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FORAMINIFERA

Families: Globigerinidae and Globorotaliidae

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PLANKTONIC FORAMINIFERA

There are about 30 described species of planktonic Foraminifera living in the world oceans. They occur primarily in the euphotic zone. The few deep water-species probably spend their earlier stages in near-surface waters. Most of the species (22) are tropical-subtropical; five are cold-temperate or subpolar species. Three species are found in Antarctic waters and of these one is also present in the Arctic Ocean. The Indo-Pacific fauna except for its greater species diversity, is essentially similar to that of the Atlantic.

The classification and key used here agrees in most respects with that of PARKER (1962). The presence or absence of spines is a major criterion in distinguishing the two families. The morphological terms in this key have been defined in a publication by BOLLI, LOEBLICH, and TAPPAN (1957).

Order FORAMINIFERIDA

Family **Globigerinidae** CARPENTER, PARKER and JONES, 1862

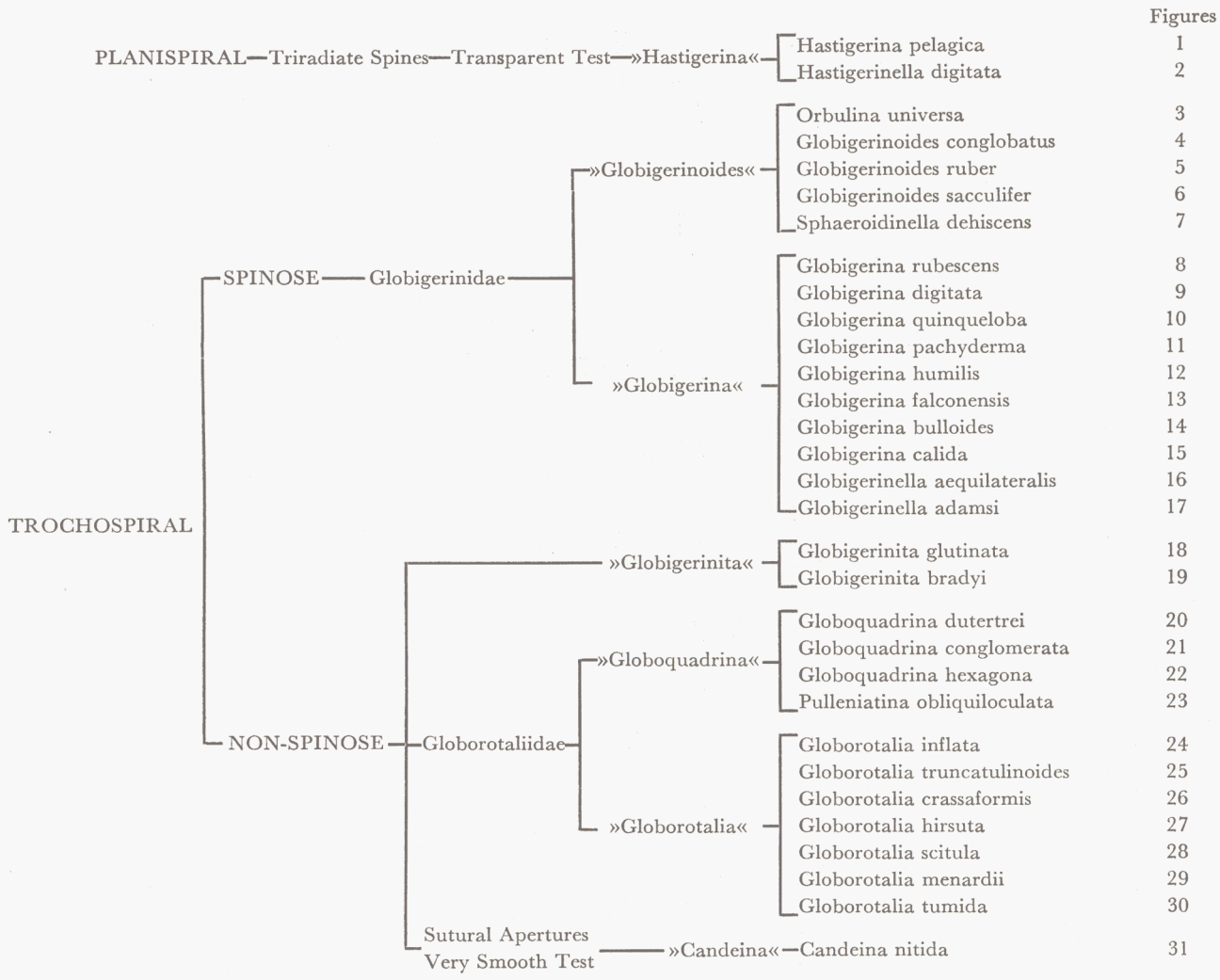
Description (after PARKER, 1962): Test trochospiral in the adult or in ontogeny, streptospiral, or globular; chambers spherical, ovate or clavate; wall calcareous, perforate, radial in structure, hispid, spinose when living either in the adult or in ontogeny; primary aperture umbilical, umbilical-extraumbilical, equatorial or spiroumbilical; may have secondary apertures; may have bullae with accessory infralaminal apertures.

