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AN INTRODUCTION TO THE MORPHOLOGY AND CLASSIFICATION OF THE FORAMINIFERA

(WITH 16 PLATES)

BY
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FOREWORD

Dr. Cushman's present contribution upon the foraminifera, dealing with the methods of study and other features of general interest, was prepared at the request of the Smithsonian Institution, first as a descriptive account of these minute protozoa, and second as a guide to lessen the work of students who wish to pursue more detailed studies of the class. The foraminifera, which are so abundant in modern seas, were equally prolific during many divisions of geological time, and are ideally constructed for preservation as fossils and for use in stratigraphic geology. However, until recent years the students of the class, employing the methods of study then in vogue, were of the opinion that the specific variability of these organisms was so great as to render them valueless in detailed stratigraphic work, indeed some went so far as to identify present day species in rocks as far back as the Early Cambrian.

Through the efforts of members of the staff and other governmental agencies, the Institution has brought together in the National Museum, great collections of fossil and recent micro-organisms, particularly foraminifera, bryozoa, ostracoda and diatoms, and it has long fostered the scientific study of these collections in the belief that detailed researches would lead to results of great practical value. This belief has been happily justified, and in the case of the foraminifera, Dr. Cushman's work has especially exemplified the economic results arising from purely scientific studies. Not only has he proved from his investigations of the National collections that the species of foraminifera can be discriminated and can be depended upon in subsurface geologic investigations, but he also has made successful practical applications of his scientific results.

Charles D. Walcott, *Secretary*.

March 23, 1925.

INTRODUCTION

The foraminifera are for the most part microscopic animals living in salt water. There are a few which live in fresh water or under brackish conditions, but they do not develop the typical test and are not found as fossils. The foraminifera belong to the general group of the Protozoa. They are single-celled animals which develop about them a test either of foreign material, which they gather and cement, or usually a calcareous test which is secreted by the animal itself. In the present oceans they occur in enormous numbers, making up a large proportion of the material forming the floors of the oceans at moderate depths. As fossils they have formed limestones thousands of feet thick in various parts of the world. The great pyramids of Egypt are composed of limestones of foraminiferal origin. In the tropical Pacific they occur in such great numbers that they often impede navigation in shoal waters among coral islands.

Until recent years their study has been largely a matter of pure science, and their interest confined, except in a general way to zoologists, to a small group of workers. In the last few years, however, they have assumed an importance for economic work. They occur in great numbers as fossils in most of the Tertiary and Cretaceous strata. Especially in connection with the petroleum industry they have great present and future possibilities. In the drilling of wells most fossils are so broken up that they become unrecognizable in the samples. The foraminifera, however, are usually of such minute size and are in such quantities that enough of them escape the destructive force of drilling so that they form a recognizable part in the well samples themselves. By close study of the section through which a well is drilled it becomes possible to recognize various zones which may be again found in adjacent wells. By such study subsurface maps may be made, which show the geologic features of the underground structures. By this means it is possible to control the placing of additional wells in a field with greater or lesser certainty of increase in production. Where the age of the strata is not definitely known a well may be abandoned before it actually reaches a producing horizon or may pass through such a horizon for a considerable distance without its being recognized. In either case a considerable economic loss results. The knowledge that might have been obtained from the borings is also lost. In many oil fields it is necessary to shut off underground water, and these water horizons may be recognized by a study of the foraminifera. This again is a great economic use of these small fossils.

From this economic aspect there is a great demand for workers on the foraminifera and for literature on the subject. The U. S. National Museum and the U. S. Geological Survey have published a considerable number of papers on the recent and fossil foraminifera of American waters and of the Cretaceous and Tertiary of our own country, based upon collections now in the U. S. National Museum. These form the basis for most of the work that has been done on American foraminifera. Much more needs to be done to describe in detail the many species of our American fossil and recent faunas.

The economic use of the foraminifera is perhaps one of the very best examples of the application of purely scientific work to economic uses. It shows also how valuable are the collections made by such agencies as the U. S. National Museum, the U. S. Bureau of Fisheries, the U. S. Geological Survey and the U. S. Coast and Geodetic Survey. Through these agencies there has been accumulated the great mass of fossil and recent material containing foraminifera which through its study has become of great economic value.

The demand for workers on the foraminifera has made necessary rapid training of numerous students, often where facilities for such study are not available. There are certain requisites which are necessary to a trained worker. Some of these are the study of good material, access to type collections, familiarity with the literature and the knowledge of the group, which can be obtained only after much study. There is a tremendous amount of literature, nearly a thousand books and papers being listed in Sherborn's Bibliography of the Foraminifera published in 1888, which number has since then more than doubled. Except for the papers published by the U. S. Governmental agencies, the U. S. National Museum and the U. S. Geological Survey, there are almost no papers dealing with American fossil and recent foraminifera. A great deal of this earlier literature is European and published in many different languages. Many of the works are available only in a few places in this country. For this reason American students have been greatly handicapped in their work. It is to help in such ways that this present paper is prepared and the rather profusely illustrated publications of the U. S. National Museum and the U. S. Geological Survey have been published. They will many times repay their cost in their economic use to the petroleum industry alone.

GENERAL ACCOUNT OF THE FORAMINIFERA

In the earliest work on this group, these animals were supposed to be molluscs, and to belong to such genera as *Nautilus*. That they were very low types of animals belonging to the Protozoa was not recognized until much descriptive work had been done upon them. They are now known to form a definite group of the Protozoa, and much is known of the animal as well as the test that it makes about itself.

LIFE HISTORY

Two distinctive forms of many species have been recognized. In general one form is large and rare, the other smaller and much more abundant. Sections of such specimens show that the large form starts with a very small initial chamber or proloculum and is called the *microspheric* form. The small form, on the other hand, commences

1

2

FIG. 1.—Idealized section of microspheric form of Nodosaria showing the small proloculum and the long test.

FIG. 2.—Idealized section of megalospheric form of Nodosaria showing the large proloculum and the short test.

with a much larger proloculum and is known as the *megalospheric* form. Two such sections are shown here, figures 1, 2. It has been discovered that the large microspheric form, when it reaches its adult stage, develops many nuclei, each of which secretes about it a test, and on the breaking down of the "parent" wall these "young" escape into the water and become new animals. This is the typical asexual method of reproduction. The smaller megalospheric form may also do this. Another manner of reproduction may be shown by the megalospheric form, where, when the adult stage is reached, the protoplasm breaks up into a great many very small masses and escapes from the test in the form of minute free swimming zoospores. These where known are of about the size of the microspheric proloculum. From what is known of other groups of Protozoa, these zoospores fuse, and the resulting cell becomes the proloculum of the miscrospheric test. This is sexual reproduction. A true alternation of generations is thus set up not unlike that found in other groups of organisms.

Before the two forms were known, "pairs" of species were described, as in the case of the Nummulites where a large and small species were often described from the same fossil horizon. These are now known to be the microspheric and megalospheric forms of the same species.

HABITS

A few species of the foraminifera live at the surface of the ocean and are truly pelagic animals. Almost all of these are species of the Family Globigerinidae. The test is modified by the addition of large pores and large apertures allowing a free passage of the protoplasm to the outside of the test. Most of the pelagic foraminifera tend to assume a spherical form most completely accomplished in *Orbulina*. They occur in enormous numbers in such regions as the Gulf Stream, and their empty tests form a very large proportion of the *Globigerina*-ooze which makes up much of the ocean bottom.

Most foraminifera are bottom-living forms, crawling about on the ocean mud or attached to various objects on the ocean bottom. Their motion is very slow. The most rapid rate I have timed at the Tortugas was in *Iridia diaphana* Heron-Allen and Earland, which travelled at the rate of about 1 centimeter in an hour. As various species must crawl about considerably over the bottom in selecting material for the test, this rate may be slower than the average.

For the most part the food of the foraminifera consists of vegetable matter, minute algæ, etc., with occasionally some of the smaller animal forms, such as copepods, which may be caught in the pseudopodia.

From observations made at the Tortugas, different species have a repellant reaction when they touch one another. From certain specimens it seems that the animal may leave the test at times and either secrete or gather together material for a new and larger test. From the life history and this last mentioned fact, it will be seen that many of the tests of foraminifera are really empty and abandoned tests of full grown individuals. This tends to make an unusual uniformity in the tests in spite of much of the supposed variation.

STRUCTURE OF THE TEST

In the fresh water foraminifera, which are all of a distinct family from the marine ones, a calcareous or agglutinated test is not developed. What test is formed, is of a gelatinous or flexible chitinous material. In what may be called the more typical forms, the test is either formed by the cementing together of foreign particles or by the secretion of a calcareous test. In the first group, the animal gets its material from the ocean bottom itself. This may consist of the ocean mud, sand, sponge spicules, mica flakes, etc. In some species, a definite selection seems to take place, and one kind of material is used to the exclusion of others. The most striking examples of this are species of *Psammosphaera*. *P. fusca* Schulze uses only sand grains of various sizes, cementing them into a spherical test. *P. parva* Flint uses sand grains of very uniform size and adds to its test a large acerose sponge spicule projecting at either side. *P. testacea* (Flint) uses the tests of other foraminifera and ignores sand grains which are present in the bottom material. *P. bowmanni* Heron-Allen and Earland makes a test entirely of mica flakes, and *P. rustica* Heron-Allen and Earland of sponge spicules.

Some species of foraminifera which secrete a calcareous test also cover the outside with sand or other fragmental material. These are not true agglutinated tests however, any more than in the case of certain molluscs which cover their shells with fragmental material.

Of the calcareous secreted tests there are two main groups, the perforate and imperforate. In the former the test has great numbers of small pores, while in the latter (Miliolidae) the test is normally without pores and has a peculiar white appearance, whence the name "porcellanous" often applied to the foraminifera belonging to this family. Under brackish conditions and in deep water where calcareous tests are easily dissolved, very thin tests are found of chitinous or even siliceous material.

The test may be simple as in many of the Lagenidae or Rotaliidae, or become complex with internal radiating canals as in the Nummulitidae. In some genera very interesting structures are developed, as in the "balloon" and "float" chambers in *Tretomphalus*.

DEVELOPMENTAL STAGES

As already noted from the habits and life history of the foraminifera, adult tests are the rule in any collection. There are, however, always some specimens which have not yet reached their adult stage and which show development. These stages show definite conformity to the law of recapitulation, in which an animal repeats in its own development certain of the stages in its ancestry. Thus the test of *Biloculina,* at least in the microspheric form, shows stages comparable to the fully developed characters of *Cornuspira, Quinqueloculina,* and *Triloculina,* before the adult character of *Biloculina* is taken on. In the megalospheric form, certain of these earlier stages are often skipped.

These early stages are important from the point of view of classification. Nearly all the Textulariidae have in the microspheric form a coiled early development closely allied to certain of the Lituolidae, and show that the alternate (Textularian) character was derived through a coiled ancestry.

Likewise in *Peneroplis* and others of the Miliolidae the very earliest stages show a perforate test, and make clear that the imperforate character is an added one and that the Miliolidae are therefore a fairly new group derived from a perforate ancestry. Instead of being a primitive group as earlier thought, the Miliolidae are high in the scale, a fact made further evident by their geologic history.

From the study of developmental stages, coupled with fossil evidence, will come a more sound classification of the group than obtains at present.

VARIATION

From statements made by many of the earlier writers on the foraminifera, it would seem that there is a very great variation in the group. From my own observations this does not seem to hold. In the case of *Ammodiscus incertus,* several hundred specimens were measured, and the amount of variation in respect to size of chamber, size of test and thickness, when reduced to ratio of the size of the initial chamber, was practically negligible. If stages of development are taken into consideration, and the differences due to the microspheric and megalospheric forms are considered, the actual variation left in adults is less than in most other groups of animals. When specific lines are drawn more sharply than at present, as will be done as more material is studied, the variation will be more apparent than real.

DISTRIBUTION IN PRESENT OCEANS

So far as dredging operations have been carried on, the foraminifera seem to be distributed over every part of the ocean bottom. Expeditions into both polar regions have shown that the ocean muds of the polar seas have an abundant foraminiferal fauna. In the shallow water of all the oceans they are abundant. In the deep ocean basins from the continental shelf out into deep water, *Globigerina*-ooze makes up the entire ocean bottom to depths of about 2,000 to 2,500 fathoms. Beyond this depth the ocean bottom consists mainly of red clay. The lack of the calcareous foraminifera in such regions is due to their solution under pressure. In red clay areas numerous species which develop arenaceous tests are characteristic, showing that deep water conditions are in no wise detrimental to the foraminifera.

If material is studied from definite regions, such as I have done for the western Atlantic, it will be found that the foraminifera group themselves into definite faunas just as do other groups of animals in the same regions. The distribution of the shallow water species includes the West Indies, the northern and northeastern coasts of South America, the shores of Mexico and Central America and our own coast as far north as Florida or to the latitude of Cape Hatteras. North of this point an entirely new fauna is found. This continues north to the regions of Nantucket, and further north is replaced by much colder water fauna which is Arctic in character. This is very largely determined by temperature.

The Indo-Pacific shows another fauna which is characteristic of the warmer parts of the Pacific and Indian oceans. A great many species are limited to comparatively shallow water in this region, a few of them extending into the West Indian region. The eastern and western sides of the Atlantic have very different faunas and in general the distribution of species living in shallow water or on continental shelves are as restricted as are those of any other groups. There are two faunas which are widely distributed. These are the pelagic species which are abundant especially in the warmer portions of the oceans like that of the W. Indies and the Gulf Stream, where a very few species occur in great abundance, their empty tests raining down on the sea floor and building up great areas of *Globigerina*-ooze. The distribution of these species on the ocean bottom is determined almost entirely by surface currents and temperatures. Another group, that which lives normally at great depths, is apparently controlled more by temperature than by depth. As a result many of these species occur in all the ocean basins and in cold shallow waters in the temperate or polar regions. These follow the same laws in their distribution as do those of crinoids and other animals which make their home under similar conditions. Very much has yet to be done in determining the geological distribution of the different species, as the tendency has been in the past for most writers not to make close specific determinations.

GEOLOGIC DISTRIBUTION

Foraminifera are known from most of the sedimentary rocks. They occur very abundantly in the Cretaceous and Tertiary of all parts of the world. In the Palaeozoic they seem to be more restricted in their distribution. In the Carboniferous, for example, *Fusulina* forms thick limestones, and various species occur in less abundance in other Palaeozoic formations. Certain groups of foraminifera become abundant and characteristic in certain geologic formations. *Fusulina* and allied forms are very characteristic of certain parts of the Carboniferous. In the Cretaceous the Textulariidae and many Miliolidae become very abundant. The latter probably reaches its highest development in the upper Cretaceous. In the early Tertiary the Nummulitidae become dominant, and form very thick limestones in the Eocene and Oligocene.

It is through the knowledge of the distribution of the various species and genera in various geologic formations that the great economic use of the foraminifera lies. When type sections are known in detail it becomes possible by the study of well cuttings to determine subsurface structure. As a result much is being done in the way of the refinement of the study of fossil forms, and the limits of range of many fossil species. When this work is done thoroughly it makes the foraminifera one of the greatest assets to the geologist in economic work.

METHODS OF HANDLING

RECENT MATERIAL

Collecting.—For systematic work, especially in deep water, it is necessary to have elaborate and rather expensive apparatus. For this reason most of the work in deep waters has to be carried on by governmental vessels, or by especially equipped expeditions for the purpose. Such work was first attempted on any considerable scale by the "Challenger" expedition sent out by the British Government in the seventies, and which explored for four years all the great ocean basins. Since that time many other expeditions have added to the knowledge obtained by the "Challenger." In our country the work of the U. S. Bureau of Fisheries, especially through the numerous voyages of the "Albatross," has resulted in the accumulation of a tremendous amount of material. This has been deposited in the U. S. National Museum, and has been the basis for a considerable amount of literature dealing with the occurrence of the foraminifera, especially of the Pacific, the Philippine region and that of the western Atlantic.

When shallower waters are studied, it is possible for the individual to make very excellent collections. The "bulldog" snappers, which are so devised that they grab up a tea-cup full of the bottom material, can be used from a small boat to a considerable depth. By adding a weight to this apparatus, it is possible to obtain excellent samples, even in two or three hundred fathoms. This method has been used in the West Indies and off the coast of Florida, as well as in the Pacific, with excellent results. It is also possible to obtain a considerable number of foraminifera from beaches where they are often left by the receding tide, in some regions very abundantly.

Preserving.—If it is desirable to study the living animals, it is necessary to preserve them in some form or other. If the cell contents are to be studied special reagents such as are used in general zoological work must necessarily be used. Formaldehyde should not be used as it tends to dissolve the lime content of the tests. As a general preservative, therefore, alcohol is much better. If only the tests are to be studied one of the best methods of preserving the material is to wash it at once in fresh water, and then dry the material, preserving it in bottles or boxes for future use.

Washing.—For the examination of the foraminifera clean tests are necessary. In order to get these the dredged material, which contains mud and fine sand, should be washed. This is best done by means of nested sieves, such as are obtainable at most laboratory supply houses. Brass sieves with meshes of 200, 120, 80, 40, etc., to the inch can be obtained. For more practical purposes sieves with 40 and 80-mesh to the inch are sufficient. The mud is placed directly in the top sieve, and a stream of water with a fine spray played upon the material. If the sieves are shaken so that the material is kept in motion the finer particles will be washed through readily. The resulting clean foraminifera can then be dried. It is sometimes more satisfactory to wash material through the coarsest sieve first into some sort of retainer, and then this again passed through the finer sieves. By this means the finer meshed sieves do not clog with the material.

Sorting.—After the material is washed it often helps in the examination if preliminary sorting can be done. There are different methods of doing this. One is that called "spinning." By this method, the material is put with clean water in a plate or watch glass or in any dish with water so that a circular motion can be set up. This is the old method by which gold was "panned" by the miners. The gold dust was heavier than the sand and came to the middle of the pan. In the case of the foraminifera, however, they, being lighter than the sand which is with them, accumulate on the outer edges of the material. This can be washed off in the process into a larger receptacle below.

Another method by which rough sorting can be done is by "decanting." If the material is shaken up in a tall vessel of some sort, the lighter specimens will stay in suspension for a short period and can be poured off, leaving the heavier ones on the bottom. Successive stages will separate most of the calcareous tests from the sand and the heavier foraminifera.

One of the most useful methods is that of "floating." The washed material is taken after drying and slightly heated. Then if this heated material is thrown upon cold water those smaller tests, which are filled with air, will float on the surface and can be poured off. In this way beautiful material can be prepared, which is very largely pure foraminiferal tests. This last method combined with "decanting" will give the best results.

Selecting and mounting.—For the study of material containing foraminifera under the microscope, blackened trays are of great service. These may be made by covering the bottom and sides of a shallow pasteboard tray with India ink. When this is scratched another coat can easily be applied. If one wishes to be more elaborate, an excellent tray can be made by placing a piece of black velvet on the bottom of such a tray and covering it with glass. This gives a very intense dull black surface against which the foraminifera stand out to great advantage. Specimens which are to be studied further, or used for future records, must be mounted in some permanent manner. One of the simplest and best methods for this is a slide made of two pieces of pasteboard, for convenience 3 x 1 inches, so that they may be used in ordinary slide boxes. The upper card should have a hole punched in the center and securely pasted to the lower one with a piece of black paper inserted below the circular opening. For additional safety a sheath with the top an ordinary glass slide and the base a thin pasteboard, the glass attached to this by two strips of paper at the sides, may be used. In this the slide with the mounted specimens can be placed, and for ordinary examination it is not necessary to remove the specimens.

