ISSN 2538-1016; 45

NEW ZEALAND
DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

BULLETIN 196

# A Key to the Recent Genera of the Foraminiferida

by
K. B. Lewis

New Zealand Oceanographic Institute
Memoir No. 45

1970

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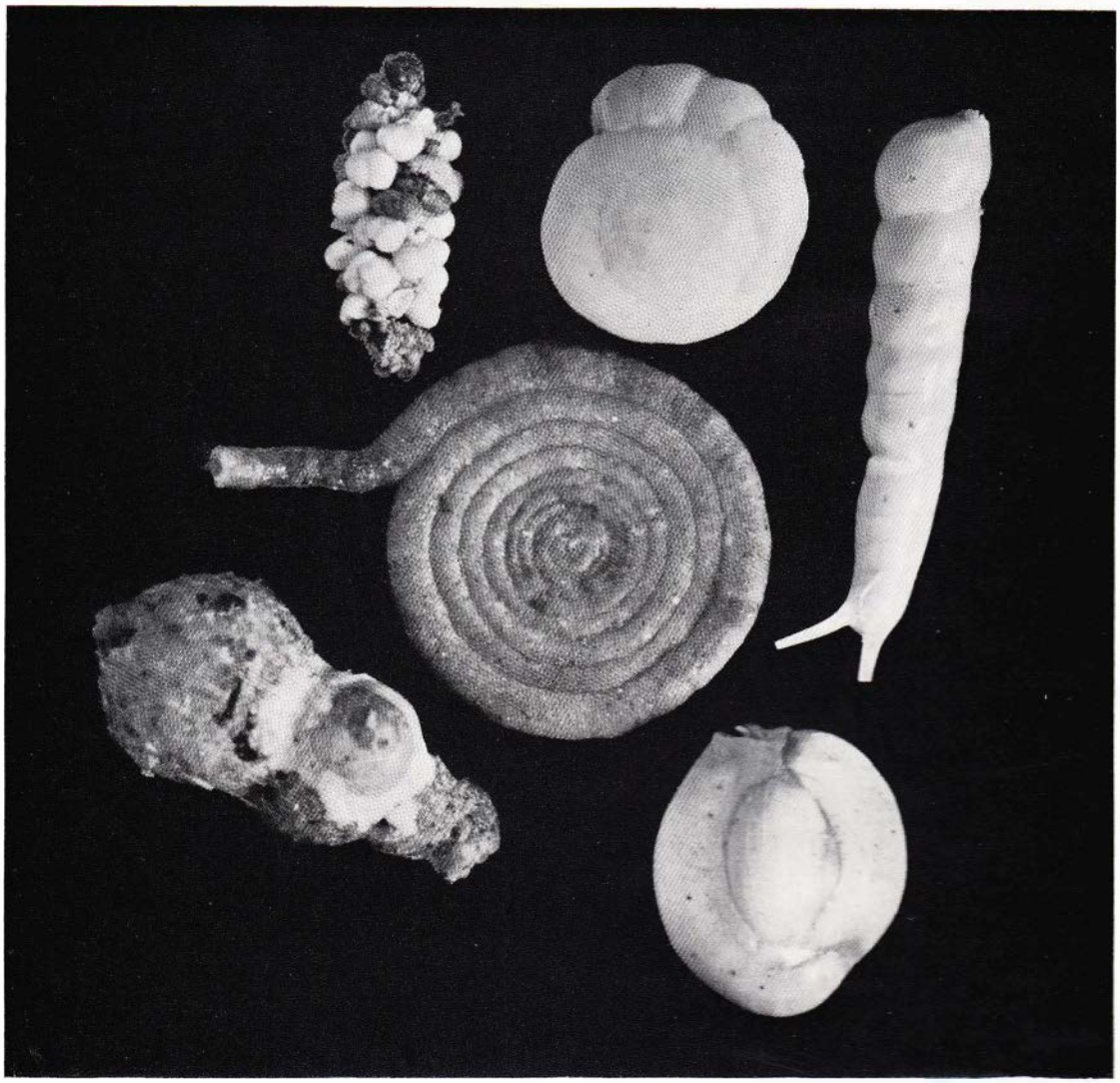

*Magnification* × *16 approx.* *Photograph: J. Whalan*

A selection of foraminifers from NZOI Sta. C 488, which was situated 30 km to the east of Cape Palliser, the most southerly point of the North Island, New Zealand. The sample, consisting of mud, was collected from a depth of 459 m.

The arenaceous species illustrate a wide variation in test form and the material selected for test construction, e.g.: UNILOCULAR GLOBOSE (top left) *Brachysiphon corbuliformis* Chapman (composed of agglutinated glauconite grains and pelagic foraminifers only); UNILOCULAR ENROLLED TUBULAR (centre) *Ammodiscus tenuis* Brady (composed of silt grains); UNISERIAL (bottom left) *Hormosina globulifera* Brady (composed of fine sand, mainly quartz); ATTACHED LOW TROCHOSPIRAL (bottom left, attached to *Hormosina*) *Tritaxis fusca* (Williamson) (composed of silt-sized grains).

The calcareous species are: QUINQUELOCULINE (bottom right) *Quinqueloculina sp.* (with an opaque white (porcellaneous) test); UNCOILING UNISERIAL (top right) *Vaginulopsis spinigera* (Brady) (with a translucent (hyaline) test and radiate aperture); LOW TROCHOSPIRAL (top centre) *Heterolepa subhardingerii* (Parr) (with a translucent (hyaline) final chamber and distinctly perforate wall).

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*Price: $2.50*

This publication should be referred to as:
*Bull. N.Z. Dep. scient. ind. Res. 196*



A. R. SHEARER, Government Printer, Wellington, New Zealand—1969

# FOREWORD

Over the last few years the attention paid to studies of the Recent Foraminifera has notably increased. These investigations have been considerably aided by the publication by A. R. Loeblich and H. Tappan of their revised classification of the Foraminifera in the "Treatise on Invertebrate Paleontology" series. The present memoir extends the general usefulness of this work by providing a key to the Recent genera.

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# CONTENTS

# A Key to the Recent Genera of the Foraminiferida

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**Abstract**

A KEY with illustrated glossary is provided to all the Recent agglutinated and calcareous foraminiferal genera recorded by Loeblich and Tappan in the *Treatise on Invertebrate Paleontology*, with special reference to those occurring in the New Zealand region. The few tectinous forms recorded from this area are also included. A summary is given of techniques used by workers on Recent foraminifers.

## INTRODUCTION

THE recently proposed classification of the Foraminiferida by Loeblich and Tappan (1964a) incorporates much up-to-date knowledge of these animals, but does not, unlike a number of its predecessors, contain a key. The construction of a workable key to all the genera from Cambrian to Recent would have been an enormous undertaking; however, a key to the Recent genera has been prepared in conjunction with, and to facilitate, current research on the Recent foraminiferal fauna of New Zealand.

The key form is simple, with the parts of the couplet together (cf. Metcalf 1954), except in a note on the natural classification of Suborder Rotaliina which is illustrated in a small separate key with the parts of the couplet separated and successive couplets indented.

The classification proposed by Loeblich and Tappan is adhered to throughout and the order of families and subfamilies is the same as in the *Treatise on Invertebrate Paleontology*. New genera proposed by these authors since the *Treatise* went to press have been included, and notes made of their revisions to the classification.

The key in many instances cuts across the natural classification, but each genus is recorded only under the family name or subfamily in which it appears in the *Treatise*. All taxa have a reference to their description in the *Treatise*.

### Using the Key

To use the key: beginning with couplet 1 (p. 8) choose one of the alternatives and proceed to the couplet indicated to the right of that alternative, e.g. if the specimen is calcareous, proceed to couplet 2, and continue in this way until a determination is reached. The key progresses to family and subfamily, but may continue through several different families before reaching a generic identification. The generic name is followed by a reference to a description and figure by Loeblich and Tappan either in the *Treatise on Invertebrate Paleontology* or in their modifications of the work, and genera recorded from the New Zealand Region (Eade, 1967) are indicated with †, e.g. *Astrorhiza*† *C184* [*103*] is described in the *Treatise* on p. C184 and illustrated in Fig. 103, and species recorded from the New Zealand region are listed in *A Checklist of Recent New Zealand Foraminifera.*

# KEY TO THE FORAMINIFERIDA

## KEY TO THE SUBORDERS

| | | | |
|---|---|---|---|
| 1. | Tectinous test (chiefly Subord. ALLOGROMIINA—New Zealand forms only) | .. | 3 |
| | Agglutinated test (Subord. TEXTULARIINA) .. .. .. .. .. | | 5 |
| | Calcareous test .. .. .. .. .. .. .. .. | | 2 |
| 2. | Test imperforate, porcellanous (Subord. MILIOLINA) .. .. .. | | 184 |
| | Test perforate, hyaline (Subord. ROTALIINA) .. .. .. .. | | 276 |

## KEY TO THE NEW ZEALAND GENERA OF THE SUBORDER ALLOGROMIINA (Loeblich and Tappan 1964 p. C164)

Sarcodina with tectinous tests cannot be identified without detailed work on the living animal and are therefore outside the scope of this key. However the few forms recorded from New Zealand can readily be distinguished by test morphology.

Forms with biflagellate gametes are included in the Family Largnidae C164
Forms with amoeboid gametes are referred to the Family Allogromiidae C173

| | | | |
|---|---|---|---|
| 3. | Attached (commonly with few adherent sand grains) *Iridia*† .. | | *C167* [*86*] |
| | Free living .. .. .. .. .. 4 | | |
| 4. | Elongate tubular .. .. .. .. *Shepheardella*† | | *C182* [*102*] |
| | Ovate to spherical .. .. .. .. *Allogromia*† .. | | *C173* [*92*] |

Note: *Gromia*† (p. C40 Fig. 21) has filopodia and uniflagellate gametes. It is not strictly a foraminifer.

## KEY TO THE RECENT GENERA OF THE SUBORDER TEXTULARIINA (Loeblich and Tappan 1964, p. C184)

| | | | |
|---|---|---|---|
| 5. | Unilocular, single rounded chamber and/or non-septate tube or tubes .. | Superfam. AMMODISCACEA .. | 6 |
| | Multilocular, test with many distinct chambers .. .. .. | Superfam. LITUOLACEA .. | 84 |

## AMMODISCACEA (C184)

| | | | |
|---|---|---|---|
| 6. | Essentially a globose or discoidal chamber, may have tubular arms, may be in groups .. .. .. .. | Fam. SACCAMMINIDAE .. .. | 37 |
| | Essentially tubular chamber; straight, enrolled or branching .. .. | .. 7 | |
| 7. | Enrolled tubular second chamber .. | Fam. AMMODISCIDAE .. .. | 73 |
| | Straight or branching tubular chambers, never enrolled .. .. .. | .. 8 | |
| 8. | With smooth outer covering of tectine, branching in one plane .. .. | Fam. SCHIZAMMINIDAE .. | 36 |
| | No outer covering of tectine, straight or branching in one or many planes .. | Fam. ASTRORHIZIDAE .. .. | 9 |

## ASTRORHIZIDAE (C184)

| | | | | |
|---|---|---|---|---|
| 9. | Test free | | 10 | |
| | Test attached or mass of entwined tubes | Subfam. DENDROPHRYINAE | .. | 29 |
| 10. | Simple tube, with open ends, rarely branching | Subfam. RHIZAMMININAE | .. | 18 |
| | With proloculus or central chamber, tube open at one end only | | 11 | |
| 11. | Central chamber with radiating arms | Subfam. ASTRORHIZINAE | .. | 13 |
| | Proloculus continued to single, non-septate, tube | | 12 | |
| 12. | Wall labyrinthic | Subfam. BOTELLININAE | .. | 28 |
| | Wall not labyrinthic | Subfam. HIPPOCREPININAE | .. | 23 |

## ASTRORHIZINAE (C184)

| | | | | |
|---|---|---|---|---|
| 13. | Central chamber with tectinous sides, arms and "framework" agglutinated | *Vanhoeffenella* | .. | *C186* [*104*] |
| | Central chamber completely agglutinated | 14 | | |
| 14. | Central chamber discoidal with short arms | *Astrorhiza*† | .. | *C184* [*103*] |
| | Central chamber not discoidal | 15 | | |
| 15. | Central chamber large spherical, few short arms | 16 | | |
| | Central chamber small, often indistinct | 17 | | |
| 16. | Tubular arms with open ends | *Astrammina* | .. | *C184* [*103*] |
| | Domed or conical protruberances with small opening at extremity | 56 | | |
| 17. | Arms numerous, irregular, very fine grained | *Radicula* | .. | *C185* [*104*] |
| | Arms few, usually straight, medium-coarse grained | *Rhabdammina*† | .. | *C185* [*103*] |

Note: *Marsipella*† *C186* [*105*] is elongate fusiform.

## RHIZAMMININAE (C186)

| | | | | |
|---|---|---|---|---|
| 18. | Branching | 19 | | |
| | Not branching | 20 | | |
| 19. | Tubes radiating from small central chamber, seen when test broken or sectioned | 17 | | |
| | No rounded cavity at point of branching | *Rhizammina*† | .. | *C186* [*105*] |

Note: *Schizammina C194* [*107*] has labyrinthic wall. *Dendronina*† *C192* [*108*] is constructed of aligned sponge spicules.

| | | | | |
|---|---|---|---|---|
| 20. | Elongate fusiform, slightly wider in middle | 21 | | |
| | Simple tube | 22 | | |
| 21. | Test medium to coarse-grained, may include unaligned sponge spicules | *Marsipella*† | .. | *C186* [*105*] |
| | Test fine-grained or composed completely of aligned sponge spicules | 53 | | |
| 22. | Tube small, thin-walled, usually curved; fine arenaceous groundmass with irregular covering of larger fragments and commonly other foraminifer tests | *Rhizammina*† | .. | *C186* [*105*] |
| | Tube large, thick, almost straight; sand and sponge spicules in calcareous cement; one end of tube may be blocked with waste material | *Bathysiphon*† | .. | *C186* [*105*] |

Note: *Protobotellina C190* [*106*] has base blocked with sand grains.

HIPPOCREPININAE (C187)

| | | | | | |
|---|---|---|---|---|---|
| 23. | Tube branching | | *Saccorhiza*† | | *C190* [*106*] |
| | Tube not branching | 24 | | | |
| 24. | Test conical; possibly very elongate cone | 25 | | | |
| | Test cylindrical | 26 | | | |
| 25. | Test simple; elongate cone; aperture open end of tube | | *Jaculella*† | | *C190* [*106*] |
| | Test with irregular transverse constrictions; small terminal aperture | | *Hippocrepina* | | *C188* [*106*] |

Note: *Pelosina C200* [*112, 113*] has no transverse constrictions.

| | | | | | |
|---|---|---|---|---|---|
| 26. | With bulbous proloculus; tubular portion generally smaller diameter than proloculus | 27 | | | |
| | No bulbous base; simple tube with one end closed by arenaceous material | | *Protobotellina* | | *C190* [*106*] |

Note: *Bathysiphon*† *C186* [*105*] has end closed by black waste material. *Brachysiphon*† *C196* [*112*] is much shorter. *Nubeculariella C192* [*108*] is tectinous with a few large sand grains.

| | | | | | |
|---|---|---|---|---|---|
| 27. | Tube with internal partial septa | 91 | | | |
| | Tube without partial septa | | *Hyperammina*† | | *C190* [*106*] |

Note: *Lagenammina C200* [*113*] has flask-shaped test with more bulbous chamber and narrower tube.

BOTELLININAE (C190)

| | | | | | |
|---|---|---|---|---|---|
| 28. | | | *Botellina*† | | *C190* [*107*] |

Note: *Schizammina C194* [*107*] has smooth tectinous outer surface.

DENDROPHRYINAE (C192)

| | | | | | |
|---|---|---|---|---|---|
| 29. | Tubes growing upwards from attached base, or mass not firmly attached to substrate | 30 | | | |
| | Tubes growing along and firmly attached to substrate for at least part of their length | 35 | | | |
| 30. | Tubes simple or branching, growing upwards from attachment | 31 | | | |
| | Complicated mass of tubes | 34 | | | |
| 31. | Short pseudochitinous tube with a few large grains attached | | *Nubeculariella* | | *C192* [*108*] |
| | Test normally agglutinated, elongate, often branching | 32 | | | |
| 32. | Erect portion of test conical; diameter of tube increasing from attachment upwards | | *Halyphysema* | | *C192* [*108*] |
| | Erect portion tubular; if anything, diameter decreases slightly away from attachment | 33 | | | |
| 33. | May branch; wall of fine sand and sponge spicules aligned in direction of growth | | *Dendronina*† | | *C192* [*108*] |
| | Branching, spreading; wall of fine sand, not sponge spicules | | *Dendrophrya* | | *C192* [*108*] |

Note: *Saccodendron C205* [*118*] has hemispherical to irregularly ovate chamber attached to substrate.

| | | | | | |
|---|---|---|---|---|---|
| 34. | Mass of anastomosing tubes, may be organised into radiating tubes joined by networks of connecting tubes | | *Syringammina*† | | *C192* [*108*] |
| | Central mass with radiating tubular portions, each expanding distally into a globular or conical mass | | *Normanina* | | *C192* [*108*] |
| 35. | Proloculus with single unbranched elongate tube | 81 | | | |
| | Two or more tubes from periphery of globular chamber or attached branching tubes, or both | 60 | | | |

## SCHIZAMMINIDAE (C192)

| | | | | |
|---|---|---|---|---|
| 36. | Tubular with dichotomous branching | *Schizammina* | | *C194* [*107*] |
| | Flabelliform; margin with projecting tubules | *Jullienella* | | *C194* [*107*] |

## SACCAMMINIDAE (C194)

| | | | |
|---|---|---|---|
| 37. | Interior not divided into chamberlets; wall not labyrinthic | 38 | |
| | Interior divided into chamberlets; every gradation between partial septa and a thick labyrinthic wall | Subfam. DIFFUSILININAE | 65 |
| 38. | Free living | 39 | |
| | Attached | Subfam. HEMISPHAERAMMININAE | 57 |
| 39. | No aperture | Subfam. PSAMMOSPHAERINAE | 40 |
| | With definite apertures, possibly at end of tubes | Subfam. SACCAMMININAE | 45 |

## PSAMMOSPHAERINAE (C194)

| | | | |
|---|---|---|---|
| 40. | Single globular or discoidal chamber | 41 | |
| | Several loosely joined globular chambers | *Sorosphaera* | *C196* [*110, 111*] |

Note: *Psammophax* is synonymised with *Sorosphaera*, but original figures of *P. consociata* and Ross Sea material show single rounded aperture in each group of chambers (J. P. Kennett, 1968). *Normanina C192* [*108*] has tubes radiating from central mass which expand distally into globular chambers.

| | | | |
|---|---|---|---|
| 41. | Discoidal | 42 | |
| | Spherical | 43 | |
| 42. | Without radiating arms; central area tectinous | *Amphifenestrella* | *C195* [*111*] |
| | With radiating arms; central area tectinous or completely arenaceous | 13 | |
| 43. | Simple globular chamber; no projections | *Psammosphaera*† | *C195* [*110*] |
| | With numerous projections | 44 | |
| 44. | Projections irregular, without small openings at ends | *Storthosphaera*† | *C196* [*111*] |
| | Projections more regular, with small apertures at ends | 16 | |

## SACCAMMININAE (C196)

| | | | |
|---|---|---|---|
| 45. | Single aperture | 46 | |
| | Two or more tubular extensions, or "apertures" where the extensions have been broken off | 52 | |
| 46. | Hemispherical; aperture on concave side | *Causia* | *C200* [*113*] |
| | Globular, fusiform, or subcylindrical | 47 | |
| 47. | Test composed mainly of longitudinally aligned sponge spicules | 48 | |
| | Sponge spicules not principal constituent | 49 | |
| 48. | Test oviform to fusiform or cylindrical; rounded aperture | *Technitella*† | *C202* [*115*] |
| | Test spherical with slit-like aperture | *Pilulina* | *C201* [*112*] |
| 49. | Globular; main chamber does not have parallel sides | 50 | |
| | Subcylindrical; with parallel sides | *Brachysiphon*† | *C196* [*112*] |

Note: *Protobotellina C190* [*106*] has a comparatively elongate cylinder.

| | | | |
|---|---|---|---|
| 50. | Test almost spherical; neck, if any, short | 51 | |
| | Test flask-shaped; aperture on elongate neck | *Lagenammina* | *C200* [*113*] |

Note: *Hyperammina*† *C190* [*106*] has a comparatively wide tube and small proloculus. *Pelosina*† *C200* [*112, 113*] has opening at both ends.

| | | | | |
|---|---|---|---|---|
| 51. | Aperture slit-like | *Pilulina* | .. | *C201* [*112*] |
| | Aperture circular | *Saccammina*† | .. | *C196* [*112*] |

Note: *Pelosphaera C201* [*112, 114*] has tectinous entosolenian tube. *Psammophax* is synonymised with *Sorosphaera C196* [*110, 111*]. However, original figures of *P. consociata* and Ross Sea material show single rounded aperture in each group of chambers (J. P. Kennett, 1968).

| | | | | |
|---|---|---|---|---|
| 52. | Test fusiform to almost globular; projections at opposite ends | 53 | | |
| | Test roughly spherical or discoidal; two or more projections around test | 54 | | |
| 53. | Test composed mainly of longitudinally aligned sponge spicules | *Technitella*† | .. | *C202* [*115*] |
| | Test composed of fine mineral grains | *Pelosina*† | .. | *C200* [*112, 113*] |
| | Test composed of coarse mineral grains possibly with some sponge spicules | 21 | | |

Note: *Vanhoeffenella C186* [*104*] has chamber centres of tectin.

| | | | | |
|---|---|---|---|---|
| 54. | Roughly spherical; projections randomly distributed | 55 | | |
| | Discoidal; projections around periphery | 13 | | |
| 55. | Projections sturdy, arenaceous | 56 | | |
| | Projections fragile, flexible, argillaceous, tubular, bifurcating near extremities; if projection broken, tectinous entosolenian tube can be seen | *Pelosphaera* | .. | *C201* [*112, 114*] |
| 56. | True tubular arms | 16 | | |
| | Domed or conical protruberances with small opening at extremity | *Thurammina*† | .. | *C202* [*115*] |

## HEMISPHAERAMMININAE (C202)

| | | | | |
|---|---|---|---|---|
| 57. | Solitary chamber | 58 | | |
| | Several chambers in loose whorl, ring, or linear series | 64 | | |
| 58. | With tubular extensions which remain attached to substrate for at least part of their length | 59 | | |
| | Test roughly hemispherical, without tubular extensions | 62 | | |
| 59. | Tubes branching | 60 | | |
| | Tubes not branching | 61 | | |
| 60. | Hemispherical to ovate chamber; extensions arising from peripheral area and may grow free of attachment | *Saccodendron* | .. | *C205* [*118*] |
| | No central chamber; branching tubes attached to substrate throughout | *Sagenina* | .. | *C205* [*117*] |
| 61. | Single elongate tube | 81 | | |
| | Two or more short protruberances | *Tholosina*† | .. | *C205* [*117*] |

Note: *Iridia C167* [*86*] has wall with tectinous base and little cement.

| | | | | |
|---|---|---|---|---|
| 62. | With apertures (may be small at periphery) | 63 | | |
| | Without apertures | *Hemisphaerammina*† | .. | *C202* [*115*] |

Note: *Iridia C167* [*86*] has wall with tectinous base and little cement.

| | | | | |
|---|---|---|---|---|
| 63. | Aperture at periphery | *Tholosina*† | .. | *C205* [*117*] |
| | Aperture at summit of chamber | *Colonammina* | .. | *C204* [*117*] |

Note: *Verrucina C210* [*119*] has thick labyrinthic wall.

| | | | | |
|---|---|---|---|---|
| 64. | Chambers hemispherical in loose whorl or ring; aperture at summit of each chamber | *Ammopemphix* | .. | *C202* [*117*] |
| | Chambers pyriform in linear series; aperture terminal against attachment | *Goatapitigba* | .. | *C795* [*652*] |

## DIFFUSILININAE (C205)

| | | | | |
|---|---|---|---|---|
| 65. | Free-living | 66 | | |
| | Attached | 70 | | |
| 66. | Spherical | 67 | | |
| | Discoidal to lenticular | 68 | | |
| 67. | Thick labyrinthic wall; small central cavity | *Oryctoderma* | | *C208* [*120*] |
| | Final chamber enveloping early planispiral development | 117 | | |
| 68. | Thin wall; cavity divided by radial septa; test fairly thick; oblong in section | *Daitrona*† | | *C205* [*120*] |
| | Labyrinthic wall; test much flattened in section | 69 | | |
| 69. | Very compressed central cavity; fine branching tubules extending to periphery | *Masonella* | | *C208* [*119*] |
| | Inner layer of loosely cemented larger grains; outer layer well cemented fine grains; concentric growth rings; often two eccentric perforations through test | *Discobotellina* | | *C205* [*119*] |
| 70. | Irregular mass; interior ramifying tubules; apertures at ends of one to four irregularly spaced pustules | *Diffusilina* | | *C205* [*119*] |
| | Regular subspherical or hemispherical chambers, sometimes with single aperture | 71 | | |
| 71. | With single partial septum | *Crithionina* | | *C205* [*120*] |
| | With several or numerous short radial portions | 72 | | |
| 72. | With single aperture in depressed area at summit of test | *Verrucina* | | *C210* [*119*] |
| | No aperture | *Pseudowebbinella* | | *C208* [*120*] |

## AMMODISCIDAE (C210)

| | | | |
|---|---|---|---|
| 73. | Test free | Subfam. AMMODISCINAE | 74 |
| | Test attached | Subfam. TOLYPAMMININAE | 81 |

## AMMODISCINAE (C210)

| | | | | |
|---|---|---|---|---|
| 74. | Axis of coiling the same throughout (planispiral and trochospiral forms) | 75 | | |
| | Axis of coiling changing (streptospiral and irregularly coiled forms) | 79 | | |
| 75. | Tubular chamber laterally compressed, tending to uncoil | *Psammonyx* | | *C212* [*124*] |
| | Tubular chamber circular or semicircular in section; closely coiled | 76 | | |
| 76. | Wall tectinous; outer whorl bordered by an agglutinated layer | *Spirillinoides* | | *C212* [*124*] |
| | Wall arenaceous throughout | 77 | | |
| 77. | Trochospiral at some stage | 78 | | |
| | Planispiral, no trochospiral stage | *Ammodiscus*† | | *C210* [*122*] |

Note: *Discobotellina C205* [*119*] has annular growth rings, not an enrolled tube.

| | | | | |
|---|---|---|---|---|
| 78. | Low trochospiral in early stages, but later planispiral or trochospiral in reverse direction | *Ammodiscoides*† | | *C210* [*122*] |
| | Elongate, high trochospiral | *Turritellella*† | | *C212* [*122*] |
| 79. | Streptospiral to planispiral to final uncoiled zigzag growth | *Ammovertellina* | | *C210* [*123*] |
| | No final zigzag stage | 80 | | |

| | | | |
|---|---|---|---|
| 80. | Initial high-spired coil to planispiral stage with axis of coiling almost perpendicular to original axis | *Usbekistania* .. .. | *C212* [*125*] |
| | Streptospiral or irregular coil .. .. .. | *Glomospira*† .. .. | *C212* [*122*] |

Note: *Lituotuba C214* [*126*] has later stages uncoiling.

## TOLYPAMMININAE (C213)

| | | | |
|---|---|---|---|
| 81. | Growth in zigzag fashion .. .. .. | *Ammovertella* .. .. | *C214* [*126*] |
| | Growth not zigzag .. .. .. .. | 82 | |
| 82. | Early planispiral, streptospiral or irregular coil; later uncoiling .. .. .. .. | *Lituotuba* .. .. | *C214* [*126*] |
| | No early coiled stage .. .. .. .. | 83 | |
| 83. | After globular proloculus, winds irregularly over surface of attachment .. .. .. | *Tolypammina*† .. | *C213* [*126*] |
| | Flask-shaped chamber with straight tubular neck | *Ammolagena*† .. | *C214* [*126*] |

## LITUOLACEA (C214)

| | | | |
|---|---|---|---|
| 84. | Uniserial series .. .. .. | Fam. HORMOSINIDAE .. .. | 89 |
| | Biserial series; may have final uniserial stage .. .. .. .. | Fam. TEXTULARIIDAE .. .. | 132 |
| | Coiled or irregular, at least in initial stages | .. 85 | |
| 85. | Irregular development of globose chambers .. .. .. .. | .. 86 | |
| | Milioline arrangement with two (rarely three) tubular chambers per whorl .. | Fam. RZEHAKINIDAE .. .. | 99 |
| | Planispiral or streptospiral, at least in early stages .. .. .. .. | 87 | |
| | Trochospiral, at least in early stages .. | .. 88 | |
| 86. | Free .. .. .. .. .. | 40 | |
| | Attached .. .. .. .. .. | 64 | |
| 87. | Close coiled or uncoiling to uniserial series | Fam. LITUOLIDAE .. .. | 104 |
| | Uncoiling to biserial series .. .. | Fam. TEXTULARIIDAE .. .. | 132 |
| 88. | Low trochospiral .. .. .. | Fam. TROCHAMMINIDAE .. | 146 |
| | High trochospiral usually with later biserial or uniserial stage .. .. | Fam. ATAXOPHRAGMIIDAE .. | 161 |

Note: Fam. NOURIIDAE (polymorphine spiral) and Fam. PAVONITINIDAE (microgranular calcite wall) key out with Fam. ATAXOPHRAGMIIDAE.

## HORMOSINIDAE (C214)

| | | | |
|---|---|---|---|
| 89. | Free-living .. .. .. .. .. | 90 | |
| | Attached .. .. .. .. .. | 130 | |
| 90. | Chambers long and tubular or irregularly globose; each chamber typically with individual aperture .. .. | Subfam. ASCHEMONELLINAE .. | 91 |
| | Chambers globose or short and flattened; only single terminal aperture .. | Subfam. HORMOSININAE .. | 92 |

## ASCHEMONELLINAE (C214)

| | | | |
|---|---|---|---|
| 91. | With rounded apertures on tubular necks, one or more on each chamber; commonly branching .. | *Aschemonella* .. .. | *C214* [*127*] |
| | With only single terminal aperture; not branching; chambers long and tubular; sutures often indistinct .. .. .. .. .. | *Kalamopsis* .. .. | *C215* [*127*] |

## HORMOSININAE (C215)

| | | | | |
|---|---|---|---|---|
| 92. | Uniserial throughout . . | 93 | | |
| | Note: Examine initial end very carefully. Specimens may have to be broken, sectioned, or immersed in aniseed oil to reveal initial coil. | | | |
| | Uniserial with initial coil or biserial stage | 97 | | |
| 93. | Branching . . | *Protoschista* | | *C215* [*130*] |
| | Not branching | 94 | | |
| 94. | Aperture curved slit, usually in slight depression on terminal face | *Sulcophax* | | *C217* [*128*] |
| | Aperture rounded, often on apertural neck | 95 | | |
| 95. | Aperture circular, no tooth | 96 | | |
| | Aperture rounded, with single tooth | 174 | | |
| | Aperture radiate because of several ribs or teeth on inside of apertural neck | *Nodosinum* | | *C215* [*129*] |
| | Note: *Nubeculina C456* [*346*] has porcellaneous neck. | | | |
| | Aperture cribrate | 141 | | |
| 96. | Very fine-grained; surface smooth; chambers almost spherical . . | *Hormosina*† | | *C215* [*128*] |
| | Medium to coarsely arenaceous; surface rough; chambers not necessarily spherical | *Reophax*† | | *C216* [*128*] |
| 97. | Initial biserial stage . . | 132 | | |
| | Initial planispiral stage | 104 | | |
| | Initial trochospiral stage | 161 | | |

## NOURIIDAE (C220)

| | | | | |
|---|---|---|---|---|
| 98. | | *Nouria*† | | *C220* [*132*] |

## RZEHAKINIDAE (C220)

| | | | | |
|---|---|---|---|---|
| 99. | Three chambers to whorl | *Ammoflintina* . . | | *C220* [*133*] |
| | Two chambers to whorl, arranged in various planes about vertical axis . . | 100 | | |
| 100. | Test planispiral or sigmoidal . . | 101 | | |
| | Test triloculine | *Trilocularena* . . | | *C224* [*134*] |
| | Test quinqueloculine . . | 102 | | |
| | Chamber added in more than five planes about vertical axis | 257* | | |
| 101. | Aperture rounded on neck and without tooth; no early quinqueloculine stage . . | *Spirolocammina* | | *C222* [*134*] |
| | Aperture rounded, with small tooth, not on pronounced neck; early quinqueloculine stage or sigmoidal arrangement | 244* | | |
| | Aperture cribrate; early quinqueloculine stage | 257* | | |
| 102. | Margin of aperture crenulate | 245* | | |
| | Margin of aperture smooth | 103 | | |
| 103. | Wall with calcareous base; tooth and lip of aperture porcellaneous; disintegrates rapidly in dil. HCl | 245* | | |
| | Wall without calcareous base; almost insoluble in dil. HCl . . | *Miliammina*† . . | | *C220* [*134*] |

*These genera have a calcareous layer below the arenaceous layer and are therefore placed in the Miliolidae.