Family **Globorotaliidae** CUSHMAN, 1927

Description (emended from that of PARKER, 1962): Coiling of test trochospiral; chambers angular to ovate or spherical; may have a keel; wall calcareous, perforate, radial in structure, smooth, pitted; non-spinose when living both in the adult and in ontogeny; primary aperture extraumbilical-umbilical or umbilical; no secondary apertures.

KEY TO GENERA

1. Trochospiral test (spines simple, if present) 2
1. Planispiral test with triradiate spines (gerontic stage streptospiral) ..... *Hastigerina*
2. Primary aperture (and, if present, secondary apertures) 3
2. Sutural apertures, smooth surface ..... *Candeina*
3. Non-spinose tests ..... *4–6 Family Globorotaliidae*
3. Spinose tests ..... *7–10 Family Globigerinidae*
4. Test with spherical or hemispherical chambers, umbilical aperture and rounded periphery 5
4. Test with angular to ovate chambers; spiral side flat or gently curved; peripheral keel may be present; aperture a narrow slit from umbilicus to periphery ..... *Globorotalia*
5. Trochospiral coiling throughout life 6
5. Streptospiral coiling in adult ..... *Pulleniatina*
6. Hemispherical chambers with umbilical aperture; coarsely pitted surface texture; umbilical tooth ..... *Globoquadrina*
6. Spherical chambers and umbilical aperture frequently covered by bulla with infralaminal apertures; smooth surface texture *Globigerinita*
7. Primary aperture only 8
7. Primary aperture and one or more secondary apertures 9
8. Aperture umbilical, chambers spherical to ovate ..... *Globigerina*
8. Aperture from umbilicus to periphery; trochospiral in ontogeny becoming nearly planispiral in adult ..... *Globigerinella*
9. Multi-chambered test 10
9. One-chambered spherical test (juvenile stage is multi-chambered with secondary apertures) ..... *Orbulina*
10. Cancellate, honeycomb-like surface ..... *Globigerinoides*
10. Pitted to smooth, translucent texture; chamber flanges ..... *Sphaeroidinella*



In the Key overleaf species marked ** are commonly found in the northeastern Atlantic between 40°N and 65°N lat. and between 25°W long. and Western Europe. Species marked * occur less commonly in this area.

Each species in the Key and in the diagram above is given a number and the same number is used in the figures, different views of the same species being lettered a, b, c.

Unless otherwise marked all the bar scales (placed underneath the middle specimen) are 500 μ.