In selecting the specimens to be mounted, much the best method is to use a moistened brush. The finest brushes obtainable, 00 size, made of red sable bristles are the best. These make a very fine point indeed, and if touched to a specimen can be used to carry it to the slide. The slides themselves should be covered with a gum made of gum arabic and water with enough glycerine added to prevent cracking. The moistened brush will soften this enough so that the specimen will be firmly fixed to the surface. If necessary it can be removed very quickly by again moistening the gum below the specimen with the brush. Specimens in this way can be mounted in any position for drawing or photographing, or to show any detail of structure.

Slides are procurable which have a large surface divided into as many as 100 numbered spaces. These may be used for the different species of a single locality but are not elastic if a collection is to be arranged in any systematic way. In the earlier collections of the U. S. National Museum wooden slides, devised by Dr. Flint, were used. These were of two different sizes. The specimens were either attached to the bottom of the cavity or were left loose. They were then covered with a square of mica, which was held in place by brass clips. These slides, however, are difficult to arrange well on account of the clips, and if these become loosened the contents may easily be lost, the pasteboard slides being much more satisfactory for general use.

In warm countries it has been found that the ordinary concave glass slide can be used to advantage, the specimens placed in these and a glass cover placed over them. This may be held in place in various ways. The disadvantage of this type of mounting is that specimens become lodged in the narrow space at the edge of the cell and the slides, themselves, are easily broken. If the pasteboard slides are made of reasonably heavy material and paste instead of glue used they will be found serviceable under almost any conditions.

Needles are sometimes used for picking out specimens, but they are not elastic, do not retain moisture and are much less satisfactory than the very fine sable brush already referred to. Camel's hair brushes are not sufficiently elastic to be of much service.

FOSSIL MATERIAL

Where fossil material can be washed as in the case of many clays, sands and marls, they can be treated exactly as recent material. Where the material has become consolidated into hard limestones very often the only method of studying the contained foraminifera is through thin sections. These may be prepared in the same manner as ordinary rock sections. The study of such sections has decided limitations. They show for the most part the outline in one plane and something of the details of the internal structure. As most foraminifera are determined specifically by their external characters it is next to impossible to determine the species of most foraminifera from thin sections alone. In the case of certain of the Orbitoid genera such as *Lepidocyclina,* etc., sections are of great importance as many of the specific characters are based on the internal structure.

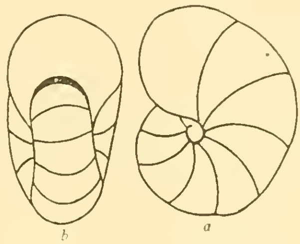
Unless something is known of the external appearance from other sources it is usually very difficult to even make generic determinations from rock sections. Certainly many of the genera of the Rotalidae cannot be told from one another in section, and the same is true of other groups. It is sometimes possible with hard material to break out whole specimens. This can be done by grinding or by breaking the rock in various ways.

CLASSIFICATION

There have been many classifications since the earliest one of d'Orbigny made in 1826. In most of the works of late years ten families have been recognized, one of these, the Gromidae, being confined largely to fresh water, and not developing the typical test as seen in most other groups of the foraminifera. As these are not preserved in the fossil state and are not usually recognizable in dried material they do not have as much attention paid to them as is given to the rest of the group.

The modern classification is not in any sense a final one but is given here for the purpose of students interested in the group. Various attempts have been made by some authors to group together genera which have a similar form ; thus *Ammodiscus,* which is planospiral made of cemented sand grains, has been placed in the same family as *Spirillina,* which has a somewhat similar form but with a perforate calcareous test, and also *Cornuspira,* which although the same form has a test calcareous and imperforate. To place in one group different species based solely on the shape of the test does not seen to be a logical method, for, as in many other groups of animals, parallelism is very marked. The structure of the test and the material of which it is made seems to be a much better character than mere form. As more is learned of the various species and genera, it is very probable that the number of families will have to be increased and somewhat new lines of classification adopted. A study of the fossil occurrences of the different genera is very necessary to this as well as the structure of recent forms. For the sake of the students in the group, a few of the descriptive terms commonly used are here given, and a series of simple diagrams.

One of the simplest arrangements of the chambers is that in such coiled bilateral forms as *Nonionina* there are two distinct positions used in description, the *apertural view* (fig. 3*b*) in the plane of coiling, with the apertural face toward the observer, and the *side view* at right angles to the plane of coiling, the two sides being alike. The *periphery* is the outer edge of the test. The *last-formed chamber* in most foraminifera has the *aperture*, and there is usually developed a distinct *apertural face*. The periphery of the test may have a definite *peripheral-angle* or be *carinate* or *keeled*. The wall of the test may be *perforate* or *imperforate*, and variously ornamented on the exterior. The number of chambers in the last-formed coil is often distinctive.



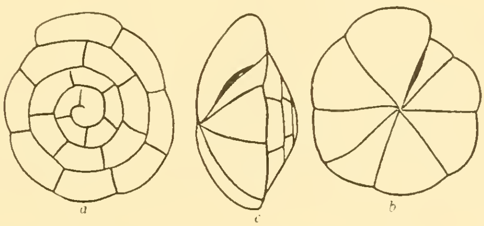


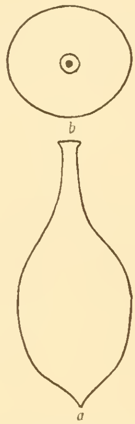
Fig. 3.—A bilaterally symmetrical form of test, showing *a*, side view; *b*, apertural view.

Fig. 4.—A trochoid form showing *a*, dorsal view; *b*, ventral view, and *c*, side or peripheral view.

In the Rotaliidae, particularly, the *trochoid* form of test is common, sometimes called "rotaliform." In this (fig. 4) it is possible to distinguish a *dorsal side* and a *ventral side* (the latter carrying the aperture). The edge view may be spoken of as the *side view* or *peripheral view*. There is a considerable modification, the dorsal side sometimes being the concave one.

In the Lagenidae there may be a *side view* and *apertural view* in such forms as *Lagena* (fig. 5) and *Nodosaria* (fig. 6), and in coiled bilateral forms such as *Cristellaria* (fig. 7), with irregular genera such as *Uvigerina* (fig. 9), and *Polymorphina* (fig. 8), the side views are not all alike.

In the Miliolidae, especially such genera as *Quinqueloculina,* the *apertural view* and two *side views* are usually necessary for complete description; one of the latter will show four chambers, the other three. In *Biloculina,* a *front view* and *side view* are frequently used, the latter in the line of the plane of the joining of the two exterior chambers.



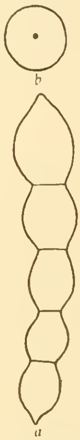


FIG. 5.—*Lagena,* showing *a,* side view and *b,* apertural view. This has a definite neck and phialine lip.

FIG. 6.—*Nodosaria,* showing *a,* side view; *b,* apertural view.

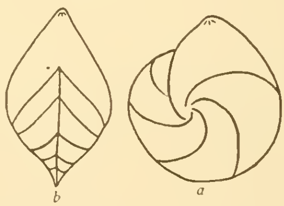
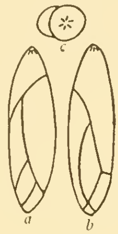


FIG. 7.—*Cristellaria,* showing *a,* side view; *b,* apertural view.

The lines between the chambers on the exterior should be known as *sutures* and the internal walls as *septae.* The initial chamber is known as the *proloculum* and may be either *microspheric* or *megalospheric.* The aperture may be modied by a distinct *tooth* as in many of the Miliolidae (fig. 10), or have a distinct phialine lip as in *Lagena* (fig. 5) or *Uvigerina* (fig. 9).

In many forms such as *Nonionina* (fig. 1), there is a distinct *umbilicus* developed. A study of published figures will give even the beginner a good general idea of the application of most of the descriptive terms used.

There is here given for the benefit of workers on the group an outline of the classification now used, with brief descriptions of the families, subfamilies and many of the genera. There are many more generic names in current use and a very great number now discarded,



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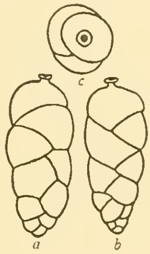

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FIG. 8.—*Polymorphina* showing *a* and *b,* two different side views, and *c,* apertural view with radiate aperture.

FIG. 9.—*Uvigerina* showing *a* and *b,* two different views, and *c,* apertural view.

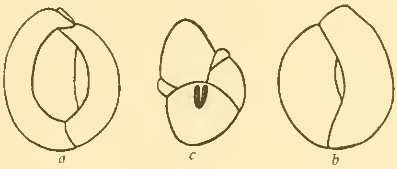

FIG. 10.—*Quinqueloculina* showing *a* and *b,* two different side views; *a,* with four chambers; *b,* the opposite side with but three chambers, and *c,* apertural view, the aperture with a single tooth.

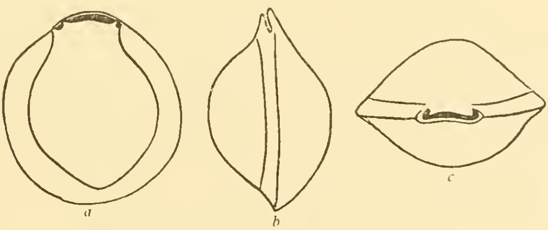

FIG. 11.—*Biloculina, a,* front view; *b,* side view; and *c,* apertural view, the aperture with a large broad tooth.

but most of those commonly used will be found here. Most of these have illustrations drawn from the publications of the U. S. National Museum.

Family 1. GROMIDAE

Test membranous or chitinous; aperture if present either single and terminal or one at each end of the test; fresh water or marine. Recent only, no fossils known.

Family 2. ASTRORHIZIDAE

Test composed of agglutinated material for the most part, occasionally with a chitinous inner layer, consisting of a chamber with several openings or a tubular test open at both ends, or in certain forms, of a closed chamber with a single aperture, but throughout the family the test is not divided into a series of chambers.

The species included in this family build tests of agglutinated material, often placed outside a chitinous base as in *Rhizammina, Pelosina,* etc. The simplest species, such as found in the genus *Astrorhiza,* simply gather about the soft parts the mud or débris from the bottom and agglutinate it somewhat with a small amount of cement, the central chamber corresponding to the main part of the cell and the arms to the pseudopodia. Next in order are tests with definite openings and later a test closed all but one point, which serves as the aperture, such as *Pelosina, Pilulina,* etc., or with several apertures, *Thurammina.* From this the series leads to the genera having a definite globular proloculum or initial chamber and a second chamber of greater or less length, *Hyperammina, Ammodiscus,* etc.

Subfamily 1. ASTRORHIZINAE

Test consisting usually of a tube open at both ends or in some species of *Astrorhiza* with several tubes entering a central chamber; in some species with the tube branching.

Genus ASTRORHIZA Sandahl, 1857

Plate 1, fig. 1

Test free, flattened or tubular, composed of sand or mud loosely cemented; chamber within connecting with the exterior by the open ends of the tubes or by several definite apertures in the flattened forms. Most of the species live in deep or cold waters.

Genus RHABDAMMINA Carpenter, 1869

Plate 1, fig. 2

Test free, either radiate, subcylindrical or branching; wall arenaceous usually rather coarsely finished on the exterior, firmly cemented; open ends of the arms serving as apertures. The species are characteristic of deep or cold waters and are widely distributed.

Genus MARSIPELLA Norman, 1878

Plate 1, fig. 3

Test free, tubular, cylindrical or fusiform, sometimes recurved at the ends; wall composed wholly or in part of sponge spicules, or in part of sand grains, thin, firmly cemented; aperture formed by the open ends of the tube or in some cases closed anteriorly by a loosely aggregated knob of spicules.

Genus BATHYSIPHON G. O. Sars, 1871

Plate 1, fig. 4

Test free, cylindrical, often tapering slightly, straight or more often somewhat curved, in some species externally constricted but not correspondingly constricted internally; wall composed of a base of broken sponge spicules cemented and overlaid with a fine grained apparently siliceous cement, aperture at the ends of the tube.

Genus RHIZAMMINA H. B. Brady, 1879

Plate 1, fig. 5

Test free, consisting of a simple or dichotomously branching, flexible tube; wall largely chitinous, bearing various foreign bodies attached to the exterior.

Subfamily 2. SACCAMMININAE

Test consisting of a single chamber, or group of superficially attached chambers, the walls made up for the most part of agglutinated material; apertures sometimes numerous but usually single; tests free or attached.

Genus PSAMMOSPHAERA F. E. Schulze, 1875

Plate 1, fig. 6

Test free or attached, single chambered, usually spherical, no definite aperture, the pseudopodia making their way out through the interstitial openings between the elements of the test; wall of sand grains, mica flakes, sponge spicules, or other foraminiferal tests firmly cemented.

Genus SOROSPHAERA H. B. Brady, 1879

Plate 1, fig. 7

Test consisting of a colony of more or less inflated chambers, without definite apertures, the walls joined to one another, composed of sand grains with interstitial openings.

Genus DIFFUSILINA Heron-Allen and Earland, 1924

Test sessile, squamous, composed of very finely comminuted sand and mud enveloping a thin labyrinthic layer of chambers. External surface smooth and finished, white to gray in color, furnished with a few sparsely distributed pustules of more loosely aggregated material.

Genus STORTHOSPHAERA F. E. Schulze, 1875

Plate 1, fig. 8

Test free, irregularly rounded, single chambered; wall thick, composed of fine whitish sand very loosely cemented, no visible aperture.

Genus IRIDIA Heron-Allen and Earland, 1914

Test usually attached, consisting of a single chamber lined with a chitinous, transparent membrane, the outer surface consisting of sand grains or other foreign material built up in a dome-shaped test, more or less hemispherical; aperture usually wanting.

Genus RHAPHIDOSCENE Vaughan Jennings, 1896

Test attached, conical, base broad extending to a point at the outer end; chamber single; wall composed of sponge spicules arranged lengthwise of the test with a cement of white calcareous amorphous material; aperture indistinct, at the outer pointed end of the test.

Genus SACCAMMINA Carpenter, 1869

Plate 1, fig. 9

Test typically free, sometimes attached, consisting of a single chamber or of several spherical chambers with distinct apertures, usually one for each chamber; wall composed of sand grains finely cemented by a yellowish or brownish cement; aperture circular, usually with a short neck.

Genus PROTEONINA Williamson, 1858

Plate 1, fig. 10

Test free, consisting of a single undivided chamber, flask shaped or fusiform with a single aperture; wall composed of coarse sand grains, mica flakes, or other foreign material; test usually broadest near the base and gradually tapering more or less evenly to the apertural end; aperture usually circular, with commonly a slight neck which in some species is prominent and extended.

Genus LAGENAMMINA Rhumbler, 1911

Test free, bottle shaped, with a pseudochitinous sublayer on which are laid quite thickly, but roughly, small foreign bodies. The presence of this sublayer distinguishes this genus from *Proteonina,* which does not have such a layer.

Genus PILULINA W. B. Carpenter, 1870

Test free, globular or ovate, consisting of a single undivided chamber; wall composed of felted sponge spicules and a slight amount of fine sand without cement, aperture elongate, with a somewhat depressed area about it.

Genus PELOSINA H. B. Brady, 1879

Plate 1, fig. 11

Test free, variously formed, rounded, cylindrical or irregularly elongate; wall usually thick, composed of mud with various foreign bodies included in the outer portions; interior with a thin, membranaceous, chitinous layer often extending out and forming the whole wall at the apertural end of some species; aperture typically single and terminal, occasionally multiple in P. *variabilis*.

Genus HIPPOCREPINA Parker, 1870

Plate 1, fig. 12

Test free, consisting of a single, elongate, somewhat tapering, straight or slightly curved chamber, closed at the somewhat bluntly pointed proximal end, distal end broad and rounded; walls comparatively thin, of fine sand grains with a reddish-brown cement, grayish toward the distal end; aperture curved, narrow, or irregular, sometimes with a raised lip.

Genus TECHNITELLA Norman, 1878

Plate 2, fig. 1

Test free, usually elongate, subcylindrical, fusiform or elongate oval, consisting of a single chamber; wall thin, composed of sponge spicules and fine sand, aperture rounded at the open end of the test.

Genus WEBBINELLA Rhumbler, 1903

Plate 2, fig. 2

Test fixed, circular in outline, the central portion convex, the peripheral portion often forming a flattened flange-like rim about the central portion; chamber single, undivided; wall of medium thickness, composed of fine sand grains with a large proportion of cement rather smoothly finished both without and within; aperture not apparent, the pseudopodia being thrust out at the basal portion of the test near the surface of attachment.

Genus THOLOSINA Rhumbler, 1895

Plate 2, fig. 3

Test attached, hemispherical, flattened on the side by which it is attached, chamber single, undivided; with pseudopodial extensions of the test along the surface of the attached surface or with the sides clear cut; wall of fine sand grains with a large proportion of calcareous cement; pseudopodial openings at base along attachment or at the end of irregular tubes running out from the base along the surface of attachment.

Genus AMMOSPHAEROIDES Cushman, 1910

Test irregularly subglobular, composed of an elongate or subspherical chamber with double apertures typically; wall finely arenaceous with a large proportion of reddish-brown cement; apertures at the end of short tubular portions of the test.

Genus VERRUCINA Goës, 1896

Test adherent, irregular-ovoid in shape; interior divided into irregular chamberlets; wall composed of sand grains, rough externally; aperture usually double, situated in the depressed area at the center of the dorsal side.

Genus CRITHIONINA Goës, 1894

Test spherical, lenticular or variously shaped, interior either labyrinthic or with a single chamber; apertures small and scattered or indistinct; wall thick, composed of sponge spicules or very fine sand, often chalky in appearance.

Genus THURAMMINA H. B. Brady, 1879

Plate 2, fig. 4

Test typically free, usually nearly spherical, but in some species compressed; chamber single and undivided in typical species; wall thin, composed of fine sand with more or less chitin; apertures several to many at the end of nipple-like protuberances of the surface, occasionally wanting.

Subfamily 3. Hyperammininae

Test consisting of a globular proloculum and a more or less elongated, sometimes branching portion, but not divided into chambers; free or attached; wall of various agglutinated materials.

Genus HYPERAMMINA H. B. Brady, 1878

Plate 2, fig. 5

Test free, elongate, in general a simple cylindrical tube, straight or slightly curved with a swollen proloculum at the proximal end, distal end open and serving as the aperture; wall composed of sand grains, interior usually smoothly finished, exterior often rough, in some species the exterior smoothly finished and the cement in greater excess.

Genus PSAMMATODENDRON Norman, 1881

Test attached by the bulbous proloculum, remainder of test free and erect, dichotomously branching, tubular, of even diameter throughout; wall arenaceous with ferruginous cement; open ends of the tubes serving as apertures.

Genus SACCORHIZA Eimer and Fickert, 1899

Plate 2, fig. 6

Test free, consisting of an ovoid proloculum with a branching tubular second chamber; wall composed of sand grains usually with the exterior roughened by projecting sponge spicules incorporated in the wall; apertures formed by the open ends of the tubular chamber.

Genus SYRINGAMMINA H. B. Brady, 1883

Test free or adherent, consisting of a bulbous base and many branching arms, or of masses of anastomosing tubes in a rounded mass; wall of fine arenaceous particles with a small amount of inorganic cement; apertures at the extremities of the tubular portions.

Genus JACULELLA H. B. Brady, 1879

Plate 2, fig. 7

Test free, elongate, conical, widest at the apertural end, opposite end typically closed; wall comparatively thick, composed of sand grains firmly cemented, rough on the exterior; aperture formed by the open end of the tube, circular,

Genus DENDROPHRYA Str. Wright, 1861

Plate 2, fig. 8

Test attached, consisting of a single chamber, erect or with spreading arms, tubular, irregular or branching; wall arenaceous, with a chitinous base; apertures at the ends of the arms. But a few species are known and these are largely confined to cold waters at comparatively shallow depths.

