CONTRIBUTIONS

FROM THE

CUSHMAN LABORATORY

FOR

FORAMINIFERAL RESEARCH

VOLUME 4, PART 1
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CONTENTS

These contributions will be issued quarterly. They will contain short papers with plates, describing new forms and other interesting notes on the general research work on the foraminifera being done on the group by the workers in this laboratory. New literature as it comes to hand will be briefly reviewed.

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CONTRIBUTIONS FROM THE CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

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54. ADDITIONAL GENERA OF THE FORAMINIFERA

By JOSEPH A. CUSHMAN

In working over various collections of material and studying phylogenetic relationships, a number of species have such definite characters and affinities that it seems best to erect new genera for them. They all fit well into the scheme of classification given in Volume 3, part 1 of these Contributions as will be noted under each.

Genus FLABELLAMMINA Cushman, new genus

Genoholotype, *Flabellammina alexanderi* Cushman, new species

Test much compressed, in the early stages close coiled, later developing low broad chambers in an inverted V-shape, the outer margin convex or broadly angled; the microspheric form of the test broad, fan-shaped, the megalospheric form more elongate and narrow; wall arenaceous, of coarse fragments with a large amount of fine material and cement; aperture in the adult terminal, elliptical.

The type species is from the Lower Cretaceous of Texas.

FLABELLAMMINA ALEXANDERI Cushman, new species

Plate 1, figures 3, 4

Test much compressed, periphery rounded, early chambers close coiled, later ones becoming elongate and in the adult with

broad low chambers either an inverted V-shape or broadly curved, the periphery rounded or broadly angled; chambers fairly distinct, often marked by the arrangement of the materials of the test, simple; sutures usually rather indistinct, not depressed; wall arenaceous of coarse calcareous, often elongate fragments with a large proportion of fine material, the whole firmly and smoothly cemented; aperture in the adult in the middle of the outer margin of the terminal face, rounded, elliptical. Length 1-1.65 mm.; breadth 0.65-1.35 mm.; thickness 0.15-0.20 mm.

Holotype, (Cushman Coll. No. 7061) from the Lower Cretaceous, Upper Goodland Formation, from a thick marl seam between two chalky-white limestone ledges at road level, Cragin Knobs, right hand side of Stove-foundry Road going from Fort Worth, and about six miles west of Fort Worth, Texas, collected by C. I. Alexander.

This species discovered by Mr. Alexander and the genus of which it is the genoholotype belong in the family Lituolidae. The closest relative of *Flabellammina* is *Ammobaculites*. *Flabellammina* is to be distinguished by the very greatly compressed form with the chambers spreading and becoming frondicularian in shape.

Genus VENTILABRELLA Cushman, new genus

Genoholotype, *Ventilabrella eggeri* Cushman, new species
Gümbelina (part) of authors.

Test in the early stages biserial, later with an increase in the number of chambers, but all in one plane, spread out in a fan-shape; chambers globular; wall calcareous, perforate, smooth or variously ornamented; aperture in the biserial stage, single, at the base of the inner margin, in the adult two apertures in each chamber, at opposite sides near the base in the median line.

Upper Cretaceous.

VENTILABRELLA EGGERI Cushman, new species

Plate 1, figures 10-12

Test rhomboid or fan-shaped in the adult, in the early stages biserial and in the very early stages of the microspheric form probably planispiral; chambers globular, in a single plane, early

ones biserial, later ones added in series, alternating in position with the preceding ones; sutures distinct, depressed; wall calcareous, perforate, ornamented with broken, longitudinal ridges; aperture in the biserial stage in the inner margin, in the adult two openings, one on either side of the chamber near the base.

The genus *Planoglobulina* Cushman closely resembles this genus, but the early development of the two is different. In Munich, I had the opportunity of studying Egger's collection containing his type and figured specimens, and among them, the species of *Pseudotextularia* and its allies from the Upper Cretaceous. The species of Egger upon which I based the genus *Planoglobulina*, *Gümbelina acervulinoides* Egger, has developed as I stated from a *Pseudotextularia*-like young, the spiral form of the test very apparent in the specimen and not all in one plane, the later chambers finally developing a fan-shaped mass generally in a single plane. The type specimen is here designated as that figured on Pl. xiv, fig. 20 of Egger's work (Abhandl. kon. Akad. Wiss. München, Cl. II, vol. 21, pt. 1, 1899). Such species occur in the Mendez of Mexico, a formation very closely like the Upper Cretaceous of Bavaria, and having most of its species identical with those of that region. This identity becomes very marked as one studies the European material and is much closer than the published figures might seem to indicate. *Planoglobulina* is therefore a genus directly derived from *Pseudotextularia* as is clearly shown in the type species. On the other hand *Ventilabrella* has developed a parallel arrangement of chambers in the adult but a more precise mathematical series and a more rhomboid test and comes directly from *Gümbelina*. Species of *Ventilabrella* occur often in great numbers in certain horizons of the Taylor Marl of Texas.

Genus CORNUSPIROIDES Cushman, new genus

Plate 1, figure 13

Genoholotype, *Cornuspira striolata* H. B. Brady

Cornuspira (part) of authors.

Test in the early stages planispiral, the coils of fairly uniform height, in the adult the height of the coil greatly increasing and no longer truly coiled but spreading out in a fan-shape; interior not divided into chambers; wall calcareous, imperforate, show-

ing distinct lines of growth; aperture in the adult very elongate, on the peripheral margin of the growing edge.

Recent. Cold water of the North Atlantic.

The type figures (H. B. Brady, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, pl. 113, figs. 18, 19) show the very enlarged adult growth, but the figure given here (after Heron-Allen and Earland, Journ. Roy. Micr. Soc., 1913, p. 275, fig. 36) shows even more distinctly the loss of coiling and development of a semicircular growing edge with the two sides of the axis becoming symmetrical. This genus plainly developed from *Cornuspira* and with the next genus probably represents the highest development of this line of imperforate calcareous tests with a coiled beginning and not divided into chambers.

Genus CORNUSPIRELLA Cushman, new genus

Plate 1, figure 14

Genoholotype, *Cornuspira diffusa* Heron-Allen and Earland

Cornuspira (part) of authors.

Test in the early stages planispiral, close coiled, the coils of fairly even diameter, later the height of the coil expanding and in the adult with long branching or flattened peripheral extensions; wall calcareous, imperforate, with depressed lines of growth on the exterior; aperture of the adult elongate, narrow, at the ends of the peripheral portions.

Recent. Eastern North Atlantic.

The figure given here, (Pl. 1, fig. 14) is after the type figure, the only one showing the early stages (Heron-Allen and Earland, Journ. Roy. Micr. Soc., 1913, pl. 12). This genus represents evidently an end development from *Cornuspira.*

Genus CORNUSPIRAMIA Cushman, new genus

Plate 3, figure 1

Genoholotype, *Nubecularia antillarum* Cushman

Nubecularia CUSHMAN, Publ. 311, Carnegie Inst. Washington, 1922, p. 58, text figs. 7, 8 (not Defrance).