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Key to Species

Species	Test				Chambers		Apertures		Spines	Diagnostic Characters	Distribution	Figs.
	Outline	Dominant Coiling Direction (spiral side)	Texture	Maximum length	Number per whorl	Shape	Primary aperture position	Secondary apertures per chamber				
**Hastigerina pelagica* (d'Orbigny)	Planispiral		Smooth	>1 mm	4 in juvenile; 6 in adult	Spherical	Equatorial		Triradiate spines	Transparent test, triradiate spines	Subtropical, tropical	1
Hastigerinella digitata (Rhumbler)	Planispiral Streptospiral		Smooth	Up to 5 mm	6	Bifurcate or trifurcate in adult	Equatorial becoming spiroumbilical		Triradiate spines	Transparent test, triradiate spines, horn-like chambers	Subtropical, tropical below 500 m depth	2
**Orbulina universa* d'Orbigny	Trochospiral in juvenile; spherical in adult		Spinose	~1 mm	4–5 in juvenile; 1 in adult	Spherical	Umbilical in juvenile; none in adult	One (in earlier stages only)	Spinose	Single spherical chamber	Tropical, subtropical	3
Globigerinoides conglobatus (Brady)	Trochospiral nearly spherical	Left+Right	Coarsely spinose	~1 mm	5–6 in juvenile; 4 in adult	Spherical becoming compressed	Umbilical	Two	Spinose	Two secondary apertures per chamber; primary aperture over 3 chambers; round outline	Tropical, subtropical surface waters	4
Globigerinoides ruber d'Orbigny	Trochospiral	Left+Right	Coarsely Spinose	~0.6 mm	5 in juvenile; 3 in adult	Spherical	Umbilical	Two	Spinose	Pink to red pigment; two secondary apertures per chamber; primary aperture over two chambers	Tropical, subtropical surface waters	5
Globigerinoides sacculifer (Brady) [= *Globigerinoides trilobus* (Reuss)]	Trochospiral ovate	Left+Right	Spinose, honeycomb texture	~1.3 mm	6–7 in juvenile; 4 in adult	Spherical; last chamber often elongate and compressed	Umbilical	One	Spinose	Sac-like final chamber (if present); one secondary and one primary aperture per chamber; honeycomb texture; primary aperture over three chambers	Dominant species in tropical surface water; common also in subtropical regions	6
»*Sphaeroidinella dehiscens* (Parker and Jones)« a terminal form of *Globigerinoides sacculifer* (Brady)	Trochospiral ovate	Left+Right	Smooth to pitted	~1.3 mm	4 in adult	Spherical with chamber flanges	Umbilical (obscured)	One (concealed)	Spinose in juvenile; non-spinose in adult	Great wall thickening producing smooth, glassy layer; chamber flanges coalesce and obscure apertures	Tropical, subtropical below 500 m depth	7
Globigerina rubescens Hofker	Trochospiral	Left+Right	Spinose Hispid	~0.25 mm	5 in juvenile; 4 in adult	Spherical	Umbilical		Spinose	Light orange-pink pigment in test	Tropical, subtropical surface waters	8
Globigerina digitata Brady	Trochospiral	Left+Right	Spinose Hispid	~0.65 mm	4–5 in juvenile; 4–6 in adult	Spherical in juvenile; digitate in adult	Umbilical spiro-umbilical in adult		Spinose	Digitate final chamber(s)	Tropical, subtropical	9
***Globigerina quinqueloba* Natland	Trochospiral compressed	Left+Right	Spinose; smooth	~0.27 mm	5–6 in juvenile and adult	Hemispherical to ovate flap-like final chamber	Umbilical; sometimes modified into infralaminal apertures		Spinose	Final chamber a lobed extension over umbilicus, but not always present	Subarctic and subantarctic cold-temperate surface waters; left-coiling population in colder waters	10
***Globigerina pachyderma* (Ehrenberg)	Trochospiral compact	Left+Right	Coarse	~0.47 mm	5 in juvenile; 4 in adult	Spherical becoming subquadrate	Umbilical becoming extra-umbilical; distinct lip		May be present in juvenile; absent in adult	Subquadrate, coarse-crystaline compact test; aperture is a narrow slit with distinct lip	Left-coiling in sub-polar; right-coiling in cold-temperate waters	11

