinge plates by their posterodorsal face or to thick socket ridges; crura distally pointed and horizontally flattened.

Genera: *Hemithyris, Notosaria, Tegulorhynchia,* and *Plicirhynchia.*

Hemithyris.—Beak long, surface striate to costellate; deltidial plates disjunct.

Notosaria.—Beak short; exterior costate; nonimbricate; deltidial plates disjunct.

Tegulorhynchia.—Costellate to costate, strongly imbricate to spinose; deltidial plates conjunct?; medium septum reaching apex.

Plicirhynchia.—Long beak, posterior striate to costellate, anterior costate to plicate; deltidial plates conjunct.

Frieleiidae Cooper, new family.—Usually capillate to costellate valves with triangular outline, strong dental plates, and brachial valve with short, straight, laterally compressed spinulifer crura supported by short plates that unite with the median ridge or septum to form a small chamber.

Genera: *Frielcia, Compsothyris, Grammetaria.*

Frielcia.—Elongate shells with the pedicle valve having the greater depth and the brachial valve with a high median septum; anterior commissure rectimarginate to ligate; deltidial plates disjunct; inner hinge plates extravagantly developed.

Compsothyris.—Roundly triangular in outline; valves of subequal depth; median septum only moderately elevated and deltidial plates disjunct; anterior commissure gently uniplicate; inner hinge plates incipiently developed.

Grammetaria.—Elongate, costellate shells with rectimarginate anterior commissure, low, thick median septum, and conjunct, strongly auriculate deltidial plates; inner hinge plates incipient.

Hispanirhynchiidae Cooper, new family.—Triangular, capillate rhynchonelloidea having a weak median ridge or no median ridge in the brachial valve; crura spinulifer; anterior commissure rectimarginate to ligate.

Genera: *Hispanirhynchia* and *Sphenarina.*

Hispanirhynchia.—Deltidial plates disjunct and median ridge of brachial valve low and thick; inequivalve, the pedicle valve being the deeper; inner hinge plates strongly developed.

Sphenarina.—Deltidial plates conjunct; subequivalve; brachial valve with no median ridge; slight or no development of inner hinge plates.

ERYMNARIIDAE Cooper, new family.—Rhynchonelloidea having septifer crura.

Genus: *Erymnaria.*

Erymnaria.—Exterior smooth, inequivalve; anterior commissure uniplicate to twisted; deltidial plates conjunct; the brachial valve having the greater depth.

Family CRYPTOPORIDAE Muir-Wood 1955

Genus CRYPTOPORA Jeffreys, 1869

Plates 1, A, B, 2, A, 5, C, 21, D; text figure 1A

Cryptopora Jeffreys, Nature, vol. 1, p. 136, 1869 (inadequately described, not figured); Thomson, Geol. Mag., n. s., dec. 6, vol. 2, pp. 387, 388, 392, 1915; Thomson, New Zealand Board Sci. Art, Manual 7, p. 146, 1927.

Atretia Jeffreys, Proc. Roy. Soc., vol. 18, No. 121, p. 421, 1870 (inadequately described, not figured); Ann. Mag. Nat. Hist., ser. 4, vol. 18, p. 250, 1876; Proc. Zool. Soc. London, p. 412, 1878; Davidson, Trans. Linnaean Soc., ser. 2, vol. 4, pt. 2, p. 173, 1887. Not *Atretium* Cope, 1861.

Neatretia Fischer and Oehlert, Exped. Sci. *Travailleur* et *Talisman*, p. 122, 1891.

Mannia Davidson, Geol. Mag., dec. 2, vol. 1, No. 4, p. 156, 1874(b).

Small, translucent to transparent, subtriangular in outline with the greatest shell width anterior to the middle; subequivalve; anterior commissure rectimarginate to broadly sulcate; surface smooth. Beak of the pedicle valve moderately long, pointed, nearly straight; foramen large, incomplete, not restricted; deltidial plates rudimentary, forming a ridge on the delthyrial edge, auriculate to alate. Shell fiber mosaic coarse.

Pedicle valve interior with small noncorrugated teeth; apex with thickened plate elevated above valve floor; teeth supported by strong, divergent dental plates. Muscle scars not well impressed.

Brachial valve interior with small, smooth or roughened sockets bounded by high socket ridges; socket ridge overlying crural base; crura of maniculifer type, long and slender, slightly curved, expanded distally and commonly with the distal edge deeply digitate. Cardinal process small, bilobed and transverse. Median septum high anteriorly but sloping steeply to the valve floor posteriorly and disappearing anterior to the apex; anterior face of septum steep. Adductor scars lightly impressed. One pair of metanephridia in the fleshy body of the animal.

Type species (by monotypy).—*Atretia gnomon* Jeffreys. Ann. Mag. Nat. Hist., ser. 4, vol. 18, p. 251, 1876.

Comparison.—This is a very distinctive little brachiopod and cannot be confused with any other modern form. It is characterized by a yellowish to white and shiny, transparent to translucent shell having peculiar deltidial plates, long, slender maniculifer crura and a short, high, slender median septum. The only described genus similar to it is *Mannia* which is said to differ in the form of the septum and the possible presence of spines on the exterior. (See *Mannia.*)

Cryptopora has frequently been compared with the Triassic genus *Dimerella* but the two are actually very different. The median septum of the brachial valve of *Dimerella* has a different form, the deltidial region of the Triassic shell is different, and the dental plates are much less strongly developed than those of the modern genus. The exterior of the two genera is also quite different, the Triassic shell being wide with a fairly wide hinge and costellate exterior. The modern genus on the other hand is narrowly triangular and smooth.

Geological horizon.—Cryptopora was recorded from the Eocene (Salt Mountain formation) by Toulmin (1940, p. 229). It is also known from the Oligocene of Cuba and Miocene of Europe (see below and *Mannia*).

Thomson (1927, p. 147) cites *Rhynchonella discites* Dreger from Vienna, *R. lovisati* Dreger from Sardinia, and *Hemithyris parvillima* Sacco from Italy, all from the Miocene, as possible fossil examples of *Cryptopora.* Thomson also cites *Terebratella acutirostra* Chapman, a possible synonym of *C. brazeri* from the Miocene of Victoria, Australia, as another fossil species. The geological range is therefore from Eocene to Recent.

Distribution.—In the North Sea and North Atlantic south to Cuba in waters ranging from 75 to 2,200 fathoms. In the Southern Hemisphere it occurs off New South Wales in 17 to 100 fathoms, and on southern Agulhas Bank, South Africa, in 500 to 565 meters or about 275 fathoms.

Assigned species.—The one Eocene form known was not named but species are known from the Miocene and in modern waters:

Atretia gnomon Jeffreys, Recent, North Atlantic.
A. brazeri Davidson, Recent, east Australia.
Cryptopora boettgeri Helmcke, Recent, southern Agulhas Bank, Africa.
C. rectimarginata Cooper, Recent, East coast Florida, Cuba.
? *Rhynchonella discites* Dreger, Miocene, Vienna.
? *R. lovisati* Dreger, Miocene, Sardinia.
? *Terebratella acutirostra* Chapman, Miocene, Australia.
? *Hemithyris parvillima* Sacco, Miocene, Italy.
Mannia nysti Davidson, Miocene, Belgium.

Discussion.—This genus differs strongly from other modern and Tertiary rhynchonelloids except *Mannia* which is discussed below. The form of the median septum and crura are unique and the deltidial plates are formed differently from those of the other rhynchonelloid genera.

The deltidial plates of *Cryptopora* are disjunct throughout life. The foramen is not greatly restricted by these plates because they usually grow at a high angle to the edge of the delthyrium rather than being a continuation of it. The foramen is thus incomplete and not circular but is deltoid and roughly parallel to the delthyrial margins.

The deltidial plates are small and elongate triangular, forming on the delthyrial margin at a high angle and commonly reflected laterally to overhang the dorsolateral slopes of the beak. In *Cryptopora rectimarginata* Cooper, new species, the deltidial plates are strongly alate, the projections being located near the posterior of the plate and narrowly rounded, bluntly pointed or rarely serrated. In the older shells the blunt points disappear.

The apex of the pedicle valve is occupied by a small elevated triangular plate against which the pedicle rests. A plate similar to this appears in other genera, such as *Hemithyris.* Aside from the strong dental plates the pedicle valve reveals no other structures. The shell is so thin that muscle scars cannot be seen easily. A suggestion of a low myophragm appears in some specimens.

The cardinalia of the brachial valve are unusual. The socket plates are small and delicate, appear to be continuous with the crural bases and lie above or posterior to them. The socket plates are attached directly to the shell wall and buttressed for a short distance by a small supporting plate. The crura are long and welded with the crural bases and supporting plates in such a way that they appear to make one plate. The main part of the crura are strong but slender and are bowed outward to a considerable degree in older specimens, less so in the young ones. The distal extremity is flattened laterally and the free end serrated or frayed into a number of small prongs. The whole suggests a tiny hand with outstretched spreading fingers or a flattened fist.

The diductor muscles were attached to a bilobed boss or cardinal process at the posterior apical part. This is somewhat thickened in old shells, the thickening spreading to the base of the crura and uniting with an extension of the median septum.

The most conspicuous feature of the brachial valve is the median septum. It is highest at about midvalve but descends rapidly posteri-

orly to disappear before reaching the apex in young shells. In old specimens a low extension of the septum extends to the apex where it unites with a thickening from the cardinal process. The septum thus makes a narrow wedge extending ventrally almost to the inner wall of the pedicle valve.

I have not observed the radial striae reported by Dall (1920, p. 293) in young shells.

The fossil species assigned doubtfully to *Cryptopora* may be the young of other species. The gaping foramen and rudimentary deltidial plates are suggestive of young rhynchonelloids. Meznerics (1943, p. 23) points out that Sacco believed *H. parvillima* to be a juvenile of *H. de buchii=Streptaria buchi.*

I have examined a specimen of *Mannia nysti* Davidson from the Miocene of Belgium. As explained in the discussion under *Mannia,* this specimen has the features of *Cryptopora* but does not conform completely with the description given by Davidson. The description of this genus is evidently inaccurate and the two genera are exact synonyms (see discussion under *Mannia*).

CRYPTOPORA RECTIMARGINATA Cooper, new species

Plates 1, B, 2, A

Atretia gnomon Dall (not Jeffreys), Proc. U. S. Nat. Mus., vol. 57, p. 293, 1920 (U.S.N.M. Cat. Nos. 83131, 274138, 274139, 94367, 336894).

Shell small, translucent to white, subtriangular in outline, with the greatest width anterior to the middle; sides gently rounded; anterior margin strongly rounded; valves subequal in depth; anterior commissure rectimarginate; surface smooth.

Pedicle valve slightly deeper than the brachial valve; lateral profile gently convex, most convex in the posterior third and flattened in the anterior third; anterior profile broadly convex, slightly more convex than the brachial valve in this profile. Beak pointed, forming an angle of about 85°, suberect; deltidial plates erect, thickened along their distal margin, commonly extravagantly auriculate, the auriculations directed laterally.

Pedicle valve interior with thick apical plate well elevated above the valve floor; teeth small, wide; dental plates stout, slightly divergent anteriorly, approximately vertical to the valve floor. Muscle field anterior to delthyrial cavity.

Brachial valve with gently convex lateral profile, the maximum convexity located just anterior to the umbo and posterior to the middle;

anterior profile broadly and gently convex; posterolateral slopes moderately steep; anterior slope long and flattened.

Brachial valve interior with long, approximately parallel crura; socket ridges stout, grown together with the cardinal process which forms a thickening between the socket ridges at the apex; median septum stout, short anteroposteriorly, narrow in profile; adductor scars deeply sunk and forming an elongate track on each side of the median septum.

MEASUREMENTS IN MILLIMETERS

	Length	Brachial length	Width	Thickness
Holotype	5.2	4.4	4.4	1.8
Paratype U.S.N.M. 274143d	5.3	4.7	4.6	1.6

Types.—Holotype, U.S.N.M. 274143a; figured paratypes, U.S. N.M. 274143b, c, d, 274168a, 336895a, and 336896a.

Horizon and locality.—Recent, Eolis Station 340, at 209 fathoms off Fowey Light; several other stations off Fowey Light at depths ranging from 85 to 205 fathoms; off Sand Key at 75 to 120 fathoms; off Sambo Reef at 135 fathoms; off Western Dry Docks, at 80 and 90 fathoms; and off Key West at 110 fathoms; all off Florida.

Comparisons.—This species is characterized by its narrowly lenticular profile, the rectimarginate anterior commissure, auriculate deltidial plates, thick cardinalia and short, stout median septum.

Cryptopora rectimarginata differs from *C. gnomon* in several respects. The latter is quite strongly sulcate, whereas the Florida species is rectimarginate; *C. gnomon* is a thicker shell than *C. rectimarginata* and has a longer median septum and does not have the auriculations on the deltidial plates. Helmcke's species *C. boettgeri* likewise does not have the auriculations on the deltidial plates and also has a longer median septum than *C. rectimarginata.* The Australian *C. brazieri* differs from *C. rectimarginata* in having a flattened brachial valve, no auriculations on the deltidial plates, and a longer and more delicate median septum.

A specimen from the Oligocene (Cojinar formation), from Sagua la Grande in Las Villas Province, Cuba (U.S.N.M. 459424a) is strongly suggestive of *C. rectimarginata* because it has auriculate deltidial plates and the form and profile of the Florida species.

Cryptopora rectimarginata appears to be a shallow-water species ranging in depth from 75 to 209 fathoms. *Cryptopora gnomon,* on the other hand, is a deeper-water form. Depth ranges given for specimens

in the U. S. National Museum collection are from 650 to 2,200 fathoms. The Australian species is a shallow-water form found in 100 fathoms. *Cryptopora boettgeri* from off Agulhas Bank, South Africa, is from deeper water, 500 meters (275 fathoms).

CRYPTOPORA GNOMON Jeffreys

Plates 5, C, 21, D

Crytopora gnomon Jeffreys, Nature, vol. 1, Dec. 2, p. 136, 1869.
Atretia gnomon Jeffreys, Proc. Roy. Soc., vol. 18, No. 121, p. 421, 1870; Davidson, Trans. Linnaean Soc., ser. 2, vol. 4, pt. 2, p. 173, pl. 25, figs. 6-13, 1887.
Neatretia gnomon (Jeffreys) Fischer and Oehlert, Exped. Sci. *Travailleur* et *Talisman,* p. 122, figs. 11a-c, 1891.

This is a deep-water form that differs markedly from *C. rectimarginata* in its nonalate deltidial plates, more strongly folded anterior commissure, and other details. Figures are introduced for comparison with the Florida species.

Types.—Figured specimens U.S.N.M. 94367, 44911a, c, d.

Horizon and locality.—Recent, 780 fathoms, off Cuba; 1,525 fathoms at U. S. Fish Commission Station 2221, south of Marthas Vineyard, Mass.

Genus MANNIA Davidson, 1874

Plates 1, A, 21, F; text figure 1, B

Mannia Dewalque, Prodrome d'une Description Géol. Belg., p. 432, 1868 (not described or figured); Davidson, Geol. Mag., dec. 2, vol. 1, No. 4, p. 156 (extract p. 6), 1874(b); Thomson, New Zealand Board Sci. Art, Manual 7, p. 296, 1927.

This interesting little brachiopod [type species (by monotypy), *Mannia nysti* Davidson, 1874] was described by Davidson who indicates that some points of its anatomy are still to be learned. The affinities of *Mannia,* as well as its anatomy, are not clearly understood because some workers have regarded it as a rhynchonelloid but one of the best informed students of brachiopods, J. Allan Thomson, thought that it is a terebratuloid. Its rhynchonelloid affinities, however, now seem clear and unquestionable. Because of the rarity of this species little is known of it but restudy of a good specimen and photographs of the types now make its features clear.

According to Davidson's description, *Mannia* is similar to *Cryptopora* externally as well as internally. The beak region is elongated and pointed and the pedicle opening is elongate triangular. The pedicle opening is bordered by attenuated, triangular deltidial plates as in

Cryptopora. An external difference between the two, on the other hand, is suggested by Davidson's report on the exterior of *Mannia* of "concentric scaly lines of growth, from which scattered adpressed spinules seem to arise." The specimen figured by Davidson is very small. Its measurements are given in lines: length 2 lines=4 mm., width 1½ lines=3 mm.

The pedicle valve interior is not well known, but Davidson (1874b, p. 157) speaks of a "narrow vertical plate" dividing the larger portion of the beak into two parts. However, no indication of a median

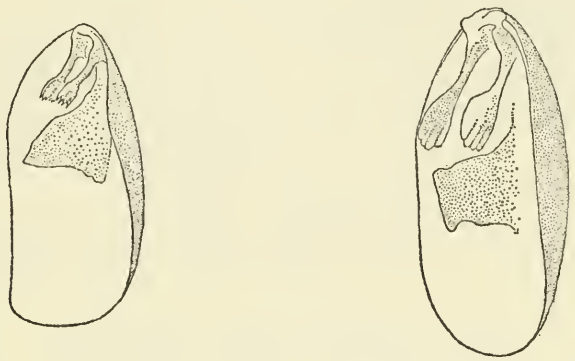

FIG. 1.—Partial side views of the brachial valves of A, *Cryptopora,* ca. × 8, and B, *Mannia,* ca. × 16, showing maniculifer crura.

septum can be seen in the beak region in Davidson's figure 10a, plate 7. Inside the brachial valve the cardinal process is medial and the crura are long but the socket plates are small. In one figure the crura are convergent; in the other they are divergent, but in both they are similar to the crura of *Cryptopora.* Davidson reports them as being broken, which is probably the reason why they are illustrated as not flattened and expanded distally.

The median septum of the brachial valve is illustrated by Davidson as like that of *Cryptopora* in being short and very high. Unlike *Cryptopora,* however, its distal extremity is embellished by "two small triangular plates united posteriorly, separate and angular anteriorly." These form a small spoonlike trough which was interpreted by Thomson (1927, p. 297) as a terebratelliform structure. Thomson goes on to state that the shell of *Mannia* will ultimately prove to be punctate, but Davidson said emphatically that it is impunctate and referred it to the Rhynchonellidae.

I am indebted to Dr. A. Vandercammen and the officials of the Institute Royal des Sciences Naturelles de Belgique for a very fine specimen of *Mannia nysti* from the Upper Miocene (Diestien-Sables de Deurne) from Wommelghem, just east of Antwerp, Belgium. When delivered to me the specimen had both valves attached. Its exterior was photographed and then the valves teased apart with only a small fracturing of the anterior margin of the pedicle valve (see pl. 1, A). Inasmuch as this specimen is essentially a topotype and from the only horizon from which the species is known, it gives an authentic check on Davidson's description and figures.

My obligation to Dr. Vandercammen is still greater because he also sent me notes on Davidson's type lot and an enlarged picture of his types. These and the fine little specimen now make it possible to correct Davidson's description and to refigure the genus with unretouched pictures. The combined result of this reevaluation is to demonstrate beyond reasonable doubt that *Mannia* is *Cryptopora*.

The specimen from Wommelghem is small, having a length of 2.5 mm. and a width of 1.8 mm. The outline is elongate triangular, the beak sharply pointed and the deltidial plates strongly elevated. The exterior appears to be completely smooth, without any trace of concentric, scaly lines or "adpressed spinules." The anterior commissure is rectimarginate. The interior shows a coarse mosaic of shell fibers, a distinctly rhynchonelloid character.

The striking feature of the pedicle valve of this specimen is the strong elevation of the deltidial plates and the large size of the apical plate. The interior of the brachial valve is generically exactly like that of modern *Cryptopora* but specific differences may be readily noted, especially in the crura. These are bowed as in the modern species but the distal expansion is greatly exaggerated in its size and flatness. Furthermore the serrations on its distal extremity are numerous and minute (text fig. 1, A).

Of features recorded by Davidson as characteristic of *Mannia* I was unable to confirm the presence of a median septum in the apex of the pedicle valve. The triangular plates on the distal extremity of the median septum of the brachial valve were not confirmed and the details of the exterior are not in accordance with Davidson's description and figures.

The information and data furnished me by Dr. Vandercammen included a photograph of Davidson's type specimens and the label accompanying them. Five specimens are shown, one complete specimen exactly like that from Wommelghem sent to the U. S. National

Museum, three brachial valve interiors, and one pedicle valve interior. The outside and inside of these specimens are exactly like those of the specimen illustrated on plate 1, A, of this monograph except in one instance. Examination of the pictures of the brachial valve interiors under a magnifier failed to show any expansion of the distal end of the median septum. A possible mixture of species has occurred because the median septum of the largest of the three brachial valves extends anterior to midvalve and nearly to the apex in the opposite direction, is not abruptly elevated as typical, and seems to have different crura. This appears to belong to some other genus but it is difficult to say what it is. The other two are quite characteristic of *Cryptopora*. The complete specimen is illustrated from the dorsal side and shows the characteristic large foramen bordered by narrow deltidial plates. I am unable to distinguish the details of the pedicle valve interior from the picture.

Davidson was a keen observer but it is difficult to escape the conclusion that his figures of *Mannia* are a misrepresentation of specimens of *Cryptopora*. I have therefore placed *Mannia* in the synonymy of *Cryptopora*.

BASILIOLIDAE Cooper, new family

Basiliolinae Cooper, new subfamily

Genus BASILIOLA Dall, 1908

Plates 11, B, 12, 13, B, 14, A, C

Basiliola Dall, Bull. Mus. Comp. Zool., Harvard Coll., vol. 43, No. 6, p. 442, 1908; Thomson, New Zealand Board Sci. Art, Manual 7, p. 154, 1927; Jackson and Stiasny, *Siboga*-Exped., Monogr. 27, p. 10, 1937.

Basiola Thomson, Geol. Mag., n. s., dec. 6, vol. 2, p. 390, 1915 (Lapsus calami).

Neohemithyris Yabe and Hatai, Proc. Imp. Acad. Japan, vol. 10, No. 9, p. 587, 1934; Hatai, Sci. Rep. Tôhoku Imp. Univ., ser. 2 (Geology), vol. 20, p. 210, 1940.

Outline elongated subpentagonal to rounded subpentagonal; widest at about midvalve; strongly inequivalve, the brachial valve being greatly swollen but the pedicle valve gently convex; anterior commissure strongly uniplicate but the fold on the brachial valve low and inconspicuous; surface smooth. Beak of pedicle valve small, nearly straight, short; foramen small, complete circular to elongate-elliptical, submesothyrid; deltidial plates small, conjunct, moderately to elaborately auriculate.

Pedicle valve interior with strong and complex pedicle collar; teeth small and corrugated, supported by short receding dental plates which

define shallow and narrow umbonal chambers. Muscle field short and narrow, the diductors surrounding the large adductors and with small adjustors in a posterolateral position. Pallial marks strongly impressed, the vascula media extending from the anterolateral end of the muscle field to converge anteriorly on the long tongue. Lateral branches few.

Brachial valve interior with deep corrugated sockets bounded by strong socket ridges; crura of falcifer type, moderately long crescentic in section, scimitarlike and attached to the socket ridges by prominent outer hinge plates. Inner hinge plates absent. Vascula media widely divergent.

Type species (by original designation).—*Hemithyris beecheri* Dall, Proc. U. S. Nat. Mus., vol. 17, p. 717, pl. 31, figs. 1-4, 1895.

Comparison.—*Basiliola* is characterized by its smooth shell, elaborate pedicle collar, conjunct and auriculate deltidial plates, small round to longitudinally elliptical foramen and the broad outer hinge plates of the cardinalia. *Basiliola* differs from *Rhytirhynchia,* which it otherwise resembles, in lack of anterior costation. It differs from *Aetheia* in the nature of the foramen and the lack of inner hinge plates in the cardinalia. *Aphelesia* is similar externally to *Basiliola* and has a similar foramen but its cardinalia are quite distinct in lacking outer hinge plates. *Basiliola* differs from *Probolarina* by its smooth exterior.

Geological horizon.—*Basiliola* is known from Pliocene to Recent.

Distribution.—The known Pliocene species of *Basiliola* are from Okinawa. Yabe and Hatai (1935) identified one Okinawa form as *Neohemithyris lucida* and identified its age as Pleistocene. Cooper (1957) described specimens of this species from the same place as new, and another, not named, in addition. Furthermore, the U. S. Geological Survey now dates the beds producing these specimens as late Pliocene. So far as known these are the only fossil basiliolas known.

Basiliola occurs in modern seas around the Hawaiian Islands, Japan, Fiji, Borneo, Malay Archipelago, the Celebes, and Philippine Islands.

Bathymetric range.—Each of the species assigned here to *Basiliola* has a different bathymetric range and different temperature tolerance. *Basiliola beecheri* ranges in depth from 143 fathoms down to 313 fathoms, and the temperature range is 43.8° F. to 60.8° F. *Basiliola pompholyx* usually occupies deeper water, from about 150 fathoms (275 meters, Jackson and Stiasny, 1937, p. 10) down to 1,105 fathoms, and with a temperature tolerance between 43.3° F. and 52° F. *Basiliola elongata* occurs in 24 fathoms but the temperature is not known.

Another specimen, possibly the same species, is from 153 fathoms. *Basiliola lucida* is from waters of 56 fathoms down to 122 fathoms and the temperature range is from 51° F. to 63° F.

Assigned species.—The following species are assigned to *Basiliola:*

Hemithyris beecheri Dall, Recent, Hawaiian Islands.
Basiliola pompholyx Dall, Recent, Philippines.
Rhynchonella lucida Gould, Recent, Japan.
Basiliola nitida Cooper, Pliocene, Okinawa.
B. elongata Cooper, new species, Recent, Philippines.

Discussion.—*Basiliola* with its strongly unequal valves and small foramen bounded by auriculate deltidial plates is usually easy to recognize. The shells range from hyalescent when living to opaque in the older or dead shells. The color ranges from pale yellow-brown to brownish gray. The anterior commissure is usually strongly folded in the dorsal direction, a long tongue from the pedicle valve fitting into the deeply reentrant brachial valve. Although the anterior uniplication is strong, the fold on the brachial valve is not, as a rule, well defined. Except for the uniplicate commissure the valves are not otherwise plicated, nor do they have any radial markings.

Aside from the smooth shell and uniplication the only other distinctive exterior feature of *Basiliola* is the beak. This is generally not much elongated but is bluntly pointed. The foramen is usually small circular, longitudinally oval, or elongated elliptical. The anterior side of the foramen is usually bounded in all the species by a moderate to elaborate flange or auriculation. In *B. beecheri* and *lucida* this is present but not as exceptionally developed as in *B. pompholyx.*

The deltidial plates are conjunct and often so tightly joined as to approximate a symphytium. The anterior margin of the deltidial plates commonly rests on the umbo of the brachial valve. In old shells the movement of the umbo against the anterior margin of the deltidial plates leaves a smooth area. In some specimens an extension grows anteriorly from the anterior margin of the deltidial plates along the surface of the umbonal slope of the brachial valve. This usually is part of the pedicle collar.

The chief character on which Dall based his genus is the pedicle collar and which is elaborate in many specimens. It is best seen in *B. pompholyx* (pl. 12, fig. 10) although it is well developed in the other species. The collar is built as a plate from the anterior edge of the deltidial plates as mentioned above and extends around the inside of the apex. The collar in many specimens is clear of the valve floor but in others shell substance has been added under the free anteroventral edge.

The muscle field of the pedicle valve is generally small in all species but it is also deeply excavated into the shell. The individual scars are usually strongly impressed. The diductor scars are small for such large shells, are somewhat rectangular in form, and surround the moderately large adductor patch. The adjustor scars are small and are located just anterior to the front edge of the dental lamellae. Posterior to the main part of the muscle field and within the delthyrial cavity the floor of the valve is considerably thickened. Here two small scars, the accessory diductors, are located.

The genital area is small and is situated on the sloping sides of the shell just anterior to the dental plates. The teeth are small, corrugated, and are supported by thin dental plates that are nearly obliterated in some specimens by thickening of the inside of the shell and filling of the umbonal cavities.

A prominent feature of *Basiliola* is the strong development of the pallial markings. One main pair of pallial trunks, the vascula media, originates between the diductor and adjustor muscles. A subsidiary pair of trunks, the vascula genitalia, originates at the same place but extends posterolaterally to surround the genital area. The vascula media extend slightly anterolaterally to just beyond midvalve where they branch. The main vascula media then extend slightly anteromedially to terminate on the outside of the tongue. The other branches at midvalve extend laterally where they divide. One branch swings posteriorly near the valve margin to die out just before reaching the teeth. The other branch extends anterolaterally. Short vascula terminalia are given off from the outside anterior part of the vascula media and their lateral branch, the vascula arcuaria.

The cardinalia of the brachial valve are characterized by the wide and flat outer hinge plates to which are attached concave scimitarlike falcifer crura. These are concave inward and are blunt at their distal extremity. The crural blades are slightly oblique or nearly vertical as viewed from the posteroventral side. The distal edge of the crura facing the pedicle valve are usually finely serrate.

No median septum is present but in some specimens the elongated adductor field is divided medially by a faint myophragm. The adductor scars are small and elongated. The posterior pair is much smaller than the anterior pair. The genital area is small like that of the pedicle valve and is surrounded anteriorly and laterally by vascula genitalia that connect with the posterior end of the vascula media. The major trunks in the brachial valve are like those of the pedicle valve. The vascula media originate at the outer ends of the adductor field and

extend anteriorly, generally following the outer slope of the median trough formed by the fold. The vascula media branch at midvalve and the branches form a course similar to those of the opposite valve.

The genus *Neohemithyris* as defined by Yabe and Hatai in 1934 is identical to *Basiliola.* The authors of this genus emphasize the conjunct deltidial plates and the nature of the foramen. Specimens of *Rhynchonella lucida* Gould, type species of *Neohemithyris,* have been compared with *B. beecheri* and proved generically identical. In fact the Japanese species suggests immature *B. beecheri.*

Specimens (U.S.N.M. 499321) from Vanua Mbalavu, Lau, Fiji, referred by Ladd and Hoffmeister (1945, pp. 329-330) to *Neohemithyris lucida,* are young forms having the characters of *Basiliola.* The genus *Basiliola* thus proves to have a far wider range in the Pacific than hitherto believed.

BASILIOLA ELONGATA Cooper, new species

Plate 14, C

Not *Basiliola pompholyx* Dall, Proc. U. S. Nat. Mus., vol. 57, p. 292, 1920 (U.S.N.M. 235844 and 300266).

Shell thin, of about medium size, elongate oval in outline; greatest width anterior to the middle; beak acute, forming an angle of about 80°. Anterior margin nearly straight; anterior commissure moderately uniplicate; valves subequal in depth, the brachial valve being slightly deeper than the other; surface marked only by concentric lines of growth.