Test attached, in the early stages with a proloculum and one or more coils of an undivided tubular chamber about it followed by irregularly branching tubular portions with the base flat-

tened and the upper side arched; wall calcareous, imperforate; apertures formed by the open ends of the tubes.

Recent. Tropical.

This is an attached form modified for its habit of growth which is very rapid, the type species growing and spreading rapidly on the newer portions of the leaves of *Posidonia* in shallow waters. It is allied to *Cornuspira* or *Nubecularia,* but apparently is not divided into chambers.

Genus PATELLINELLA Cushman, new genus

Plate 1, figures 8 *a-c*

Genoholotype, *Textularia inconspicua* H. B. Brady

Textularia (part) of authors (not Defrance).
Discorbis (part) CUSHMAN (not Lamarck).

Test conical, trochoid, chambers in the adult with two making up each whorl; wall calcareous, perforate; aperture on the ventral side, umbilical.

Tertiary and Recent.

The type species has long been a perplexing one. It was originally placed in *Textularia* by Brady and later authors have followed him. In 1911, (Bull. 71, U. S. Nat. Mus., pt. 2, 1911, p. 18), I kept it under *Textularia* as had previous authors, but on page 19, noted that it might belong to *Discorbis.* In 1919, (Proc. U. S. Nat. Mus., vol. 56, p. 626), I placed it under *Discorbis* noting that the material "seems to determine definitely that it should be placed among the Rotaliidae. In some of its markings it resembles *Patellina,* and is here placed under *Discorbis.*" I now have this species from many localities, and a study of the initial stages shows it to be related to *Patellina* with a long second chamber following the proloculum. The species is different from either *Patellina* or *Discorbis,* but related to them. The slightly compressed test and the two chambers making a whorl caused Brady to place it under *Textularia,* but it is definitely a rather primitive genus of the Rotaliidae.

Genus PLANORBULINOIDES Cushman, new genus

Plate 1, figure 5

Genoholotype, *Planorbulina retinaculata* Parker and Jones.

Planorbulina (part) PARKER and JONES (not d'Orbigny), Phil. Trans., 1865, p. 380, pl. 19, fig. 2.

Test attached, in the early stages similar to *Planorbulina,* but the later chambers spreading, becoming elongate and more or less separated to form a net work; apertures in the early stages as in *Planorbulina,* later several on the sides of the chambers, with very short necks.

Recent.

This species represents a specialized development from *Planorbulina,* with an open net work of chambers and an increase in number of the apertures with short tubular necks.

Genus NEOCRIBRELLA Cushman, new genus

Plate 1, figures 6, 7

Genoholotype, *Discorbina globigerinoides* Parker and Jones

Discorbina (part) PARKER and JONES, Phil. Trans., 1865, pp. 385, 421, pl. 19, figs. 7 *a-c.*

Test trochoid but becoming somewhat involute in the later stages; chambers comparatively few, inflated; wall calcareous, perforate; aperture in the adult composed of several small rounded pores in a slight depression of the ventral side of the chamber.

Eocene.

The genotype, *N. globigeriniformis,* was described and figured by Parker and Jones from the Eocene (Lutetian) of Grignon, France. It represents a genus close to *Baggina* and *Cancris.*

Genus EPISTOMELLA Cushman, new genus

Plate 1, figures 9 *a-c*

Genoholotype *Discorbina rimosa* Parker and Jones

Discorbina (part) PARKER and JONES, Phil. Trans., 1865, pp. 385, 421, pl. 19, figs. 6 *a-c.*

Test trochoid, the dorsal side wide with regular chambers, the ventral side with supplementary chambers or alar projections toward the umbilicus which is covered; wall calcareous, finely

perforate; apertures on the ventral side at the periphery of the secondary chambers and supplementary apertures on the dorsal side at the inner edge of the chamber along the suture between it and the preceding chamber, narrow and elongate.

Eocene to Recent.

This represents a peculiar modification related on its ventral side to some species of *Discorbis* and on the dorsal side having supplementary apertures which suggest a relationship with *Epistomina*. Such forms are known from the Eocene of the Paris Basin and apparently migrated to the Indo-Pacific region as did many other constituents of the same fauna.

Genus NORMANINA Cushman, new genus

Genoholotype, *Haliphysema confertum* Norman

Haliphysema (part) NORMAN (not Bowerbank), Ann. Mag. Nat. Hist., ser. 5, vol. 1, 1878, p. 279, pl. 16, figs. 1, 2.

Test consisting of a globular proloculum and small elongate tubular second chamber, individuals gathered together in masses, the tubular portions toward the center of the mass; wall chitinous with agglutinated material on the exterior, of sand grains or other foraminiferal tests; aperture at the end of the tubular chamber.

Recent. Davis Strait in 1,750 fathoms.

This is a very peculiar genus known from the one species and related to *Saccorhiza, Hyperammina* and other genera of the Hyperamminidae.

Genus CYMBALOPORETTA Cushman, new genus

Genoholotype, *Rosalina squammosa* d'Orbigny

Rosalina (part) D'ORBIGNY, in De la Sagra, Hist. Fis. Pol. Nat. Cuba, 1839, "Foraminifères", p. 91, pl. 3, figs. 12-14.

Cymbalopora of authors (not Hagenow).

Discorbina (part) GOËS (not Parker and Jones), 1882.

Test conical, the early chambers trochoid, later ones in annular series separated somewhat from one another along the periphery, with depressions between radiating from the central umbilical area, the next series of chambers placed in these depressions and filling them; wall calcareous, coarsely perforate; aperture in the adult consisting of fine rounded pores along the ventral sides of the chamber.

Late Tertiary and Recent.

In Carpenter's Introduction, 1862, p. 215, the foraminifera of this genus were placed under Hagenow's genus *Cymbalopora* which was erected for a Bryozoan of the Maestrichtian Upper Cretaceous of Maestricht, Holland. The resemblance of the foraminifera to Hagenow's figure is marked until a closer examination is made. Then the apertures of the bryozoan are seen to be grouped in the central portion differently than in the foraminifera, the spire is not a trochoid spiral and other details are not the same. My thanks are due to Dr. R. S. Bassler for sending me material some years ago when this relationship was first questioned and more recently for information in regard to the bryozoan. It is apparently a worn form figured by Hagenow which makes the resemblance more striking than would be apparent from a complete, uneroded specimen. It seems definitely established therefore that the foraminifera of this group do not belong to the Cretaceous genus *Cymbalopora* which is a bryozoan. The name *Cymbaloporetta* is used to keep close to the older name for convenience. The species are known from tropical regions of the present ocean and as fossils in the later Tertiary of the Indo-Pacific. The one record from the Cretaceous, that of Egger, does not belong to this genus. This change of generic name necessitates a change also in the family name and Cymbaloporettidae is substituted for Cymbaloporidae.