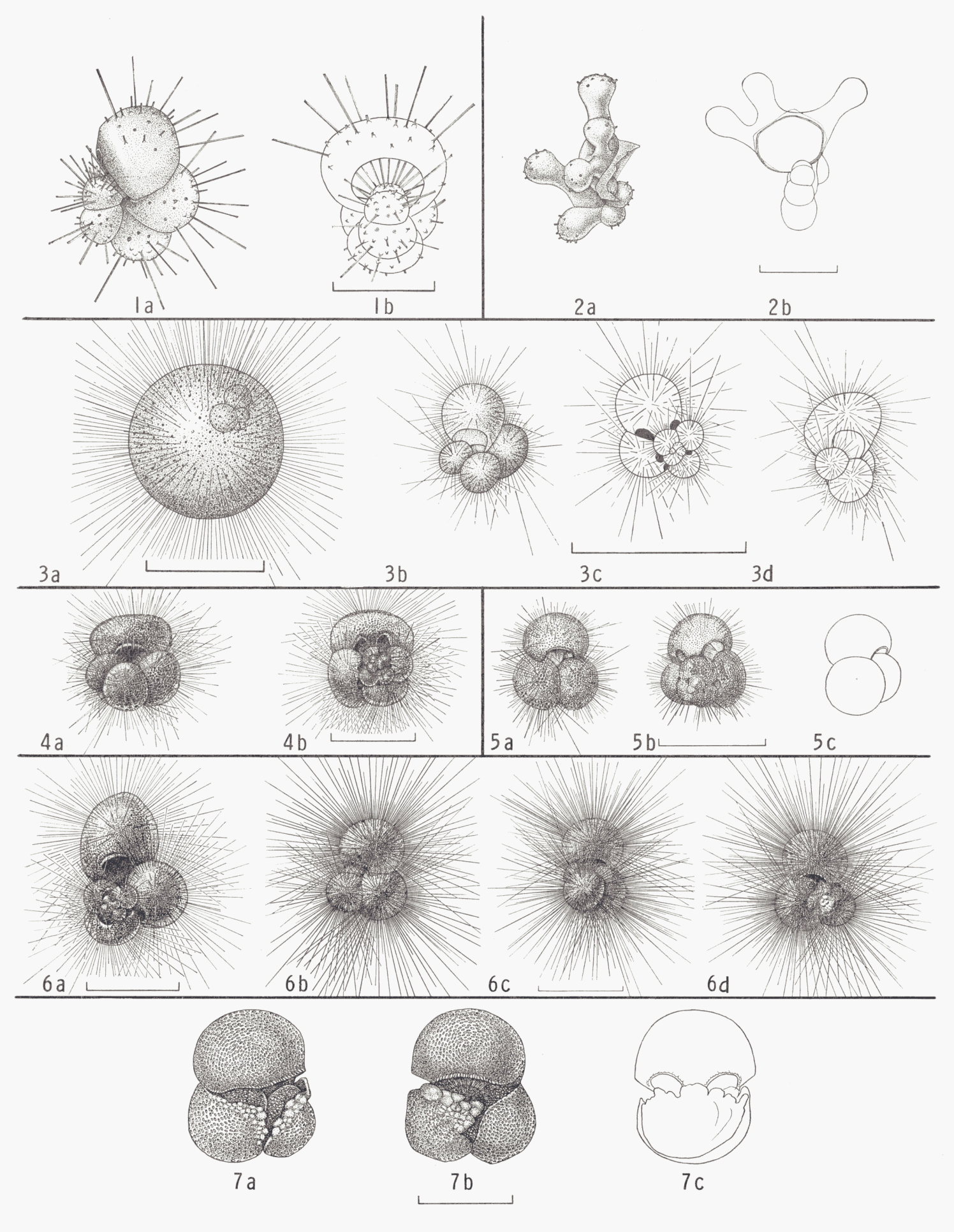
Globigerina humilis (Brady)	Trochospiral compressed	Left+Right	Spinose smooth	~0.21 mm	5–6 in juvenile; 6–8 in adult	Hemispherical to ovate; flap-like final chamber	Umbilical; sometimes modified into infralaminal apertures		Spinose	Six to eight chambers per whorl and bulla-like final chamber	Subtropical to subpolar	12
Globigerina falconensis Blow	Trochospiral	Left+Right	Spinose hispid	~0.43 mm	5 in juvenile; 4 in adult	Spherical to ovate	Umbilical with lip		Spinose	Resembles *Globigerina bulloides* but has more elongate chambers, low arched aperture with lip and smaller test	Cold-temperate and subtropical	13
****Globigerina bulloides*** d'Orbigny	Trochospiral	Left+Right	Spinose hispid	~0.8 mm	5 in juvenile; 4 in adult	Spherical	Umbilical		Spinose	Large, high-arched aperture	Subpolar, cold-temperate	14
Globigerina calida Parker	Trochospiral	Left+Right	Spinose hispid	~0.8 mm	5 in juvenile; 4–6 in adult	Spherical becoming elongate	Umbilical becoming extra-umbilical		Spinose	Elongate final chambers, highly arched aperture, intergrades with *Globigerina bulloides* and *Globigerinella aequilateralis*	Subtropical, tropical	15
Globigerinella aequilateralis (Brady) [= *Globigerinella siphonifera* (d'Orbigny)]	Trochospiral becoming nearly planispiral	Left+Right	Spinose hispid	~0.9 mm	5 in juvenile; 5–6 in adult	Spherical	Equatorial, interio-marginal arch		Spinose	Nearly planispiral test	Subtropical, tropical	16
Globigerinella adamsi (Banner and Blow)	Trochospiral becoming nearly planispiral	Left+Right	Spinose hispid	~1.48 mm	5 in juvenile; 5–7 in adult	Spherical becoming radially elongate	Umbilical becoming interio-marginal equatorial		Spinose	Radially elongate, pointed final chambers	Subtropical, tropical in Indian and Pacific Oceans only	17