## LITUOLIDAE (C225)

| | | | | |
|---|---|---|---|---|
| 104. | Planispiral or streptospiral throughout; not uncoiling | 105 | | |
| | Uncoiling after early planispiral stage | 107 | | |

| | | | |
|---|---|---|---|
| 105. | Wall simple | 106 | |
| | Wall labyrinthic | Subfam. CYCLAMMININAE | 119 |
| 106. | Only one to three chambers visible externally; test globose | Subfam. SPHAERAMMININAE | 116 |
| | More than three chambers visible externally; test rarely globose | Subfam. HAPLOPHRAGMOIDINAE | 109 |
| 107. | Test free | Subfam. LITUOLINAE | 122 |
| | Test attached | 108 | |
| 108. | Wall labyrinthic | Subfam. COSCINOPHRAGMATINAE | 131 |
| | Wall not labyrinthic | Subfam. PLACOPSILININAE | 130 |

## HAPLOPHRAGMOIDINAE (C225)

| | | | |
|---|---|---|---|
| 109. | Axis of coiling the same throughout | 110 | |
| | Streptospirally coiled | 115 | |
| 110. | Septa thick and arenaceous representing previous apertural faces; wall finely to fairly coarsely arenaceous not appearing labyrinthic | 111 | |
| | Septa thin and tectinous; wall coarsely arenaceous giving interior labyrinthic appearance | *Discammina*† | *C226* [*136*, *137*] |
| 111. | Interiomarginal aperture, bordered by lip on upper margin only | 112 | |
| | Areal aperture, may be a slit very low down an apertural face with only faint lip between it and previous whorl, i.e. lips on upper and lower margins | 114 | |
| 112. | Aperture equatorial; test symmetrical; typically short axis of coiling | 113 | |
| | Aperture to one side of periphery; test slightly asymmetrical; globose, with elongate axis of coiling | *Adercotryma*† | *C225* [*135*] |

Note: *Thalmannammina C226* [*136*] has axis of coiling changing throughout growth.

| | | | |
|---|---|---|---|
| 113. | Involute to slightly evolute | *Haplophragmoides*† | *C225* [*135*] |
| | Evolute | *Trochamminoides* | *C227* [*136*] |
| 114. | Aperture slit-like, or series of pores in line, commonly low down on apertural face | *Cribrostomoides*† | *C225* [*136*] |
| | Aperture multiple, rarely single, rounded with prominent raised lips scattered over apertural face | *Trochamminita*† | *C226* [*135*] |

Note: Later chambers of *Trochamminita* are often irregular so may appear to be trochospiral.

| | | | |
|---|---|---|---|
| 115. | Aperture areal, usually rounded with lip | *Recurvoides* | *C226* [*136*] |

Note: *Trochamminita*† *C226* [*135*] may have last few chambers irregular. *Ammoflintina C220* [*133*] has three tubular chambers per whorl.

| | | | |
|---|---|---|---|
| | Aperture interiomarginal | *Thalmannammina* | *C226* [*136*] |

Note: *Adercotryma*† *C225* [*135*] has axis of coiling same throughout and a symmetrical aperture. *Ammosphaeroidina*† *C259* [*174*] has only two or three globular chambers visible.

## SPHAERAMMININAE (C227)

| | | | |
|---|---|---|---|
| 116. | Free-living | 117 | |
| | Attached | *Ammosphaerulina* | *C227* [*139*] |
| 117. | Aperture interiomarginal or slit paralleling and close to basal margin | 148 | |
| | Aperture areal, rounded or slit-like, not close to basal margin | 118 | |

| | | | |
|---|---|---|---|
| 118. | Aperture with tooth; wall fine-grained .. .. | *Sphaerammina* | *C227* [*139, 140*] |
| | Aperture simple slit, no tooth; wall coarse-grained | *Canepaia* .. .. | *C228* [*141*] |

## CYCLAMMININAE (C228)

| | | | |
|---|---|---|---|
| 119. | Septa arenaceous; coiling involute to slightly evolute | 120 | |
| | Septa thin tectinous; coiling evolute to partly involute, wall very coarsely arenaceous .. | 110 | |
| 120. | Interiomarginal aperture only, has single lip on upper margin .. .. .. .. | *Recticulophragmium* .. | *C233* [*142*] |
| | With areal aperture, may be a slit low down on apertural face with only very faint lip between it and previous whorl, i.e. lips on upper and lower margins .. .. .. .. .. | 121 | |
| 121. | Slit-like aperture low down on apertural face .. | *Alveolophragmium*† .. | *C228* [*143*] |
| | Interiomarginal aperture plus series of rounded pores with raised margins scattered over apertural face .. .. .. .. | *Cyclammina*† .. | *C228* [*142*] |

## LITUOLINAE (C238)

| | | | |
|---|---|---|---|
| 122. | Uniserial portion triangular or quadrate in section | *Triplasia* .. .. | *C245* [*155*] |
| | Uniseral portion circular or compressed in section | 123 | |
| 123. | Biserial stage between planispiral and uniserial stages .. .. .. .. .. | 124 | |
| | No biserial stage in development .. .. | 125 | |
| 124. | Aperture rounded; periphery typically rounded .. | *Ammobaculoides* .. | *C241* [*151*] |
| | Aperture slit-like; periphery acutely angular .. | 133 | |
| 125. | Initially close-coiled; almost straight uniserial portion growing off at tangent to original coil .. | 126 | |
| | Gradually uncoiling series; chambers elongate, extending down towards coil at inner margin .. | 129 | |
| 126. | Aperture cribrate .. .. .. .. | *Lituola* .. .. | *C238* [*151*] |
| | Aperture single .. .. .. .. | 127 | |
| 127. | Aperture terminal but displaced towards outer rim; sutures oblique; test compressed .. .. | *Ammomarginulina* .. | *C241* [*151*] |
| | Aperture terminal on axis running through centre of uniserial portion; sutures roughly perpendicular to growth; usually circular or oval in section | 128 | |
| 128. | Chambers separated by porcellaneous calcite septa or long porcellaneous stolons .. .. | 221 | |
| | Chambers separated by normal arenaceous septa, i.e., terminal portion of earlier chamber .. | *Ammobaculites*† .. | *C239* [*151*] |
| | Chambers separated by straight tectinous septa .. | *Ammoscalaria*† .. | *C241* [*152*] |
| | Undivided tube but growth constrictions give the appearance of sutures .. .. .. | 82 | |
| 129. | Aperture rounded terminal, at peripheral angle .. | *Ammotium*† .. .. | *C241* [*152*] |
| | Aperture transverse areal slit near centre of terminal face; secondary aperture cribrate at lower end of final chamber near proloculus .. .. | *Ammoastuta* .. .. | *C238* [*151*] |

PLACOPSILININAE (C247)

130. Aperture single or double row of pores; test rarely branching .. .. .. .. 131
Aperture slit-like with projecting teeth; test may be branching .. .. .. .. *Haddonia* .. .. *C248* [*159*]
Aperture rounded; test not branching .. .. *Placopsilina*† .. .. *C247* [*159*]

Note: *Goatapitigba C795* [*652*] has few pyriform chambers. *Lituotuba C214* [*126*] has growth constrictions but no true septa.

COSCINOPHRAGMITINAE (C248)

131. .. .. .. .. .. .. *Bdelloidina* .. .. *C250* [*126*]

TEXTULARIIDAE (C250)

132. No initial coiled stage (mainly Subfam. TEXTULARIINAE plus Subfam. TAWITAWIINAE and Subfam. PSEUDOBOLIVININAE) .. .. .. .. 136

Note: Examine initial end very carefully. Specimens may have to be broken, sectioned, or soaked in aniseed oil to reveal initial coil.

Initial planispiral or streptospiral stage .. Subfam. SPIROPLECTAMMININAE .. 133
Initial trochospiral stage .. .. .. 161

SPIROPLECTAMMININAE (C251)

133. Aperture low interiomarginal arch; no uniserial stage .. .. .. .. .. 134
Aperture areal terminal in adult uniserial development .. .. .. .. .. 124

134. Initial planispiral coil .. .. .. 135
Initial streptospiral coil .. .. .. *Morulaeplectra* .. *C251* [*163*]

135. Acutely angled periphery; broad low chambers, outer edges curving down towards proloculus; finely arenaceous; adult or gerontic stage may be uniserial with areal slit in plane of compression *Vulvulina* .. .. *C251* [*163*]
Periphery rounded to fairly angular; chambers not low and broad; never any final uniserial development .. .. .. .. .. *Spiroplectammina*† .. *C251* [*163*]

Note: Microspheric specimens of *Textularia*† *C253* [*165*] may have initial coil.

TEXTULARIINAE (C253)

136. Aperture low interiomarginal arch .. .. 137
Aperture areal in adult; in early stages may be interiomarginal arch or slit-like up apertural face 138

137. Test attached, at least in early stages .. .. *Textularioides* .. *C255* [*165*]
Test free throughout life .. .. .. *Textularia*† .. .. *C253* [*165*]

Note: *Textulariella*† *C299* [*202*] has labyrinthic interior and exterior of microgranular calcite.

138. Aperture multiple in adult .. .. .. 139
Aperture single in adult .. .. .. 142

139. Test compressed; aperture linear series of openings across terminal portion of final chamber .. 140
Test rounded; aperture group of pores not in linear series .. .. .. .. .. 141

140. Interior simple .. .. .. .. *Poritextularia* .. .. *C254* [*165*]
Interior labyrinthic .. .. .. .. 145

141. Uniserial portion absent or of only few chambers; aperture one to three rounded openings .. 144
Uniserial portion well developed; aperture cribrate *Cribrobigenerina* .. *C254* [*166*]

Note: *Liebusella*† *C287* [*195*] has internal chamber partitions.

142. No true uniserial portion with horizontal sutures, although may tend towards uniseriality .. 143
Well developed uniserial portion with horizontal sutures .. .. .. .. .. *Bigenerina*† .. .. *C254* [*165*]

Note: *Vulvulina C251* [*163*] has terminal slit-like aperture in plane of compression.

PSEUDOBOLIVININAE (C255)

143. Roughly quadrangular in section .. .. *Siphotextularia*† .. *C258* [*168*]
Not quadrangular in section .. .. .. 144

144. Twisted biserial; aperture slit-like to rounded, terminal on short neck .. .. .. *Pseudobolivina*† .. *C255* [*167*]
Plane of growth not twisted; aperture one to three rounded openings, without neck .. .. *Planctostoma* .. .. *C256* [*168*]

TAWITAWIINAE (C258)

145. .. .. .. .. .. .. *Tawitawia* .. .. *C258* [*170*]

TROCHAMMINIDAE (C259)

146. Interior simple .. .. .. Subfam. TROCHAMMININAE .. 147
Interior partly divided by infolding of septial wall .. .. .. Subfam. REMANEICINAE .. 160

TROCHAMMININAE (C259)

147. Total number of visible chambers few (less than five), usually globose; form of coiling often difficult to see .. .. .. .. 148
Chambers numerous, usually somewhat flattened; obvious true trochospiral coil .. .. 151

148. Aperture areal, may be slit-like, paralleling and near to basal margin .. .. .. .. 149
Aperture interiomarginal .. .. .. 150

149. Coiling trochospiral; chambers domed to high-oviform; aperture slit or oval, close to basal margin .. .. .. .. .. *Cystammina*† .. .. *C263* [*177*]
Coiling planispiral; chambers rounded, embracing; aperture slit well removed from basal margin .. 116

150. Coiling trochospiral arenaceous isomorph of *Globigerina* .. .. .. .. *Trochammina*† .. *C259* [*173*]
Coiling streptospiral arenaceous isomorph of *Sphaeroidina* .. .. .. .. *Ammosphaeroidina*† .. *C259* [*174*]

Note: *Thalmannammina C226* [*136*] has more than three chambers visible externally. *Rugidia C587* [*462*] is calcareous, perforate with rugose appearance. *Adercotryma*† *C225* [*135*] is planispirally coiled with eccentric aperture.

151. Test free, not deformed .. .. .. 152
Test attached or deformed to shape of some attachment .. .. .. .. 159

152. With final stage uncoiling biserial .. .. 169
Coiled throughout .. .. .. .. 153

153. Low interiomarginal aperture only, extraumbilical-umbilical, usually difficult to see .. .. 154
With areal aperture or slit up apertural face .. 156

| | | | | | |
|---|---|---|---|---|---|
| 154. | Aperture rounded at end of forward directed siphon-like lobe at umbilical margin of final chamber .. | | *Siphotrochammina* | .. | *C266* [*174*] |
| | Aperture low arch or slit-like .. | | 155 | | |
| 155. | Ventral sutures sinuate; final chamber appears to be T-shaped | | *Tiphotrocha* | .. | *C266* [*174*] |
| | Ventral sutures curved not sinuate | | *Trochammina*† | .. | *C259* [*173*] |

Note: *Thalmannammina C226* [*136*] is streptospirally coiled. *Adercotryma*† *C225* [*135*] is planispirally coiled with eccentric aperture.

| | | | | | |
|---|---|---|---|---|---|
| 156. | Having slit-like aperture extending up apertural face; may have secondary aperture .. | | 157 | | |
| | Having rounded areal apertures without slit up apertural face | | 158 | | |
| 157. | With numerous circular openings near peripheral angle | | *Arenoparrella* | .. | *C262* [*173*] |
| | Without secondary cribrate aperture | | *Trochamminula* | .. | *C266* [*173*] |
| 158. | Two pairs of openings symmetrical on apertural face, lower pair large and ovate, upper pair small and rounded | | *Entzia* | .. | *C264* [*176*] |
| | One to several openings randomly placed on apertural face often with lips | | *Jadammina* | .. | *C265* [*176*] |

Note: *Tritaxis*† *C266* [*177*] is without primary low interiomarginal arch; flattened on umbilical side; usually attached in later stages. *Trochamminita C226* [*135*] is planispiral with final irregular chambers. *Recurvoides*† *C226* [*136*] is streptospirally coiled.

| | | | | | |
|---|---|---|---|---|---|
| 159. | Rather coarse-grained; three or four chambers per whorl; free-living early stage with areal ovate aperture with lip .. | | *Trixtaxis*† | .. | *C266* [*177*] |
| | Fine-grained; more than four chambers per whorl; flexible test bending round attachment | | *Rotaliammina* | .. | *C265* [*174*] |

## REMANEICINAE (C266)

| | | | | | |
|---|---|---|---|---|---|
| 160. | Test of agglutinated material | | *Remaneica*† | .. | *C266* [*178*] |
| | Test of secreted fusiform crystals of calcite | | 723 | | |

## ATAXOPHRAGMIIDAE (C268)

| | | | | | |
|---|---|---|---|---|---|
| 161. | Without internal pillars or partitions | | 162 | | |
| | With internal vertical pillars or partitions | Subfam. ATAXOPHRAGMIINAE | | .. | 181 |
| 162. | Without tooth protruding into aperture | | 163 | | |
| | With apertural tooth | Subfam. VALVULININAE | | .. | 174 |
| 163. | Initial part triserial, usually triangular in section | Subfam. VERNEUILININAE | | .. | 164 |
| | Initial part not triserial nor triangular, usually more than three chambers in initial whorl | Subfam. GLOBOTEXTULARIINAE | | .. | 169 |

## VERNEUILININAE (C268)

| | | | | | |
|---|---|---|---|---|---|
| 164. | Triserial and triangular throughout | | 165 | | |
| | Triserial reducing to biserial and even uniserial | | 166 | | |
| | Triserial increasing to five or more chambers per whorl | | 177 | | |
| 165. | Aperture interiomarginal, arched | | *Verneuilina*† | .. | *C268* [*179*] |
| | Aperture areal, terminal, rounded | | *Barbourinella* .. | .. | *C268* [*179*] |
| 166. | Final stage biserial | | 167 | | |
| | Final stage uniserial .. | | 168 | | |

167. Final stage irregularly spreading, aperture terminal rounded with lip on short neck .. .. *Rudigaudryina* .. *C272 [181]*
Straight biserial series; aperture interiomarginal, arched .. .. .. .. .. *Gaudryina*† .. .. *C269 [179]*

Note: Many species of *Gaudryina* show tendency toward *Tritaxia C272 [182]* by developing final uniserial stage with terminal aperture in gerontic specimens. Character of major part of population must determine generic position.

168. Final stage irregularly spreading .. .. *Rudigaudryina* .. *C272 [181]*
Straight uniserial stage .. .. .. *Tritaxia* .. .. *C272 [182]*

Note: See note for *Gaudryina* above.

## GLOBOTEXTULARIINAE (C273)

169. Growth into high spire; axis of coiling or growth same throughout .. .. .. .. 170
Coiling in low trochospiral; later biserial portion growing with axis perpendicular to axis of coil *Plectotrochammina* .. *C279 [185]*

170. Final stage with four chambers in the whorl .. *Globotextularia*† .. *C273 [183]*
Final stage triserial .. .. .. .. *Eggerella* .. .. *C275 [186]*

Note: *Tritaxis*† *C266 [177]* has flattened umbilical side attached to substrate.

Final stage biserial .. .. .. .. 171
Final stage uniserial .. .. .. .. 173

171. Aperture areal, may have rounded lip or short neck 172
Aperture interiomarginal .. .. .. *Dorothia*† .. .. *C275 [184]*

Note: *Textulariella*† *C299 [202]* has labyrinthic interior. *Morulaeplecta C251 [163, 164]* has initial streptospiral coil.

172. Chambers few, elongate, overhanging laterally, in polymorphine spiral; sutures at high angle .. 98
Chambers many, not elongate or strongly overhanging; sutures usually at low angle .. *Karreriella*† .. .. *C277 [186]*

173. Uniserial portion short (about six chambers); aperture terminal, cribrate .. .. .. *Cribrogoesella* .. *C273 [184]*

Note: *Goesella*† *C281 [188]* has rounded aperture with tooth. *Liebusella*† *C287 [195]* has labyrinthic interior.

Uniserial portion long, giving narrow, very elongate test; aperture variously aligned slits with bordering lips .. .. .. .. .. *Multifidella* .. .. *C277 [185]*

Note: *Martinottiella*† *C282 [188]* has single slit-like or arcuate aperture.

## VALVULININAE (C279)

174. With initial trochospiral coil .. .. .. 175
Uniserial throughout; no initial coil .. .. *Dusenburyina* .. .. *C281 [188]*

Note: *Cylindroclavulina*† *C281 [188]* has an initial coil which is often very difficult to see.

175. Initial portion triserial; usually triangular in section 176
Initial portion not triserial or triangular in section; usually more than three chambers in the initial whorl .. .. .. .. .. 179

176. Triserial throughout .. .. .. .. *Valvulina* .. .. *C279 [187]*
Only initial stage triserial .. .. .. 177

177. Later portion in loose spiral; five or more chambers to whorl; large plate with series of openings around edge covering umbilical region .. *Cribrobulimina* .. *C279 [187]*
Later portion uniserial .. .. .. 178

178. Initial portion triangular in section .. .. *Clavulina* .. .. *C279 [187]*
Initial portion rounded in section .. .. *Cylindroclavulina*† .. *C281 [188]*

| | | | | |
|---|---|---|---|---|
| 179. | Reducing to true uniserial development . . | 180 | | |
| | Reducing to loosely biserial | *Plectina* | *C283* | [*189*] |

Note: Some species may tend to develop a single terminal (uniserial) chamber in gerontic specimens.

| | | | | |
|---|---|---|---|---|
| 180. | Short uniserial development; aperture terminal, rounded with projecting tooth | *Goesella* | *C281* | [*188*] |
| | Long uniserial development giving narrow elongate test; aperture terminal elongate slit, commonly arcuate with bordering lip or short neck | *Martinottiella*† | *C282* | [*188*] |

Note: *Cylindroclavulina*† *C281* [*188*] has three chambers in initial coil.

ATAXOPHRAGMIINAE (C283)

| | | | | |
|---|---|---|---|---|
| 181. | Aperture interiomarginal; final stage biserial | 183 | | |
| | Aperture areal; final stage uniserial | 182 | | |
| 182. | Wall medium to coarsely arenaceous; aperture irregular or multiple | *Liebusella*† | *C287* | [*195*] |
| | Wall finely arenaceous with distinct pores; aperture circular with ring of teeth | *Tritaxilina* | *C291* | [*197*] |

PAVONITINIDAE (C291)

PAVONITININAE (C295)

| | | | | |
|---|---|---|---|---|
| 183. | | *Textulariella*† . . | *C299* | [*202*] |

## KEY TO RECENT GENERA OF SUBORDER MILIOLINA
(Loeblich and Tappan 1964 p. C436)

### MILIOLACEA (C436)

| | | | | |
|---|---|---|---|---|
| 184. | Unilocular | 185 | | |
| | Multilocular | 186 | | |
| 185. | Single globular chamber; attached | Fam. SQUAMULINIDAE | | 200 |
| | Undivided tubular chamber enrolled for most of its length | Fam. FISCHERINIDAE | | 191 |
| 186. | Coiled throughout or in annular series | 187 | | |
| | Uncoiling or rectilinear series, or, rarely, irregular mass | 190 | | |
| 187. | Chambers tubular to hemispherical, elongate in direction of growth | 188 | | |
| | Chambers not tubular in direction of growth | 189 | | |
| 188. | More than two chambers in planispiral or low trochospiral coil | Fam. FISCHERINIDAE | | 191 |
| | Two chambers in planispiral, streptospiral, or milioline coil | Fam. MILIOLIDAE | | 227 |
| 189. | Axis of coiling short; discoidal or lenticular | Fam. SORITIDAE | | 261 |
| | Axis of coiling long; sperical to fusiform | Fam. ALVEOLINIDAE | | 274 |
| 190. | Interior divided into chamberlets | Fam. SORITIDAE | | 261 |
| | Interior of chambers simple | Fam. NUBECULARIIDAE | | 201 |

## FISCHERINIDAE (C438)

| | | | | |
|---|---|---|---|---|
| 191. | Undivided tubular coiled chamber .. | Subfam. CYCLOGYRINAE .. | | 192 |
| | Series of tubular chambers in coil .. | Subfam. FISCHERININAE .. | | 195 |

## CYCLOGYRINAE (C438)

| | | | | |
|---|---|---|---|---|
| 192. | Streptospiral; tube may zigzag as it coils .. | 193 | | |
| | Planispiral; may uncoil in final stage .. .. | 194 | | |
| 193. | Simple streptospiral coiling; may be one or many changes of axis and plane of coiling .. .. | *Gordiospira* .. .. | | *C439* [*329*] |
| | Tube zigzagging as it coils .. .. .. | *Meandrospira* .. | | *C440* [*333*] |
| 194. | Rounded tubular throughout; uncoiling portion, if present, also rounded .. .. .. | *Cyclogyra*† .. .. | | *C438* [*329*] |
| | Later stages gradually uncoiling to flattened flabelliform portion .. .. .. .. | *Cornuspiroides*† .. | | *C438* [*329*] |
| | Later stage uncoiling to flattened, irregular, rectilinear, branching and spreading portion .. | *Cornuspirella*† .. | | *C438* [*329*] |

Note: *Cornuspiramia C447* [*338*] is attached with later branching portion divided by septa. *Tubinella*† *C477* [*365*] has straight unbranched uniserial portion.

## FISCHERININAE (C441)

| | | | | |
|---|---|---|---|---|
| 195. | Aperture simple open end of chamber, rounded to slit-like .. .. .. .. .. | 196 | | |
| | Aperture with bifid tooth, may be modified to rounded plate with central hole .. .. | 238 | | |
| | Aperture with broad flat apertural flap .. .. | 250 | | |
| | Aperture cribrate .. .. .. .. | 253 | | |
| 196. | Early quinqueloculine stage .. .. .. | 237 | | |
| | Early trochospiral stage .. .. .. | 219 | | |
| | Early streptospiral stage .. .. .. | 214 | | |
| | Early undivided cyclogyrine coil of up to three volutions .. .. .. .. | 197 | | |
| 197. | Adjacent whorls separated by thin plate .. | 214 | | |
| | Adjacent whorls in contact .. .. .. | 198 | | |
| 198. | Low trochospiral .. .. .. .. | *Fischerinella*† .. | | *C443* [*334*] |
| | Planispiral .. .. .. .. .. | 199 | | |
| 199. | No lateral laminae; initial whorls visible .. | *Fischerina*† .. .. | | *C441* [*334*] |
| | Laminae from each chamber covering entire test and obscuring initial whorls .. .. .. | *Planispirinella*† .. | | *C443* [*334*] |

## SQUAMULINIDAE (C444)

| | | | | |
|---|---|---|---|---|
| 200. | .. .. .. .. .. .. | *Squamulina* .. .. | | *C444* [*337*] |

## NUBECULARIIDAE (C445)

| | | | | |
|---|---|---|---|---|
| 201. | Chambers coiled throughout .. .. .. | 202 | | |
| | Chambers uncoiling to a rectilinear series possibly branching, or to an irregular mass .. .. .. .. .. | 203 | | |
| | Chambers becoming annular .. .. | Subfam. DISCOSPIRININAE .. | | 226 |
| 202. | Aperture simple open end of chamber .. | Subfam. OPHTHALMIDIINAE .. | | 209 |
| | Aperture with tooth or apertural flap .. | Subfam. SPIROLOCULININAE .. | | 215 |
| | Aperture with cribrate trematophore .. .. | 251 | | |

| | | | |
|---|---|---|---|
| 203. | Attached .. .. .. .. | Subfam. NUBECULARIINAE .. | 204 |
| | Free living .. .. .. .. | Subfam. NODOBACULARIINAE .. | 218 |

## NUBECULARIINAE (C445)

| | | | |
|---|---|---|---|
| 204. | No initial coil .. .. .. .. | 205 | |
| | Note: Examine initial end very carefully. Specimens may have to be broken, sectioned, or immersed in aniseed oil to reveal initial coil. | | |
| | With initial coil .. .. .. .. | 206 | |
| 205. | Chambers irregular, elongate; without fimbriate keel .. .. .. .. .. | *Calcituba*† .. .. | *C446* [*338*] |
| | Chambers more regular, inflated; with fimbriate keel and faint transverse "growth lines" .. | *Webbina* .. .. | *C448* [*338*] |
| 206. | True uniserial portion after initial coil .. .. | 207 | |
| | Group of irregular chambers in roughly coiled mass with no true uniserial development .. .. | *Nubecularia*† .. .. | *C445* [*338*] |
| | Note: *Parrina C478* [*365*] is not attached. *Glomulina C450* [*340*] is streptospirally coiled. | | |
| 207. | Coil of several chambers; uniserial portion not branching .. .. .. .. | 208 | |
| | Initial coil of single chamber of almost one whorl in length; later in irregular rectilinear series branching at frequent intervals .. .. | *Cornuspiramia* .. | *C447* [*338*] |
| 208. | Attached throughout; aperture against attachment; initial coil with arcuate chambers; later chambers short .. .. .. .. | *Nubeculopsis* .. .. | *C448* [*339*] |
| | Attached by initial end only; aperture not against attachment; initial coil with one to three tubular chambers; later elongate or with elongate neck | 223 | |

## OPHTHALMIDIINAE (C448)

| | | | |
|---|---|---|---|
| 209. | Two chambers to the whorl .. .. .. | 210 | |
| | One to numerous chambers in each whorl but not exactly two .. .. .. .. | 214 | |
| 210. | Globular with chambers streptospirally coiled .. | *Glomulina* .. .. | *C450* [*342*] |
| | Flat in planispiral coil with opposed chambers .. | 211 | |
| 211. | Aperture large rounded with large everted lip .. | *Weisnerella* .. .. | *C452* [*340*] |
| | Aperture does not have large everted lip .. | 212 | |
| 212. | Roughly rounded in outline .. .. .. | *Ophthalmina* .. .. | *C450* [*342*] |
| | Ovate to fusiform in outline .. .. .. | 213 | |
| 213. | Early coil and many succeeding chambers visible.. | *Ophthalmidium*† .. | *C448* [*340*] |
| | Only two to four elongate chambers visible on either side .. .. .. .. | *Edentostomina* .. | *C448* [*341*] |
| 214. | Planispirally coiled throughout; rarely more than three chambers in the final whorl .. .. | *Cornuloculina*† .. | *C448* [*340*] |
| | Early streptospiral coil; later planispiral with numerous chambers per whorl .. .. | *Zoyaella* .. .. | *C453* [*342*] |

## SPIROLOCULININAE (C453)

| | | | |
|---|---|---|---|
| 215. | Planispiral throughout .. .. .. | 216 | |
| | Final stage in milioline coil .. .. .. | 217 | |
| 216. | Two opposed chambers per whorl; most of earlier chambers visible; aperture with narrow single or bifid tooth .. .. .. .. | *Spiroloculina*† .. | *C453* [*343*] |
| | Note: *Riveroina C477* [*363*] has labyrinthic interior. | | |

| | | | | |
|---|---|---|---|---|
| | Two or three chambers in final whorl are only ones visible; aperture with apertural flap .. .. | *Planispironoides*† | .. | *C453* [*344*] |

Note: *Flintina C461* [*349*] has complex tooth. *Nummoloculina*† *C468* [*355*] has laminae which cover early milioline coil. *Planispirinella*† *C443* [*334*] has no apertural flap.

| | | | | |
|---|---|---|---|---|
| 217. | Quinqueloculine adult with rounded plate-like tooth which has central hole and ring of apertures around edge .. .. .. .. | *Cribrolinoides* .. | .. | *C453* [*343*] |
| | Triloculine adult with apertural flap .. .. | *Planispirinoides*† | .. | *C453* [*344*] |

NODOBACULARIINAE (C455)

| | | | | |
|---|---|---|---|---|
| 218. | Test compressed; apertural face long and thin .. | 219 | | |
| | Test not compressed; chambers and apertural face rounded to oval .. .. .. .. | 220 | | |
| 219. | Uniserial portion flaring and flabelliform; aperture row of slits in apertural face; early portion planispiral .. .. .. .. | 267 | | |
| | Test not flaring; aperture elongate slit along length of apertural face; early portion trochospiral .. | *Vertebralina* .. .. | | *C456* [*346*] |
| 220. | Later chambers regular, in rectilinear series; single aperture .. .. .. .. .. | 221 | | |
| | Later chambers irregular, in irregular uniserial development; typically with more than one aperture in final chamber .. .. .. | 259 | | |
| 221. | Initial coil of one or several tubular chambers, may be difficult to see .. .. .. .. | 222 | | |
| | *Initial coil of many non-tubular chambers* .. | *267* | | |
| 222. | Chambers pyriform or rounded with tubular neck; some agglutinated material; often attached by initial end .. .. .. .. | 223 | | |
| | Chambers tubular or rounded without distinct neck; no agglutinated material; never attached .. | 224 | | |
| 223. | Aperture rounded without lip .. .. .. | *Nodobacularia*† | .. | *C455* [*345*] |
| | Aperture with phialine lip and inwardly projecting teeth .. .. .. .. .. | *Nubeculina* .. .. | | *C456* [*346*] |
| 224. | With well developed initial milioline coil (usually quinqueloculine) .. .. .. .. | 260 | | |
| | No initial milioline coil; planispiral second chamber of approximately half coil in length .. .. | 225 | | |
| 225. | Chambers distinct; definite sutures and septa; rounded to slit-like, triradiate or cruciform aperture with lip .. .. .. .. | *Nodophthalmidium* .. | | *C456* [*345*] |
| | Chambers indistinct; vestigial septa visible in transmitted light; aperture simple open end of tube .. .. .. .. .. | 260 | | |

DISCOSPIRININAE (C457)

| | | | | |
|---|---|---|---|---|
| 226. | With well developed initial cyclogyrine coil .. | *Discospirina* .. .. | | *C457* [*348*] |