Pedicle valve gently convex in lateral profile, with the maximum convexity in the posterior half; anterior profile broadly but gently convex; umbonal region moderately and narrowly swollen and with steep lateral slopes; sulcus originating just anterior to the middle, broad and shallow; tongue short and abruptly truncated; flanks gently inflated and with gentle slopes. Foramen elongate-oval, fairly large; deltidial plates conjunct and with a marked lip on the anterior side of the foramen.

Brachial valve fairly evenly and moderately convex in lateral profile; strongly convex in anterior profile; umbonal and median regions inflated; umbonal slopes steep; fold originating at about midvalve, in the anterior third slightly elevated above the surrounding flanks which are moderately swollen and steep sided.

Pedicle valve interior with small teeth and short, inconspicuous dental plates; diductor field moderately large, flabellate not strongly inserted; genital areas narrowly crescentic; pallial marks not strongly

impressed. Brachial valve interior with long, stout, slightly curved crura and moderately wide outer hinge plates.

MEASUREMENTS IN MILLIMETERS

	Length	Brachial length	Greatest width	Thickness
Holotype	14.8	13.7	13.4	8.9
Figured paratype	15.8	13.8	13.2	9.0

Types.—Holotype, U.S.N.M. 235844a; figured paratype, U.S.N.M. 235844b.

Locality.—U. S. Bureau of Fisheries Station 5146 at 24 fathoms, off Sulade Island, Tapul Group, southern Philippines.

Discussion.—This pretty little species is listed by Dall (1920, p. 292) as *B. pompholyx* but it is a proportionally much longer shell and with completely different outline. Compared with the growth lines of specimens of *B. pompholyx* corresponding in length to those of *B. elongata* the two species prove to be quite distinct.

Basiliola elongata is intermediate between *B. beecheri* and *B. lucida.* It is larger than the latter but smaller than the former although its outline is similar. The Hawaiian shell is stouter and has somewhat stronger shoulders than *B. elongata.* The Japanese *B. lucida* is also less elongated than the new species.

Inside the brachial valves of these three species *Basiliola elongata* has the longest crura whereas *B. pompholyx* has shorter crura relative to *B. elongata* and *B. beecheri.*

It is interesting to note that the bathymetric range of most of the specimens of *B. pompholyx* listed by Dall (1920) is deeper than 300 fathoms except for the new species and specimen U.S.N.M. 300863 which appears to be referable to *B. elongata.*

The specimen mentioned by Jackson and Stiasny (1937, p. 10) as very small and coming from Kei Island is suggestive of the new species. This is cited by them as a juvenile.

Genus EOHEMITHYRIS [1] Hertlein and Grant, 1944

Plates 5, A, 8, B, 15, B, 20, A, B, 22, A

Eohemithiris Hertlein and Grant, Publ. Univ. California at Los Angeles, Math. and Phys. Sci., vol. 3, p. 55, 1944.

Subpentagonal in outline, thick shelled, coarsely fibrous, translucent to transparent; subequivalved, the brachial valve having a slightly

[1] The spelling of *Eohemithiris* is here corrected to *Eohemithyris* to make it coincide with the corrected spelling of *Hemithyris.* Inasmuch as *Eohemithiris*

greater depth than the pedicle valve; anterior commissure uniplicate, the fold being broad and gentle; beak erect, small, inconspicuous; foramen small, round, slightly auriculate, submesothyrid; deltidial plates conjunct. Surface smooth but with obscure anterior costation in old individuals.

Pedicle valve with narrow delthyrial cavity bounded by short dental plates plastered against the shell wall; vascula media short, prominent.

Brachial valve with short, slender socket ridges bounding narrow corrugated sockets; outer socket plates moderately broad and shallow, attached to long and exceptionally broad falcifer crura; adductor field subcircular, deeply inserted; pallial trunks not impressed.

Type species (by original designation).—*Eohemithiris alexi* Hertlein and Grant, 1944, p. 55.

Comparison.—The entire anatomy of *Eohemithyris* is most like that of *Basiliola* and other members of the Basiliolidae. It differs, however, in being more nearly equivalve, whereas *Basiliola* is strongly inequivalve; the deltidium of *Eohemithyris* is only slightly auriculate and does not have the elaborate development of the pedicle collar seen in *Basiliola.* The pallial marks of *Basiliola* are more strongly developed in all species but those of the type species of *Eohemithyris* are much abbreviated. The outer hinge plates attaching the crura to the socket ridges are narrower in *Eohemithyris* than in *Basiliola.*

Comparison of *Eohemithyris* and *Rhytirhynchia* is essentially the same as that with *Basiliola.* The brachial valve of *Rhytirhynchia* is much deeper than that of *Eohemithyris* but the anterior costation of the former is much stronger than that seen in *Eohemithyris* which seems to be a rare feature.

Eohemithyris is quite suggestive of *Aetheia* in outline and beak characters but differs from it in interior details. No development of inner hinge plates appears to have taken place in *Eohemithyris.*

No other members of the Basiliolidae compare closely with *Eohemithyris.*

Geological horizon.—Eocene (Domengine and Capay formations).

Assigned species.—Four species are assigned to this genus, two fossil and two Recent:

Eohemithiris alexi Hertlein and Grant, Eocene, California.
Eohemithyris? gettysburgensis Cooper, Miocene, California.
Hemithyris colurnus Hedley, Recent, Australia.
Rhynchonella grayi Woodward, Recent, Fiji Islands.

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was thought by its authors to be similar to *Hemithyris* and an early relative of it, the correction of spelling in the latter by Bronn is essential in the former. The spelling of *Eohemithiris* is corrected to *Eohemithyris* in Zoological Record for 1950, p. 21.

Distribution.—The fossil species are from the Eocene and Miocene of California but one Recent form is from off southeastern Australia, and another off the Fiji Islands.

Discussion.—The name chosen for this genus is unfortunate and inappropriate because the interior details now make it clear that it is totally unrelated to *Hemithyris* as its name implies. Relationship to the Basiliolidae seems clear in the broad falcifer crura, the details of the deltidial plates, foramen, and smooth exterior. *Eohemithyris* is the oldest known member of the Basiliolidae but its roots are probably deep in the Cretaceous. It is also interesting that species are living today.

Hemithyris colurnus Hedley is here assigned to this Eocene genus. This Australian species has never been satisfactorily placed and some objections may be raised to assigning it to *Eohemithyris,* an Eocene species now known only from California. In spite of the time gap indicated, close comparison of the California and modern Australian species leaves few anatomical points of difference. The exterior of *H. colurnus* is essentially identical to that of *Eohemithyris alexi.* Both are thick-shelled forms with translucent to almost transparent shells, especially when they are wet. They are both coarsely fibrous. The beak characters of the two are identical. It is not possible to make a comparison of the pedicle collars of the two species because it is very difficult to determine these details in *Eohemithyris.* Actually some uncertainty exists as to whether the fossil species has a pedicle collar, but the area of the beak is so thickened that some sort of tubular arrangement must be present.

Inside the pedicle valve the dental plates of the modern species may be somewhat less prominent than those of the fossil form; dental plates are definitely present in both however. It is to be expected that those of the older species might be better developed than those of the modern form. The delthyrial cavities and muscle areas of the two seem identical; the pallial trunks of the modern form are better impressed but this may be a matter of preservation rather than one of generic distinction.

Inside the brachial valve the crura and hinge plates are almost identical, no features of generic value having been detected. The outer hinge plates are of about the same size, narrower than in *Basiliola* but much wider than in *Aphelesia.* The adductor field of the modern species is deeply impressed as in *Eohemithyris alexi* but the pallial marks of the Recent species are more plainly impressed. The sockets of *H. colurnus* are strongly corrugated but the corrugation of the

Eocene species is not so strong in the specimens examined. This however could hardly be regarded as a generic difference. Other species of *Eohemithyris* can be expected in other Tertiary deposits and should be looked for.

Rhynchonella grayi Woodward is another species that has never been correctly placed generically. Through the kindness of Dr. Helen M. Muir-Wood and the authorities of the British Museum I am able to furnish exterior and interior views of this species. It is clearly very similar to *Hemithyris colurnus* but is more strongly costate in the anterior third. *Eohemithyris alexi* and *colurnus* are both obscurely to definitely costate in the anterior part. Davidson's figures of *R. grayi* greatly exaggerate the plication. The interiors and beak characters of *R. grayi* are clearly identical to those of *E. colurnus* and *E. alexi,* except for the swellings of shell material on the hinge plate, consequently the species is assigned to *Eohemithyris.* The shell profile and beak characters exclude *R. grayi* from assignment either to *Basiliola* or *Rhytirhynchia.* Lack of inner hinge plates separates *R. grayi* from *Aetheia* which, except for the anterior costation, it otherwise resembles in its exterior characters.

EOHEMITHYRIS? GETTYSBURGENSIS Cooper, new species

Plate 8, B

Shell large, subpentagonal in outline, slightly wider than long; sides narrowly rounded; widest slightly anterior to midvalve; anterior commissure strongly uniplicate; surface marked only by concentric lines of growth.

Pedicle valve less deep than the brachial valve, moderately convex in lateral profile and with the strongest convexity in the posterior third; anterior profile nearly flat but with the median region slightly concave; beak low, incurved; umbo moderately swollen; sulcus originating on the umbo, shallow and narrow but deepening and widening anteriorly to occupy slightly more than half the width at the anterior; flanks somewhat flattened and with gentle slopes to the margins; tongue moderately geniculate, moderately long and broadly rounded.

Brachial valve gently and fairly evenly convex in lateral profile; anterior profile moderately strongly domed; fold originating at about midvalve, low, flattened, and prominent only at the anterior; flanks bounding fold slightly depressed, gently rounded. Umbonal region only slightly convex.

Interior.—Strong, short dental plates visible in pedicle valve; small, short socket ridges visible in brachial valve but no trace of a median septum or ridge seen through the moistened shell.

MEASUREMENTS IN MILLIMETERS

	Length	Brachial length	Maximum width	Thickness
Holotype	24.3	22.2	28.0	13.0

Type.—Holotype, U.S.N.M. 549382.

Horizon and locality.—Miocene, Station 69, on coast, 4½ miles west of Gettysburg, Washington.

Discussion.—This is a large and distinctive species unlike any figured by Hertlein and Grant (1944) in their monograph on the Tertiary and Recent brachiopods of the west coast of the United States. Tentative assignment to *Eohemithyris* is made because the exterior is smooth, dental plates are present, but a median septum or ridge is absent. The species differs from *E. alexi* in its greater size and more pronounced fold and sulcus.

Genus NEOHEMITHYRIS Yabe and Hatai 1934

Plate 13, B

Neohemithyris Yabe and Hatai, Proc. Imp. Acad. Japan, vol. 10, No. 9, p. 587, 1934; Hatai, Sci. Rep. Tôhoku Imp. Univ., ser. 2 (Geology). vol. 20, p. 210, 1940.

Yabe and Hatai (1934, p. 587) described their new genus *Neohemithyris* with type species (by original designation) *Rhynchonella lucida* Gould as resembling *Hemithyris* "in shape, folding, beak characters and microstructure" but differing "only in possessing an entire foramen and conjunct deltidial plates in the ventral valve." In the brachial valve a cardinal process is absent and no median ridge is present. Although these characters do distinguish *Neohemithyris* from *Hemithyris* they do not differentiate the Japanese shell from *Basiliola* with which it seems to be identical. Consequently I have placed *Neohemithyris* in the synonymy of *Basiliola.* [For further discussion see under *Basiliola;* see also pl. 13, B, figs. 6-23, for illustrations of *Rhynchonella lucida* Gould type species of *Neohemithyris* (=*Basiliola*).]

Genus NEORHYNCHIA Thomson, 1915

Plate 2, B

Neorhynchia Thomson, Geol. Mag., n. s., dec. 6, vol. 2, p. 388, 1915; Dall, Proc. U. S. Nat. Mus., vol. 57, p. 290, 1920; Thomson, New Zealand Board Sci. Art, Manual 7, p. 149, 1927; Hertlein and Grant, Publ. Univ. California, Math. and Phys. Sci., vol. 3, p. 57, 1944.

Pentagonal in outline, with the greatest width at midvalve; valves unequal in depth, the pedicle valve having the greater depth; anterior

commissure deeply sulcate; surface smooth. Beak of pedicle valve short, nearly straight, and bluntly pointed; foramen of moderate size, hypothyrid; deltidial plates disjunct.

Pedicle valve interior with small corrugated teeth supported by short dental plates which define a small delthyrial chamber; muscle area small.

Brachial valve interior with corrugated sockets bounded by overhanging socket ridges; crura short, falcifer type, crescentic in section, attached to socket ridges by broad outer hinge plates. Inner hinge plates small and inconspicuous. Median ridge short and reaching the apex. Adductor field small.

Type species (by original designation).—*Hemithyris strebeli* Dall, Bull. Mus. Comp. Zool., Harvard Coll., vol. 43, p. 441, 1908.

Comparison and *discussion.*—The important and striking difference between *Neorhynchia* and all known Recent and Tertiary rhynchonelloid genera is the sulcation of the anterior commissure. Rhynchonelloids of similar habit are known from the Mesozoic. They are also known from the Devonian, Mississippian, and Permian as well. Sulcation is a folding tendency that has appeared many times in different stocks of the rhynchonelloids.

Neorhynchia is most closely related to *Basiliola* in the presence of the wide outer hinge plates and falcifer crura having a crescentic section. The presence of incipient inner hinge plates in *Neorhynchia* is another difference between the two genera.

Assigned species.—Only one species is so far known in this genus:

Hemithyris strebeli Dall, Recent, Pacific.

Distribution.—The known specimens of this species are all from great depths: 2,084 fathoms at 35.1° F. in mid-Pacific and 2,035 fathoms at 35.3° F. off the Galápagos Islands, both on *Globigerina* ooze.

Genus RHYTIRHYNCHIA Cooper, 1957

Plate 11, A

Rhytirhynchia Cooper, U. S. Geol. Surv. Prof. Pap. 314-A, p. 8, 1957.

Subcircular to suboval in outline and with the maximum width at midvalve; strongly inequivalve, the brachial valve being swollen and deep; anterior commissure sulciplicate, surface smooth except anterior which is paucicostate. Beak small, rounded, inconspicuous; foramen rounded, submesothyrid to mesothyrid; deltidial plates short, conjunct.

Pedicle valve with thick, coarsely corrugated teeth and moderately developed to remnantal dental plates; pedicle collar well formed;

muscle field short and narrow, somewhat longitudinally rectangular in outline; diductor scars small; adductor scars large and surrounded anteriorly by the diductors. Vascula media strong, converging anteriorly on the tongue.

Brachial valve interior with deep sockets bordered by overhanging socket ridges; crura attached to socket ridges by narrow outer hinge plates; crura falcifer, long crescentic in section, convex outward; inner hinge plates incipient, forming a slight thickening on the inside of the crura near their proximal end; median ridge or septum absent; adductor field small, rounded in outline with large anterior scars and small posterior ones; vascula media prominent, diverging widely at the anterior end of the adductor field.

Type species (by original designation).—*Hemithyris sladeni* Dall, Trans. Linnaean Soc. London, ser. 2, Zool., vol 13, pt. 3, p. 440, pl. 26, figs. 7-12, 1910.

Comparisons.—This genus is most like *Basiliola* in form and outline but differs in having anterior costation. Inside the pedicle valve the dental plates are reduced to remnants or are wanting in the modern species. In the brachial valve the development of outer hinge plates in *Basiliola* is usually greater than that in *Rhytirhynchia* but otherwise the details of the valves are the same. Incipient inner hinge plates appear in *Rhytirhynchia.*

Rhytirhynchia in its anterior costation suggests *Eohemithyris* which likewise has anterior costation in old adults. In the latter this seems to be a rare feature but the two genera are not likely to be confused because their lateral profiles are different, that of *Rhytirhynchia* having an extremely deep brachial valve, whereas *Eohemithyris* has both valves nearly equal.

Geological range.—Pliocene to Recent.

Distribution.—*Rhytirhynchia* occurs as a fossil in the Pliocene of Okinawa and today lives in the Indian Ocean south of the Saya de Malha banks.

Assigned species.—Two species are now assigned to this genus, one living and one fossil:

Hemithyris sladeni Dall, Recent, Indian Ocean.
Rhytirhynchia hataiana Cooper, Pliocene, Okinawa.

Discussion.—This genus is essentially a semicostate *Basiliola.* In the one modern species the dental plates are remnantal but in *R. hataiana* from the Pliocene of Okinawa the dental plates are moderately developed. This is a small and delicate form in which internal

thickening of the shell is not great. The degrees of development of the dental plates are, in this case, not regarded as generic in character.

PROBOLARINA Cooper, new genus

(Gr. *probolos,* projection)

Plate 17, A, B

Subpentagonal to subtriangular in outline, with the greatest width at or near the middle; inequivalve, the brachial valve having the greater depth and convexity; anterior commissure uniplicate; surface semicostate, the posterior third to half smooth, anterior half to two-thirds costate. Beak moderately long, pointed, nearly straight; foramen small, longitudinally elliptical, hypothyrid to submesothyrid and with strongly auriculate margins. Deltidial plates prominent, wholly visible, conjunct throughout their length and anteriorly resting on the umbo of the brachial valve.

Pedicle valve interior with strong pedicle collar, small teeth supported by vertical dental plates separated from the side wall by narrow umbonal chambers. Details of the musculature not available.

Brachial valve interior with narrow sockets bounded by erect but not greatly thickened socket ridges; crural bases attached to socket ridge by a prominent, flat outer hinge plate; crura falcifer, long, scimitarlike, crescentic in section and convex outward. No cardinal process. Muscle and pallial marks not visible in available material.

Type species.—*Rhynchonella holmesii* Dall, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, p. 1536, pl. 58, figs. 10, 12 (not 11), 1903.

Comparisons.—This genus is most like *Rhytirhynchia* in its exterior characters but differs importantly in the interiors as well as in details of the exterior. *Rhytirhynchia* has almost nude valves except for the costation at the very anterior margin. In *Probolarina* on the other hand the costation affects more than two-thirds of the valve, only the umbones being free of costation. The deltidial plates of the two genera are conjunct and both are auriculate but those of *Probolarina* are more developed and more elaborately auriculate than those of *Rhytirhynchia.*

Inside the pedicle valve of *Probolarina* a strong pedicle collar strengthens the beak and strong but thin dental plates buttress the teeth. In *Rhytirhynchia* on the other hand the dental plates are rudimentary in the type species and can be seen only as a trace on the sides of the shell. In *R. hataiana* Cooper from the Pliocene of Japan moderately developed dental plates are present but they are not to be compared with the strong and vertical plates of *Probolarina.*

The cardinalia of the brachial valves of the two genera are very similar and a median septum or ridge is lacking from both of them. The crura of both genera are of the same falcifer type and the outer hinge plates are developed to about the same degree.

Assigned species.—At present two species only are assigned to this genus:

Rhynchonella salpinx Dall.
R. holmesii Dall.

Distribution.—Eocene (Castle Hayne), North Carolina.

Discussion.—Tertiary brachiopods are a rarity in the United States and that is especially true of the genus *Probolarina.* The two species of this genus are represented by a few specimens only. They are also quite different in form but the beak characters and the cardinalia of the two appear to be identical. It is interesting that the cardinalia of *Probolarina* are so like those of *Rhytirhynchia,* a modern inhabitant of the Indian Ocean and represented in the fossil state in Okinawa.

PROBOLARINA HOLMESII (Dall)

Plate 17, B

Rhynchonella holmesii Dall, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, p. 1536, pl. 58, figs. 10, 12 (not 11), 1903.

In Dall's description of this species it is stated that one of the figured specimens is a young individual. The other specimen figured is somewhat fragmentary, probably belonging to a different and undescribed species. I here select the smaller of the two specimens as the type of *R. holmesii,* U.S.N.M. 109298a. This specimen is clearly a young form of those figured on plate 17, B. Specimen U.S.N.M. 549359 is a well-preserved adult of *R. holmesii.*

STREPTARIA Cooper, new genus

(Gr. *streptos,* twisted)

Plate 19, B, C

Pentagonal in outline with the greatest thickness near midvalve; valves unequal in depth, the brachial valve having the greater depth; anterior commissure uniplicate to twisted, either right or left; surface marked only by concentric lines of growth, occasionally with obscure marginal costae. Beak short, deltidial plates conjunct, foramen hypothyrid to submesothyrid, small and usually with prominent elevated rim.

Pedicle valve interior with remnantal dental plates and strong corrugated teeth. Other details not yet known.

Brachial valve with deep corrugated sockets, long falciform crura attached to fairly broad outer hinge plates; inner marginal rim present on crura but no inner hinge plates; socket ridges thick and curved. No median septum. Other details not yet known.

Type species.—*Terebratula De Buchii* Michelotti, Cenn. Brach., Acefali foss. Italia, p. 4, 1938.

Comparison and discussion.—This genus is characterized by its smooth exterior, small, short beak, twisted to uniplicate anterior commissure, nearly obsolete dental plates, and long falciform crura attached to broad outer hinge plates. In the latter character and the smooth, uniplicate shell *Streptaria* is like *Basiliola* but it differs in beak characters, lack of a pedicle collar, and the small development of the dental plates of the pedicle valve.

Specimens of this genus are similar to *Erymnaria* in the smooth exterior, beak characters, and the twisted anterior margin, but the latter genus possesses two strong, diverging septa in the brachial valve—a character unlike any other known rhynchonelloid from Tertiary rocks or Recent seas.

Assigned species.—This genus is known in Mediterranean and West Indian rocks.

Terebratula De Buchii Michelotti, Miocene, Italy.
Rhynchonella deformis Seguenza, Miocene, Italy.
R. eocomplanata Sacco and var., Eocene, Italy.
Streptaria streptimorpha Cooper, new species, Eocene, Cuba.

Distribution.—The known species of this genus are from the Tertiary of Italy, southern Europe, northern Africa, and Cuba.

Discussion.—One of the interesting features of *Streptaria* is the twisted anterior margin. This character occurs in rhynchonelloid stocks from Paleozoic to Tertiary times. It has been seen in many different stocks and undoubtedly is an aberration of the anteriorly produced folding that facilitates the passage of nourishing currents into the valve and their elimination with waste from the valves. *Streptaria* and *Erymnaria* form isochronous homeomorphs in this respect. The Ordovician genus *Streptis* is like *Streptaria* in having shells twisted to right and left but also has normally uniplicate individuals or species.

Cuba has produced another species of *Streptaria* which is not described because of insufficient material. Three specimens of this undescribed shell are known from the Eocene of Camaguey Province

in which the valves are normally folded (uniplicate), but a third specimen has a wider sulcus on the pedicle valve which shows a definite twist. This species has abbreviated dental plates and the same cardinalia as the Italian forms and *S. streptimorpha.*

STREPTARIA STREPTIMORPHA Cooper, new species

Plate 19, B

Of medium size for a rhynchonelloid, subcircular in outline; sides narrowly rounded; greatest width at the middle; anterior commissure twisted. Surface marked only by concentric growth lines.

Pedicle valve gently convex in lateral profile; broadly and slightly convex in anterior profile; depth less than that of the brachial valve; umbonal and median regions slightly swollen; sulcus indefinite, shallow; beak short, blunt, forming an obtuse angle (about 110°). Foramen hypothyrid, small, oval; deltidial plates forming low rim around foramen.

Brachial valve deeper than the pedicle valve, moderately convex in lateral profile but strongly domed in anterior profile; umbonal region somewhat flattened; median region and flanks strongly swollen; fold ill defined because of twisted commissure.

Interior.—Pedicle valve with remnantal deltidial plates and no pedicle collar. Brachial valve with long falciform crura attached to the socket ridges by fairly broad outer hinge plates. Median septum absent. Other details not yet known.

MEASUREMENTS IN MILLIMETERS

	Length	Brachial length	Width	Thickness
Holotype	17.0	15.2	18.0	10.6

Types.—Holotype, U.S.N.M. 549386a; figured paratype, U.S.N.M. 549386b.

Horizon and locality.—Eocene, deep cut north of Grua 9, Ramal Juan Criollo, Camaguey Province, Cuba (Palmer locality 1640).

Discussion.—This species is characterized by its rounded form, small foramen, and broadly twisted anterior commissure. It is suggestive of *Streptaria de buchii* (Michelotti) from the Mediterranean region but differs in its rounded form, less narrow twist to the anterior commissure, smaller foramen, and lesser development of the foraminal lip.

Aphelesiinae Cooper, new subfamily

APHELESIA Cooper, new genus

(Gr. *apheles,* smooth)

Plates 7, B, 8, C, 22, D

Outline subtriangular to subpentagonal; widest anterior to the middle; strongly inequivalve, the brachial valve being deep and swollen, the pedicle valve gently convex; anterior commissure strongly uniplicate but fold of brachial valve defined only at the anterior; smooth on most of the surface but the anterior with incipient costation. Beak of pedicle valve moderately elongated, nearly straight to suberect, pointed; foramen complete, elongate-oval, small hypothyrid; deltidial plates thick, conjunct, moderately auriculate; beak apex thickened internally.

Pedicle valve interior with elongated, corrugated teeth supported by thick dental plates. Muscular field large and flabellate, extending to about midvalve with the diductor scars surrounding the adductors; adjustor scars small and laterally disposed.

Brachial valve interior with deep corrugated sockets bounded by strong overhanging socket ridges; crura of falcifer type, long, crescentic in section, broad, scimitarlike and cemented directly to the socket ridges with no outer hinge plates developed; inner hinge plates lacking; crural supporting plates thick. Median ridge low and thick; adductor field narrow and elongated. Pallial trunks not deeply impressed.

Type species.—*Anomia bipartita* Brocchi, Conch. Foss. Subapp., vol. 2, p. 469, pl. 10, fig. 7, 1814.

Comparisons.—This species is generally referred to *Hemithyris* but it actually does not have either the exterior or interior features of this genus. *Aphelesia* is completely smooth or with slight and very obscure costation. It does not have the numerous and regular subdued costellae or striae of *Hemithyris.* Furthermore the foramen of *Aphelesia* is small and the deltidial plates are conjunct. The foramen of *Hemithyris* is large and not enclosed anteriorly because the deltidial plates are disjunct.

The interior of the pedicle valve of each of these genera is quite similar except for the fact that the dental plates of *Hemithyris* are somewhat more prominently developed and with deeper umbonal chambers than those of *Aphelesia.* Important differences appear on the inside of the brachial valves where the cardinalia of the two genera are quite distinctive. In *Hemithyris* the crura are of radulifer

type, long and slender and with only a slight development of outer hinge plates. The crura however are flattened horizontally as one observes them from the posteroventral side and the distal extremities are quite thin. In *Aphelesia* the crura are long, broad, of falcifer type, and the bases attached to the socket ridges with no development of outer hinge plates. The distal ends of the crura, unlike *Hemithyris* are scimitarlike, are laterally compressed and their distal extremities serrate. In cross section these crura are crescentic and the convex surface faces laterally. The crural blades are broad and thick and thus quite unlike those of *Hemithyris*.

The crura of *Aphelesia* are like those of *Rhytirhynchia, Neorhynchia,* and *Basiliola* but differ from all of them in the absence of outer hinge plates which are so prominent in the other genera. *Aphelesia* differs from these genera also in other important respects.

Geological horizon.—Eocene through Pliocene.

Geographic distribution.—Mediterranean region.

Assigned species.—At present it is difficult to assign the several species of Mediterranean Tertiary rhynchonelloids to their proper genus because the interiors are poorly known or completely unknown.

Anomia bipartita Brocchi, Pliocene, Italy.
Terebratula plico-dentata Costa, Miocene-Pliocene, Italy.
Rhynchonella (*Hemithyris*) *saccoi* Patané, Pleistocene, Sicily.
Hemithyris acuta Meznerics, Miocene, Hungary.
Rhynchonella bipartita pseudobipartita Patané, Pleistocene, Sicily.

Discussion.—These species have been assigned to *Hemithyris* at one time or another but the exterior characters preclude such a placement. The little that is known of the interior also excludes these shells from assignment to *Hemithyris*. The beak characters and cardinalia of *Aphelesia* as shown by *A. bipartita* are quite unlike the same features of *Hemithyris*. The exterior of most of these shells is smooth or nearly so. Some exhibit anterior costation but it is generally not regularly developed. None of them have the fine striate exterior of *Hemithyris*. The latter, too, has disjunct deltidial plates and an elongate beak, whereas the beaks of the Italian species are short and the deltidial plates conjunct. The crura of *Hemithyris* are long, curved, and slender, quite different from the broad-bladed *Aphelesia bipartita*.

Aetheiinae Cooper, new subfamily

Genus AETHEIA Thomson, 1915

Plates 4, A, 9, B

Aetheia Thomson, Geol. Mag., n. s., dec. 6, vol. 2, p. 389, 1915; Thomson, New Zealand Board Sci. Art, Manual 7, p. 156, 1927.

Thomsonica Cossmann, Rev. Crit. Pal., vol. 24, No. 3, p. 137, 1920; Finlay, Trans. New Zealand Inst., vol. 57, p. 532, 1927.

Outline elongate-oval to triangular with the greatest width at the front; inequivalve, the brachial valve having the greater depth; anterior commissure broadly uniplicate, the brachial fold low and inconspicuous. Surface marked by concentric lines of growth only. Beak small, erect; foramen minute, submesothyrid; deltidial plates conjunct, forming a concave plate.

Pedicle valve interior with thick teeth attached directly to the shell wall; dental plates absent; muscle field short and narrow, the diductors small but surrounding the adductor scars. Vascula media strong, branching about two-thirds the shell length from the beak.

Brachial valve interior with deep corrugated sockets bounded by long vertical socket ridges to which the long crura are cemented; crura of falcifer type, crescentic in section, convex outward; inner hinge plates thick and filling the intercrural space. Cardinal process small and transversely triangular. Median ridge short and low, but thick, united with the cardinalia. Adductor field large, with large anterior scars.

Type species (by original designation).—*Waldheimia (?) sinuata* Hutton, Catalogue of the Tertiary Mollusca and Echinodermata of New Zealand in the collection of the Colonial Museum, p. 36, 1873= ?*Terebratula gualteri* Morris, Quart. Journ. Geol. Soc., London, vol. 6, p. 329, pl. 28, figs. 2, 3, 1850.

Comparisons.—This interesting genus has exterior and interior features that set it aside from nearly all other rhynchonelloids. It is unlike all other known Tertiary and modern rhynchonelloids except *Patagorhynchia* in the extremely small pedicle foramen and concave deltidial plates. It differs from *Patagorhynchia* in being smooth rather than marked by squamose costellae. Internally it differs from all other known Tertiary and Recent rhynchonelloids except *Frieleia* in the great development of the inner hinge plates which grow and swell between the crural bases to plug the entire posterior.

Geological horizon.—Upper Cretaceous to Miocene.

Distribution.—New Zealand.

Assigned species:

Terebratula gualteri Morris.
Waldheimia ? sinuata Hutton.

