Palaeontology

Lecture 6

Protists

Protista

- Single cell eukaryotic aquatic organisms
  Autotrophs and heterotrophs
  They evolved from algae
  They appeared in the Palaeoproterozoic
  Shell organic or inorganic
  Usually tiny, in large numbers and with great diversity
  Extremely useful in biostratigraphy

Protista

Recent estimates estimate 18 phyla (Cavalier-Smith, 2002)
Paraphyletic group
Two main groups (subkingdoms or kingdoms) found as fossils

1. Protozoa
2. Chromista

Kingdom Protozoa (Cavalier-Smith, 2004)

Subkingdom Sarcomastigota

Subkingdom Eozoa

- infrakingdom Excavata
- infrakingdom Euglinozoa

Kingdom Chromista

Subkingdom Harosa

- infrakingdom Rhizaria

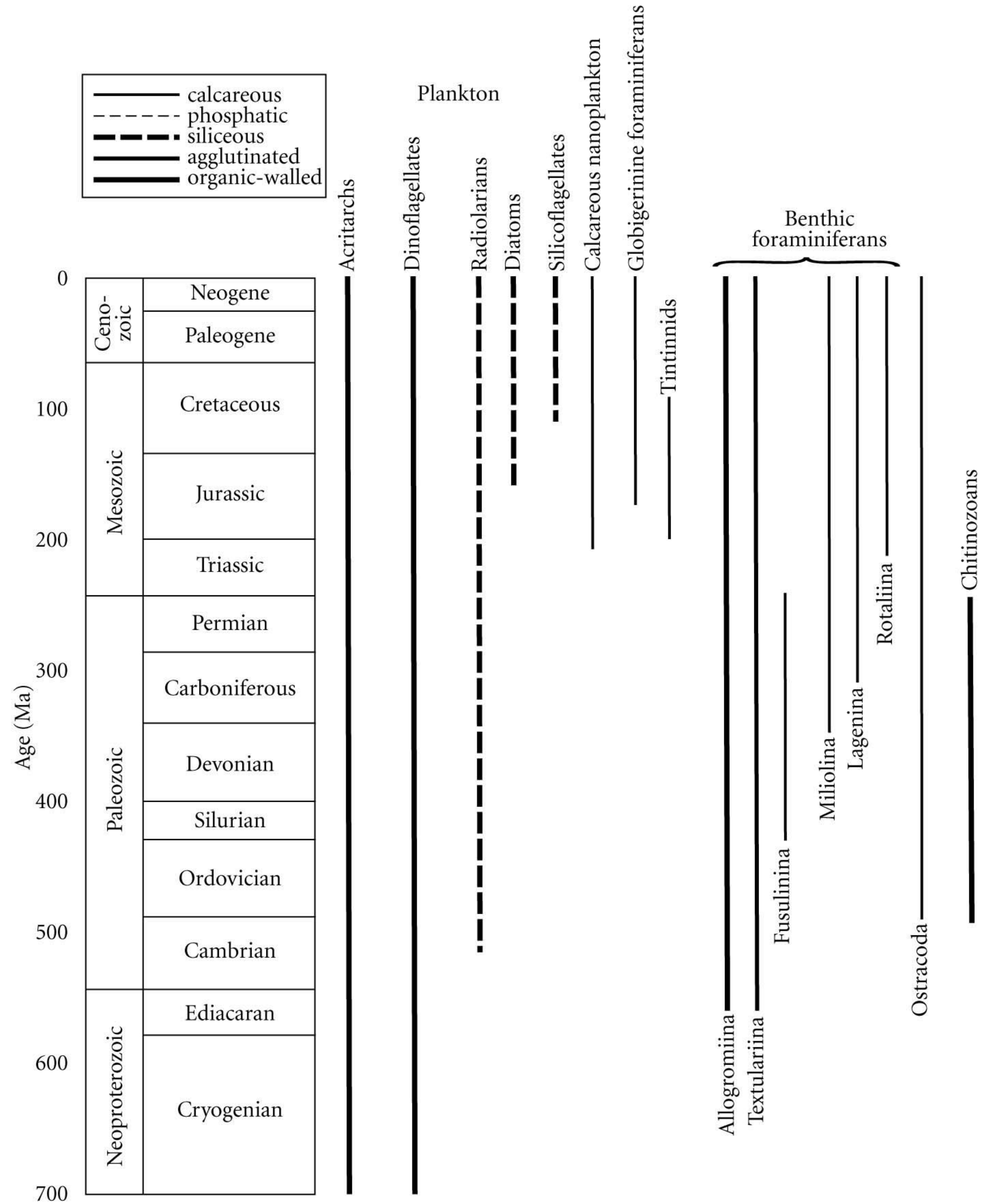
- Phylum Foraminifera
- Phylum Radiozoa
- Phylum Cercozoa
- Acritarcha
  - infrakingdom Heterokonta
  - infrakingdom Alveolata
- Phylum Ochrophyta (Diatoms)