MILIOLIDAE (C458)

| | | | | |
|---|---|---|---|---|
| 227. | No uniserial development .. .. .. | 228 | | |
| | Uniserial development from milioline coil | Subfam. TUBINELLINAE .. .. | | 259 |
| 228. | Interior complex; each chamber divided into chamberlets .. .. .. | Subfam. FABULARIINAE .. | | 258 |
| | Interior simple .. .. .. .. | 229 | | |

| | | | |
|---|---|---|---|
| 229. | Aperture simple open end of tube .. | Subfam. QUINQUELOCULININAE .. | 230 |
| | Aperture with bifid tooth or modification of it, e.g., (1) rounded plate with central hole. (2) chevron, triradiate, cruciform, or dendritic slit .. .. .. | Subfam. QUINQUELOCULININAE .. | 230 |
| | Aperture with apertural flap .. .. | Subfam. MILIOLINELLINAE .. | 246 |
| | Aperture cribrate trematophore .. | Subfam. MILIOLINAE .. .. | 251 |

## QUINQUELOCULININAE (C458)

| | | | | |
|---|---|---|---|---|
| 230. | Exterior porcellaneous calcite .. .. .. | 231 | | |
| | Exterior with arenaceous covering .. .. | 244 | | |
| 231. | Streptospiral .. .. .. .. | 210 | | |
| | Planispiral adult .. .. .. .. | 232 | | |
| | Biloculine or sigmoidal adult .. .. .. | 242 | | |
| | Triloculine adult .. .. .. .. | 241 | | |
| | Quinqueloculine adult .. .. .. | 239 | | |
| 232. | Two chambers, rarely up to two and a half chambers per whorl .. .. .. | 233 | | |
| | Three chambers per whorl .. .. .. | 238 | | |
| 233. | With bifid, rarely single tooth .. .. .. | 234 | | |
| | No tooth present .. .. .. .. | 236 | | |
| 234. | Close-coiled; exactly two chambers per whorl .. | 235 | | |
| | Loose coil of about two and a half chambers per whorl or uncoiling .. .. .. | *Ptychomiliola* .. .. | | *C465* [*353*] |
| 235. | Planispiral throughout .. .. .. | 216 | | |
| | Initial quinqueloculine coil .. .. .. | *Massilina*† .. .. | | *C462* [*350*] |
| 236. | Initial quinqueloculine coil .. .. .. | 237 | | |
| | Planispiral throughout .. .. .. | 211 | | |

Note: Specimens may have to be broken, sectioned, or immersed in aniseed oil to reveal the initial coil.

| | | | | |
|---|---|---|---|---|
| 237. | With network of fine canals in wall .. .. | *Pseudomassilina* .. | | *C463* [*352*] |
| | Wall smooth .. .. .. .. | *Pateoris*† .. .. | | *C462* [*350*] |

Note: This may be a junior synonym of *Wellmanella C466* [*353*].

| | | | | |
|---|---|---|---|---|
| 238. | Aperture with simple bifid tooth on elongate neck | *Ptychomiliola* .. | | *C465* [*353*] |
| | Apertural plate with central hole developing from early bifid tooth; bar loops over to support plate; no neck .. .. .. .. | *Flintina* .. .. | | *C461* [*349*] |
| 239. | Apertural plate with central hole developing from early bifid tooth .. .. .. .. | 217 | | |
| | Aperture with simple bifid tooth .. .. | 240 | | |
| 240. | Test flattened with final chambers at 180° .. | *Massilina*† .. .. | | *C462* [*350*] |
| | Test not flattened; chambers at 144° throughout .. | *Quinqueloculina*† .. | | *C458* [*349*] |
| 241. | Aperture areal, triradiate, cruciform or dendritic .. | *Cruciloculina*† .. | | *C458* [*349*] |
| | Aperture rounded or elongate with simple or bifid tooth .. .. .. .. .. | *Triloculina*† .. .. | | *C466* [*353*] |
| 242. | Internal sigmoidal development; viewed from above, suture is sigmoidal .. .. .. | *Sigmoilina*† .. .. | | *C465* [*353*] |
| | Biserial throughout or quinqueloculine changing rapidly to biserial, penultimate chamber visible from one side only; keel and suture straight when viewed from above .. .. .. | 243 | | |
| 243. | Aperture with bifid tooth or low flat plate with lateral extensions .. .. .. .. | *Pyrgo*† .. .. | | *C465* [*352*] |
| | Aperture of areal slits, may be straight, chevron-shaped or almost dendritic .. .. .. | *Pyrgoella*† .. .. | | *C465* [*352*] |
| | Aperture of radiating slits between curved bars which meet in ring around small central hole .. | 255 | | |

244. Sigmoidal development of chambers; small tooth — *Sigmoilopsis*† .. *C466* [*353*]
Quinqueloculine throughout; bifid tooth .. 245

245. Aperture with crenulate margin .. .. *Dentostomina* .. *C458* [*350*]
Aperture with smooth, often porcellaneous margin and tooth .. .. .. .. *Siphonaperta*† .. *C466* [*351*]

Note: See Fam. RZEHAKINIDAE Couplet 99.

## MILIOLINELLINAE (C466)

246. Two chambers per whorl .. .. .. 247
Three to six chambers per whorl in planispiral coil 250

247. Planispiral and flat; many chambers visible .. 249
Biloculine; two chambers visible .. .. *Biloculinella*† .. *C467* [*355*]

Note: *Pyrgo*† *C465* [*352*] may have "flap" but with slight lateral extensions.

Triloculine; three chambers visible .. .. 248
Quinqueloculine; five chambers visible .. .. *Scutuloris*† .. .. *C468* [*356*]

Note: *Cribrolinoides C453* [*343*] has apertural plate with central hole and apertures around its edge.

248. With initial cyclogyrine coil .. .. .. 217
With initial quinqueloculine or triloculine coil .. *Miliolinella*† .. .. *C466* [*355*]

Note: *Flintina C461* [*349*] has flap with central hole and bar curving over to support it.

249. Chambers with internal oblique secondary septa .. 258
Chambers not labyrinthic .. .. .. 216

250. Laminae from each chamber covering most of previously formed exterior of test and obscuring sutures .. .. .. .. .. *Nummoloculina*† .. *C468* [*355*]
Chambers without laminae obscuring sutures .. 248

## MILIOLINAE (C468)

251. Porcellaneous surface .. .. .. 252
Arenaceous outer layer .. .. .. 257

252. Three to six chambers per whorl in planispiral coil 253
Two chambers per whorl in milioline coil .. 255

253. Rows of sutural pores and retral processes giving *Elphidium*-like appearance .. .. .. *Polysegmentina* .. *C472* [*359*]
Without sutural pores or retral processes .. 254

254. Compressed; lenticular to discoidal; evolute .. *Hauerina*† .. .. *C470* [*357*]
Globular; involute; only three chambers visible .. *Involvohauerina* .. *C472* [*359*]

Note: *Flintina C461* [*349*] has flap with central hole and holes around edge.

255. Test pyriform; aperture as radiate slits between curved bars which meet in ring around small central hole .. .. .. .. *Nevillina* .. .. *C472* [*359*]
Test globular, as *Pyrgo*; aperture cribrate trematophore .. .. .. .. .. 256

256. Interior simple, not divided into chamberlets .. *Cribropyrgo* .. .. *C470* [*357*]
Interior labyrinthic .. .. .. .. 258

257. Flat planispiral; early milioline stage; trematophore at peripheral angle .. .. .. *Ammomassilina* .. *C470* [*357*]
Milioline, but chambers added in more than five planes about vertical axis; trematophore in apertural face .. .. .. .. *Schlumbergerina* .. *C472* [*360*]

Note: See Fam. RZEHAKINIDAE Couplet 99.

## FABULARIINAE (C473)

| | | | | |
|---|---|---|---|---|
| 258. | Biloculine with cribrate aperture .. .. | *Fabularia* .. .. | *C473* [*362*] |
| | Planispiral with two opposed chambers per whorl; aperture areal, terminal, curved slit .. .. | *Riveroina* .. .. | *C477* [*363*] |

## TUBINELLINAE (C477)

| | | | | |
|---|---|---|---|---|
| 259. | Later chambers in rectilinear series .. .. | 260 | | |
| | Later chambers irregularly uniserial; commonly more than one asymmetrically placed aperture | *Parrina*† .. .. | *C478* [*365*] |

Note: *Nubecularia C445* [*338*] is attached with early cyclogyrine coil.

| | | | | |
|---|---|---|---|---|
| 260. | Vestigial milioline coil; simple proloculus with next chamber reversing direction of growth; typically lacks heavy longitudinal costae .. | *Tubinella*† .. .. | *C477* [*365*] |
| | Well developed milioline coil; usually heavy longitudinal costae .. .. .. .. | *Articulina* .. .. | *C478* [*365*] |

Note: *Ptychomiliola C465* [*353*] has small aperture with bifid tooth and no everted margin.

## SORITIDAE (C482)

| | | | |
|---|---|---|---|
| 261. | Chambers (in coiled, rectilinear, or flaring growth) divided into chamberlets, or many small chambers in annular series .. | 262 | |
| | Chambers (in coiled, uniserial rectilinear or flaring growth) not divided .. | Subfam. PENEROPLINAE .. | 264 |
| 262. | Uniserial rectilinear throughout .. | Subfam. RHAPYDIONININAE .. | 269 |
| | Planispiral or annular; test discoidal .. .. | 263 | |
| | Spherical mass of chamberlets .. .. | Subfam. KERAMOSPHAERINAE .. | 273 |
| 263. | Small chambers of many shapes which alternate more or less regularly with those of adjacent series; planispiral stage, if any, minute .. .. | Subfam. SORITINAE .. .. | 272 |
| | Chambers divided into rectangular chamberlets which do not alternate regularly with those of adjacent series; flaring planispiral with very curved almost spiral sutures; often final annular portion .. .. .. .. | Subfam. ARCHAIASINAE .. | 270 |

## PENEROPLINAE (C482)

| | | | | |
|---|---|---|---|---|
| 264. | Close-coiled throughout .. .. .. | 265 | | |
| | Uncoiling becoming uniserial .. .. .. | 267 | | |
| 265. | Aperture open end of tube; possibly simple slit up apertural face; no tooth .. .. .. | 196 | | |
| | Aperture with apertural flap .. .. .. | 260 | | |
| | Aperture dendritic slit .. .. .. | *Dendritina* .. .. | *C482* [*370*] |
| | Aperture cribrate or row of pores or slits .. | 266 | | |
| 266. | With rows of sutural pores and retral processes; early milioline stage .. .. .. | 253 | | |
| | Without sutural pores, retral processes or early milioline stage; may have ridges between sutures | *Peneroplis* .. .. | *C482* [*369*] |

Note: *Archaias C494* [*382*] has chambers divided into many rectangular chamberlets and has more swept back sutures.

| | | | |
|---|---|---|---|
| 267. | Test rounded in section; aperture single, rounded | 268 | |
| | Test very compressed and commonly flaring; aperture multiple, usually in row or rows .. | *Peneroplis* .. .. | *C482 [369]* |
| | Note: *Cornuspiroides*† *C438 [329]* may have growth lines, but no internal septa. | | |
| 268. | Aperture without neck or lip; tooth-like projections extending into opening .. .. .. | *Spirolina* .. .. | *C484 [371]* |
| | Aperture with slight neck or phialine lip; no teeth | *Monalysidium*.. .. | *C484 [369]* |
| | Note: *Vertebralina C456 [346]* has early trochospiral coil. | | |

RHAPYDIONININAE (C493)

| | | | |
|---|---|---|---|
| 269. | Attached; slightly narrower above basal expansion | *Craterites* .. .. | *C493 [381]* |
| | Free; conical .. .. .. .. | *Ripacubana* .. .. | *C493 [380]* |

ARCHAIASINAE (C494)

| | | | |
|---|---|---|---|
| 270. | Planispiral with spiralling septa and sutures; no transverse sutures .. .. .. .. | *Archaias* .. .. | *C494 [382]* |
| | Planispiral early stage, usually becoming very flaring, and finally annular; with transverse sutures .. .. .. .. .. | 271 | |
| 271. | Initial cyclogyrine coil of several whorls; aperture single row of slits around periphery .. .. | 226 | |
| | No initial cyclogyrine coil but well developed *Archaias*-type planispiral stage with spiralling sutures; aperture double row of pores .. | *Cyclorbiculina* .. | *C495 [383]* |

SORITINAE (C496)

| | | | |
|---|---|---|---|
| 272. | Single row of apertures and chambers round periphery .. .. .. .. .. | *Sorites* .. .. | *C496 [385]* |
| | Note: *Discospirina C457 [348]* has initial cyclogyrine coil. | | |
| | Double row of apertures and double row of alternating chambers from peripheral view .. | *Amphisorus* .. | *C496 [385, 386]* |
| | Numerous minute pores scattered in peripheral depression; test several chamberlets thick at periphery .. .. .. .. | *Marginopora* .. .. | *C498 [385]* |

KARAMOSPHAERINAE (C501)

| | | | |
|---|---|---|---|
| 273. | .. .. .. .. .. .. | *Karamosphaera* .. | *C501 [390]* |

ALVEOLINIDAE (C503)

| | | | |
|---|---|---|---|
| 274. | Spherical ball of chambers; simple growth outwards from central point; irregular to vermiform sutures | 273 | |
| | Planispiral; elongate axis of coiling, straight or gently curved sutures .. .. .. | 275 | |
| 275. | Spherical to fusiform; single row of apertures .. | *Borelis* .. | *C505 [393, 394]* |
| | Elongate fusiform; several rows of apertures .. | *Alveolinella* .. .. | *C506 [395]* |

## KEY TO RECENT GENERA OF SUBORDER ROTALIINA (Loeblich and Tappan 1964a, C511) WITH CLASSIFICATION OF SUPERFAMILIES

### Classification of Superfamilies of Suborder Rotaliina

| | | | |
|---|---|---|---|
| I | Test Calcite | | |
| A | Radial wall | | |
| | 1 Monolamellar: | | |
| | a. All forms with radiate aperture | Superfam. Nodosariacea | 343 |
| | b. All forms with apertural tooth or internal tooth plate | Superfam. Buliminacea | 409 |
| | c. Slit-like, rounded, or cribrate aperture without tooth-plate: | | |
| | i. Planispiral coil, uniserial or single chamber | Superfam. Nodosariacea | 343 |
| | ii. High trochospiral, biserial (may be enrolled) or uniserial | Superfam. Buliminacea | 409 |
| | iii. Low trochospiral coil | Superfam. Discorbacea | 463 |
| | 2 Rotaliid septa | Superfam. Rotaliacea | 526 |
| | 3 Bilamellar septa: | | |
| | a. Pelagic; typically with globular and/or hispid chambers | Superfam. Globigerinacea | 564 |
| | b. Benthonic; chambers not typically globular or hispid; wall usually thick | Superfam. Orbitoidacea | 586 |
| B | Granular wall | Superfam. Cassidulinacea | 646 |
| C | Wall of single crystal or few large crystals | Superfam. Spirillinacea | 515 |
| D | Wall of fusiform calcareous spicules | Superfam. Carterinacea | 723 |
| II | Test aragonite | Superfam. Robertinacea | 724 |

### Key to Families of Suborder Rotaliina

| | | | |
|---|---|---|---|
| 276. | Unilocular | .. 277 | |
| | Multilocular | .. 278 | |
| 277. | Single rather globular chamber | Fam. Glandulinidae | 393 |
| | Non-septate tube in planispiral or low trochospiral coil | Fam. Spirillinidae | 516 |
| 278. | Aperture radiate, possibly only as crenulate rim; test glossy | Superfam. Nodosariacea | 343 |
| | Aperture not radiate | .. 279 | |
| 279. | Exterior of single chamber only | Fam. Glandulinidae | 393 |
| | Exterior of two chambers only | .. 280 | |
| | Exterior of more than two chambers | .. 281 | |
| 280. | Aperture crescentic slit | Fam. Nonionidae | 676 |
| | Aperture absent or at ends of tubular canals piercing plug | Fam. Rotaliidae | 529 |
| 281. | Uniserial series; may be initial biserial or coiled stage | .. 282 | |
| | Biserial series; may be initial coil | .. 289 | |
| | Coil, spiral, flat sheet or ball of chambers | .. 295 | |
| 282. | Single globular chambers *irregularly* joined to one another, often by elongate stolons | Fam. Polymorphinidae | 382 |
| | Chambers in uniserial rectilinear or curved series | .. 283 | |
| 283. | Uniserial throughout | .. 285 | |
| | Early biserial stage | Fam. Bolivinitidae | 415 |
| | Early coiled stage | .. 284 | |

| | | | |
|---|---|---|---|
| 284. | Early planispiral or low trochospiral coil; axis of growth of uniserial stage perpendicular to axis of coiling of initial stage | .. 298 | |
| | Early high trochospiral coil; often triserial; axis of growth of uniserial stage continuation of initial axis .. .. | .. 330 | |
| 285. | Test elongate series of chambers .. | .. 286 | |
| | Test flat cone; chambers appear annular from apex .. .. .. | Fam. ANNULOPATELLINIDAE .. | 657 |
| 286. | Aperture rounded; often with tooth, lip, or neck .. .. .. .. | .. 287 | |
| | Aperture slit-like .. .. .. | .. 288 | |
| | Aperture cribrate .. .. .. | Fam. NODOSARIIDAE .. .. | 350 |
| 287. | Free-living .. .. .. .. | Fam. EOUVIGERINIDAE .. .. | 432 |
| | Attached .. .. .. .. | Fam. ROTALIIDAE .. .. | 529 |
| 288. | Aperture straight in plane of compression | Fam. NODOSARIIDAE .. .. | 350 |
| | Aperture C- or V-shaped in rounded test slight hood on one side .. .. | Fam. PLEUROSTOMELLIDAE .. | 654 |
| 289. | Test elongate; double series of chambers which may be straight enrolled, or twisted; without flattened terminal face of final two chambers .. .. | .. 290 | |
| | Test conical; flattened umbilical face of final two chambers .. .. | Fam. SPIRILLINIDAE .. .. | 516 |
| 290. | Early trochospiral stage, soon becoming biserial .. .. .. .. | .. 291 | |
| | Without early trochospiral stage; may be early enrolled or twisted biserial stage .. .. .. .. | .. 292 | |
| 291. | Early low trochospiral coil; biserial stage growing away at tangent to initial coil | Fam. CIBICIDIDAE .. .. | 609 |
| | Early high trochospiral coil; biserial stage grows up axis of initial coil .. | .. 330 | |
| 292. | Planispirally enrolled biserial series, at least in early stage; curved axis of growth .. .. .. | .. 293 | |
| | Twisted or flat biserial series; straight axis of growth .. .. .. | .. 294 | |
| 293. | Toothplate extending inwards from aperture to previous foramen; wall radial | Fam. ISLANDIELLIDAE .. | 429 |
| | No toothplate visible; wall granular .. | Fam. CASSIDULINIDAE .. .. | 670 |
| 294. | Wall radial; plane of addition of chambers flat throughout .. .. .. | Fam. BOLIVINITIDAE .. .. | 415 |
| | Wall granular; typically with plane of growth twisted at least in early stages | Fam. CAUCASINIDAE .. .. | 658 |
| 295. | Chambers in planispiral, streptospiral, or trochospiral coil .. .. .. | .. 296 | |
| | Chambers annular or encrusting or mass of chamberlets growing into ball or twig-like form .. .. .. | .. 335 | |
| 296. | Chambers in planispirally enrolled biserial series, alternating on either side of plane of coiling; may uncoil .. .. | .. 293 | |
| | Chambers in simple planispiral, streptospiral or trochospiral coil; may uncoil | .. 297 | |
| 297. | Surface hispid or finely cancellate; usually hundreds of long thin delicate spines on living specimens; chambers typically globular; pelagic .. .. .. | Superfam. GLOBIGERINACEA .. | 564 |

| | | | |
|---|---|---|---|
| | Surface not hispid or finely cancellate and without the many long delicate spines in living specimens; benthonic | .. | 298 |
| 298. | Chambers in symmetrical planispiral coil | .. | 299 |
| | Chambers in streptospiral coil; plane of coiling changing | .. | 302 |
| | Chambers in asymmetrical planispiral or trochospiral coil | .. | 304 |
| 299. | Chambers divided into chamberlets | Fam. NUMMULITIDAE | 559 |
| | Chambers not divided | .. | 300 |
| 300. | Aperture areal slit in plane of compression or cribrate, at or near peripheral angle | Fam. NODOSARIIDAE | 350 |
| | Aperture low interiomarginal slit or cribrate at base of, or in, apertural face | .. | 301 |
| 301. | Aperture row of pores at base of, or rarely in, apertural face; usually with sutural pores; spiral ridges between raised sutures or solid bars over depressed sutures; wall radial | Fam. ELPHIDIIDAE | 549 |
| | Aperture low interiomarginal arch; no sutural pores, spiral ridges or sutural bars; wall granular | Fam. NONIONIDAE | 676 |
| 302. | Aperture single | .. | 303 |
| | Aperture multiple | Fam. DISCORBIDAE | 468 |
| 303. | Aperture areal circular on slight neck with lip | Fam. SIPHONINIDAE | 505 |
| | Aperture interiomarginal arch, with or without tooth | Fam. SPHAEROIDINIDAE | 414 |
| 304. | Test trochospiral, completely evolute spiral side and involute umbilical side; may later uncoil or become annular | .. | 310 |
| | Test asymmetrical planispiral, or trochospiral with partly involute spiral side and/or partly evolute umbilical side | .. | 305 |
| 305. | With aperture extending up or isolated in apertural face; may also have interiomarginal arch | .. | 306 |
| | Aperture low interiomarginal arch only, or rarely absent | .. | 307 |
| 306. | Test aragonite | Fam. ROBERTINIDAE | 729 |
| | Test calcite | Fam. EPISTOMARIIDAE | 509 |
| 307. | Series of secondary chambers wedging between primary chambers on one side | Fam. AMPHISTEGINIDAE | 608 |
| | Without umbilical series of secondary chamberlets | .. | 308 |
| 308. | Aperture interiomarginal between periphery and umbilicus | Fam. DISCORBIDAE | 468 |
| | Aperture interiomarginal at periphery | .. | 309 |
| | Aperture absent or at ends of tubular canals piercing plug | Fam. ROTALIIDAE | 529 |
| 309. | Discoidal; both sides of test flattened with truncate periphery | Fam. CIBICIDIDAE | 609 |
| | Not discoidal | Fam. ANOMALINIDAE | 703 |
| 310. | Two chambers per whorl | Fam. SPIRILLINIDAE | 516 |
| | One to many chambers per whorl but not regular arrangement of two per whorl | .. | 311 |

| | | | |
|---|---|---|---|
| 311. | Ornamentation of radial costae or radial lines of pustules on flattened umbilical surface; commonly two specimens fused by umbilical surfaces .. .. | Fam. GLABRATELLIDAE .. | 502 |
| | No radial lines or pustules on umbilical surface; two specimens rarely fused by umbilical surfaces .. .. .. | .. 312 | |
| 312. | High trochospiral coil .. .. | .. 326 | |
| | Low trochospiral coil .. .. | .. 313 | |
| 313. | Ornamentation of either bars bridging depressed sutures or spiral ridges linking raised sutures .. .. | Fam. ELPHIDIIDAE .. .. | 549 |
| | No spiral ridges or bars across chambers | .. 314 | |
| 314. | Aperture sutural pores only .. .. | Fam. DELOSINIDAE .. .. | 669 |
| | Aperture interiomarginal or areal .. | .. 315 | |
| 315. | Aperture oval on neck with phialine lip, commonly with fimbriate keel .. | Fam. SIPHONINIDAE | 505 |
| | Aperture without neck and phialine lip .. | .. 316 | |
| 316. | Slits or elongate patches of clear shell material in lateral peripheral position | Fam. CERATOBULIMINIDAE .. | 725 |
| | Without lateral peripheral slits or elongate patches of clear shell material .. | .. 317 | |
| 317. | Six to thirty thick, blunt, longitudinally striated peripheral spines .. .. | Fam. CALCARINIDAE .. .. | 543 |
| | No thick blunt peripheral spines .. | .. 318 | |
| 318. | Test composed of secreted fusiform calcareous spicules embedded in calcareous ground mass .. .. .. | Fam. CARTERINIDAE .. .. | 723 |
| | Test not of fusiform calcareous spicules.. | .. 319 | |
| 319. | With secondary septa .. .. | .. 324 | |
| | Without secondary septa .. .. | .. 320 | |
| 320. | With umbilical plug or pillars, or pustulose area in centre of umbilical region .. | Fam. ROTALIIDAE .. .. | 529 |
| | Without umbilical plug, pillars or pustulose area .. .. .. .. | .. 321 | |
| 321. | With umbilical flaps projecting into umbilicus; umbilical side may be covered by final globose chamber .. .. | Fam. DISCORBIDAE .. .. | 468 |
| | Without umbilical flaps at any stage .. | .. 322 | |
| 322. | Primary aperture single slit up apertural face; extending from base or areal .. | Fam. OSANGULARIIDAE .. | 698 |
| | Primary aperture low interiomarginal only; may be supplementary apertural pores on spiral or umbilical side .. | .. 323 | |
| 323. | Planar or very low domed spiral side and elevated umbilical side .. .. | Fam. CIBICIDIDAE .. .. | 609 |
| | Biconvex or elevated spiral side .. | Fam. EPONIDIDAE .. .. | 596 |
| 324. | Test calcite; aperture low interiomarginal arch between periphery and umbilicus | Fam. ASTERIGERINIDAE .. | 507 |
| | Test aragonite; aperture umbilical extending as slit up apertural face .. | .. 325 | |
| 325. | Aperture extending as slit up apertural face .. .. .. .. | Fam. ROBERTINIDAE .. .. | 729 |
| | Aperture umbilical arch without slit up apertural face .. .. .. | Fam. CERATOBULIMINIDAE .. | 725 |
| 326. | Attached at initial end and growing upwards in loose spiral .. .. | Fam. ROTALIIDAE .. .. | 529 |
| | Not attached at initial end .. .. | .. 327 | |

| | | | |
|---|---|---|---|
| 327. | One to two chambers per whorl throughout | .. 334 | |
| | Triserial, $2\frac{1}{2}$–$3\frac{1}{2}$ chambers per whorl; may later become biserial or uniserial | .. 330 | |
| | Four or more chambers per whorl | .. 328 | |
| 328. | Sutures raised and granulate | Fam. ROTALIIDAE | 529 |
| | Sutures not raised | .. 329 | |
| 329. | With secondary septa; test aragonite | Fam. ROBERTINIDAE | 729 |
| | No secondary septa; test calcite | Fam. TURRILINIDAE | 413 |
| 330. | Single primary aperture | .. 331 | |
| | Multiple aperture, possible sutural | .. 333 | |
| 331. | Aperture rounded on neck or with pronounced lip, areal typically terminal | Fam. UVIGERINIDAE | 451 |
| | Aperture slit-like, arched, or loop-shaped up apertural face, typically interiomarginal | .. 332 | |
| 332. | With internal chamber partitions; test aragonite | Fam. ROBERTINIDAE | 729 |
| | Without internal partitions; test calcite | Fam. BULIMINIDAE | 437 |
| 333. | Aperture multiple in final chamber | Fam. BULIMINIDAE | 437 |
| | Aperture sutural pores only | Fam. DELOSINIDAE | 669 |
| 334. | Aperture loop-shaped up apertural face; test aragonite; chamber arrangement fairly regular | Fam. ROBERTINIDAE | 729 |
| | Aperture ovate, subterminal; test calcite; chamber arrangement very irregular | Fam. ISLANDIELLIDAE | 429 |
| 335. | Annular or encrusting; growth outwards from central point in two dimensions horizontally; test thin sheet or cone | .. 336 | |
| | Growth outwards from central point in three dimensions; each concentric layer of chambers covers whole of unattached area of test; domed to spherical forms | .. 342 | |
| | Growth upwards away from attachment; twig or bryozoan-like forms | Fam. HOMOTREMATIDAE | 640 |
| 336. | Flat or conical; only final annulus visible on lower surface | .. 337 | |
| | Growth of chambers in flat sheet; similar number of chambers visible above and below | .. 339 | |
| 337. | Each annulus only partially divided by radial tubules; growth actually compressed uniserial | Fam. ANNULOPATELLINIDAE | 657 |
| | Each annulus consisting of many distinct chambers | .. 338 | |
| 338. | Test of secreted fusiform calcareous spicules | Fam. CARTERINIDAE | 723 |
| | Test of granular calcite | Fam. CYMBALOPORIDAE | 636 |
| 339. | Each annulus a true tubular circle which may be divided into chamberlets | .. 340 | |
| | Each annulus of distinct contemporary chambers not forming complete or regular circle | .. 341 | |
| 340. | Annular chambers undivided; distinct sutural apertures | Fam. CIBICIDIDAE | 609 |
| | Annular chambers divided into chamberlets; aperture not sutural | Fam. NUMMULITINIDAE | 559 |

341. With single central aperture; chambers in ring around it .. .. .. Fam. HOMOTREMATIDAE .. 640
With one or two apertures on each of peripheral series of chambers .. Fam. PLANORBULINIDAE .. 624
No opening except mural pores .. Fam. ACERVULINIDAE .. .. 626

342. With thick blunt spines round periphery of lenticular forms or over whole of spherical types .. .. .. Fam. CALCARINIDAE .. .. 543
Without spines; domed (attached) or spherical .. .. .. Fam. ACERVULINIDAE .. .. 626

## NODOSARIACEA (C511)

343. Single chamber only .. .. .. Fam. GLANDULINIDAE .. 393
Multilocular .. .. .. .. 344

344. Uniserial throughout, regular or irregular .. 345
Biserial at least in early stages .. .. 347
Coiled at least in early stages .. .. .. 349

345. Irregular uniserial development; may branch, and/or one or more apertures on each chamber .. .. .. Fam. POLYMORPHINIDAE .. 382
Regular uniserial development with single aperture .. .. .. .. 346

346. With short entosolenian tube .. .. Fam. GLANDULINIDAE .. 393
Without entosolenian tube .. .. Fam. NODOSARIIDAE .. .. 350

347. Test compressed; periphery angular; uniserial chambers when present are chevron-shaped .. .. .. Fam. NODOSARIIDAE .. .. 350
Test rounded to compressed with well rounded periphery; chambers always globular to ovate .. .. .. .. 348

348. With entosolenian tube .. .. Fam. GLANDULINIDAE .. 393
Without entosolenian tube .. .. Fam. POLYMORPHINIDAE .. 382

349. Planispiral coil, rarely low trochospiral; may later uncoil .. .. .. Fam. NODOSARIIDAE .. .. 350
High trochospiral or sigmoidal coil; may later become biserial or uniserial (polymorphine coil) .. .. .. .. 348

## NODOSARIIDAE (C511)

350. Biserial at least in early stages .. Subfam. PLECTOFRONDICULARIINAE 376
No biserial stage .. .. .. .. 351

351. Aperture elongate slit only .. .. Subfam. LINGULININAE .. 378
Aperture rounded, cribrate, or radiate with or without additional small slit .. Subfam. NODOSARIINAE .. 352

## NODOSARIINAE (C512)

352. Test of single chamber or final chambers enveloping all previous chambers .. .. .. 353
Exterior of many chambers .. .. .. 354

353. Unilocular .. .. .. .. .. *Lagena*† .. .. *C518* [*404*]
Internal uniserial development but last chamber enveloping all previous chambers .. .. *Lagenoglandulina* .. *C518* [*404*]

354. Enrolled throughout .. .. .. .. 355
Uncoiling or rectilinear .. .. .. 356

| | | | | |
|---|---|---|---|---|
| 355. | With cribrate aperture | *Cribrorobulina* | .. | *C516* [*405*] |
| | With radiate aperture | *Lenticulina*† | .. | *C518* [*406*] |

Note: New Zealand forms with an enlarged slit in the apertural face are referred by Eade (1967) to *Robulus*.

| | | | | |
|---|---|---|---|---|
| 356. | Uncoiling | 357 | | |
| | Straight or uniformly curved uniserial series; no early coiled stage | 365 | | |
| 357. | Initial stage completely enrolled and involute with sudden change to rectilinear uniserial stage, usually with sutures near horizontal | 358 | | |
| | Early stage coiled but not usually tightly enrolled; uncoiling gradually; uniserial stage with sutures sloping down towards proloculus, although may be horizontal sutures between final few chambers | 361 | | |
| 358. | Uniserial portion triangular in section | *Saracenaria*† | .. | *C524* [*408*] |
| | Uniserial portion rounded in section | 359 | | |
| | Uniserial portion compressed | 360 | | |
| 359. | Initial coiled stage rounded periphery; aperture on neck | *Dimorphina* | .. | *C516* [*403*] |
| | Initial coiled stage with angular or carinate periphery; aperture not on neck | *Marginulinopsis*† | .. | *C521* [*403*] |