Genus HALIPHYSEMA Bowerbank, 1862

Plate 2, fig. 9

Test attached, with an expanded basal portion, and a columnar erect portion either simple or branched; wall arenaceous, usually with numerous included sponge spicules especially near the tips of the arms or the apertural end of the single chambered species; aperture at the free end of the chamber or at the ends of the branches, partially obscured by the irregular clustering of spicules.

Genus SAGENINA Chapman, 1900

Test attached, tubular, branching; wall arenaceous; apertures terminal.

Subfamily 4. AMMODISCINAE

Test composed of a globular proloculum and long, undivided tube, closely coiled, either planospirally or in changing planes or to form a spiral test; wall of fine sand with much cement, usually of a reddish or yellowish brown.

Genus AMMOLAGENA Eimer and Fickert, 1899

Plate 2, fig. 10

Test firmly attached, composed of an oval proloculum flattened on the under side and a second tubular chamber of variable length but of nearly uniform diameter, the open end serving as the aperture; wall finely arenaceous, the cement in excess of the sandy particles.

Genus TOLYPAMMINA Rhumbler, 1895

Plate 3, fig. 1

Test typically adherent by its undersurface, but may become free; consisting of an elongate oval proloculum and a long irregular second chamber, tubular, with nearly even diameter, unbranched; composed of sand grains and a large proportion of yellowish or reddish brown cement.

Genus AMMODISCUS Reuss, 1861

Plate 3, fig. 2

Test free, planospiral, composed of a globular proloculum and long, undivided tubular second chamber, coiled regularly in one plane;

wall finely arenaceous, cement yellowish or reddish brown, surface smooth, aperture formed by the open end of the chamber.

Genus AMMODISCOIDES Cushman, 1909

Plate 2, fig. 11

Test free, spiral, initial chamber followed by a coiled nonseptate tube the microspheric form at least, with the early portion forming a hollow cone; later portions becoming broadly flaring usually slightly concave in the opposite direction from that of the early conical portion; wall finely arenaceous, smooth, aperture terminal.

Genus GLOMOSPIRA Rzehak, 1888

Plate 2, fig. 12

Test composed of a subglobular proloculum and long, undivided second chamber, winding upon itself in various planes, not completely spiral throughout; wall finely arenaceous, with a predominance of cement, smooth both without and within, color reddish or yellowish brown.

Genus TURRITELLELLA Rhumbler, 1903

Test free, consisting of a proloculum and long, undivided second chamber, coiled in an elongate, close spiral; wall composed of sand grains and much cement, smooth; aperture, the open end of the tubular chamber.

Family 3. LITUOLIDAE

Test consisting typically of two or more chambers connected with one another, arranged in a linear, planospiral, or trochoid, coiled or irregular series; wall of agglutinated material, the relative amounts of cement and foreign material varying greatly; apertures usually one to each chamber, but sometimes several.

Subfamily 1. ASCHEMONELLINAE

Test composed of agglutinated material, divided irregularly into chambers without definite plan of arrangement.

Genus ASCHEMONELLA H. B. Brady, 1879

Plate 3, fig. 3

Test free, composed of a number of tubular or inflated chambers in a single or branching series, size and form irregular; walls arenaceous, firm, thin; apertures often several at the end of the tubular necks.

Subfamily 2. REOPHACINAE

Test composed of agglutinated material, sand grains, sponge spicules, tests of other foraminifera, etc., with a varying amount of cement; chambers in a linear series; aperture usually single and at the distal end of the chamber but occasionally at the side, rarely multiple or cribrate.

Genus REOPHAX Montfort, 1808

Plate 3, fig. 4

Test free, composed of chambers in a linear series, usually joined end to end in a straight or slightly curved line, ranging from closely overlapping chambers to remotely separated ones with stoloniferous connections between; chambers few or numerous; wall of sand grains, mica scales, sponge spicules, chitinous or of tests of other foraminifera; chambers undivided, aperture simple, terminal, at the distal end of the last-formed chamber.

Genus HORMOSINA H. B. Brady, 1879

Plate 3, fig. 5

Test free, composed of a linear series of subglobular, fusiform, or pyriform chambers joined end to end in a single moniliform series, straight, somewhat curved or irregular; walls usually thin, finely arenaceous with an excess of cement; chambers undivided; aperture a single circular opening usually at the dorsal end of the last-formed chamber, often with a neck, but occasionally at the side of the chamber; color yellowish or reddish brown.

Genus HAPLOSTICHE Reuss, 1861

Plate 3, fig. 6

Test free, cylindrical or tapering, composed of a linear series of chambers, interior labyrinthic; walls thick, coarsely arenaceous, but usually fairly smooth on the exterior; aperture terminal in the middle of the distal portion of the last-formed chamber, in the earlier chambers usually simple, in the adult made up of several pores or in large specimens often dendritic, occasionally with a short neck.

Subfamily 3. TROCHAMMININAE

Test composed of several chambers, either in a planospiral coil, trochoid, or otherwise arranged; wall composed of sand grains of varying degrees of coarseness cemented with a calcareous or ferruginous cement, free or attached.

Genus TROCHAMMINOIDES Cushman, 1910

Plate 3, fig. 7

Test free, typically planospiral, composed of several coils, each constricted into a number of chamber-like portions with the openings between large; wall of fine sand and a yellowish-brown cement; aperture simple at the end of the last-formed chamber.

Genus HAPLOPHRAGMOIDES Cushman, 1910

Plate 3, fig. 8

Test free, planospiral, composed of several coils, each composed of a number of chambers; wall arenaceous, varying much in texture and in the relative amount of cement in the different species; aperture at the ventral border or on the lower portion of the apertural face of the chamber.

Genus CRIBROSTOMOIDES Cushman, 1910

Plate 4, fig. 1

Test free, planospiral, composed of numerous chambers in several coils, the last-formed coil with several chambers progressively increasing in size; wall arenaceous, with much cement usually of a light brown color; aperture in young specimens a simple elongate slit at the base of the apertural face, later subdivided by tooth-like processes, and in the adult represented by a linear series of distinct rounded openings.

Genus CYCLAMMINA H. B. Brady, 1876

Plate 3, fig. 9

Test free, planospiral, composed of numerous chambers in a close-coiled involute series, final volution usually embracing the preceding ones except at the umbilicus; walls thick, composed of fine arenaceous material with a large amount of reddish-brown cement, exterior smooth; chambers with secondary labyrinthic structures interiorly, especially on the peripheral portion of each chamber, early chambers often becoming completely filled by this secondary growth; aperture a curved fissure at the proximal portion of the apertural face, supplemented by numerous pores in the central portion of the apertural wall.

Genus LOFTUSIA Carpenter and Brady, 1869

Test of large size, spiral; elongated in the direction of the axis; fusiform or elliptical; resembling *Alveolina* in contour.

Genus LITUOTUBA Rhumbler, 1895

Plate 4, fig. 2

Test of two distinct parts, an early close-coiled portion and a long tubular uncoiled later portion; wall arenaceous, with an excess of cement, either indistinctly or irregularly divided.

Genus AMMOBACULITES Cushman, 1910

Plate 4, fig. 3

Test free, composed of several chambers, early portion close coiled in a single plane, later portion uncoiled and made up of a more or less linear series of chambers; wall coarsely arenaceous, usually rather thick; aperture single at the distal end of the last formed chamber in the adult uncoiled specimen, but in the young usually at the base of the apertural face.

Genus HAPLOPHRAGMIUM Reuss, 1860

Test in the early portion close coiled, planospiral, later becoming uncoiled and straight; chambers distinct, not labyrinthic; wall arenaceous; aperture in the adult consisting of a number of pores, the apertural face often becoming sieve-like.

Genus LITUOLA Lamarck, 1804

Plate 4, fig. 4

Test crozier-shaped, the early portion planospiral, the later portion uncoiled and straight, test arenaceous, the chambers labyrinthic with radial vertical partitions and secondary septæ; aperture typically of several pores.

Genus PLACOPSILINA d'Orbigny, 1850

Test attached, composed of numerous chambers, the early portion close-coiled, later portions uncoiling and spreading out in an irregular but in general a linear series of chambers, building no floor; last portion of the test may be entirely free, made up of an irregular series of chambers; wall coarsely arenaceous, aperture rounded, at the end of the last-formed chamber.

Genus ROTALIAMMINA Cushman, 1925

Test rotaliform, attached by the ventral side, all chambers visible from above, only those of the last-formed coil from below, chambers numerous with thick arenaceous walls of matted spicules, the areas between softer and somewhat flexible; aperture ventral, along the growing edge of the test.

Genus TROCHAMMINA Parker and Jones, 1860

Plate 4, fig. 5

Test free or sometimes adherent, spiral, trochoid, chambered; all chambers visible when viewed from above, only the chambers of the last-formed volution visible from below; wall arenaceous usually with considerable cement; aperture an arched slit on the ventral side of the chamber at its contact with the preceding volution.

As here considered, *Trochammina* is restricted to those species like *T. inflata* (Montagu) or *T. squamata* Jones and Parker, which have a true spiral, trochoid test with all the chambers visible only from above.

Genus GLOBOTEXTULARIA Eimer and Fickert, 1899

Plate 4, fig. 6

Test arenaceous, the early chambers in a spire, the later ones irregular, globular, Globigerina-like.

Genus AMMOCHILOSTOMA Eimer and Fickert, 1899

Plate 3, figs. 10, 11

Test free, early chambers spiral, later ones very involute, and the last-formed volution often entirely covering the previously formed chambers and usually at an oblique angle to the earlier growth; wall arenaceous, with a variable, usually excessive amount of cement; aperture at or near the base of the apertural face of the chamber, elongate, narrow, color usually reddish or yellowish brown.

Genus AMMOSPHAEROIDINA Cushman, 1910

Plate 4, fig. 7

Test globose, arenaceous, early portion spiral, later chamber like *Sphaeroidina* in form, embracing; aperture rounded, at one side of the chamber in the adult.

Genus SPHAERAMMINA Cushman, 1910

Test composed of a series of chambers, the last one formed completely enveloping the preceding ones, but the axis straight; wall arenaceous.

Genus AMMOSPHAERULINA Cushman, 1912

Test spherical, adherent; wall arenaceous; composed of two or more chambers, each included by the one next-formed, eccentric; color light yellowish-brown.

Genus NOURIA Heron-Allen and Earland, 1914

Test free, composed of several chambers, in a generally *Polymorphina*-like arrangement; wall arenaceous or composed of sponge spicules; sutures indistinct; aperture terminal.

Subfamily 4. NEUSININAE

Test arenaceous with some chitin, flattened and broad, composed of many chambers, early portion coiled with the later chambers broad and spreading, sides with elongate chitinous filaments.

This subfamily containing the single species, *Neusina agassizii* Goës, is different from the other arenaceous foraminifera but in its general plan of structure is not unlike certain other genera.

Genus NEUSINA Goës, 1892

Test expanded, flat, made up of a series of very broad, low, flattened chambers, early ones in complete specimens apparently coiled, later ones in a broad, flat expanse of varying shape; wall arenaceous or of fine mud and sand with a chitinous network, flexible with a thread-like border of chitin; apertures numerous, along the edge of the chamber; color in fresh specimens brown.

Genus BOTELLINA, W. B. Carpenter, 1869

Test arenaceous, cylindrical, one end rounded and more or less swollen; walls of the test of firm consistence, rough, subdivided irregularly by a labyrinth of sand grains cemented together at various angles forming rude chamberlets which open out into a main tube or chamber, which runs through nearly the whole test.

Subfamily 5. ORBITOLININAE

Test siliceous, imperforate, crateriform and composed of concentric annuli which are partitioned off into numerous chambers.

Genus ORBITOLINA Lamarck

Test conical, usually broader than high, base flattened or often concave, chambers numerous divided into chamberlets; a central mass of chamberlets more or less compressed with the walls usually labyrinthic; base with numerous apertures.

Genus CONULITES

Test conical, usually higher than broad, base flattened or convex, early chambers spiral, outer chamberlets rectangular; walls straight; internal chamberlets usually in curved layers; apertures in the basal wall.

Subfamily 6. ENDOTHYRINAE

Test arenaceous with calcareous cement wall distinctly perforate.

Genus NODOSINELLA Brady, 1876

Test Nodosariform, finely arenaceous, nearly smooth externally; interior sometimes slightly labyrinthic; aperture simple.

Genus STACHEIA Brady, 1876

Test adherent, composed either of numerous segments subdivided into chamberlets, or of an acervuline mass of chamberlets either arranged in layers or confused.

Genus ENDOTHYRA Phillips, 1846

Test polythalamous; nautiloid or Rotaliform; aperture simple, situated at the inner margin of the final chamber.

Genus BRADYINA Möller, 1878

Test nautiloid; aperture consisting of a number of pores on the face of the terminal chamber; with pores (?) also in the septal depressions.

Genus INVOLUTINA Terquem, 1862

Test lenticular, consisting of a planospiral tube with a deposit of shell-substance on both faces, thickest near the middle; tube sometimes slightly constricted at intervals; shell-wall more or less perforate.

Family 4. TEXTULARIIDAE

Test either arenaceous or calcareous, perforate, the chambers usually numerous, typically biserial or triserial, or in some genera spirally arranged.

Subfamily 1. SPIROPLECTINAE

Test either coarsely arenaceous or calcareous, or even hyaline, the early chambers following the proloculum closely coiled, the later chambers biserial, occasionally tending to become uniserial in the last developed chambers.

Genus SPIROPLECTA Ehrenberg, 1844

Plate 4, fig. 8

Test with the early chambers close-coiled in both the microspheric and megalospheric forms; later chambers biserial; wall typically arenaceous.

Subfamily 2. TEXTULARIINAE

Test typically biserial, wholly or in part, the early portion in the microspheric form often with a few coiled chambers, followed by the biserial chambers; later chambers variously modified in the different genera, uniserial, broadly extended, etc.; wall either arenaceous or calcareous and hyaline, perforate; aperture single, or in a few cases, many present in a single chamber.

Genus TEXTULARIA Defrance, 1824

Plate 5, fig. 1

Test elongate, tapering, composed of two series of alternating chambers; wall calcareous in the young, hyaline and perforate, occasionally so throughout the test, often with an external coating of siliceous or calcareous sand, or in some species nearly the whole test arenaceous; aperture typically an arched slit at the inner margin of the chamber close to its line of attachment to the preceding chamber; occasionally with the aperture surrounded by a raised lip, or in some species with the aperture circular and terminal.

Genus TEXTULARIOIDES Cushman, 1911

Test attached, consisting of a *Textularia*-like series of chambers, arranged in two series, the chambers of one series alternating with those of the other; wall arenaceous; aperture an elongated slit in a depression at the base of the inner margin of the chamber.

Genus BIGENERINA d'Orbigny, 1826

Plate 4, fig. 9

Test free, generally elongate, cylindrical or compressed, the early portion textularian, composed of a series of biserially arranged chambers, later chambers arranged in a single line; wall usually thick, arenaceous, usually coarse but often smoothly finished; aperture in the young at the base of the inner margin of the last-formed chamber, as in *Textularia,* but in the adult, in the uniserial portion terminal, rounded or oval according to the form of the chamber.

Genus CLIMACAMMINA H. B. Brady, 1876

Test arenaceous with a calcareous base, early chambers biserial, later ones uniserial; aperture of numerous rounded pores.

Genus BOLIVINA d'Orbigny, 1839

Plate 4, fig. 10

Test elongate, distinctly biserial throughout; wall usually thin and hyaline in the young, but becoming thickened with age in many species, ornamented by punctæ, striæ, costæ, knobs, and spines, with carinæ developed in some species; aperture elongate, usually symmetrical.

Genus PLEUROSTOMELLA Reuss, 1860

Plate 5, fig. 2

Test elongate, somewhat compressed, composed of numerous chambers, usually biserially arranged; wall calcareous, perforate, smooth or ornamented; aperture distinctive, an arched opening with a vertical notch or slit in the middle of the lower edge usually with tooth-like projections upward at either side.

Genus PAVONINA d'Orbigny, 1826

Plate 5, fig. 3

Test calcareous, hyaline, perforate, many chambered, the early chambers biserial, the later ones becoming uniserial, broad, curved, in the type species finally becoming embracing, and the embracing series each composed of one or more chambers; apertures numerous on the peripheral margin.

Genus CUNEOLINA d'Orbigny, 1839

Test biserial, tapering, broadest near the apertural end, compressed so that the two alternating series of chambers form a zigzag line on the narrow sides of the test; chambers numerous, low, and very broad, wall arenaceous, composed of very fine material, smooth, chamber wall labyrinthic, composed of numerous openings, the smaller near the exterior; aperture elongate, narrow, either simple or a row of pores.

Genus BIFARINA Parker and Jones, 1872

Test with the early chambers like *Bolivina* but in later development becoming uniserial.

Subfamily 3. VERNEUILININAE

Test with the early chambers triserial, in some genera later becoming biserial or uniserial.

Genus VERNEUILINA d'Orbigny, 1840

Plate 5, fig. 4

Test free, more or less elongate, tapering, in cross section round or triangular, composed of a series of chambers spirally arranged, but in three vertical columns; walls variable, arenaceous or hyaline; aperture a slit at or near the base of the inner margin of the chamber.

Genus VALVULINA d'Orbigny, 1826

Plate 5, fig. 5

Test spiral, conical, with three chambers in a whorl, umbilicate, usually attached; wall arenaceous, fairly smooth; aperture provided with a valvular tooth; color usually reddish-brown, area of fixation white or light gray.

Genus CHRYSALIDINA d'Orbigny, 1846

Plate 5, fig. 7

Test many chambered, triserial, at least in the early portion, tapering; apertures numerous, scattered over the terminal wall of the chamber; other walls also porous.

Genus TRITAXIA Reuss, 1860

Plate 5, fig. 6

Test triserial, at least in the earlier portion, usually triangular in cross section; aperture central and terminal with or without a distinct neck and lip, rounded; wall usually arenaceous.

Genus GAUDRYINA d'Orbigny, 1839

Plate 6, fig. 1

Test free, composed of two distinct portions, the earlier consisting of a series of chambers arranged triserially, followed by a later portion consisting of a series arranged biserially; wall arenaceous, varying much in coarseness in the different species; aperture variable as in the various species of *Textularia,* either an opening at the base of the inner margin of the chamber, between it and the wall of the preceding chamber, or a perforation near the base of the inner margin, often with a raised border, or in some species a terminal more or less circular opening.

Genus TRITAXILINA Cushman, 1911

Plate 6, fig. 2

Test in its early development triserial, later becoming biserial and in the adult uniserial; chambers numerous, distinct, interior labyrinthic; wall arenaceous; aperture in the triserial portion elongate with a valvular lip, at the edge of the inner side of the chamber, in the adult central, terminal, usually with a series of peripheral teeth projecting in and partially closing the opening.

Genus CLAVULINA d'Orbigny, 1826

Plate 7, fig. 1

Test free, elongate, cylindrical or angled; early portion consisting of a number of chambers arranged triserially; later portion consisting of numerous chambers arranged uniserially; walls arenaceous, usually smooth; aperture in early chambers with a valvular tooth; in the later portion aperture central or nearly so, rounded, and with or without a tooth.

Genus MIMOSINA Millett, 1900

Test triserial; wall thin; aperture of two openings, one a slit at the base of the ventral face, the other varying in shape and near the outer end of the ventral face; the two sometimes connected on the interior of the test.

Subfamily 4. BULIMININAE

Test elongate spiral; wall usually hyaline at least in the early stages, calcareous; perforate; aperture typically a comma-shaped slit.