Kingdom Chromista

Subkingdom Hacrobia

- phylum Haptophyta (coccolithophorids)

Subkingdom Cryptophyta


calcareous
phosphatic
siliceous
agglutinated
organic-walled
Plankton
Acritarchs
Dinoflagellates
Radiolarians
Diatoms
Silicoflagellates
Calcareous nanoplankton
Globigerinine foraminiferans
Tintinnids
Benthic foraminiferans
Allogromiina
Textulariina
Fusulinina
Miliolina
Lagenina
Rotaliina
Ostracoda
Chitinozoans
Age (Ma)
0
100
200
300
400
500
600
700
Ceno-zoic
Mesozoic
Paleozoic
Neoproterozoic
Neogene
Paleogene
Cretaceous
Jurassic
Triassic
Permian
Carboniferous
Devonian
Silurian
Ordovician
Cambrian
Ediacaran
Cryogenian

Phylum Foraminifera

- They belong to the Rhizaria
  They appeared in Lower Cambrian
  Useful in Biostratigraphy, biozonations
  Today, 55% of the Arctic water biomass
  Benthic and planktonic
  A wide variety of forms
  The most important group of microfossils
  Their name from their perforated shells
  Manufacturers of limestone layers

Rhizarians

Cercozoa

Gromia

Komokiacea

Allogromiids

Reticulomyxa

other Monothalames(p)

Miliolids

Xenophyophores

Globigerinids

Rotaliids(p)