Discussion.—This genus presents some peculiarities not seen in most of the Tertiary and Recent rhynchonelloids. The small foramen is submesothyrid, an unusual position for this group of animals. The

deltidial plates are conjunct but they do not overlie the umbo of the brachial valve as in *Hemithyris* and several other genera. They are concave and lie ventrally to the umbo of the brachial valve.

The teeth are large, corrugated and not buttressed by dental plates. Instead of dental plates a thickening extends posteroventrally but does not meet the floor. I have never seen immature specimens and therefore cannot say whether or not dental plates existed in the young as in some other genera.

The pallial marks of the pedicle valve are like those of *Hispanirhynchia* and *Basiliola*. In the one specimen showing these marks the course of the sinuses appears as an elevated ridge rather than a depression. This bifurcates near midvalve as in the genera mentioned.

The great thickening of the apical region of the brachial valve obscures many of the details of the cardinalia that can only be cleared up by a study of young specimens. These are not available in the National collections. The true nature of the crural bases is not known, whether they attach to the median ridge or to the valve floor or whether they have supports that extend dorsally.

Thomson (1927, p. 157) assigned *Hemithyris colurnus* Hedley and *H. sladeni* Dall to his genus *Aetheia* even though they differed to some extent from the fossil genus. Because of its anterior costation and the bulbous brachial valve the latter of these two species is here placed in *Rhytirhynchia,* and the former, because of its nearly equally deep valves, among other characters, is placed in *Eohemithyris.*

In their correction of brachiopod homonyms in 1951, Cooper and Muir-Wood suggested that *Thomsonica* Cossmann, 1920, should be substituted for *Aetheia* because the latter name is preoccupied by *Aethia* Merrem 1788 (Aves). It is now the sense of the Zoological Commission as outlined in the Copenhagen Proceedings (Hemming 1953, Article 34, paragraph 153, p. 78), that these two names are not in conflict. It is therefore necessary to return to *Aetheia* and reject *Thomsonica* as Thomson did in 1927 (p. 156).

Genus PATAGORHYNCHIA Allan, 1938

Plates 6, A, 21, B

Patagorhynchia Allan, Rec. Canterbury (N.Z.) Mus., vol. 4, No. 4, p. 199, 1938.

Subcircular to subpentagonal in outline; inequivalve, the brachial valve having the greater depth; anterior commissure uniplicate, the fold of the brachial valve being moderately strong. Surface costellate, lamellose to imbricate. Beak short, nearly straight, bluntly pointed; foramen minute, submesothyrid, deltidial plates conjunct and forming a concave plate.

Pedicle valve interior without dental plates. Other details not known.

Brachial valve interior with short crura and with the inner hinge plates thickened and filling the intercrural space.

Type species (by original designation).—*Rhynchonella patagonica* von Ihering, Anal. Mus. Nac. Buenos Aires, ser. 3, vol. 9, t. 2, p. 334, pl. 3, figs. 11a, b, 1903.

Comparisons.—*Patagorhynchia* is comparable to two genera from the Southern Hemisphere: *Tegulorhynchia* and *Aetheia.* The first genus is ornamented like *Patagorhynchia* but there the similarity ends because the South American genus has completely different beak characters and the interiors are wholly unlike. Close comparison is possible with *Aetheia* on the inside and in beak characters but *Aetheia* is a smooth shell and externally not to be confused with *Patagorhynchia.* The Argentine shell has the minute foramen and concave deltidial plates like the New Zealand shell. Inside the pedicle valve no dental plates were observed in *Patagorhynchia.* The interior of the brachial valve is not well known and the published illustration of it is poor. It does indicate, however, cardinalia with moderately long crura, concave inward, probably of falcifer type and a thickening of the inner hinge plates to fill the posterior space between them with shell substance. The illustration indicates a condition even more extreme than that seen in *Aetheia.*

Geological horizon.—Eocene (Patagonian).

Distribution.—Argentina and Chile.

Assigned species.—Only one species, the type of the genus, is known.

Discussion.—Allan (1938) discussed the interior details of *Patagorhynchia,* especially those of the pedicle valve. Specimens of pedicle valves in the Canterbury Museum enabled him to determine some characteristics not before seen, such as the strong concavity of the deltidial plates and the fact that they do not exhibit the suture line. He also described the great thickening formed by coalescence of the deltidial plates with a platform made by a thickening at the base of the teeth.

Family HEMITHYRIDAE Rzhonsnitzkaia 1956

Genus HEMITHYRIS d'Orbigny, 1947

Plates 3, A, B, 4, E

Hemithiris d'Orbigny, Paléont. France Ter. Crét., vol. 4, p. 342, 1847; Hertlein and Grant, Publ. Univ. California at Los Angeles, Math. and Phys. Sci., vol. 3, p. 41, 1944.

Hemithyris d'Orbigny, Bronn, Neues Jahrb. Min., Geog., Geol. u. Petrefaktenk, p. 246, 1848; Thomson, Geol. Mag., dec. 6, vol. 2, p. 387, 1915; Thomson, New Zealand Board Sci. Art, Manual 7, p. 149, 1927; Grabau, Sci. Quart. Nat. Univ. Peking, vol. 3, No. 2, p. 112, 1932; Hatai, Sci. Rep. Tôhoku Imp. Univ., ser. 2 (Geology), vol. 20, p. 194, 1940.

Outline triangular, greatest width at or anterior to the middle; inequivalve, the brachial valve having the greater depth and convexity; anterior commissure broadly to narrowly uniplicate; surface obscurely to moderately costellate, the costellae broad and separated by fine striae. Beak of pedicle valve prominent, elongate, and suberect. Foramen incompletely hypothyrid; deltidial plates disjunct; apical region thickened and buttressed by a short median ridge.

Pedicle interior with strong, somewhat elongated, corrugated teeth; dental plates vertical and strong, the umbonal cavities becoming partially filled by adventitious deposit in old specimens. Delthyrial cavity occupied by the pedicle. Apical plate thick, commonly somewhat elevated. Muscle field anterior to the delthyrial cavity, subflabellate, the diductor scars surrounding the adductors. Adjustor scars lateral to the diductors. Lateral areas bounding muscle field pitted; pallial marks obscure.

Brachial valve with deep, corrugated sockets defined by strong crural supporting plates; socket ridges prominent; crura of radulifer type, long, slender, curved, forming horizontally flat blades distally, widening posteriorly to form a narrow hinge plate and strengthened anteriorly by an oblique ridge running from the outside of the tip to the inside of the hinge plate; crural supporting plates buttressing hinge plate; inner hinge plate absent or incipient. Cardinal process absent, the diductor muscles being attached to an apical, roughened pit. Median ridge low, defined chiefly at midvalve and disappearing posteriorly in the umbonal chamber. Adductor field small consisting of a large pair of triangular anterior scars and a pair of small, elongate, subrhomboidal scars situated on the outside posterior to the anterior set.

Type species (by subsequent designation, d'Orbigny, 1847).—*Anomia psittacea* Gmelin, Syst. Nat., vol. 2, p. 3348, 1790.

Comparisons.—The exterior and interior details of *Hemithyris* are distinctive and have no known close counterparts among the Tertiary and Recent brachiopods. The genera nearest like *Hemithyris* are *Aphelesia* and *Notosaria*. The former differs from *Hemithyris* in being exteriorly smooth and in having broad, concave, falcifer crura. The external form of *Notosaria* is suggestive and the beak charac-

ters are similar but that genus has well-marked costae and the crura are shorter.

Geological horizon.—Miocene to Recent.

Distribution.—All of the northern seas from the Arctic south to Japan in the Pacific and south to the coast of Maine in the Atlantic.

Assigned species.—The following species, fossil and Recent are placed in *Hemithyris:*

Anomia psittacea Gmelin, Pleistocene to Recent, Northern Hemisphere.
Hemithyris psittacea alaskana Dall, Recent, Alaska.
Rhynchonella woodwardi (A. Adams), Recent, Japan.
H. braunsi Hayasaka, 1928, Pliocene to Recent, Japan.
H. peculiaris Nomura and Hatai, 1936, Recent, Japan.

Discussion.—The most distinctive features of *Hemithyris* are the ornamentation and cardinalia. The type species is strongly marked but other species assigned here are very delicately or obscurely ornamented. *Hemithyris* is really better described as striate rather than costellate. The surface is marked by radial grooves or impressed lines, fairly uniform in *H. psittacea* but discontinuous and irregular in *H. woodwardi.* The spaces intervening between the lines are flat and broad and thus simulate costellae. In *H. woodwardi* the impressed lines are very delicate and so irregular that broad, smooth patches of shell are separated by the striae. These cannot be construed as costellae. This type of ornamentation was seen in this study in only one other rhynchonelloid, *Plicirhynchia.* In this Argentinian genus the region around the umbones is marked as in *Hemithyris* but the striae do not extend to the costate portion of the valves.

The crura are unusual because they are long and slender and are usually flattened in a dorsoventral direction rather than laterally as in most of the other genera. They are thus unlike the crura of any other modern rhynchonelloid. The flat blade is attached to the outer hinge plate on its posteroventral surface. In side view the edge of the outer hinge plate forms an oblique ridge and the crus lies at angle under it. The distal end of the crus is usually pointed, the point being on the inside of the plate. This type of crura is generally classified as belonging to the "radulifer" group.

The cardinal process is seldom conspicuous. It is a triangular area at the apex, roughened horizontally and usually divided by the cleft in the hinge plate which extends to the apex. It is quite like that of several other genera such as *Notosaria.*

Median septa or ridges are never well developed in *Hemithyris,*

even in old and obese specimens. This makes a ready distinction and helps to show that septate specimens from the West Coast Tertiary of the United States are not referable to *Hemithyris* where some of them have been placed.

The name *Hemithyris* has been applied to many Tertiary and modern species without regard to geographic realm or biological considerations. Many smooth species have been referred here and some plicated species have also been given this name. The ornament of the genus is so distinctive that confusion with other genera should not occur. *Hemithyris* as now defined appears to be confined to the Northern Hemisphere. Most of the species assigned to this genus from the Southern Hemisphere clearly belong to other genera. As explained above it is difficult to place the rhynchonelloid species generically from descriptions which do not include the interior details. It has thus proved impossible to reassign many of the species now described as *Hemithyris* or placed in that genus.

NOTOSARIA Cooper, new genus

(Gr. *notos,* south)

Plates 6, B, 22, C

Subpentagonal in outline, usually widest at the middle; inequivalve, the brachial valve having the greater depth and convexity; anterior commissure uniplicate; brachial valve fold usually low. Surface costellate; costellae crossed by growth lines and growth varices only. Beak short to moderately long, nearly straight to suberect; foramen large, incomplete, hypothyrid; deltidial plates vestigial to prominent, disjunct; beak with thick, transversely striated apical plate.

Pedicle valve interior with large corrugated teeth supported by short receding dental plates; muscle field large, wide and flabellate, lobate anteriorly and leaving adductor scars open to the anterior. Pallial marks consisting of numerous anteriorly directed channels.

Brachial valve interior with deep, coarsely corrugated sockets and overhanging, thick socket ridges; crura of radulifer type moderately long, horizontally flattened and attached to socket ridges without outer hinge plates. No inner hinge plates. Pallial marks as in the pedicle valve. Cardinal process transversely widely triangular, thickened and somewhat elevated. Median ridge short, low, not reaching the apex.

Type species.—Terebratula nigricans Sowerby, Proc. Zool. Soc., p. 91, 1846.

Comparisons.—This genus was hitherto placed under *Tegulorhynchia* and was generally regarded as the reference species for that genus because it is a Recent as well as fossil form, the interior details of which are well known. Significant differences between this and the type species of *Tegulorhynchia* make it impossible to keep the two in intimate association. The exterior ornamentation of the two is quite distinct, *Tegulorhynchia* having the strongly squamose or spinose exterior whereas *Notosaria* is costellate but with only fine growth lines.

Another exterior difference of importance is the presence in *Notosaria* of disjunct deltidial plates. *Tegulorhynchia* has conjunct deltidial plates and an entire foramen. Inside the pedicle valve the pedicle collar of the modern form is not well developed. A major difference appears inside the brachial valve of *Tegulorhynchia.* In that genus the median septum extends posteriorly to unite with extensions from the crural base to form a thickened plate at the posterior. This is illustrated by Chapman and Crespin (1923) for *T. coelata,* plate 12, figure 17. In shells of modern *Notosaria* the median septum is not extended to the apex.

Geological horizon.—Miocene to Recent.

Distribution.—New Zealand and Kerguelen Island; Belgium.

Assigned species:

Rhynchonella nigricans Sowerby, Miocene to Recent, New Zealand.
R. nigricans pyxidata Davidson, Recent, Kerguelen Island.
R. nysti Davidson, Pliocene, Belgium.
Hemithyris sublaevis Thomson, Miocene, New Zealand.

Discussion.—It may come as a surprise that the group of shells so long associated under the generic name of *Tegulorhynchia* could be separated, but the differences in ornamentation, beak characters, and cardinalia are sufficient. The interior differences of significance are in the pallial markings and cardinalia.

As indicated on plate 6, B, figures 12 and 14, the pallial markings in both valves of *Notosaria* are entirely different from those figured by Leidhold (1922, pl. 11) for *Tegulorhynchia döderleini* (this monograph pl. 22, C, figs. 16 and 17). In *Notosaria* the vascula media cannot be easily distinguished on the inner shell surface and the pallial marks make numerous short trunks extending anteriorly and anterolaterally from the muscle and ovarian fields. The latter is also not distinctly impressed but seems to be a quite narrow crescent in the pedicle valve but somewhat wider in the brachial valve. The pallial trunks of *Tegulorhynchia* as figured by Leidhold are like those common to many other genera illustrated herein.

The cardinalia of the two genera are similar except for the median ridge. In *Notosaria* the median ridge is short and thick and is usually on a small callosity between the posterior adductors. The ridge does not extend to the apex which is generally smooth. In *Tegulorhynchia* on the other hand the median septum is short but extends to the apex where it meets short extensions from the crural bases which form a small apical callosity. The cardinal process of *Notosaria* is well developed but that of *Tegulorhynchia* can scarcely be distinguished.

Rhynchonella nysti Davidson from the Pliocene of Belgium was referred by Thomson (1927, p. 154) to *Tegulorhynchia* with the remark that Davidson (1874a, p. 7) had compared the species to *Tegulorhynchia nigricans*. Comparison of the interior and exterior details corroborates this assignment and comparison. The beak characters of a pedicle valve in the national collection (U.S.N.M. 549417a) has the characteristic foramen and deltidial plates of *Notosaria*. The cardinalia, too, are like those of *Notosaria* as shown by a brachial valve (U.S.N.M. 549417b). The sockets are large and the socket plates broad and strong. The cardinal process is a thickened triangular callosity like that of the New Zealand species. These features combined with the exterior ornament clinch the assignment. *Rhynchonella nysti* is costate and the costae bifurcate at places on the valve as in the New Zealand shell, a feature unusual in the Rhynchonelloidea. This occurrence, as Thomson remarks, leads to interesting speculation on the paleogeographic distribution of *Notosaria*. It is possible that the Austral members of the genus originated in European waters and thus constitute a clearly distinct stock from *Tegulorhynchia* as its anatomy suggests.

Genus TEGULORHYNCHIA Chapman and Crespin, 1923

Plates 5, D, 21, E

Tegulorhynchia Chapman and Crespin, Proc. Roy. Soc. Victoria, n. s., vol. 35, pt. 2, p. 175, 1923; Thomson, New Zealand Board Sci. Art, Manual 7, p. 152, 1927.

Transversely triangular to subpentagonal in outline; inequivalve, the brachial valve having the greater depth; anterior commissure rectimarginate, the brachial valve having a moderately well-defined fold; surface costellate and lamellose, the lamellae being produced into hollow spines in some species. Beak of pedicle valve long and pointed; foramen complete in the type of the genus (Allan, 1940, p. 279). large, hypothyrid; deltidial plates usually conjunct.

Pedicle valve interior with strong corrugated teeth supported by

short, receding dental plates; muscle field large, located anterior to the delthyrial cavity; diductor scars of moderate size, surrounding the large adductor scars; adjustor scars large; pallial sinuses sparse, with the vascula media short and branching near midvalve, one branch continuing anteromedially, the other laterally and posteriorly (pl. 21, E, fig. 15).

Brachial valve interior with small cardinalia having strong and elevated socket ridges, no outer hinge plates and no inner hinge plates; crura short, of radulifer type, stout, curved; median septum short, low, and meeting the crural bases at the apex; diductor attachments a pit at the apex. Adductor field small.

Type species (by original designation).—*Rhynchonella squamosa* Hutton, Cat. Tertiary Mollusca and Echinodermata of New Zealand, p. 37, 1873.

Comparison.—The squamose to spiny ornamentation of this genus makes it one of the most conspicuous of modern and Tertiary shells. The distinctive ornamentation is, however, only one means of differentiation from other genera. Interior differences also exist in the form of the moderately short crura and apical callosity formed by the crural bases. This and the difference in the pallial markings are means of distinction from *Notosaria* which is most like *Tegulorhynchia.*

Geological horizon.—The type species and most other species of *Tegulorhynchia* are found in the fossil state. The genus ranges from Oligocene into the Recent where it is represented by *T. döderleini* (Davidson).

Distribution.—The fossil species occur chiefly in the Southern Hemisphere in the southern part of Australia and New Zealand. One fossil form, identified as *T. döderleini* occurs in the Pliocene of Okinawa.

The geographic range of the one living species *T. döderleini* is from Japan south to Borneo.

Assigned species.—The species of *Tegulorhynchia* are:

Rhynchonella squamosa Hutton, Miocene, New Zealand.
R. tubulifera Tate, Miocene, Australia.
R. döderleini Davidson, Recent, Japan to Borneo.
Hemithyris antipoda Thomson, Miocene, New Zealand.
? H. *depressa* Thomson, Miocene, New Zealand.
H. squamosa Buckman (not Hutton), Miocene-Oligocene, Antarctic.
H. imbricata Buckman, Miocene-Oligocene, Antarctic.
Tegulorhynchia thomsoni Chapman and Crespin, Miocene, Tasmania.
T. coelospina Chapman and Crespin, Miocene, Tasmania.

T. coelata (Tension-Woods), Oligocene to Miocene, Tasmania and Australia.
T. masoni Allan, Miocene, New Zealand.

Discussion.—As here limited, the name *Tegulorhynchia* is applied only to imbricate species with cardinalia and hinge characters like those of *T. squamosa.*

Genus PLICIRHYNCHIA Allan, 1947

Plate 7, A

Plicirhynchia Allan, Journ. Paleont., vol. 21, No. 5, p. 493, 1947.

Subtriangular to subpentagonal in outline with the maximum width near the middle; inequivalve, the brachial valve having the greater depth; anterior commissure uniplicate, the fold of the brachial valve being conspicuous and fairly long; surface ornate, the posterior half being marked by fine radial lines and striae, the anterior half strongly costate. Beak of the pedicle valve long, narrowly pointed, and nearly straight; foramen complete, large, longitudinally oval, hypothyrid; deltidial plates thick and conjunct.

Pedicle valve interior with thick corrugated teeth supported by long, stout dental plates; pedicle collar long; muscle field large and flabellate, enclosing the adductor scars.

Brachial valve interior with corrugated sockets bounded by thick overhanging socket ridges; crural bases attached directly to the socket ridges; crura of radulifer type, long, horizontally flattened; inner hinge plates strongly developed. Cardinal process thick and bilobed. Median ridge small.

Type species (by original designation).—*Rhynchonella plicigera* von Ihering, Rev. Mus. Paulista, vol. 2, p. 270, text fig. 7, 1897.

Comparisons.—This genus is characterized by its peculiar exterior ornament, the posterior and umbonal regions being finely costellate but the anterior half strongly costate. The only other semicostate genus marked like this is *Probolarina,* but from that genus it differs in beak characters, cardinalia, and the presence of a cardinal process.

Geological horizon.—*Plicirhynchia* occurs in the Eocene (Patagonian) of Argentina.

Assigned species.—Only one species is assigned here with assurance:

Rhynchonella plicigera von Ihering.
? *Hemithyris plicigera* Buckman, not von Ihering.

Distribution.—Known only from Argentina and possibly from the Antarctic.

Discussion.—The exterior characters of this genus, except for the anterior costation, are most like *Hemithyris.* The general form of the shell, the obscure, fine costellation of the umbonal region, and the large foramen are suggestive of the northern genus. The deltidial plates are conjunct, however, and there the resemblance ends.

The specimens available for study of the interior are not good because the muscle marks are obscure and the cardinalia partially broken. Nevertheless some important details can be distinguished. Inside the pedicle valve the pedicle collar is fairly long and slightly elevated above the valve floor. The dental plates are solid but of the receding type. They are separated from the valve walls by moderately deep and wide umbonal cavities. The muscle field is large and reaches to about midvalve, possibly somewhat beyond in old specimens.

Inside the brachial valve the cardinalia are stout and thick. The cardinal process is a thick, bilobed boss at the apex. The socket ridges are thick and the crura are long, slender, and flattened horizontally. These features are well shown in specimen U.S.N.M. 549423a. The crural bases are attached directly to the socket ridges without outer socket plates. An inner thickening along the edge of the crural bases suggests some development of inner hinge plates. Median ridge small and inconspicuous. The cardinalia appear to be related to those of *Hemithyris, Notosaria,* and *Tegulorhynchia.*

According to Jaanusson (1951, p. 196) the shell referred by Buckman (1910, p. 12) to *Hemithyris plicigera* should be referred to *Plicirhynchia.* Jaanusson also points out in connection with *Hemithyris dibbleei* and *H. reagani,* both of Hertlein and Grant (1944), that these do not belong to *Hemithyris* but, because of their anterior costation, may be assigned to *Plicirhynchia.* Unfortunately the interior details of these two species are unknown and the suggested assignment can only be tentative (see discussion of *Hemithyris*).

FRIELEIIDAE Cooper, new family

Genus FRIELEIA Dall, 1895

Plates 4, B, 14, B, 15, A, 21, A

Frieleia Dall, Proc. U. S. Nat. Mus., vol. 17, p. 713, 1895; Thomson, Geol. Mag., n. s., dec. 6, vol. 2, pp. 389, 392, 1915; Jackson, British Antarctic ("Terra Nova") Exped., 1910, Nat. Hist. Rep., Zool., vol. 2, No. 8, pp. 192, 193, 1918; Thomson, New Zealand Board Sci. Art, Manual 7, p. 157, 1927; Hatai, Sci. Rep. Tôhoku Imp. Univ., ser. 2 (Geology), vol. 20, p. 219, 1940; Hertlein and Grant, Publ. Univ. California at Los Angeles, Math. and Phys. Sci., vol. 3, p. 57, 1944.

Elongate oval to subtriangular in outline, with the greatest width at or anterior to the middle; thin shelled; inequivalved, the pedicle valve having the greater depth and convexity; rectimarginate to ligate; surface smooth to obscurely and minutely costellate. Beak of pedicle valve short, nearly straight to suberect; foramen incomplete, elongate oval, hypothyrid; deltidial plates thick, disjunct but nearly united; apex marked by a small triangular plate elevated above the valve floor.

Pedicle valve interior with long, curved, corrugated teeth buttressed by prominent and strong dental plates; muscle and pallial marks lightly impressed; diductor field subquadrate, small, surrounding adductors; vascula media branching at about midvalve, the branches diverging anteromedially and anterolaterally.

Brachial valve interior with deep corrugated sockets margined by thick overhanging socket ridges; crura, of spinulifer type, thin, long, divergent, attached directly to the socket ridges; inner hinge plates small, rounded, disjunct or coalesced at the posterior to form a central bilobed plate; median septum long, slender, elevating posteriorly and united to the inner hinge plates to form a small V-shaped chamber which may be filled by callus in old specimens. Median septum rising to a crest just anterior to the apex; cardinal process a small, triangular, transversely striated pit at the apex; adductor scars long and narrow, posteriorly situated.

Type species.—*Frieleia halli* Dall, Proc. U. S. Nat. Mus., vol. 17, p. 714, pl. 24, figs. 6, 9-13, 1895.

Comparisons.—This is a thin-shelled, fragile brachiopod with both valves somewhat sulcate in the Recent species and characterized by a great development of inner hinge plates and a camerate apex in the brachial valve. It is unlike all other described genera in these respects.

Geological horizon.—Possibly Miocene to Recent. Species from the California Tertiary now referred to *Hemithyris* or other genera may belong here.

Assigned species:

Frieleia halli Dall, Recent, West Coast North America, Japan.

? *Terebratula nitens* Conrad = *Hemithyris astoriana* Dall, Miocene, Oregon.

Hemithyris pellucida Yabe and Hatai, Recent, Japan.

Distribution.—Known from Alaska to California, Japan, and Kamchatka in waters ranging from 21 to 1,059 fathoms.

Discussion.—The important exterior features of this genus are

the obscurely costellate surface, the rectimarginate anterior commissure, and the disjunct deltidial plates. In most specimens the median portion of one or both valves is marked by a depressed line or flattening that produces an emargination of the anterior. The deltidial plates are usually strongly developed but have not been observed to meet.

In the apex of the pedicle valve a small triangular plate appears which is elevated above the valve floor. This forms a partial sheath for the pedicle which rests against it. The teeth, as in most modern rhynchonelloids, are corrugated and are supported by well-developed, erect dental plates defined by deep umbonal cavities. The muscle field is small, with a large subquadrate flabellate diductor field surrounding the adductors anteriorly. The adjustor scars are small and are located just anterior to the front of the dental plates. Faint pallial marks preserved in one specimen show the vascula media as in *Hispanirhynchia*.

The most interesting parts of *Frieleia* are the cardinalia. The diductor muscles are attached in a small, triangular, horizontally striated pit at the apex. In some specimens this is much thickened to form a cardinal callus. The socket ridges are strong and curved. To them are attached small triangular outer hinge plates. The hinge plates bear the crural bases and crura. The crural bases are further strengthened by inner hinge plates that extend dorsally to unite with the median septum to form a small chamber. I am unable to detect any substantial resemblance of this structure to that of *Camarotoechia* or even to the camerate Mesozoic rhynchonelloids.

The median septum in *Frieleia* is a narrow, strong, elevated plate that is a myophragm and a crural buttress. It is interesting to note that the inner hinge plates, in decking over the space between the crural bases, do not form a septal chamber as in *Camarotoechia* but fill in the space solid. In some specimens the inner hinge plates coalesce in such a way as to form an undivided but concave hinge plate.

The adductor field is divided by the median septum and is long and slender. The anterior scars are elongate, tear shaped in outline. The posterior pair is smaller and lies posterolateral to the anterior pair.

Frieleia has not yet been definitely identified in the Tertiary of California or Japan. It has distinctive characters and is one of the few modern or Tertiary brachiopods having a prominent median septum. Several species occurring on the Pacific Coast of the United States may be referable to *Frieleia,* especially if the definition were to be broadened to some extent. The so-called *Hemithyris astoriana*

Dall (=*Terebratula nitens* Conrad) has interior characters strongly suggesting *Frieleia,* especially the strong median septum in the brachial valve. The species is fairly strongly uniplicate, however, which is not in accordance with the current definition of *Frieleia.* All the specimens of *H. astoriana* available for study, including the type specimen, are badly exfoliated. The exterior is therefore not yet wholly known. The exfoliated shells have fairly strong radial costellae, but these may be only a feature of the exfoliated shell. A cross section of the beak of the brachial valve reveals a small triangular chamber. No modern specimens of *Frieleia* are uniplicate. The specimens of *H. astoriana* are here referred to *Frieleia* with a query. They are nearer that genus than they are to *Hemithyris.* Ultimately it may be necessary to erect a new genus for uniplicate *Frieleia* if specimens good enough for detailed description are brought to light.

Genus COMPSOTHYRIS Jackson, 1910

Plate 16

Compsothyris Jackson, British Antarctic ("Terra Nova") Exped., 1910, Nat. Hist. Rep., Zool., vol. 2, No. 8, p. 188, 1918; Thomson, New Zealand Board Sci. Art, Manual 7, p. 161, 1927.

Rounded triangular in outline with the greatest width at about the middle; valves subequal in depth, the pedicle valve having a greater depth than the brachial valve; anterior commissure broadly and gently uniplicate, the brachial fold inconspicuous. Surface marked by fine radial costellae. Beak of pedicle valve nearly straight to suberect, bluntly pointed; foramen incomplete, of moderate size, elongate elliptical, hypothyrid (permesothyrid according to Jackson, 1918); deltidial plates disjunct.

Pedicle valve interior with small teeth supported by strong dental plates; muscle field located well anterior to the delthyrial cavity, small; diductor scars small, surrounding the adductor pair. Pallial marks not impressed.

Brachial valve interior with narrow corrugated sockets bounded by strongly overhanging socket ridges; crura of spinulifer type, short, attached to the socket ridges by narrow hinge plates. Inner hinge plates incipiently developed. Median ridge or myophragm slender, moderately elevated and reaching the apex where it is divided and supports the proximal ends of the crural bases. Adductors closely crowded against the myophragm, the right and left pairs being tear shaped in outline.

Type species (by original designation).—*Rhynchonella racovitzae*

Joubin, Résultats voyage S. Y. *Belgica,* 1897-1898-1899, Zool., Rapt. Sci. Commiss. *Belgica,* p. 5, pl. 1, figs. 1-4, 1901.

Comparisons.—The genera to which *Compsothyris* can profitably be compared are: *Frieleia, Hispanirhynchia,* and *Grammetaria.* The differences between *Compsothyris* and *Frieleia* are chiefly exterior characters but the cardinalia also vary importantly. *Frieleia* is not so strongly and evenly costellate as *Compsothyris* and the shape and folding of the two are quite different. In *Frieleia* it is common for both valves to have a sulcus and for the front to be emarginate. *Compsothyris* is faintly uniplicate. Furthermore, *Frieleia* is much more triangular than *Compsothyris* and has a great development of inner hinge plates in the cardinalia of the brachial valve, a feature not shared by the Antarctic shell.

Hispanirhynchia differs in shape from *Compsothyris,* having a compressed profile and strongly triangular outline. The two genera are similarly marked on the exterior however. Inside the brachial valve only a slight development of inner hinge plates appears in *Compsothyris,* and the small chamber at the apex is not obliterated by shell growth in the adults as it is in *Hispanirhynchia.*

Compsothyris differs from *Grammetaria* in the form of the valves and in the less elaborate deltidial plates. *Compsothyris* is nearly circular in outline whereas *Grammetaria* is strongly triangular. The deltidial plates of *Grammetaria* are elaborately auriculate but those of the Antarctic genus are small and not auriculated. Inside the brachial valve no inner hinge plates are developed by *Grammetaria* but the small apical chamber present in the young is sealed off in the adult by the sides growing shut. In adult *Compsothyris* this chamber remains open.