Genus AMMOVERTELLA Cushman, new genus

Genoholotype, *Psammophis inversus* Schellwien

Psammophis SCHELLWIEN, Palaeontographica, vol. 44, 1898, p. 266 (not Boie, 1827).

To Dr. Glover M. Allen of the Museum of Comparative Zoology at Cambridge I am indebted for calling my attention to the fact that Schellwien's *Psammophis* is already preoccupied by Boie who in 1827 used the name for a genus of snakes in the family Colubridae. Therefore a new name must be given the foraminiferal genus, and *Ammovertella* is proposed.

55. A NEW GENUS, DEPRATELLA, AND ITS RELATION TO ENDOTHYRA

By YOSHIAKI OZAWA

In the paper on the classification of Fusulinidae, (Journ. Coll. Sci. Imper. Univ. Tokyo, vol. 45, art. 4, 1925) I gave the following remarks on Deprat's *Neofusulinella:* "Judging from his illustrations, the group undoubtedly consists of two types. The one type is represented by *Neofusulinella schwagerinoides, N. praecursor* and *N. lantenoisi* which have the wall and septa more or less uniformly covered with the deposition layers quite similar to those of *Fusulinella,* so that they may be considered as belonging to that genus. The other type is represented by small forms such as *Neofusulinella giraudi, N. minima* and *N. elongata,* which have evidently no internal deposition layers, and their general structure is undoubtedly similar to that of *Fusulina.*"

When J. Deprat erected the new genus *Neofusulinella* he did not give the genotype, and all the species described under *Neofusulinella* in his second memoir on Fusulinidae, as already noted by me, must be included in *Fusulinella.* Therefore *Neofusulinella* becomes a synonym of *Fusulinella.* On the other hand, the second type consisting of species described much later (1915) in Deprat's later paper is distinguished from other genera of Fusulinidae by its very much smaller size, and *Endothyra*-like asymmetrical early volutions, and to this type I formerly proposed to restrict the name of *Neofusulinella.* But it is best to give this type a new name, *Depratella,* the genotype of which is *Neofusulinella giraudi* Deprat.

Depratella might be derived directly from *Endothyra* by being axially elongated and losing the arenaceous nature of test.

The test of *Endothyra* was at first considered by H. B. Brady as being imperforate and to a greater or less degree arenaceous, but later v. Möller observed its perforate character. By the courtesy of Professor S. H. Reynolds of the University of Bristol, I had an opportunity to examine in detail the shell structure of Lower Carboniferous *Endothyra* from the Avon gorge, and I found some forms of *Endothyra* having quite the same texture of test as that of agglutinantia, but in some species the wall

becomes very thin and more or less loses its arenaceous texture approaching the shell structure of primitive *Fusulina* and there appears a thin lamella. Some forms of *Endothyra* may have the perforate test, but others are undoubtedly imperforate like *Fusulina*, and there is no doubt but what *Staffella* characterized by a lenticular or nautiloidal test is derived from *Endothyra* by losing the arenaceous character of the test in the Visean time, and *Depratella* comes from *Endothyra* in the Lower Permian.

Depratella is hitherto known only from the Permian rocks of Asia and North America.

EXPLANATION OF PLATE 1

FIGS. 1, 2. *Neobulimina canadensis* Cushman and Wickenden, new species. × 125.
a, front view; *b*, side view; *c*, apertural view.

FIGS. 3, 4. *Flabellammina alexanderi* Cushman, new species. × 35.
b, apertural view.

FIG. 5. *Planorbulinoides retinaculata* (Parker and Jones). × 10. (After type figure.)

FIGS. 6, 7. *Neocribrella globigerinoides* (Parker and Jones). × 15. (After type figures.)
6 *a*, 7, showing apertures.

FIG. 8. *Patellinella inconspicua* (H. B. Brady). × 50. (After type figure.)
a, dorsal view; *b*, ventral view; *c*, peripheral view.

FIG. 9. *Epistomella rimosa* (Parker and Jones). × 15. (After type figures.)
a, dorsal view; *b*, ventral view; *c*, peripheral view.

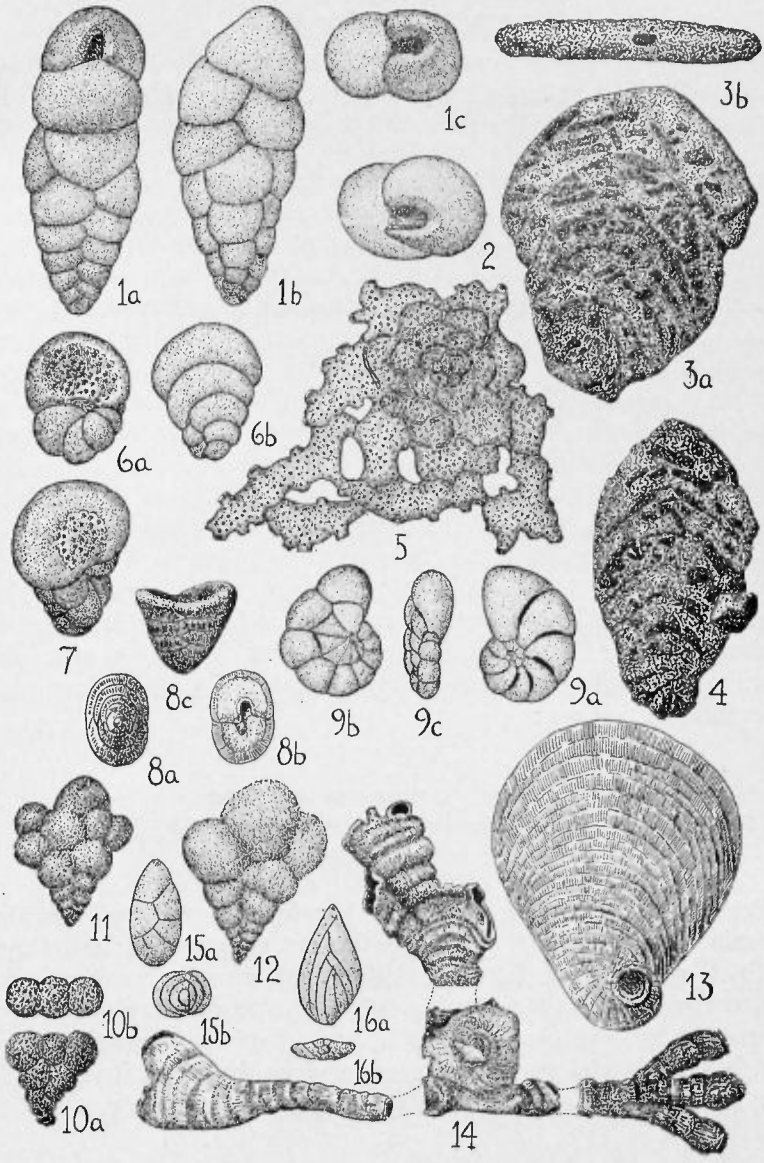
FIGS. 10-12. *Ventilabrella eggeri* Cushman, new species. × 60.
b, end view.