Textulariids

Ascetosporea

Phytomyxea

Radiolaria

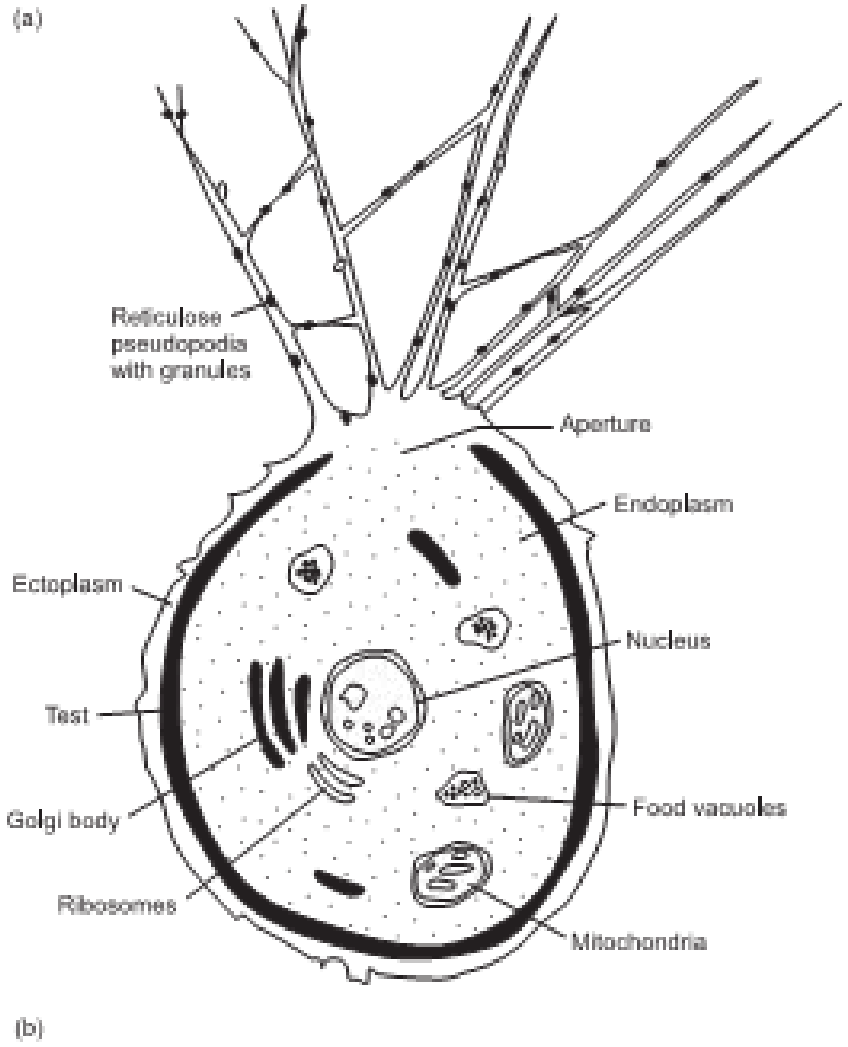
Foraminifera

Sources:

Pawlowski et al. 2003 *PNAS* (1)
DeLaca et al. 2002 *J Foram Res* (2)
Tendal & Hessler 1977 *Galathea Report* 14 (3)
Flakowski et al. 2005 *J Foram Res*
Habura et al. 2006 *JEM*
Longet & Pawlowski 2007 *Eur J Protistol*
Saldarriaga *JF personal comm. Feb 2010*