Globigerinita glutinata (Egger)	Trochospiral	Left+Right	Smooth finely hispid	~0.48 mm	5 in juvenile; 4 in adult	Spherical	Umbilical, sometimes modified into infra-laminal apertures			Bulla and infralaminal apertures; smooth test	Subpolar to tropical	18
Globigerinita bradyi Wiesner [= *Globigerinita uvula* (Ehrenberg)]	Trochospiral	Left+Right	Smooth finely hispid	~0.19 mm	5 in juvenile; 4 in adult	Spherical	Umbilical sometimes modified into infra-laminal apertures			Bulla and infralaminal apertures; high spire and numerous chambers	Subpolar and cold-temperate	19
Globoquadrina dutertrei (d'Orbigny) (= *Globigerina eggeri* Rhumbler)	Trochospiral	Right mostly	Coarse pitted	~0.68 mm	5 or 6 in juvenile; 4–6 in adult	Hemispherical	Umbilical with umbilical tooth			Non-spinose, pitted wall; umbilical tooth; predominantly right-coiling	Tropical, subtropical	20
Globoquadrina conglomerata (Schwager)	Trochospiral	Left+Right	Coarse, pitted	~0.86 mm	6 in juvenile; 4 in adult	Hemispherical	Umbilical with umbilical tooth			Non-spinose, pitted wall; umbilical tooth; 4 chambers in last whorl of adult	Tropical Pacific and Indian Oceans only	21
Globoquadrina hexagona (Natland)	Compressed trochospiral becoming nearly planispiral	Left+Right	Coarse, pitted	~0.58 mm	5 in juvenile; 5–6 in adult	Hemispherical	Umbilical becoming extra umbilical with tooth			Non-spinose, pitted wall; umbilical tooth; compressed test with apertural and spiral sides depressed	Tropical, subtropical in Pacific and Indian Oceans only	22
Pulleniatina obliquiloculata (Parker and Jones)	Trochospiral becoming streptospiral	Right mostly	Pitted in juvenile; very smooth in adult	~0.8 mm	4–5 in juvenile; 3½ in adult	Hemispherical, later overlapping earlier chambers	Umbilical becoming extra umbilical			Streptospiral, right-coiling; highly polished test with crescent-shaped aperture; juvenile resembles *Globoquadrina dutertrei*	Tropical, subtropical; abundant in November in subtropical North Atlantic	23