FIG. 13. *Cornuspiroides striolata* (H. B. Brady). × 2. (After Heron-Allen and Earland.)

FIG. 14. *Cornuspirella diffusa* (Heron-Allen and Earland). × 13. (After type figure.)

FIG. 15. *Pseudopolymorphina hanzawai* Cushman and Ozawa, new species.
b, from below.

FIG. 16. *Sigmomorpha (Sigmomorphina) yokoyamai* Cushman and Ozawa, new species.
b, from below.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15a
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16a
16b

56. A NEW FORAMINIFERAL GENUS FROM THE UPPER CRETACEOUS

By J. A. CUSHMAN and R. T. D. WICKENDEN

A study of Upper Cretaceous material from Western Canada has brought to light a number of interesting foraminifera. One of these described here is very clearly related to *Bulimina* but shows additional characters that make it seem worthy of generic distinction. In typical *Bulimina* the entire test is triserial throughout, and the chambers usually inflated, the aperture "comma-shaped" and oblique. In this new genus, the early portion is typically bulimine and triserial with the normal aperture for *Bulimina*. In its adult development, this new generic form becomes definitely biserial. The aperture of the biserial portion is more open than that of *Bulimina*, and the oblique character is largely lost, the long axis of the aperture being nearly at right angles to the base of the chamber. Both microspheric and megalospheric specimens show this character. The triserial portion is not greatly reduced as in *Virgulina* and its derivatives, nor is the test compressed as in that genus, the chambers remaining inflated throughout. The genus may be described as follows:

Genus NEOBULIMINA Cushman and Wickenden, new genus

Genoholotype, *Neobulimina canadensis* Cushman and Wickenden, new species

Test in the early stages of both microspheric and megalospheric forms triserial, later biserial, not compressed; chambers distinct, subglobular, inflated throughout, simple; wall calcareous, perforate; aperture in the triserial stage elongate, oblique, narrowest near the base of the chamber, widest near the inner end, in the biserial stage much less oblique, broader, its elongate axis nearly at right angles to the base of the chamber.

NEOBULIMINA CANADENSIS Cushman and Wickenden, new species

Plate 1, figures 1, 2

Test elongate, fusiform, greatest width near the middle, tapering slightly toward either end, about 2½ times as long as wide in adult specimens, early triserial stage of 12 to 18 chambers, the biserial adult stage of 4 to 6 chambers, each part making about one half the mass of the test; chambers distinct, subglobular, inflated; sutures very distinct, depressed; wall calcareous, coarsely perforate, in some of the thicker-walled specimens appearing almost reticulate, no other surface ornamentation; aperture in the early triserial portion, oblique and "comma-shaped" in the adult biserial stage broader, the portion at the basal edge of the chamber broad and the elongate axis nearly at right angles to the margin of the chamber; the whole aperture in the adult at the base of a distinct depression. Length 0.30 mm.; breadth 0.13 mm.; breadth of biserial portion 0.12 mm.; thickness 0.9 mm.

Holotype (National Museum of Canada) from the Upper Cretaceous of Alberta from Imperial Ribstone Well at a depth of 360-370 feet located in Land Subdivision 6, Section 6, Township 45, Range I W, 4th meridian.

This genus is to be looked for in the Upper Cretaceous of the general deposition southward into Texas as many of the species of this Canadian Cretaceous range far to the southward.

(Published by permission of W. H. Collins, Director of The Geological Survey of Canada.)

57. AN OUTLINE OF A REVISION OF THE POLYMORPHINIDAE

By JOSEPH A. CUSHMAN and YOSHIAKI OZAWA

During a study at this Laboratory of a large accumulation of material of the Polymorphinidae together with a large collection from Japan, the authors prepared two papers which have not yet been published. These will be published shortly in Japan. Meanwhile as the publication has been delayed for some months, it has been thought best to make available at least in outline

form the scheme of classification worked out for the Polymorphinidae. More detailed information and numerous other figures will soon be available in the papers referred to above.

As the study progressed, it was apparent that there is no such simple problem as has been represented by the previous classification of the family but that development has taken place along a number of lines. The early fossil records as well as later forms seem to show that the earliest development is of spirally sigmoid forms about an elongate axis. Such primitive forms probably arose from coiled forms of the Lagenidae. Brady in the *Challenger* Report, gives a figure, (Pl. 71, fig. 10) in which the early chambers of the specimens are coiled as in *Lenticulina* or *Vaginulina* with the last chamber appearing in an entirely different position. The base of this chamber extends backward and if this were followed by other chambers of similar character, the structure seen in the simpler form of the Polymorphinidae would result. The primitive spiral structure may well have arisen in some such manner. An outline of the classification follows:

FAMILY POLYMORPHINIDAE

Test spiral or sigmoid in the earlier stages, later in some genera becoming biserial, uniserial, or irregularly branching; chambers simple, not labyrinthic; wall calcareous, very finely perforate; aperture radiate except in the more degenerate genera where there is a simple rounded opening.

SUBFAMILY 1. POLYMORPHININAE

Test with the chambers in a closed spiral or sigmoid series at least in the early stages, later becoming in some genera biserial or uniserial.

Genus GUTTULINA d'Orbigny, 1826

Genotype, by designation, *Polymorphina (Guttulina) communis* d'Orbigny

Guttulina D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 266 (as a subgenus of *Polymorphina).*

Polymorphina (part) of authors (not d'Orbigny), s. str.

Test rounded, spherical to fusiform; chambers sphaeroidal to ellipsodial or clavate, not at all compressed, arranged more or

less in an elongate spiral series so that they form generally a clockwise close sigmoid series viewed from the base, successive chambers added in planes less than 180°, three or four chambers in a cycle; sutures distinct; aperture radiate.

Jurassic to Recent.

The following three subgenera may be distinguished by the sutures and form.

Guttulina s. str. having much depressed sutures.

Pyrulina d'Orbigny, Ann. Sci. Nat., vol. 7, 1826, p. 267, (subgenotype, monotypic, *Polymorphina (Pyrulina) gutta* d'Orbigny) characterized by an elongated test and non-depressed sutures.

Globulina d'Orbigny, Ann. Sci. Nat., vol. 7, 1826, p. 266 (subgenotype, by designation, *Polymorphina (Globulina) gibba* d'Orbigny) characterized by a generally globular test and non-depressed sutures.