Genus BULIMINA d'Orbigny, 1826

Plate 5, fig. 8

Test usually fusiform or tapering, free, composed of numerous chambers arranged typically in a spiral, each chamber situated above the third preceding one, making a triserial arrangement, not always visible from the surface except in the last convolution; wall calcareous, perforate, usually thin and transparent, but thickening somewhat with age, smooth or ornamented with raised costæ, spines, etc.; aperture typically a comma-shaped slit broadest above and tapering obliquely to a point below, usually with a raised margin and often partly closed by a tooth-like rim at one side.

Genus BULIMINELLA Cushman, 1911

Plate 6, fig. 3

Test composed of chambers triserially arranged, but in later development becoming involute and spirally coiled, the aperture being in the umbilicus thus formed; wall calcareous, perforate; aperture in the species but little twisted spirally, long and narrow, nearly vertical, in the closely spiral species becoming rounded in the middle of the concave umbilical area.

Genus BULIMINOIDES Cushman, 1911

Plate 7, fig. 2

Test triserial, spiral, elongate, subcylindrical; wall calcareous, perforate; aperture nearly circular, terminal, in a depression of the truncated apertural end.

Genus VIRGULINA d'Orbigny, 1826

Plate 6, fig. 4

Test elongate, tapering, typically biserial, often becoming irregularly twisted in a spiral manner; chambers distinct; sutures usually depressed; wall calcareous, thin and translucent, in adults sometimes becoming thicker and opaque, perforate; aperture typically a comma-shaped opening with the narrow end coming to the base of the chamber; color white.

Subfamily 5. CASSIDULININAE

Test both spiral and biserial, the early chambers somewhat spirally placed, the later ones biserial; wall usually hyaline and perforate; aperture comma-shaped.

Genus CASSIDULINA d'Orbigny, 1826

Plate 6, fig. 5

Test complex, at least the early portion coiled, the chambers arranged biserially, alternating on the sides of the axis of coiling, chambers usually extending to the umbilicus on the sides, in some species the later portion of the test uncoiling; wall calcareous, perforate, usually smooth and without ornamentation; chambers numerous, the sutures usually distinct; aperture loop-like, modified in breadth and length in the different species.

Genus EHRENBERGINA Reuss, 1850

Plate 6, fig. 6

Test free, early portion coiled, later portion uncoiled, composed of numerous chambers arranged biserially about an elongate axis, evenly united on the dorsal side but forming a deep groove on the ventral border, generally triangular in cross section; wall calcareous, perforate, smooth, or ornamented with spines or ridges; aperture elongate, curved, nearly at right angles to the edge of the chamber, with a slight lip.

Family 5. LAGENIDAE

Test calcareous, vitreous, finely perforate, either monothalamous or made up of a series of chambers arranged in a straight or curved axis, or close-coiled or spirally, or even in an alternating manner; aperture either radiate or simple or with a neck and phialine lip.

Subfamily 1. LAGENINAE

Test consisting of a single chamber, the aperture either ecto- or entosolenian.

Genus LAGENA Walker and Boys, 1784

Plate 6, fig. 7

Test monothalamous, smooth or ornamented, generally flask-shaped; aperture ecto- or entosolenian.

Subfamly 2. NODOSARIINAE

Test polythalamous; chambers arranged in a straight, arcuate, planospiral or uncoiling series; apertures either radiate or with neck and phialine lip.

Genus NODOSARIA Lamarck, 1812

Plate 7, fig. 3

Test composed of a straight or arcuate series of chambers, either loosely joined together by stolons or close set and overlapping or various forms between; surface smooth or ornamented; aperture either radiate or with a definite neck and phialine lip.

Genus LINGULINA d'Orbigny, 1826

Plate 7, fig. 4

Test compressed; chambers arranged in a linear series, usually closely set; aperture usually elongate, corresponding to the form of the chamber.

Genus TRIFARINA Cushman, 1923

RHABDOGONIUM H. B. Brady, not Reuss

Plate 7, fig. 5

Test elongate, triangular in transverse section; the early chambers in an irregular spiral, later ones very loosely so or even uniserial; wall thin, translucent, finely punctate; aperture terminal not radiate, at the end of a short, often phialine lip.

Genus CRISTELLARIA Lamarck, 1812

Plate 8, fig. 1

Test planospiral, typically close-coiled, but becoming much uncoiled in some species; chambers numerous; wall hyaline, perforate, variously ornamented; aperture usually distinctly radiate.

Genus MARGINULINA d'Orbigny, 1826

Plate 7, fig. 6

Test subcylindrical, early portion close-coiled, later chambers uncoiled, rounded in transverse section, the last-formed chambers often inflated; aperture in early chambers marginal, later often becoming nearly median, usually radiate.

Genus VAGINULINA d'Orbigny, 1826

Plate 8, fig. 2

Test elongate; chambers in a linear series, placed so that the sutures are oblique; aperture marginal; chambers laterally compressed.

Genus FRONDICULARIA, Defrance, 1824

Plate 6, fig. 8

Test compressed, in the adult consisting of chambers, elongate and narrow, running back on either side of the test; wall vitreous, finely perforate; aperture single, either radiate or surrounded with a lip which is usually cut in a radial manner; surface smooth or ornamented with costæ; microspheric specimens with a coiled development in the earlier chambers; megalospheric specimens without the coiled chambers as a rule.

Subfamily 3. POLYMORPHININAE

Test polythalamous; chambers usually arranged in an irregular spiral, in later growth sometimes approaching a biserial arrangement or sometimes uniserial; surface smooth or ornamented by spines or costæ; aperture radiate.

Genus POLYMORPHINA d'Orbigny, 1826

Plate 7, fig. 8

Test more or less rounded, usually not equilateral; chambers few, obliquely placed in a more or less spiral arrangement; aperture terminal, radiate; wall calcareous, perforate, either smooth or variously ornamented with spines, costæ, or tubercles.

Genus DIMORPHINA d'Orbigny, 1826

Test with the early chambers polymorphine, later ones uniserial.

Subfamily 4. UVIGERININAE

Test composed of several chambers, typically spirally arranged, especially in the earlier portion, later chambers often becoming loosely arranged, or even uniserial; wall smooth or variously ornamented; aperture typically consisting of a neck with a definite phialine lip.

Genus UVIGERINA d'Orbigny, 1826

Plate 8, fig. 3

Test elongate, spiral, consisting of numerous chambers, usually arranged triserially, occasionally in later growth with fewer than three chambers in each volution; wall calcareous, perforate, hyaline, smooth or ornamented with spines or costæ or modifications of them; aperture with usually a tubular neck at the end of which is a phialine lip.

Genus SIPHOGENERINA Schlumberger, 1883 (SAGRINA of Authors, not d'Orbigny)

Plate 8, fig. 4

Test elongate, composed at least in the microspheric form of a series of chambers arranged tri- or bi-serially, followed by a later uniserial development; walls hyaline and perforate; aperture in the uniserial portion central and terminal, usually with an elongated neck and flaring lip; interior of the chamber with a tubular connection running from the base of the apertural neck to the lip of the aperture below; wall smooth or ornamented by costæ, pits, etc.

Subfamily 5. RAMULININAE

Test composed of branching tubular masses with rounded chamber-like portions at irregular intervals.

Genus RAMULINA Rupert-Jones, 1875

Plate 8, fig. 5

Test free, branching, consisting of more or less rounded chambers connected by long stoloniferous tubes; wall hyaline.

Genus VITREWEBBINA Chapman, 1892

Test attached, composed of a series of rounded chambers increasing in size as added, usually in a curved line; test finely perforate; aperture a small arched opening at the base of the last-formed chamber.

Family 6. CHILOSTOMELLIDAE

Test calcareous, conspicuously punctate, chambers usually somewhat inflated, irregularly coiled, the last-formed chamber in the various genera making up a large portion of the last-formed volution; aperture usually a curved opening between the base of the chamber and its predecessor, sometimes terminal.

Genus CHILOSTOMELLA Reuss, 1850

Plate 8, fig. 6

Test composed of a series of chambers in a coil, each chamber making a half coil of 180° and embracing so that but a small part of the preceding chamber is visible from the exterior; wall smooth, finely perforate, either thin and transparent or thick and opaque; aperture at the inner margin of the ventral face of the chamber curved, often with a slightly upward-turned lip.

Genus ALLOMORPHINA Reuss, 1850

Plate 7, fig. 7

Test made up of a few ovate chambers in a coil, each chamber making up 120° of the volution so that but three chambers are visible from the exterior; wall thin, translucent, finely punctate; aperture a narrow slit at the base of the chamber.

Genus SEABROOKIA H. B. Brady, 1890

Test composed of a series of chambers, each partially or entirely inclosing the preceding one; wall thin, hyaline, perforate; aperture terminal, rounded, with a slightly thickened lip.

Genus ELLIPSOIDINA Seguenza, 1859

Test uniserial, each chamber added from the base of the preceding one and entirely enclosing it; aperture terminal with a projecting lip, often connected interiorly by a tubular neck with the preceding aperture.

Family 7. GLOBIGERINIDAE

Test composed of numerous chambers, usually much inflated, arranged typically in a trochoid coil, but in some species becoming planospiral; often umbilicate; wall calcareous and perforate, usually with a more or less regular reticulation and in perfect specimens in some species with long slender spines; aperture either large and simple or with numerous accessory openings.

Genus GLOBIGERINA d'Orbigny, 1826

Plate 8, fig. 7

Test composed of numerous inflated chambers arranged typically in a trochoid manner, but which in later development may be variously arranged; wall typically coarsely perforate, reticulate; aperture large, arched, at the base of the inner margin of the chamber, in some species opening on the umbilicus, in others with numerous accessory openings.

Genus ORBULINA d'Orbigny, 1839

Plate 8, fig. 8

Test in the early stages composed of several *Globigerina*-like chambers rapidly increasing in size as added, finally entirely surrounded by the adult chamber which is spherical, with numerous small pores, and one large circular orifice, or occasionally more than one; wall reticulated, in living condition with long, fine spines.

Genus HASTIGERINA Wyville Thomson, 1876

Plate 8, fig. 9

Test composed of numerous chambers arranged in a planospiral manner, inflated; surface with numerous spines, the edges parallel and toothed; aperture large, broad, oval, at the inner margin of the chamber.

Genus CANDEINA d'Orbigny, 1839

Plate 9, fig. 1

Test generally trochoid, usually with the spire somewhat compressed and the later chambers often irregular; chambers numerous, rapidly increasing in size as added, inflated; wall usually clear and translucent, in old-age specimens occasionally thickened and opaque; apertures numerous, elliptical in form, placed in a somewhat regular manner along the sutural lines between the chambers.

Genus SPHAEROIDINA d'Orbigny, 1826

Plate 9, fig. 2

Test composed of a few chambers arranged in an irregular spire, the later chambers especially much inflated, increasing rapidly in size and embracing, a few only visible from the exterior; wall perforate; aperture an arched opening at or near the inner margin of the chamber, often with a calcareous, tooth-like process partially closing the opening.

Genus PULLENIA Parker and Jones, 1862

Plate 9, fig. 3

Test composed of several chambers arranged in a planospiral or oblique nautiloid more or less involute spiral, chambers not greatly inflated, only those of the last-formed volution visible; wall smooth, perforations small and indistinct; aperture a curved opening at the base of the inner face of the chamber.

Genus HANTKENINA Cushman, 1924

Test free, planospiral, consisting of about three coils, chambers few, usually about five in the adult coil, laterally compressed, wall finely or coarsely perforate, sutures distinct and depressed, each chamber, at least in the adult, with a stout peripheral spine with a hollow center, aperture tripartite, one arm running along either side of the base of the chamber, the other extending peripherally in the apertural face of the chamber.

Family 8. ROTALIIDAE

Test calcareous, perforate, composed usually of numerous chambers, except in the subfamily Spirillininae, early chambers coiled, and later chambers in typical genera spirally coiled so that the chambers are all visible from the dorsal side and only those of the last formed coil from the ventral side, convexity of the two sides varying greatly; later development in specialized genera being columnar or even arborescent.

Subfamily 1. SPIRILLININAE

Test free or attached, composed of a proloculum and a long coiled tubular second chamber; variously ornamented; aperture at the end of the tube; wall calcareous, perforate.

Genus SPIRILLINA Ehrenberg, 1841

Plate 8, fig. 10

Test typically free, occasionally attached, spiral, composed of a subcircular or ovoid proloculum and a long undivided tubular second chamber, coiled regularly in one plane; wall hyaline and perforate; surface smooth or variously ornamented; aperture formed by the open end of the tube.

Subfamily 2. ROTALINAE

Test spiral, rotaliform, rarely evolute, very rarely irregular or acervuline; chambers numerous, distinct or in some few species largely obscured by shell growth, early chambers in all distinctly rotaliform.

Genus PATELLINA Williamson, 1858

Plate 9, fig. 4

Test conical in form or plano-convex; the early chambers spirally arranged, later ones long and becoming annular or nearly so about the periphery; chambers of living forms usually simple but often patially divided by internal septæ, visible from the exterior; aperture elongate, at the inner border of the chamber.

Genus DISCORBIS Lamarck, 1804 (DISCORBINA of Authors)

Plate 10, fig. 1

Test free or attached, spiral and rotaliform, plano-convex or biconvex, or modified variously in different species; typically plano-convex with the ventral side flattened and the dorsal convex; all chambers visible from the dorsal side, only those of the last-formed coil visible from the ventral side; test composed of several coils, usually three or four in the adult test; chambers rather numerous; aperture a slit at the umbilical margin of the ventral side of the chamber.

Genus CYMBALOPORA Hagenow, 1850

Plate 10, fig. 2

Test free, early chambers spirally arranged, later ones annular or irregular; umbilicate; wall finely perforate; chambers as added often not contiguous, but separated from one another by some distance along the periphery, marked on the ventral side by depressions radiating from the central umbilicus; in the various species the early chambers following the proloculum are usually brownish in color, this being wanting in the later adult chambers.

Genus TRETOMPHALUS Moebius, 1880

Plate 10, fig. 3

Test free, early stages *Discorbis*-like, in a low conical spire; last formed chamber globular, larger than the entire early growth; wall perforate, the last formed chambers with very large ones; aperture in adult chamber rounded with an entosolenian neck.

Genus PLANORBULINA d'Orbigny, 1826

Plate 11, fig. 1

Test typically adherent; early chambers in a close coil, later chambers surrounding the periphery in an annular arrangement; chambers in a single layer; test attached by its dorsal side, noninvolute; all chambers usually visible from either dorsal or ventral side; wall perforate, often rather coarsely so; aperture in the early chambers single on the inner border of the chamber in the coiled chambers, in those arranged in an annular manner usually two, one at either end of the chamber and near the preceding chambers adjacent and together forming a series of apertures about the periphery of the test; each newly added chamber connects with the two adjacent chambers at either side in the series next previously formed.

Genus TRUNCATULINA d'Orbigny, 1826

Plate 9, fig. 5

Test free or adherent, rotaliform, the ventral face usually the more convex but passing into species which are nearly biconvex; chambers usually visible from both sides, occasionally with limbate sutures; wall either smooth or with raised papillæ, occasionally with limbate margins, coarsely punctate; aperture usually a curved slit at the margin of the inner end of the chamber, often with a definite lip.

Genus SIPHONINA Reuss, 1849

Plate 11, fig. 5

Test free, composed of numerous chambers arranged in a somewhat irregular spiral, rounded or biconvex, perforate; wall smooth or ornamented; aperture rounded, usually with a short neck and phialine lip.

Genus ANOMALINA d'Orbigny, 1826

Plate 11, fig. 4

Test nautiloid, composed of numerous chambers, but slightly involute; the two faces usually much alike, biconvex or slightly unsymmetrical; aperture a narrow curved slit at the base of the final chamber.

Genus CARPENTERIA Gray, 1858

Plate 9, fig. 6

Test attached, early chambers rotaliform, later ones becoming irregular and inflated, extending upward in an irregular column; chambers few; wall coarsely perforate; aperture in adult specimens usually with a tubular neck.

Genus RUPERTIA Wallich, 1877

Plate 11, figs. 2, 3

Test attached, columnar; early chambers coiled, later chambers extending up into a coiled column; wall coarsely punctate; aperture a narrow curved slit at the inner margin of the chamber.

Genus PULVINULINA Parker and Jones, 1862

Plate 12, fig. 1

Test usually rotaliform, dorsal side usually convex, ventral side usually flattened; outline typically circular but in some species elongate; wall finely porous, variously ornamented by costæ, bosses, reticulations, or smooth; aperture typically ventral, extending from near the periphery to the umbilicus.

Genus ENDOTHYRA Phillips, 1846

Test calcareous, composed of an outer coarsely perforated layer and inner finely granular, compact layer, chambers numerous, in an irregular spiral coil, aperture of several rounded openings.

Genus ROTALIATINA Cushman, 1925

Test free, trochoid, spiral, composed of about three volutions, the last one composed of numerous chambers, all the chambers exposed from the dorsal side, only those of the last-formed coil visible from the ventral side, umbilicate ventrally; chambers distinct; sutures distinct and usually slightly depressed; wall in the known species smooth; aperture an arched slit between the base of the apertural face and the previous coil.

Genus ROTALIA, Lamarck, 1804

Plate 12, fig. 2

Test free, composed of numerous chambers arranged in a flattened spire, the two sides biconvex or varying from flat above and convex below to convex above and flattened below; all chambers visible from the dorsal side, only those of the last-formed coil visible from below; the umbilical region usually filled with clear shell material; surface variously ornamented with raised bosses or costæ or smooth and unornamented; aperture a single curved opening toward the periphery on the ventral side of the chamber.

Genus CALCARINA d'Orbigny, 1826

Plate 12, fig. 3

Test composed of numerous chambers, close coiled, biconvex; periphery usually with radiating spines; chambers visible at least on the ventral side, sometimes on the dorsal side as well; aperture typically consisting of a row of small openings along the inner margin of the apertural face; supplemental skeleton and canal system highly developed.

Genus SIDEROLITES Lamarck, 1801

Plate 12, fig. 4

Test with early chambers close-coiled, Rotaliform, later with numerous chambers, a few large spines running from the early chambers to the exterior and thence outward; aperture at the base of the last-formed chamber, later in the large perforations of the chamber.

Genus BACULOGYPSINA Sacco (1893) (Tinoporus of Authors)

Plate 12, fig. 5

Test in the very young, rotaliform, later irregular, with numerous small finely punctate chambers, with four to eight or even more sharp tapering spines; supplementary skeleton greatly developed, at the surface, when well preserved, with bosses of clear shell material united with surrounding ones by radial connecting portions of the same sort of material, making a reticulate marking standing out slightly above the surface.

Genus GYPSINA Carter, 1877

Plate 13, fig. 1

Test free or adherent, when free it may be spherical or compressed, when adherent the test takes the form of the object to which it is attached or becomes a raised mass of chambers more or less symmetrical; early chambers forming a flat spire in the higher species, but in most irregularly arranged throughout; wall coarsely porous.

Genus POLYTREMA, Risso, 1826

Test adherent; early chambers small, spirally arranged, soon covered by the irregular loosely growing chambers making an irregular spreading mass, later chambers forming an arborescent growth; wall calcareous, areolated, numerous apertures appearing at the surface on papillæ; interior often of loosely arranged chambers with lacunæ between; color red or pink or sometimes white.

Genus HOMOTREMA Hickson, 1911

The surface is marked by clearly defined areolæ about 0.1 mm. in diameter, perforated by a large number of small foramina, 0.001 mm. in diameter. The boundaries of the areolæ are solid, and there are no pillar pores. Below the surface there may be seen a number of chambers communicating with one another by large open passages and bounded by solid walls. There are no hollow pillars and no foramina except those on the outer walls of the superficial chambers.