Geological horizon.—Not known in the fossil state.

Distribution.—Ross Sea area and western Antarctic in depths ranging from 45 to 300 fathoms.

Assigned species.—So far only one species can be definitely assigned here but two others may belong:

Rhynhonella racovitzae Joubin, Recent, Antarctic.
? *Hemithyris striata* Thomson, Recent, Antarctic.
? *Rhynchonella valdiviae* Helmcke, Recent, Indian Ocean.

Discussion.—Jackson (1918, p. 193) expressed interest over the fact that the features of *Compsothyris* and *Frieleia* were suggestive of certain Paleozoic genera, especially *Camarotoechia.* Comparison with interiors of *Camarotoechia* (see pl. 4, D, figs. 6-8), however, show the relationship to be quite remote because the structures in

the two genera, which look similar, actually are developed differently. In the Paleozoic genus the median septum is strong and high and supports a V-shaped chamber having strong walls. This is in turn covered by a flat plate connecting the crural bases. This plate is apparently built, at least in part, posteriorly because it does not generally close the chamber but leaves a small round cavity at the apical end. This chamber of *Camarotoechia* is more like the structure in *Septaliphoria.* The chamber of this Jurassic shell is, however, also different from that of *Camarotoechia,* although the two look alike. The chamber of *Compsothyris* is a much more delicate affair and, it seems to me, not related to any Paleozoic form.

GRAMMETARIA Cooper, new genus

(Gr. *gramme,* line)

Plates 4, C, 9, A

Outline elongate triangular with the maximum width at the anterior; valves subequal in depth, the pedicle valve having a slightly greater depth; anterior commissure rectimarginate; surface marked by fine costellae. Beak small, bluntly pointed, suberect; foramen incomplete, rounded, hypothyrid; deltidial plates auriculate, conjunct.

Pedicle valve interior with small corrugated teeth, supported by strong vertical dental plates. Muscle field small and subcircular; diductor scars small; adjustor scars large, posterolaterally placed.

Brachial valve interior with corrugated sockets bounded by strong, thick socket ridges; crura short, of spinulifer type, triangular in section but laterally flattened distally, attached to the socket ridges by very narrow, inconspicuous outer hinge plates; median ridge thick, not quite reaching the apex in the adult, but in the young forming a low, wide V-shaped chamber with the crural bases; V-shaped chamber covered by shell substance in the adult. Adductor field elongate triangular, the anterior and posterior scars on each side of the median ridge tear shaped in outline; posterior set of adductors located outside the anterior set.

Type species.—Hemithyris bartschi Dall, Proc. U. S. Nat. Mus., vol. 57, p. 289, 1920.

Comparison.—This genus is most suggestive of *Frieleia* and *Compsothyris* among described genera, but it has important differences from both of them. In the first place, *Frieleia* has a strong tendency to ligation while *Compsothyris* is broadly uniplicate. *Grammetaria,* on the other hand, is rectimarginate. The deltidial plates of the pedicle valve of *Grammetaria* are elaborately auriculate but such

features have not been seen in the other two genera. The deltidial plates of *Grammetaria* are conjunct but those of the other two genera are disjunct. However, those of *Frieleia* nearly meet.

The interior of the brachial valve is the significant part of each of these genera. In *Frieleia* the crural bases are attached to the median septum but in addition a strong development of inner hinge plates may create a small chamber at the apex. In *Compsothyris* the crural bases are likewise supported by the median septum but no comparable development of the inner hinge plates is known. In *Grammetaria* the very young are similar to *Compsothyris* in having the crural bases united to the median septum but the apical V-shaped chamber thus formed is much broader and shallower than that of *Compsothyris*. In the adult of *Grammetaria* the spaces between the septum, shell wall, and the broad chamber are filled to form a thick apical callosity between the crura. Thus the low septum ends in a callosity at the rear of the adult shell.

Assigned species.—At present only *Hemithyris bartschi* Dall is known in this genus.

Distribution.—*Hemithyris bartschi* is known only from Philippine waters from depths of 161 and 298 fathoms.

Discussion.—Only two specimens of this genus are known but they indicate a brachiopod having several unusual characters. Although the deltidial plates of the adult specimen are broken, probably in separating the valves, those of the young specimen are quite definitely conjunct even though broken slightly at their line of junction. This is one feature that distinguishes this genus from *Frieleia* and *Compsothyris*. Another feature of considerable interest is the development of the brachial interior from a camerate brachial valve to one having only a callosity at the posterior. The small camera of the young is buried in callus as the valve grows and is completely obliterated. This takes place to a lesser extent in *Hispanirhynchia*. The crura of *Grammetaria* are more like those of *Frieleia* in not having prominent outer hinge plates developed. In *Compsothyris* modest but definite outer hinge plates are present, making the crura more suggestive of *Basiliola* than of *Frieleia*.

HISPANIRHYNCHIIDAE Cooper, new family

Genus HISPANIRHYNCHIA Thomson, 1927

Plates 10, 13, A, 21, G

Hispanirhynchia Thomson, New Zealand Board Sci. Art, Manual 7, p. 159, 1927.

Outline elongate triangular with the greatest width in the anterior third; inequivalve, the pedicle valve being deeper than the brachial

valve; anterior commissure rectimarginate to ligate to slightly uniplicate; surface marked by concentric lines of growth and fine obscure radial costellae; beak of the pedicle valve short, suberect; foramen incomplete, large, hypothyrid; deltidial plates small, disjunct.

Pedicle valve interior with well-developed but incomplete pedicle collar and thick teeth supported by small, somewhat receding dental plates; muscle field small, rounded, with small diductor scars surrounding large adductor scars. Vascula media prominent, originating between diductor and adjustor scars, extending anteriorly to branch about one-third the length from the front margin.

Brachial valve interior with corrugated sockets and overhanging socket ridge to which the short, bladelike, spinulifer crura are attached by small and narrow outer hinge plates. Inner hinge plates small and narrow. Median ridge low, thick, extending to the apex. Adductor field small, divided by a low median ridge; anterior adductors rounded, posterior pair elongated. Vascula media widely divergent.

Type species (by original designation).—*Rhynchonella cornea* Fischer, *in* Davidson, Trans. Linnaean Soc., ser. 2, vol. 4, Zool., pt. 2, p. 171, pl. 25, figs. 2-4, 1887.

Comparisons.—This is one of several triangular or nearly triangular genera with faint radial ornamentation. It differs from *Frieleia* and *Compsothyris* in not having a strongly camerate apex in the brachial valve of the adult. It differs from *Grammetaria* in its less prominent radial markings, nonalate deltidial plates, and the development of the cardinalia which are camerate in the young of *Grammetaria*. *Aetheia* can be readily distinguished from *Hispanirhynchia* by its small foramen, concave deltidial plates and the great development of inner hinge plates on the interior.

Distribution.—In modern seas *Hispanirhynchia* is known from off the coasts of Morocco, the Sudan, and the Canary Islands. It is also known from west of Cape Finistere, northwestern Spain. It is generally found in deep water, from 577½ fathoms [2] off Cape St. Vincent, Portugal, to below 1,000 fathoms off the coast of Spain. One species, *H. ?craneana* (Dall) doubtfully assigned, taken off Cocos Island, Panama, came from 117 fathoms.

Geological horizon.—Possibly present in the Eocene of Cuba.

Assigned species.—Two Recent species are assigned to this genus:

Rhynchonella cornea Fischer, Recent, North Atlantic.
? *Hemithyris craneana* Dall, off Panama, Pacific Ocean.
Hispanirhynchia sp., Eocene, Cuba.

[2] See note by Jackson (1918, p. 192, footnote).

Discussion.—External features of importance in this genus are the beak characters, the ornamentation, and the anterior commissure. In the type species the deltidial plates are well developed and disjunct but in some specimens approach each other very closely. Dall describes the deltidial plates of *H. ?craneana* as "obsolete" but the specimen has definitely been damaged in the beak region. In some old specimens of *H. cornea* these plates are also lacking, possibly due to abrasion.

The shell of young specimens of *Hispanirhynchia* is generally translucent and a pale brown. Adults are opaque and a deeper brown in color. The surface is minutely costellate, the costellae extremely fine and very closely crowded.

Specimens of *H. cornea* are generally rectimarginate but Thomson (1927, p. 159) speaks of some as being ligate, that is, with a gentle depression in each valve which will produce an emarginate anterior. The anterior commissure of *H. ?craneana,* on the other hand, has a slight wave in it toward the pedicle valve, thus producing a faint sulcation.

The interior of the pedicle valve of the mature to old shells usually shows the details to perfection because the muscles and pallial marks are deeply impressed. The pedicle collar is well developed and may be elevated above the valve floor. The teeth are strong and corrugated. The dental plates are strong and separated from the lateral shell wall by deep cavities. In old shells these tend to become nearly obliterated by deposition of shell substance inside the cavities.

The muscle field is small. The flabellate diductor scars are small and surround a fairly large adductor patch anteriorly. The adjustor scars are deeply impressed at the anterior edge of the dental plates. Accessory diductor scars are not visible in the delthyrial cavity. The vascula media take off anterior to the adjustor scars and along the outside of the diductor scars. The main trunk branches at about mid-valve, one branch extending laterally, the other anteromedially. Both of these branches bifurcate again to produce distributaries anteriorly and laterally.

The genital area is small and located on the shell wall just anterior to the dental plates. This area is smaller than that in *Basiliola* and *Rhytirhynchia.*

The cardinalia of this genus are interesting because the young show features that are buried by excess shell in the adult. The insertion of the diductor muscles appears as a small, triangular, horizontally striated pit at the apex. No swollen cardinal process is present as in

Plicirhynchia. The socket ridges are thick and curved; the crura are attached to them by small, triangular outer hinge plates. The crura are laterally compressed blades, not concave in section and their distal end is serrated. Prominent inner hinge plates are formed at the apical end of the shell which attach to the floor of the valve. With the septum they form a poorly defined chamber but in old specimens the inner plates become thickened at the apex and fuse to form a thick callus. In such cases the extensions of the inner plates to the valve floor are obscured.

The adductor field is small and elongated. The anterior pair of scars is the larger and the posterior pair more elongated, at least in the old shells. The field is divided medially by a short, thick median ridge which extends no farther than the anterior end of the adductor field. At the anterior end of the ridge a small scar appears in old specimens. The genital areas are small like those of the pedicle valve. The vascula media originate at the inside ends of the anterior adductors and surround the small scar mentioned above. These pallial trunks divide near midvalve in a manner similar to that of the pedicle valve.

Comparison of *Hispanirhynchia ?craneana* with middle-aged specimens of *H. cornea* show slight differences but they do not appear to be great enough to exclude the species from *Hispanirhynchia.* The outer hinge plates of the brachial valve appear slightly wider than those of the Atlantic shells and the inner hinge plates are not so well developed, but they are there.

Rhynchonella sicula Seguenza, here made the type of the genus *Sphenarina,* was early identified with *H. cornea,* but examination of the interior of the Sicilian shell makes it clear that the two have little in common but shape and ornament. *Sphenarina* has no median septum and its beak characters are different from those of *Hispanirhynchia.*

SPHENARINA Cooper, new genus

(Gr. *sphenos,* wedge)

Plates 5, B, 8, A

Shell triangular in outline, with the greatest width in the anterior third; subequivalve, the pedicle valve having a slightly greater depth than the brachial valve; anterior commissure rectimarginate; surface marked by minute radial lines. Beak long, suberect; foramen small, circular, hypothyrid; deltidial plates conjunct, elaborately auriculate.

Pedicle valve interior with short pedicle collar and well-developed dental plates with wide umbonal cavities.

Brachial valve interior with prominent socket ridge to which the short crural bases are attached without outer hinge plates. Crura moderately long, of spinulifer type, nearly straight, compressed to slightly crescentic in section and with distal extremities flattened; no inner hinge plates. Posterior of crural bases attached to floor of valve by short plates; cavity between plates occupied by callus, thus making the apex solid. Median ridge or septum absent; adductor field elongate.

Type species.—*Rhynchonella sicula* Seguenza, *in* Davidson, Geol. Mag., vol. 7, No. 76, p. 461, pl. 20, fig. 6, 1870.

Comparisons.—This is a wedge-shaped form with fine radial ornamentation comparable to *Hispanirhynchia, Grammetaria,* and *Compsothyris.* It differs from all these in the nature of the cardinalia. On the inside of the brachial valve the cardinalia of *Sephenarina* differ from all three in the almost total absence of a median ridge or septum and in the fact that the plates supporting the crural bases at the apex meet the floor of the valve directly.

Geological horizon.—Pliocene of the Mediterranean region.

Assigned species.—The following species are placed in this genus:

Rhynchonella sicula Seguenza.
R. soricina Defrance = *R. sicula* Seguenza.
? *Hemithyris eotrigona* Sacco and variety *obliquatella* Sacco.

Discussion.—This species has commonly been referred to *Hispanirhynchia* because of the close similarity of form and ornamentation. In fact Jeffreys (1878, p. 413) identified dredged specimens of the latter as identical with the Italian species. Examination of the beak and brachial valve interior of *R. sicula* will dispel the idea of identity almost immediately.

The material of *S. sicula* showing interior details is scanty. The two specimens in the National Museum from which the above description was drawn were prepared by needles, a delicate operation considering the thin shell of the species and the fragile nature of the cardinalia. The length of the crura is moderate and the ends are flattened laterally, strongly suggesting the crura of *Frieleia.*

The cardinalia of *Sphenarina* are suggestive of those of *Hispanirhynchia* but the median septum is lacking. The plates supporting the crural bases thus rest directly on the valve floor rather than on the median septum. A young specimen dissected shows no trace of a septum and no evidence of supporting plates for the crural bases.

ERYMNARIIDAE Cooper, new family

ERYMNARIA Cooper, new genus

(Gr. *erymnos,* fenced)

Plates 18, A, B, 19, A, 22, B

Outline irregular triangular to rounded pentagonal, usually with the greatest width at or anterior to the middle; inequivalve, the brachial valve having the greater depth; anterior commissure irregular, twisted or regularly uniplicate; surface smooth or marked by concentric growth lines and short, irregular costae occupying the anterior third or half. Beak of pedicle valve short, deltidial plates conjunct, slightly auriculate; foramen small to moderately large, oval, hypothyrid.

Pedicle valve with short dental plates defining a deep delthyrial cavity; muscle field small, with small adductor scars surrounded by subflabellate diductor scars. Vascula media short.

Brachial valve with large, deep, corrugated sockets; socket ridges elevated and strong; outer hinge plate broad; crura of septifer type, curved, supported by two long septa that extend along the valve floor for about one-fifth the valve length. Vascula media thin, moderately long.

Type species.—*Terebratula polymorpha* Massalongo, Schizzo geognostico sulla valle del Progno o Torrente D'Illasi, con un saggio sopra la flora primordiale del M. Bolca, Verona, pp. 18, 19, 1850.

The septifer type of crura are not well known but have been recognized in the Jurassic. Rothpletz recognized two groups or Sippe having septifer crura. One of these is the Inversa-Sippe in which the species have a sulcate anterior commissure and are smooth or semicostate; the other group is the Trigona-Sippe in which the shells are rectimarginate to uniplicate and are wholly costate.

Septocrurella of Wisniewska is a paucicostate genus having a sulcate anterior commissure and the septifer type of crura. *Rhynchonella deluxa* Oppel, which is similar exteriorly to *Septocrurella sanctaclarae* Wisniewska, also has the septifer type of crura.

No Cretaceous rhynchonelloids having this structure are now known to me, but the fact that septifer genera appear in the Jurassic and Eocene indicate the strong likelihood that specimens with this structure occur in the Cretaceous. It is interesting to note that the known Eocene septifer genus is smooth pauciplicate but is uniplicate rather than sulcate.

Comparison.—The exterior form of two species of *Erymnaria* is like that of *Streptaria* in having the strongly twisted anterior com-

missure, but there the similarity ends. The interior of *Erymnaria* is so unlike that of *Streptaria* that confusion of the two is not possible.

Geological horizon.—Eocene of Italy and Cuba.

Distribution.—Two species of this genus are known in the Eocene of northeastern Italy and one at the same horizon in Cuba. Only one specimen is known from the latter occurrence but the interior details visible through the shell make the identification with this genus quite certain.

Assigned species.—Three species of this genus are now known:

Terebratula bolcensis Massalongo, Eocene, Italy.
T. polymorpha Massalongo, Eocene, Italy.
Erymnaria cubensis Cooper, new species, Eocene, Cuba.

Discussion.—The genus is characterized by having strong supporting plates buttressing the crura and constituting the septifer type of Rothpletz. It is the only Tertiary genus known to me having this peculiar structure. The supporting plates of the crura make two long, dark suture lines diverging from the beak. In several specimens the socket plates are also visible as dark lines on the inner filling of the shell. In such cases the socket plates occupy the outside and are shorter than the crural supports.

ERYMNARIA CUBENSIS Cooper, new species

Plate 19, A

Shell of about median size for a rhynchonelloid, slightly wider than long; subpentagonal in outline; widest at midvalve; sides narrowly rounded; beak forming an angle of 100°; anterior margin truncated. Anterior commissure strongly uniplicate; surface marked only by concentric growth lines.

Pedicle valve evenly and gently convex in lateral profile; nearly flat in anterior profile with margins abruptly bent dorsally; umbo somewhat narrowly swollen; median region flattened; sulcus originating at about midvalve, broad and shallow; tongue moderately long, narrowly rounded, and bent nearly at right angles to the lateral commissure; flanks bounding sulcus narrow, gently convex, and moderately steep. Beak small, rounded; beak ridges not prominent; deltidial plates conjunct; foramen moderately large, longitudinally elliptical, and with the anterior margin having a small lip.

Brachial valve deeper than the pedicle valve; gently convex in lateral profile but narrowly domed in anterior profile, the sides long and steep. Umbo and median region swollen; fold originating anterior to midvalve, low and gently rounded, scarcely protruding beyond the flanks; sides steep, gently inflated.

MEASUREMENTS IN MILLIMETERS

	Length	Brachial length	Width	Thickness
Holotype	14.1	12.8	15.0	10.0

Types.—Holotype, U.S.N.M. 549385.

Horizon and locality.—Eocene, 80 meters northeast of school, Chucho Machin, Matanzas Province, Cuba.

Discussion.—Only a single complete specimen is known of this interesting species, but it is well preserved and some of the interior details are visible through the transluscent shell. It is most like *T. bolcensis* (Massalongo) in its symmetrical form and folding, but differs in having a broader and less narrowly folded anterior commissure, a larger foramen, and the crural supporting plates seem to be somewhat shorter than those of the Italian species.

That this species belongs to the Italian genus seems certain because the crural supporting plates and socket ridges are clearly visible through the thick but transluscent shell as narrowly divergent septa. Visibility was made better by washing the beak and umbo of the brachial valve with dilute acid to thin the shell.

UNPLACED SPECIES

Rhynchonella lamothei Dautzenberg (1909, p. 271). This is a completely costate (16 costae) species from the Pliocene of Algeria. It has a sulcus on the pedicle valve with 7 costae and a prominent fold with 6 costae. No details of the hinge or interior were described. It is unlike any other Tertiary rhynchonelloid.

R. (Hemithyris) vinassai Boni (1933, p. 86). Miocene, Monte Vallassa, Italy. This is a semicostate form suggestive of *Aphelesia bipartita* but the interior details are not figured.

Rhynchonella washingtoniana Weaver (1912, p. 55). Weaver's figures of this species indicate a brachiopod with a type of ornamentation never seen in rhynchonelloids. Examination of specimens from the Cowlitz River proves the shell to be punctate and the ornamentation to be that of the genus *Terebratulina*. The species is thus not a rhynchonelloid.

Rhynchonella meneghiniana Davidson (1870, p. 463). This is a small completely costate species from the Eocene of Bolca, Italy. It is quite distinct from any other Tertiary species but nothing is known of its beak characters and interiors. It may be related to *R. polymorpha* (=*Erymnaria*) which may be strongly costate.

Hemithiris dibbleei Hertlein and Grant (1944, p. 46). Eocene of California. No details of the interior of this species are given but it is semicostate. In exterior view it accords with *Plicirhynchia* but this is a much younger genus located in a completely different faunal realm.

Hemithiris reagani Hertlein and Grant, (1944, p. 54). Oligocene, California. This species is also semicostate like that above and might be referable to *Plicirhynchia,* but no details of the interior are known.

"Rhynchonella" supraoligocaenica Görges (1952, p. 5). This species is from the upper Oligocene of Germany. It is a large, smooth form suggestive of *Aphelesia bipartita.* The interior is, however, unknown and the species cannot be assigned with confidence.

"Rhynchonella" valdiviae Helmcke (1940, p. 290). This species is found near New Amsterdam in the south-central part of the Indian Ocean. It resembles *Compsothyris* in form, ornamentation, and beak characters. The color is brownish gray and the shell transparent as in *Compsothyris.* Dental plates are present in the pedicle valve. The cardinalia consist of spoon-shaped, curved crura truncated at the end. The brachial valve is provided with a "very weak median-septum, the front end of which is about even with the ends of the crura. The septum is highest in the middle." The figure given by Helmcke (fig. 37) does not show the septum clearly. The species strongly suggests *Compsothyris,* but it is not possible to be sure until better details of the interior are known.

This species also suggests *Hemithyris striata* Thomson from off Shackleton Glacier, Davis Sea, Antarctica, by its rounded outlines and fine costellae. These two species are assigned to *Compsothyris* with a query.

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EXPLANATION OF PLATES

Plate 1

Cryptopora

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A. *Mannia nysti* Davidson = *Cryptopora nysti* (Davidson)..... 22

Figs. 1-14. 1, Dorsal view of a complete specimen showing triangular outline, × 10, hypotype U.S.N.M. 549422a. 2, Same view as preceding, × 20, showing strongly elevated deltidial plates and large triangular foramen. 3-5, Respectively partial side, side, and ventral views of the same specimen showing the profile and large deltidial plates, × 10. 6, Interior of the pedicle valve of the same specimen showing teeth and deltidial plates, × 10. 7, Interior of the brachial valve of the same individual showing high, narrow median septum, and crura with flattened distal extremities, × 10. 8-10, Respectively interior, partial side, and side views of the same valve, × 20, showing median septum and details of the cardinalia. 11, 12, Interior and partial side views of another pedicle valve interior, × 10, showing teeth and deltidial plates, hypotype U.S.N.M. 549422b. 13, 14, Partial side and anterior views of the preceding specimen, × 20, showing dental plates, apical plate and deltidial plates.

Upper Miocene (Diestien-Sables de Deurne), Wommelghem, east side of Antwerp, Belgium.

B. *Cryptopora rectimarginata* Cooper, new species..... 20

Fig. 15. Dorsal view of a complete specimen showing alate deltidial plates and apical plate, × 15, paratype U.S.N.M. 274143d.

Recent, Eolis Station 340, at 209 fathoms, off Fowey Light, Florida.

Fig. 16. Another specimen showing the alate deltidial plates and apical plate, × 15, paratype U.S.N.M. 274168a.

Recent, Eolis Station 320, at 80 fathoms, off Western Dry Docks, Florida.

Figs. 17, 18. Respectively tilted to the side and full views of a specimen showing elaborate alae on the deltidial plates, × 15, paratype U.S.N.M. 336896a.

Recent, Eolis Station 378, at 165 fathoms, off Fowey Light, Florida.

Fig. 19. Interior of a pedicle valve with tooth broken on right side but showing alae with scalloped edges on deltidial plates and the large plate just anterior to the apex, × 15, paratype U.S.N.M. 336895a.

Recent, Eolis Station 377, at 190 fathoms, off Fowey Light, Florida.

Plate 2

Cryptopora and *Neorhynchia*

T. *Cryptopora rectimarginata* Cooper, new species..... 20

Figs. 1-11. 1-3, Respectively dorsal, side, and anterior views of a complete specimen, × 6, showing rectimarginate commissure, holotype

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U.S.N.M. 274143a. 4, Partial side view of another individual showing the alate deltidial plates, × 6, paratype U.S.N.M. 274143b. 5, Posterior of the specimen shown in figure 4, illustrating the alate deltidial plates, × 8. 6, 7, Respectively anterior and full views of the interior of the pedicle valve, × 6, showing strong dental plates, paratype U.S.N.M. 274143c. 8-11, Respectively partial side, full, anterior, and posterior views of the brachial interior of the preceding, showing the long slender maniculifer crura, the short, strongly elevated median septum and the bilobed cardinal process, × 8, paratype U.S.N.M. 274143c.

Recent, Eolis Station 340, 209 fathoms, off Fowey Light, Florida.

B. *Neorhynchia strebeli* Dall 34

Figs. 12-23. 12-15, Respectively ventral, dorsal, anterior, and side views of a complete specimen, × 2, showing the sulcate anterior commissure, paratype U.S.N.M. 110741a. 16, 17, Respectively anterior and full views of the posterior pedicle valve, × 4, showing dental plates, corrugated teeth, and disjunct deltidial plates, holotype U.S.N.M. 110741. 18, 19, 21, 22, Respectively full, posterior, anterior, and partial side views of the posterior of the brachial valve of the holotype, × 4, showing broad outer hinge plates, low median ridge, small inner hinge plates, and falcifer crura. 20, 23, Partial anterior and partial side views of the paratype showing socket ridges and short crura, × 6.

Recent, U. S. Fish Commission Station 4721, 2,084 fathoms in *Globigerina* ooze, 35.1° F., mid-Pacific.

Plate 3

Hemithyris

A. *Hemithyris woodwardi* (Davidson) 47

Figs. 1-11. 1-3, Respectively side, anterior, and dorsal views of a complete specimen, × 1, hypotype U.S.N.M. 111083a. 4, Dorsal view of the same specimen, × 2, showing fine radial striae. 5, Beak of a pedicle valve, × 3, showing large foramen and discrete deltidial plates, hypotype U.S.N.M. 111083b. 6, Interior of the same pedicle valve tilted to show the vertical dental plates, × 2. 7, 8, Respectively anterior and full views of a brachial valve showing cardinalia, inconspicuous median ridge and muscle scars, × 2, U.S.N.M. 111083c. 9, Posterior view of the same brachial valve showing socket ridges, outer hinge plates, and radulifer crura, × 4. 10, Partial side view of the same brachial valve showing the long slender crura, × 4. 11, Posterior view of another brachial valve showing the cardinalia and the scars of the diductor muscles at the apex, × 4, hypotype U.S.N.M. 111083d.

Recent, Hakodate, southern Hokkaido, Japan.

B. *Hemithyris psittacea* (Gmelin) 45

Figs. 12-21. 12-14, Respectively anterior, side, and dorsal views of a complete specimen showing the long beak, × 1, hypotype U.S.N.M. 111004a. 15, Dorsal view of the preceding specimen, × 2, showing

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the closely crowded costellae separated by narrow, shallow striae. 16, Interior of the pedicle valve of another specimen tilted to show apical and dental plates, × 2, hypotype U.S.N.M. 111004b. 17, Posterior of the preceding pedicle valve, × 3, showing large, incomplete foramen, large teeth, and small disjunct deltidial plates. 18, 19, Respectively anterior and full views of the brachial valve interior showing cardinalia, myophragm, and muscle scars, × 2, hypotype U.S.N.M. 111004b. 20, Posterior of the preceding specimen tilted to show socket ridge, corrugated socket, and long, slender, curved, radulifer crura with the strengthening ridge on their under or dorsal surface, × 3. 21, Posterior view of the cardinalia of the same specimen showing socket ridge, small outer hinge plates, and distally flattened crura, × 3.

Recent, Coal Harbor, Unga Island, Shumagins, Alaska.

Plate 4

Aetheia, Fricleia, Grammetaria, Camarotoechia, and *Hemithyris*

A. *Aethcia gualteri* (Morris) 42

Fig. 1. Rubber impression of a pedicle valve interior prepared to show the muscle scars and pallial marks, × 2, hypotype U.S.N.M. 369298a (see pl. 9, B).

Miocene (Duntroon greensand), Otago, New Zealand.

B. *Frieleia halli* Dall 53

Figs. 2, 3. 2, Posterior of a brachial valve, × 6, showing the hinge plates surrounding a plug of the median septum, and the inner hinge plates engulfing the septum, hypotype U.S.N.M. 111021a. 3, Posterior of another brachial valve interior, × 6, with well-preserved cardinalia and elongate adductor scars, and showing inner hinge plates not yet coalesced, hypotype U.S.N.M. 111021b.

Recent, 559 fathoms, in ooze, 38.4° F., U. S. Fish Commission Station 2871, off the coast of Washington.

C. *Grammetaria bartschi* (Dall) 58

Figs. 4, 5. 4, Dorsal view of a young but imperfect specimen, × 6 above and × 10 below, showing elaborate auriculations on the deltidial plates, paratype U.S.N.M. 274134. 5, Same specimen with brachial valve tilted to show cardinalia and dental plates, × 6, and also showing septum united with hinge plates and long curved crura.

Recent, at 161 fathoms, 57.4° F., on sand, U. S. Bureau of Fisheries Station 5735, off Jolo, Philippine Islands.

D. *Camarotoechia* species 10

Figs. 6-8. 6, 7, Two views of the posterior part of a silicified brachial valve, × 4, showing crura and median hinge plate welding them together, figured specimen U.S.N.M. 134812e. 8, The same specimen tilted to show apical chamber (septalium?) and crural plates, × 4 (see p. 10).

Devonian (Norway Point formation), junction French and Truckey roads, SW1/4SW1/4 sec. 4, T. 31 N., R. 8 E., Alpena County, Michigan.

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E. *Hemithyris psittacea* (Gmelin) 45

Figs. 9, 10. 9, Posterior of a large brachial valve showing cardinalia with the narrow outer hinge plates and slender radulifer crura with the transverse cardinal process at the apex, × 3, hypotype U.S.N.M. 111013. 10, Same specimen, × 3, tilted to the side to show the slender radulifer crura with their flattened distal extremity and strengthening ridge on dorsal side.

Recent, 13 fathoms, Upernavik Harbor, east coast of Greenland.

Figs. 11, 12. 11, Posterior of another brachial valve, × 3, tilted to show the long, slender crura and slight development of outer hinge plates, hypotype U.S.N.M. 549379. 12, Side view of the pedicle valve interior belonging to the preceding and showing the inner face of the dental plate and tooth with its corrugations, × 2.

Recent, north end of Nunivak Island, Alaska.

Plate 5

Eohemithyris, Sphenarina, Cryptopora, and *Tegulorhynchia*

A. *Eohemithyris alexis* Hertlein and Grant..... 30

Figs. 1-5. Respectively anterior, posterior, side, dorsal, and ventral views of a somewhat crushed paratype cracked at the beaks, × 1, U.C.L.A. 7257.