GUTTULINA ORIENTALIS Cushman and Ozawa, new species

Plate 2, figure 1

Test broadly fusiform, greatest breadth usually slightly below the middle, base broadly rounded; chambers arranged in a closed sigmoid series, each succeeding chamber further from the base; chambers few, usually four in megalospheric form, distinct, inflated, periphery rounded, slightly longer than broad; suture only slightly depressed, very distinct; wall smooth, polished, thick but transparent; aperture radiate. Length of type specimen: 1.42 mm., breadth 0.83 mm., thickness 0.69 mm.

Holotype (Geological Institute, Imperial University of Tokyo, Japan) from the Upper Pliocene of Sawane, Island of Sado.

Genus PSEUDOPOLYMORPHINA Cushman and Ozawa, new genus

Genoholotype, *Pseudopolymorphina hanzawai* Cushman and Ozawa, new species

Polymorphina (part) of authors.

Test elongate, often somewhat compressed; chambers rounded, generally as long as broad, arranged in a closed sigmoid series in the earlier stages, becoming biserial in the adult; sutures distinct, depressed; aperture radiate.

Jurassic to Recent.

PSEUDOPOLYMORPHINA HANZAWAI Cushman and Ozawa, new species

Plate 1, figure 15.

Test large, about twice as long as broad, the later portion somewhat depressed and tending to become biserial in the last chambers, greatest breadth above the middle, broadly rounded at the base; chambers numerous, only slightly longer than broad, arranged in an elongate closed sigmoid series becoming biserial; sutures distinct, but very slightly depressed; wall thick, smooth, translucent; aperture radiate, terminal. Length of holotype 2.4 mm.; breadth 1.26 mm.; thickness 0.85 mm.

Holotype (Geological Institute, Imperial University of Tokyo, Japan) from Sawane, Island of Sado.

Pliocene.

Genus PYRULINELLA Cushman and Ozawa, new genus

Genoholotype, *Polymorphina lanceolata* Reuss

Polymorphina (part) of authors.

Test fusiform or cylindrical; chambers rounded in the earlier *Guttulina* stage but often elongate in the later biserial stage; the arrangement of the chambers sometimes tending to become uniserial; sutures distinct, not depressed.

Jurassic to Recent.

Genus DIMORPHINA d'Orbigny, 1826

Genoholotype, *Dimorphina tuberosa* d'Orbigny

Dimorphina D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 264.

Test cylindrical; chambers rounded, arranged at first in a closed sigmoid series, becoming uniserial in the adult; sutures distinct, depressed.

Cretaceous to Recent.

Genus POLYMORPHINA d'Orbigny, 1826

Genotype, by designation, *Polymorphina burdigalensis* d'Orbigny

Polymorphina D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 265.

Test generally compressed, elliptical in side view, often much elongated; chambers cylindrical or much compressed, arranged in a clockwise sigmoid series at least in the early stages of the

microspheric form, later becoming biserial in the microspheric form or entirely so in the megalospheric; sutures depressed or not, often limbate.

Genus SIGMOMORPHA Cushman and Ozawa, new genus

Genoholotype, *Sigmomorpha sadoensis* Cushman and Ozawa, new species

Polymorphina (part) of authors.

Test flattened, oval to subelliptical in side view; chambers elongate, angular in transverse section, arranged at first like *Guttulina*, then open sigmoidal; sutures distinct, depressed.

This genus may be divided into two subgenera:

Sigmomorpha s. str.

Rounded chambers arranged in a more or less closed sigmoid series, and five or six chambers of each series complete one cycle.

Sigmomorphina CUSHMAN and OZAWA, new subgenus.

(Subgenotype, *Sigmomorphina yokoyamai* CUSHMAN and OZAWA, new species.)

Chambers much compressed, triangular in section and the successive chambers added in planes of more than 180°, often much twisted.

SIGMOMORPHA SADOENSIS Cushman and Ozawa, new species

Plate 2, figure 11

Test more or less rhomboid, greatest breadth usually below the middle, generally triangular in end view; chambers numerous, elongate, two to three times as long as broad, varying considerably in the amount of the overlapping, some of the specimens being almost involute, others with the chambers considerably above the base and the last formed chamber in the adult often not reaching back more than half way to the base of the test; chambers arranged in the young in a close, contra-clockwise, sigmoid manner becoming somewhat open in the adult; sutures depressed, distinct; wall thick but translucent, often almost transparent, smooth; aperture terminal, radiate. Length of holotype, 0.83 mm., breadth 0.50 mm., thickness 0.36 mm.

Holotype (Geological Institute, Imperial University of Tokyo, Japan) from Sawane, Island of Sado where it is very abundant.

SIGMOMORPHA (SIGMOMORPHINA) YOKOYAMAI Cushman and Ozawa, new species

Plate 1, figure 16

Test ovate, greatest breadth toward base, tapering toward the apertural end, periphery sharply angled and carinate in the adult; chambers comparatively few in the megalospheric form, more numerous in the microspheric; chambers elongated and very narrow, arranged in an open sigmoid series and added so that the axis of each chamber is somewhat oblique giving a peculiar twisted appearance to the test; sutures distinct, very slightly depressed; wall thin, transparent, with longitudinal costae which are continuations from the ridges of the radiate apertures of each chamber, in some specimens with additional costae covering the entire surface; aperture radiate, terminal, somewhat produced into a cylindrical neck. Length 0.93 mm. and breadth 0.50 mm.

Holotype (Geological Institute, Imperial University of Tokyo, Japan) from Sawane, Island of Sado.

Genus SIGMOIDELLA Cushman and Ozawa, new genus

Genoholotype, *Sigmoidella kagaensis* Cushman and Ozawa, new species

Polymorphina (part) of authors.

Test ovate to elliptical in side view, compressed; chambers elongate, angular, regularly arranged in open sigmoid series, gradually increasing in length in the later ones which include the earlier ones, but often the adult chambers not reaching the base; sutures distinct.

The following two subgenera may be distinguished.

Sigmoidella s. str.

Having much compressed chambers arranged in planes more than 180° from one another similar to *Sigmoilina* in the Miliolidae.

Sigmoidina CUSHMAN and OZAWA, new subgenus.

Subgenoholotype, *Sigmoidella (Sigmoidina) pacifica* CUSHMAN and OZAWA, new species.

Having rather rounded chambers arranged in a sigmoid series, added successively in planes 180° apart, five or six chambers completing a cycle.

SIGMOIDELLA KAGAENSIS Cushman and Ozawa, new species
Plate 2, figure 14

Test broadly ovate, base very broadly rounded, apertural end somewhat tapering, sides nearly parallel for more than half the length, compressed, periphery subacute; chambers elongate, narrow, five or six times as long as broad, arranged in an open clockwise sigmoid form, resulting in a test in which when viewed from either side, one elongate chamber appears at the left and all other visible chambers are in a series of gradually increasing length on its right, and involute; sutures very distinct, curved, not depressed, except on the growing edge which is depressed; wall smooth, translucent; aperture terminal, radiate. Length of the figured specimen 1.5 mm., breadth 0.70 mm., and thickness 0.34 mm.