Genus SPORADOTREMA Hickson, 1911

The surface of the stem, and, in many cases, of the proximal parts of the branches as well, are not marked by areolæ at all. The foramina are scattered irregularly on the surface and are of relatively large size. There are no pillar pores. Below the surface there may be seen a number of chambers communicating with one another by large open passages and bounded by solid walls. There are no hollow pillars and no foramina except those on the outer walls of the superficial chambers.

Family 9. NUMMULITIDAE

Test calcareous, perforate, the chambers usually numerous, arranged in a spiral, either umbilicate or completely involute, surface variously ornamented; chamber walls in the higher forms with secondary canal system.

Subfamily 1. FUSULININAE

Test fusiform or subglobular, chambers extending from pole to pole, each convolution completely covering the preceding whorls, wall finely perforate; aperture an elongated slit or series of pores at the base of the last-formed chamber.

Genus SCHWAGERINA Möller, 1887

Test subspherical, chambers divided into chamberlets by simple, straight, secondary septæ; aperture a single opening or series of pores.

Genus FUSULINA Fischer, 1829

Test fusiform or subglobular; chambers not completely subdivided; aperture simple.

Subfamily 2. POLYSTOMELLINAE

Test bilaterally symmetrical; nautiloid, higher forms with a supplemental skeleton and secondary canal system.

Genus NONIONINA d'Orbigny, 1826

Plate 13, fig. 2

Test composed of numerous chambers arranged to form a bilateral, planospiral coil, the last formed volution usually embracing all the preceding ones; walls usually smooth, sometimes pitted, very finely perforated; aperture a narrow opening or row of openings at the base of the apertural face between it and the preceding volution.

Genus POLYSTOMELLA Lamarck, 1822

Plate 13, fig. 3

Test composed of numerous chambers, arranged in a regular, bilaterally symmetrical, involute spire, the chambers extending back to the umbilical region so that only the last formed whorl is visible, chambers either inflated with depressed sutures bridged across at regular intervals or the sutures may be limbate and the processes form a regular series of elevated ridges connecting the sutures; aperture either a simple opening at the base of the apertural face of the chamber or subdivided into a series of openings.

Genus ARCHAEDISCUS H. B. Brady, 1873

Test lenticular, unsymmetrical, spirally coiled; segments irregularly constricted and expanded to form chambers; canal system and supplementary skeleton wanting.

Genus AMPHISTEGINA d'Orbigny, 1826

Plate 13, fig. 4

Test spiral, lenticular, more convex on one side than the other, the last-formed volution usually covering the others, chambers with the alar projections on one side simple, divided on the other side by deep constrictions to form supplementary lobes; wall thickened near the umbilicus, usually smooth except near the aperture on the ventral side where it is usually papillose, no true secondary canal system developed; aperture on the ventral side at the base of the chamber, simple.

Genus OPERCULINA d'Orbigny, 1826

Plate 13, fig. 5

Test coiled, compressed, consisting of numerous chambers in three or four volutions, bilaterally symmetrical, and all visible from either side, not embracing, except in the early whorls, in face view very thin, usually thickest at the umbonal region; surface smooth or ornamented with bosses; aperture single at the base of the apertural wall of the chamber.

Genus HETEROSTEGINA d' Orbigny, 1826

Plate 13, fig. 6

Test compressed, especially the last-formed whorl, the early whorls often embracing and fairly thick, lenticular in side view; chambers numerous, subdivided into chamberlets by transverse partitions and visible from the exterior; secondary canal system developed and comparable to *Operculina;* aperture consisting of a row of pores on the outer face of the chamber, one pore for each of the chamberlets.

Genus NUMMULITES Lamarck, 1801

Test coiled, biconvex, usually bilaterally symmetrical, composed of numerous volutions. The chambers numerous and extending to the umbo, each volution completely inclosing the preceding ones, the periphery often keeled, aperture a simple V-shaped opening at the base of the apertural face of the chamber.

Genus OPERCULINELLA Yabe, 1918

Test in early development lenticular and close coiled, later developing an alar projection, supplementary skeleton and canal system well developed.

Subfamily 4. CYCLOCLYPEINAE

Test flat with a thickened center, or lens-shaped, with two sets of chambers, equatorial, forming a central plane of the test and lateral, piled in columns at either side; test strengthened by solid pillars extending from the equatorial band to the surface; septæ double with internal canals.

Genus ORBITOIDES d'Orbigny, 1847

Test discoidal, equatorial chambers diamond-shaped.

Genus ORTHOPHRAGMINA Munier-Chalmas

Plate 16, fig. 6

Test discoidal or stellate, equatorial chambers rectangular.

Genus LEPIDOCYCLINA Gümbel, 1868

Plate 16, figs. 4, 5

Test discoidal, equatorial chambers typically hexagonal.

Genus MIOGYPSINA Sacco 1893

Test irregularly discoidal, equatorial chambers rounded.

Genus CYCLOCLYPEUS Carpenter, 1856

Test thin, compressed, discoidal, usually of a single layer of chambers, centrally thickened, chambers rectangular.

Family 10. MILIOLIDAE

Test typically calcareous, imperforate except in the very early stages of certain genera, porcellanous; sometimes the exterior with arenaceous covering, but always on an imperforate calcareous base, aperture typically with a tooth variously modified in different genera.

Subfamily 1. CORNUSPIRININAE

Test usually free, the early stages composed of a proloculum and elongate, coiled second chamber, later chambers typically planospiral, of various lengths in typical chambers of the included genera.

Genus CORNUSPIRA Schultze, 1854

Plate 12, fig. 6

Test consisting of a proloculum followed by a long coiled tubular chamber, typically without septæ, complanate, the open end serving as the aperture, occasionally somewhat constricted or with a thickened lip, wall porcellanous.

Genus OPTHALMIDIUM Zwingli and Kübler, 1870

Plate 14, fig. 1

Test in general planospiral, compressed, all chambers visible from the exterior on both sides, proloculum globular, followed by a coiled second chamber making usually two or more coils, the following chambers gradually decreasing in relative length, more or less loose coiled, the intermediate area filled in with a shelly plate; aperture at the end of the chamber, rounded, without lip or teeth.

Genus SPIROLOCULINA d'Orbigny, 1826

Plate 14, fig. 2

Test composed of chambers arranged planospirally, all visible typically from opposite sides of the test, early chambers after the proloculum sometimes a coil or more in length, but the adult chambers one-half coil in length; aperture typically somewhat produced; aperture circular, with a prominent lip and a bifid tooth occasionally, with a secondary tooth directly opposite the primary one.

Genus PLANISPIRINA Seguenza, 1880

Test planospiral, chambers in the later growth often more or less involute, concealing the early development, which consists of an oval proloculum, followed by the typical *Cornuspira*-like second chamber, in turn followed by several chambers gradually becoming shorter, those of the adult being less than a half coil in length, usually three or four necessary to make a complete coil.

Genus Vertebralina d'Orbigny, 1826

Plate 14, fig. 3

Test with the early chambers planospiral, at least from external appearances, later ones becoming rectilinear; wall porcellanous, imperforate, usually ornamented by striations or costæ; aperture a long narrow slit either at the outer end of the chamber or somewhat laterally placed; typically with a definite lip.

Genus NODOBACULARIA Rhumbler, 1895

Plate 14, fig. 4

Test composed of a proloculum and second *Cornuspira*-like chamber, usually directly followed by a linear series of subcylindrical chambers; test imperforate, calcareous.

Genus NUBECULARIA Defrance, 1825

Plate 14, fig. 5

Test typically coiled, planospiral, free or attached, consisting of an oval proloculum and second *Cornuspira*-like chamber of variable length, followed by several chambers irregular in shape and arrangement, but usually more or less distinctly planospiral, apertures one or more, irregularly arranged, wall smooth, roughened, or with incorporated sand grains.

Subfamily 2. QUINQUELOCULININAE

Test in the adult or in the early development of the test, at least in the microspheric form with the chambers a half coil in length and added in planes 144° from one another, five planes being necessary to complete a cycle before a new chamber is added directly above one of the previous ones, aperture at this stage at least alternately at opposite poles of the test.

Genus QUINQUELOCULINA d'Orbigny, 1826

Plate 14, fig. 6

Test in the young with the usually oval proloculum and short, *Cornuspira*-like second chamber, followed by the adult character both in the microspheric and megalospheric forms of the species. This adult character consists of chambers a half coil in length added successively in planes 144° apart, five chambers being thus added before a cycle is completed and a new chamber added in the plane of the fifth preceding chamber and covering it exteriorly. The chambers are thus 72° from one another, but each as added is 144° from its immediately preceding one in the series; aperture typically elongate with a simple tooth and with little or no elongation of the neck except in certain of the more complex species.

Genus MASSILINA Schlumberger, 1893

Plate 14, fig. 7

Test composed of a globular proloculum followed by a *Cornuspira*-like chamber, making a half coil, these in turn followed by a series of quinqueloculine chambers, in the adult composed of chambers arranged like *Spiroloculina* in a single plane, leaving the center open and the chambers a half coil in length.

Genus ARTICULINA d'Orbigny, 1826

Plate 14, fig. 8

Early chambers usually quinqueloculine or triloculine, later ones in a uniserial arrangement, varying considerably in number according to the species; aperture in the adult a rounded, usually elliptical opening, in a depression with a definite phialine lip.

Genus SIGMOILINA Schlumberger, 1887

Plate 14, fig. 9

Test in its early stages quinqueloculine, later developing chambers a half coil in length in two series, with each newly added chamber in a plane more than 180° from the previous one, so that the horizontal plane in section shows a gradual turning about the elongate axis of the test, aperture typically with a single, simple tooth.

Genus HAUERINA d'Orbigny, 1848

Plate 15, fig. 1

Test compressed with the early chambers milioline, the later and greater portion of the test having the chambers arranged in a plano-spiral manner, usually in the last-formed coil at least with more than two chambers in each whorl, surface smooth or ornamented; aperture of a large number of small pores forming a sieve-like plate, usually much longer than wide.

Genus TRILOCULINA d'Orbigny, 1826

Plate 15, fig. 2

Test in its adult development consisting, as seen from the exterior, of three visible chambers added in planes 120° from one another, the third of each series added in the plane of the third preceding and covering it.

Genus ADELOSINA d'Orbigny, 1826

Test in its early portion consisting of a large, laterally compressed proloculum, followed by a second chamber making a complete coil and covering the exterior of the proloculum, later chambers making a half coil, variously ornamented, most frequently with longitudinal costæ.

Genus BILOCULINA d'Orbigny, 1826

Plate 15, fig. 3

Test in the adult, composed of chambers one-half coil in length, in planes 180° from one another, only the two chambers last formed visible from the exterior; aperture usually broader than long, typically with a bifid tooth.

Genus FABULARIA Defrance, 1820

Like Biloculina but the chambers with secondary divisions, aperture cribrate.

Genus NEVILLINA Sidebottom, 1905

Plate 15, figs. 4, 5

Test free, elongate, more or less pyriform, circular in transverse section, the final single chamber completely embracing the previous one; aperture circular, complex, formed by numerous incurved lamellæ, meeting centrally.

Genus IDALINA Schlumberger and Munier-Chalmas, 1884

Test subglobular, early stages as in Biloculina, final chamber covers all previous ones; aperture cribrate.

Genus PENEROPLIS Montfort, 1808

Plate 15, fig. 6

Test planospiral, at least in the early stages, whole test lenticular, thick or much compressed, circular, crosier-shaped or cylindrical; surface smooth or the chambers longitudinally striate; chambers entire, not subdivided as in the following genera; aperture in the complanate forms consisting of a linear series of pores on the apertural face, in the less compressed forms an irregularly arranged series of pores and in the more or less uncoiled forms often becoming dendritic.

Genus ORBICULINA Lamarck, 1816

Plate 16, figs. 2, 3

Test planospiral, at least in its early stages, the chambers numerous, and in the later stages, at least, subdivided into chamberlets, the early chambers in all forms extending over the early test to the umbilical region, making a completely involute test in the early stages, later chambers may continue the completely involute character, or may become annuli or build a crosier-shaped test, wall usually pitted, sometimes smooth; aperture in the adult usually consisting of a double row of small circular openings usually opposite, along the median portion of the apertural face of the test.

Genus ORBITOLITES Lamarck, 1801

Plate 16, fig. 1

Test typically discoidal, the early chambers, in the microspheric form at least, following the proloculum and *Cornuspira*-like second chamber, arranged in a gradually widening spiral, followed by chambers extending in length and becoming annuli; chambers divided into chamberlets, each with one or more apertures on the rim of the test.

Genus CRATERITES Heron-Allen and Earland, 1924

Test apparently sessile or becoming free, with a basal layer of a nubecularine mass of chambers without spiral arrangement, arising from which is a thick trunk, nearly circular in section, composed of superimposed rings of chamberlets, orbitoline in appearance but without marginal pores; test widest near the top, the upper surface with a thin, highly convex apertural surface, entirely covered with close perforations forming the apertures.

Genus ALVEOLINA d'Orbigny, 1826

Plate 15, figs. 7, 8

Test usually elliptical or fusiform, composed in the adult of elongate chambers, each running the entire length of the test, the apertural face of the last-formed chamber forming the growing edge of the test; chambers divided into chamberlets with small circular apertures upon the apertural face, at least in the larger species; whole test spirally coiled about the elongate axis.

Genus KERAMMOSPHAERA H. B. Brady

Test spherical, chambers more or less irregularly arranged in concentric layers.

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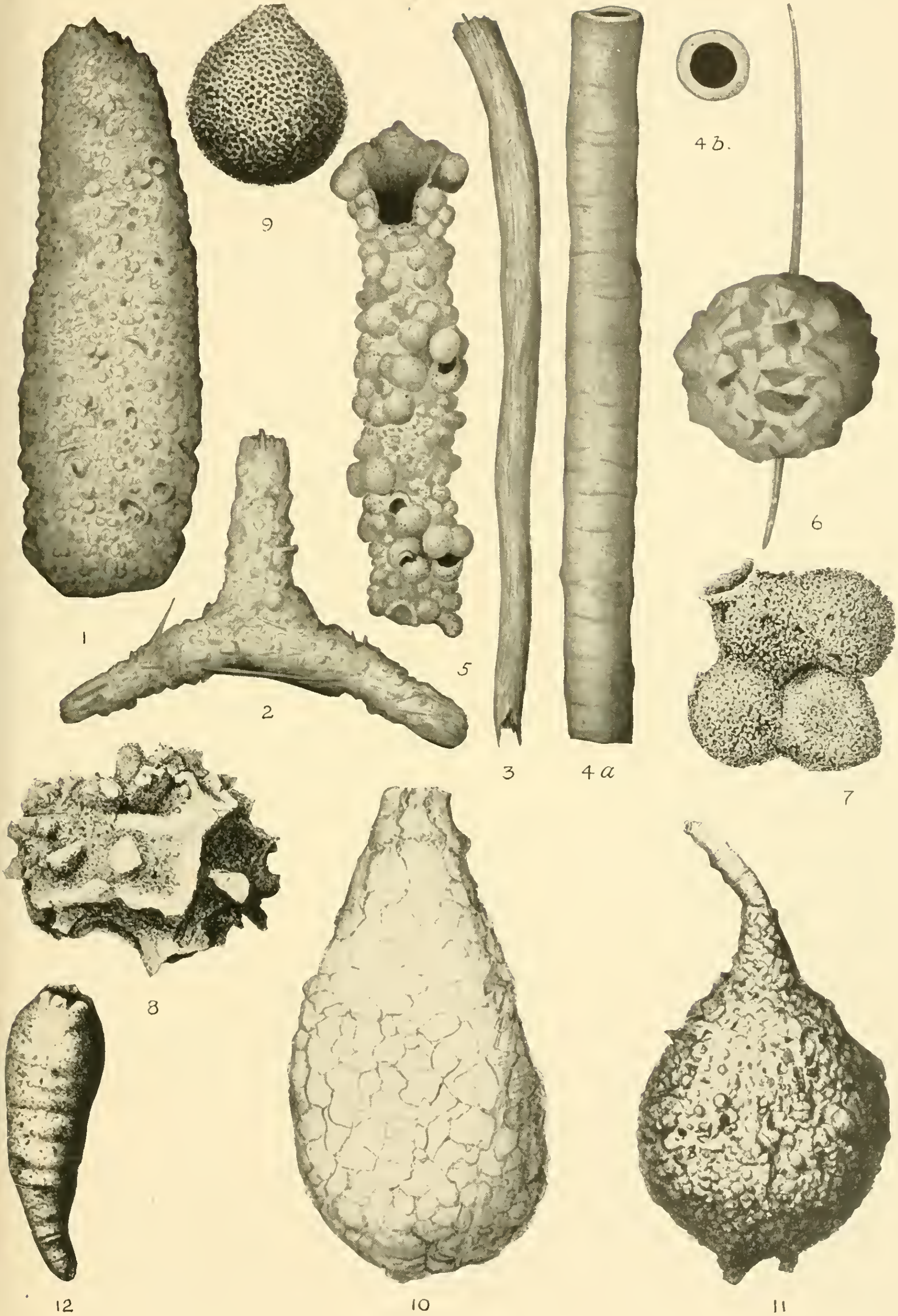
EXPLANATION OF PLATES