Eocene (Domengine formation), from section line, 2,600 feet south of the northeast corner of sec. 20, T. 28 S., R. 19 E., M. D. B. and M., near headwaters of west branch of Agua Media Creek, McKittrick Quadrangle, Temblor Range, California.

B. *Sphenarina sicula* (Seguenza)..... 62

Figs. 6-15. 6-10, Respectively dorsal, posterior, ventral, side, and anterior views of a well-preserved complete specimen, × 1, showing the strongly triangular outline, hypotype U.S.N.M. 549353a. 11, Dorsal view of the preceding showing the foramen and obscure radial lines, × 2. 12, Posterior of the same specimen, × 4, showing alate conjunct deltidial plates. 13, 14, Two views of the interior of another specimen showing the cardinalia, × 4, with their small outer hinge plates, dental plates and lack of a median ridge or septum in the brachial valve, hypotype U.S.N.M. 549353c. 15, Enlargement of the shell surface, × 6, showing the delicate radial lines, hypotype U.S.N.M. 549353b.

Pliocene, Milasso, Messina, Sicily.

C. *Cryptopora gnomon* (Jeffreys)..... 22

Fig. 16. Brachial valve tilted to the side, × 8, to show the high median septum and the long maniculifer crura with the distal end handlike and with fingers extended, paratype U.S.N.M. 94367.

Recent, 780 fathoms, off Cuba.

D. *Tegulorhynchia.*

Tegulorhynchia squamosa (Hutton)..... 50

Figs. 17-24. 17-20, Respectively ventral, dorsal, anterior, and side views of a complete specimen, × 1, hypotype U.S.N.M. 89855a. 21-23, Respectively dorsal, anterior, and side views of the preceding speci-

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men, × 2, showing the imbricating ornament. 24, A partially exfoliated pedicle valve showing the impression of the muscle scars, × 2, hypotype U.S.N.M. 89855b.

Miocene (Ototaran), Broken River, Trelissick Basin, Canterbury, New Zealand.

Tegulorhynchia döderleini (Davidson) 51

Figs. 25-31. 25, Dorsal view of a complete but small specimen, × 2, showing imbricate ornament, hypotype U.S.N.M. 549317b. 26, 27, Tilted and full views of the interior of the pedicle valve showing the muscle field and dental plates, × 2, hypotype U.S.N.M. 549317d. 28, Beak and teeth of the pedicle valve, × 4, showing nearly conjunct deltidial plates, hypotype U.S.N.M. 549317f. 29-31, Respectively full view of the cardinalia, lateral view, and with shell tilted to show short median ridge and hinge plates, × 4, hypotype U.S.N.M. 549317c. The crural points have been broken off.

Miocene or Pliocene (Shinzato tuff), high road cut along Highway 64, about 0.1 mile west of sharp bend in road about 0.3 mile east of Yashitomi, Okinawa, Ryûkyû Islands.

Plate 6

Patagorhynchia and *Notosaria*

A. *Patagorhynchia patagonica* (von Ihering) 44

Figs. 1-4. Respectively dorsal, posterior, side, and anterior views of a complete but imperfect specimen showing imbricated ornamentation, × 1, hypotype Princeton University.

Eocene (Patagonian), Lake Pueyrredon, Argentina.

Figs. 5, 6. Interior of the pedicle and brachial valves, × 1, showing concave deltidial plates and thickened cardinalia. (After von Ihering, 1903, pl. 3, figs. 11a, 11b.)

Eocene (lower Patagonian), north of Seco River and San Julián, Argentina.

B. *Notosaria nigricans* (Sowerby) 48

Figs. 7-17. 7-9, Respectively side, dorsal, and anterior views of a complete specimen showing commissure and folding, × 1, hypotype U.S.N.M. 111018b. 10, The beak of the preceding specimen enlarged, × 3, to show apical plate, small disjunct deltidial plates, and large, incomplete foramen. 11, 12, Interior of pedicle valve respectively tilted and in full view, × 2, to show apical plate, teeth, muscle scars, dental plates, deltidial plates, and numerous pallial sinuses, hypotype U.S.N.M. 111018a. 13, Posterior of same, × 3, showing foramen, small disjunct deltidial plates, and large teeth. 14, 15, Brachial valve in full and tilted views to show cardinalia, transverse cardinal process, inconspicuous median ridge, muscle scars, and numerous pallial sinuses, × 2, hypotype U.S.N.M. 111018a. 16, Posterior of same, × 4, showing cardinal process and curved crura. 17, Same tilted to show crura in side view, × 4.

Recent, Stewart Island, New Zealand.

Plate 7

Plicirhynchia and *Aphelesia*

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A. *Plicirhynchia plicigera* (von Ihering) 52

Figs. 1-11. 1-3, Respectively anterior, side, and dorsal views of a complete specimen showing the long beak and anterior costation, × 1, hypotype U.S.N.M. 549346a. 4, Exterior of the dorsal side of the same specimen showing the posterior obscure striation and the strong anterior costation, × 2. 5, Posterior of the same specimen, × 4, showing the large foramen, conjunct deltidial plates, and the fine striae on the umbo of the brachial valve. 6, 7, Full and tilted views of interior of a pedicle valve showing the deltidial plates and strong vertical dental plates, × 2, hypotype U.S.N.M. 549346b. 8, 9, Full and tilted views of a fragmentary brachial valve showing cardinal process and incomplete crura, × 2, hypotype U.S.N.M. 549346c. 10, 11, Full and partial side views of the cardinalia of the same brachial valve showing the radulifer crura, thick socket plates, and cardinal process, × 4.

Eocene (Patagonian), Mazaredo, Patagonia, Argentina.

B. *Aphelesia bipartita* (Brocchi) 41

Figs. 12-22. 12-14, Respectively side, anterior, and dorsal views of a complete specimen showing small beak, small foramen, and anterior fold, × 1, hypotype U.S.N.M. 549349a. 15, 16, Interior of a pedicle valve in full view and tilted to show the small teeth, small dental plates, oval foramen, conjunct deltidial plates, and muscle field, × 2, hypotype U.S.N.M. 549349b. 17, Posterior of the same pedicle valve, × 4, showing the oval foramen and conjunct deltidial plates. 18-20, Respectively partial side, anterior, and full views of the brachial valve belonging to the preceding specimen (pedicle valve), × 2, showing the cardinalia. 21, 22, Respectively side and posterior views of another brachial valve, × 3, showing the broad falcifer crura, hypotype U.S.N.M. 549380.

Pliocene, Messina, Sicily.

Plate 8

Sphenarina, Aphelesia, and *Eohemithyris*

A. *Sphenarina sicula* (Seguenza) 62

Figs. 1-7. 1-5, Respectively dorsal, ventral, anterior, side, and posterior views of a complete and nearly perfect specimen, × 1, showing triangular form, rectimarginate anterior commissure, and nearly erect beak, hypotype U.S.N.M. 173728. 6, The same specimen enlarged, × 2. 7, Interior of another specimen showing cardinalia, × 10, with their long, slender, spinulifer crura, narrow outer hinge plates, and narrow, elevated socket ridges, hypotype U.S.N.M. 549381a.

B. *Eohemithyris*? *gettysburgensis* Cooper, new species 33

Pliocene, Messina, Sicily.

Figs. 8-12. Respectively anterior, posterior, side, dorsal, and ventral views of a large and complete specimen, × 1, holotype U.S.N.M. 549382.

Miocene, on coast 4½ miles west of Gettysburg, Washington.

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C. *Aphelesia bipartita* (Brocchi) 41

Figs. 13-18. 13, Imperfect brachial valve showing falcifer cardinalia, lack of outer hinge plates, deeply entrenched muscle scars, and short median ridge (myophragm) in full view, × 3, hypotype U.S.N.M. 549380a. 14, Same tilted slightly toward the observer to demonstrate absence of outer hinge plates, × 3. 15, Same in side view, showing the serrated edge and convex outer surface of the falciform crus, × 4. 16, Same in side view, × 3, showing falcifer crura and socket. 17, Same tilted to show posterior face of cardinalia with the short socket ridges, lack of outer hinge plates and falcifer crura, × 3. 18, Same tilted to show cardinalia and serrated distal extremity of crus, × 3.

Pliocene, Messina, Sicily.

Plate 9

Grammetaria and *Aetheia*

A. *Grammetaria bartschi* (Dall) 58

Figs. 1-12. 1-4, Respectively dorsal, side, anterior, and posterior views of the holotype U.S.N.M. 239269, × 1, showing the rectimarginate commissure. 5, 6, Ventral and dorsal views of the holotype, × 2, showing the fine radial costellae. 7, Posterior of the pedicle valve of the holotype showing the corrugated teeth, large foramen, and auriculate but broken deltidial plates, × 4. 8, Anterior view of the same pedicle valve showing the vertical dental plates, × 2. 9, 10, Full and slightly tilted views of the interior of the brachial valve of the holotype showing the cardinalia with their spinulifer crura, × 2. 11, Partial side view of the cardinalia of the preceding brachial valve showing the strong socket ridge, corrugated socket, and short, slender spinulifer crura, × 4. 12, Posterior view of the same, brachial interior, × 4, showing socket ridges, small inner hinge plates, and plug closing apical chamber.

Recent, U. S. Bureau of Fisheries Station 5621, off Jolo Island, Philippines; 298 fathoms, in Mollucca Pass off Makyan Island.

B. *Aetheia gualteri* (Morris) 42

Figs. 13-22. 13-15, Respectively dorsal, side, and anterior views of a complete specimen, × 1, hypotype U.S.N.M. 89828a. 16, Dorsal view of the preceding specimen, × 2. 17, Posterior of the preceding, × 3, showing the minute foramen and concave deltidial plates. 18, 19, Respectively full and anterior views of the pedicle valve interior of another specimen showing deeply impressed muscle field, × 2, hypotype U.S.N.M. 369298a. Note absence of dental plates. 20, Interior of an imperfect brachial valve, hypotype U.S.N.M. 89828b, × 2, 21, Full view of the preceding specimen showing the thick socket ridges, corrugated sockets and thick coalesced inner hinge plates, and long falcifer crura, × 4. 22, Same as preceding, × 4, but tilted to show the slender bladelike falcifer crura, socket ridge, and corrugated socket.

Miocene (Duntroon greensand), 1 mile north of Kakanui, north of Otago, New Zealand.

Plate 10

Hispanirhynchia

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Hispanirhynchia cornea (Fischer) 59

Figs. 1-21. 1-3, Respectively dorsal, anterior, and side views of a complete specimen, × 1, hypotype U.S.N.M. 130327a. 9, Pedicle valve interior of same tilted to show small dental plates, × 2. 4, Exterior of preceding hypotype showing fine costellae, × 2. 5, Anterior of pedicle valve of another specimen, × 3, showing fine, subdued costellae, U.S.N.M. 130327b. 6, 8, Two views of the interior of the preceding pedicle valve, × 2, showing teeth, dental plates, small muscle field, and pallial marks. 7, Interior view of another pedicle valve showing teeth and pallial marks, × 2, hypotype U.S.N.M. 130327c. 10, Beak of preceding, × 4, showing teeth, foramen, and remnantal deltidial plates. 11, Interior of the brachial valve of a young specimen showing strong development of inner hinge plates, × 2, hypotype U.S.N.M. 130327d. 13, Same, × 6, showing inner hinge plates in great detail. 12, Same specimen as preceding, × 4, tilted to the side to show the spinulifer laterally flattened crus with serrated distal extremity, the inner hinge plates, and corrugated socket. 14, Same as preceding tilted to show junction of septum and inner hinge plates, × 4. 15, Posterior of an old specimen showing deeply impressed adductor field, × 3, hypotype U.S.N.M. 130327c. 16, Same, ca. × 6, tilted to show inner hinge plates and median ridge. 17, Interior of another brachial valve showing pallial sinuses, small genital areas, and cardinalia, × 2, hypotype U.S.N.M. 130327a. 19, Same tilted to show direct view of cardinalia and septum, × 2. 18, 20, Same specimen, respectively side view showing bladelike spinulifer crura and view showing strong socket ridges and inner hinge plates, ca. × 6. 21, Interior of another brachial valve tilted to show socket ridges, inner hinge plates and rostral chamber, × 3, hypotype U.S.N.M. 130327e.

Recent, 240 fathoms off the coast of Mogador, Morocco.

Plate 11

Rhytirhynchia and *Basiliola*

A. *Rhytirhynchia sladeni* (Dall) 35

Figs. 1-11. 1-3, Respectively anterior, side, and dorsal views of a complete specimen showing anterior costation, × 1, lectotype U.S.N.M 111086. 4, 5, Respectively full and tilted views of the interior of the pedicle valve showing pallial sinuses, small conjunct deltidial plates, deeply incised muscle scars, and pedicle collar, × 2. 6, Posterior of the pedicle valve of the lectotype, × 3, showing small foramen, conjunct deltidial plates, and corrugated teeth. 7-9, Respectively anterior, full, and partial side views of the interior of the brachial valve showing cardinalia, deeply impressed adductor field, and pallial sinuses, × 2. 10, Partial side view of the falcifer crura showing serrate distal extremity and corrugated socket, × 4. 11, Posterior view of the same

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brachial valve, × 4, showing curved socket ridges, modestly developed outer hinge plates, incipient inner hinge plates, and falcifer crura.

Recent, *Sealark* Expedition, 1905, Station CI, 123 to 158 fathoms, south of the Saya de Malha Banks, Indian Ocean.

B. *Basiliola beecheri* (Dall) 25

Figs. 12-16. 12-14, Respectively side, anterior, and dorsal views of a complete specimen showing the smooth exterior fold, × 1, hypotype U.S.N.M. 334678. 15, Dorsal view of the same specimen, × 2. 16, Posterior of the preceding specimen showing conjunct, auriculate deltidial plates, × 3.

Recent, U. S. Bureau of Fisheries Station 4130, 283 to 309 fathoms, 46.1° F., near Kauai Island, Hawaiian group.

Figs. 17-23. 17, 18, Respectively tilted and full views of the pedicle interior of another specimen showing deeply impressed muscle scars and pallial sinuses, × 2, hypotype U.S.N.M. 334679. 19, Posterior of the preceding pedicle valve, × 4, showing corrugated teeth, conjunct and auriculate deltidial plates. 20, 21, Respectively full and anterior views of the brachial valve of the preceding pedicle valve showing the cardinalia and pallial marks, × 2. 22, Posterior view of the cardinalia of the preceding specimen showing socket ridges, corrugated sockets, broad outer hinge plates, and falcifer crural plates, × 4. 23, Side view of the preceding specimen showing the broad, distally serrate, falcifer crura and the corrugated sockets, × 4.

Recent, 147 to 198 fathoms, 49° F., off west coast of Hawaii.

Plate 12

Basiliola

Basiliola pompholyx Dall 27

Figs. 1-6. 1-5, Respectively dorsal, posterior, anterior, ventral, and side views of the lectotype, × 1, showing robust form, smooth exterior and strong dorsal fold, U.S.N.M. 229301b. 6, Beak of the preceding specimen, × 3, showing small round foramen and auriculate deltidial plates.

Recent, U. S. Bureau of Fisheries Station 5592, 305 fathoms, 43.3° F., gravel and mud bottom, Sibuko Bay, south of Silungan Island, Borneo.

Figs. 7-15. 7, Posterior of the pedicle valve of another specimen, × 4, showing corrugated teeth, and conjunct and auriculate deltidial plates, hypotype U.S.N.M. 274135. 8, 9, Respectively full and tilted views of the preceding pedicle valve, × 2, showing dental plates, muscle area and pallial sinuses. 10, Interior of the apex of the preceding pedicle valve, × 4, showing pedicle collar, auriculation of deltidial plates, corrugated teeth, and small genital areas. 11, 12, Tilted and full views of the interior of the brachial valve of the preceding specimen showing cardinalia, pallial sinuses, and muscle scars, × 2. 13, 14, Two views of the apex of the preceding brachial valve tilted to show the cardinalia in partial side and partial anterior position, the strongly corrugated sockets, and the broad outer hinge plates, × 4. 15, Poste-

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rior view of the cardinalia of the same brachial valve as the preceding, × 4, showing the broad and flat outer hinge plates. The crura are shorter than normal because of slight breakage at the distal extremity.

U. S. Bureau of Fisheries Station 5487, 585 fathoms, 52° F., on mud, off Panaon Island, Philippines.

Plate 13

Hispanirhynchia? and *Neohemithyris* (=*Basiliola*)

A. *Hispanirhynchia?* species 60

Figs. 1-5. 1-3, Respectively ventral, dorsal, and anterior views of a somewhat crushed specimen, × 1, figured specimen U.S.N.M. 549361. 4, Dorsal view of the preceding specimen, × 2, showing foramen. 5, Beak of the preceding, × 4, showing foramen and disjunct deltidial plates.

Eocene (lower), 200 meters south of the south side of the Riverside Yacht Club, west side Almendares River, in Reparto Kohly, Habana Province, Cuba.

B. *Basiliola lucida* (Gould) 34

Figs. 6-23. 6-10, Respectively posterior, anterior, dorsal, side, and ventral views of a complete specimen, × 1, showing small size, rounded form, and nearly smooth exterior, hypotype U.S.N.M. 110826a. 11-13, Respectively anterior, side, and dorsal views, × 2, of the preceding specimen showing the same features. 14, Interior of the pedicle valve, × 2, showing pallial marks indistinctly, hypotype U.S.N.M. 110826b. 15, Apex of same specimen, × 4, showing corrugated tooth and conjunct deltidial plates. 16, The same specimen tilted to show the pedicle collar and dental plates, × 4. 17, 18, Interior and tilted views of another pedicle valve showing the pallial marks, foramen, teeth, and deltidial plates, × 4, hypotype U.S.N.M. 110826c. 19, Interior of the brachial valve, × 2, hypotype U.S.N.M. 110826b. 20, Posterior part of the same specimen showing the cardinalia with the long falcifer crura, × 4. 21-23, Respectively side, tilted anterior, and full views of another brachial valve, × 4, showing the long falcifer crura, the small elevated inner hinge plates, corrugated sockets, small genital areas, and pallial marks, hypotype U.S.N.M. 110826c.

Recent, U. S. Fish Commission Station 4936, rocky bottom at 103 fathoms, Kagashima Gulf, Kyushu, Japan.

Plate 14

Basiliola and *Frielcia*

A. *Basiliola beecheri* (Hall) 25

Fig. 1. Interior of the pedicle valve of an obese specimen, × 2, showing thickened marginal rim and pallial marks, hypotype U.S.N.M. 334667.

Recent, U. S. Fish Commission Station 3864, 163 to 198 fathoms, 55.9° F., Pailolo Channel, Hawaiian Islands.

Fig. 2. Dorsal view of the apex of a pedicle valve showing the deltidial plates with their reflected rim and the anterior smooth area of the

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pedicle collar which slides over the umbo of the dorsal valve, × 4, hypotype U.S.N.M. 274136.

Recent, U. S. Fish Commission Station 3811, 238 to 252 fathoms, 70.5° F.?, south coast of Oahu, Hawaiian Islands.

B. *Frieleia? nitens* (Conrad) = *F.? astoriana* (Dall) 55

Figs. 3-6. 3-5, Respectively side, dorsal, and ventral views of the holotype, U.S.N.M. 3487. 6, Ventral view of another specimen showing broad sulcus and radial lines on exfoliated shell, × 1, paratype U.S.N.M. 3487a.

Miocene, Astoria, Clatsop County, northwest Oregon.

C. *Basiliola elongata* Cooper, new species 29

Figs. 7-21. 7-11, Respectively dorsal, anterior, ventral, posterior, and side views of the holotype, × 1, U.S.N.M. 235844a. 12-14, Respectively dorsal, side, and anterior views of the holotype, × 2, showing smooth surface, elongate form, and growth lines. 15, Interior of the pedicle valve of the paratype U.S.N.M. 235844b, × 2. 16, Beak region of the same pedicle valve, × 4, showing the fused deltidial plates and the reflected rim around the foramen. 17, Same pedicle valve, × 3, tilted to show the pedicle collar, dental plates, and small genital region. 18, Interior of the brachial valve of the same paratype, × 2, showing elongated falcifer crura. 19, 20, Side and anterior views of the preceding showing the broad falcifer crura, concave inward, and with serrate distal extremity, the small reflected inner hinge plates, and the broad outer hinge plates, × 4. 21, Interior of the apex of the same brachial valve, × 6, showing the falcifer crura, broad outer hinge plates, small inner plates, and corrugated sockets.

Recent, U. S. Bureau of Fisheries Station 5146, 24 fathoms on coral sand, Sulade Island, Tapul Group, Philippines.

Plate 15

Frieleia and *Eohemithyris*

A. *Frieleia halli* Dall 53

Figs. 1-5, 12-14. 1-3, Respectively anterior, brachial, and side views, × 1, of a complete specimen showing the narrow sulcus in each valve and the rectimarginate anterior commissure, hypotype U.S.N.M. 110830a. 4, Interior of the pedicle valve tilted to show the strong dental plates and small teeth, × 2, hypotype U.S.N.M. 110830b. 5, Apical region of the preceding, × 4, showing the disjunct deltidial plates and incomplete foramen. 12, Brachial valve tilted to show apical chamber of the cardinalia, × 2, hypotype U.S.N.M. 110830c. 13, Another brachial valve tilted to show the apical chamber, × 2, hypotype U.S.N.M. 110830b. 14, The same, × 4, showing the apical chamber and cardinal process.

Recent, U. S. Fish Commission Station 4797, 682 fathoms, off Avacha Bay, Kamchatka.

Figs. 6-11. 6-8, Respectively full, partial side, and tilted views of a brachial valve showing cardinalia and median septum, × 2, hypotype U.S.N.M. 549348a. 9, 11, Apical part of another brachial valve in full

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and anterior views showing the cardinalia, ×2, hypotype U.S.N.M. 549348b. 10, The same, ×4, showing the large inner hinge plates covering the apical chamber and the small transverse cardinal process.

Recent, U. S. Fish Commission Station 2923, 522 fathoms, off San Diego, California.

B. *Eohemithyris columnus* (Hedley) 32

Figs. 15-26. 15-17, Respectively brachial, anterior, and side views of a complete specimen showing the anterior costation and uniplicate anterior commissure, ×1, hypotype U.S.N.M. 333012b. 18, Enlargement, ×2, of the beak of the preceding specimen showing the small submesothyrid foramen and conjunct deltidial plates. 19, 20, Two views of the interior of a pedicle valve, ×2, one in full view, the other anteriorly tilted to show the minute dental plates, small genital areas, and pallial sinuses, hypotype U.S.N.M. 333012a. 21, Apical part of the preceding specimen showing beak, foramen, and conjunct deltidial plates, ×4. 22, 23, Full view and slightly tilted view of the brachial valve of the preceding specimen showing the cardinalia, pallial sinuses, and genital areas, ×2. 24, 25, Partial side and full views of the cardinalia showing the distally serrate, falcifer crus, corrugated sockets, and thickening over the crural bases, ×4. 26, Posterior part of the preceding tilted to show the concave ends of the crura, the small genital areas, and the interior thickening, ×4.

Recent, 115-135 fathoms, off Gabo Island, Victoria, Australia.

Plate 16

Compsothyris

A. *Compsothyris racovitzae* (Joubin) 56

Figs. 1-17. 1-4, Respectively anterior, dorsal, ventral, and side views of a complete individual, showing faintly uniplicate commissure, ×1, hypotype U.S.N.M. 549343. 5, Dorsal view of the preceding specimen showing fine closely crowded costellae, ×2. 6, 7, Interior of the pedicle valve of the same specimen, ×2, showing small foramen and small dental plates. 8, Beak of the preceding valve, ×4, showing small corrugated teeth and small disjunct deltidial plates. 9-11, Respectively full, slightly tilted, and strongly tilted views of the brachial interior of the same specimen showing cardinalia, median septum, and muscle scars, ×2. 12, Same brachial interior tilted to show the socket ridges and distally serrate spinulifer crura, ×4. 13-15, Three views of the cardinalia variously tilted to show socket ridges, narrow outer hinge plates, and crura, ×4. 16, Same brachial valve strongly tilted to show junction of crural supporting plates with median septum, ×4. 17, Exterior of the pedicle valve, ×6, showing the very fine radial costellae.

Recent, British Antarctic Expedition 1910, Station 316 of Terra Nova, 190 to 250 fathoms, 30.5° F., off Glacier Tongue, 8 miles north of Hut Point, McMurdo Sound, Antarctic.

Plate 17

Probolarina

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A. *Probolarina salpinx* (Dall) 38

Figs. 1-19. 1-5, Respectively, posterior, ventral, side, dorsal, and anterior views of a small but complete individual, × 2, hypotype U.S.N.M. 549357a. 6, 7, Dorsal and ventral views of another hypotype showing variation of costation, × 1, U.S.N.M. 549355. 8-10, Respectively dorsal, ventral, and anterior views of a specimen larger and more strongly costate than the two preceding ones, × 1, hypotype U.S.N.M. 549357b. 11-14, Respectively side, anterior, ventral, and dorsal views of a small specimen with few costae, × 3, holotype U.S.N.M. 109293a. 15, Apical portion of a large specimen showing the small submesothyrid foramen, conjunct and auriculate deltidial plates, × 4, hypotype U.S.N.M. 549354a. 16, Interior of a brachial valve, × 3, showing cardinalia, hypotype U.S.N.M. 549356d. 17, 18, Partial side and full views of the apical part of the same specimen, × 6, showing the concave falcifer crura and large outer hinge plates. 19, The same tilted anteriorly to show the concave crura and lack of median ridge, × 6.

Eocene (Castle Hayne formation), at the city quarry near the cemetery, Wilmington, North Carolina.

B. *Probolarina holmesii* (Dall) 38

Figs. 20-36. 20-24, Respectively posterior, anterior, dorsal, ventral, and side views of a complete specimen, × 2, hypotype U.S.N.M. 549359a. 25, The same, × 3, showing the ornamentation and long beak. 26, 27, Beak of the same specimen, × 5, showing conjunct and strongly auriculate deltidial plates. 28, Small specimen showing foramen and conjunct deltidial plates, × 4, hypotype U.S.N.M. 549359b. 29, 30, Apical part of another specimen showing conjunct and auriculate deltidial plates, × 6, and the same tilted to show the dental plates and pedicle collar, × 6, hypotype U.S.N.M. 549359e. 31, The same tilted to the side to show the pedicle collar, × 4. 32, Apex of another pedicle valve showing strongly auriculate deltidial plates, × 6, hypotype U.S.N.M. 549359f. 33, Interior of the brachial valve, × 3, showing cardinalia and absence of median ridge, hypotype U.S.N.M. 549359g. 34, 35, Apical part of the preceding tilted to show concave falcifer crura, × 6. 36, Same in full view to show the outer hinge plates, × 6.

Horizon and locality same as above.

Plate 18

Erymnaria

A. *Erymnaria bolcensis* (Massalongo) 64

Figs. 1-17. 1-5, Respectively dorsal, side, posterior, anterior, and ventral views of a decorticated specimen showing symmetrical form, × 1, U.S.N.M. 549383b. 6, Posterior view of preceding, × 3, to show dorsal umbo, trace of the crural supporting plates, and the shorter socket ridges outside of them (photographed under water). 7, Anterior of same specimen, × 2, showing symmetrical fold on brachial valve.

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8-12, Respectively posterior, anterior, side, dorsal, and ventral views of another symmetrical specimen, × 1, hypotype U.S.N.M. 549383a. 13-15, Respectively dorsal, anterior, and side views of the preceding, × 2. 16, 17, Two views of cross sections of the beak of the brachial valve U.S.N.M. 549383c, ca. × 8, respectively 2.6 mm. and ca. 6.0 mm. anterior to the beak, showing crura, crural supports, and socket ridges (see pl. 22, fig. 9, and explanation).

Lower Eocene (Spilecciano), Spilecco, Verona, Italy.

B. *Erymnaria polymorpha* (Massalongo) 64

Figs. 18-25, 31-34. 18-22, Respectively ventral, dorsal, side, anterior, and posterior views of a large but imperfect specimen showing twisted anterior commissure and traces of pallial marks, × 1, hypotype U.S.N.M. 75888a. 23, 24, Dorsal and anterior views of the same specimen, × 2, showing trace of vascula media and twisted anterior commissure. 25, Dorsal view of the same specimen taken under water and tilted away from the observer to show the long crural supporting plates as black lines and the shorter socket ridges, × 3. 31-33, Respectively side, anterior, and dorsal views of the preceding specimen, × 2, showing costae along the anterior margin. 34, Another specimen tilted away from the observer and taken under water to show the trace of the long crural supporting plates and the shorter socket ridges diverging widely from the beak, × 4, hypotype U.S.N.M. 75888b.

Lower Eocene, Spilecco, Verona, Italy.

Figs. 26-30, 35, 36. 26-30, Respectively anterior, ventral, side, posterior, and dorsal views of another specimen, not decorticated like the preceding, and showing, in addition to the twisted commissure, short radial costae, × 1, hypotype U.S.N.M. 549384a. 35, Posterior of a brachial valve excavated to show cardinalia and crural supporting plates, × 6, hypotype U.S.N.M. 549384b. 36, Another brachial valve interior showing cardinalia with their fairly broad outer hinge plates, and crural supporting plates, × 6, hypotype U.S.N.M. 549384c.

Lower Eocene (Spilecciano), Spilecco, 400 meters southwest of Purga di Bolca, Monti Lessini, Verona, Italy.

Plate 19

Erymnaria and *Streptaria*

A. *Erymnaria cubensis* Cooper 65

Figs. 1-10. 1-5, Respectively dorsal, anterior, ventral, posterior, and side views of the holotype, × 1, U.S.N.M. 549385. 6-8, Respectively side, dorsal, and anterior views of the same specimen, × 2, showing folding. 9, Posterior of holotype, × 3, showing conjunct deltidial plates and foramen. 10, Holotype tilted and photographed under water to show crural supporting plates and the shorter, more widely divergent socket ridges, × 3.

Eocene, 80 meters northeast of school, Chucho Machin, Matanzas Province, Cuba.

B. *Streptaria streptimorpha* Cooper, new species 40

Figs. 11-21. 11-15, Respectively anterior, ventral, side, dorsal, and pos-

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terior views of the holotype, × 1, showing twisted anterior commissure, U.S.N.M. 549386a. 16, Dorsal view of the holotype showing smooth exterior, × 1½. 17, 18, Side and anterior views of the holotype, × 2, showing twisted commissure. 19, Posterior of the holotype, × 3, showing deltidial plates and foramen. 20, 21, Posterior of another specimen, × 4, showing short dental plates and cardinalia with falcifer crura (see discussion), paratype U.S.N.M. 549386b.

Eocene, deep cut north of Grua 9, Ramal Juan Criollo, Camaguey Province, Cuba.