Holotype (Geological Institute, Imperial University of Tokyo, Japan) from Okuwa in Province Kaga.

SIGMOIDELLA (SIGMOIDINA) PACIFICA Cushman and Ozawa, new species
Plate 2, figure 13

Test small, involute, somewhat compressed, few chambers visible from the exterior, ovate, the greatest breadth below the middle; chambers few, distinct, the last-formed one somewhat angled at the periphery; sutures distinct, very slightly depressed; wall smooth, translucent; aperture radiate, terminal. Length 0.76 mm., breadth 0.53 mm., and thickness 0.31 mm.

Holotype (U. S. National Museum No. 20313) from *Albatross* Station D 5318. China Sea, near Formosa, 340 fathoms.

SUBFAMILY 2. RAMULININAE

Test free or attached, chambers widely separated by stoloniferous connections.

Genus RAMULINA Rupert Jones, 1875

Genotype, by designation, *Ramulina laevis* Rupert Jones

Ramulina RUPERT JONES, in J. Wright, Rept. Proc. Belfast Nat. Field Club, 1873-74, App. III, 1875, p. 88 (90).

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

Jurassic to Recent.

Genus VITRIWEBBINA Chapman, 1892

Genotype, by designation, *Vitriwebbina sollasi* Chapman

Vitriwebbina CHAPMAN, Geol. Mag., dec. 3, vol. 9, 1892, p. 53.

Test attached, consisting of a series of rounded chambers with tubular connections; wall very finely perforate; early chambers sometimes polymorphine.

Cretaceous and Eocene.

The relationships of the different genera and subgenera are shown on the accompanying plate.

EXPLANATION OF PLATE 2

Polymorphinidae

FIG. 1. *Guttulina orientalis* Cushman and Ozawa, new species. From side and base.

FIG. 2. *Guttulina (Pyrulina) gutta* d'Orbigny. (After d'Orbigny.) From side and base.

FIG. 3. *Pyrulinella lanceolata* (Reuss). From side and front.

FIG. 4. *Guttulina (Globulina) gibba* d'Orbigny. (After d'Orbigny.) From side and apertural end.

FIG. 5. *Pseudopolymorphina doanei* (Galloway and Wissler). From side and apertural end.

FIG. 6. *Dimorphina tuberosa* d'Orbigny. (After d'Orbigny.) From side.

FIG. 7. *Vitriwebbina sollasi* Chapman. (After Chapman.)

FIG. 8. *Ramulina globulifera* H. B. Brady. (After H. B. Brady.)

FIG. 9. *Polymorphina charlottensis* Cushman. Megalospheric form. From side and apertural end.

FIG. 10. *Polymorphina burdigalensis* d'Orbigny. (After d'Orbigny's Model.) From two sides and base.

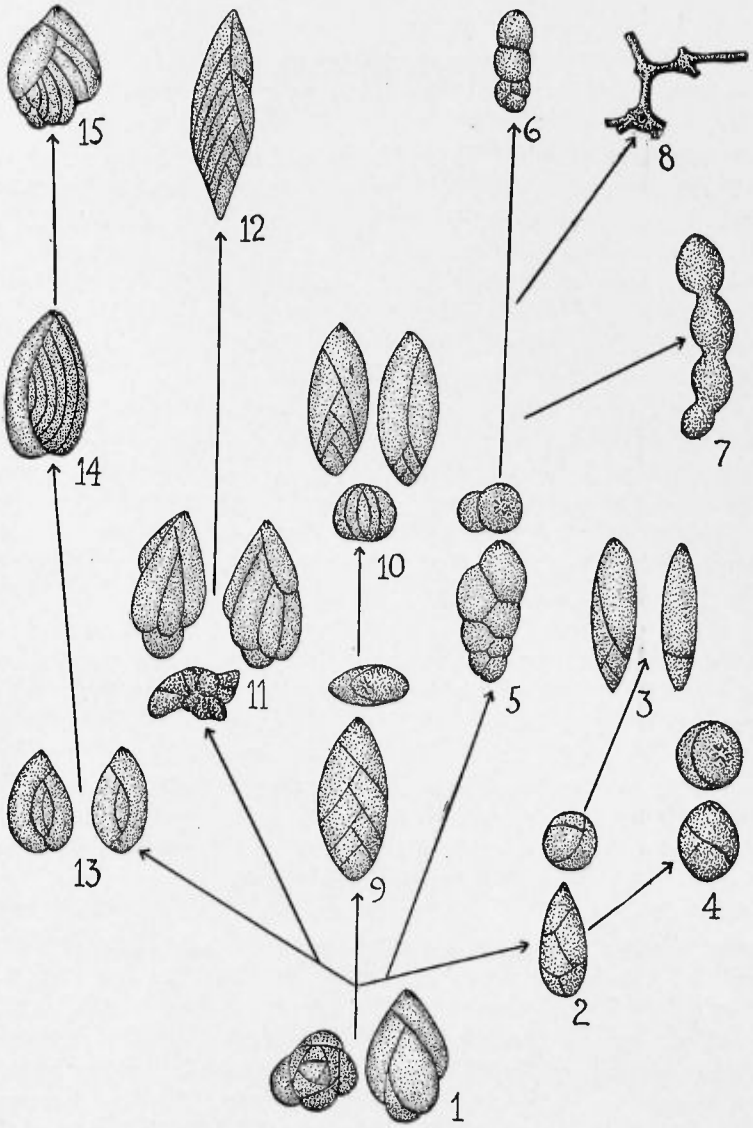
FIG. 11. *Sigmomorpha sadoensis* Cushman and Ozawa, new species. From two sides and base.

FIG. 12. *Sigmomorpha (Sigmomorphina) frondicularis* (Galloway and Wissler).

FIG. 13. *Sigmoidella (Sigmoidina) pacifica* Cushman and Ozawa, new species. From two sides.

FIG. 14. *Sigmoidella kagaensis* Cushman and Ozawa, new species.

FIG. 15. *Sigmoidella elegantissima* (Parker and Jones).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58. APERTURAL CHARACTERS IN THE LAGENIDAE

By JOSEPH A. CUSHMAN

For the most part the Lagenidae are characterized by radiate apertures. Except for the closely related family, Polymorphinidae, radiate apertures are very rare in the foraminifera. Just how such a structure came to arise has long puzzled me.

In a previous paper, Apertural Characters in Cristellaria with Descriptions of a New Species (these Contributions, Vol. 1, No. 1, 1925, p. 7) I noted a structure there termed "apertural chamberlet" the outer opening of which was radiate and the inner one opening into the main chamber a simple rounded one. The following statement was made "A similar apertural chamberlet should be looked for in other groups of the Lagenidae, where radiate apertures are the rule". Since then material has been laid aside from time to time for such a study. A few selected specimens have been figured on Plate 3, and will be referred to in the following paragraphs.