PLATE 1

Fig. 1. *Astrorhiza granulosa* (H. B. Brady.) × 13.
2. *Rhabdammina abyssorum* W. B. Carpenter. × 13.
3. *Marsipella gigantea* Cushman. × 7.
4. *Bathysiphon flavidus* de Folin, var. *giganteus* Cushman. × 3. *a*, side view; *b*, end view.
5. *Rhizammina indivisa* H. B. Brady. × 27.
6. *Psammosphaera parva* Flint. × 66.
7. *Sorosphaera confusa* H. B. Brady. × 15. (After Brady.)
8. *Storthosphaera albida* F. E. Schulze. × 20. (After Brady.)
9. *Saccammina sphaerica* G. O. Sars. × 15. (After Brady.)
10. *Proteonina diffugiformis* (H. B. Brady). × 50. (After Rhumbler.)
11. *Pelosina rotundata* H. B. Brady. × 20. (After Brady.)
12. *Hippocrepina indivisa* Parker. × 45. (After Brady.)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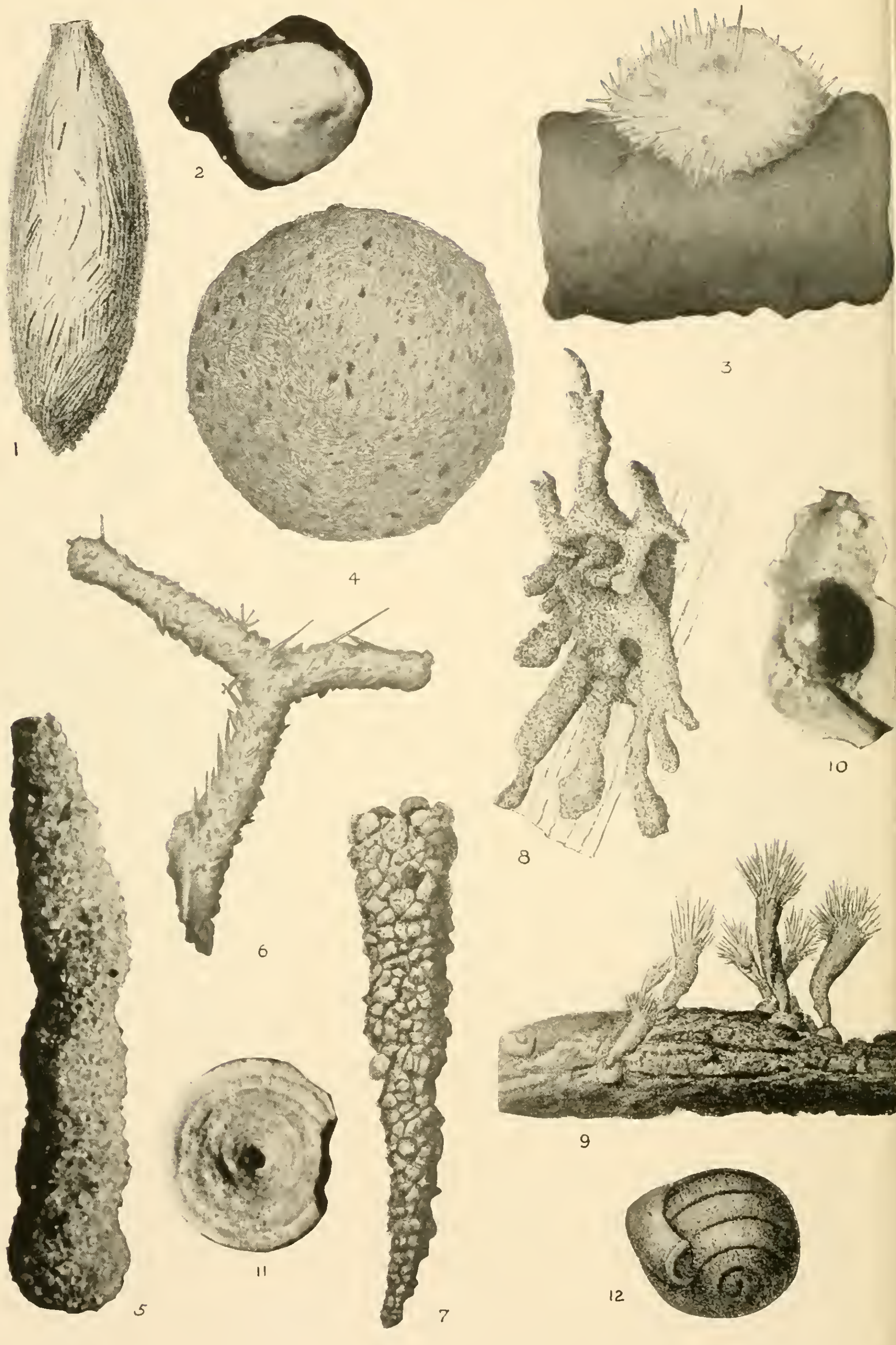
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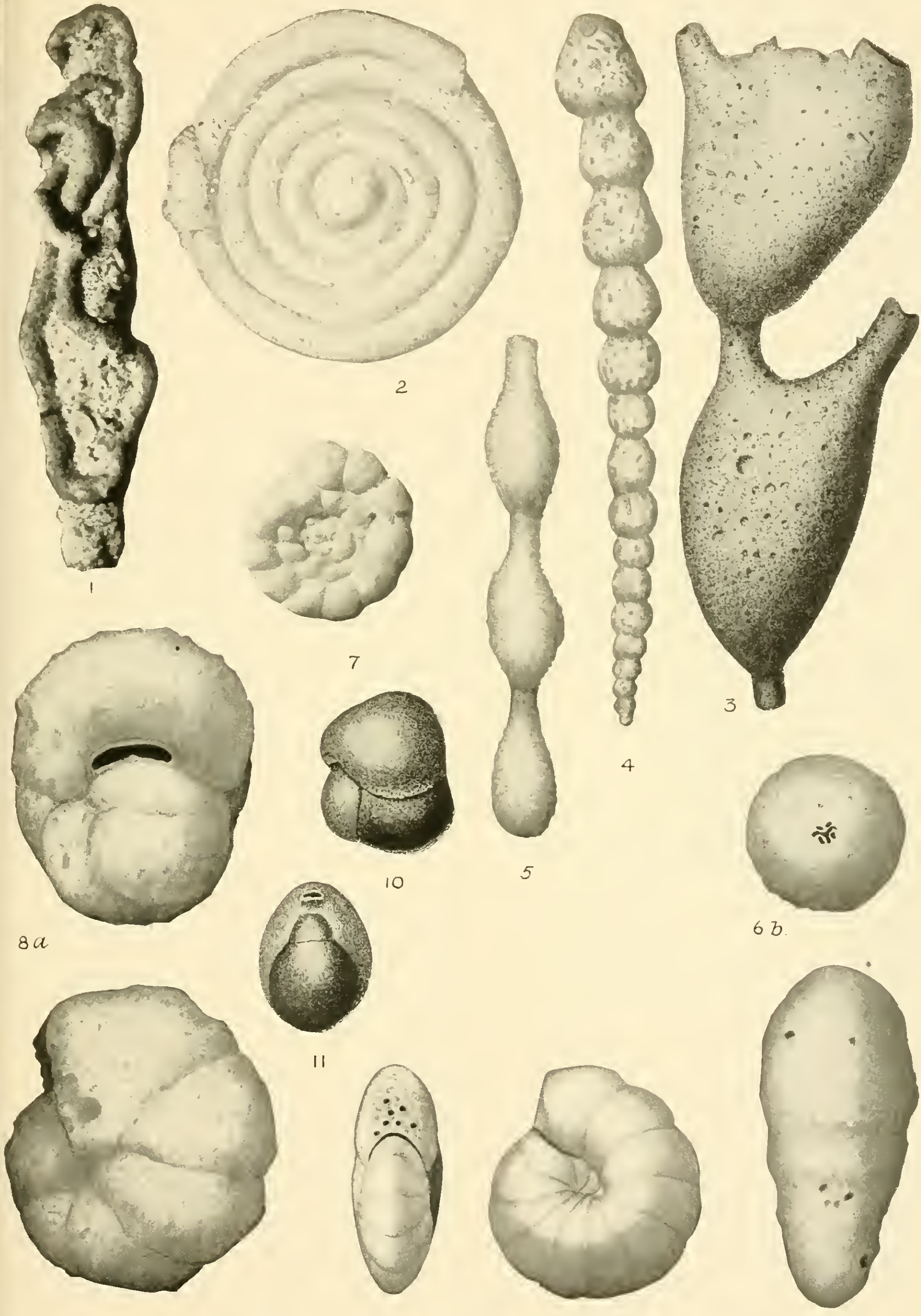
PLATE 2

FIG. 1. *Technitella legumen* Norman. × 50. (After Brady.)

2. *Webbinella hemisphaerica* (Jones, Parker, and H. B. Brady). × 15. Specimen attached to black pebble.
3. *Tholosina bulla* (H. B. Brady). × 33.
4. *Thurammina papyracea* Cushman. × 33.
5. *Hyperammina subnodosa* H. B. Brady. × 15.
6. *Saccorhiza ramosa* (H. B. Brady). × 30.
7. *Jaculella acuta* H. B. Brady. × 12.
8. *Dendrophrya radiata* Str. Wright. × 45. (After Brady.)
9. *Haliphysema tumanowiczii* Bowerbank. × 20. Group of attached specimens. (After Brady.)
10. *Ammolagena clavata* (Parker and Jones). × 30.
11. *Ammodiscoides turbinatus* Cushman. × 15.
12. *Glomospira charoides* (Jones and Parker). × 70. (After Brady.)

PLATE 3

FIG. 1. *Tolypammina vagans* (H. B. Brady). × 30.
2. *Ammodiscus incertus* (d'Orbigny). × 10. Megalospheric form.
3. *Aschemonella catenata* (Norman). × 15. (After Brady.)
4. *Reophax nodulosus* H. B. Brady. × 15.
5. *Hormosina ovicula* H. B. Brady. × 15.
6. *Haplostiche dubia* (d'Orbigny). × 7. *a*, side view; *b*, apertural view.
7. *Trochamminoides proteus* (Karrer). × 20.
8. *Haplophragmoides subglobosum* (G. O. Sars). × 25. *a*, apertural view; *b*, side view.
9. *Cyclammina pauciloculata* Cushman. × 18. *a*, side view; *b*, apertural view.
10, 11. *Ammochilostoma galeata* (H. B. Brady). × 50. (After Brady.) 10, side view; 11, apertural view.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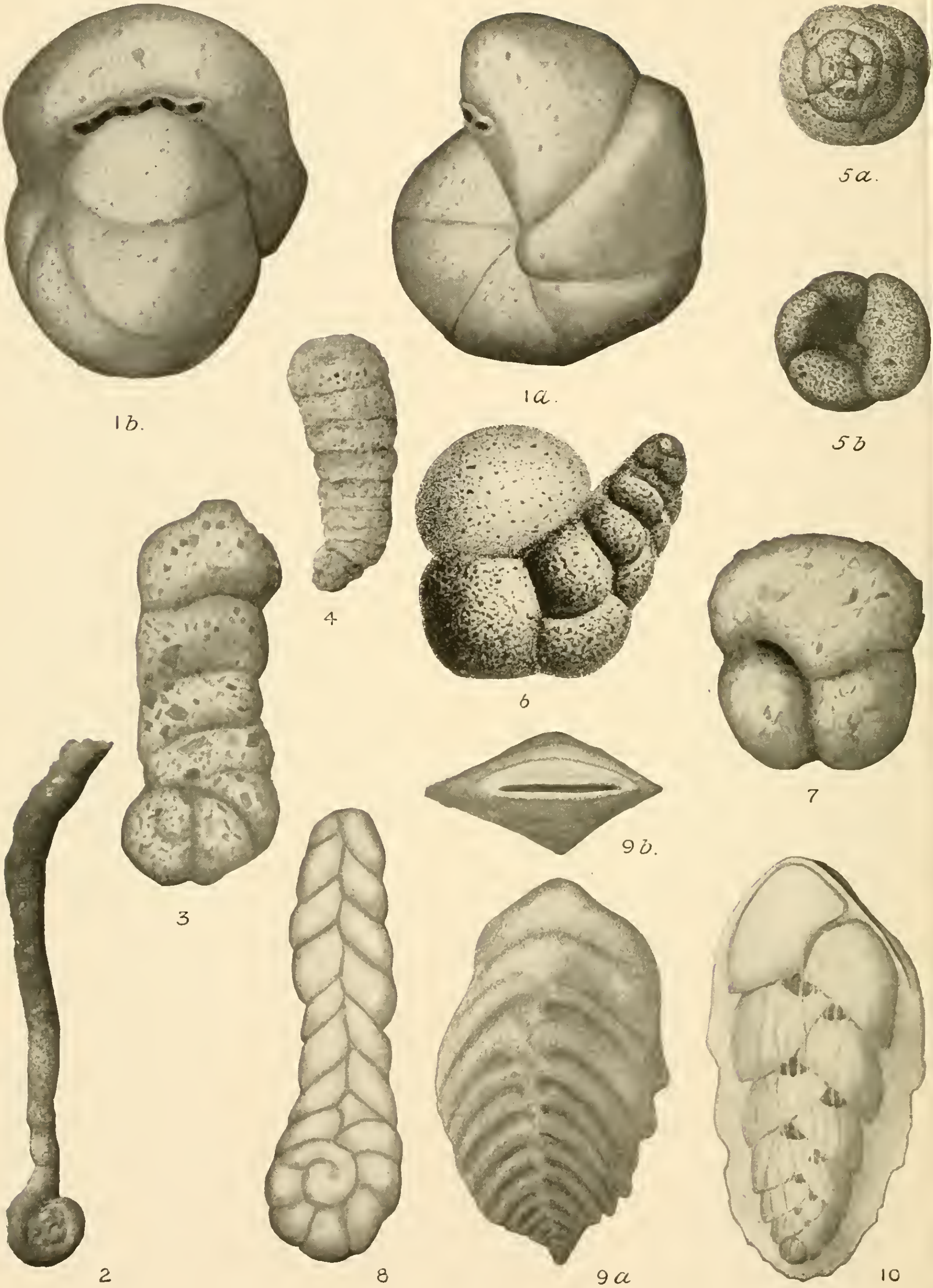
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9b.
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9a
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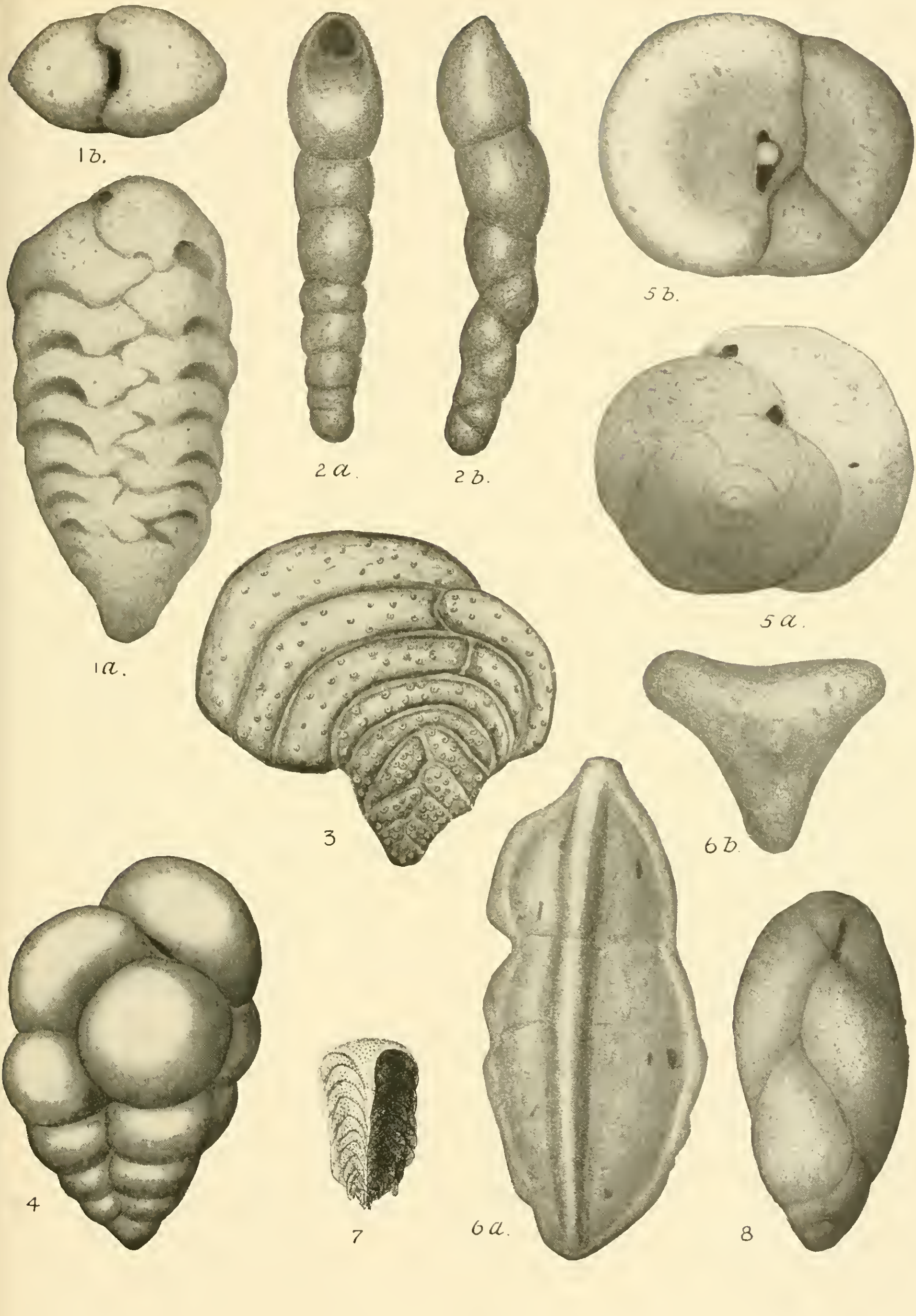
PLATE 4

FIG. 1. *Cribrostomoides bradyi* Cushman. × 25. *a,* side view; *b,* apertural view.
2. *Lituotuba lituiformis* (H. B. Brady). × 20.
3. *Ammobaculites calcareum* (H. B. Brady). × 18.
4. *Lituola mexicana* Cushman. × 15.
5. *Trochammina globulosa* Cushman. × 20. *a,* dorsal view; *b,* ventral view.
6. *Globotextularia anceps* (H. B. Brady). × 20. (After Brady.)
7. *Ammosphaeroidina grandis* Cushman. × 15.
8. *Spiroplecta bulbosa* Cushman. × 85.
9. *Bigenerina capreolus* (d'Orbigny). × 25. *a,* front view; *b,* apertural view.
10. *Bolivina hantkeniana* H. B. Brady. × 35.

PLATE 5

FIG. 1. *Textularia rugosa* (Reuss). × 35. *a,* front view; *b,* apertural view.
2. *Pleurostomella subnodosa* (Reuss). × 75. *a,* front view; *b,* side view.
3. *Pavonina flabelliformis* (d'Orbigny). × 75. Front view.
4. *Verneuilina bradyi* Cushman. × 75.
5. *Valvulina fusca* (Williamson). × 60. *a,* dorsal view; *b,* ventral view.
6. *Tritaxia tricarinata* (Reuss). × 25. *a,* front view; *b,* apertural view.
7. *Chrysalidina dimorpha* H. B. Brady. × 70. Front view. (After Brady.)
8. *Bulimina pupoides* d'Orbigny. × 75.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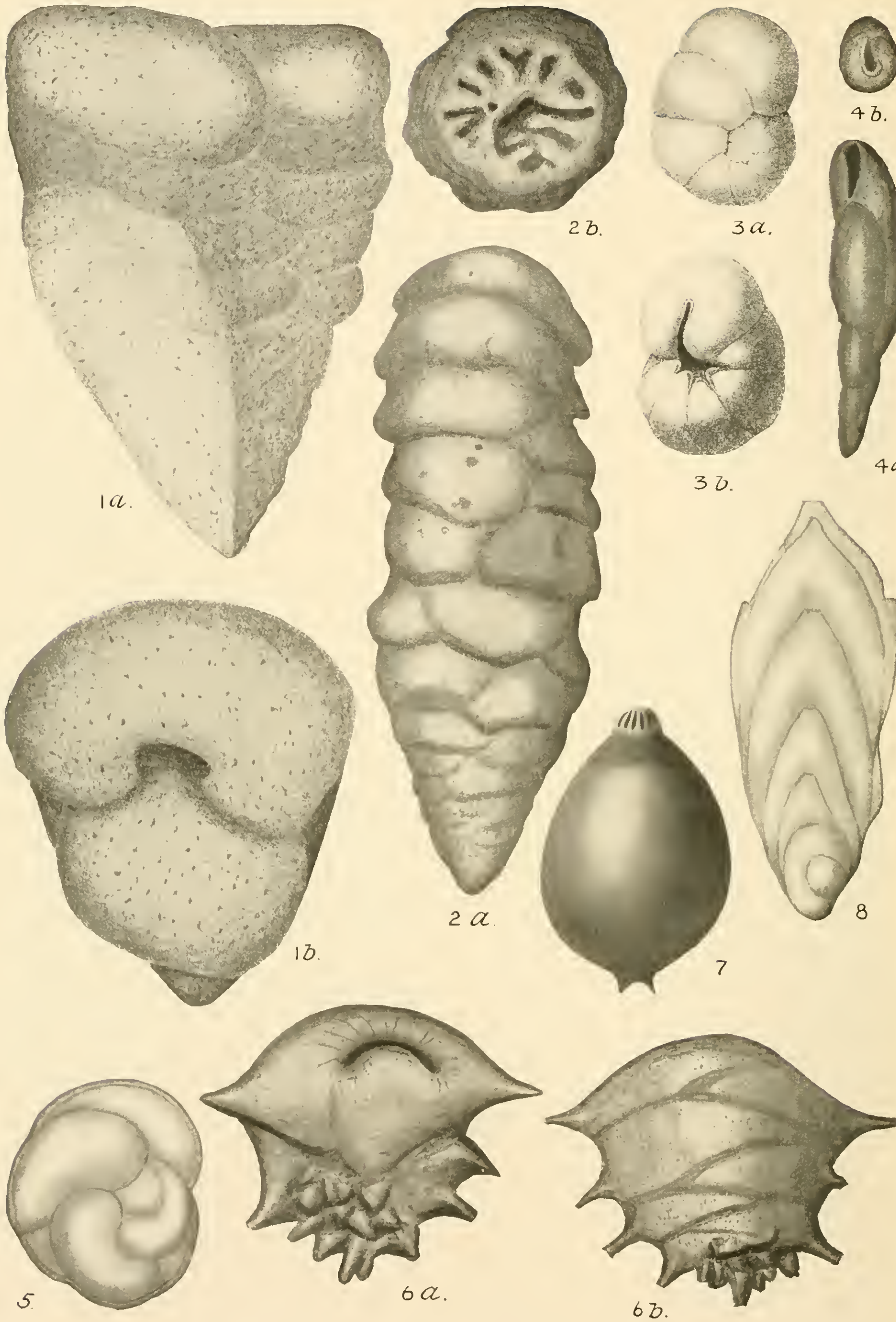
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6a.
6b.
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PLATE 6

FIG. 1. *Gaudryina robusta* Cushman. × 18. *a,* ventral view; *b,* apertural view.