C. *Streptaria buchi* (Michelotti) 38

Figs. 22-31. 22-26, Respectively ventral, dorsal, anterior, side, and posterior views of a complete specimen showing twisted anterior commissure, × 1, hypotype U.S.N.M. 549352a. 27-29, Respectively anterior, dorsal, and side views of the preceding specimen, × 2, showing twisted commissure. 30, Posterior of the same specimen, × 3, showing large foramen with elevated rim. 31, Posterior of the brachial valve of another specimen prepared to show the strong socket ridges, wide outer hinge plates, and falcifer crura with thickened ventral edge, × 6, hypotype U.S.N.M. 549352b.

Middle Miocene, Messina, Sicily.

Plate 20

Eohemithyris

A. *Eohemithyris alexi* Hertlein and Grant 30

Figs. 1-16. 1-5, Respectively dorsal, posterior, ventral, side, and anterior views of a complete and undistorted specimen, showing form and true profile of valves, × 1, hypotype U.C.M.P. 15524. 6-9, Respectively, anterior, ventral, dorsal, and side views of the same specimen, × 2. 10, Dorsal view of another nearly perfect specimen showing rounded outlines and low fold, × 1, hypotype U.C.M.P. 15526. 11, Posterior of the same specimen, × 3, showing small foramen. 12, Posterior of another specimen, × 3, showing small foramen and conjunct deltidial plates, hypotype U.C.M.P. 15541. 13, 14, Dorsal and ventral views of a specimen from which the shell has been scraped to show the muscle fields, × 2, hypotype U.C.M.P. 15542. 15, 16, Full view and partial side view of the cardinalia, × 6, showing narrow outer hinge plates and broad, long falcifer crura, hypotype U.C.M.P. 15545.

Eocene (Domengine formation), from just below the 1/4 section marker toward the top of the 25-foot last sandstone "reef" on the ridge on the east side of the North Fork of Media Agua Creek, grid. coord. 142001-139004, McKittrick (15′) Quadrangle, Kern County, California (see text for further information).

B. *Eohemithyris grayi* (Woodward) 33

Figs. 17-23. 17, Dorsal view of the exterior, ca. × 2, showing anterior costae and minute foramen, holotype British Museum (Nat. Hist.) ZB280. Specimen coated by ammonium chloride. 18-20, Respectively

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side, dorsal, and anterior views of the same specimen, ca. × 2. 21, Posterior of the same specimen (coated) showing small foramen, ca. × 2½. 22, Interior of the pedicle valve of the holotype, ca. × 2½, showing small foramen, muscle field, and pallial marks. 23, Interior of the brachial valve of the holotype showing cardinalia with falcifer crura, thickened inner edges of crural bases, muscle field, and pallial marks, ca. × 4.

Recent, Fiji Islands.

Photographs by permission of the Trustees of the British Museum (Natural History) through Dr. H. M. Muir-Wood Deputy Keeper, Department of Palaeontology.

Plate 21

Frieleia, Patagorhynchia, Septaliphoria, Cryptopora, Tegulorhynchia, Mannia, and *Hispanirhynchia?*

A. *Hemithyris astoriana* Dall = *Frieleia* ? *nitens* Conrad 56

Fig. 1. Section of the apex of the brachial valve showing the small chamber and median septum, × 8, paratype U.S.N.M. 3487a.

Miocene, Astoria, Clatsop County, Oregon.

B. *Patagorhynchia patagonica* (Ihering) 44

Figs. 2-5. Respectively anterior, dorsal, side, and ventral views of a fairly well-preserved specimen showing costellate ornamentation, × 1, figured specimen U.S.N.M. 549387.

Eocene, 1 to 2 miles southwest of Ancha Terriza, Rio de los Ciervos, Provincia de Magallones, Chile.

C. *Septaliphoria* species 10

Fig. 6. Interior of the dorsal valve tilted to show septalium and median septum, × 2, figured specimen U.S.N.M. 129896a.

Jurassic (Lower Callovian), in the railroad cut 300 meters east of the station at Chatillon-sur-Seine, Department of Côte d'Or, France.

D. *Cryptopora gnomon* (Jeffreys) 22

Figs. 7-14. 7-9, Respectively anterior, side, and ventral views of a complete specimen, × 6, hypotype U.S.N.M. 449111a. 10, Anterior of another specimen, × 6, showing the sulcate anterior margin, hypotype U.S.N.M. 449111c. 11, Dorsal view of the preceding, × 8, showing the nonauriculate deltidial plates. 12, Posterior of the pedicle valve, × 8, showing deltidial plates, apical plate, and teeth, hypotype U.S.N.M. 449111d. 13, 14, Full and partial side views of the brachial valve of the preceding interior showing median septum and maniculifer crura.

Recent, U. S. Fish Commission Station 2221, 1,525 fathoms, 36.9° F., south of Marthas Vineyard, Massachusetts, in gray ooze.

E. *Tegulorhynchia döderleini* (Davidson) 51

Fig. 15. Interior of the pedicle valve, × 1, showing pallial sinuses, after Leidhold, Neues Jahrb. Min., Geol., Paläont., BB. 45, pl. 11, fig. 1b [here reduced 1/2], 1922. Original in Institute of Zoology, Strasburg University.

Recent, Sagami Bay, Honshu, Japan.

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F. *Mannia nysti* Davidson 22

Figs. 16-20. 16, Drawing of the dorsal side, ca. × 1. 17, Exterior of the dorsal side, ca. × 7, showing large foramen and long, elevated deltidial plates. 18, 19, Interior of two brachial valves showing septum with spoonlike plate and long maniculifer crura. 20, Cross section through a complete individual showing relationship of valves, median septum, spoonlike plate, and crura. All from Davidson, Geol. Mag., dec. 2, vol. 1, No. 4, pl. 7, 10-13, 1874.

Miocene (Diestien), 3 miles east of Antwerp, Belgium.

G. *Hispanirhynchia ? craneana* (Dall) 61

Figs. 21-26. 21-23, Respectively dorsal, anterior, and side views of the holotype showing gently sulcate anterior commissure, × 1, U.S.N.M. 122861. 24, The holotype, × 2, showing the beak area. 25, The beak region of the holotype, × 4, showing teeth (the deltidial plates probably have been broken away). 26, Posterior of the brachial valve showing spinulifer crura and small outer hinge plate (these structures have been damaged).

Recent, U. S. Fish Commission Station 3362, mud at 117 fathoms and 36.8° F., off Cocos Island, Pacific Ocean off Panama.

Plate 22

Eohemithyris, Erymnaria, Notosaria, Aphelesia

A. *Eohemithyris alexi* Hertlein and Grant 30

Figs. 1-3. 1, 2, Full and partial side views of the cardinalia to show broad, falcifer crura, ca. × 5, hypotype U.C.M.P. 15545. 3, Drawing of the posterior of a pedicle valve, ca. × 4, showing the conjunct deltidial plates and small, round foramen, hypotype U.C.M.P. 15524.

Horizon and locality as in plate 20, figures 1-16.

B. *Erymnaria polymorpha* (Massalongo) 64

Figs. 4-9. Sections through a slightly distorted individual, ca. × 4, hypotype U.S.N.M. 549384e. Sections measured from pedicle beak respectively: (4) ca. 1 mm., (5) 1.7 mm., (6) 1.95 mm., (7) 2.25 mm., (8) 2.6 mm., and (9) ca. 4.0 mm.

Lower Eocene (Spilecciano), 400 meters southwest of Purga di Bolca, Monti Lessini, Verona, Italy.

Figs. 10-15. Sections through another individual showing long crural supporting plates, ca. × 4, British Museum (Natural History) B 8088. Sections respectively 0.3 mm. apart except figure 13 which is 0.4 mm. from figure 12.

Eocene, Castelvecchio, Vicentin, Italy.

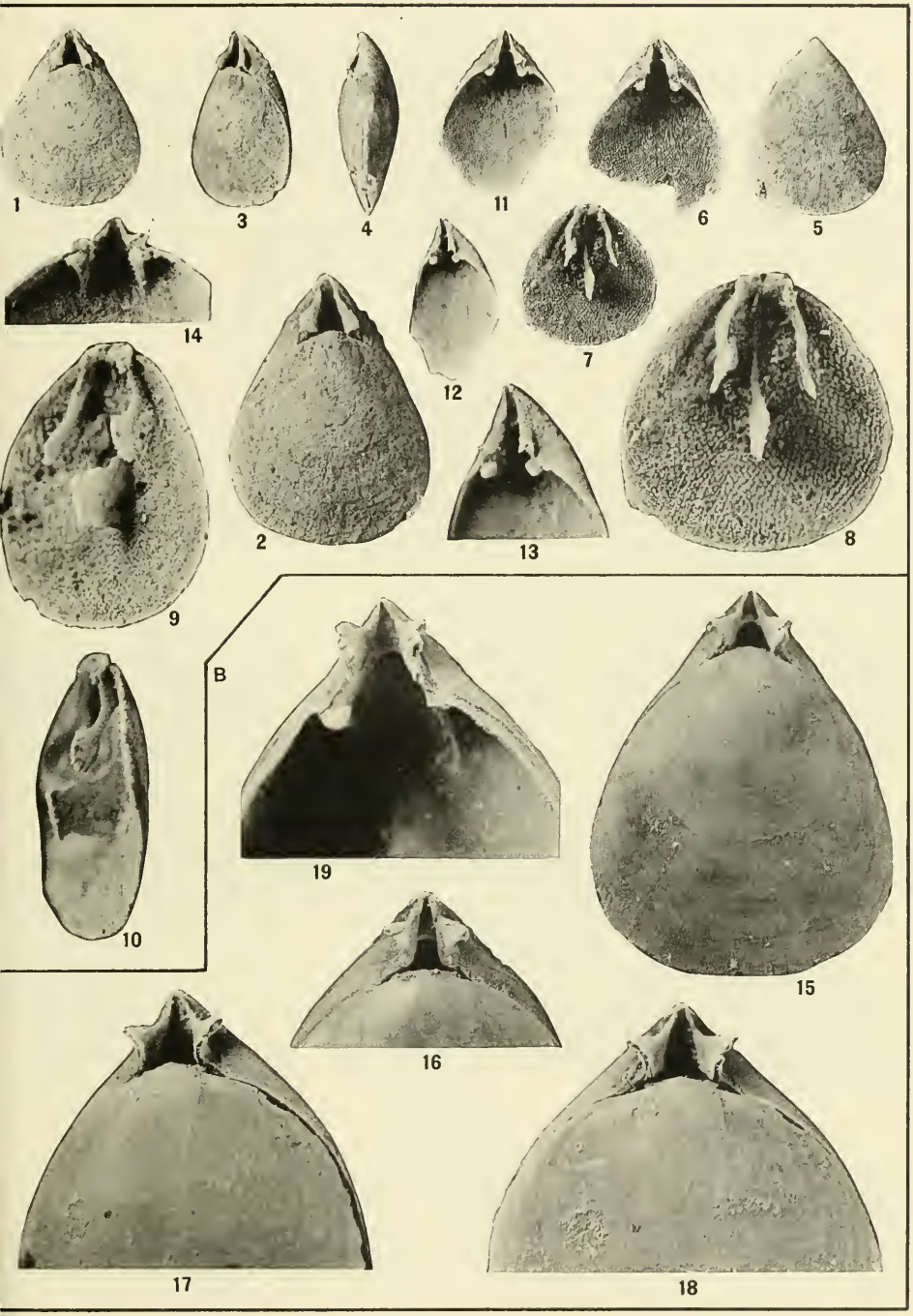
C. *Tegulorhynchia* (= *Notosaria*) *nigricans* (Sowerby) 48

Figs. 16, 17. Diagram of the interior of the pedicle and brachial valves of the adult showing pallial sinuses, ca. × 1.5, after Williams (1956, fig. 7, No. (4) on p. 276).

Recent, New Zealand.

Photographs of figures 10-15 and 18-25 by permission of the Trustees of the British Museum (Natural History) through Dr. H. M. Muir-Wood, Deputy Keeper, Department of Palaeontology.

PLATES



CRYPTOPORA

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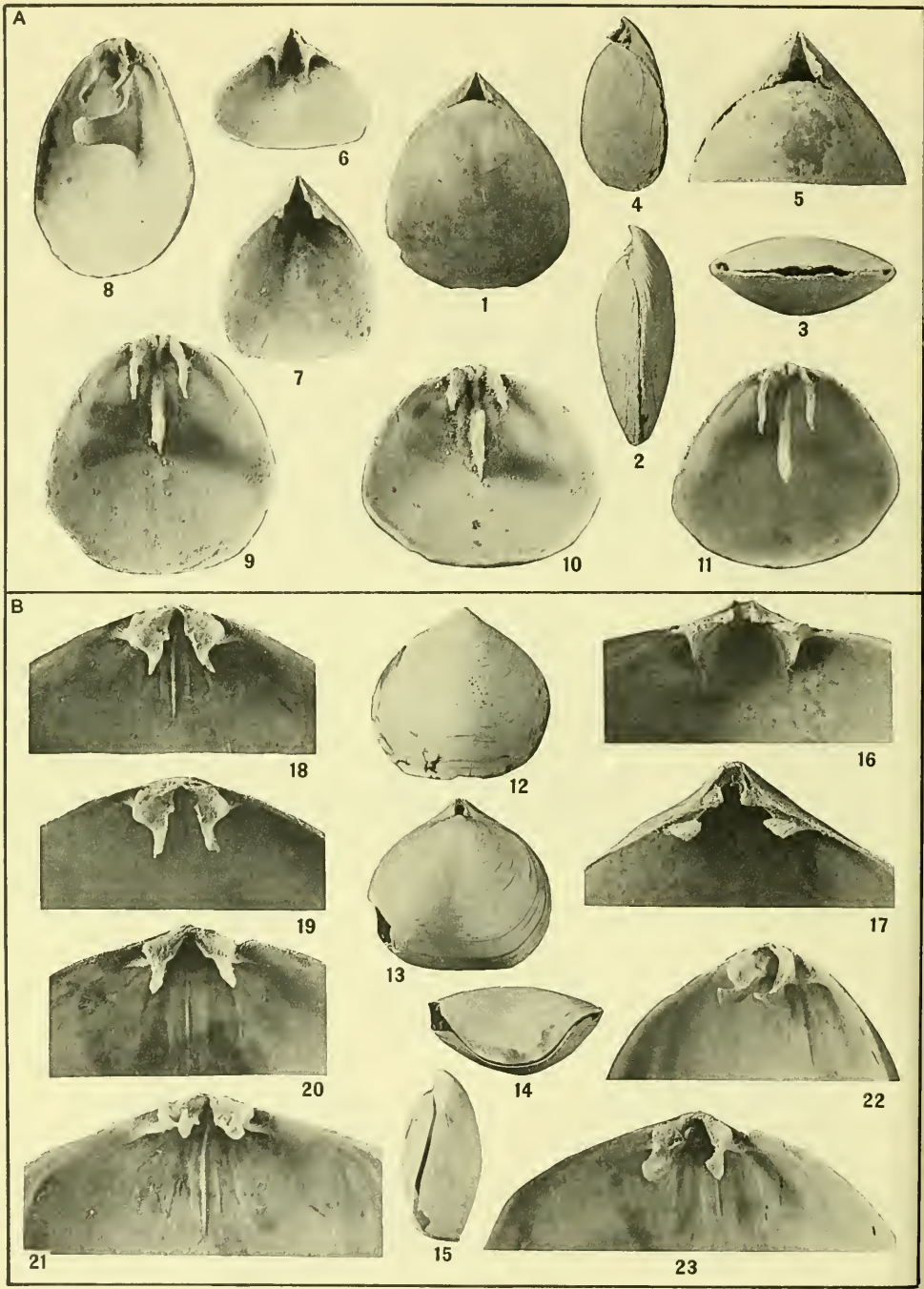

CRYPTOPORA AND NEORHYNCHIA

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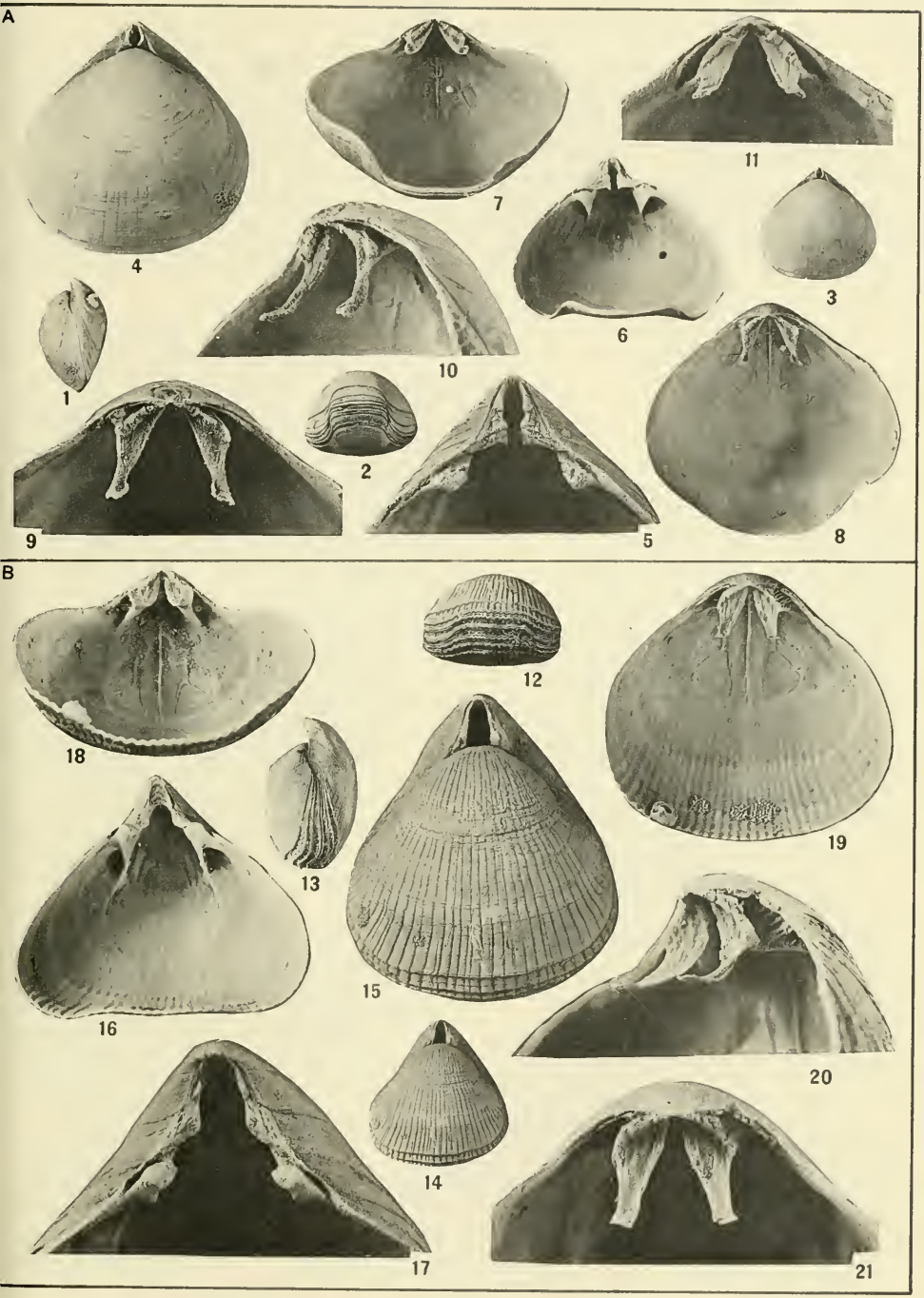

HEMITHYRIS

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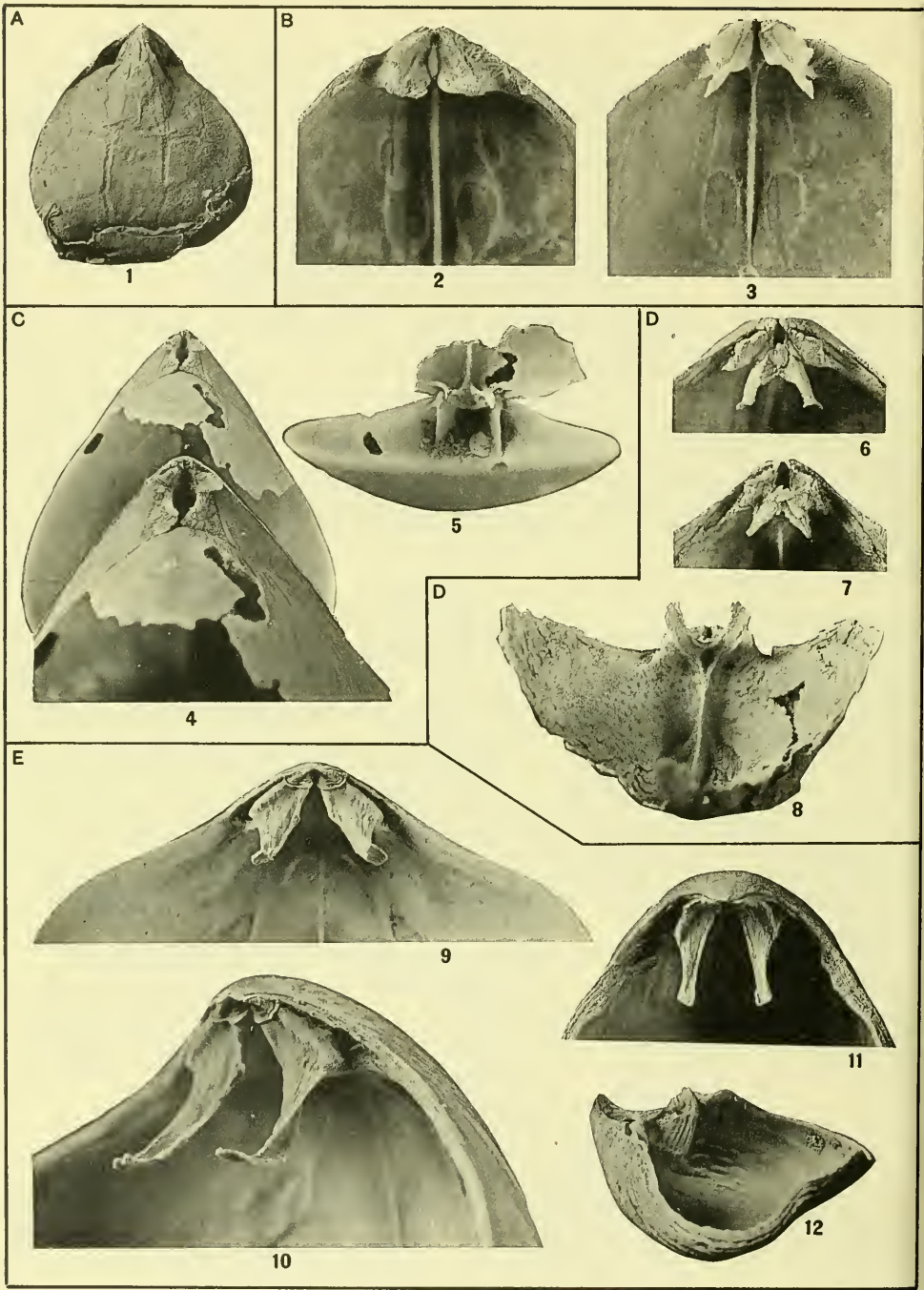

AETHEIA, FRIELEIA, GRAMMETARIA, CAMAROTOECHIA, AND HEMITHYRIS

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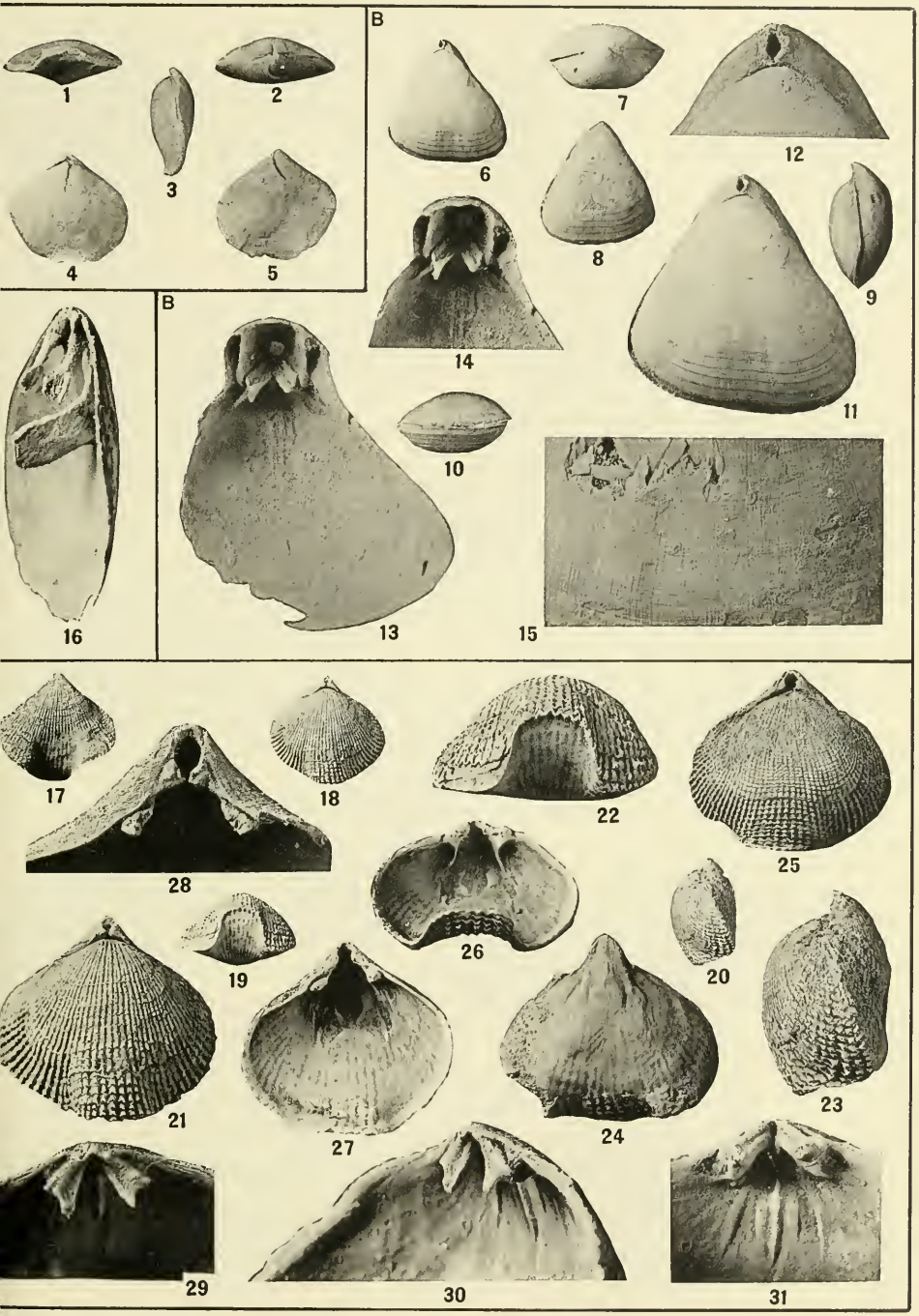

EOHEMITHYRIS, SPHENARINA, CRYPTOPORA, AND TEGULORHYNCHIA

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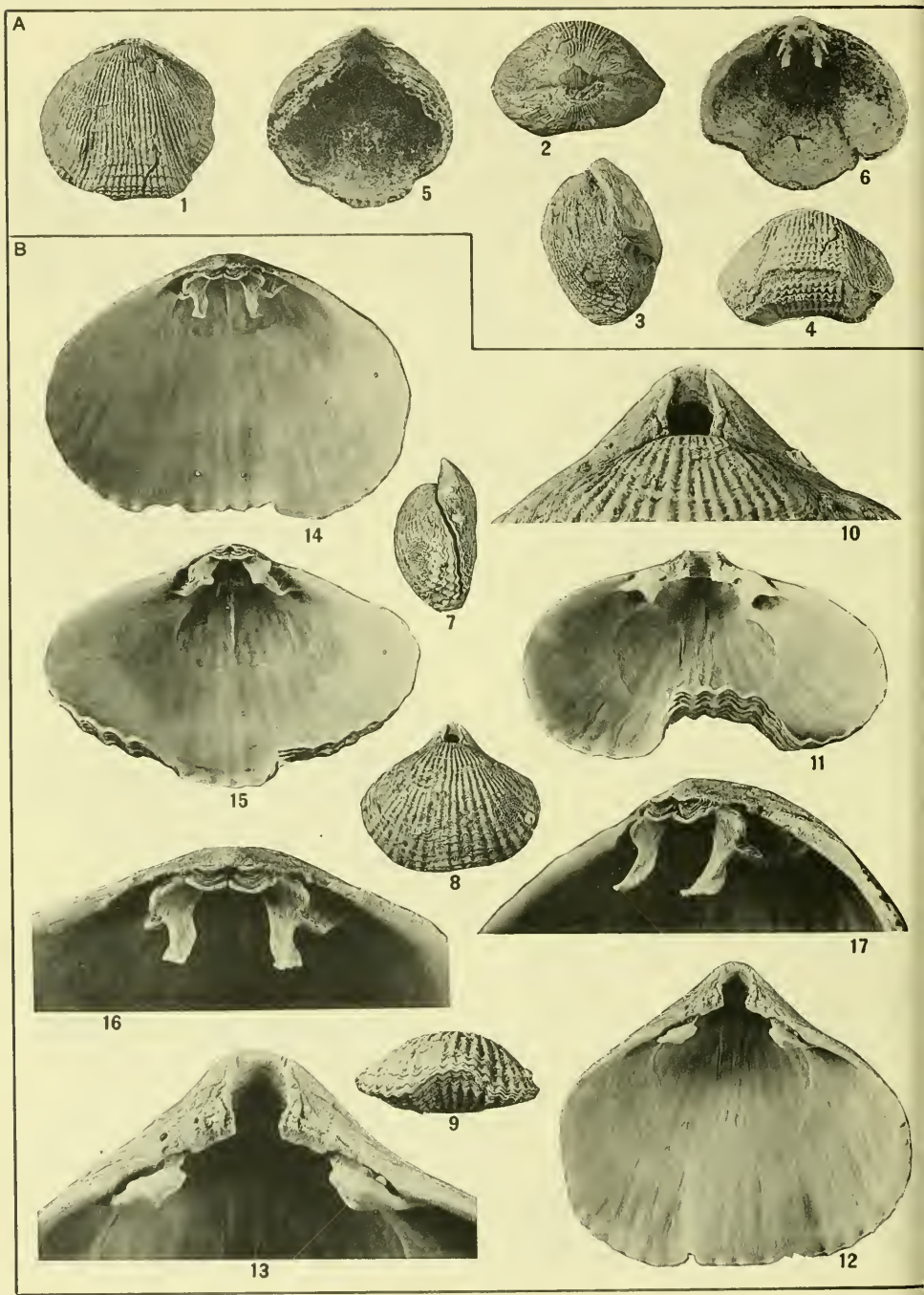