In other groups of the foraminifera, coiled forms have been found to be primitive, and uncoiled forms as a rule specialized ones. That this same relationship was to be suspected in the Lagenidae I stated as early as 1913. In most coiled forms there is a tendency for the aperture to occupy the whole of the end of the tubular portion and later to be confined to the base of the apertural face or to appear in the face itself. In the Lagenidae, the aperture does not normally appear at the base of the face although in fig. 23 such a specimen is shown. This is one I collected at Pegwell Bay in the Thanetian beds in the lowest Eocene, a locality well known for the variation of the coiled and uncoiled Lagenidae that occur there. In *Robulus*, the genus is characterized by an opening in the apertural face in addition to the radiate aperture at the peripheral angle. In the Jurassic there are numerous forms in which the rounded opening apparently forms the only aperture as in fig. 19. The line between *Robulus* and *Lenticulina* (the former *Cristellaria)* cannot be sharply drawn although the type species of *Lenticulina, L. rotulata* Lamarck, in the Upper Cretaceous of France and England does not show the supplementary aperture so marked in some

species of *Robulus*. Figs. 2-13 show some of the different forms of aperture in one group of *Robulus* all from a recent station in the Gulf of Mexico. In these specimens the radiate aperture is present although often in modified form. Fig. 2 shows the aperture partially included in flap-like plates extending out from the sides of the apertural face of the test. Figs. 3-6 show the gradual progression of this type from the triangular opening at the base of the face and extending along the sides of the previous coil. This may withdraw still more as in figs. 7-10 until in fig. 10 the aperture is as in *Lenticulina*. These projecting portions are to be considered as portions of the apertural chamberlet which in fig. 10 is completely enclosed. Figs. 12 and 13 show very large apertures where the plate-like projections are reduced to a simple raised ridge. In fig. 11 is a large specimen which is so placed as to show the great extent of the radiate aperture but with the inner rounded aperture showing directly above the line of the keel of the previous coil. The aperture chamberlet is not completely closed, but appears as an arched opening.

In fig. 16, the outer radiate portion is partially cut away exposing the whole of the lower opening of the apertural chamberlet which is large and rounded, and represents the primitive aperture. The floor of the chamberlet is indicated.

Fig. 17 is a specimen of another species broken back to one of the earlier chambers. Here the front portion of the apertural chamberlet is lost by resorption as is usually the case in this group, and a trace of it is noted in the two ridges below the opening. As the new chamber is built over the earlier one, the wall of the apertural chamberlet being usually very translucent shows through as a series of radiating lines. The free portion of the chamber itself is almost invariably resorbed, and the primitive aperture frequently enlarged to make the opening between chambers greater.

Figs. 14 and 15 show the apertural characters in the species noted in 1925, fig. 14 the radiate aperture from the exterior, and fig. 15 with a part of the outer wall removed showing the primitive inner rounded aperture in the basal wall of the apertural chamberlet opening into the main body of the chamber. Fig. 18 shows this structure in section, the apertural chamber above with radiate aperture in the upper wall, and the simple rounded one in the lower wall.

Some of the uncoiled species have the aperture near the edge

of the test and the whole apertural chamberlet is raised as shown in fig. 20.

In the more specialized uncoiled forms such as *Nodosaria* and *Dentalina,* (figs. 21 and 22), the openings of the apertural chamberlet are carried further from each other, the wall becomes very thick and translucent, and the chamberlet itself reduced in width. Fig. 21*a* shows the definite change in contour toward the apertural end of the test setting off the apertural chamberlet. Fig. 21*b* shows the characters in longitudinal section with the reduced apertural chamberlet, the upper opening radiate, the lower one simple. Fig. 21*c* shows the opening from the interior of the chamber, this specimen being viewed from below. A similar fragment viewed from the exterior is shown in fig. 21*d*. *Dentalina,* (figs. 22*a-d*), shows almost the same identical structure except that the apertural chamberlet is excentric, near the peripheral angle as in the uncoiled forms. Fig. 22*c* is a sectioned specimen viewed from the interior of the chamber showing the circular primitive opening in the basal wall of the apertural chamberlet, and fig. 22*d* is a longitudinal section of another specimen.

Fig. 24*a* shows similar characters in *Frondicularia,* the chamberlet standing well above the general outline of the test. Fig. 24*b* shows the section of the apertural chamberlet in another specimen.

I have many times stressed the primitive and plastic characters of the Lagenidae. The series of apertures given will show the difficulties of distinguishing between *Robulus* and *Lenticulina* in many species. Typical *Robulus* is evidently the more primitive form. In the literature, there is apparent the fact that authors have often figured broken specimens as *Robulus* on account of the exposure of the primitive rounded opening in the earlier chambers, a character showing also in similarly broken specimens of *Lenticulina.* Most species of *Robulus* have the sides of the apertural face with distinct angular borders and the apertural face itself usually flattened, while in *Lenticulina* the face itself is usually convex and the angled periphery becomes less pronounced. This is not a hard and fast rule for determination however.

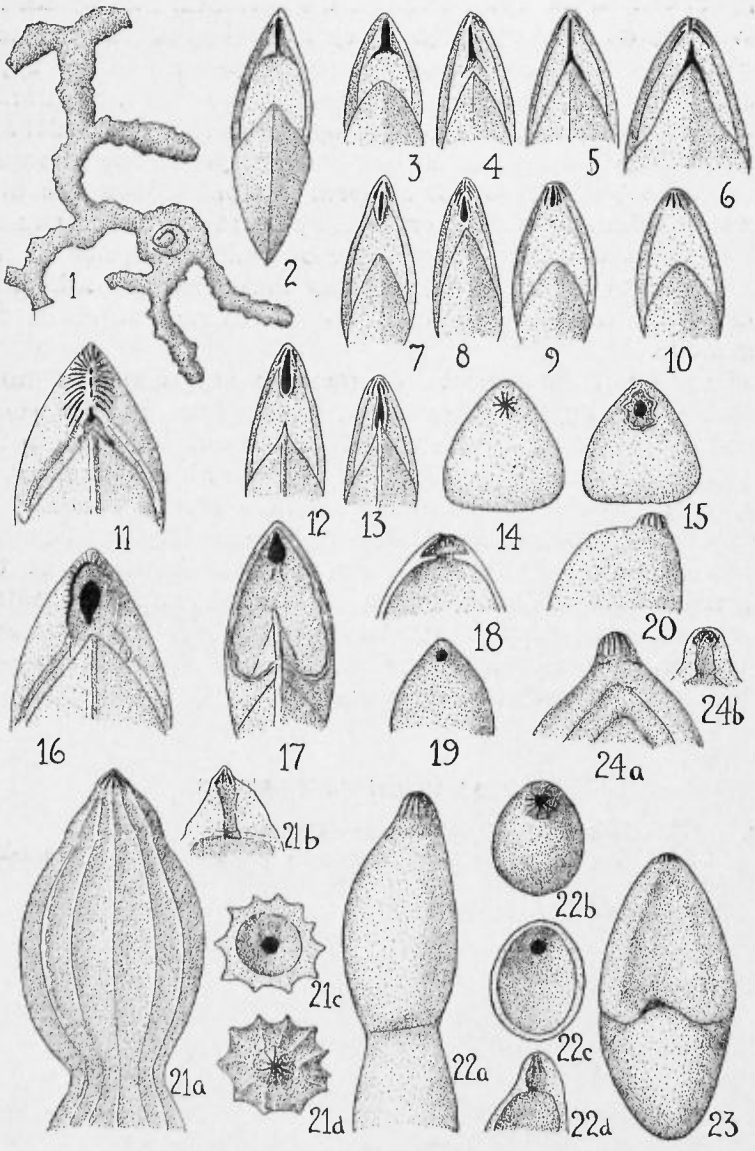
The older figures of coiled Lagenidae are very difficult to place with entire satisfaction. For example in *Astacolus* Montfort, the figure given shows a radiate aperture in the upper part of the apertural face. This figure curiously made up from the