Psi Wavefunction 09 Feb 2010
http://skepticwonder.blogspot.com

The living cell



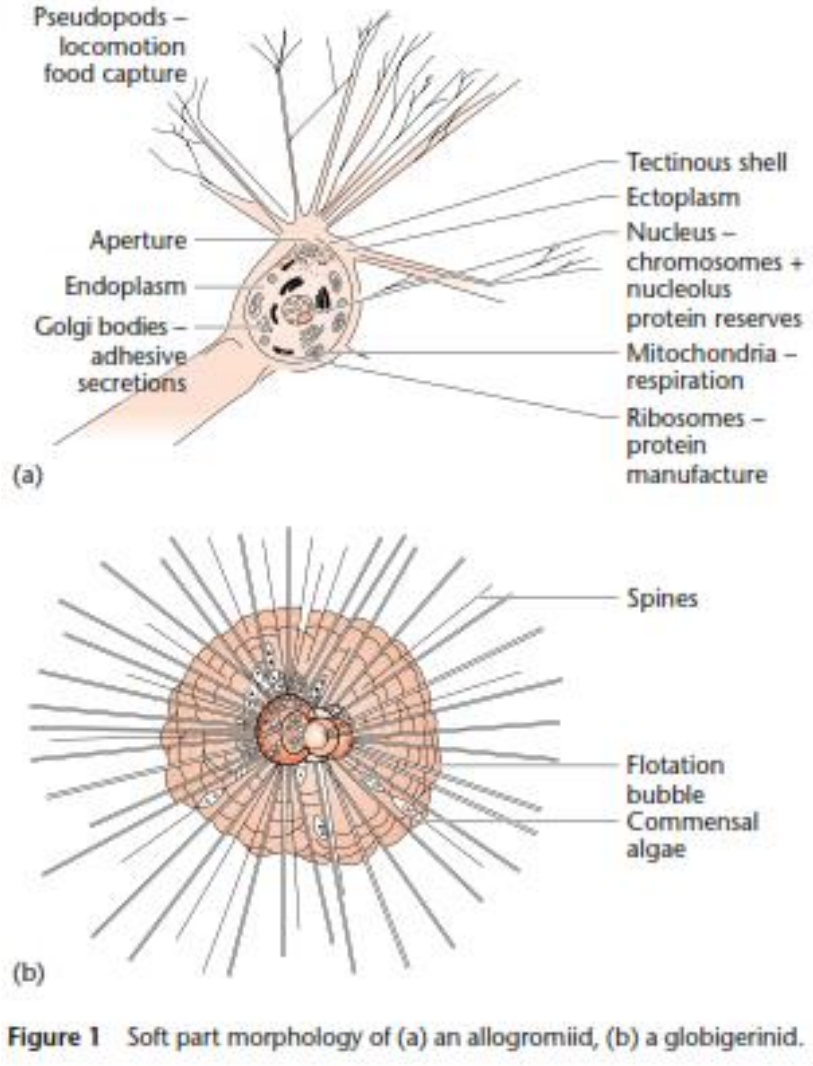


Figure 1 Soft part morphology of (a) an allogromiid, (b) a globigerinid.

The living cell

Protoplasm

- exoplasm (is surrounded by a membrane and manufactures the pseudopodia)
- endoplasm:
  - nucleus
  - Golgi body
  - Mitochodria
  - Ribosomes
  - Vacuoles

Pseudopodia

- Used for:
  To attach the animal
  For food intake
  For movement and locomotion
  For the construction of the shell

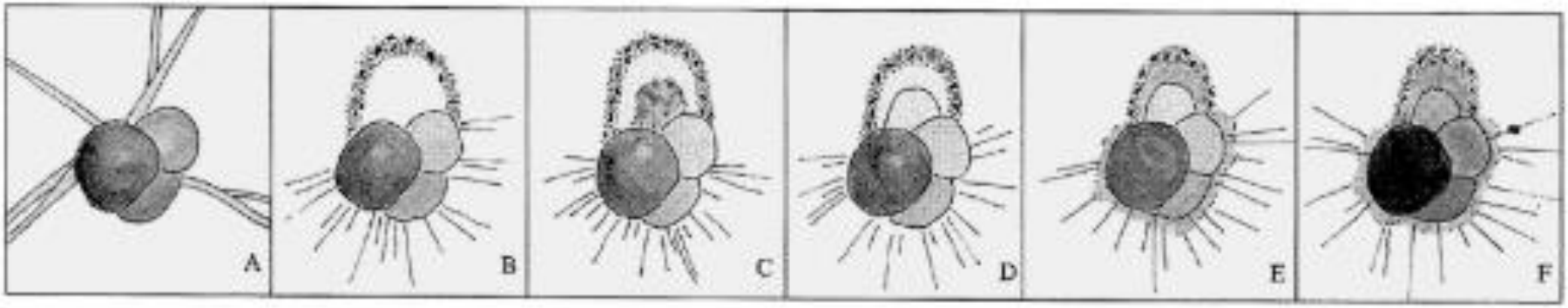


Figure 3.10 The sequence of chamber formation in the calcareous perforate species *Ammonia tepida*. A. Juvenile with three chambers. B. Construction of a cyst that includes foreign materials over the region where the fourth chamber will form (cyst does not cover the entire test). Pseudopodia appear finer and more numerous. C. Anlage constructed of cytoplasm in the shape of the new chamber. D. Organic lining constructed on the outside of the anlage cytoplasm. E. Sheath of 'frothy' cytoplasm extruded to cover the entire test. F. Calcification occurring over the surface of the new chamber and the entire test. Illustration by Elizabeth Gardiner.

Reproductive cycle

- Two reproduction phases:
  Schizogonia (asexual reproduction - small shells with many chambers - Winter)
  Gamogonia (big shells-Summer)

  Planktonic foraminifera are reproduced only with Gamogonia .