Note: *Vaginulinopsis*† *C524* [*410*] has neither initial angular periphery nor apertural neck. *Amphicoryna*† *C513* [*401*] has both, and initial stage which is not tightly enrolled.

| | | | | |
|---|---|---|---|---|
| 360. | With chevron-shaped sutures; very compressed | *Palmula* | .. | *C522* [*407*] |
| | With straight or slightly curved sutures; ovate in section | *Vaginulinopsis*† | .. | *C524* [*410*] |
| 361. | Triangular in section | *Saracenaria*† | .. | *C524* [*408*] |
| | Rounded in section | 362 | | |
| | Compressed | 363 | | |
| 362. | Aperture centrally situated on distinct neck with phialine lip; sutures in later stages horizontal | *Amphicoryna*† | .. | *C513* [*401*] |
| | Aperture at peripheral angle and maybe somewhat produced, but without true neck and lip; sutures oblique | *Marginulina*† | .. | *C520* [*406*] |

Note: *Marginulinopsis*† *C521* [*403*] has tightly enrolled initial coil.

| | | | | |
|---|---|---|---|---|
| 363. | With straight or curved sutures | 364 | | |
| | With chevron-shaped sutures | *Palmula* | .. | *C522* [*407*] |

Note: *Plectofrondicularia*† *C525* [*411*] has initial biserial stage in at least some members of a population.

| | | | | |
|---|---|---|---|---|
| 364. | Later chambers ovate in transverse section with rounded periphery | *Astacolus*† | .. | *C514* [*401*] |
| | Later chambers thin and flat with angular or carinate periphery | *Planularia*† | .. | *C522* [*407*] |
| 365. | Aperture radiate | 369 | | |
| | Aperture rounded (beware of damaged specimens), sometimes with teeth | 368 | | |
| | Aperture cribrate or ring of pores (modified radial) | 366 | | |
| 366. | Triangular in section | 446 | | |
| | Rounded to quadrangular or compressed in section | 367 | | |
| 367. | Aperture three to six pores in circle round central plate formed by fusion of radial ribs of a radiate aperture; microspheric form biserial | 377 | | |
| | Aperture of many randomly arranged pores; microspheric form not biserial | *Chrysalogonium* | .. | *C514* [*402*] |

Note: *Ripacubana C493* [*380*] has interior divided into chamberlets.

| | | | | |
|---|---|---|---|---|
| 368. | Aperture circular, smooth, without projecting teeth or internal tooth plate | *Orthomorphina*† | .. | *C522* [*407*] |
| | Aperture with indentation or crenulation of lip and internal tooth plate | 436 | | |

| | | | | |
|---|---|---|---|---|
| 369. | Rounded in section throughout | | 370 | |
| | Compressed, at least in early stages | | 374 | |
| 370. | Chambers near spherical; aperture with lip at end of long cylindrical neck usually with rings around it; later chambers often separated by stolons; initial uncoiling stage in microspheric form | *Amphicoryna*† | *C513* [*401*] | |
| | Chambers rarely spherical; aperture rarely with lip, may be produced but not on cylindrical neck; chamber addition similar throughout in micro- and megalospheric forms | | 371 | |
| 371. | Symmetrical; aperture central; sutures horizontal; test straight | | 372 | |
| | Asymmetrical, aperture eccentric and/or sutures oblique and/or test arcuate | | 373 | |
| 372. | Chambers, even in early stages, not strongly embracing | *Nodosaria*† | *C512* [*400*] | |
| | Note: *Entolingulina C539* [*422*] has entosolenian tube. | | | |
| | Chambers, at least in early stages, strongly embracing | *Pseudonodosaria*† | *C522* [*408*] | |
| | Note: *Lagenoglandulina C518* [*404*] has final chamber completely embracing all earlier chambers. | | | |
| 373. | Chambers, at least in early stages, strongly embracing | *Pandoglandulina* | *C522* [*408*] | |
| | Chambers, even in early stages, not strongly embracing | *Dentalina*† | *C516* [*403*] | |
| | Note: *Phlegeria* Loeblich and Tappan 1963, p. 213 Fig. 2, and *Tomaculoides* Loeblich and Tappan 1963, p. 213 Fig. 2, have short entosolenian tube. | | | |
| 374. | Compressed throughout | | 375 | |
| | Early chambers only compressed with chevron-shaped sutures, later chambers rounded in section | *Alfredosilvestris* | *C512* [*401*] | |
| | Note: *Amphimorphina C525* [*411*] has ribs of radial aperture fusing centrally. | | | |
| 375. | Aperture eccentric; sutures straight or slightly curved | *Vaginulina*† | *C524* [*410*] | |
| | Aperture central; sutures chevron-shaped | *Frondicularia*† | *C516* [*404*] | |
| | Note: *Plectofrondicularia C525* [*411*] has initial biserial portion in at least some members of a population. | | | |

## PLECTOFRONDICULARIINAE (C525)

| | | | | |
|---|---|---|---|---|
| 376. | Biserial throughout | *Bolivinella* | *C526* [*411*] | |
| | Uniserial with or without initial biserial stage | 337 | | |
| 377. | Compressed with angular to carinate margins | *Plectofrondicularia*† | *C525* [*411*] | |
| | Note: Recorded by Eade (1967) as *Proxifrons* a name given by Vella (1963) to the compressed flaring forms of *Plectofrondicularia.* | | | |
| | Rounded or (rarely) quadrangular in section | *Amphimorphina* | *C525* [*411*] | |
| | Note: *Paradentalina C533* [*417*] has a normal radiate aperture, not the ring of pores typical of this group. | | | |

## LINGULININAE (C528)

| | | | | |
|---|---|---|---|---|
| 378. | Unilocular; aperture slit down one edge | *Rimulina* | *C529* [*413*] | |
| | Multilocular; uniserial at least in later part | 379 | | |
| 379. | Early stage planispirally enrolled | *Lingulopsis* | *C528* [*412*] | |
| | Uncoiled uniserial throughout | 380 | | |
| 380. | With keeled margins and very elongate chambers | *Mucronina* | *C528* [*414*] | |
| | Rounded margins; chambers somewhat embracing | 381 | | |
| 381. | Without entosolenian tube | *Lingulina* | *C528* [*412*] | |
| | With entosolenian tube | 396 | | |

## POLYMORPHINIDAE (C530)

382. Attached .. .. .. .. Subfam. WEBBINELLINAE .. 390
Test free .. .. .. .. .. 383

383. Chambers in high trochospiral coil to biserial to regular uniserial series; single aperture; chambers overlapping Subfam. POLYMORPHININAE .. 384
Chambers in irregular uniserial series commonly branching; commonly several apertures per chamber and/or chambers joined by stolons .. .. Subfam. RAMULININAE .. .. 391

## POLYMORPHININAE (C530)

384. Biserial in early stages; may later become uniserial 385
Sigmoidal in early stages; may later become biserial 386
Two and a half chambers per whorl (chambers at 144°) in early stages; may later become biserial 388
Triserial (chambers at 120°) in early stages; may later become biserial .. .. .. *Pyrula*† .. .. *C533* [*416*]

Note: Initial coil form best seen if test is balanced on its aperture in thick gum tragacanth.

385. Biserial becoming uniserial .. .. .. *Paradentalina* .. .. *C533* [*417*]
Biserial throughout .. .. .. .. *Polymorphina* .. .. *C530* [*415*]

386. Chambers reach base of test .. .. .. *Sigmoidella*† .. .. *C533* [*418*]
Chambers overhanging but do not reach base each time .. .. .. .. .. 387

387. Sigmoidal throughout .. .. .. *Sigmomorphina*† .. *C533* [*418*]
Sigmoidal becoming flat biserial .. .. *Polymorphina* .. .. *C530* [*415*]

388. Later biserial stage .. .. .. .. *Pseudopolymorphina*† .. *C533* [*415*]
Five chambers per whorl throughout .. .. 389

389. Globular or ovate with sutures flush .. .. *Globulina* .. .. *C530* [*416*]
Elongate or ovate with sutures depressed .. *Guttulina*† .. .. *C531* [*416*]

## WEBBINELLINAE (C535)

390. Irregular uniserial growth, attached at initial end 542
Early polymorphine coil surrounded by flange-like chambers and spreading over substrate .. *Webbinella* .. .. *C535* [*420*]

Note: *Acervulina*† *C694* [*564*] has few globular chambers with coarse perforations.

## RAMULININAE (C537)

391. Chambers irregular and somewhat overlapping .. 392
Chambers near spherical, joined by stolons; apertures at ends of stolons or long necks .. *Ramulina*† .. .. *C537* [*420*]

Note: Uniserial members of *Nodosariinae C512* may have stolons but are regular with only single, usually radiate, aperture. *Siphouvigerina*† *C571* [*449*] has initial coil and internal tooth plate.

392. With many radiate apertures, several per chamber *Sporadogenerina* .. *C537* [*420*]
With single subterminal aperture .. .. 429

## GLANDULINIDAE (C537)

393. Unilocular or final chamber completely embracing all previous chambers .. .. 394
Chambers in loose high trochospiral coil to biserial or uniserial .. .. Subfam. GLANDULININAE .. 395

394. Unilocular .. .. .. .. Subfam. OOLININAE .. .. 403
Multilocular, final chamber embracing all earlier ones .. .. .. Subfam. SEABROOKIINAE .. 400

## GLANDULININAE (C537)

| | | | |
|---|---|---|---|
| 395. | Uniserial throughout . . | 396 | |
| | Biserial in early stages; may later become uniserial | 398 | |
| | Sigmoidal . . | *Laryngosigma*† | *C539* [*421*] |
| | High trochospiral with approximately three chambers per whorl | 399 | |
| 396. | Test straight, compressed; sutures not oblique . . | *Entolingulina* . . | *C539* [*422*] |
| | Test arcuate; rounded in section; sutures oblique | 397 | |
| 397. | Symmetrically added chambers; sutures not overlapping on one side of test; increasing gradually in size | *Phlegeria* (Loeblich & Tappan 1963 p. 212 Fig. 1) | |
| | Asymmetrically added chambers; sutures overlapping on one side; test of nearly constant breadth . . | *Tomaculoides* (Loeblich & Tappan 1963 p. 213 Fig. 2) | |
| 398. | Biserial becoming uniserial | *Glandulina*† . . | *C537* [*421*] |
| | Biserial throughout . . | *Esosyrinx* . . | *C539* [*421*] |
| 399. | Short free entosolenian tube | *Globulotuba* . . | *C539* [*421*] |
| | Long entosolenian tube attached to inner wall of final chamber | *Siphoglobulina* | *C539* [*421*] |

## SEABROOKIINAE (C540)

| | | | |
|---|---|---|---|
| 400. | Compressed ovate | *Seabrookia* . . | *C540* [*425*] |
| | Spherical or nearly so | 401 | |
| 401. | Aperture rounded; internal uniserial development | 353 | |
| | Aperture absent but large pores usually seen . . | 402 | |
| 402. | Surface cancellate or with long spines in living specimens; wall thin; internal trochospiral coil | 583 | |
| | Surface with beads or pustules of clear shelly material; wall thick; internal group of few chambers | 541 | |
| | Surface with many short thick spines; test composed of mass of small chambers . . | 548 | |

## OOLININAE (C540)

| | | | |
|---|---|---|---|
| 403. | No true aperture; many large mural pores; test perfectly spherical . . | 583 | |
| | One or several apertures; test globular to compressed . . | 404 | |
| 404. | Aperture rounded or radiate; circular in section . . | 405 | |
| | Aperture slit-like to oval or rounded in fissure-like cavity; test compressed | 407 | |
| 405. | Two or more stolons protruding from various points around test; asymmetrical | 391 | |
| | Single aperture or two symmetrically placed at opposite ends of test | 406 | |
| 406. | With entosolenian tube; with or without neck . . | *Oolina*† . . | *C540* [*425*] |
| | Without entosolenian tube; with neck . . | 353 | |
| 407. | Aperture slit along periphery . . | 408 | |
| | Aperture subterminal, on one side of test with projecting hood | *Parafissurina*† | *C541* [*425*] |
| 408. | Aperture at apex; with entosolenian tube . . | *Fissurina*† . . | *C540* [*425*] |
| | Aperture extending from apex half way down one side; without entosolenian tube | 378 | |

| | | | |
|---|---|---|---|
| 409. | Uniserial rectilinear series | Fam. EOUVIGERINIDAE | 432 |
| | Biserial rectilinear series; may become uniserial in later stages | Fam. BOLIVINITIDAE | 415 |
| | Enrolled, at least in early stages | 410 | |
| 410. | Planispirally enrolled biserial series | Fam. ISLANDIELLIDAE | 429 |
| | Streptospirally enrolled series | Fam. SPHAEROIDINIDAE | 414 |
| | High trochospiral coil; may become biserial or uniserial | 411 | |
| 411. | More than three chambers per whorl | Fam. TURRILINIDAE | 413 |
| | Less than three chambers per whorl | 412 | |
| 412. | Aperture loop-shaped in apertural face; no neck | Fam. BULIMINIDAE | 437 |
| | Aperture rounded terminal with neck | Fam. UVIGERINIDAE | 451 |

## TURRILINIDAE (C543)

### TURRILININAE (C543)

| | | | |
|---|---|---|---|
| 413. | Numerous chambers per whorl; chambers very high and narrow; sutures near vertical; aperture loop-shaped in apertural face | *Buliminella*† | *C543* [*426*] |
| | About five chambers per whorl; chamber not high and narrow; sutures oblique; aperture umbilical | *Buliminoides*† | *C544* [*426*] |

Note: *Angulodiscorbis C589* [*466*] has very low broad crescentic chambers; umbilical face perpendicular to axis of growth.

## SPHAEROIDINIDAE (C547)

| | | | |
|---|---|---|---|
| 414. | Chambers many; regular trochospiral coil with final chamber covering umbilical area | 578 | |
| | Chambers few; no early trochospiral coil visible, axis of coiling changing many times | *Sphaeroidina*† | *C547* [*432*] |

Note: *Sphaeroidinella*† *C673* [*541*] has cancellate surface with fimbriate flange around each chamber. *Allomorphina C743* [*611*] is involute planispirally coiled with asymmetrical aperture.

## BOLIVINITIDAE (C548)

| | | |
|---|---|---|
| 415. | Biserial becoming uniserial | 416 |
| | Biserial throughout | 422 |
| 416. | Uniserial chambers divided into many chamberlets | 433 |
| | Uniserial portion not divided into chamberlets | 417 |
| 417. | Aperture single, rounded, or slit-like; internal tooth plate or tube | 418 |
| | Aperture absent or multiple; row or ring of pores (modified radial aperture); without internal tooth or tube | 421 |
| 418. | Aperture subterminal slit with projecting hood on one side | 655 |
| | Aperture terminal or subterminal, rounded, without projecting hood | 419 |
| 419. | Wall granular; uniserial stage short with cuneate chambers | 667 |
| | Wall radial; uniserial stage well developed with rounded chambers | 420 |

| | | | |
|---|---|---|---|
| 420. | Internal twisted tooth plates of successive chambers alternating in position i.e. in planes 180° apart; megalospheric form often uniserial throughout | *Rectobolivina*† .. | *C553* [*438*] |
| | Internal twisted tooth plates of successive chambers added in plates 120° apart; microspheric form typically triserial in early stages .. .. | 462 | |
| 421. | Aperture absent or row of pores across terminal face of final compressed arcuate chamber .. | 450 | |
| | Aperture modified radial aperture; projecting radial bars fusing centrally leaving ring of rounded or eliptical openings .. .. .. .. | 377 | |
| 422. | Aperture areal .. .. .. .. | 427 | |
| | Aperture interiomarginal, may be indistinct .. | 423 | |
| 423. | Aperture slit-like, loop-shaped or high arch in apertural face; without radiating lines of pustules .. .. .. .. .. | 424 | |
| | Aperture indistinct; low arch with pustules radiating in lines from apertural area .. .. | 376 | |
| 424. | Rectangular in transverse section, four angles with well developed keels .. .. .. | *Bolivinita*† .. .. | *C548* [*434*] |
| | Not rectangular in section .. .. .. | 425 | |
| 425. | Wall granular .. .. .. .. | 665 | |
| | Wall radial .. .. .. .. | 426 | |
| 426. | Lower margins of chambers frilled and overlapping to give few broad to many small retral processes; test rounded or compressed .. .. | *Bolivina*† .. .. | *C549* [*434*] |
| | Lower margin of chambers straight or gently curved without crenulations or retral processes; test compressed, commonly keeled .. .. | *Brizalina*† .. | *C552* [*434, 436*] |

Note: *Stainforthia C561* [*442*] has large ∩ shaped aperture partly closed by tooth plate leaving only slit at one side. *Stainforthia* and *Virgulinopsis C572* [*449*] have initial, twisted biserial, or triserial stage.

| | | |
|---|---|---|
| 427. | Aperture subterminal slit with projecting hood on one side .. .. .. .. .. | 655 |
| | Aperture terminal or subterminal, rounded, without projecting hood .. .. .. | 428 |
| 428. | Test granular .. .. .. .. | 667 |
| | Test radial .. .. .. .. .. | 454 |

## ISLANDIELLIDAE (C556)

| | | | |
|---|---|---|---|
| 429. | Extremely irregular; chambers in smooth-sided high spiraling column; test elongate and slightly arcuate .. .. .. .. .. | *Orthoplecta* .. .. | *C556* [*439*] |
| | Planispirally enrolled biserial series, later stages may uncoil .. .. .. .. .. | 430 | |
| 430. | Initially enrolled, later uncoiling .. .. | 431 | |
| | Enrolled throughout .. .. .. | *Islandiella*† .. .. | *C556* [*439*] |

Note: *Cassidulina*† *C737* [*604*] has granular wall.

| | | | |
|---|---|---|---|
| 431. | Uncoiling portion rounded or compressed in plane of coiling of initial coil; two sides of test similar shape .. .. .. .. .. | *Cassidulinoides*† .. | *C556* [*439*] |
| | Uncoiling portion compressed perpendicular to plane of coiling of initial coil; concave and convex sides of very different appearance .. | *Reissia* Loeblich and Tappan 1964b, p. 28. | |

Note: *Ehrenbergina*† *C738* [*604*] has granular wall.

## EOUVIGERINIDAE (C556)

| | | | | |
|---|---|---|---|---|
| 432. | Regular undivided globular chambers in regular uniserial series | | 434 | |
| | Chambers divided into chamberlets or irregular chambers in irregular uniserial development | | 433 | |
| 433. | Chambers divided into honeycomb pattern | *Millettia* | | *C558* [*441*] |
| | Chambers very irregular; sutures irregular; test smooth arcuate | | 429 | |
| 434. | Uniserial rectilinear throughout; chambers globose typically without longitudinal costae | | 435 | |
| | Early coil, biserial stage or eccentric second chamber in at least some members of a population; chambers typically compressed with longitudinal costae | | 420 | |
| 435. | Aperture with circular smooth lip, without internal tooth plate | | 368 | |
| | Aperture with indentation or crenulation of phialine lip, and internal tooth plate | | 436 | |
| 436. | Aperture with smooth lip and small tooth or indentation of phialine lip | *Stilostomella*† | | *C559* [*440*] |
| | Aperture on slight neck with crenulate or dentate phialine lip and distinct apertural tooth | *Siphonodosaria* | | *C556* [*440*] |

Note: *Amphicoryna*† *C513* [*401*] does not have internal tooth plate.

## BULIMINIDAE (C559)

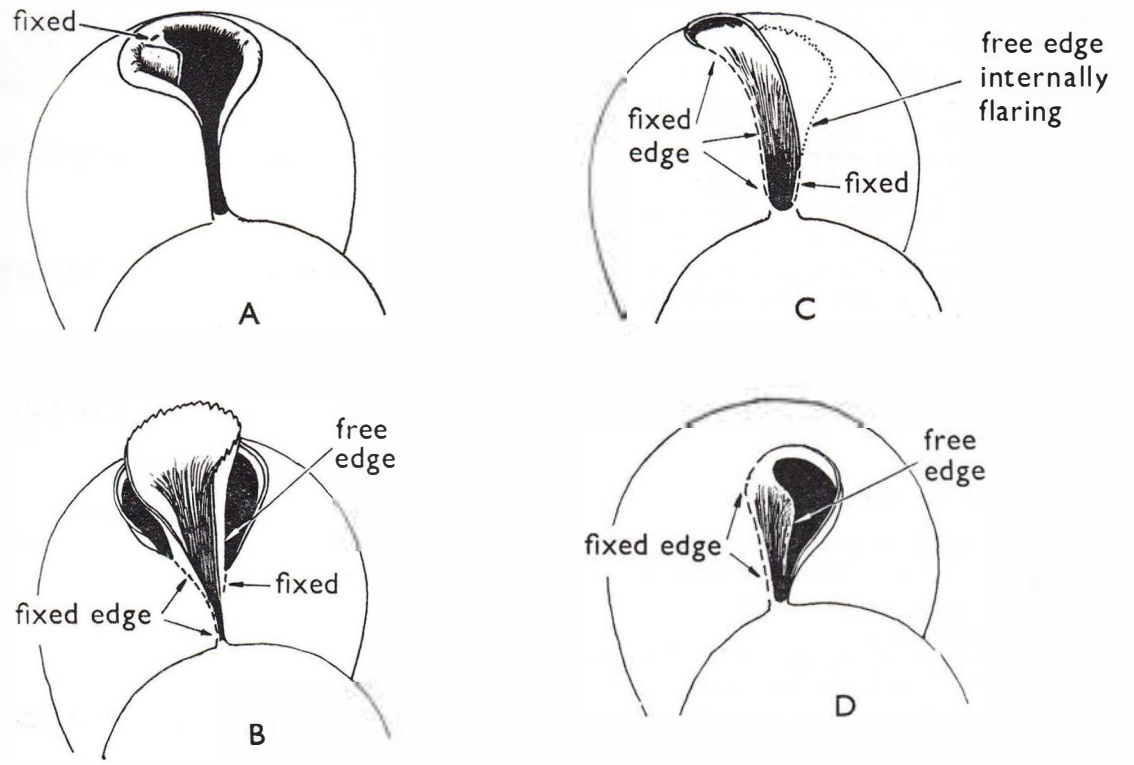
| | | | | |
|---|---|---|---|---|
| 437. | Aperture single | | 438 | |
| | Aperture multiple, or mural pores only | Subfam. PAVONININAE | | 446 |
| 438. | Aperture loop-shaped or slit-like up apertural face typically with tooth plate; may be areal, almost terminal | Subfam. BULIMININAE | | 439 |
| | Aperture low arch, interiomarginal, or areal paralleling base of final chamber | Subfam. PAVONININAE | | 446 |

## BULIMININAE (C559)

| | | | | |
|---|---|---|---|---|
| 439. | Triserial throughout; final chamber may tend to uniseriality | | 443 | |
| | Initially triserial becoming biserial, possibly twisted biserial | | 440 | |
| 440. | Chambers very compressed and cuneate in side view; aperture elongate slit occupying almost whole of distal face | | 449 | |
| | Chambers more rounded; aperture slit-like or loop-shaped in apertural face | | 441 | |
| 441. | Aperture more slit-like, commonly with lip; tooth plate distinct and only touching aperture at one point | | 442 | |
| | Aperture large ∩ shaped with tooth plate passing across and leaving only narrow slit or loop-shaped opening to chamber interior | *Stainforthia* | | *C561* [*442*] |

Note: *Virgulopsis*† *C561* [*442*] has pustulose surface and is recorded from the Recent of New Zealand.

| | | | |
|---|---|---|---|
| 442. | Wall radial | 456 | |
| | Wall granular | 668 | |




TEXT FIG. 1. Diagrammatic sketches of aperture: A. *Uvigerinella;* B. *Globobulimina;* C. *Praeglobobulimina;* D. *Bulimina.*

| | | | | |
|---|---|---|---|---|
| 443. | Internal tooth plate fused to final chamber along whole of one side of loop-shaped or elongate aperture; aperture usually without elevated rim or collar .. .. .. .. .. | 444 | | |
| | Internal tooth plate fused to final chamber only at single point; open rounded aperture, typically with elevated rim or collar (Text fig. 1A) .. | 460 | | |
| 444. | Curved fan-like portion of tooth plate projecting from aperture which is usually nearly terminal; chambers typically strongly embracing (Text fig. 1B) .. .. .. .. .. | *Globobulimina*† | .. | *C559* [*442*] |
| | No fan-like projection from aperture; tooth plate may flare internally; chambers rarely embracing | 445 | | |
| 445. | Aperture elongate extending up toward apex; free edge of tooth plate normally flaring internally and joined to lower edge of the aperture (Text fig. 1C) .. .. .. .. .. | *Praeglobobulimina*† | .. | *C561* [*442*] |
| | Aperture loop-shaped near base of apertural face; free edge of tooth plate not joined to lower margin of aperture (Text fig. 1D) .. .. | *Bulimina*† .. | .. | *C559* [*442*] |

PAVONININAE (C561)

| | | | | |
|---|---|---|---|---|
| 446. | Triserial throughout .. .. .. | 447 | | |
| | Triserial to biserial only .. .. .. | 448 | | |
| | Triserial, possibly via biserial, to uniserial .. | 450 | | |
| | Uniserial throughout .. .. .. | *Acostina* .. | .. | *C563* [*444*] |

| | | | |
|---|---|---|---|
| 447. | Aperture interiomarginal arch | *Reussella*† | *C563* [*445*] |
| | Aperture areal slit paralleling basal margin | *Trimosina* | *C565* [*445*] |
| | Aperture cribrate | *Fijiella* | *C563* [*444*] |
| 448. | Aperture in two parts, basal oval and nearly terminal rounded part; chambers globose, each with a single spine | *Mimosina* | *C563* [*445*] |
| | Aperture single slit or arch; chambers usually somewhat compressed with or without spine | 449 | |
| 449. | Aperture elongate slit up one side of compressed cuneate chamber; interior simple | *Valvobifarina* | *C565* [*445*] |
| | Aperture low arch in flattened chamber; interior labyrinthic | 183 | |
| 450. | Uniserial stage triangular or quadrate in section | *Chrysalidinella* | *C563* [*444*] |
| | Uniserial stage compressed with low broad arcuate chambers | *Pavonina* | *C563* [*444*] |

## UVIGERINIDAE (C565)

| | | | |
|---|---|---|---|
| 451. | With well developed biserial stage | 452 | |
| | No biserial stage, triserial and/or uniserial | 457 | |
| 452. | Initial stage only biserial, later well developed uniserial stage | 462 | |
| | Mainly biserial, may be initial triserial coil and/or final chamber or two may tend to uniseriality | 453 | |
| 453. | With angular periphery and twisted plane of growth | *Compressigerina* | *C565* [*446*] |
| | Test well rounded; plane of growth twisted or straight | 454 | |
| 454. | Aperture rounded, terminal | 455 | |
| | Aperture elongate extending up from base of chamber | 456 | |
| 455. | Aperture well removed from basal margin with phialine lip on slight neck | *Hopkinsina*† | *C567* [*446*] |
| | Aperture close to basal margin with lip but without neck | *Sagrina* | *C569* [*448*] |
| 456. | Aperture in imperforate apertural face; penultimate aperture not visible; toothplate narrow, not flaring, part of free edge with fimbriate margin | *Virgulinopsis* | *C572* [*449*] |
| | No imperforate apertural face; usually outer portion of penultimate aperture also visible; toothplate internally wide and flaring with fimbriate margin | *Sagrina* | *C569* [*448*] |
| 457. | Triangular in section | *Trifarina*† | *C751* [*450*] |
| | Rounded in section | 458 | |
| 458. | Later chambers loosely attached, with very deep sutures, or may be separated by stolons; apertural neck perforate | *Siphouvigerina*†* | *C571* [*449*] |
| | Chambers somewhat overlapping throughout; apertural neck, if present not perforate | 459 | |

*New Zealand species referable to *Siphouvigerina* are recorded as *Neouvigerina* by Eade (1967).

| | | | |
|---|---|---|---|
| 459. | Almost completely triserial, may tend to uniseriality in final chamber or two | 460 | |
| | Predominantly uniserial usually with early coiled or biserial stage | 462 | |
| 460. | Aperture oval to slit-like extending up from base of chamber, may have rim but no neck or phialine lip | *Uvigerinella* | *C572* [*449*] |
| | Aperture rounded, on neck with phialine lip | 461 | |

461. Straight and narrow tooth plate, base of which is attached to margin of previous foramen .. *Euuvigerina*† .. .. *C566* [*447*]
Tooth plate as above but with broad wing-like projection from one side .. .. .. *Uvigerina*† .. .. *C565* [*446*]

462. Triserial to uniserial .. .. .. .. *Rectouvigerina*† .. *C569* [*448*]
Biserial to uniserial .. .. .. .. *Siphogenerina*† .. *C569* [*449*]

Note: *Siphogenerina* has initial triserial stage in microspheric specimens *Rectobolivina*† *C553* [*438*] has tooth plates of successive chambers in planes 180° apart instead of 120° and is uniserial only in megalospheric specimens.