earlier ones of Fichtel and Moll is not particularly convincing. The original of Fichtel and Moll's *Nautilus crepidulus* has a small aperture, rounded, but drawn as apparently with radiating portions, in the upper angle of the apertural face within the lateral angles. The figure given by Blainville, called "Crepiduline Astacole" on the plate, has a long aperture in the upper angle of the apertural face and another one above, apparently at the peripheral angle. The type species is that of Fichtel and Moll although later renamed by Montfort, yet in the literature the species passing as *"Cristellaria" crepidula* has a convex apertural face with a simple radiate aperture and no trace of the second rounded aperture in the apertural face itself, nor the lateral angles to the face. This simply illustrates the difficulties with which one must contend in the nomenclature of the Lagenidae.

The study of the apertural characters seems to show definitely that in the Lagenidae as elsewhere in the Foraminifera, coiled forms are primitive as a rule. There should be found in the early coiled forms of the Lagenidae, forms with the simple aperture at the base or in the middle of the apertural face and no trace of the radiate aperture which is a secondary development. The apertural chamberlet, a characteristic structure of the Lagenidae and Polymorphinidae, developed with the radiate aperture as a supplementary chamberlet outside the usual wall of the chamber, and in many of the genera of the family now definitely fused with the outer wall.

EXPLANATION OF PLATE 3

FIG. 1. *Cornuspiramia antillarum* (Cushman).
FIGS. 2-24. Illustrating apertural characters in the Lagenidae, (see text).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RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the most recent works on the foraminifera that have come to hand.

Franke, A.

Die Foraminiferen der Aachener Kreide, Engänzungen und Berichtigung zu dem gleichnamigen Buch mit Atlas von Ignaz Beissel, Herausgegeben von E. Holzapfel 1891.

(Jahrb. Preuss. Geol. Landes. für 1927, vol. 48, 1927, pp. 667-698.) *Berlin.*

The species of the Beissel collection have been restudied, and the author interprets them in accordance with his many other studies of European Cretaceous.

Hofker, J.

De Nummulitidae.

(Tijds. Ned. Dierk. Ver., ser. 2, vol. 10, 1927, pp. 3, 4.) *Leiden.*

A short account of the family and its limitation to a few genera, other genera often included being scattered among several other families.

Chapman, C.

Sedimentary Rocks Under The Microscope.

(Proc. Micr. Soc. Victoria, vol. 4, July, 1927, pp. 142-144.) *Melbourne.*

A short account of a lecture given before the society and mention of the genera of the foraminifera shown.

Palmer, R. H.

Geology of Eastern Hidalgo and Adjacent Parts of Vera Cruz, Mexico.

(Bull. Amer. Assoc. Petr. Geol., vol. 11, Nov. 1927, pp. 1173-1220, 10 figs.) *Chicago.*

Reference to the Tertiary and Cretaceous foraminifera are given with notes as to occurrences of the group in various Mexican formations. No foraminifera are figured.

Cushman, Joseph A.
Foraminifera of the Genus Siphonina and Related Genera.
(Proc. U. S. Nat. Mus., vol. 72, Art. 20, 1927, pp. 1-15, pls. 1-4.) *Washington*
A review of the known species, with descriptions and figures of seven new species and one new variety.

Davies, A. Morley.
Lower Miocene Foraminifera from Pemba Island.
(Rep. Pal. Zanzibar Protectorate, Sep. 1927, pp. 7-12, pls. 1, 2.) *Zanzibar.*
A number of species are recorded and figured from this little known region.

Cole, W. Storrs.
A Foraminiferal Fauna from the Guayabal Formation in Mexico.
(Bull. Amer. Pal., vol. 14, No. 51, Dec. 23, 1927, pp. 1-46, pls. 1-5.) *Ithaca.*
The author records eighty-three species and varieties from this Eocene formation of which forty are described as new. Nearly all of the species are figured.

Iddings, Arthur and A. A. Olsson.
Geology of Northwest Peru.
(Bull. Amer. Assoc. Petr. Geol., vol. 12, No. 1, Jan. 1928, pp. 1-39, 3 text figs.) *Chicago.*
The occurrences of several genera of foraminifera are noted.

Vlerk, I. M. van der and R. E. Dickerson.
Distinctions Among Certain Genera of Larger Foraminifera for the Field Geologist of the East Indies.
(Journ. Pal., vol. 1, No. 3, Jan. 1928, pp. 183-192, text figs. 1-3.) *Chicago.*
The distinguishing characters are given for a number of genera with suggestions for field study.

Galloway, J. J. and Stanley G. Wissler.
Corrections of Names of Foraminifera.
(Journ. Pal., vol. 1, No. 3, Jan. 1928, p. 193.) *Chicago.*
The authors give new names for their species found to be

preoccupied. Their generic name, *Carinina,* being already used by Rubrecht in 1887, a new name, *Laticarinina* is proposed.

Hanna, G. D. and C. C. Church.

A Collection of Recent Foraminifera Taken off San Francisco Bay, California.

(Journ. Pal., vol. 1, No. 3, Jan. 1928, pp. 195-202.) *Chicago.*

The authors note thirty-seven species off the Farallon Islands.

Cushman, Joseph A.

The American Cretaceous Foraminifera Figured by Ehrenberg.

(Journ. Pal., vol. 1, No. 3, Jan. 1928, pp. 213-217, pls. 34-36.) *Chicago.*

The figures of Ehrenberg published in 1854 from the American Cretaceous are given so as to be made available to American workers.

Stadnichenko, Maria M.

The Foraminifera and Ostracoda of the Marine Yegua of the Type Sections.

(Journ. Pal., vol. 1, No. 3, Jan. 1928, pp. 221-243, pls. 38, 39.) *Chicago.*

Twelve species of foraminifera from this Eocene formation are recorded and four described as new.