Reproductive cycle

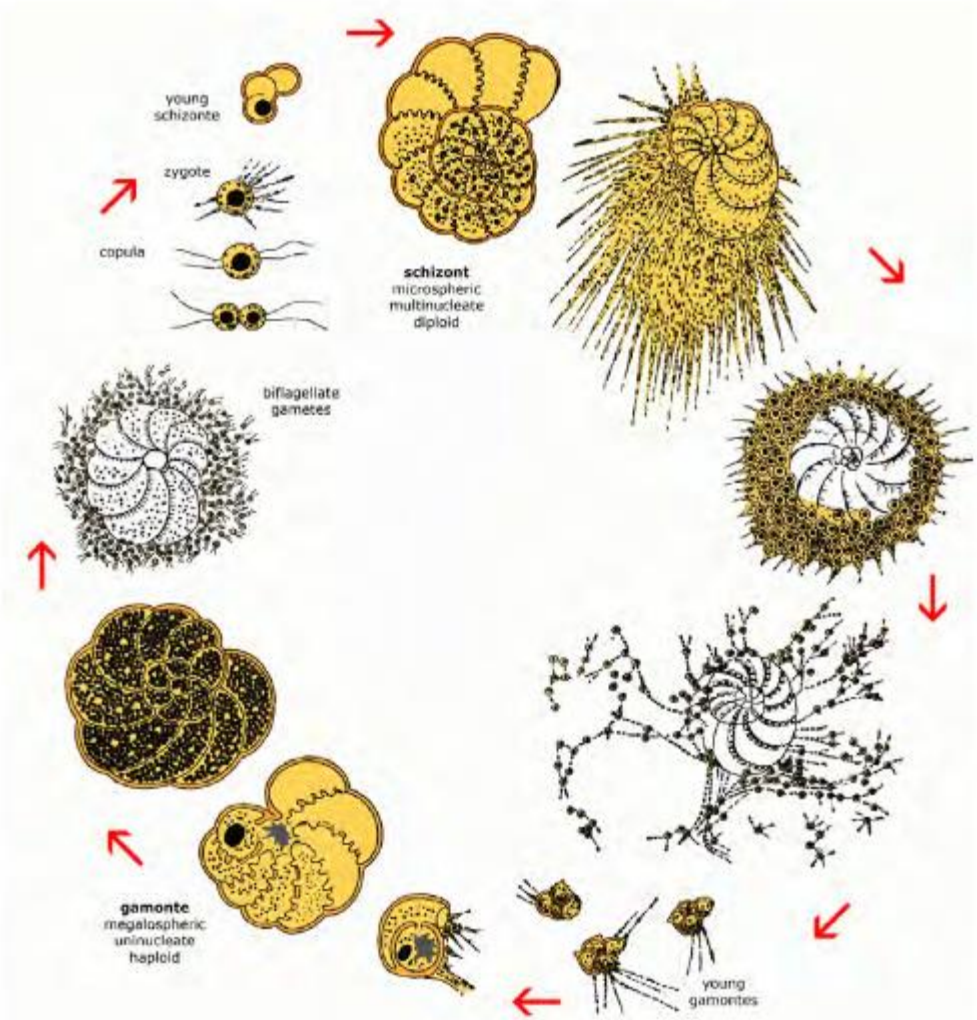
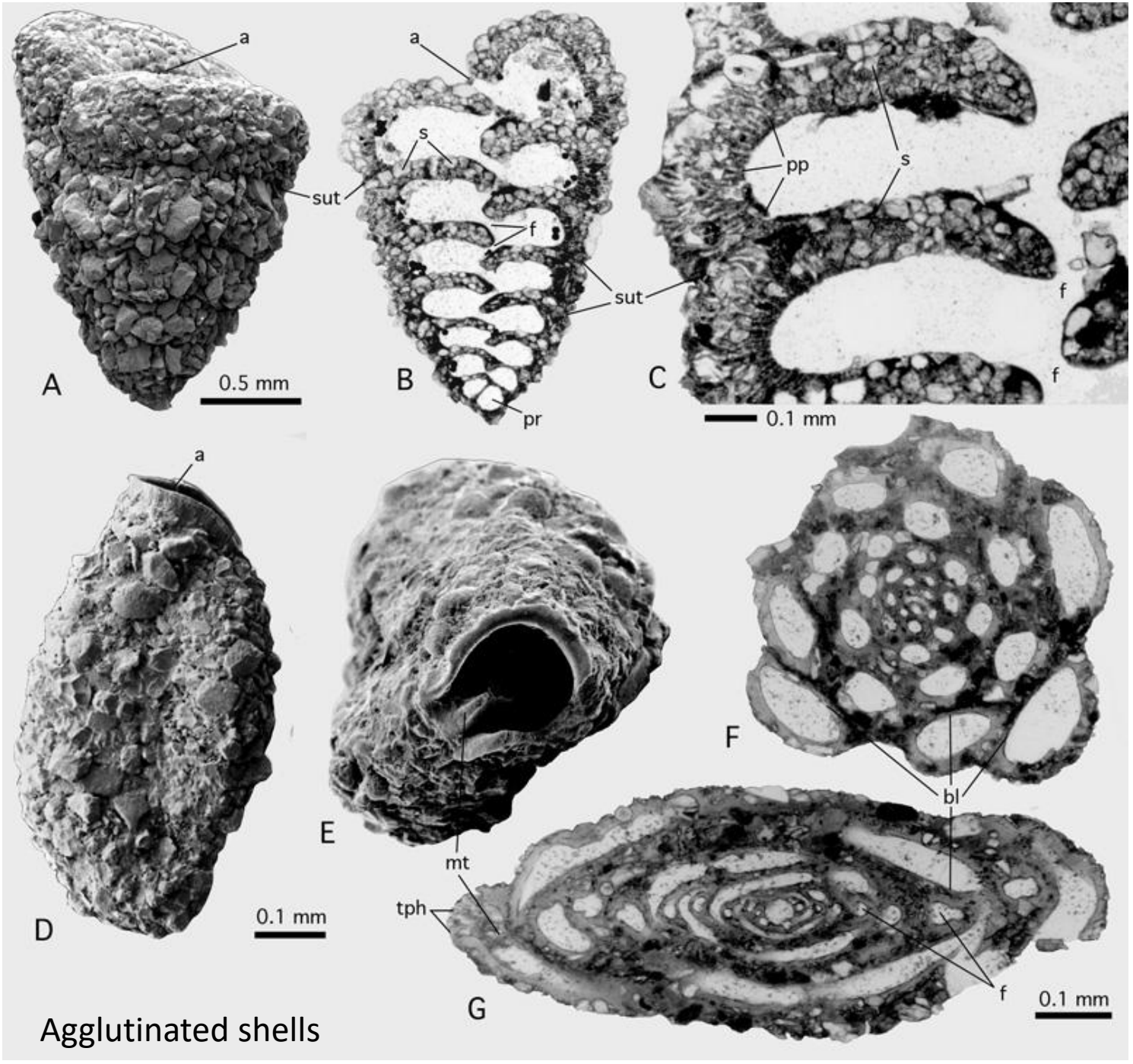