## DISCORBACEA (C572)

463. Aperture interiomarginal .. .. .. 464
Aperture areal .. .. .. .. 465

464. Aperture umbilical with radial grooves or radial rows of pustules on umbilical side only .. .. .. .. Fam. GLABRATELLIDAE .. .. 502
Aperture extraumbilical-umbilical .. .. 466

465. With pronounced neck and phialine lip .. Fam. SIPHONINIDAE .. .. 505
Without neck or phialine lip .. .. .. 466

466. Without internal partitions; commonly with umbilical chamber flaps .. Fam. DISCORBIDAE .. .. 468
With internal partitions, usually forming ring of chamberlets on umbilical side .. 467

467. With rosette of alternating chamberlets .. Fam. ASTERIGERINIDAE .. .. 507
Internal partitions confused or dividing off umbilical part of chamber .. Fam. EPISTOMARIIDAE .. .. 509

## DISCORBIDAE (C572)

468. Coiled test of two to four chambers .. Subfam. BAGGININAE .. .. 498
More than four chambers in trochospiral or asymmetrical planispiral coil .. .. 469

469. Without imperforate area above aperture Subfam. DISCORBINAE .. .. 470
With clear imperforate area above aperture Subfam. BAGGININAE .. .. 498

## DISCORBINAE (C572)

470. With two chambers per whorl, i.e., conical biserial, in later stages .. .. .. .. 497
Not regular arrangement of two chambers per whorl .. .. .. .. .. 471

471. With single chamber covering whole of umbilical side at least in megalospheric adult .. .. *Tretomphalus*† .. *C585* [*459*]
Without chamber covering umbilical side .. 472

472. Test minute (usually less than 64 $\mu$); aperture rounded umbilical with umbilical teeth .. 525
Adult usually retained in 64 $\mu$ (240 mesh) sieve; aperture extraumbilical-umbilical .. .. 473

473. True trochospiral, completely evolute spiral side and involute umbilical side; may have open umbilicus .. .. .. .. 474
Trochospiral, somewhat involute on spiral side and/or evolute on umbilical side .. .. 491

474. Biconvex or elevated spiral side .. .. 475
Flattened spiral side, elevated umbilical side .. 485

475. Without umbilical plug .. .. .. 476
With umbilical plug .. .. .. .. 488

| | | | | |
|---|---|---|---|---|
| 476. | Without supplementary apertures on spiral side .. | 477 | | |
| | With apertural slits which are sutural or paralleling suture on spiral side .. .. .. | 489 | | |
| 477. | Without pustulose or granulate coating of umbilical region .. .. .. .. | 478 | | |
| | With pustulose or granulate umbilical region .. | 490 | | |
| 478. | Chambers without secondary septa .. .. | 479 | | |
| | Chambers with secondary septa .. .. | 509 | | |
| 479. | Aperture low interiomarginal arch .. .. | 480 | | |
| | Aperture slit-like up apertural face .. .. | *Epistominella*† .. | *C578* [*453*] | |
| 480. | Periphery angular, sometimes carinate .. .. | 481 | | |
| | Periphery well rounded .. .. .. | 501 | | |
| 481. | Test auricular; imperforate area above aperture .. | 501 | | |
| | Test rounded; no imperforate area above aperture | 482 | | |
| 482. | Chambers not lunate; many to whorl .. .. | 483 | | |
| | Chambers lunate with final chamber occupying much of the periphery .. .. .. | *Neoconorbina*† .. | *C582* [*457*] | |
| 483. | Without very coarse perforation on umbilical side | 484 | | |
| | Final chamber with very coarse perforation (cribrate aperture) on umbilical side .. | 604 | | |
| 484. | Umbilical flaps coalescing over umbilicus .. | *Discorbis*† .. .. | *C572* [*451*] | |
| | Umbilical flaps not coalescing leaving open umbilicus .. .. .. .. | *Rosalina*† .. .. | *C584* [*459*] | |

Note: *Lamarkina*† *C769* [*631*] has umbilical aperture and test of aragonite.

| | | | | |
|---|---|---|---|---|
| 485. | Periphery keeled; wall radial .. .. .. | 486 | | |
| | Periphery not keeled, usually rounded; wall granular .. .. .. .. .. | 694 | | |
| 486. | Bilamellar; usually coarsely perforate, aperture low interiomarginal arch extending on to high domed umbilical side .. .. .. .. | 615 | | |
| | Monolamellar; usually finely perforate; aperture peripheral or extending on to spiral side; test usually compressed .. .. .. | 487 | | |
| 487. | Aperture low arch on flattened spiral side .. | *Planodiscorbis*† .. | *C583* [*458*] | |
| | Aperture peripheral on flattened spiral side .. | *Discorbinella*†* .. | *C575* [*453*] | |

*Some New Zealand species referred to *Discorbinella* by Loeblich and Tappan 1964a are recorded under *Discopulvinulina* by Eade (1967).

| | | | | |
|---|---|---|---|---|
| 488. | Without umbilical flaps .. .. .. | *Gavelinopsis*† .. .. | *C578* [*456*] | |
| | With umbilical flaps .. .. .. .. | *Discorbis*† .. .. | *C572* [*451*] | |

Note: *Pararotalia C612* [*486*] has internal "tooth plate" with areal intercameral foramen. *Cibicidoides C757* [*621*] has granular wall.

| | | | | |
|---|---|---|---|---|
| 489. | Supplementary apertures slit-like, along sutures on both sides of test .. .. .. .. | *Helenina* .. .. | *C580* [*457*] | |
| | Apertures on spiral side are areal, close to and paralleling spiral sutures, apertures on umbilical side perpendicular to radial sutures .. .. | 514 | | |
| 490. | With supplementary sutural apertures near periphery on umbilical side; primary aperture without pustulose lip .. .. .. .. | *Buccella*† .. .. | *C575* [*451*] | |
| | Without supplementary sutural apertures; primary aperture with thick pustulose lip .. .. | 603 | | |
| 491. | With double keel or keel plus angular peripheral ridge; both sides flat to concave .. .. | 495 | | |
| | With single keel or angular periphery; planoconvex | 492 | | |
| | Without keel, periphery well rounded; biconvex .. | 496 | | |

| | | | | |
|---|---|---|---|---|
| 492. | With broad peripheral keel; high-domed chambers with deep sutures between .. .. .. | *Laticarinina*† .. .. | *C580* [*457*] |
| | Keel not broad and flat; chambers not high-domed with deep sutures .. .. .. .. | 493 | |
| 493. | Convex side completely evolute .. .. | *Earlmyersia* .. .. | *C577* [*455*] |
| | Convex side partly evolute to involute .. .. | 494 | |
| 494. | Umbilical to sutural flaps with alar projections; tips of projections are fused to test near periphery leaving openings in front and behind; umbo on convex side .. .. .. .. | *Lamellodiscorbis* .. | *C580* [*456*] |
| | Umbilical flaps not modified with alar projections; without umbo on convex side .. .. | *Discorbinella*†* .. | *C575* [*453*] |

*Some New Zealand species referred to *Discorbinella* by Loeblich and Tappan 1964a are recorded under *Discopulvinulina* by Eade (1967).

| | | | | |
|---|---|---|---|---|
| 495. | With double keeled periphery; aperture peripheral ovate opening with lip .. .. .. | *Planulinoides*† .. | *C584* [*458*] |
| | Truncate periphery between marginal keel and unkeeled peripheral ridge; aperture slit-like beneath chamber flaps .. .. .. | *Bronnimannia*† .. | *C574* [*451*] |
| 496. | Involute on both sides; aperture peripheral slit up apertural face .. .. .. .. | *Stetsonia* .. .. | *C585* [*459*] |
| | Involute umbilical side, partly evolute spiral side; aperture umbilical .. .. .. .. | 500 | |
| 497. | With initial undivided spiral coil .. .. | 522 | |
| | With initial triserial or biserial development .. | *Patellinella*† .. .. | *C582* [*457*] |

## BAGGININAE (C586)

| | | | | |
|---|---|---|---|---|
| 498. | Two to four subglobular chambers arranged in coil | 499 | |
| | More than four chambers; trochospiral .. | 500 | |
| 499. | Wall thicker with rough appearance due to many knobs and ridges; aperture interiomarginal arch divided by bars .. .. .. .. | *Rugidia* .. .. | *C587* [*462*] |
| | Wall thin and smooth; aperture low interiomarginal arch .. .. .. .. | *Physalidia* .. .. | *C587* [*462*] |
| | Note: *Allomorphina C743* [*611*] has asymmetrical aperture. | | |
| 500. | Without umbilical flaps; partly involute on spiral side .. .. .. .. .. | *Baggina* .. .. | *C586* [*462*] |
| | With umbilical flaps extending over umbilical area; evolute spiral side .. .. .. .. | 501 | |
| 501. | Chamber rapidly enlarging, text auricular; commonly with keel .. .. .. .. | *Cancris*† .. .. | *C586* [*462*] |
| | Chambers increasing gradually in size; test and periphery rounded .. .. .. .. | *Valvulineria*† .. .. | *C587* [*462*] |

## GLABRATELLIDAE (C587)*

| | | | | |
|---|---|---|---|---|
| 502. | Low trochospiral .. .. .. .. | 503 | |
| | High trochospiral .. .. .. .. | 504 | |
| 503. | Aperture large ovate opening in umbilical area of final chamber; limbate sutures on spiral side .. | *Heronallenia*† .. | *C589* [*464*] |
| | Aperture inconspicuous, restricted to umbilicus; sutures on spiral side depressed .. .. | *Glabratella*† .. .. | *C588* [*464*] |
| | Note: Umbilical surfaces are often dissolved during plastogamy so specimens appear to have an oversized umbilical aperture. | | |

*This family is now placed in the ORBITOIDACEA (Loeblich and Tappan 1964b).

| | | | | |
|---|---|---|---|---|
| 504. | With flat umbilical face perpendicular to axis of growth, chambers low | *Angulodiscorbis* | .. | *C589* [*466*] |
| | With umbilical face at low angle to axis of growth; chambers high so test increases rapidly in size .. | 413 | | |

SIPHONINIDAE (C591)

| | | | | |
|---|---|---|---|---|
| 505. | Test subglobular without fimbriate keel; commonly with random blunt spines or pustules .. | *Siphoninoides* .. | .. | *C591* [*468*] |
| | Test compressed with fimbriate keel | 506 | | |
| 506. | Coiled throughout | *Siphonina*† | .. | *C591* [*468*] |
| | Uncoiling in later stages | *Siphoninella* | .. | *C591* [*468*] |

ASTERIGERINIDAE (C592)

| | | | | |
|---|---|---|---|---|
| 507. | Rosette of chamberlets wedged between primary chambers around umbilicus; aperture interiomarginal arch only; periphery typically angular | 508 | | |
| | Secondary septae or plates extending from apertural face to septa; aperture interiomarginal, areal or sutural; periphery typically rounded .. | 509 | | |
| 508. | Star-like rosette of diamond or leaf-shaped secondary chamberlets on high-domed umbilical side | *Asterigerina* .. | .. | *C592* [*469*] |
| | Ring of rounded secondary chamberlets on almost flat umbilical side .. | *Asterigerinata* .. | .. | *C592* [*469*] |

EPISTOMARIIDAE (C592)

| | | | | |
|---|---|---|---|---|
| 509. | Primary aperture in terminal face either extending up from the base, or areal .. | 510 | | |
| | Primary aperture low interiomarginal slit between umbilicus and periphery, often difficult to see .. | 513 | | |
| 510. | Aperture divided by vertical partition into two parallel slits or rows of perforations .. | *Palmerinella* | .. | *C598* [*473*] |
| | Aperture simple slit or rounded | 511 | | |
| 511. | Periphery rounded | 512 | | |
| | Periphery with single keel or angular | 492 | | |
| | Periphery with double keel and truncate | 495 | | |
| 512. | Without secondary septa; aperture elongate slit extending from base diagonally across apertural face | 496 | | |
| | With secondary septa dividing off umbilical series of chamberlets; aperture loop-shaped in apertural face, or rarely areal | *Eponidella* | .. | *C595* [*472*] |

Note: *Cerobertina*† *C781* [*641*] and *Ceratobulimina*† *766* [*630*] have test of aragonite.

| | | | | |
|---|---|---|---|---|
| 513. | With bars of clear shell material bridging sutures.. | *Epistomaroides* | .. | *C594* [*473*] |
| | Without bars of shell material bridging sutures .. | 514 | | |
| 514. | With supplementary slit-like apertures on spiral side near to, and paralleling spiral sutures; tooth plate, if present, vertically across chamber between spiral and umbilical sides | *Pseudoeponides* | .. | *C598* [*474*] |
| | Without supplementary apertures on spiral side, chambers divided by numerous secondary septa projecting inwards from periphery and apertural face | *Torrosina* | .. | *C598* [*474*] |

## SPIRILLINACEA (C598)

| | | | | |
|---|---|---|---|---|
| 515. | Three chambers per whorl in trochospiral coil; aperture umbilical with teeth; test very small | Fam. ROTALIELLIDAE | | 525 |
| | Undivided tubular chamber or regular arrangement of two chambers per whorl | Fam. SPIRILLINIDAE | | 516 |

## SPIRILLINIDAE (C598)

| | | | | |
|---|---|---|---|---|
| 516. | Enrolled non-septate tube | Subfam. SPIRILLININAE | | 517 |
| | Conical biserial series with flattened umbilical side | Fam. PATELLININAE | | 522 |

## SPIRILLININAE (C600)

| | | | | |
|---|---|---|---|---|
| 517. | Discoidal, planispiral or almost so | 518 | | |
| | Conical, trochospiral | 520 | | |
| 518. | One side covered with pustules obscuring coiling | *Planispirillina*† | | *C602* [*475*] |
| | Both sides similarly ornamented | 519 | | |
| 519. | Whorls separated from one another by solid plate-like areas of calcite | *Sejunctella* | | *C602* [*477*] |
| | Whorls lie in contact with one another | *Spirillina*† | | *C600* [*475*] |

Note: *Cyclogyra*† *C438* [*329*] has imperforate porcellaneous wall.

| | | | | |
|---|---|---|---|---|
| 520. | Hollow cone, all coils visible on spiral and umbilical sides | *Turrispirillina* | | *C602* [*477*] |
| | Only last-formed whorl visible on umbilical side | 521 | | |
| 521. | Umbilical side involute | *Conicospirillina* | | *C600* [*475*] |
| | Umbilical side evolute but central area of high cone filled with clear or laminated calcite plug | *Alanwoodia* | | *C600* [*476*] |

## PATELLININAE (C602)

| | | | | |
|---|---|---|---|---|
| 522. | Primary chambers not divided by secondary septa | 523 | | |
| | Primary chambers divided by secondary septa | 524 | | |
| 523. | Initial undivided spiral tube of one or two volutions | *Patellinoides* | | *C604* [*477*] |
| | Two or three chambers in initial whorl | 497 | | |
| 524. | Numerous incomplete secondary septa; initial undivided coil of one or two volutions; wall radial | *Patellina*† | | *C603* [*477*] |
| | Interior labyrinthic; three or more chambers in initial whorl; wall agglutinated very fine-grained calcite | 183 | | |

## ROTALIELLIDAE (C604)

| | | | | |
|---|---|---|---|---|
| 525. | | *Rotaliella* | | *C604* [*478*] |

## ROTALIACEA (C605)

| | | | | |
|---|---|---|---|---|
| 526. | With sutural pores and typically spiral ridges which either bridge depressed sutures or link raised sutures | Fam. ELPHIDIIDAE | | 549 |
| | Without sutural pores or spiral ornamentation | 527 | | |
| 527. | Test with large, longitudinally striated peripheral spines | Fam. CALCARINIDAE | | 543 |
| | Without longitudinally striated peripheral spines | 528 | | |

528. Planispiral or annular; typically compressed .. .. .. .. Fam. NUMMULITIDAE .. .. 559
Trochospiral; not compressed .. .. Fam. ROTALIIDAE .. .. 529

## ROTALIIDAE (C605)

529. One to four inflated chambers visible, arranged side by side or embracing previous chambers .. .. Subfam. PEGIDIINAE .. .. 541
Many chambers visible in trochospiral coil, possibly becoming uniserial .. .. 530

530. Not attached; low to fairly high trochospiral coil with umbilical plug or pustulose area .. .. .. Subfam. ROTALIINAE .. .. 531
Attached by initial end, later growing upwards in high trochospiral coil; without umbilical plug or pustulose area .. .. .. .. Subfam. RUPERTININAE .. 542

## ROTALIINAE (C605)

531. With three slender spines radiating from test; spines continuous from umbilicus .. .. *Asterorotalia* .. .. *C608* [*482*]
Without elongate spines .. .. .. 532

532. Test very globose; relatively high trochospiral coil with strongly convex spiral and umbilical sides; chambers well rounded .. .. *Asanoina* .. .. *C607* [*481*]
Test not so globose and/or with angular periphery 533

533. With areal foramen; commonly chambers pointed or each with short peripheral spine or scattered pustules .. .. .. .. .. *Pararotalia* .. .. *C612* [*486*]
Interiomarginal foramen .. .. .. 534

534. With double row of sutural canals and pores on both sides of test, may be difficult to see around granular thickening of sutures .. .. *Pseudorotalia* .. .. *C613* [*487*]
Without sutural pores or canals on spiral side .. 535

535. With central glassy plug in open umbilicus; plug may be divided by fissures into many pillars, but is continuous to proloculus .. .. 536
With central pustulose area, pustules or pillars not continuous from one whorl to next .. .. 537

536. Septa double; periphery typically rounded .. *Ammonia*† .. .. *C607* [*479*]
Note: *Cibicidoides C756* [*621*] has granular wall.
Septa single; periphery typically angular .. 488

537. With thickened pustulose apertural lip, pustulose area is visible remains of previous lips, typically well elevated spiral side .. .. .. 603
Without thickened pustulose apertural lip .. 538

538. Test granular; perforations in pustulose area lead to cavity beneath .. .. .. .. 692
Test radial; no cavity under pustulose area .. 539

539. Monolamellar septa; finely pustulose or granulate umbilical region; small sutural slits near periphery on umbilical side .. .. .. 490
Rotallid septa; umbilical region coarsely pustulose or with pillars or plug; may have sutural slits 540

| | | | |
|---|---|---|---|
| 540. | With single glassy plug often divided by fissures in adult | *Ammonia*† | *C607* [*479*] |
| | No early stage with undivided glassy plug; umbilical pillars not continuous from one whorl to the next | *Rotalia*† | *C606* [*479, 480*] |

PEGIDIINAE (C625)*

| | | | |
|---|---|---|---|
| 541. | Test sublenticular; two to four chambers in apposition or coil; pustulose side separated from smooth side by broad keel | *Pegidia* | *C625* [*498*] |
| | Test globular; final chamber pustulose and strongly embracing | *Sphaeridia* | *C626* [*498*] |

Note: *Orbulina C675* [*541*] has cancellate surface without large pustules.

*This group has been transferred by Loeblich and Tappan (1964b) to the Orbitoidacea as the Family PEGIDIIDAE.

RUPERTININAE* (C627)

| | | | |
|---|---|---|---|
| 542. | Aperture interiomarginal slit with lip | *Rupertina* | *C627* [*499*] |
| | Aperture rounded, terminal, with lip or neck of non-perforate calcite | *Biarritzina*† | *C628* [*499*] |

*This group has been transferred by Loeblich and Tappan (1964b) to the Orbitoidacea as a subfamily of the CIBICIDIDAE.

CALCARINIDAE (C628)

| | | | |
|---|---|---|---|
| 543. | Lenticular; spines around periphery | 544 | |
| | Spherical; spines randomly distributed | 548 | |
| 544. | Trochospiral throughout | 545 | |
| | Early coiled stage; later covering of small chambers in layers over whole test | 547 | |
| 545. | Three long slender smooth spines radiating from proloculus | 531 | |
| | Three or more spines which are usually thick with striations, not continuing to proloculus | 546 | |
| 546. | Foramen areal, restricted by internal tooth plate; one spine on each chamber | 533 | |
| | Foramen interiomarginal, without internal tooth plate; spine growth somewhat irregular around periphery | *Calcarina* | *C628* [*500*] |
| 547. | Early minute planispirally coiled stage | *Baculogypsina*† | *C629* [*501*] |
| | Early well developed trochospiral stage | *Baculogypsinoides* | *C629* [*501, 502*] |
| 548. | Minute initial coil; later concentric layers of small chambers | *Schlumbergerella* | *C629* [*503*] |
| | Well developed trochospiral stage with few concentric layers of small chambers | *Baculogypsinoides* | *C629* [*501, 502*] |

ELPHIDIIDAE (C631)

| | | | |
|---|---|---|---|
| 549. | Trochospiral | Subfam. FAUJASININAE | 557 |
| | Planispiral and uncoiling | | 550 |
| 550. | With vertical ridges up apertural face; spiral ridges somewhat irregular; minute anastomosing canals passing through wall and umbilical plug | Subfam. FAUJASININAE | 557 |
| | Without ridges up apertural faces; spiral ridges, if present, straight; without anastomosing canals in walls, canals in septa and umbilical plug simple | Subfam. ELPHIDIINAE | 551 |

## ELPHIDIINAE (C631)

| | | | | |
|---|---|---|---|---|
| 551. | Whole of apertural face covered with pores; test porcellaneous .. | 266 | | |
| | With row of pores at base of apertural face possibly with few additional pores in apertural face | 552 | | |
| 552. | With retral processes | 553 | | |
| | Without retral processes but may have solid bars crossing sutural depression | 555 | | |
| 553. | Later stage uncoiling | *Ozawaia* | | *C640* [*510*] |
| | Close coiled throughout | 554 | | |
| 554. | Septa double in upper half, single in lower half; umbilical plug, if any, small; sutural pores single | *Elphidium*† | | *C631* [*505, 506*] |
| | Septa completely double; umbilical plug often very large, often double row of sutural pores | *Cellanthus* | | *C635* [*507*] |
| 555. | With double row of sutural pores; commonly with grooves extending from pores onto chamber wall on either side | *Elphidiella* | | *C638* [*508*] |
| | With single row of pores, may be difficult to see | 556 | | |
| 556. | With single opening or row of pores at base of apertural face plus one or more areal pores in apertural face | *Cribroelphidium*† | | *C635* [*508*] |
| | With basal slit or row of pores; no areal aperture | *Cribrononion* | | *C637* [*509*] |

Note: Forms with granular walls are referred to the Fam. NONIONIDAE, Couplet 676.

## FAUJASININAE (C640)

| | | | | |
|---|---|---|---|---|
| 557. | Planispiral .. | *Parrellina* | | *C642* [*513, 515*] |
| | Trochospiral | 558 | | |
| 558. | With supplementary umbilical chamberlets; aperture low interiormarginal arch, areal slit may be visible; ornamentation solid pillars across depressed sutures | 513 | | |
| | Without supplementary chamberlets; aperture row of pores near base of apertural face; ornamentation of spiral ribs between elevated sutures | *Polystomellina*† | | *C642* [*513*] |

Note: Hornibrook (1967) and Eade (1967) prefer to retain the name *Notorotalia* for South Pacific species.

## NUMMULITIDAE (C643)

| | | | | |
|---|---|---|---|---|
| 559. | Simple planispiral; not divided into chamberlets | Subfam. NUMMULITINAE | | 560 |
| | Annular or flaring planispiral; chambers divided into chamberlets | Subfam. CYCLOCLYPEINAE | | 561 |

## NUMMULITINAE (C645)

| | | | | |
|---|---|---|---|---|
| 560. | .. .. .. .. .. .. | *Nummulites*† .. | | *C645* [*518, 519*] |

## CYCLOCLYPEINAE (C647)

| | | | | |
|---|---|---|---|---|
| 561. | Flaring planispiral chambers divided into chamberlets, possibly final few chambers annular | 562 | | |
| | Annular series of chamberlets; initial flaring planispiral stage may rarely be seen | 563 | | |

562. Test perforate, radial; aperture interiomarginal arch, single row of terminal slits, or absent .. *Heterostegina* *C650 [518, 521]*
Test imperforate, porcellaneous; aperture single or double row of pores on peripheral face of last chamber .. .. .. .. .. 270

563. Test perforate radial; mural pores but no proper apertures .. .. .. .. *Cycloclypeus* .. *C647 [518, 521]*
Test imperforate porcellaneous; peripheral apertures .. .. .. .. .. 272

## GLOBIGERINACEA (652)

564. Adult planispiral; aperture equatorial .. Fam. HANTKENINIDAE .. .. 566
Adult trochospiral or streptospiral, aperture umbilical to extraumbilical-umbilical; rarely sutural or areal .. .. .. 565

565. Aperture umbilical in adult or with areal or sutural pores; may have bulla .. Fam. GLOBIGERINIDAE .. .. 573
Aperture extraumbilical-umbilical in adult .. .. .. .. Fam. GLOBOROTALIIDAE .. 569

### HANTKENINIDAE (C663)

### HASTIGERININAE (C663)

566. Test finely hispid all over .. .. .. 567
Chambers with few broad trigonally prismatic spines concentrated at periphery .. .. 568

567. Chambers radially elongate .. .. .. *Boliella* .. .. *C665 [531]*
Chambers rounded to ovate .. .. .. *Hastigerina*† .. *C663 [531 No. 1]*

Note: Parker (1962) would prefer to retain the name *Globigerinella* for this group.

568. Chambers rounded to ovate; planispiral throughout *Hastigerina*†* *C663 [531 No. 2–4]*
Chambers radially elongate; later part streptospirally coiled .. .. .. .. 577

*Bé (1965) thinks that the type species of *Hastigerina* and *Hastigerinella* are merely the adult and gerontic stages of the same species. Parker (1962) "would like to see the combination of *Hastigerina* and *Hastigerinella* into one genus rather than *Hastigerina* and *Globigerinella*." Banner and Blow (1960) are convinced that the types are not conspecific or congeneric, and retain *Hastigerina* and *Hastigerinella* in the same sub-family. Loeblich and Tappan (1964b) refer the two "genera" to different families.

### GLOBOROTALIIDAE (C666)

### GLOBOROTALIINAE (C666)

569. With angular imperforate periphery, usually with keel .. .. .. .. .. *Globorotalia*† .. *C667 [533, 534]*
With more rounded perforate periphery, no keel .. 570

570. Chamber radially elongate .. .. .. 577
Chambers not radially elongate .. .. 571

571. With single chamber covering umbilical region .. 584
Without chamber covering umbilicus .. .. 572
Chambers well rounded and/or with apertural lip or teeth .. .. .. .. .. 581

572. Somewhat compressed spiral side and elevated umbilical side; without apertural lip .. .. *Turborotalia*† .. .. *C668 [533]*

Note: Eade (1967) includes species of *Turborotalia* in the genus *Globorotalia*.

## GLOBIGERINIDAE (C669)

573. With large umbilical (to slightly extra-umbilical) aperture, clearly visible in adult; may be additional sutural apertures .. .. .. .. Subfam. GLOBIGERININAE .. 576
Without large umbilical aperture in typical adult; aperture areal or sutural pores, or around edge of umbilical bulla .. .. 574

574. With umbilical bulla in typical adult .. Subfam. CATAPSYDRACINAE .. 584
Without umbilical bulla .. .. .. 575

575. Test thick; aperture sutural below frilled flange .. .. .. .. Subfam. SPHAEROIDINELLINAE .. 582
Test thin-walled; aperture multiple areal or small sutural .. .. .. Subfam. ORBULININAE .. .. 583

## GLOBIGERININAE (C669)

576. Chambers radially elongate .. .. .. 577
Chambers globular .. .. .. .. 578

577. Test finely hispid all over .. .. .. *Beella*† .. .. *C669* [*537*]
Test with few broad trigonally prismatic spines concentrated at periphery .. .. .. *Hastigerinella*†* .. *C671* [*539*]

*See footnote to couplet 568

578. Without final embracing umbilical chamber; bullae do not have thickened glassy lip .. .. 579
Final chamber embracing entire umbilical side; aperture interiomarginal with thickened glassy lip; surface smooth .. .. .. *Pulleniatina*† .. .. *C671* [*539*]
Note: *Tretomphalus*† *C585* [*459*] has cribrate aperture.

579. With secondary sutural apertures on the spiral side *Globigerinoides*† .. *C670* [*536*]
Without secondary sutural apertures .. .. 580

580. Aperture umbilical throughout life; no apertural lip or flaps .. .. .. .. *Globigerina*† .. .. *C669* [*536*]
Aperture extraumbilical-umbilical at least in young stage; commonly with apertural lip or flap .. 581

581. Chambers increasing rapidly in size and strongly inflated; surface coarsely cancellate; apertural lip .. .. .. .. .. *Subbotina* .. .. *C673* [*539*]
Chambers not increasing so rapidly in size; surface hispid, smooth, or cancellate; aperture becoming umbilical in adult; commonly with lip or umbilical teeth .. .. .. .. *Globorotaloides* .. *C671* [*540*]
Note: *Globoquadrina* †*C670* [*539*], which keys out here, is regarded as a Recent genus by Eade (1967).

## SPHAEROIDINELLINAE (C673)

582. .. .. .. .. .. .. *Sphaeroidinella*† .. *C673* [*541*]
Note: Bé (1965) infers that this form is merely the gerontic stage of *Globigerinoides sacculifera.*

## ORBULININAE (C675)

583. Single spherical chamber, usually with internal Globigerina-like coil .. .. .. *Orbulina*† .. .. *C675* [*541*]
High trochospiral coil with small sutural apertures almost completely surrounding later chambers *Candeina*† .. .. *C675* [*541*]
Note: *Globigerinoides C670* [*536*] has few large sutural openings.

## CATAPSYDRACINAE (C676)

584. Final chamber globose and enveloping entire umbilical side; single aperture with thick glassy lip .. .. .. .. .. 578
With umbilical bulla or bulla-like extension of final chamber, aperture usually multiple around edge of bulla; without thickened lips .. .. 585

585. With bulla-like extension of final chamber extending across umbilical region .. .. .. *Globigerinita*† .. *C676 [543]*
With true umbilical bulla .. .. .. *Tinophodella* .. .. *C678 [543]*

Note: Most pelagic species have occasional specimens with a bulla, but *Tinophodella* includes those forms in which the vast majority of adult specimens have a bulla.

## ORBITOIDACEA (C678)

586. Test free; in low trochospiral or planispiral coil, or may be strongly embracing .. .. 587
Test attached; commonly annular or encrusting or growing upwards from attachment .. .. .. .. 590

587. Many chambers visible in spiral series .. .. 588
One or two chambers visible which embrace earlier chambers .. .. Subfam. PEGIDIINAE .. .. 541

588. Spiral side flattened .. .. .. Fam. CIBICIDIDAE .. .. 609
Test biconvex .. .. .. .. 589

589. With rosette of chamberlets around umbilicus .. .. .. Fam. AMPHISTEGINIDAE .. 608
Without umbilical series of chamberlets.. Fam. EPONIDIDAE .. .. 596

590. Coil or at least initial coiled portion, with flattened spiral side .. .. .. 591
Initial coil, if present, with spiral side not flattened .. .. .. .. .. 592

591. Low coil not growing away from attachment; with umbilical aperture .. Fam. HOMOTREMATIDAE .. 641
Coiled portion with peripheral aperture, may later spread over substrate or grow upwards .. .. .. Fam. CIBICIDIDAE .. .. 609

592. Encrusting forms .. .. .. .. 593
Growth upwards from attachment; may branch .. .. .. .. .. 595

593. All chambers visible above and below .. .. 594
Only peripheral chambers visible on lower surface .. .. .. .. Fam. CYMBALOPORIDAE .. 636

594. Apertures at periphery, one or two per chamber, each with lip .. .. Fam. PLANORBULINIDAE .. 624
No apertures except mural pores .. Fam. ACERVULINIDAE .. .. 626

595. Test multitude of small chambers; several pores per chamber; bryozoan-like forms Fam. HOMOTREMATIDAE .. 641
Test of few to several dozen chambers in spiral series, with single aperture .. Fam. CIBICIDIDAE .. .. 609

## EPONIDIDAE (C678)

596. Test attached by umbilical surface; later chambers spreading over substrate .. .. .. 607
Test free .. .. .. .. .. 597

| | | | | |
|---|---|---|---|---|
| 597. | Test globular with high spiral and umbilical sides, sutures raised and granulate | 532 | | |
| | Test not globular with raised granulate sutures | 598 | | |
| 598. | Aperture umbilical; test aragonite | 727 | | |
| | Aperture equatorial to extraumbilical-umbilical; test calcite | 599 | | |
| 599. | Aperture interiomarginal at periphery | 717 | | |
| | Aperture between periphery and umbilicus | 600 | | |
| 600. | Supplementary apertural pores on spiral side or both sides | 606 | | |
| | Supplementary apertural pores on umbilical side only | 604 | | |
| | Without supplementary apertural pores | 601 | | |
| 601. | Wall granular | 693 | | |
| | Wall radial | 602 | | |
| 602. | Wall monolamellar | 480 | | |
| | Wall bilamellar | 603 | | |
| 603. | High-domed spiral side; apertural lip much thickened | *Neoeponides*† | | *C680* [*547*] |
| | Lenticular; apertural lip not greatly thickened | *Eponides*† | | *C678* [*544*] |

Note: *Globorotalia*† *C667* [*533*] usually has a cancellate or hispid surface and is pelagic.

| | | | | |
|---|---|---|---|---|
| 604. | Supplementary areal pores scattered over umbilical surface of final chamber | *Poroeponides* | | *C683* [*546*] |
| | Supplementary apertures in row paralleling periphery | 605 | | |
| 605. | With umbilical pustulose area | 490 | | |
| | Without umbilical pustulose area | *Paumotua* | | *C682* [*546*] |
| 606. | Wall granular; sutures on umbilical side typically sinuate | 695 | | |
| | Wall radial; sutures on umbilical side typically almost radial | 514 | | |
| 607. | Spiral side (upper) pustulose | *Planopulvinulina* | | *C682* [*546*] |
| | Spiral side not pustulose | 638 | | |

AMPHISTEGINIDAE (C685)

| | | | | |
|---|---|---|---|---|
| 608. | Not symmetrical; unequally biconvex and/or chamberlets clearly visible on one side | *Amphistegina* | | *C685* [*549*] |
| | Symmetrical; equally biconvex without rosette of chamberlets round umbo | 560 | | |

CIBICIDIDAE (C685)

| | | | | |
|---|---|---|---|---|
| 609. | Partly evolute or evolute on both sides; biplanar or biconcave with truncate periphery | Subfam. PLANULININAE | | 610 |
| | Flattened spiral side with domed involute umbilical side at least in early stages | Subfam. CIBICIDINAE | | 612 |

PLANULININAE (C686)

| | | | | |
|---|---|---|---|---|
| 610. | Primary aperture low equatorial interiomarginal arch | 611 | | |
| | Primary aperture areal and somewhat oblique, or absent | 495 | | |
| 611. | Supplementary apertures beneath umbilical flaps on less evolute side | *Planulina*† | | *C686* [*552*] |
| | Apertures beneath umbilical flaps on both sides | *Hyalinea* | | *C686* [*552*] |

Note: *Paromalina*† *C763* [*627*] has perforate periphery and granular wall.