2. *Tritaxilina caperata* (H. B. Brady). × 25. *a,* front view; *b,* apertural view.

3. *Buliminella contraria* (Reuss). × 60. *a,* dorsal view; *b,* ventral view. (After Brady.)

4. *Virgulina schreibersiana* Czjzek. × 60. *a,* apertural view; *b,* front view.

5. *Cassidulina laevigata* d'Orbigny. × 75.

6. *Ehrenbergina hystrix* H. B. Brady. × 40. *a,* ventral view; *b,* dorsal view.

7. *Lagena apiculata* (Reuss). × 33.

8. *Frondicularia inaequalis* Costa. × 66.

PLATE 7

FIG. 1. *Clavulina difformis* (H. B. Brady). × 50. *a,* front view; *b,* apertural view.

2. *Buliminoides williamsoniana* (H. B. Brady). × 60. *a,* apertural view; *b,* front view.

3. *Nodosaria raphanus* (Linnaeus). × 16. *a,* apertural view; *b,* front view.

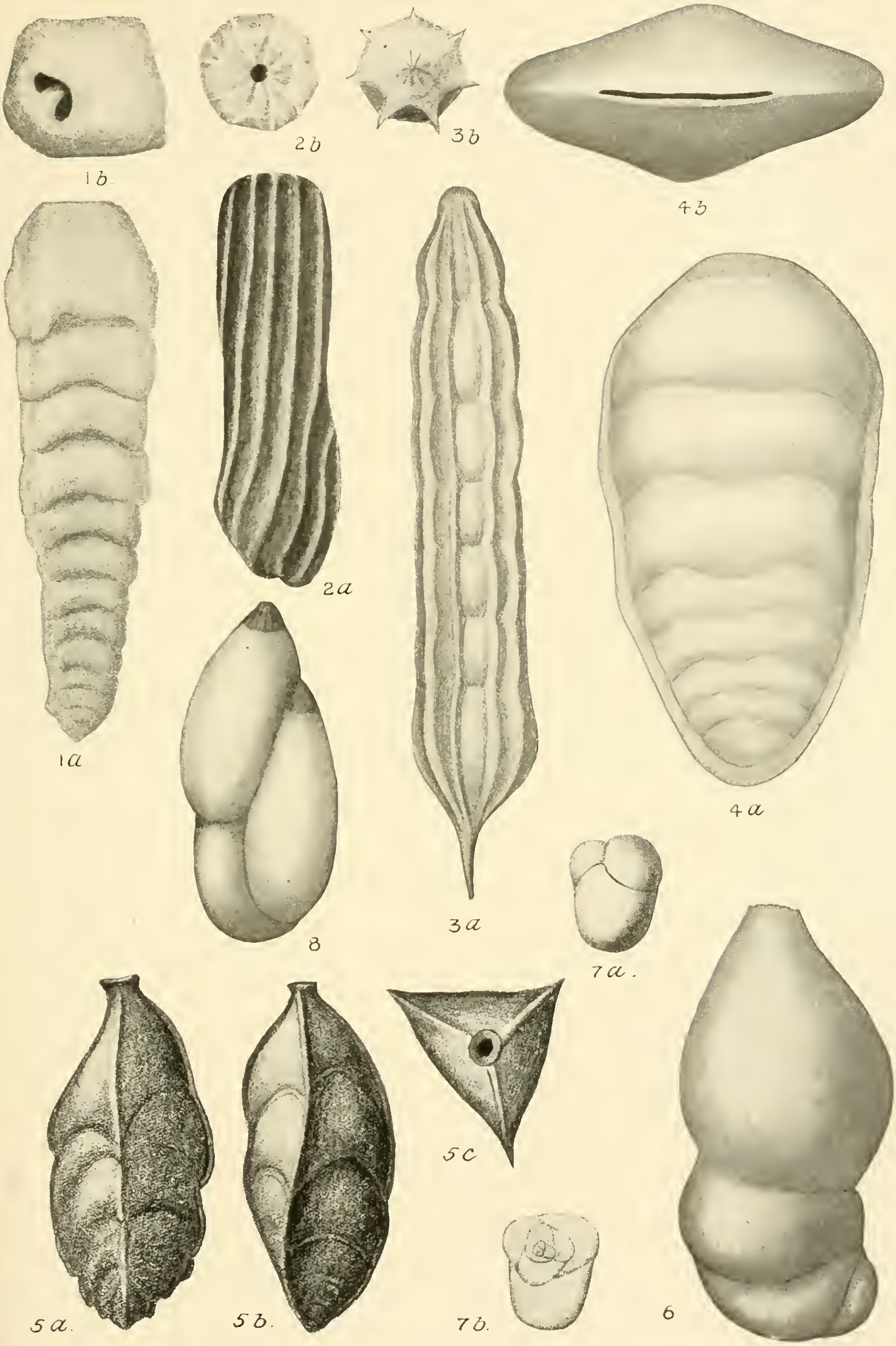
4. *Lingulina grandis* Cushman. *a,* front view, × 12; *b,* apertural view, × 16.

5. *Trifarina bradyi* Cushman. × 80. *a, b,* side view; *c,* apertural view.

6. *Marginulina striatula* Cushman. × 66.

7. *Allomorphina trigona* Reuss. × 60. (After Brady.) *a,* ventral view; *b,* dorsal view.

8. *Polymorphina lactea* (Walker and Jacob), var. *oblonga* Williamson. × 66.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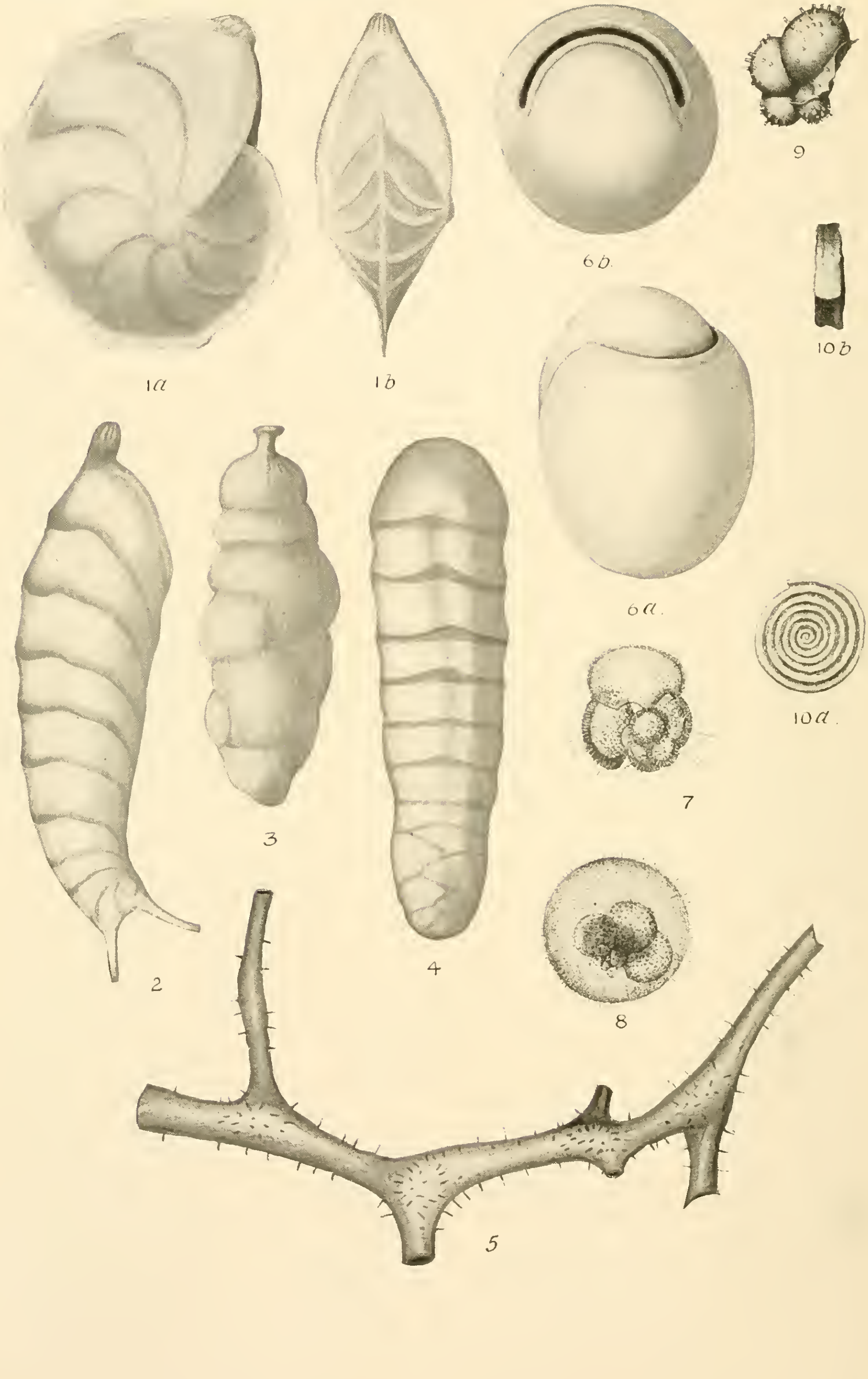
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PLATE 8

Fig. 1. *Cristellaria calcar* (Linnaeus). × 33. *a,* side view; *b,* edge view.
2. *Vaginulina spinigera* H. B. Brady. × 33.
3. *Uvigerina tenuistriata* Reuss. × 66.
4. *Siphogenerina bifrons* (H. B. Brady). × 66.
5. *Ramulina globulifera* H. B. Brady. × 33.
6. *Chilostomella grandis* Cushman. × 20. *a,* side view; *b,* apertural view.
7. *Globigerina conglobata* H. B. Brady. × 50. (After Brady.)
8. *Orbulina universa* d'Orbigny. × 50. (After Brady.) Specimen viewed by transmitted light showing *Globigerina*-like young within.
9. *Hastigerina pelagica* d'Orbigny. × 38. (After Brady.)
10. *Spirillina limbata* H. B. Brady. × 60. *a,* side view; *b,* peripheral view. (After Brady.)

PLATE 9

FIG. 1. *Candeina nitida* d'Orbigny. × 75. *a,* side view; *b,* ventral view.

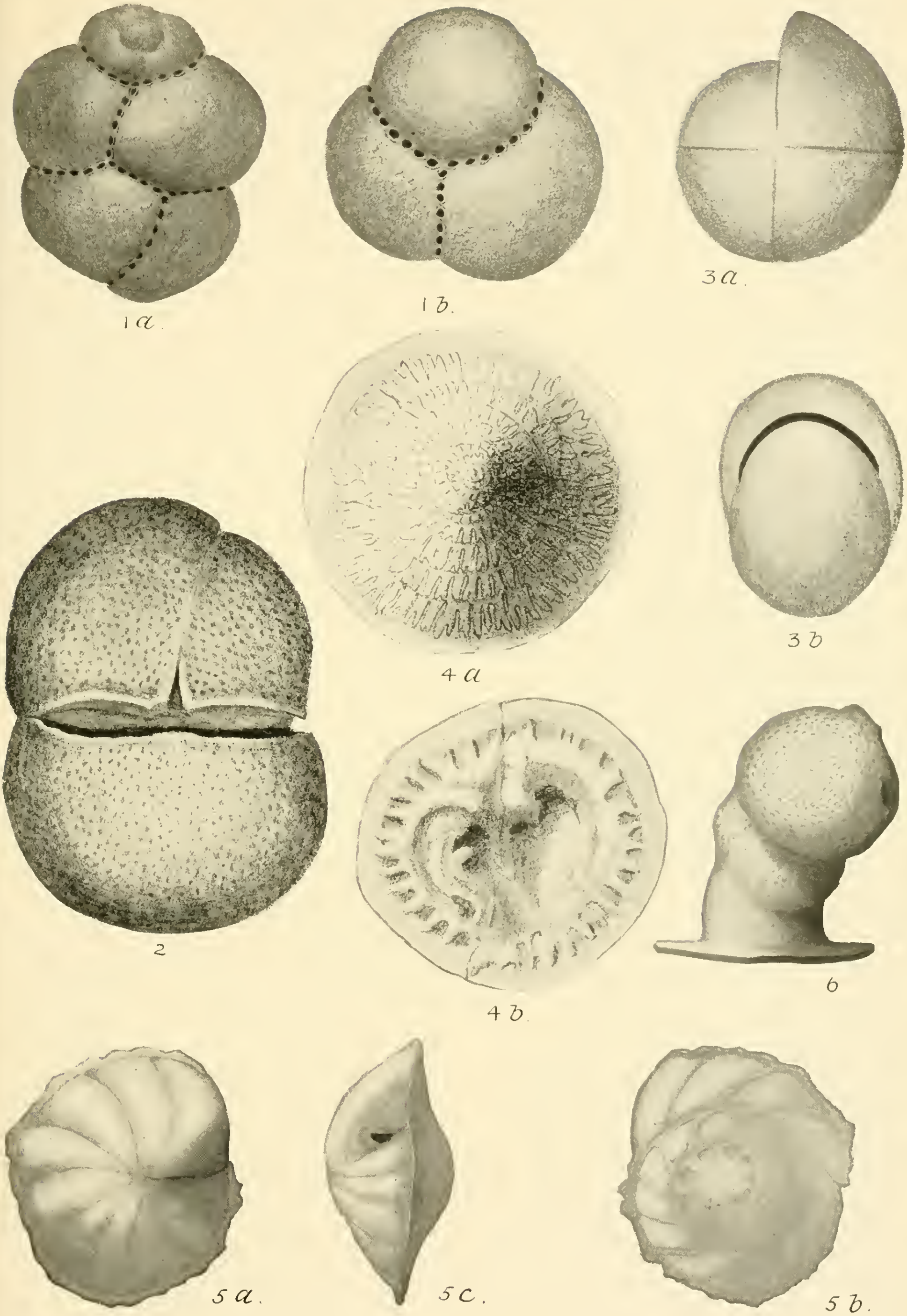
2. *Sphaeroidina dehiscens* Parker and Jones. × 55.

3. *Pullenia sphaeroides* (d'Orbigny). × 75. *a,* side view; *b,* apertural view.

4. *Patellina corrugata* Williamson. × 120. *a,* dorsal view; *b,* ventral view. (After Brady.)

5. *Truncatulina culter* (Parker and Jones). × 66. *a,* ventral view; *b,* dorsal view; *c,* apertural view.

6. *Carpenteria proteiformis* Goës. × 15.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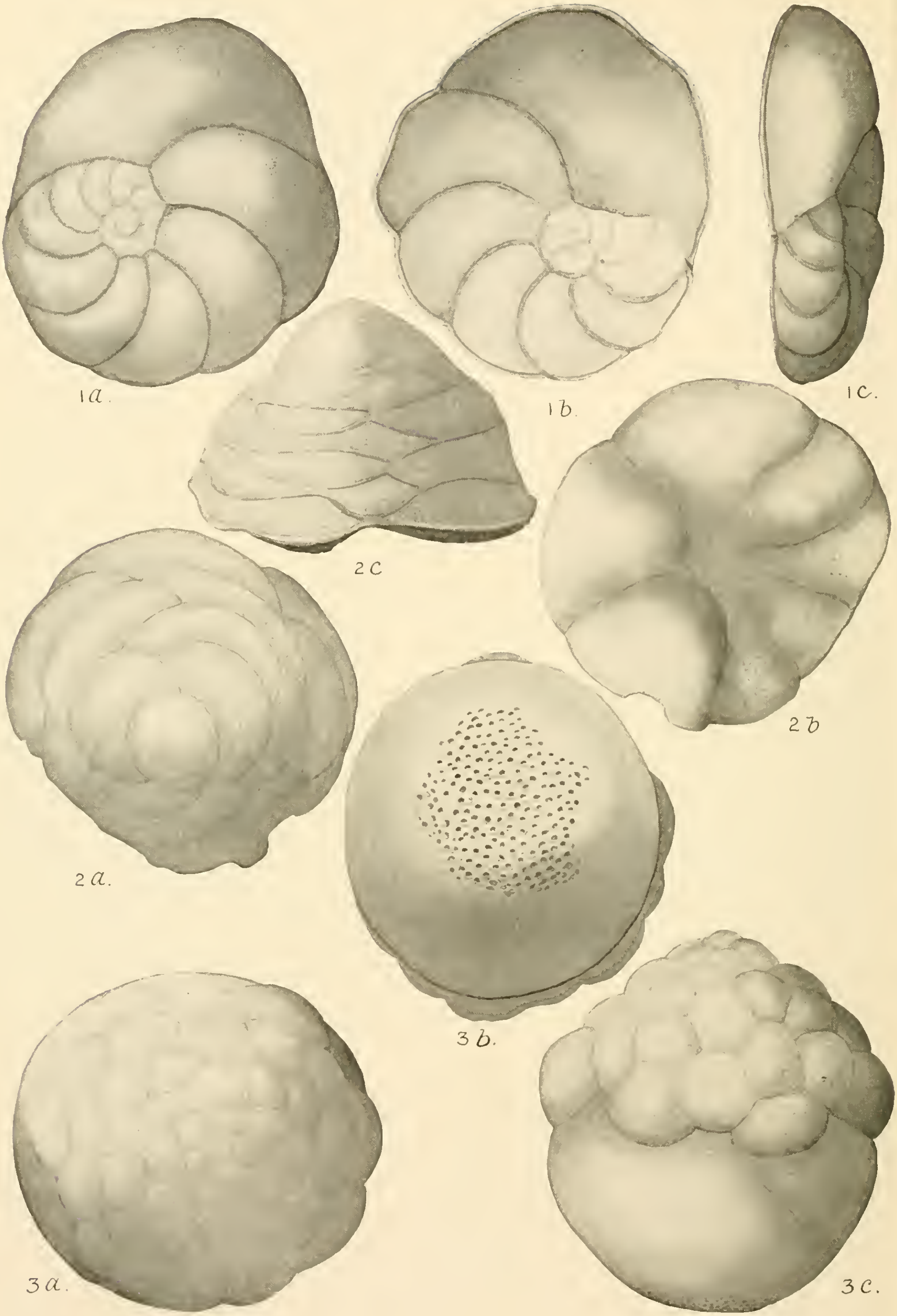
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PLATE 10

Fig. 1. *Discorbis bertheloti* (d'Orbigny). × 25. *a,* dorsal view; *b,* ventral view; *c,* side view.