PATAGORHYNCHIA AND NOTOSARIA

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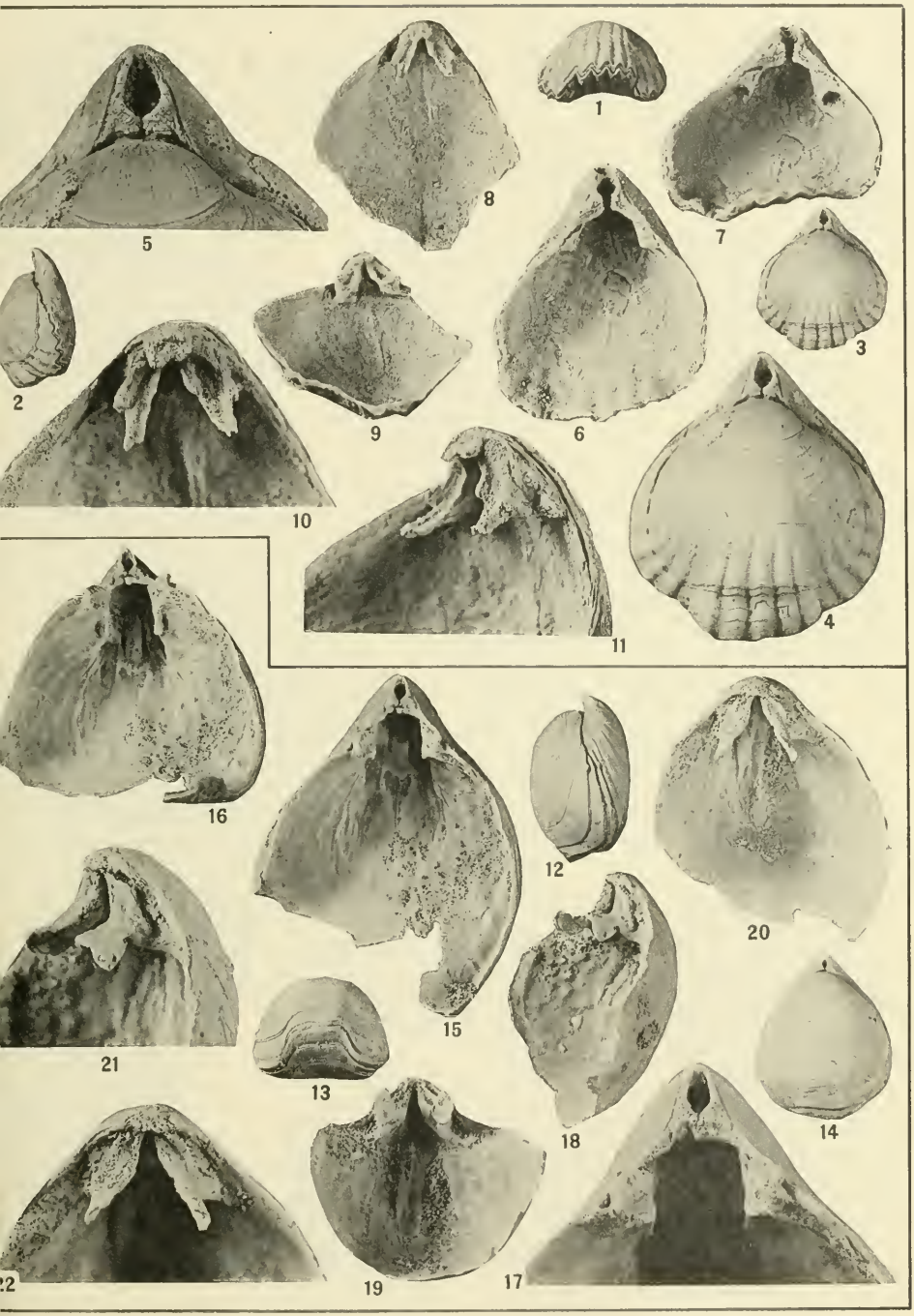

PLICIRHYNCHIA AND APHELESIA

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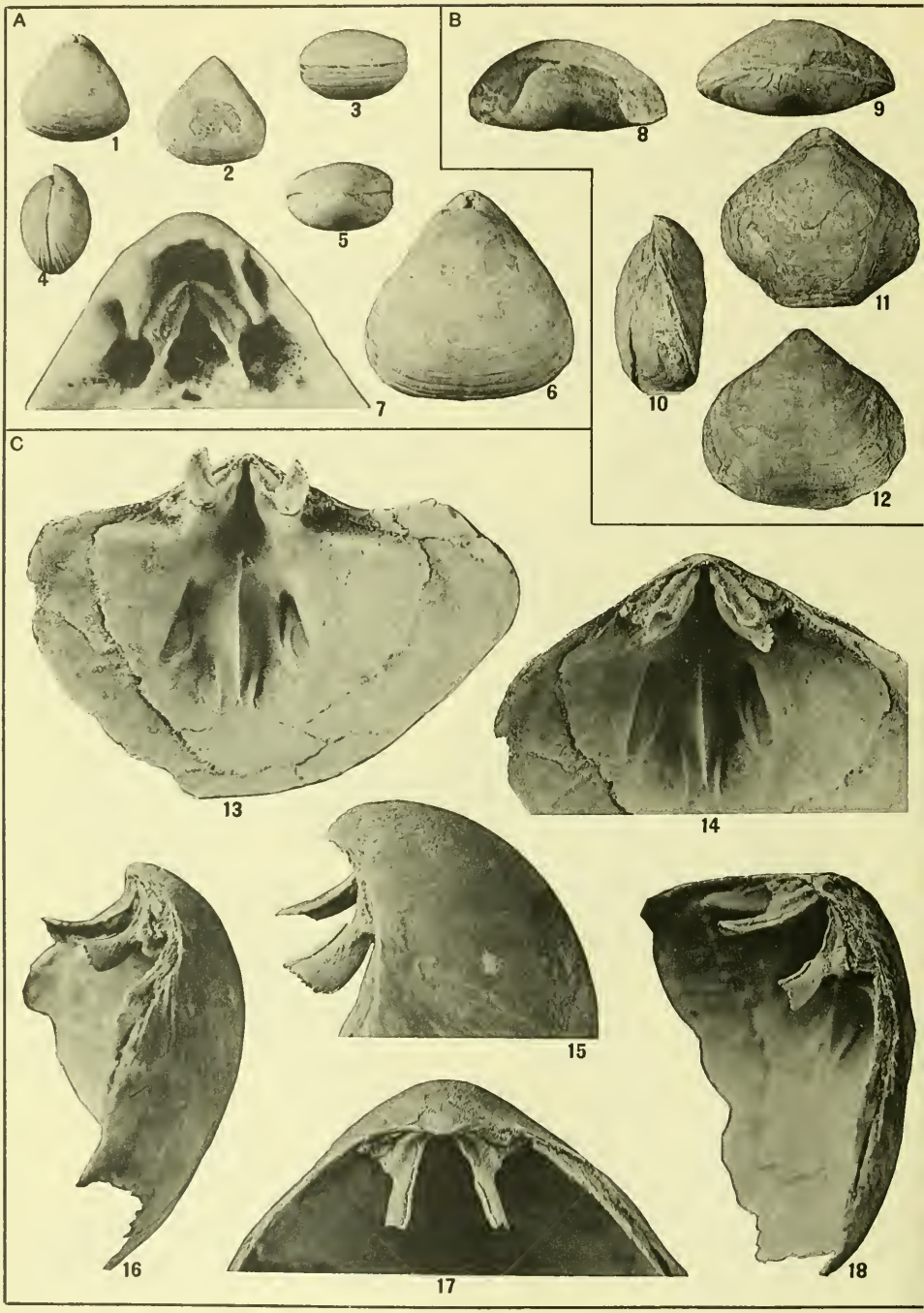

SPHENARINA, APHELESIA, AND EOHEMITHYRIS?

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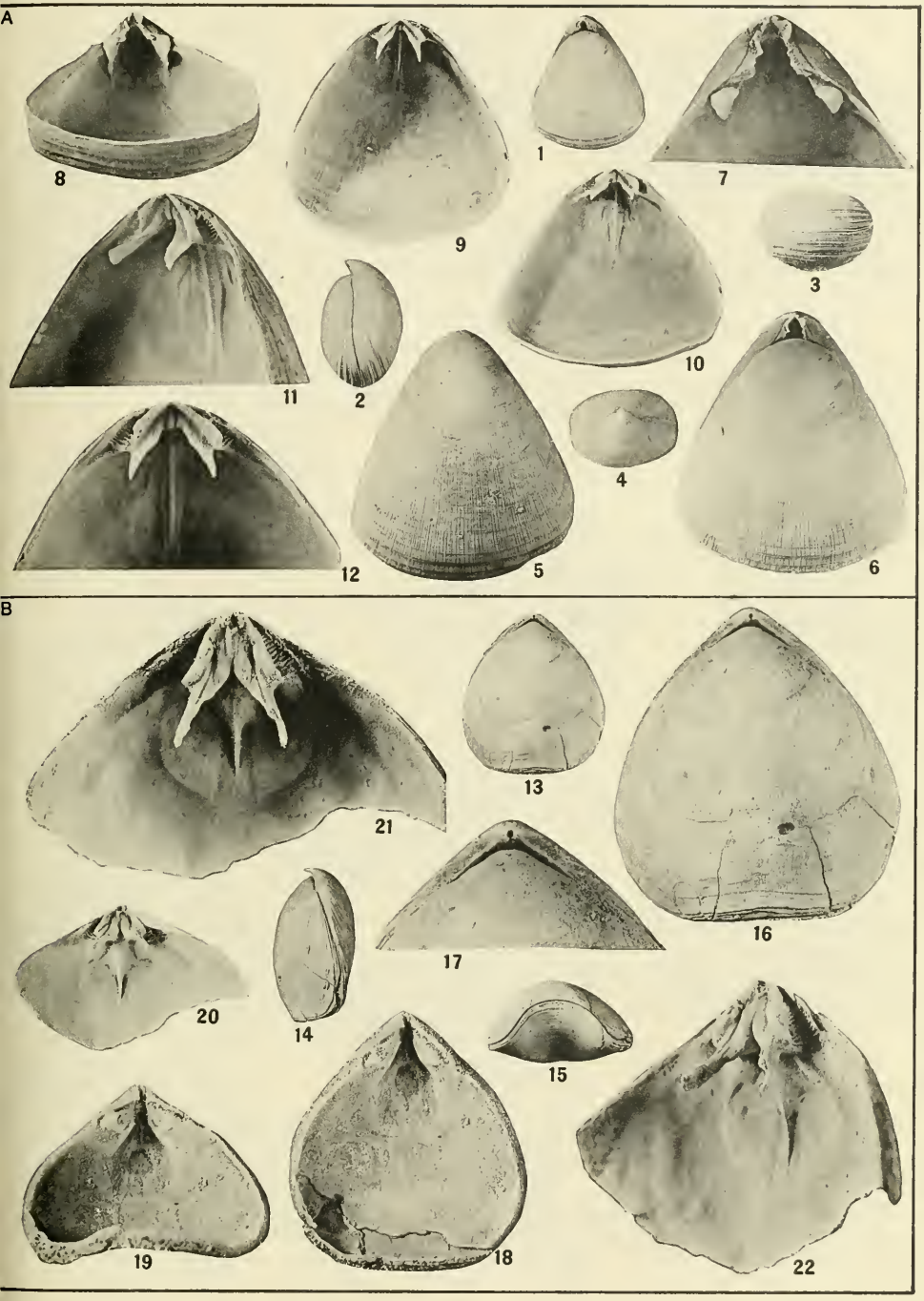

GRAMMETARIA AND AETHEIA

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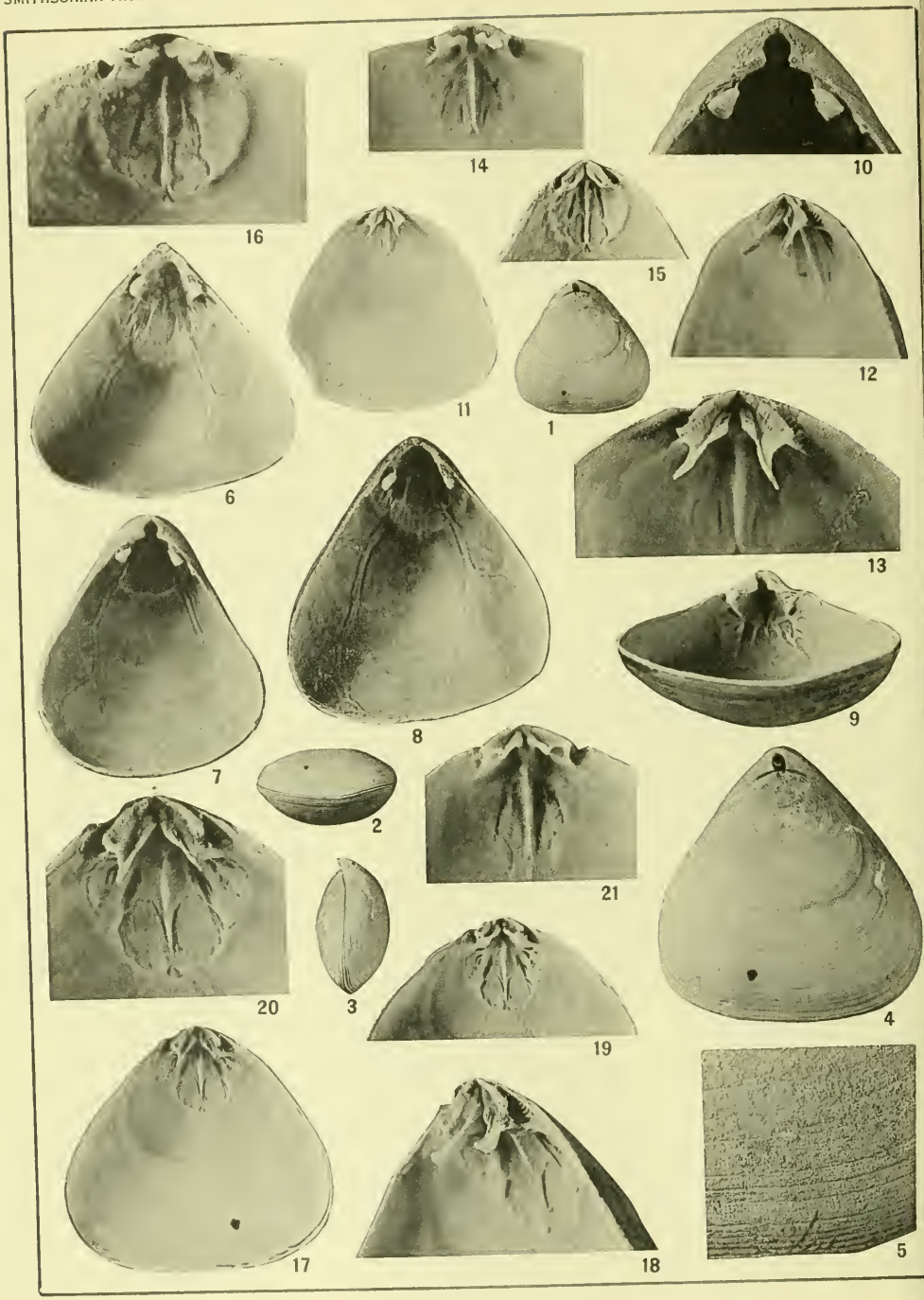

HISPANIRHYNCHIA

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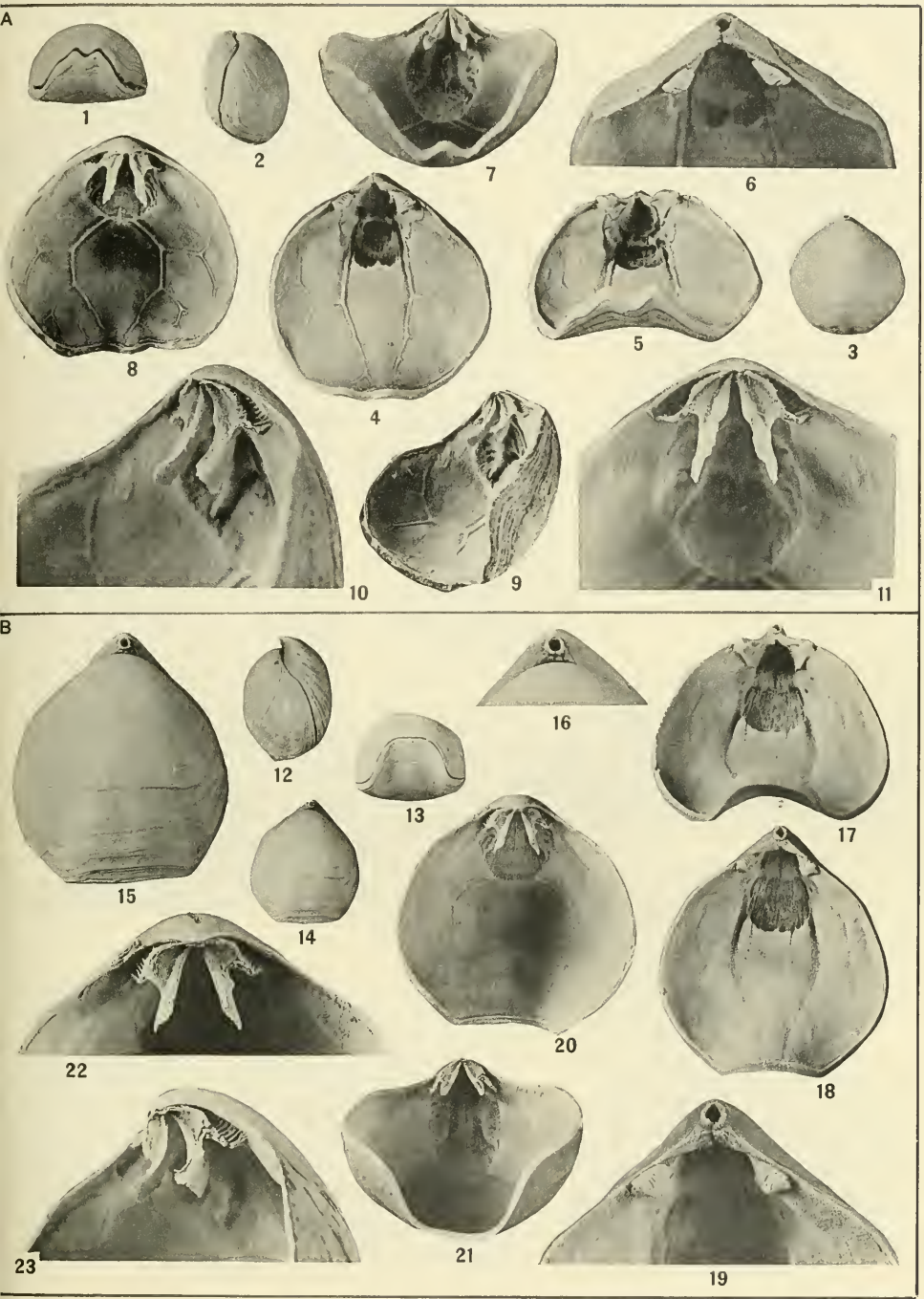

RHYTIRHYNCHIA AND BASILIOLA

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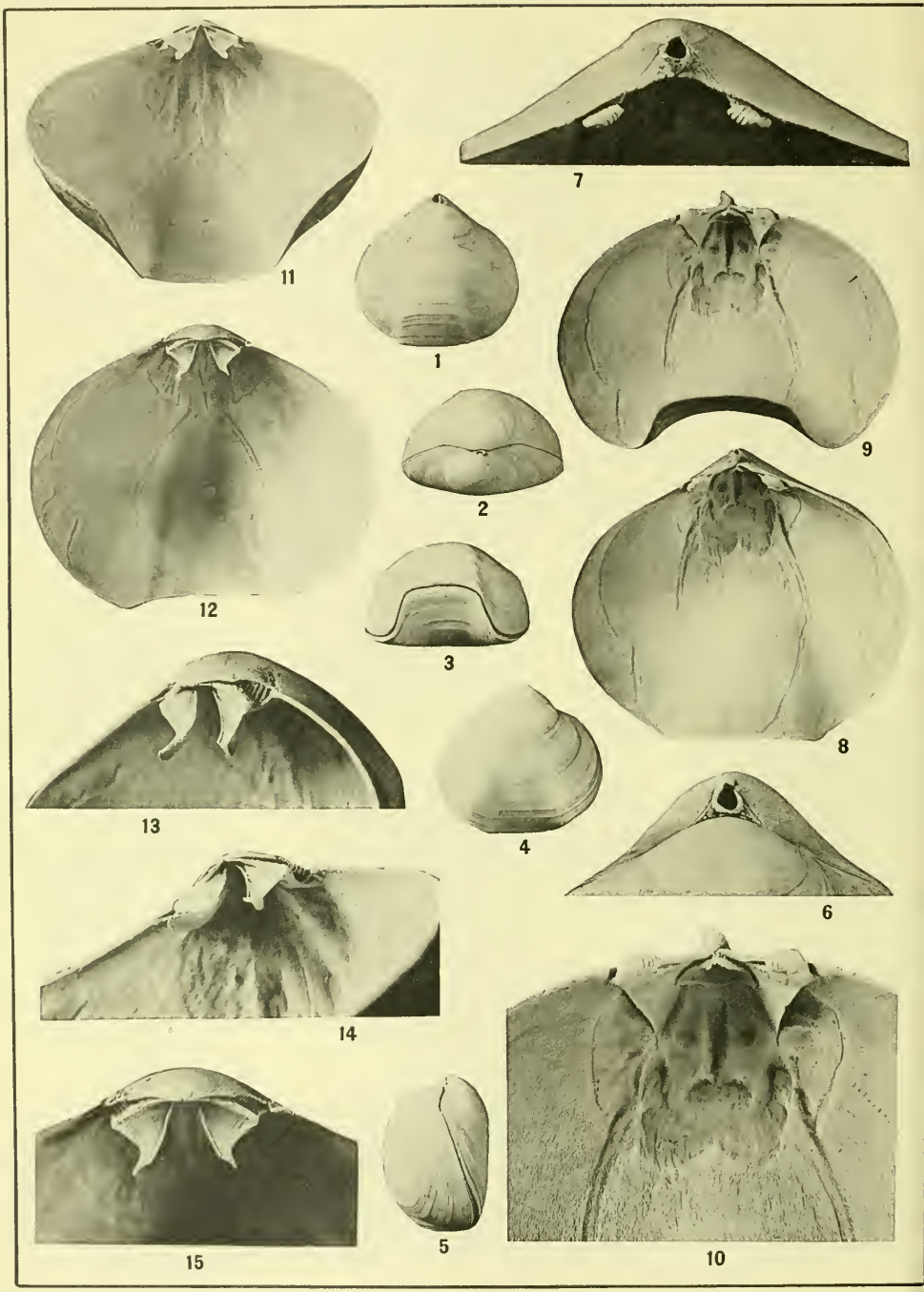

BASILIOLA

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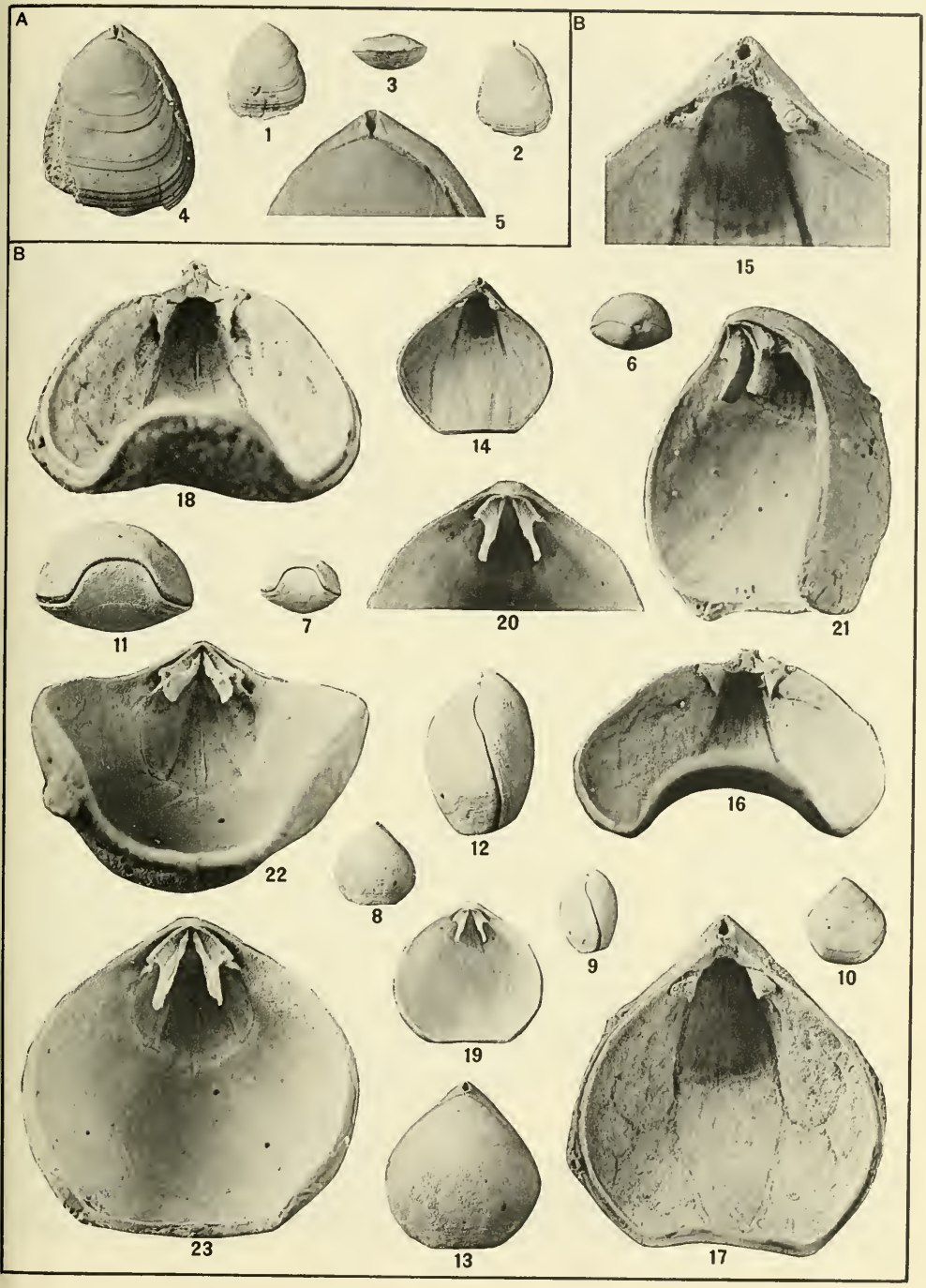

HISPANIRHYNCHIA? AND NEOHEMITHYRIS = BASILIOLA

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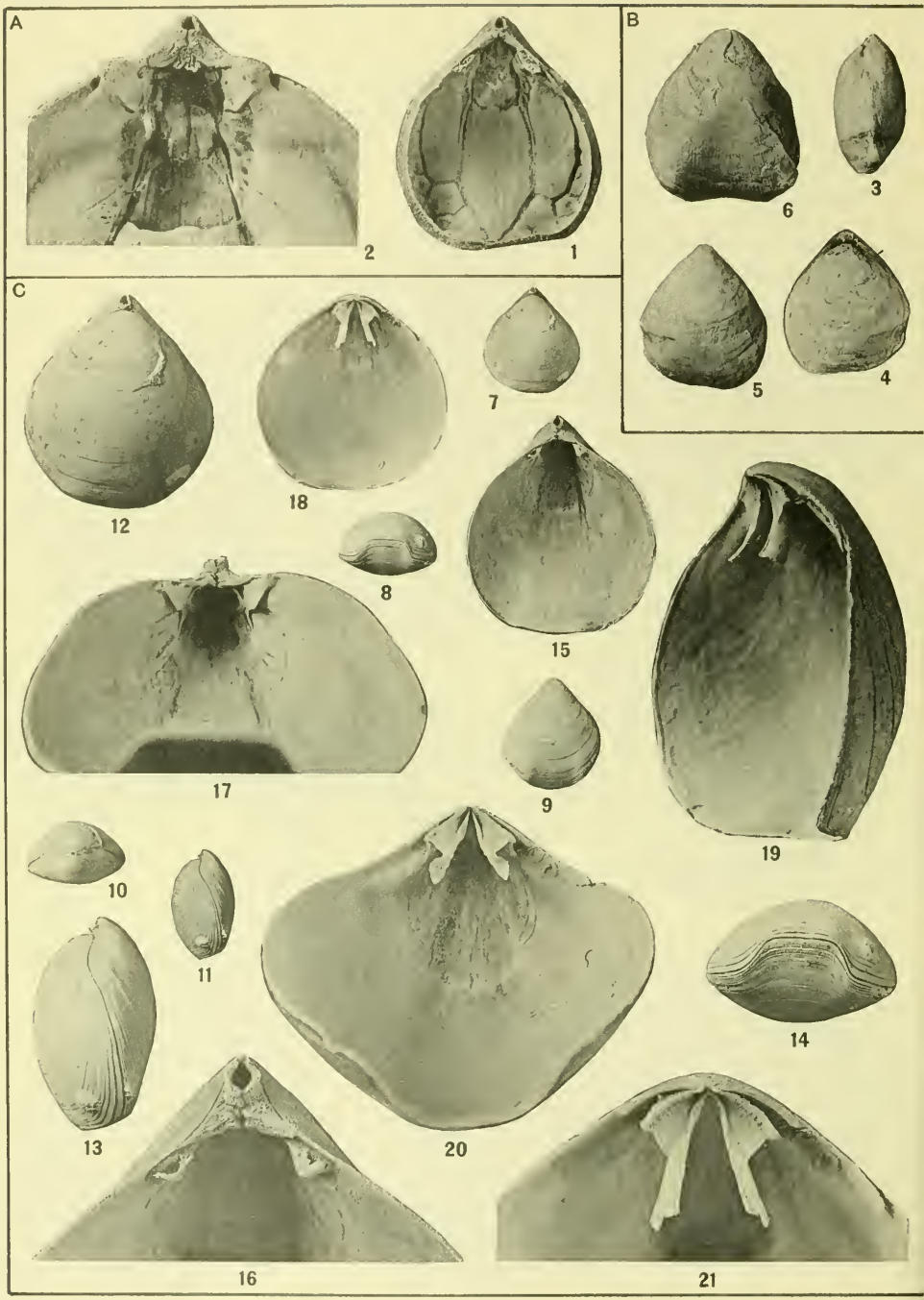