## CIBICIDINAE (C687)

612. Close-coiled throughout .. .. .. 613
Early coiled stage, later uncoiling or annular .. 621

613. Aperture at periphery, may extend slightly on to umbilical and spiral sides .. .. .. 614
Aperture not peripheral; may reach umbilicus .. 618

614. With supplementary sutural apertures either at periphery or on umbilical side .. .. 615
No supplementary sutural apertures at periphery or on umbilical side .. .. .. .. 616

615. With supplementary apertures at proximal margin of each chamber on periphery .. .. *Caribeanella* .. .. *C688* [*555*]
With supplementary apertures at proximal margin of each chamber near umbilicus giving effect of umbilical flaps projecting into umbilicus .. *Montfortella* (Loeblich and Tappan 1963: 213, Figs. 7–9b)

Note: *Helenina C580* [*457*] has rounded periphery, aperture extending to umbilicus and monolamellar wall.

616. Wall radial .. .. .. .. .. 617
Wall granular .. .. .. .. 716

617. Wall monolamellar; test compressed .. .. 487
Wall bilamellar; test not typically compressed .. *Cibicides*† .. .. *C688* [*554*]

618. Aperture extending to umbilicus .. .. 619
Aperture not reaching umbilicus .. .. 620

619. Wall radial; usually attached by flat spiral side; peripheral keel .. .. .. .. 645
Wall granular; not attached; usually without keel 699

620. Aperture between periphery and umbilicus on high-domed umbilical side .. .. .. 694
Aperture on spiral side; umbilical side low-domed 487

621. Later stages biserial, possibly to uniserial .. 622
Later stages annular .. .. .. .. *Cyclocibicides* .. .. *C690* [*554*]
Later stages irregular or spreading network .. 623

622. Wall granular; typically uniserial but sutures may be oblique; finely perforate .. .. .. 704
Wall radial; more typically biserial or staggered uniserial; coarsely perforate .. .. *Dyocibicides*† .. .. *C690* [*556*]

623. Later chambers closely arranged around initial coil; single large aperture per chamber .. *Cibicidella*† .. .. *C690* [*554*]

Note: *Carpentaria*† *C707* [*580*] has chambers arranged around single central chamber.

Later chambers in loose network spreading over attachment; several apertures per chamber .. *Planorbulinoides* .. *C691* [*558*]

## PLANORBULINIDAE (C692)

624. Later chambers in open network; apertures on projecting necks round edge of each chamber against attachment .. .. .. 623
Compact throughout; one or two peripheral interiomarginal apertures to each chamber of outer series .. .. .. .. 625

625. Regular annular series; outer row alternating with previous ring of chambers .. .. .. *Planorbulinella* .. *C694* [*563*]
Irregular series .. .. .. .. *Planorbulina*† .. *C693* [*561*]

Note: *Cibicidella C690* [*554*] has large initial *Cibicides*-type coil with few later irregular chambers.

## ACERVULINIDAE (C694)

626. Chambers numerous (hundreds) .. .. 627
Chambers few (up to several dozen) .. .. 633

627. Thin encrusting sheet; single layer of chambers, or may irregularly encrust its own early growth .. 628
Test of several layers of chambers; usually with one layer alternating with those of row below; typically growing into domed or spherical mass 629

628. Chambers globular .. .. .. .. *Acervulina*† .. .. *C694* [*564*]
Chambers vermiform.. .. .. .. *Planogypsina* .. .. *C698* [*568*]

Note: *Miniacina*† *C705* [*577*] and *Sporadotrema C705* [*578*] (couplet 644) have pores of two types.

629. Test spherical .. .. .. .. 630
Test a dome of chambers, possibly irregularly protruding in places .. .. .. 631

630. Chambers rounded, rectangular, or polygonal with many pores per chamber .. .. .. *Sphaerogypsina* .. *C698* [*569*]
Chambers irregular with only single pore at margin of each chamber .. .. .. .. 273

631. Surface with pores of two sizes .. .. 644
Surface with pores of only one size; commonly with limbate sutures .. .. .. 632

632. Interior with layers of chambers .. .. *Gypsina*† .. *C694* [*566*, *567*]
Interior with large passages and irregular hollows due to resorption .. .. .. .. 643

633. Initial polymorphine coil with radiate aperture .. 390
Initial coil not polymorphine with radiate aperture 634

634. Initial coil with flattened spiral side as *Cibicides* .. 623
Initial coil not like *Cibicides* .. .. .. 635

635. Chambers globose; with deep sutures; surface with many fairly large perforations .. .. *Acervulina*† .. .. *C694* [*564*]
Chambers not globose or with deep sutures; upper surface pustulose .. .. .. .. 607

## CYMBALOPORIDAE (C698)

636. Test conical; chambers alternating in annular series *Cymbaloporetta*† .. *C701* [*570*]
Test discoidal or flattened; chambers in annular series or irregular .. .. .. 637

637. Aperture several series of pores in vertical lines on peripheral face, commonly sutural; initial coil obscured .. .. .. .. *Cymbaloporella* .. *C699* [*570*]
Aperture on umbilical side; commonly a series of areal and/or sutural pores; initial coil usually obvious .. .. .. .. .. 638

638. Aperture series of pores commonly in rows and sutural .. .. .. .. .. 639
Aperture umbilical with sutural slit or slits .. 484

639. Surface smooth .. .. .. .. *Pyropilus* .. .. *C702* [*575*]
Surface pustulose .. .. .. .. 607

## HOMOTREMATIDAE (C702)

640. Trochospiral; attached by spiral side; single central aperture .. .. Subfam. VICTORIELLINAE .. 645
Growing upwards away from attachment or encrusting; many bryozoan-like forms; aperture multiple small pores Subfam. HOMOTREMATINAE .. 641

## HOMOTREMATINAE (C702)

| | | | | |
|---|---|---|---|---|
| 641. | With single rounded or slit-like terminal aperture | 542 | | |
| | With aperture of pores only | 642 | | |
| 642. | Test conical or club-shaped; pores only on broad terminal face | 269 | | |
| | Test encrusting or twig-like, commonly branching; pores over whole test | 643 | | |
| 643. | Aperture of cribrate plates surrounded by imperforate rims | | *Homotrema* | *C702* [*577*] |
| | Aperture cribrate without imperforate rims | 644 | | |
| 644. | Two series of pores, one much larger than the other | | *Miniacina*† | *C705* [*577*] |
| | Pores of single size over most of test, larger pores only at tips of branches | | *Sporadotrema* | *C705* [*587*] |

## VICTORIELLINAE (C705)

| | | | |
|---|---|---|---|
| 645. | | *Carpentaria*† | *C707* [*580*] |

## CASSIDULINACEA (C725)

| | | | |
|---|---|---|---|
| 646. | Essentially uniserial | 647 | |
| | Essentially biserial, includes enrolled twisted and embracing forms | 648 | |
| | Essentially trochospiral or planispiral | 649 | |
| 647. | Test elongate rectilinear series | Fam. PLEUROSTOMELLIDAE | 654 |
| | Test depressed, conical; chambers appear annular from apex | Fam. ANNULOPATELLINIDAE | 657 |
| 648. | Chambers alternating at 180°, and embracing all except penultimate chamber | Fam. NONIONIDAE | 676 |
| | Elongate biserial series; straight or twisted about elongate axis | Fam. CAUCASINIDAE | 658 |
| | Biserial enrolled | Fam. CASSIDULINIDAE | 670 |
| 649. | High trochospiral with sutural pores only | Fam. DELOSINIDAE | 669 |
| | Low trochospiral or planispiral; primary aperture interiomarginal | 650 | |
| 650. | Monolamellar (these forms are now referred to the Superfam. Nonionacea)* | 651 | |
| | Bilamellar (these forms are now referred to the Superfam. Anomalinacea)* | 653 | |

*Loeblich and Tappan 1964b.

| | | | |
|---|---|---|---|
| 651. | Planispiral, may be asymmetrical | Fam. NONIONIDAE | 676 |
| | Trochospiral | 652 | |
| 652. | Less than five chambers per whorl | Fam. NONIONIDAE | 676 |
| | Five or more chambers per whorl | Fam. ALABAMINIDAE | 692 |
| 653. | Aperture equatorial interiomarginal | Fam. ANOMALINIDAE | 703 |
| | Aperture either extraumbilical-umbilical, interiomarginal or areal slit | Fam. OSANGULARIIDAE | 698 |

## PLEUROSTOMELLIDAE (C725)

| | | |
|---|---|---|
| 654. | Aperture loop-shaped in glassy apertural face; test actually high trochospiral with about one chamber per whorl; test radial aragonite | 731 |
| | Aperture curved slit in subterminal position, with hood on one side; true uniserial development; test granular calcite | 655 |

| | | | | |
|---|---|---|---|---|
| 655. | Early biserial or staggered uniserial stage or biserial throughout .. .. .. .. | *Pleurostomella* .. | *C725* [*594*] | |
| | No biserial stage; sutures horizontal throughout | 656 | | |
| 656. | Chambers not greatly overlapping; sutures constricted .. .. .. .. .. | *Nodosarella* .. .. | *C730* [*594*] | |
| | Chambers strongly overlapping; sutures not greatly constricted .. .. .. .. | *Ellipsoglandulina* .. | *C728* [*595*] | |

ANNULOPATELLINIDAE (C730)

| | | | |
|---|---|---|---|
| 657. | .. .. .. .. .. .. | *Annulopatellina*† .. | *C730* [*599*] |

CAUCASINIDAE (C731)

| | | | |
|---|---|---|---|
| 658. | Initial stage high trochospiral, later biserial .. .. .. .. | Subfam. CAUCASININAE .. | 668 |
| | Initial stage biserial, possibly very twisted, may later remain biserial or become uniserial .. .. .. | Subfam. FURSENKOININAE .. | 659 |

FURSENKOININAE (C731)

| | | | |
|---|---|---|---|
| 659. | Angular periphery with keel or spines .. .. | 660 | |
| | Rounded periphery without keel or spines .. | 662 | |
| 660. | Aperture terminal ovate; chambers low; without spine .. .. .. .. .. | 661 | |
| | Aperture extending up from base of chamber, possibly divided into two; chambers more cuniform in side view; usually with spines .. .. | 448 | |
| 661. | Test radial .. .. .. .. .. | 453 | |
| | Test granular .. .. .. .. | *Sigmavirgulina* .. | *C733* [*601*] |
| 662. | Aperture extending up from base of apertural face; biserial throughout .. .. .. | 663 | |
| | Aperture areal, terminal or subterminal; may tend to uniseriality .. .. .. .. | 666 | |
| 663. | Aperture large ∩ shaped with tooth passing across and leaving only narrow loop or slit to chamber interior .. .. .. .. .. | 441 | |
| | Aperture more slit-like without tooth passing across .. .. .. .. .. | 664 | |
| 664. | Test granular .. .. .. .. | 665 | |
| | Test radial .. .. .. .. .. | 456 | |
| 665. | Initial portion very twisted biserial (may appear high trochospiral); chambers greater in height than breadth throughout; tooth plate with crenulate margin .. .. .. .. | *Fursenkoina*† .. .. | *C731* [*600*] |
| | Initial portion not so greatly twisted; early chambers greater in breadth than height; tooth plate with smooth margin .. .. .. .. | *Cassidella* .. .. | *C732* [*600*] |
| 666. | Aperture curved subterminal slit with projecting hood on one side .. .. .. .. | 655 | |
| | Aperture rounded and terminal or nearly so .. | 667 | |
| 667. | Wall radial; usually thickened apertural lip or neck | 455 | |
| | Wall granular; apertural lip thin and without neck | *Coryphostoma* .. | *C733* [*600*] |

Note: New Zealand species that key out as *Coryphostoma* are recorded under *Loxostomum* by Eade (1967).

## CAUCASININAE (C734)

668. Aperture very elongate slit extending from base across top and half way down opposite side, one margin projecting slightly above other; without apertural tooth plate .. .. .. *Francesita* (Loeblich and Tappan 1963, p. 215, Figs. 3–6)

Aperture not such an elongate slit, lips of similar height; usually with apertural tooth .. .. 659

## DELOSINIDAE (C735)

669. Canals from sutural pores lead to spongy cribrate area in apertural face, wall granular .. .. *Delosina* .. .. *C735* [*602*]

Without subsutural canals; sutural pores only; wall radial .. .. .. .. .. 583

## CASSIDULINIDAE (C736)

670. Uncoiling .. .. .. .. .. 671

Close-coiled throughout .. .. .. 673

671. Uncoiling portion compressed in plane of coiling of initial coil; two sides of test of similar appearance 431

Uncoiling portion compressed perpendicular to plane of coiling of initial coil; concave and convex sides of very different appearance (test shape reminiscent of crayfish tail) .. .. 672

672. Wall radial .. .. .. .. .. 431

Wall granular .. .. .. .. *Ehrenbergina*† .. *C738* [*604*]

673. Surface smooth .. .. .. .. 674

Surface ornamented by reticulate ridges.. .. *Favocassidulina*† .. *C738* [*604*]

674. With internal tooth plate; wall radial; aperture elongate interiomarginal partly closed by free edge of tooth plate .. .. .. 430

Without internal tooth plate; wall granular; aperture slit-like up apertural face, usually paralleling distal margin .. .. .. 675

675. Test lenticular; periphery angular .. .. *Cassidulina*† .. .. *C737* [*604*]

Test globular; periphery broadly rounded .. *Globocassidulina*† .. *C738* [*604*]

## NONIONIDAE (C742)

676. Total of two to four chambers only .. .. 499

Test of more than four chambers, although early ones may be covered in embracing or involutely coiled forms .. .. .. 677

677. Aperture equatorial; planispiral or trochospiral, usually more than four chambers per whorl .. .. .. Subfam. NONIONINAE .. .. 680

Aperture extraumbilical-umbilical or umbilical; asymmetrical planispiral or trochospiral, two to four chambers per whorl; forms with two chambers per whorl may appear to be embracing biserial .. .. .. .. Subfam. CHILOSTOMELLINAE .. 678

## CHILOSTOMELLINAE (C742)

678. Three or four chambers in final whorl; obviously in asymmetrical planispiral or trochospiral coil — 679
Two chambers to whorl; each ovate chamber at 180° to previous chamber and embracing almost all except penultimate chamber — *Chilostomella*† — *C742* [*611*]

Note: *Globobulimina*† *C559* [*442*] has tooth plate and radial wall.

679. Only final whorl (usually of three chambers) visible externally — *Allomorphina* — *C743* [*611*]
All chambers visible on spiral side; usually three to four chambers in final whorl — *Quadrimorphina* — *C744* [*611*]

## NONIONINAE (C742)

680. Without final enveloping chamber — 681
Final chamber globose and enveloping most of test; fimbriate margin at base of apertural face — *Chilostomellina* — *C746* [*613*]
Adult without projection of final chamber over one side only — 682

681. Adult with projection of final chamber over umbilicus on one side; opposite side partly evolute — *Nonionella*† — *C748* [*613*]

Note: Trochospiral forms lacking well formed umbilical chamber projections are recorded as *Zeaflorius* by Eade (1967).

682. With sutural flaps attached to proximal edge of chamber and partly covering preceding suture and possibly umbilicus — 683
Without sutural and umbilical flaps — 684

683. Flaps very large extending across apertural face obscuring aperture — *Bisaccium* — *C746* [*612*]
Flaps not extending across apertural face — *Astrononion*† — *C746* [*612*]

684. Test aragonite; with areal slit paralleling interiomarginal arch — 735
Test calcite; without aperture in apertural face — 685

685. Chambers increasing gradually in size; test fairly rounded in side view — 686
Chambers increase rapidly in size; test flaring; height and breadth of chambers increase approximately threefold or more in final whorl — 690

686. Periphery angular test usually large; compressed or lenticular with very large number of chambers per whorl — 560
Periphery well rounded; test size moderate; rarely more than 20 chambers per whorl — 687

687. Wall radial; with fine sutural pores, sometimes difficult to see — 555
Wall granular; without sutural pores — 688

688. Umbilicus filled with granulate calcite material or solid boss — *Nonion*† — *C746* [*612*]
Not with filled umbilicus — 689

689. Closed umbilicus; three to six rarely to nine chambers per whorl; wall monolamellar — *Pullenia*† — *C748* [*613*]
Deep open umbilicus; usually more than six chambers per whorl; wall bilamellar — 715

690. Early trochospiral stage with extension over one side of umbilicus; adult planispiral — *Nonionellina* — *C748* [*613*]

Note: The species recorded as *Florilus flemingi* by Eade (1967) is a *Nonionellina* (Lewis and Jenkins, 1969).

Without early stage with single umbilical projection — 691

691. Wall radial; with fine sutural pores, sometimes difficult to see .. .. .. .. 555
Wall granular; usually without sutural pores .. *Florilus*† .. .. *C746* [*612*]
Note: Trochospiral forms recorded as *Zeaflorius* by Eade (1967).

## ALABAMINIDAE (C748)

692. Umbilical side not obscured by secondary growth material .. .. .. .. .. 693
Umbilical side covered by plate of secondary shelly material .. .. .. .. .. *Trichohyalus* .. .. *C750* [*614*]
Note: *Trichohyalus* is transferred by Loeblich and Tappan 1964b to the Fam. ANOMALINIDAE.

693. Spiral side flattened; umbilical side elevated and umbilicate .. .. .. .. 694
Spiral side and umbilical side low-domed .. 695

694. Short low interiomarginal aperture near midline of apertural face; secondary openings below umbilical flaps .. .. .. .. *Gyroidina*† .. .. *C750* [*614*]
Long low interiomarginal aperture; extending from periphery to umbilicus .. .. .. 699

695. With small supplementary apertures on spiral side at junction of spiral and radial sutures; periphery carinate .. .. .. .. .. *Oridorsalis*† .. .. *C750* [*614*]
Without supplementary apertures on spiral side; periphery sub-angular to rounded .. .. 696

696. Aperture not in recessed apertural face, interiomarginal or on umbilical side with lip or flap 679
Aperture in recessed apertural face formed by projection of final chamber along the periphery, interiomarginal at the base of this face or extending slightly up face .. .. .. 697

697. Finely perforate; surface smooth .. .. *Alabamina* .. .. *C748* [*614*]
Coarsely perforate; surface pustulose .. .. *Svratkina* .. .. *C750* [*614*]

## OSANGULARIIDAE (C752)

698. Aperture low interiomarginal arch from periphery to umbilicus .. .. .. .. 699
Aperture extending up apertural face or isolated in apertural face .. .. .. .. 700

699. Without umbilical flaps extending into umbilicus.. 719
With umbilical flaps extending over umbilicus .. *Gyroidinoides*† .. *C753* [*615*]
Note: *Gyroidina*† *C750* [*614*] has aperture confined to middle of apertural face.

700. Test aragonite; aperture umbilical extending as slit up umbilical face of final chamber .. .. 734
Test calcite; aperture extending from extra umbilical position up apertural face or isolated in apertural face .. .. .. .. 701

701. Chambers with secondary septa giving umbilical series of chamberlets .. .. .. 512
Without secondary septa .. .. .. 702

702. Aperture elongate slit up apertural face near to and paralleling periphery; wall radial .. .. 479
Aperture partly basal, partly extending at oblique angle up apertural face; wall granular .. *Osangularia* .. .. *C752* [*615*]

## ANOMALINIDAE (C753)

| | | | | |
|---|---|---|---|---|
| 703. | With supplementary apertures or strips of clear shell material around peripheral margin | Subfam. ALMAENINAE | | 721 |
| | Without supplementary apertures or strips of clear shell material round peripheral margin | Subfam. ANOMALININAE | | 704 |

## ANOMALININAE (C753)

| | | | | |
|---|---|---|---|---|
| 704. | Coiled throughout | 705 | | |
| | Early coiled portion, later uncoiling to uniserial or irregularly biserial development | *Karreria*† | | *C760* [*623*] |
| 705. | With very broad flat keel, commonly almost sheet-like with growth lines | 492 | | |
| | Keel, if present, not broad and flat | 706 | | |
| 706. | With umbilical flaps having apertural openings beneath | 707 | | |
| | Without umbilical flaps, but may have final chambers overhanging umbilicus | 711 | | |
| 707. | With umbilical flaps on both sides | *Paromalina*† | | *C763* [*627*] |
| | With umbilical flaps on one side only | 708 | | |
| 708. | Wall radial | 486 | | |
| | Wall granular | 709 | | |
| 709. | Side with umbilical flaps high-domed convex | 694 | | |
| | Side with umbilical flaps flat or concave | 710 | | |
| 710. | Periphery angular; upper side involute | *Hanzawaia* | | *C759* [*623*] |
| | Periphery broadly rounded; upper side partly involute | *Discanomalina*† | | *C757* [*622*] |
| 711. | With granulate shell material filling umbilicus and possibly covering whole umbilical side | 712 | | |
| | Without umbilical granulate shell material | 713 | | |
| 712. | Granulate shell material confined to umbilicus and possibly extending along sutures | 691 | | |
| | Plate of granulate shell material covering entire umbilical side; hollow beneath granulate plate | 692 | | |
| 713. | Completely involute (may have open umbilicus) | 714 | | |
| | At least partly evolute on one side | 716 | | |
| 714. | Three ovate chambers per whorl; aperture not equatorial | 679 | | |
| | More than four chambers per whorl; aperture equatorial | 715 | | |
| 715. | Periphery angular; umbilici closed; wall radial | 608 | | |
| | Periphery rounded; umbilici open and deep; wall granular | *Melonis*† | | *C761* [*627*] |
| 716. | Periphery angular | 717 | | |
| | Periphery rounded | 718 | | |
| 717. | Aperture short, interiomarginal at periphery | *Cibicidoides* | | *C757* [*621*] |
| | Aperture elongate interiomarginal from half way to umbilicus, across periphery on to spiral side | *Heterolepa* | | *C759* [*623*] |
| | Aperture extending to umbilicus or not extending to periphery | 694 | | |
| 718. | Final chamber overhanging umbilical region on one side | 681 | | |
| | Final chamber not overhanging umbilicus | 719 | | |

| | | | | |
|---|---|---|---|---|
| 719. | Aperture interiomarginal at periphery continuous on to spiral side | *Anomalinoides*† | .. | *C755* [*619*] |
| | Aperture not extending on to spiral side .. | 720 | | |
| 720. | Nearly planispiral with umbo on spiral side and depressed umbilicus | *Anomalina*† | .. | *C754* [*618*] |
| | Trochospiral with flattened spiral side and high-domed umbilical side | 694 | | |

ALMAENINAE (C763)

| | | | | |
|---|---|---|---|---|
| 721. | Apertures on proximal margins of chambers at periphery | 615 | | |
| | With lateral peripheral apertures or areas of clear shell material | 722 | | |
| 722. | Involute on both sides; test calcite | *Anomalinella* | .. | *C764* [*628*] |
| | At least partly evolute on one side; test aragonite .. | 728 | | |

## CARTERINACEA (C764)

### CARTERINIDAE (C764)

| | | | | |
|---|---|---|---|---|
| 723. | .. .. .. .. .. .. | *Carterina* | .. | *C765* [*629*] |

## ROBERTINACEA (C766)

| | | | | |
|---|---|---|---|---|
| 724. | Foramen formed by resorption of the septa; not homologous with aperture; mainly low trochospiral forms | Fam. CERATOBULIMINIDAE | .. | 725 |
| | Foramen homologous with part of primary aperture; mainly high trochospiral forms | Fam. ROBERTINIDAE | .. | 729 |

### CERATOBULIMINIDAE (C766)

| | | | | |
|---|---|---|---|---|
| 725. | Aperture umbilical, possibly extending as slit up apertural face | Subfam. CERATOBULIMININAE | .. | 726 |
| | Apertures or strips of clear shell material in lateral peripheral position | Subfam. EPISTOMININAE | .. | 728 |

### CERATOBULIMININAE (C766)

| | | | | |
|---|---|---|---|---|
| 726. | Aperture continuing as slit up apertural face | *Ceratobulimina*† | .. | *C766* [*630*] |
| | Aperture low umbilical arch .. | 727 | | |
| 727. | Each chamber completely divided into two; division marked by sutures on spiral and umbilical sides; anterior half of chamber non-perforate | *Rubratella* | .. | *C770* [*633*] |
| | Chambers not completely divided; partial secondary septa do not form sutures at surface; perforate throughout | *Lamarckina*† .. | .. | *C769* [*631*] |

Note: *Baggina C586* [*462*] has imperforate area above aperture.

### EPISTOMININAE (C771)

| | | | | |
|---|---|---|---|---|
| 728. | Trochospiral with lateral peripheral aperture on one side only | *Hoeglundina*† | .. | *C775* [*636*] |
| | Partly evolute on both sides; lateral peripheral apertures or strips of clear shell material on both sides | *Mississippina*† | .. | *C776* [*637*] |

## ROBERTINIDAE (C777)

| | | | | |
|---|---|---|---|---|
| 729. | High trochospiral to almost uniserial | 731 | | |
| | Low trochospiral to planispiral | 730 | | |
| 730. | Completely evolute spiral side, involute umbilical side | 733 | | |
| | Asymmetrical planispiral or planispiral | 735 | | |
| 731. | Single chamber to whorl, parallel sides | *Ungulatella* | | *C782* [*642*] |
| | Several chambers to whorl, test expanding | 732 | | |
| 732. | Aperture slit up apertural face only | *Robertina*† | | *C777* [*641*] |
| | Aperture slit up apertural face plus low interiomarginal or sutural slit | *Robertinoides*† | | *C782* [*642*] |
| 733. | Sutures of secondary septa visible on spiral side only or absent; test close-coiled throughout | 734 | | |
| | Sutures of secondary septa visible on umbilical side only; test uncoiling | *Cerobertina*† | | *C781* [*641*] |
| | Note: *Eponidella C595* [*472*] has calcite test. | | | |
| 734. | Partial secondary septa; chambers not divided by sutures; aperture umbilical extending as slit up apertural face | 726 | | |
| | Complete secondary septa with sutures on spiral side; aperture two divergent slits, one up apertural face, one low interiomarginal sutural | *Pseudobulimina*† | | *C782* [*641*] |
| 735. | Symmetrical with areal slit-like aperture parallel to equatorial interiomarginal arch | *Cushmanella* | | *C781* [*641*] |
| | Asymmetrically developed; aperture areal oblique plus interiomarginal arch | *Alliatina* | | *C778* [*641*] |
| | Note: *Eponidella C595* [*472*] has calcite test. | | | |

# ILLUSTRATED GLOSSARY

**agglutinated:** composed of foreign particles bound together by cement. (Fig. 1) e.g., *arenaceous* (Fig. 8) *argillaceous* (Fig. 9)

**alar projection:** wing-like extension. e.g. *alar projections from umbilical flaps* (Fig. 3)

**anastomosing tubes:** system of intercommunicating tubes (Fig. 2)

**angular periphery:** sharp or acutely angled outer edge giving clear distinction between two sides of test, possibly with keel. (Figs. 16, 31, 39, 57) (cf. *rounde l periphery*)

**annular:** circular o arranged in rings round central point. (F gs. 4, 5)

**apertural face:** flattened, usually distal, portion of final chamber which contains main opening to exterior. (Figs. 13, 24, 32A, 46A, 51B, 53C, 58, 74, 75A, 78, 82, 83)

**apertural flap:** flattened, broadly rounded projection into principal opening to exterior. (Fig. 6)

**aperture:** major opening(s) of test to exterior, through which protoplasm projects in life. e.g., *single interiomarginal aperture* (Fig. 32A) *multiple interiomarginal aperture* (Fig. 51A) *single areal aperture* (Fig. 77) *multiple areal aperture* (Fig. 24) (*secondary*) *sutural aperture* (Figs. 51A, B; 90)

**apposition:** placing side by side; usually refers to two chambers or two sets of enveloping chambers. (Fig. 63)

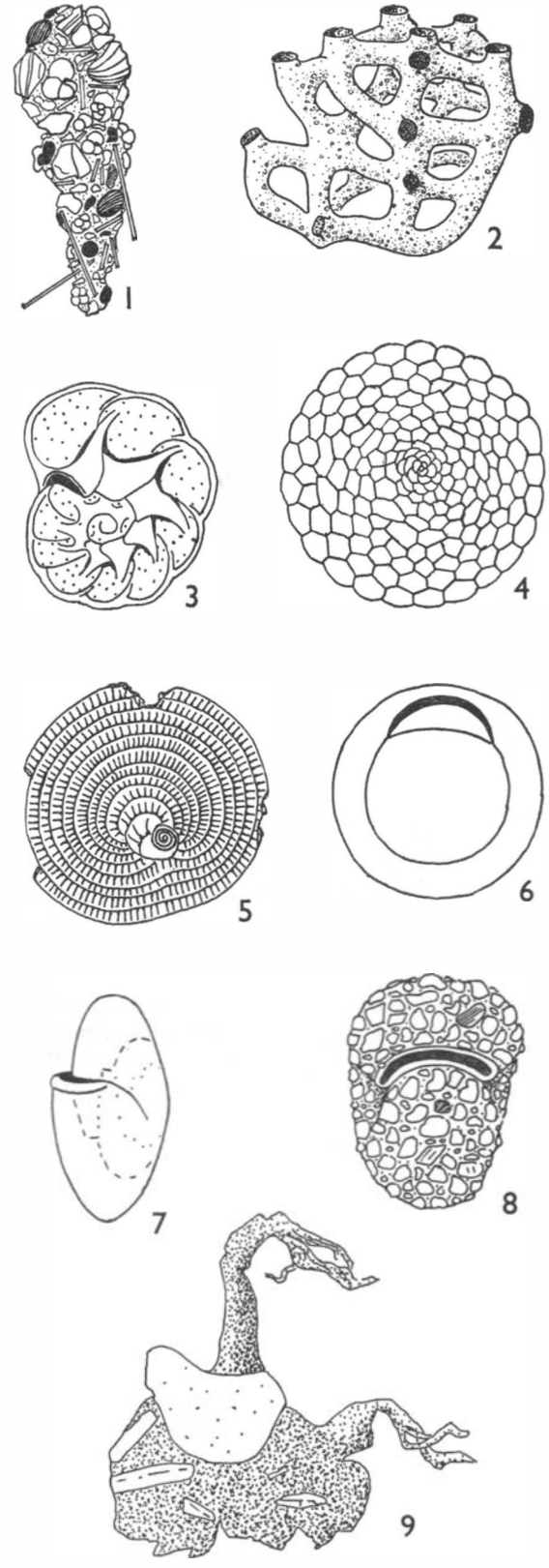
**aragonite:** metastable orthorhombic form of calcium carbonate. (*See* Identification Techniques 4, p. 81)

**arch:** curved or domed opening, typically interiomarginal. (Figs. 3; 32A; 53A, C; 58; 85A)

**arcuate:** bent, curved. e.g., *arcuate chambers* (Fig. 37) *arcuate test* (Fig. 41) *arcuate aperture* (Fig. 44)

**areal:** describing opening(s) in chamber wall not bounded at any point by wall of earlier chamber. In some species all that separates opening from earlier chamber is thin lip. e.g., *single areal aperture* (Figs. 8, 25, 77) *multiple areal aperture* (Figs. 24, 82) *areal foramen.* (Fig. 39) (cf. *interiomarginal*)

**arenaceous:** composed of inorganic sand grade material. (Figs. 8, 54, 91)




1. *Reophax.* 2. *Syringammina.* 3. *Lamellodiscorbis.* 4. *Sorites.* 5. *Discospirina.* 6. *Biloculinella.* 7. *Chilostomella.* 8. *Alveolophragmium.* 9. *Pelosphaera.*

**argillaceous:** composed of silt or clay grade material. e.g., *argillaceous with few large sand grains* (Fig. 9)

**asymmetrical planispiral:** having chambers coiled in single flat plane, not spiralling. Usually similarly evolute or involute on both sides, but chambers or apertures are not symmetrical about central plane. (Figs. 10A, B, C; 13)

**auricular:** ear-shaped. e.g., *auricular test* (Fig. 11)

**axis:** imaginary line around which chambers are arranged or coiled, or along which chambers appear to grow. (Figs. 12, 14, 15) e.g., *axis of coiling* (Fig. 12) *axis of growth* (Figs. 58Y, 87)

**axis of coiling:** imaginary line around which planispiral or trochospiral forms are coiled. (Figs. 12, 57X)

**axis of growth:** imaginary line passing symmetrically through test from proloculus to apertural region in biserial and uniserial forms; line along which test appears to grow. (Figs. 57Y, 58Y, 87)

**bar:** rod of solid shell material forming a link, between two parts of test. e.g., *sutural bars* (Figs. 51A, B)

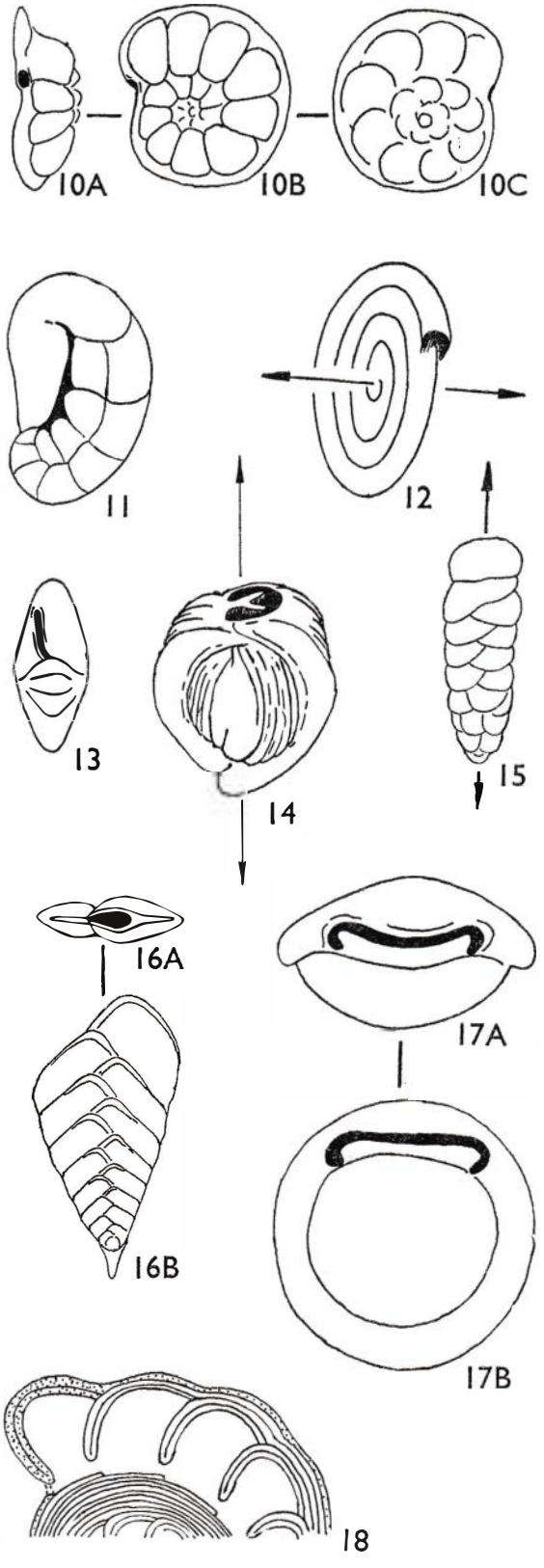
**bifid tooth:** projection into test opening divided into two minor projections, typically Y-shaped. (Figs. 14; 17A, B; 66C)

**bilamellar:** having chamber wall primarily of two layers. Outer layer of each chamber covers whole of previously formed exterior of test. Septa do not incorporate canal systems between the two layers, and wall of final chamber consists of two layers. (Fig. 18, equatorial section)

**biloculine:** milioline, with each chamber added in plane at 180° to previous chamber, "embracing" so that only final two chambers visible. (Figs. 6; 17A, B)

**biserial:** with two rows of chambers alternating on either side of test, not typically "embracing" (Figs. 16A, B, 58) e.g., *twisted biserial* (Figs. 86, 87) *enrolled biserial* (Figs. 30A, B, C; 31A, B; 57)

**bulla:** blister-like structure partially or completely covering primary or secondary apertures; independent of primary chambers; typically covers umbilical region; may have one or more accessory interiomarginal apertures. (Fig. 19)




10. *Laticarinina.* 11. *Cerobertina.* 12. *Spirillina* (axis of coiling). 13. *Stetsonia.* 14. *Quinqueloculina* (axis of coiling). 15. *Goesella* (axis of growth and coiling). 16. *Brizalina.* 17. *Pyrgo.* 18. Diagramatic section through bilamellar test.