Keel is absent in all species listed on these two pages.

Key to Species

Species	Test				Chambers		Apertures		Keel	Diagnostic Characters	Distribution	Figs.
	Outline	Dominant Coiling Direction (spiral side)	Texture	Maximum length	Number per whorl	Shape	Primary aperture position	Secondary apertures per chamber				
****Globorotalia inflata*** (d'Orbigny)	Trochospiral; flat spiral side; inflated apertural side	*Left mostly*	Smooth; crystalline at apertural base	~0.65 mm	5 in juvenile; 4 in adult	Inflated, hemispherical	Large; umbilical to extra umbilical			Large aperture, rounded periphery; left-coiling and smooth test	Cold-temperate regions between subpolar and subtropical; in winter in subtropics	24
Globorotalia truncatulinoides (d'Orbigny)	Trochospiral conical	Left+Right	Smooth to hispid	~0.9 mm	6 in juvenile; 5–6 in adult	Angular conical	Elongate from umbilicus to periphery, with lip		Well-developed keel	Conical test	Subtropical, especially abundant between December and March in Sargasso Sea; distinct provinces of left- and right-coiling populations in Atlantic and Pacific	25
Globorotalia crassaformis (Galloway and Wissler) [= *Globorotalia punctulata* (d'Orbigny)]	Trochospiral planoconvex	Left mostly	Smooth to hispid	~0.65 mm	5–6 in juvenile; 4–5 in adult	Angular conical	Elongate from umbilicus to periphery, with lip		Obscure, thin keel	Differs from *Globorotalia inflata* in its slit-like aperture and angular periphery; differs from *Globorotalia hirsuta* in its convex apertural side and flat spiral side	Subtropical, often below 300 m	26
Globorotalia hirsuta (d'Orbigny)	Compressed trochospiral; biconvex or apertural side flat	Right mostly	Coarsely hispid	~1.0 mm	4–5 in adult	Angular rhomboid	Elongate from umbilicus to periphery, with lip		Obscure in juvenile; thin in adult	More lobulate periphery and fewer chambers than *Globorotalia scitula;* right-coiling mostly	Subtropical, especially in winter	27
Globorotalia scitula (Brady)	Compressed trochospiral biconvex	Left+Right	Smooth in juvenile, becoming hispid	~0.66 mm	5–6 in juvenile and adult	Angular rhomboid	Elongate from umbilicus to periphery, with lip		Absent or obscure	More rounded periphery and smoother test than *Globorotalia hirsuta*	Subpolar to equatorial especially below 500 m	28
Globorotalia menardii (d'Orbigny) [= *Globorotalia cultrata* (d'Orbigny)]	Compressed trochospiral subcircular outline	Left mostly	Smooth in juvenile; coarsely hispid at aperture base	~1.5 mm	5–6 in adult	Angular rhomboid	Elongate from umbilicus to periphery, with lip		Well-developed keel	Rounded, moderately lobulate periphery; differs from *Globorotalia tumida* in flatter and subcircular, thinner test	Tropical, subtropical	29
Globorotalia tumida (Brady)	Compressed trochospiral elongate oval outline	Left mostly	Smooth in juvenile; coarsely crystalline in adult	~1.4 mm	5–6 in adult	Angular rhomboid	Elongate from umbilicus to periphery, with lip		Well-developed keel	Elongate oval outline and higher spire than *Globorotalia menardii;* test often greatly thickened	Tropical, subtropical	30
Candeina nitida d'Orbigny	Trochospiral	Right mostly	Very smooth	~0.76 mm	4 in juvenile; 3 in adult	Spherical	Umbilical but absent in adult	Sutural apertures		Multiple sutural apertures between all chambers; very smooth globular test	Tropical, subtropical surface waters	31

Spines are absent in all species listed on this page.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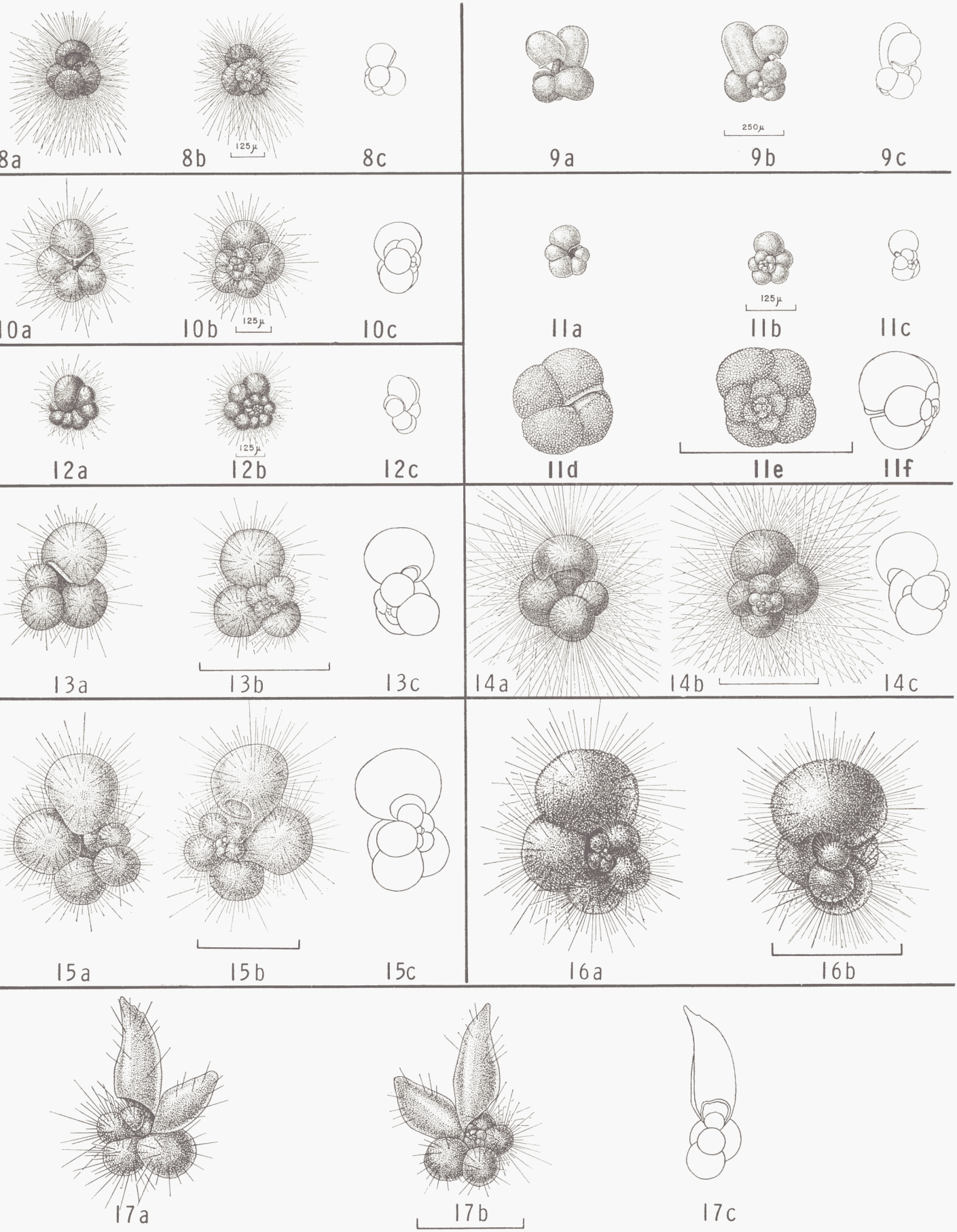