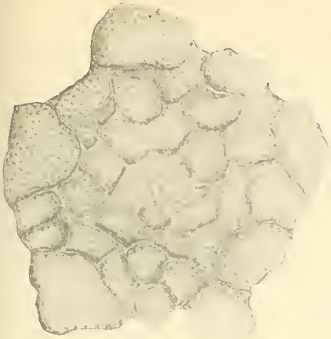
2. *Cymbalopora poeyi* (d'Orbigny). × 50. *a,* dorsal view; *b,* ventral view; *c,* side view.

3. *Tretomphalus bulloides* (d'Orbigny). × 50. *a,* dorsal view; *b,* ventral view; *c,* side view.

PLATE 11

FIG. 1. *Planorbulina mediterranensis* (d'Orbigny). × 75. *a,* dorsal view; *b,* peripheral view.

2. *Rupertia stabilis* Wallich. × 40. (After Brady.)
3. *Rupertia stabilis* Wallich. × 40. (After Brady.) Section.
4. *Anomalina ammonoides* (Reuss). × 66. *a,* ventral view; *b,* dorsal view; *c,* apertural view.
5. *Siphonina reticulata* (Czjzek). × 70. *a,* dorsal view; *b,* ventral view; *c,* side view.



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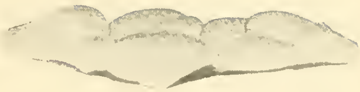

1 b.

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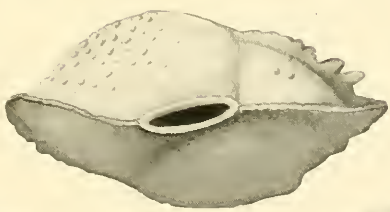
4 a

4 c.

4 b.



5 c.

5 a.

5 b.

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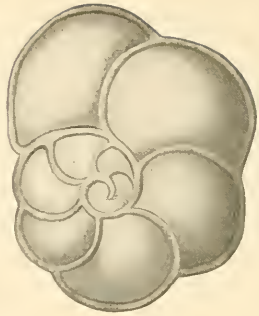

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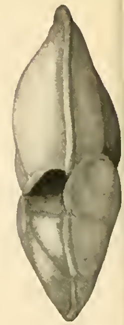
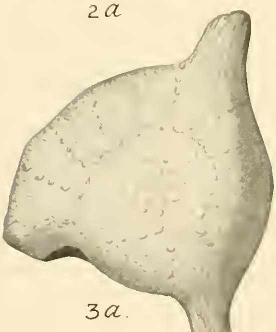


1c.

2a

2c.

2b.



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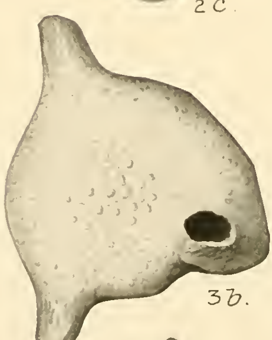

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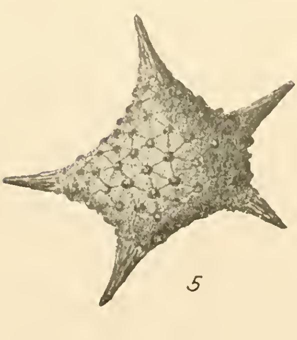

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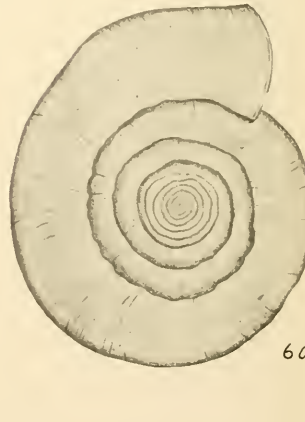
6b.



6a.

PLATE 12

FIG. 1. *Pulvinulina menardii* (d'Orbigny). × 33. *a*, ventral view; *b*, dorsal view; *c*, apertural view.

2. *Rotalia beccarii* (Linnaeus). × 66. *a*, ventral view; *b*, dorsal view; *c*, apertural view.

3. *Calcarina spengleri* (Gmelin). × 30. *a*, dorsal view; *b*, ventral view.

4. *Siderolites tetraedra* (Gümbel). × 15.

5. *Baculogypsina sphaerulatus* (Parker and Jones). × 20.

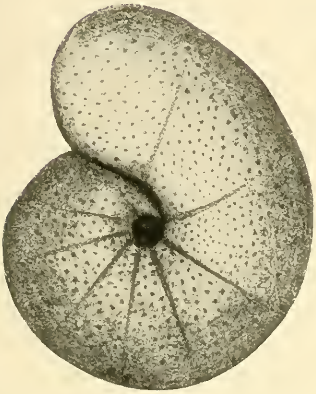
6. *Cornuspira foliacea* (Philippi). × 20. *a*, front view; *b*, apertural view.

PLATE 13

Fig. 1. *Gypsina inhaerens* (Schultze). × 30. (After Brady.)

2. *Nonionina umbilicatula* (Montagu). × 75. *a,* side view; *b,* face view.
3. *Polystomella macella* (Fichtel and Moll). × 66. *a,* side view; *b,* face view.
4. *Amphistegina lessonii* d'Orbigny. × 30.
5. *Operculina bartschi* Cushman, var. *ornata* Cushman. × 10. *a,* side view; *b,* apertural view.
6. *Heterostegina depressa* d'Orbigny, young specimen. × 35.

1



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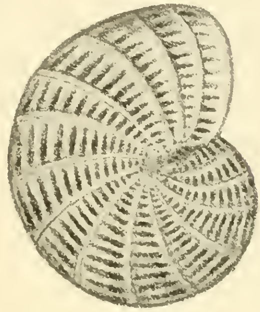

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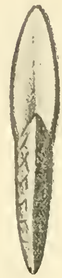

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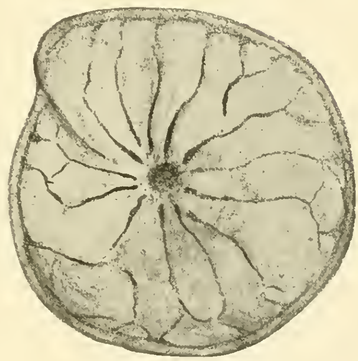

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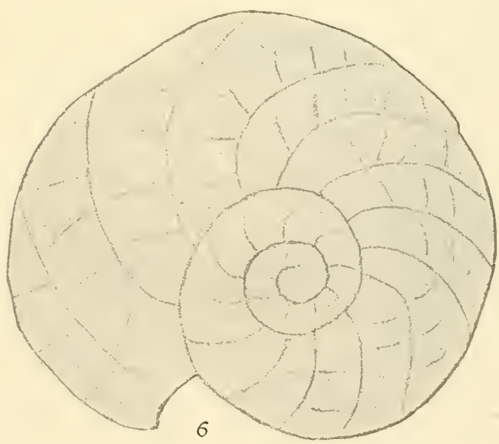

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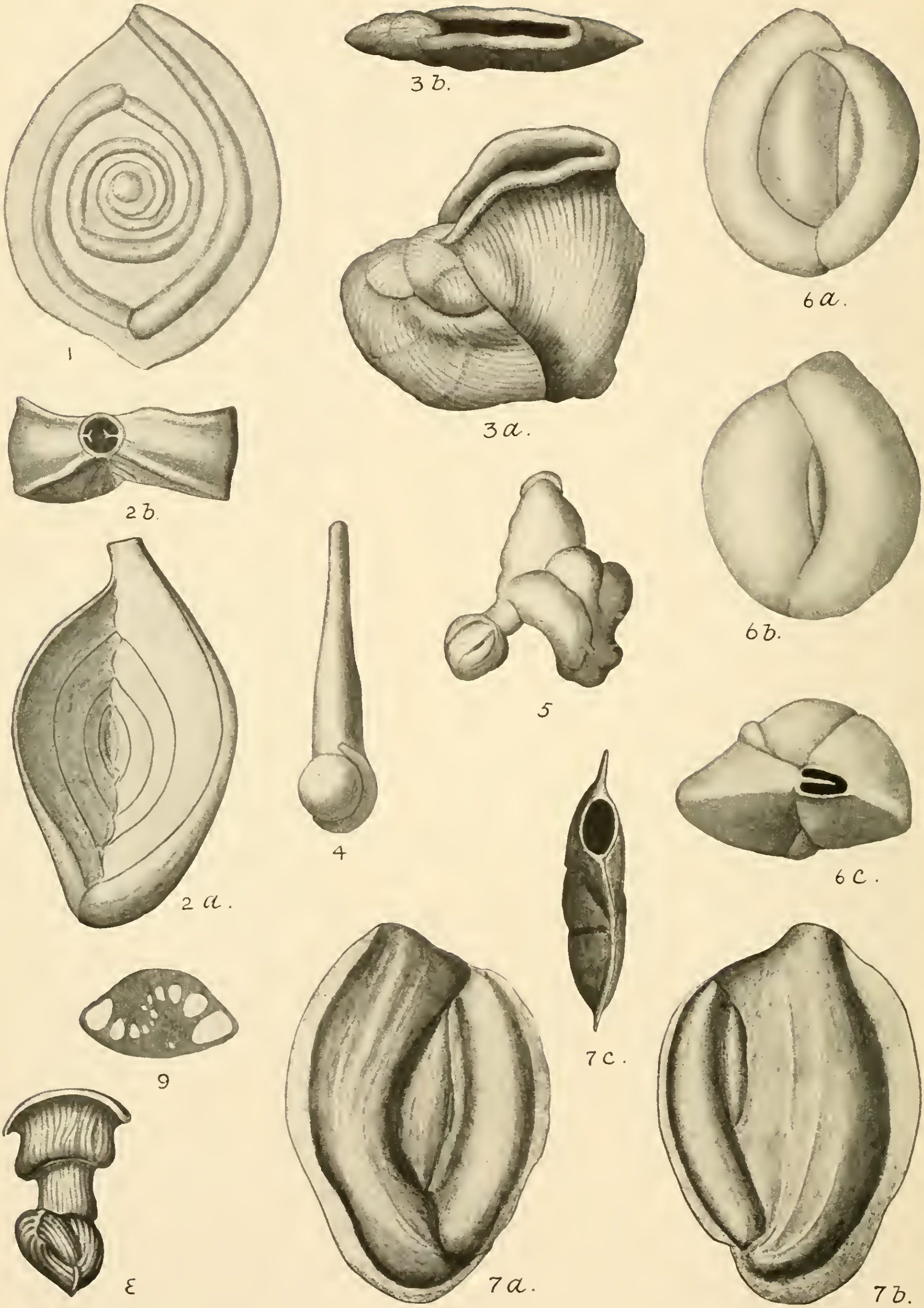
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7 a.
7 b.

PLATE 14

FIG. 1. *Opthalmidium inconstans* (H. B. Brady.) × 65.

2. *Spiroloculina grateloupi* d'Orbigny. × 35. *a,* front view; *b,* apertural view.

3. *Vertebralina striata* d'Orbigny. × 65. *a,* front view; *b,* apertural view.

4. *Nodobacularia tibia* Jones and Parker. × 130. Showing proloculum, second *Cornuspira*-like chamber and the first of the uniserial chambers. (After Rhumbler.)

5. *Nubecularia bradyi* Millett. × 190. (After Rhumbler.)

6. *Quinqueloculina vulgaris* d'Orbigny. × 23. *a,* side view; *b,* opposite view; *c,* apertural view.

7. *Massilina durrandii* Millett. × 20. *a, b,* opposite sides; *c,* apertural view.

8. *Articulina sagra* d'Orbigny. × 35. (After Brady.)

9. *Sigmoilina sigmoidea* (H. B. Brady), section. × 40. (After Brady.)

PLATE 15

Fig. 1. *Hauerina ornatissima* (Karrer). × 65. *a,* front view; *b,* apertural view.

2. *Triloculina oblonga* (Montagu). × 39. *a,* side view; *b,* opposite side; *c,* apertural view.

3. *Biloculina anomala* Schlumberger. × 50. *a,* front view; *b,* side view; *c,* apertural view.

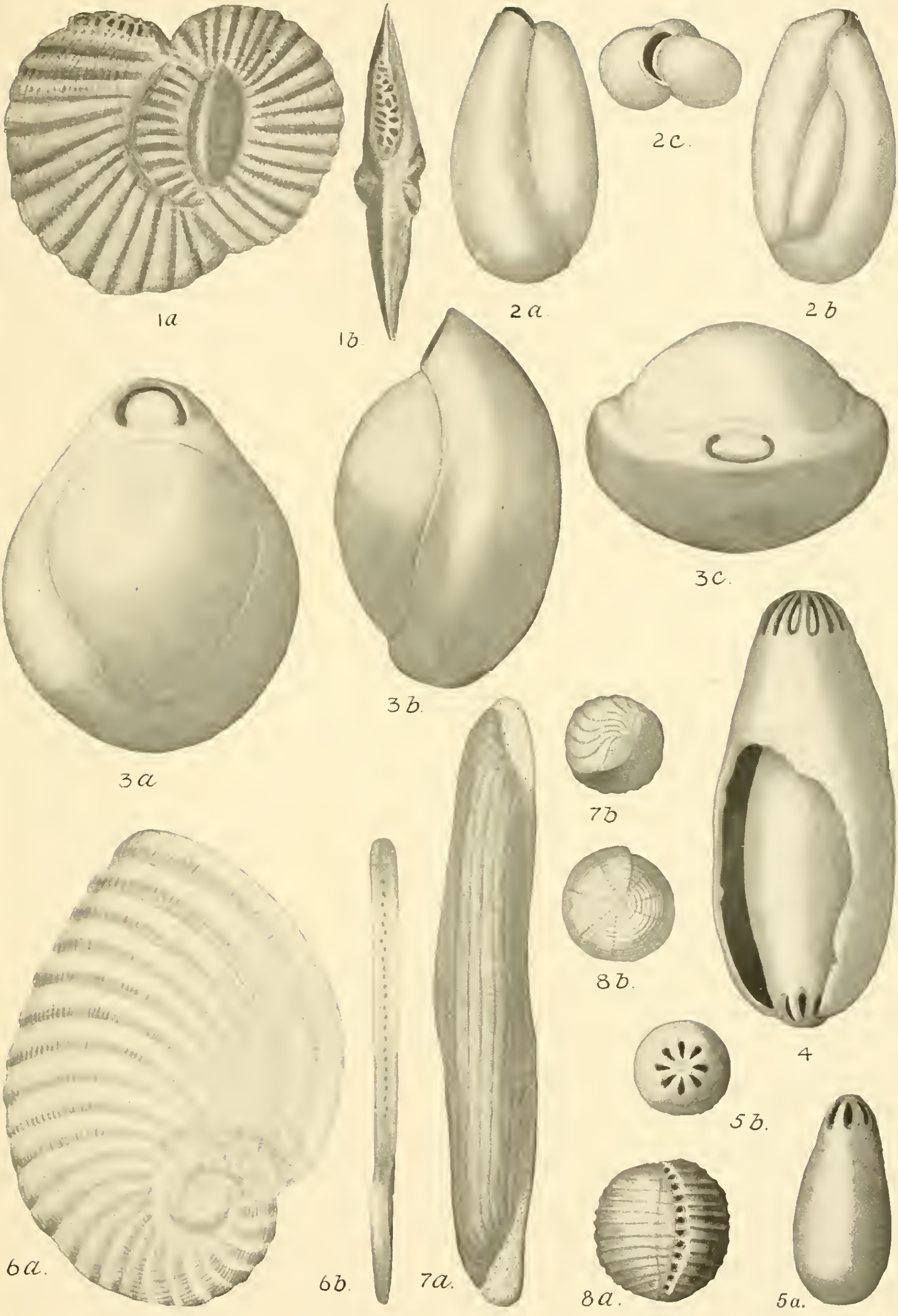
4. *Nevillina coronata* (Millett). × 25. Showing penultimate chamber within.

5. *Nevillina coronata* (Millett). × 25. *a,* front view; *b,* apertural view.

6. *Peneroplis pertusus* (Forskål), var. *planatus* (Fichtel and Moll). × 65. *a,* side view; *b,* apertural view.

7. *Alveolina boscii* (Defrance). × 12. *a,* front view; *b,* end view. (After Brady.)

8. *Alveolina melo* (Fichtel and Moll). × 33. *a,* front view; *b,* end view. (After Brady.)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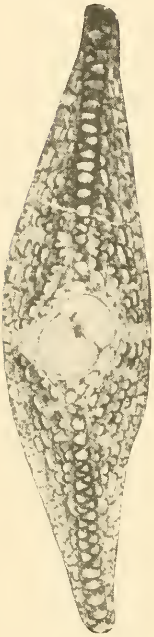

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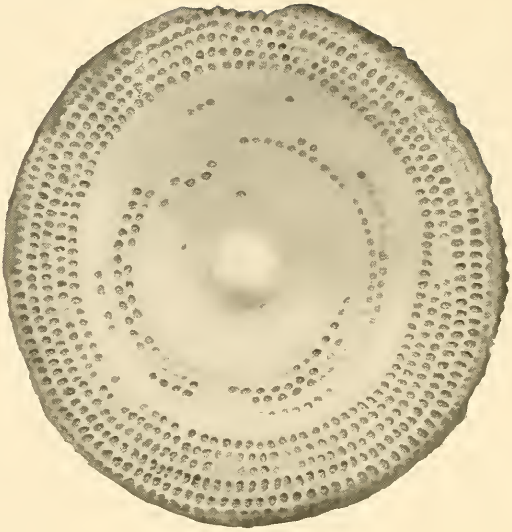

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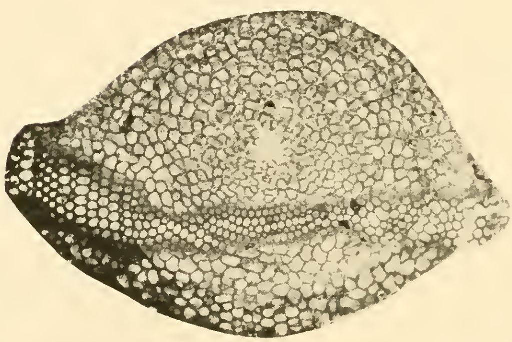

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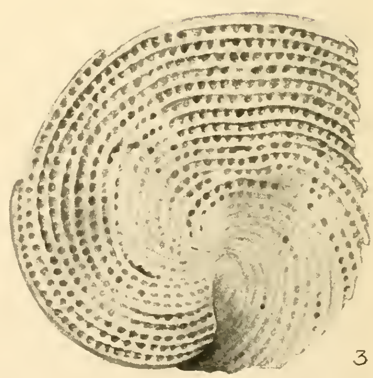

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PLATE 16

FIG. 1. *Orbitolites complanata* Lamarck. × 30. *a*, surface view; *b*, peripheral view.

2. *Orbiculina compressa* d'Orbigny. × 30.
3. *Orbiculina adunca* (Fichtel and Moll). × 30. Showing interior chamber divisions.
4. *Lepidocyclina macdonaldi* Cushman. Vertical section. × 20.
5. *Lepidocyclina canellei* Lemoine and Douvillé. Oblique section. × 20. Showing narrow zone of equatorial chambers and two broader zones of lateral chambers.
6. *Orthophragmina minima* Cushman. Vertical section. × 20.