**calcite:** stable hexagonal-rhombohedral form of calcium carbonate (*see* Identification Techniques 4, p. 81)

**cancellate:** having surface with very fine regular latticework of raised ridges. (Fig. 20)

**carinate:** having keel or flange. (Figs. 10A, B, C; 46A, B; 59)

**chamberlet:** subdivision of chamber produced by secondary septa. (Figs. 5, 11)

**chevron:** Λ-shaped. e.g., *chevron suture* (Fig. 21) *chevron aperture* (Fig. 45A)

**close-coiled:** completely and tightly enrolled, not uncoiling; may be involute or evolute. (Figs. 20, 22, 26, 46A, B) (cf. *uncoiling*)

**closed umbilicus:** inner margins of chambers meet at centre of umbilical side and do not leave central depression. (Figs. 22, 55) (cf. *open umbilicus*)

**costa:** ridge or rib. (Figs. 47, 48)

**costate:** having ridges. (Figs. 47, 48)

**crenulate:** having edge finely notched or scalloped. e.g., *crenulate margin of aperture* (Figs. 66A, B, C)

**cribrate aperture:** multiple areal aperture of rounded holes grouped together. (Figs. 24, 54, 82)

**cruciform aperture:** opening consisting of four divergent slits; an x-shaped opening. (Fig. 25)

**cuniform:** wedge-shaped. e.g., *cuniform chambers* (Figs. 27, 45B)

**cyclogyrine:** having undivided tubular planispiral test. (Figs. 12, 26)

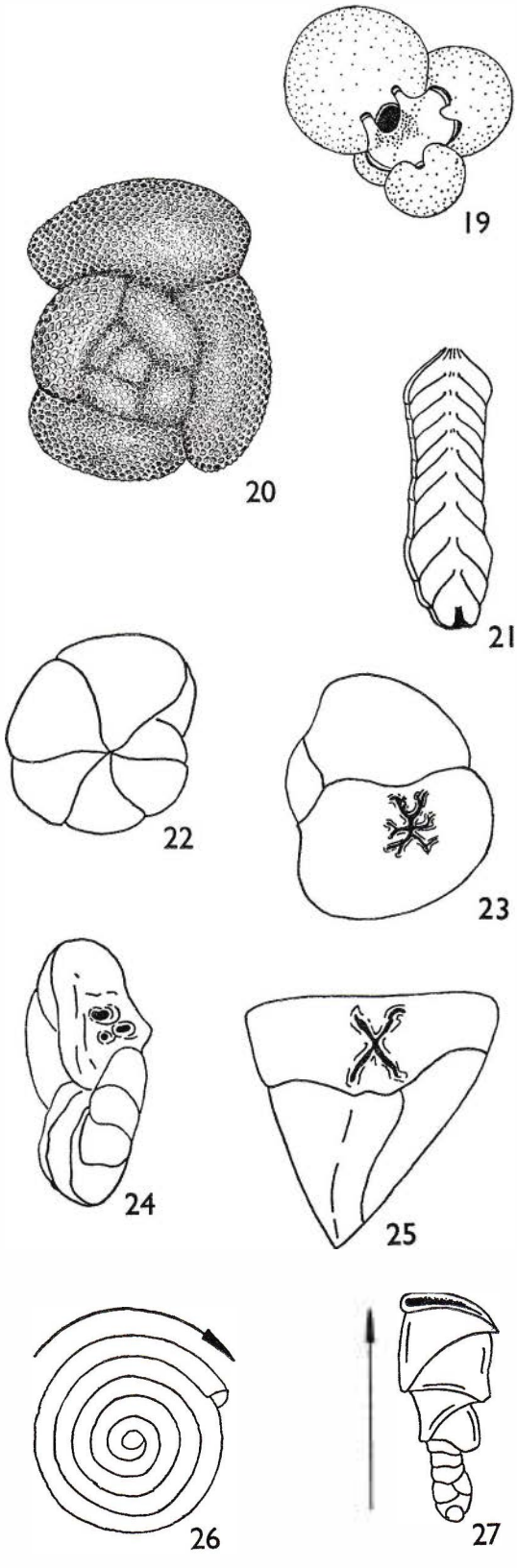
**dendritic aperture:** opening or openings which branch irregularly. (Fig. 23)

**dichotomous branching:** repeated division into two. (Fig. 28)

**discoidal:** round and flat, like a coin. (Figs. 85A, B)

**distal:** direction away from proloculus in direction of growth. (Figs. 26, 27)

**embracing:** with later chambers partly covering or completely surrounding earlier chambers. e.g., *partly embracing* (Figs. 7, 79) *completely embracing* (Fig. 29)




19. *Tinophodella.* 20. *Globoquadrina* (del. N. de B. Hornibrook). 21. *Frondicularia.* 22. *Alabamina.* 23. *Cruciloculina.* 24. *Jadammina.* 25. *Cruciloculina.* 26. *Cyclogyra* (arrow pointing distally). 27. *Valvobifarina* (arrow pointing distally).

**enrolled biserial:** with two rows of chambers planispirally enrolled. Chambers alternate on opposite sides of test giving Y-shaped sutures when viewed from either side. Test may be uncoiling to give a biserial form with curved axis of growth. (Figs. 31A, B) e.g., *uncoiling biserial, compressed in plane of coiling* (Fig. 57) *uncoiling biserial, compressed perpendicular to plane of coiling* (Figs. 30A, B, C)

**entosolenian tube:** internal tube-like extension from aperture. (Figs. 33, 64)

**equatorial aperture:** symmetrical opening of planispiral test, may be interiomarginal or areal. (Figs. 8, 32B)

**evolute:** with each whorl of enrolled forms not embracing earlier whorls, all whorls visible. (Fig. 26) e.g., *completely evolute spiral side of trochospiral forms* (Figs. 20, 50A, 53B, 75C) *partly evolute* (Figs. 3, 61) (cf. *involute*)

**extraumbilical aperture:** opening in final chamber not extending to umbilicus, commonly interiomarginal midway between periphery and umbilicus. (Figs. 53A, C, 59, 90)

**extraumbilical-umbilical aperture:** interiomarginal opening in final chamber that extends from umbilicus to point outside umbilical region, possibly to periphery. (Fig. 34)

**fimbriate:** having fringe-like margin. (Figs. 35A, B)

**fistulose chamber:** final irregular chamber with tubular extensions commonly seen in Polymorphinidae and Glandulinidae. (Fig. 36)

**fixed edge:** side of tooth plate fixed to apertural lip or border. (Text figs. 1B, C, D, p. 43) (cf. *free edge*)

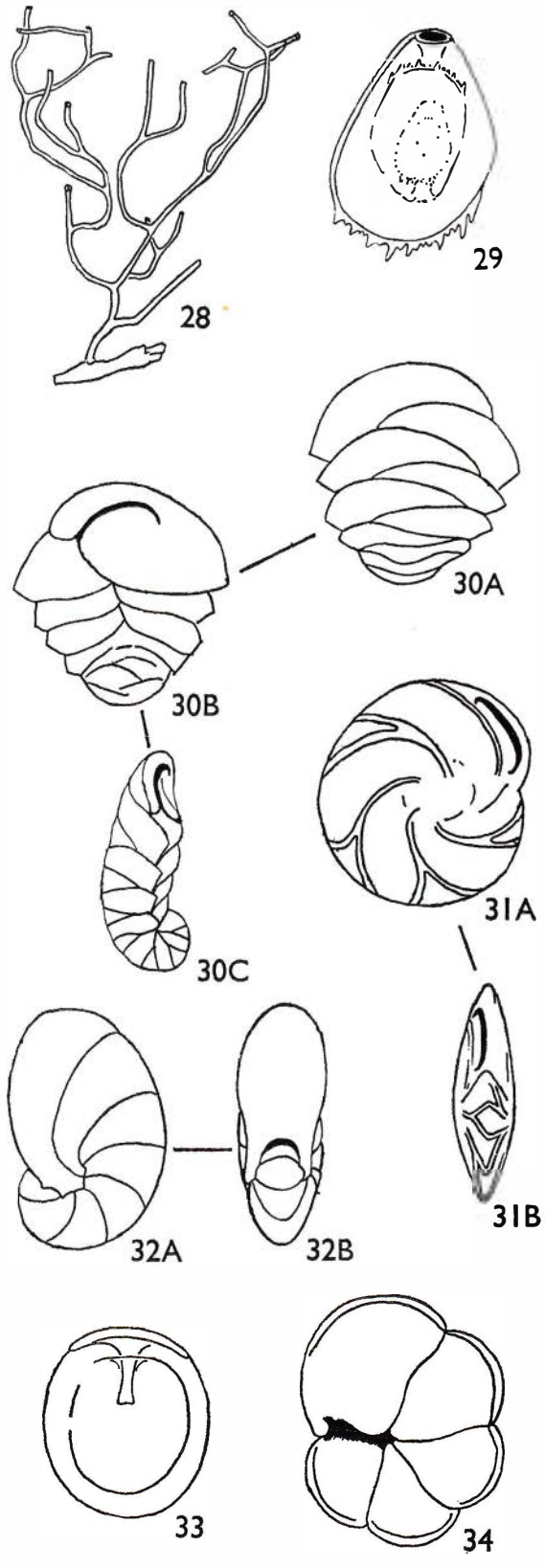
**flabelliform:** shaped like a fan. (Figs. 37, 38)

**flap:** flattened projection from chamber wall. e.g., *apertural flap* (Fig. 6) *umbilical flap* (Fig. 53C) *sutural flap* (Fig. 81)

**flaring:** rapidly increasing in size. Usually refers to test, i.e. each chamber is considerably larger than previous one. (Figs. 11, 32B) e.g., *flaring with final arcuate chambers* (Fig. 37)

**flask-shaped:** rounded with long narrow neck. (Fig. 40)

**foramen:** opening in septum between two chambers; may represent a previous aperture or be formed secondarily. (Fig. 39)




28. *Dendrophrya.* 29. *Seabrookia.* 30. *Ehrenbergina.* 31. *Cassidulina.* 32. *Nonionellina.* 33. *Fissurina.* 34. *Globorotalia.*

**free edge:** side of tooth plate not fused to apertural lip or border. In rare instances free edge may be fused at one point. (Text fig. 1B, C, D, p. 43) (cf. *fixed edge*)

**fusiform:** spindle-shaped, tapering at each end. (Fig. 42)

**gerontic:** pertaining to senile stage in life history. Often growth form is different from that in ordinary adult giving whole test very different appearance.

**granular:** having test composed of randomly orientated minute crystals of calcite; seen between crossed Nicols as a multitude of tiny flecks of colour (*see* Identification Techniques 3, p. 81)

**granulate:** with small prominences; having roughened surface as if sprinkled with grains. (Figs. 85A, B)

**high trochospiral:** spirally coiled, height of spire being greater than breadth of terminal face. (Figs. 78, 83.) e.g., *high trochospiral with embracing chambers* (Fig. 79)

**hispid:** covered with fine hair-like spines. (Fig. 41)

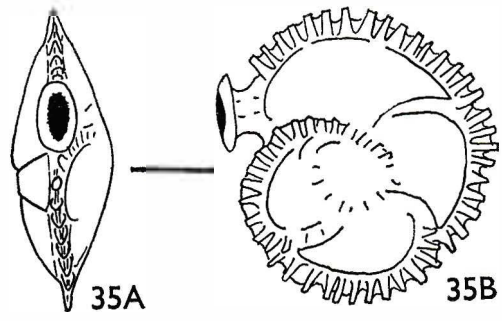
**hood:** terminal or marginal portion of chamber projecting above aperture. (Figs. 45A, B)

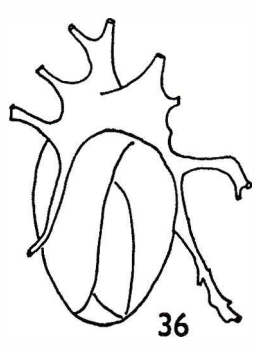
**hyaline:** colourless, glassy; in the strict sense, transparent, but term usually extended to all transparent or translucent forms which appear colourless, white, or pale blue in transmitted light (*see* Identification Techniques 3, p. 81) (cf. *porcellaneous*)

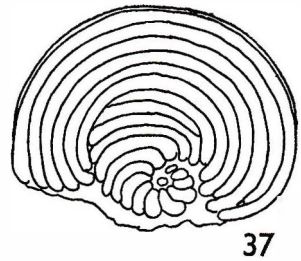
**interiomarginal aperture:** opening in final chamber touching margin of that chamber so that part of opening is bounded by wall of earlier chamber. e.g., *loop-shaped interiomarginal* (Figs. 78, 79, 83) *extraumbilical interiomarginal* (Figs. 53A, C; 59; 89) *extraumbilical-umbilical* (Fig. 34) *umbilical* (Fig. 88) *multiple interiomarginal* (Figs. 51A, B; 75A) (cf. *areal aperture*)

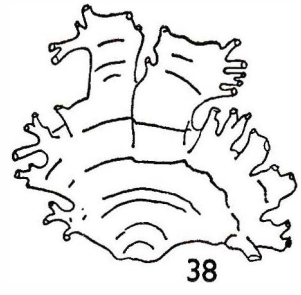
**involute:** each whorl of enrolled forms completely embracing earlier whorls; only final whorl visible. (Figs. 32A, B; 46A, B) e.g., *completely involute umbilical side of trochospiral forms* (Figs. 22, 34, 50B, 53C, 59, 75B) *partly involute* (Figs. 3, 61) (cf. *evolute*)

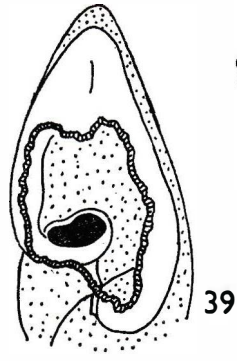
**keel:** peripheral shell thickening. (Figs. 10A, B, C; 46A, B; 59)



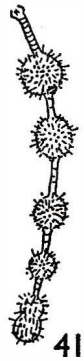






35. *Siphonina.* 36. *Sigmomorphina.* 37. *Peneroplis.* 38. *Jullienella.* 39. *Pararotalia* (final chamber broken). 40. *Lagena.* 41. *Amphicoryna.* 42. *Lagena.*

**labyrinthic:** having complex spongy wall with interlaced dendritic channels perpendicular to test surface. (Fig. 43)

**lamella** or **lamina:** thin plate-like layer of aragonite or calcite which partly or completely covers test, one being formed with addition of each new chamber. (Figs. 18; 52; 69B, C; 70)

**lateral peripheral:** near to and paralleling periphery e.g., *lateral peripheral aperture* (Fig. 44)

**lenticular:** lens-shaped, approximately equally biconvex with angular periphery. (Figs. 46A, B)

**limbate suture:** thickened or elevated line of union between two chambers or two whorls. (Figs. 31A, B; 50A)

**lip:** thickened, elevated, or in some way differentiated, border to aperture. (Figs. 7, 8, 27, 47, 48, 77, 80, 85A, 90) e.g., *phialine lip* (Figs. 35A, B)

**loop-shaped aperture:** ovate or comma-shaped opening in apertural face usually with narrow end extending towards base or umbilical region of apertural face. (Figs. 78, 83)

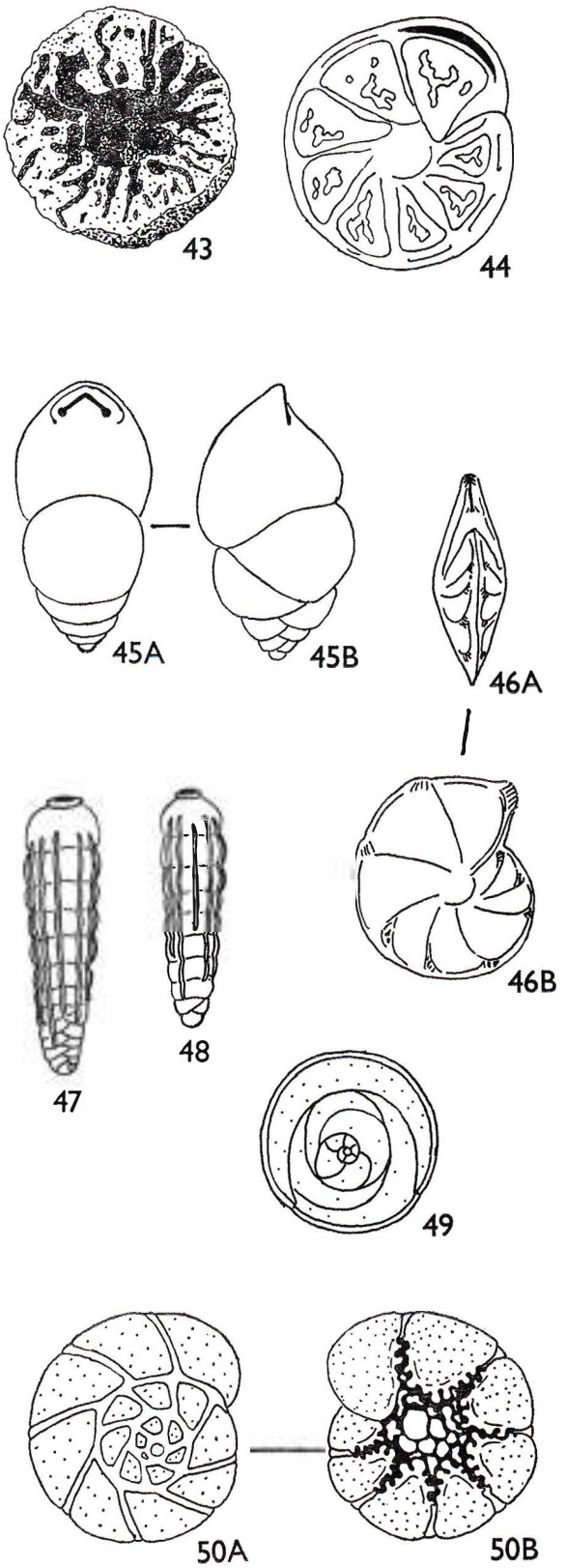
**low trochospiral:** spirally coiled with one side (spiral side) more evolute than other (umbilical side), height of spire being less than breadth of final whorl. (Figs. 50A, B; 53A, B, C; 75A, B, C)

**lunate:** crescent-shaped. e.g., *lunate chambers* (Fig. 49)

**megalospheric:** having large initial chamber. Commonly represents generation formed by asexual reproduction and usually undergoes sexual reproduction. (Fig. 48) (cf. *microspheric*)

**microspheric:** having small initial chamber. Commonly represents generation formed by sexual reproduction and which undergoes asexual reproduction. (Fig. 47) (cf. *megalospheric*)

**milioline:** with elongate tubular chambers (may be sausage-shaped to hemispherical in external appearance), each half a whorl in length, arranged in various planes from 120° to 180° apart about central axis. This is a rather vague term, but is generally used to exclude planispiral evolute coiling (e.g., Figs. 54, 82), although the elongate tubular chambers may still be described as milioline. e.g. *biloculine* Figs. 6; 17A, B) *triloculine* (Figs. 23; 25; 84A, B, C) *quinqueloculine* (Figs. 14; 66A, B, C)




43. *Oryctoderma.* 44. *Hoeglundina.* 45. *Pleurostomella.* 46. *Lenticulina.* 47. *Rectobolivina* (microspheric form). 48. *Rectobolivina* (megalospheric form). 49. *Neoconorbina.* 50. *Ammonia.*

**monolamellar:** having chamber primarily of single layer which continues as thin lamella to cover whole exterior of test; septa composed of single layer throughout. (Fig. 52)

**multilocular:** test of many chambers. (Figs. 51A, B; 52; 53A, B, C; 54; 55; 56) (cf. *unilocular*)

**multiple aperture:** two or more openings of similar type constituting major opening to exterior. e.g., *multiple areal* (Figs. 24; 51A, B; 54; 82) *multiple interiomarginal at base of apertural face* (Figs. 51A, B; 75A) *multiple sutural* (Figs. 51A, B; 69A)

**mural pores:** minute openings, general over test of many foraminifers; have pseudochitinous linings and sieve plates seen only by electron microscope. (Indicated as dots in Figs. 3; 50A, B; 68; 90)

**neck:** narrow tubular portion connecting aperture with chamber cavity. (Figs. 35A, B, 40, 41, 42)

**open umbilicus:** central depression, often continuous to proloculus, between inner margins of chambers in involute coil; previous whorls not visible in depression. e.g., *open umbilicus with umbilical plug* (Figs. 50B, 59) *open umbilicus with umbilical flaps* (Fig. 53C)

**ovate:** egg-shaped, usually in outline only. e.g., *ovate chambers* (Fig. 61)

**oviform:** three-dimensional egg-shaped body. e.g., *oviform chambers* (Fig. 56)

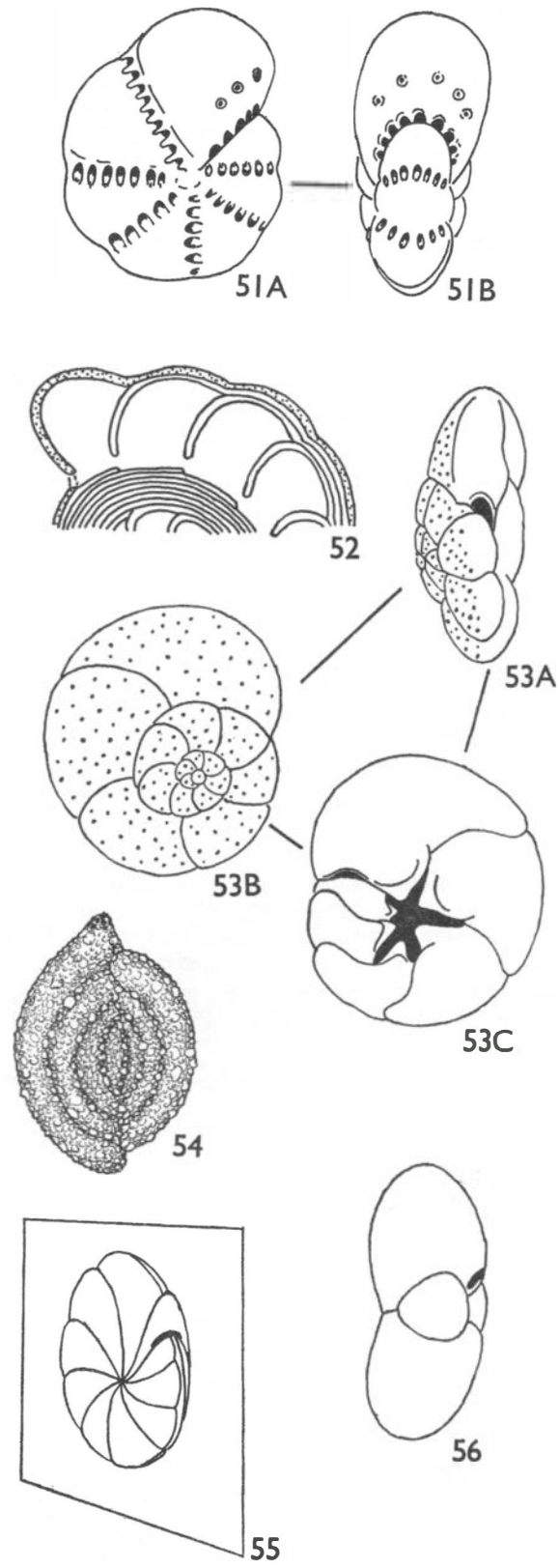
**peripheral angle:** region where periphery meets terminal or apertural face in coiled forms. e.g., *aperture at peripheral angle* (Figs. 46A, B; 54)

**periphery:** outer edge as seen when specimen is lying in its most stable position. e.g., *angular periphery* (Figs. 16; 31A, B; 39; 57) *rounded periphery* (Figs. 32A, 51B, 58) *periphery with keel* (Figs. 10A, B, C; 46A, B) *aperture at periphery* (Figs. 33, 54, 61, 85A)

**phialine lip:** everted rim of aperture, commonly on neck. (Figs. 35A, B)

**pillar:** column of solid shell material, commonly formed by subdivision of umbilical plug. (Fig. 50B)

**plane of coiling:** imaginary plane surface through coiled or spiral forms perpendicular to axis of coiling. (Figs. 55, 57a)




51. *Cribroelphidium.* 52. Diagrammatic section through monolamellar test. 53. *Rosalina.* 54. *Ammomassilina.* 55. *Anomalinella* (plane of coiling). 56. *Cystammina.*

**plane of growth:** imaginary plane surface symmetrically through two rows of chambers of biserial forms; in some genera may be twisted or curved. e.g., *flat plane of growth* (Fig. 58) *twisted plane of growth* (Fig. 87) *curved plane of growth* (Figs. 57b; 30A, B, C)

**planispiral:** coiled in single plane; similarly involute or evolute on both sides. (Figs 12; 32A, B; 46A, B; 54; 85A, B) see also *asymmetrical planispiral* (Figs. 10A, B, C) *planispirally enrolled biserial* (Figs. 31A, B)

**plastogamy:** fusion of adults by umbilical surfaces at time of sexual reproduction ensuring fertilisation of gametes. (Fig. 60)

**plug:** filling of solid shell material: e.g., *umbilical plug* (Figs. 50B, 59)

**polymorphine coil:** high trochospiral to biserial or sigmoidal series; chambers overlapping; sutures at large angle to horizontal; aperture terminal. (Figs. 64; 71A, B) e.g., *polymorphine coil with final fistulose chamber* (Fig. 36)

**porcellaneous:** white, opaque, or slightly translucent in reflected light; fragments usually appear amber to chestnut in transmitted light (*see* Identification Techniques 3, p. 81) (cf. *hyaline*)

**pore:** minute rounded opening in chamber wall. e.g., *sutural pores* (Figs. 51A, B; 69A) *areal pores* (Figs. 51A, B; 82) *mural pores* (Figs. 3; 50A, B; 68; 90)

**primary aperture:** main opening of test to exterior. e.g., *primary interiomarginal aperture* (Fig. 90) *primary multiple interiomarginal aperture* (Figs. 51A, B) (cf. *supplementary aperture*)

**proloculus:** initial embryonic chamber, usually well rounded. (Conspicuous in Figs. 20, 48, 61, 62, 64, 71A)

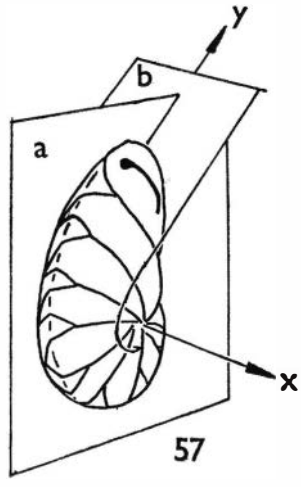
**proximal:** nearer to proloculus in direction of growth. (Figs. 61, 62)

**pustule:** small rounded elevation, hollow or solid. (Figs. 63, 65)

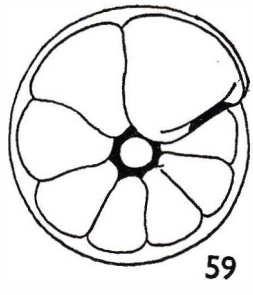
**pustulose:** having surface ornamented with pustules. (Figs. 63, 65)

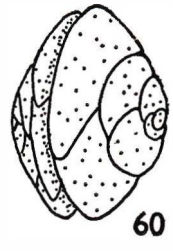
**pyriform:** pear-shaped. e.g., *pyriform chambers* (Fig. 67A)

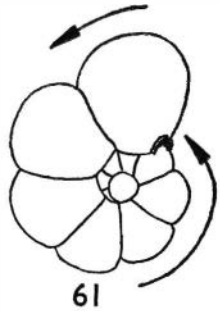
**quinqueloculine:** milioline; each chamber added in plane at 144° to previous chamber; five chambers visible. (Figs. 14; 66A, B, C)



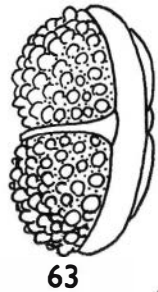




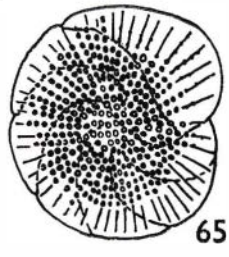












57. *Cassidulinoides* (a = plane of coiling, b = plane of growth, x = axis of coiling, y = axis of growth). 58. *Textularia* (b = plane of growth, y = axis of growth). 59. *Gavelinopsis.* 60. A plastogamic pair of *Glabratella.* 61. *Anomalinoides* (arrow pointing proximally). 62. *Saccorhiza.* 63. *Pegidia.* 64. *Esosyrinx.* 65. *Glabratella.*

**radial suture:** suture between successive chambers in spiral forms. (Fig. 22) e.g., *limbate radial sutures* (Figs. 50A; 75B, C) (cf. *spiral sutures*)