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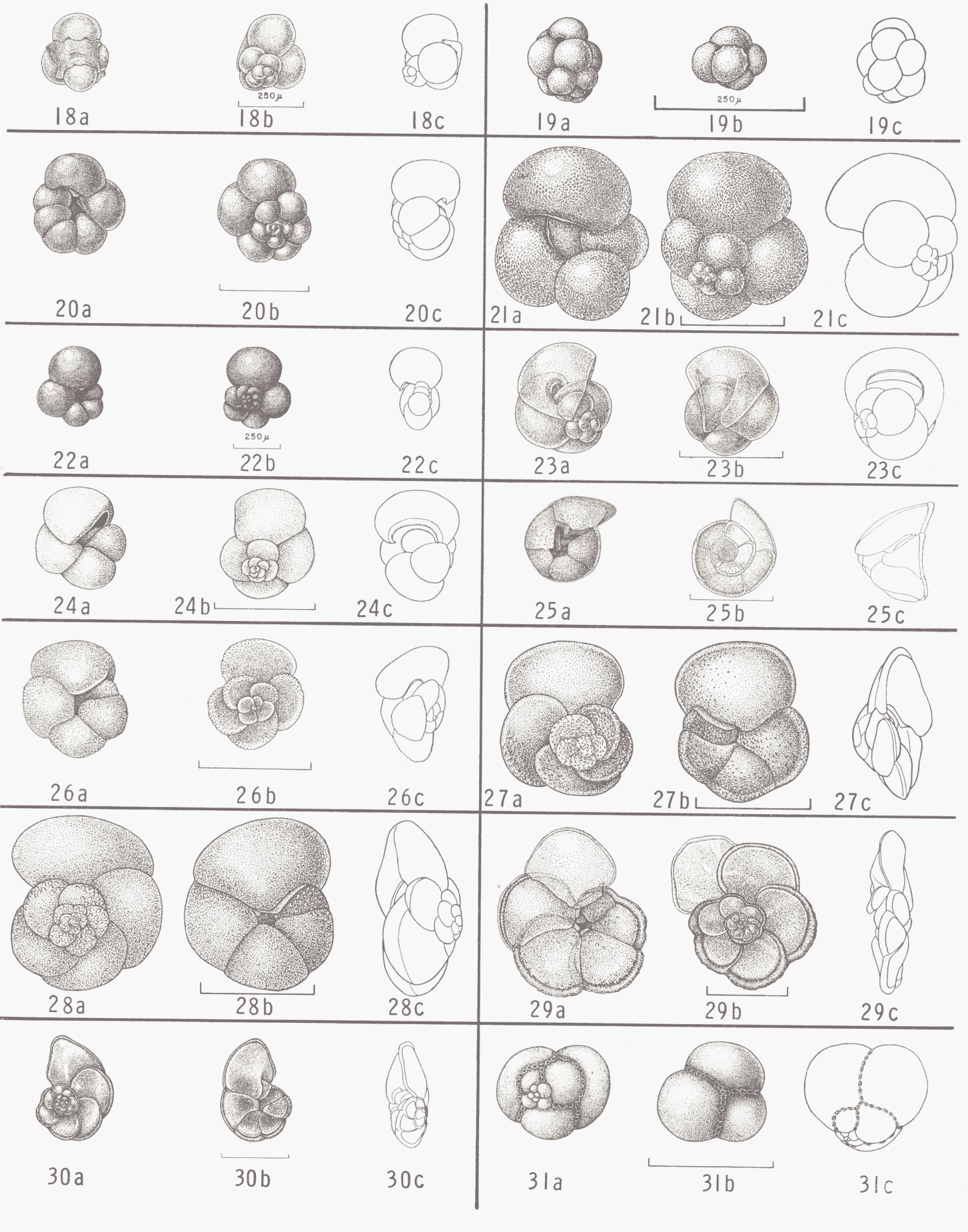
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DISTRIBUTION OF PLANKTONIC FORAMINIFERA IN THE WORLD OCEANS