BASILIOLA AND FRIELEIA

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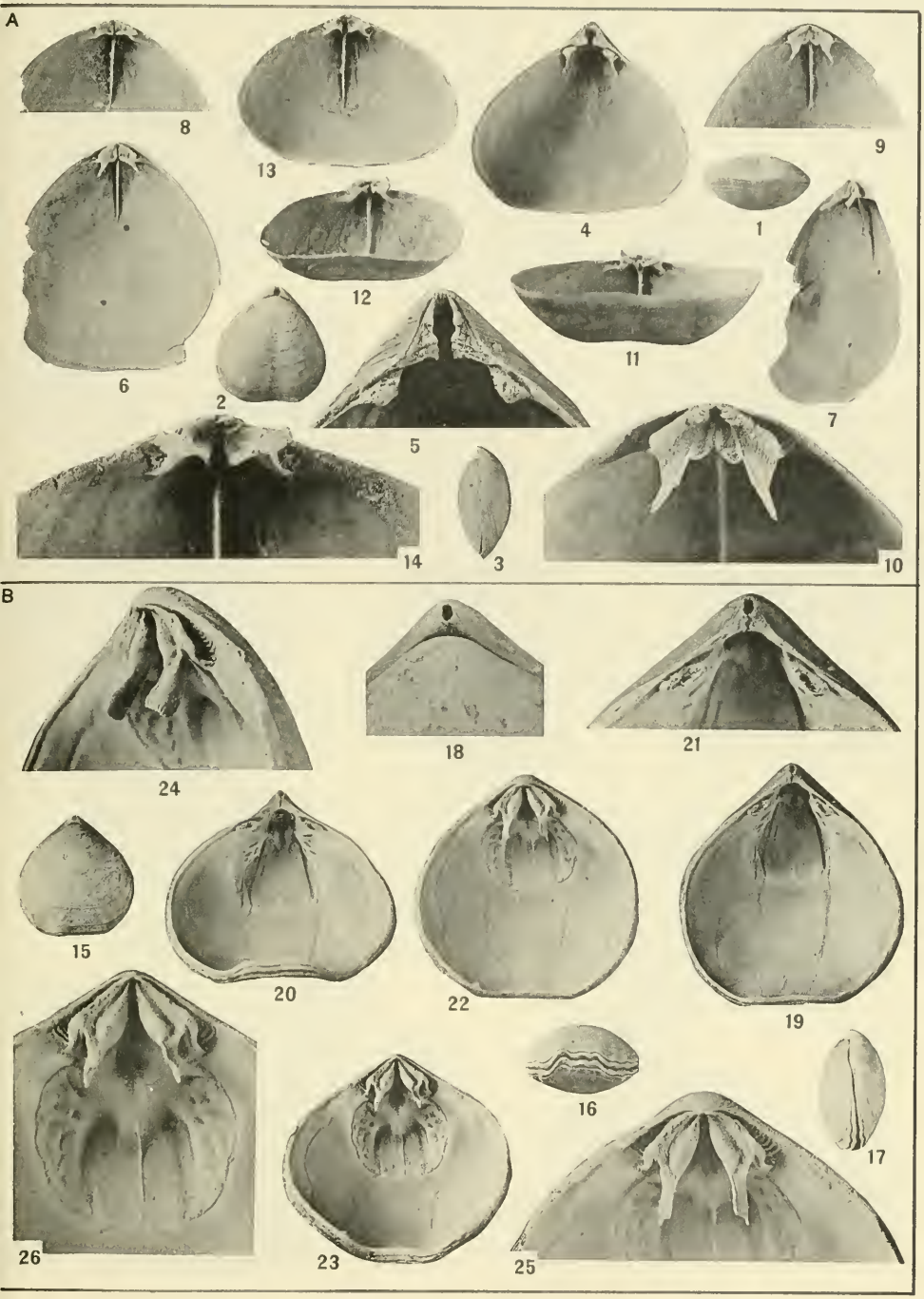

FRIELEIA AND EOHEMITHIRIS

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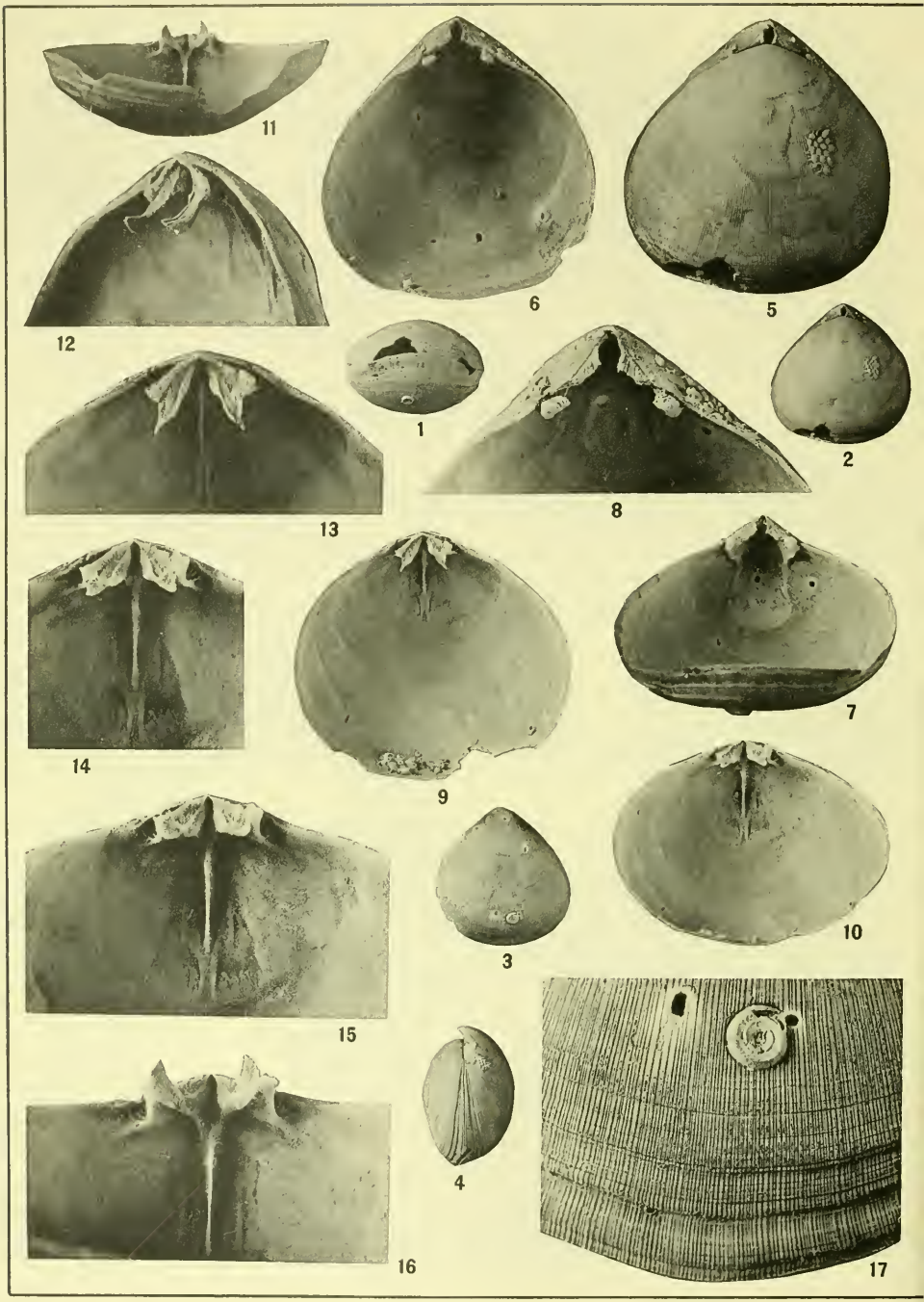

COMPSOTHYRIS

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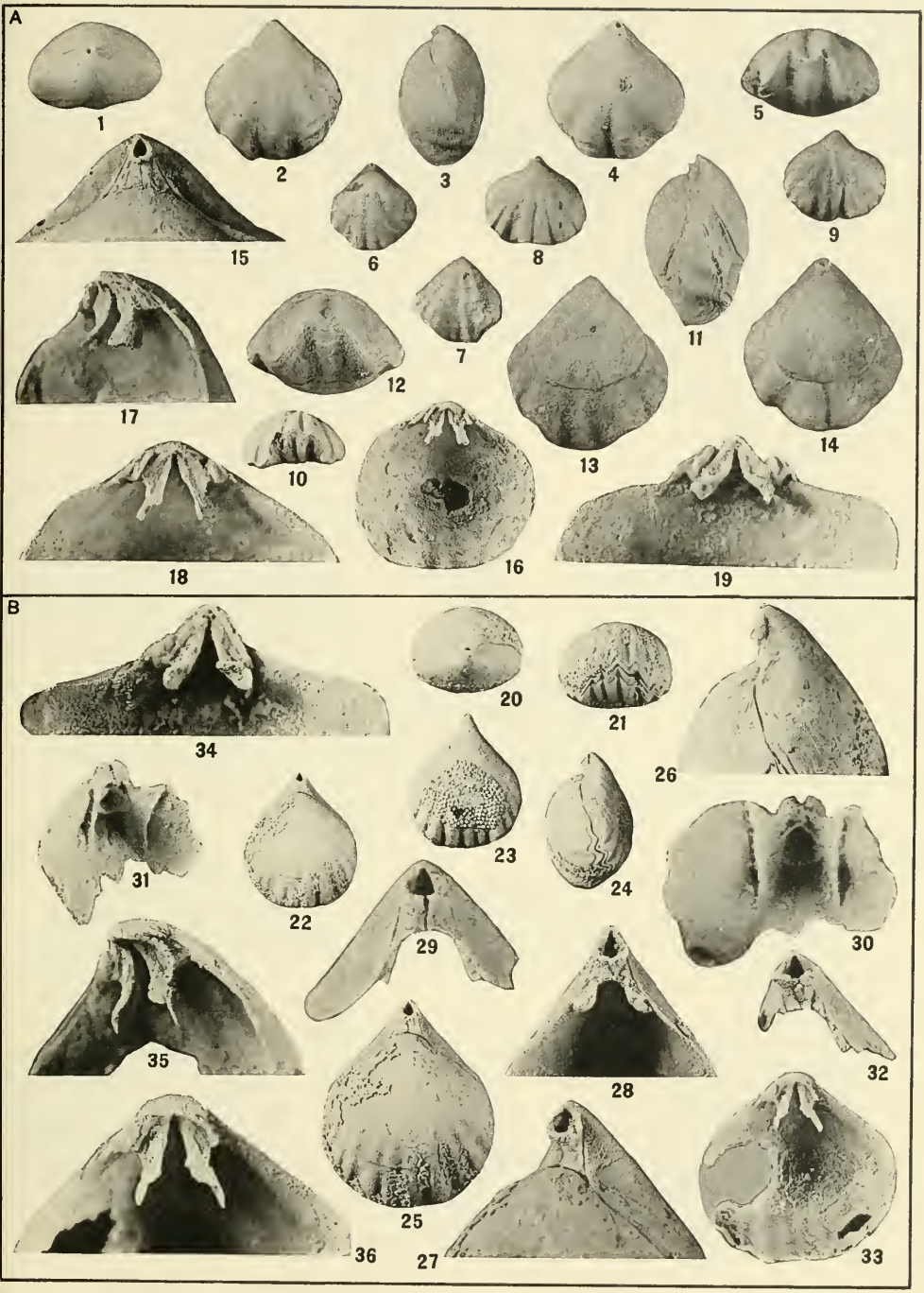

PROBOLARINA

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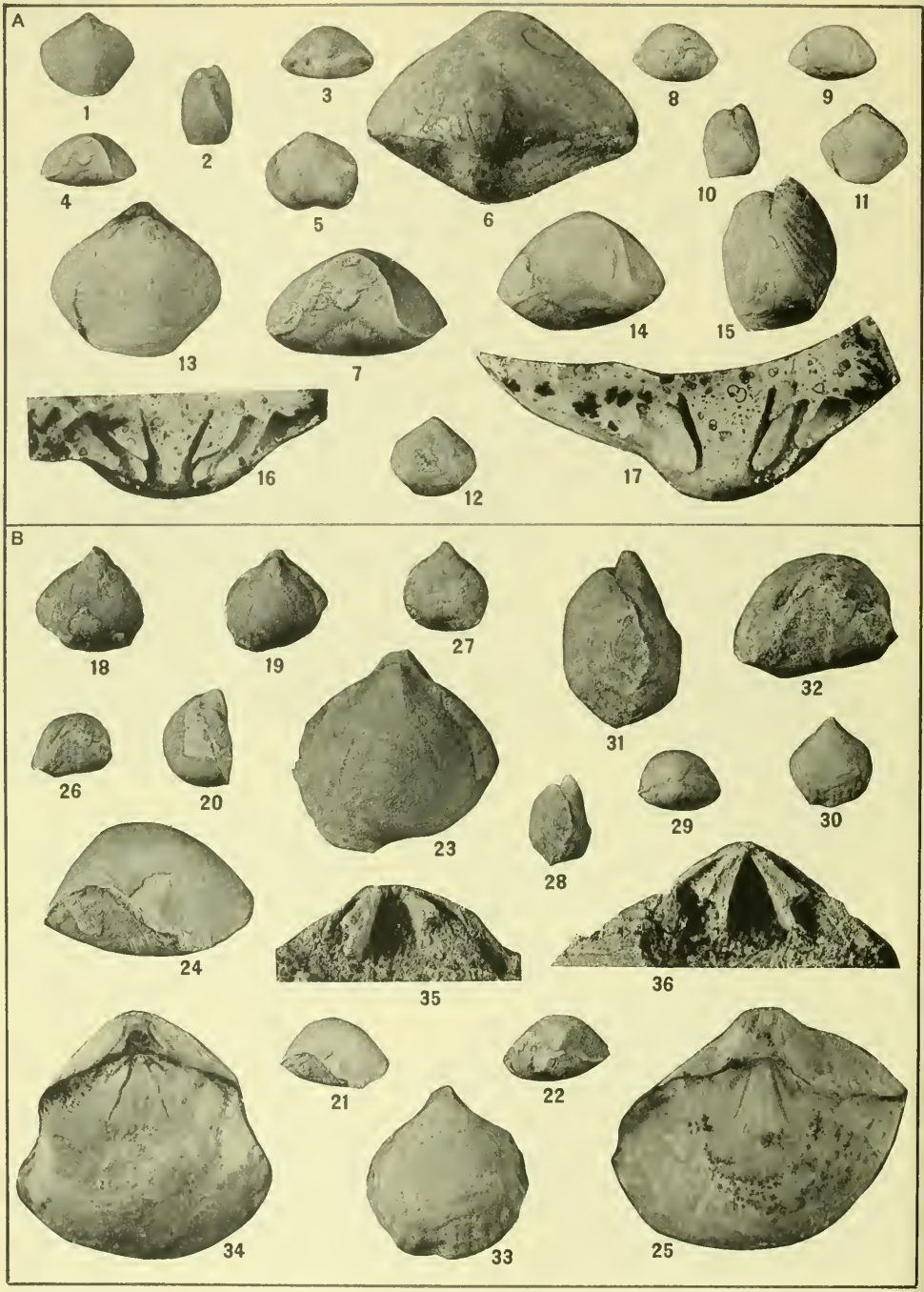

ERYMNARIA

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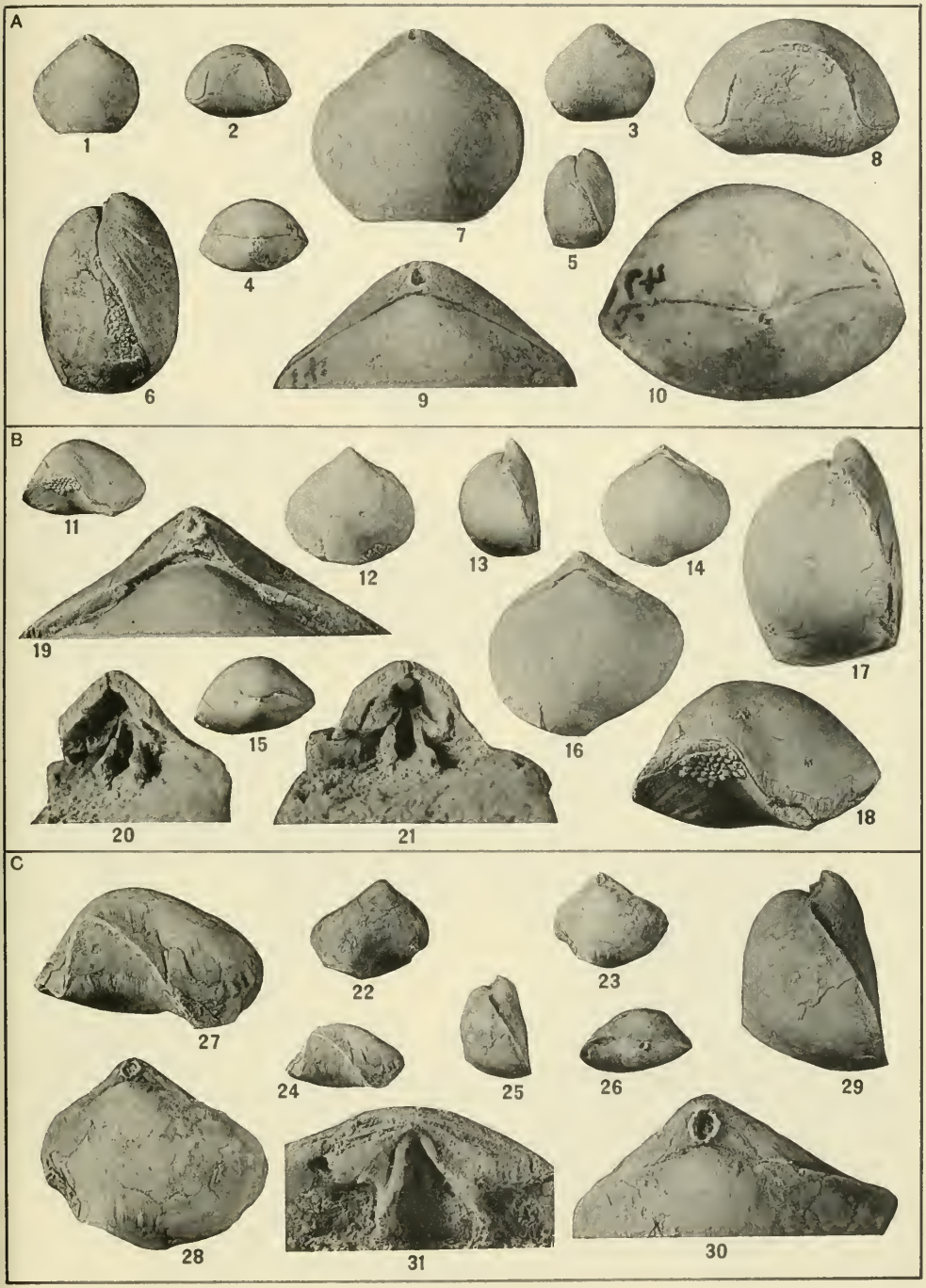

ERYMNARIA AND STREPTARIA

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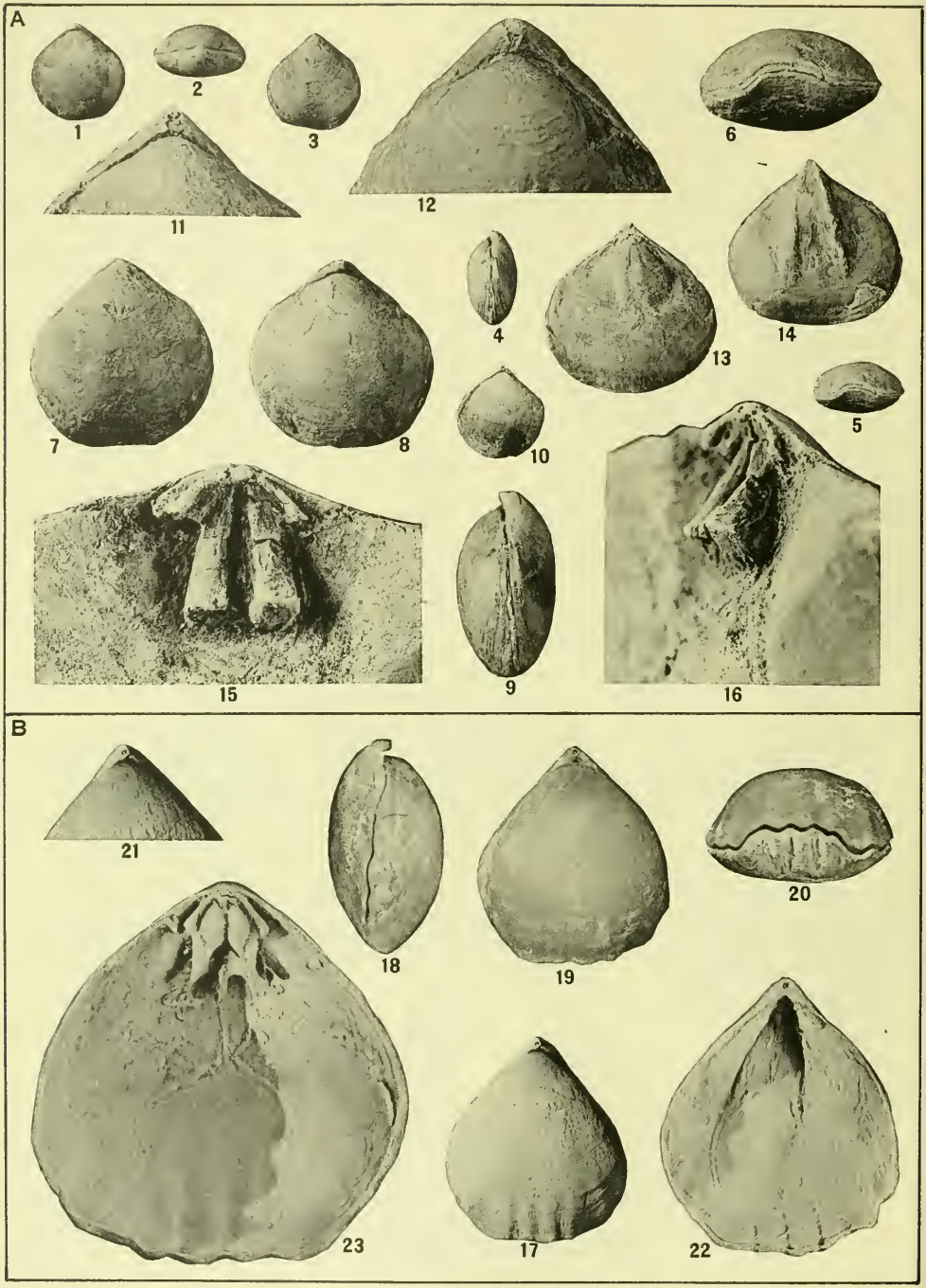

EOHEMITHYRIS

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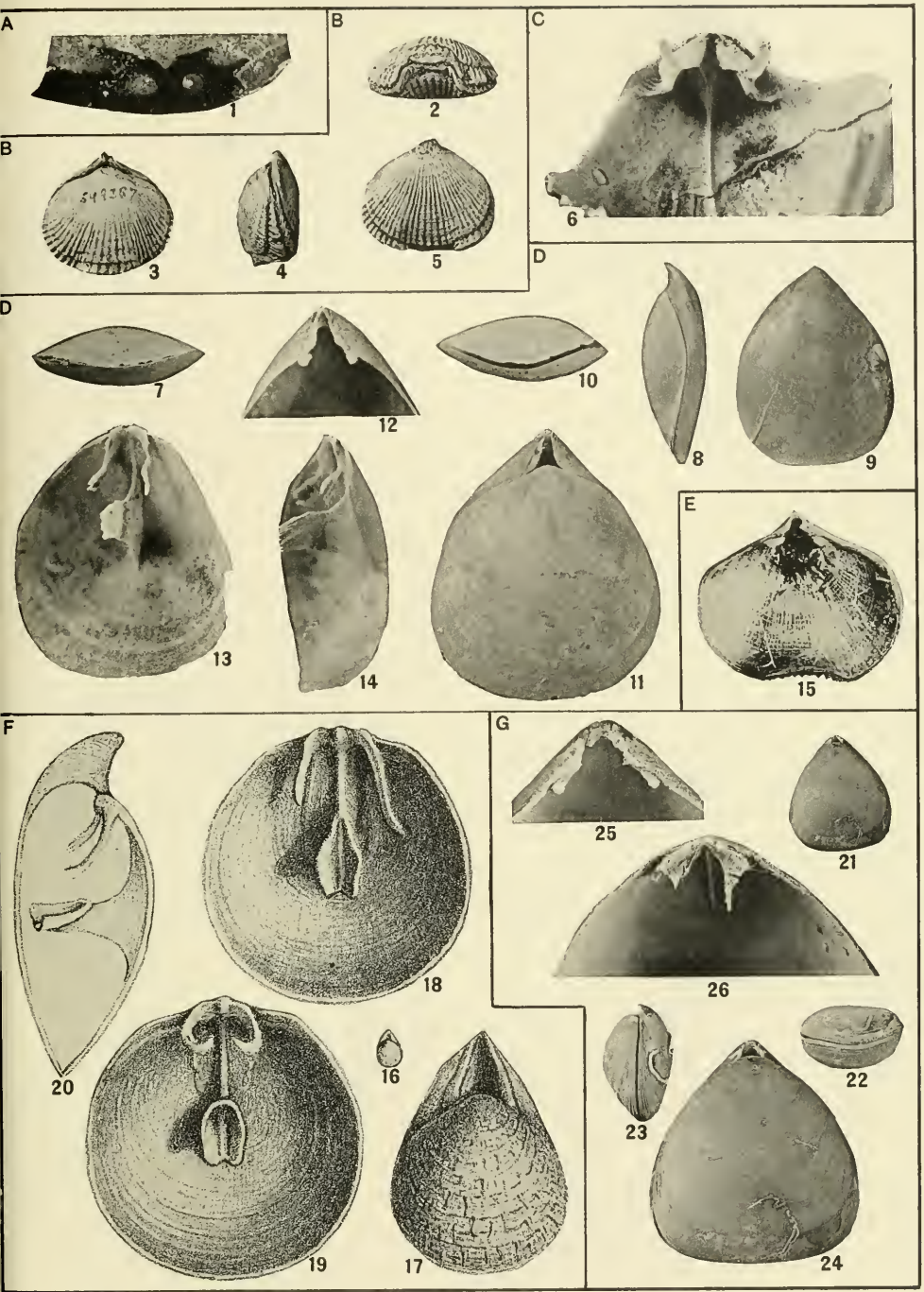

FRIELEIA, PATAGORHYNCHIA, SEPTALIPHORIA, CRYPTOPORA, TEGULORHYNCHIA, MANNIA, AND HISPANIRHYNCHIA?

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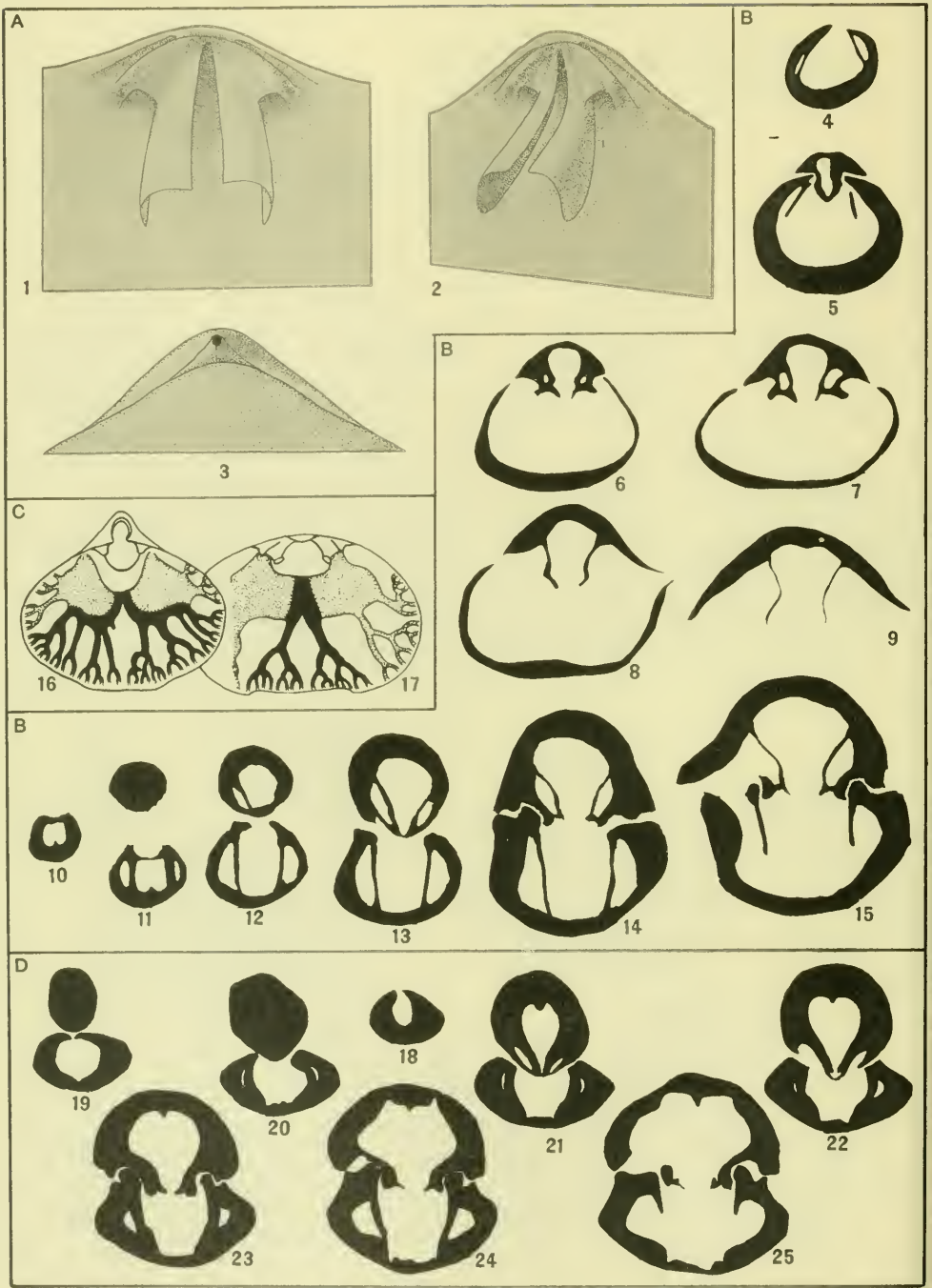

EOHEMITHYRIS, ERYMNARIA, NOTOSARIA, AND APHELESIA

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