**radial wall:** test composed of calcite or aragonite crystals with c-axis perpendicular to surface; seen between crossed Nicols as black cross with concentric rings of colour mimicking negative uniaxial figure. (*see* Identification Techniques 3, p. 81)

**radiate aperture:** opening associated with numerous divergent slits. (Figs. 21; 40; 41; 46A, B; 64; 67A, B; 71B)

**rectilinear:** growing in a straight line; usually refers to uniserial forms, but may be applied to biserial forms. (Figs. 1, 21, 48, 67A)

**reticulate:** having surface marked by network, usually of raised ornamental ridges, not necessarily regular. (Figs. 68; 75B, C) (Note: Forms with a very fine regular network of ridges are referred to as *cancellate*)

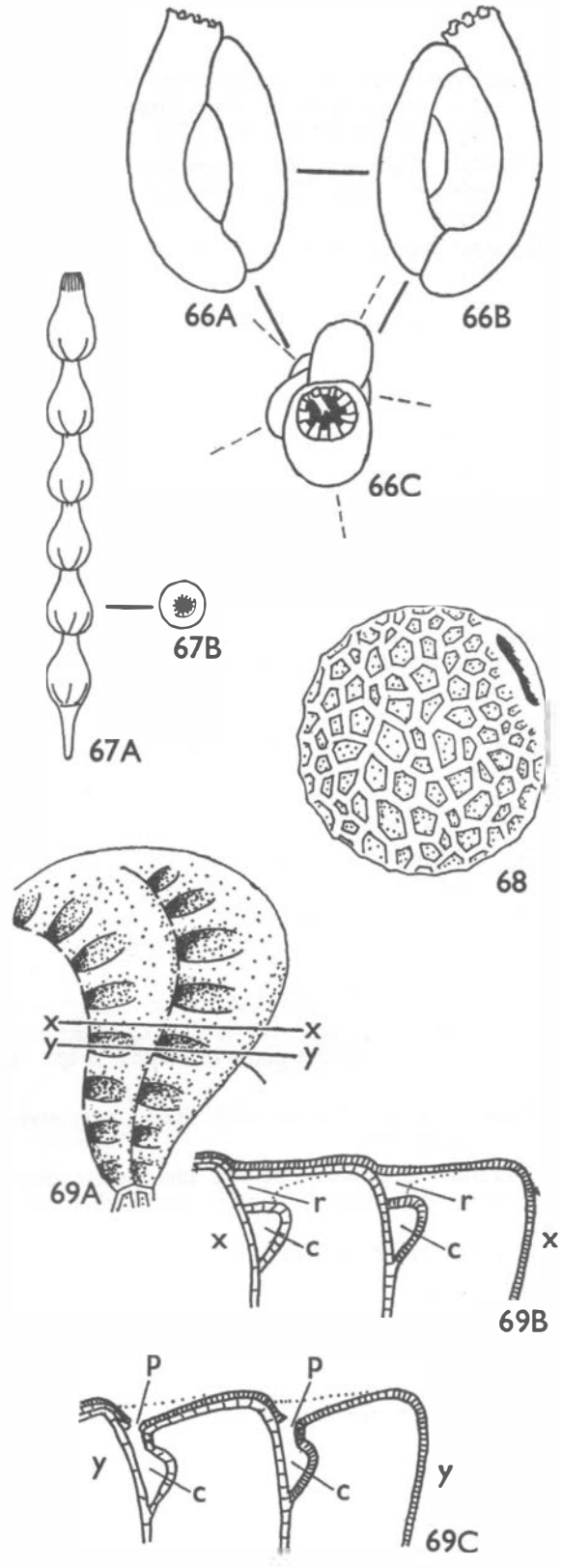
**retral processes:** proximally projecting extensions of chamber cavity located beneath external ridges on chamber wall (commonly above internal canal system) and ending blindly at face of previous chamber. (Figs. 69A, B, C. r = retral process; c = canal system; p = pore)

**rotallid wall:** chamber primarily of single layer continuing as thin lamella over whole of previously formed exterior of test. As each new chamber is added a lamella is also added over distal face of previously formed chamber enclosing a canal system between septal layers. Wall of final chamber single; all others double but incorporating a canal system. (Figs. 69B, C; 70)

**rounded periphery:** smooth transition between two sides of test; outer edge as viewed from stable position not angled. (Figs. 8, 32B, 51B) (cf. *angular periphery*)

**secondary septum:** plate inside chamber formed simultaneously with, or subsequent to, more distal portion of test, partly or completely dividing chamber into two or more chamberlets; independent of, and typically perpendicular to, true septa. (Fig. 5) (Sutures of secondary septa visible in Fig. 11)

**septate:** having partitions or septa dividing test into several chambers




66. *Dentostomina*. 67. *Nodosaria*. 68. *Favocassidulina*. 69. *Elphidium:* A part of exterior; B diagrammatic section through a retral process (x–x); C diagrammatic section between retral processes (y–y); r = retral process, c = canal, p = sutural pore.

**septum:** partition between chambers, often consisting of distal face of previously formed chamber. (Figs. 18; 39; 52; 69A, B, C; 70)

**sigmoidal:** S-shaped. e.g., *sigmoidal suture and periphery* (Fig. 72B) *sigmoidal coiling* (*see* below)

**sigmoidal coiling:** chambers added at slightly less than 180° so that two sets of chambers curve outwards in opposite directions from central point producing S-shaped arrangement in median section of miliolids or basal view of polymorphinids. Two to many chambers visible. (Figs. 71A, B; 72A, B, C)

**sinuate:** having several bends. e.g., *sinuate suture* (Fig. 73)

**spinose:** having elongate and/or pointed projections from surface of test. (Fig. 74) e.g., *spinose periphery* (Fig. 29) (Note: Forms with a dense covering of very fine spines are referred to as hispid)

**spiral ridges:** elongate elevations roughly parallel with periphery or spiral suture of coiled forms, usually between adjacent radial sutures. (Figs. 69A; 75B, C)

**spiral side:** side of trochospiral forms where all whorls are visible, or side which is more evolute than opposite side. (Figs. 50A, 53B, 75C) (cf. *umbilical side*)

**spiral suture:** suture between adjacent whorls in evolute forms. (Fig. 26) (cf. *radial suture*)

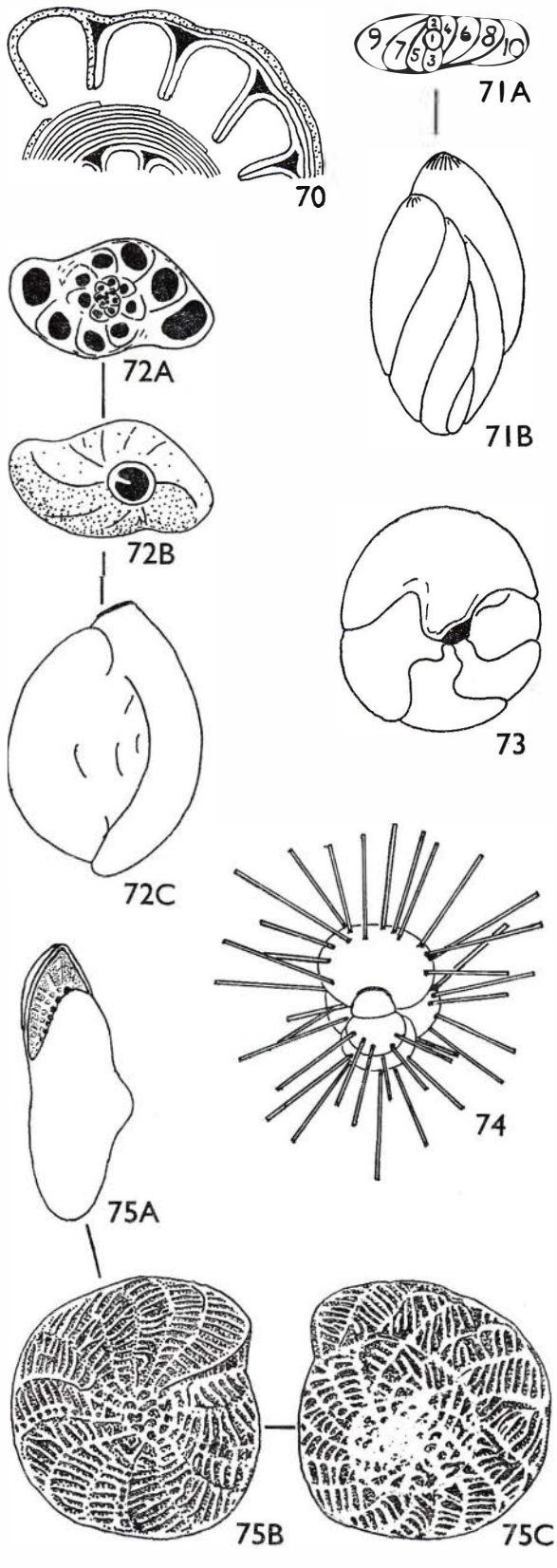
**stolon:** prolonged extension of test; often tubular portion connecting chambers. (Fig. 41)

**streptospiral:** coiled like ball of wool. During growth axis and plane of coiling change; may be one change or many or final chamber only may be in different plane of coiling. (Figs. 76, 77)

**striate:** marked with parallel lines or grooves. (Figs. 14, 78)

**subterminal aperture:** opening just below distal point of uniserial, biserial, and high trochospiral forms, or to one side of periphery of uniserial forms. (Figs. 45A, B)

**supplementary aperture:** opening of test to exterior additional to and independent of *primary aperture* (q.v.); in some forms may completely replace primary aperture, e.g., *supplementary areal apertures* (Figs. 51A, B); *supplementary sutural apertures* (Figs. 51A, B, 81, 90)




70. Diagrammatic section through a rotallid wall. 71. *Sigmomorphina.* 72. *Sigmoilina.* 73. *Tiphotrocha.* 74. *Hastigerina.* 75. *Polystomellina* (*Notorotalia*).

**sutural aperture:** opening situated on suture, not on apertural face. (Figs. 51A, B; 69A; 81; 90)

**sutural flap:** flattened extension of proximal wall of chamber over suture. (Fig. 81)

**suture:** line of union between two chambers or two whorls. e.g., *limbate suture* (Figs. 31A, B; 50A) *spiral suture* (Fig. 26) *radial suture* Fig. 22)

**tectin:** organic substance, basically glycoprotein. Looks like chitin but is distinct chemically. (Synonym of *pseudochitin*)

**tectinous:** having shell or layer of tectin

**terminal:** at distal point. e.g., *areal terminal aperture* (Figs. 21, 41, 47, 48, 67A) *interiomarginal terminal aperture* (Fig. 79)

**test:** agglutinated or secreted shell of animal

**tooth:** projection into principal opening of test. e.g., *simple tooth* (Fig. 72B) *bifid tooth* (Figs. 14; 17A, B; 66C) *apertural flap* (Fig. 6) *umbilical teeth* (Fig. 90) *tooth plate* (see below)

**tooth plate:** internal apertural modification consisting of contorted plate that extends from aperture, through chamber, commonly as far as previous foramen. (Fig. 80) e.g., *part of tooth plate projecting through aperture* (Fig. 79)

**trematophore:** perforate plate over aperture of some members of Miliolacea; sometimes referred to as a sieve plate. (Fig. 82)

**triloculine:** milioline, each chamber added in a plane at 120° to previous chamber, three chambers visible. (Figs. 84A, B, C)

**triradiate aperture:** opening consisting of three divergent slits. (Fig. 84A)

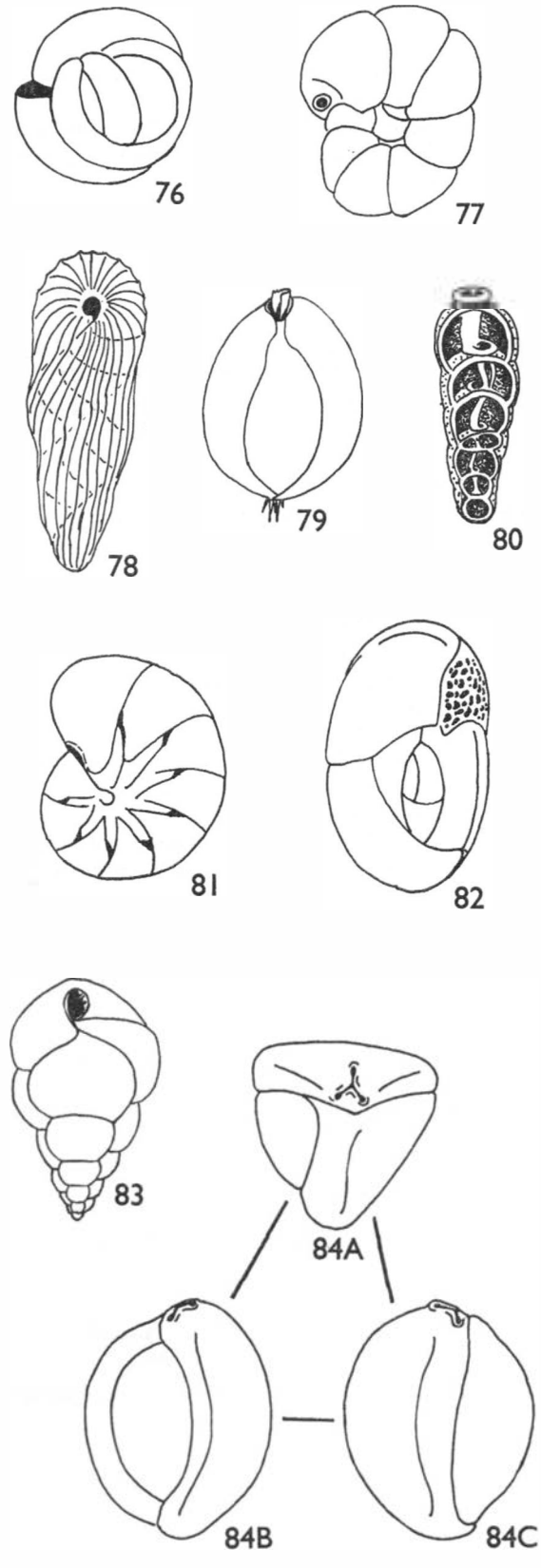
**triserial:** high trochospiral, with three chambers in each whorl, which results in three columns of chambers. (Fig. 83)

**trochospiral:** chambers spirally coiled, evolute on one side, involute on opposite side. e.g., *low trochospiral* (Figs. 50A, B; 53A, B, C; 75A, B, C) *high trochospiral* (Figs. 78, 83)

**truncate periphery:** flattened periphery with sharp angle to two sides. (Figs. 21; 85A, B)

**twisted biserial:** with chambers in two columns which spiral around central axis; plane of growth twisted about axis of growth. (Figs. 86, 87)

**umbilical aperture:** arched opening in final chamber; lower boundary defined by umbilicus; does not extend outside umbilical region. (Figs. 88, 89)




76. *Glomospira.* 77. *Recurvoides.* 78. *Buliminoides.* 79. *Globobulimina.* 80. *Rectobolivina.* 81. *Astrononion.* 82. *Hauerina.* 83. *Bulimina.* 84. *Cruciloculina.*

**umbilical bulla:** blister-like structure that covers umbilical region. (Fig. 19)

**umbilical flap:** extension of chamber wall over umbilicus, possibly covering umbilicus. (Figs. 53C, 90)

(Note: when main aperture is umbilical (e.g. Fig. 89), flaps are called umbilical teeth)

**umbilical plug:** solid shell material occupying open umbilicus. Surface of plug may be subdivided. (Figs. 50B, 59)

**umbilical region:** area round umbilicus. e.g., *granulate covering of umbilical region* (Fig. 85)

**umbilical side:** surface of trochospiral forms where only final whorl visible or which is more involute than opposite surface. (Figs. 50B, 53C, 75B) (cf. *spiral side*)

**umbilical tooth:** plate-like extension of inner margin of chamber into umbilical aperture, usually triangular. (Fig. 89)

**umbilicate:** having an umbilicus. Usually used to describe forms with a very depressed umbilicus. (Figs. 24; 53A, C)

**umbilicus:** centre (possibly depressed) of involute planispiral forms, or umbilical (involute) side of trochospiral forms where all chambers of last-formed whorl meet. e.g., *open umbilicus* (Fig. 53C) *closed umbilicus* (Fig. 22)

**umbo:** dome, cone, or knob of solid shell material in centre of planispiral coil or spiral side of low trochospiral coil; usually only surface thickening. (Figs. 75A, C; 85A, B)

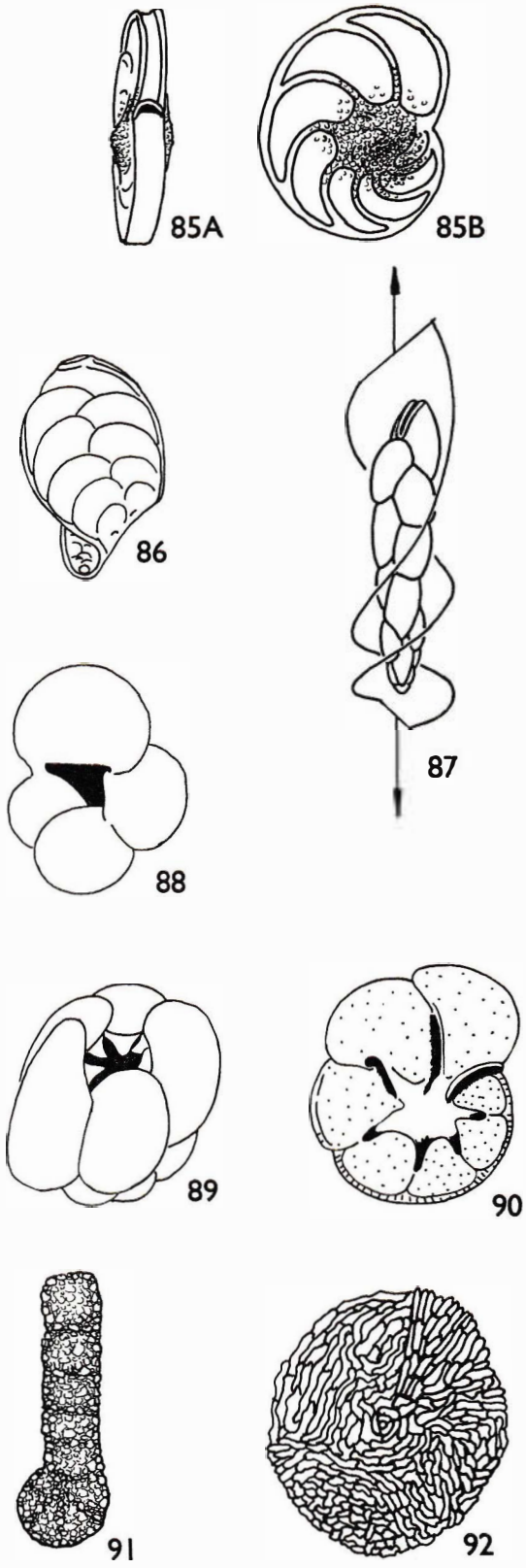
**uncoiling:** having early chambers enrolled, usually planispirally, later portion biserial or uniserial with axis of growth perpendicular to axis of coiling. e.g., *close-coiled changing suddenly to rectilinear uniserial* (Fig. 91) *gradually uncoiling (biserial) series* (Fig. 57) *uncoiling with later chambers arcuate* (Fig. 37)

**unilocular:** single chambered, test not divided by septa into chambers. Also used to describe undivided tubular forms which arise from an initial proloculus. e.g., *single globose chamber* (Figs. 9, 33, 40, 42) *essentially tubular chamber* (Figs. 2, 12, 26, 28, 62) cf. multilocular

**uniserial:** having chambers in single row. (Figs. 1, 21, 41, 67A)

**vermiform:** long, thin, cylindrical, usually irregularly bent. e.g., *vermiform chambers* (Fig. 92)

**whorl:** single turn or volition of coiled test through 360°.




85. *Planulina.* 86. *Compressigerina.* 87. *Fursenkoina.* 88. *Globigerina.* 89. *Globoquadrina.* 90. *Discorbis.* 91. *Ammobaculites.* 92. *Planogypsina.*

# USEFUL TECHNIQUES

## Collecting

*Pelagic*

1. An N70 plankton net (Kemp and Hardy 1929) with fine mesh of about 200 microns (86 meshes per in.) is satisfactory for normal vertical or oblique tows (cf. Bé 1959a).
2. A Clarke-Bumpus sampler (Clarke and Bumpus 1940) is towed at constant depth (horizontal tow) and the volume of water strained is measured by a flow meter. It must be towed slowly through considerable distances.
3. The continuous plankton recorder (Hardy 1936) is suitable for high-speed towing through near-surface waters.
4. The multiple plankton sampler (Bé, Ewing, and Linton, 1959) will take samples at successive depth ranges in a vertical haul. Several nets are opened and closed at the required depth by messengers or in more refined models (Bé 1962) by a pressure gauge.

*Benthonic*

1. The Phleger corer (Phleger 1951), a short corer with a 1½ in. diameter plastic inner lining, collects a relatively undisturbed sample of known surface area. At the N.Z. Oceanographic Institute an even shorter barrel with 2 in. diameter plastic liner and much wider weights (to prevent deep penetration) has been found satisfactory. Square weights will prevent the equipment rolling on deck in rough weather, and a bayonet-fix cutter described by Willis (1966) is easily fixed and removed but does not slip off when the corer is being used. Care must be taken to keep all apparatus vertical until the sample is removed. The same volume of sediment is removed from the surface of the core on each occasion (about 1 cm depth) and placed in a jar with the water from immediately above the sediment and 90% ethyl alcohol as preservative. The short corer is the normal equipment for sediment and foraminiferal distribution studies at the New Zealand Oceanographic Institute, but it is of little use in areas of pure sand or pebbles.
2. An orange-peel grab modified with a canvas skirt (Phleger 1952; Reish 1959) or with plates at the top of the blades to protect the surface layer will collect a suitable sample of sand or gravel. A piece of plastic liner is pressed into the surface and the upper 1 cm of sediment removed, placed in a jar, and 90% ethyl alcohol added. Alternatively, a shorter corer can be built into the orange-peel grab as illustrated by Willis (1966).
3. If sampling is done in very shallow water from a small boat, lightweight equipment must be used. A short corer with movable weights is particularly suitable (Murray 1961). The line is attached to the weights so that by repeatedly raising them and letting them fall the corer is driven into the sediment. If the investigation is not quantitative, a small snapper grab (Lafond and Dietz 1948) or even simply a piece of tube, one end of which is closed and the opposite end attached by a line to the surface, will collect a sample of the surface sediment.
4. Waves lapping onto a beach commonly leave a faint white line as each one recedes. If this is very carefully removed with a sharp knife or razor blade, it is usually found to be rich in empty tests of the local littoral and sub-littoral foraminiferal population.
5. Living specimens for observations and culture studies can be obtained from intertidal weeds. Around New Zealand the calcareous algae *Corallina officinalis* (Linnaeus) forms a purplish brown carpet in many tide pools and usually provides a varied fauna of living foraminifers (Hedley *et al.*, 1967). The algae can be collected in handfuls and shaken under water over a coarse sieve (about 16 meshes per in., 1·0 mm aperture) with a finer sieve (about 120 meshes per in., 0·125 mm aperture) below it. If the debris from the finer sieve is left to stand overnight in a shallow dish of sea water, many foraminifers, particularly miliolids which are negatively geotropic, will climb to local high points and up the sides of the dish. These can easily be removed for experiments.

   If, during calm weather, glass slides are left over night among weeds in a tide pool, the animals will commonly crawl on to the slide and so can be removed completely unharmed from their natural habitat.

## Sample Processing

*Pelagic*

Shelled planktonic organisms (foraminifers, radiolaria, and pteropods) can be separated from the mass of unshelled organisms by a density separation in saturated sodium chloride solution (Bé 1959b).

*Benthonic*

1. *Washing:* Wash through a 240 mesh per in. sieve (0.064 mm aperture), which removes alcohol and all material of silt and clay grade, including juvenile and very small foraminifers.

2. *Staining:* Protoplasm is stained satisfactorily by Rose Bengal (Walton 1952).
   (a) Transfer the residue to a beaker containing an aqueous solution of Rose Bengal. The solution should be dark pink; the concentration is not critical.
   (b) Leave for more than 30 minutes, preferably several hours.
   (c) Drain off the stain on a 240 mesh per in. sieve then wash the sample thoroughly to remove all excess stain. The sample is easier to study if it is washed through a nest of sieves and the fractions of similar size are examined separately. Removal of surface staining is most effective if the sample is left to stand in clean water and washed again.
   (d) Wash the sample on to a counting tray.
   (e) The sample is best examined under water at this stage; as the shell wall is usually less opaque when wet very fragile specimens may be broken by further processing and tectinous forms would shrivel beyond recognition when dried. Specimens that were alive when the sample was collected usually have blobs of pink- or red-stained protoplasm in one or many chambers. Empty tests may have an epizoic fauna of bacteria or algae which when stained appears as a patchy pink film on the interior surface.
3. *Dividing large samples:* Large samples may be repeatedly divided into two roughly equal portions by either
   (a) make a mound of the sample, divide it twice at right angles then take opposite quarters, or
   (b) use the microsplitter described by Parker (1948), which consists of a trough bisected by a knife edge, or
   (c) for more accurate work use the microsplitter designed by Otto (1933) which has channels pointing in opposite directions.

   The sample can then be spread evenly and sparsely on the counting tray and each specimen in random squares identified. When the required number has been counted the total of each group of formaminifers in the sample can be estimated. For counts of dead or total population, the material is more easily sieved and picked if it is first dried.
4. *Concentrating:* Except for quantitative studies the foraminifers can be concentrated by a density separation in carbon tetrachloride (Cushman 1940).
   (a) The washed and dried sample is poured into a beaker containing carbon tetrachloride.
   (b) The floating portion with the carbon tetrachloride is decanted off into a filter funnel.
   (c) The filtered carbon tetrachloride is retained for further use. The residue in the filter paper, which contains most of the whole, airfilled foraminifers, is dried. The residue in the beaker contains all the mineral grains, and broken and dense foraminifers.

*Warning:* Carbon tetrachloride vapour is extremely dangerous if inhaled in large quantities, through a lighted cigarette, or after drinking alcohol. It is recommended that concentration be done in the open air or in a room with doors open to create a draught. Fume cupboards are often ineffective in removing the dense vapour.

Bromoform or tetrabromethane diluted with acetone to a specific gravity of about 2.3 can be used instead of carbon tetrachloride. Both heavy liquids are less volatile and toxic than carbon tetrachloride and float off a far higher proportion of the foraminifers (Gibson and Walker 1967). However, pellets, ash, and glauconite grains may also float, sometimes in large numbers, and thorough washing of the concentrate and residue can be time consuming.

## Removing Specimens From Sample

1. Specimens can be picked from the dry sample with an artist's OO or O sable hair brush. Dipped in water and drawn lightly across a piece of cloth this will produce a very fine point to which dry tests will adhere. Specimens immersed in water can be removed, with practice, by wedging them between the bristles of the brush.
2. A vacuum-needle segregating pick (Stinemeyer 1965) is a useful tool, if large numbers of dry samples are to be picked and sorted.

## Mounting

1. Cardboard slides with a black-based tray are customarily used for mounting specimens. A thin layer of gum tragacanth is painted on to the tray as an adhesive. Before it is mixed to a thin paste with water, about 5% by weight of mercuric chloride or clove oil should be added to the gum tragacanth powder to inhibit mould growth and attack by mites and silverfish.
2. Plastic slides are now being produced with a photopaper base to which a damp foraminifer will stick automatically. These are very convenient and cheap. Gum tragacanth must still be used to stick large specimens and the mounts are easily damaged by some oils (not clove oil), repeated moistening, and mercuric chloride.

## Identification Techniques

1. *To reveal surface ornamentation or apertural details*

Blue or green fountain pen ink painted on to the surface usually enhances detail; a solution of methyl blue or malachite green may be useful for very fine structures.

2. *To reveal internal structure*

If the specimen is dampened with water or oil, considerably more internal detail is usually revealed. Oil of cedarwood and aniseed oil are both satisfactory, but aniseed oil damages plastic mounts.

Greater detail can be observed if the specimen is transferred to a glass slide with a central cavity, covered with a few drops of oil, and examined in transmitted light. Glycerine or castor oil may be used to make the mount semi-permanent. If necessary the specimen can be crushed or cut with a razor blade while immersed in oil.

With care the shell wall can be dissected away with the point of a fine brush that has been dipped in very dilute hydrochloric acid.

3. *To distinguish optical characters of calcareous wall*

The optical characters and arrangement of crystals in the calcareous wall are most readily distinguished if the specimen is transferred to a glass slide, covered with a drop of oil, crushed, and the fragments examined in transmitted light and between crossed Nicols (polaroids) (Table 1).

4. *To reveal mineralogical composition of calcareous walls*

Calcite and aragonite can be distinguished by using Feigl's solution (Feigl 1954).

To make up Feigl's solution:

(a) Dissolve 11·8 g of $MnSO_4$ $4H_2O$ in 100 ml of water.
(b) Dissolve 1 g of $AgSO_4$ in the $MnSO_4$ solution.
(c) Bring to boil.
(d) Cool.
(e) Filter off suspension.
(f) Add 1 or 2 drops of dil. NaOH solution to filtrate.
(g) Filter after 2 hours.
(h) Store solution in small dark airtight bottle away from direct sunlight; it will then keep for many months or even years.

To stain with Feigl's solution:

(a) Transfer specimen to glass slide.
(b) Etch surface by painting with very dilute $H_2SO_4$ and leaving for about 1 minute.
(c) Add several drops of pure alcohol to wash away excess acid, then wait for specimen to dry.
(d) Paint on Feigl's solution, wait for 5–10 minutes.

If specimen remains unaffected by Feigl's solution it is calcite. If specimen becomes black in Feigl's solution it is aragonite.

TABLE 1. **Distinguishing optical characters in calcareous walls**

| Transmitted light | X Nicols | Type of wall | |
|---|---|---|---|
| amber or reddish brown without pores | no figure, possibly specks of colour | porcellaneous wall | |
| colourless, milky, or pale blue with pores | black cross with rings of colour mimicking uniaxial figure | radial wall | hyaline wall |
| | mottled with specks of colour | granular wall | |

TABLE 2. **Lamellar nature of calcareous walls observed in thin section**

| Lamella from each chamber continuing over previously formed exterior of test | Septa | Final chamber | Type of wall |
|---|---|---|---|
| absent; test typically of single layer throughout | of single lamella | of single lamella | non-lamellar |
| present | of single lamella | of single lamella | monolamellar *see* Glossary Fig. 52 |
| present | double or partly double, with canal system between lamellae | of single lamella | rotallid wall *see* Glossary Figs. 69 B, C; 70 |
| present | double, without canal system between lamellae | double | bilamellar *see* Glossary Fig. 18 |

5. *To reveal lamellar nature of calcareous wall*

The structure of the shell wall can be readily observed in thin section. Preparation of thin section (Hornibrook, 1968):

(a) Heat specimen gently on clean slide with very small piece of Lakeside 70C cement. Use hot plate at about 140°C.

(b) Transfer to binocular microscope and orientate specimen with hot needle.

(c) Allow to cool.

(d) Grind on glass plate with aluminium oxide powder mixed to a thin paste with water. 302 grade aluminium oxide is preferable for large specimens, 303 for more delicate forms.

(e) Wash and examine under microscope at frequent intervals. If necessary reheat so that interiors of chambers are filled with cement.

(f) When nearing required state of grinding, transfer to microscope stage and continue grinding under observation in reflected light by slowly rotating over the specimen another slide lubricated with aluminium oxide paste.

(g) When required position is reached reheat slide and turn specimen over with a hot needle, pressing the flattened face against slide.

(h) Allow to cool.

(i) Continue grinding on glass plate.

(j) Grind final stages under observation, but this time use of transmitted light and fine (304) grade grinding powder is advisable.

(k) When required thickness is reached wash and dry slide.

(l) Add drop of fairly fluid Canada balsam/xylene mixture.

(m) Rest one edge of cover slip in place, then lower it slowly into position.

(n) Heat for some time on hot plate at 90°–100°C.

(o) Allow to cool.

Layers (lamellae) making up the walls and septa can be seen by examining the thin section under high magnification on a petrological microscope. (Table 2).

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# INDEX

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1,530/7/68—35367 A