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There are about 30 species of planktonic Foraminifera living in the world oceans, and they can be grouped into three major distributional zones — a warm-water belt between approximately 40° N and 40° S Latitudes, which divides the northern cold-water region from its southern counterpart. The bipolar nature of the species distributions is evident from the striking similarity of the foraminiferal faunas in reciprocal latitudinal zones between the northern and southern hemispheres.

The majority of the species (22) belong to the warm-water province. Its faunal diversity suggests that here evolution proceeded more rapidly than in the colder areas. The warm-water species can be grouped into (a) the Equatorial or Tropical species (e. g., *Globigerinoides sacculifer*, *Globorotalia menardii*, *Globoquadrina dutertrei*, *Pulleniatina obliquiloculata*, and *Globorotalia tumida*), which are transported to mid-latitudes via the warm currents (Gulf Stream, Kuroshio Currents, etc.) along the eastern margins of the continents; and (b) the Central-water or Subtropical species (e. g., *Globorotalia hirsuta*, *G. truncatulinoides* and *Hastigerina pelagica*) which occur in the central oligotrophic areas of the oceans. Some species (*Globigerinoides ruber*, *Globigerinella aequilateralis* and *Orbulina universa*) occur abundantly in both tropical as well as subtropical waters. The seasonal succession of these foraminiferal assemblages was documented in the the Sargasso Sea off Bermuda from plankton tows collected biweekly between 1958 and 1962.

There are at least three warm-water species that occur in the Indo-Pacific region, but which are no longer present in the Atlantic Ocean. They are *Globoquadrina hexagona*, *G. conglomerata* and *Globigerinella adamsi*. The former two species are known from Pleistocene deep-sea sediments, but they have apparently disappeared since from the Atlantic.

The cold-water fauna can be divided into Subpolar species (*Globigerina quinqueloba*, right-coiling *G. pachyderma*, *G. bulloides sensu stricto* and *Globigerinita bradyi*) and a single Polar species (left-coiling *G. pachyderma*). The bipolarity in the faunal zonations is clearly observed in the distributional patterns of the coiling directions of *G. pachyderma* and *G. truncatulinoides* in the North and South Atlantic.

The two transitional zones between the warm-water and cold-water faunas are characterized by the prolific occurrence of *Globorotalia inflata*. Its distribution is generally limited to the middle latitudes, with the exception of incursions equator-ward along the western margins of continents, where upwelling takes place.

Planktonic Foraminifera apparently spend their earlier stages in the euphotic zone and later descend to deeper depths. Life at great depths is accompanied by considerable shell thickening in most species which is estimated to add about 50% or more $CaCO_3$ by weight to the foraminiferal test (e. g., *Globorotalia menardii*, *G. truncatulinoides*, *Globigerinoides sacculifer* — «*S. dehiscens*»). Some species such as *Globorotalia crassaformis*, *G. scitula*, and *Hastigerinella digitata* appear to be truly meso- or bathypelagic. The spinose species are generally epipelagic, whereas the non-spinose ones exhibit a great range in depth habitats.

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