Figure 4: The reproductive cycle of benthic foraminifers (illustrated by *Elphidium crispum* (LINNE), ex "*Polystomella crispa*", after J.J. LISTER, modified).

Shell morphology

- The shell is an endoskeleton
  Originally chitinous made of tectin, but we can have mineralized shells afterwards
  Three categories:
  1. Chitinous (tectin)
  2. Agglutinated (from grains stuck together, the cement is secreted)
  3. Secreted

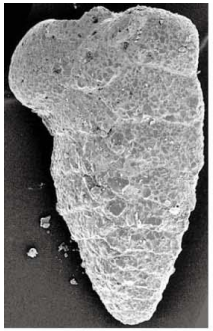


Agglutinated shells

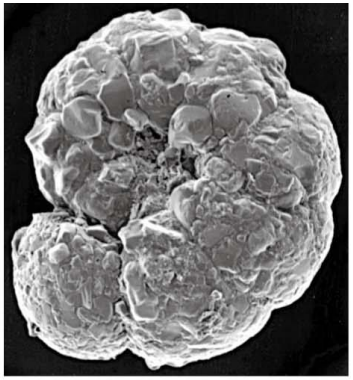
Shell morphology

Secreted

1. Calcitic (most)
2. Silicate (scarce)
3. Aragonitic (scarce)



(a)



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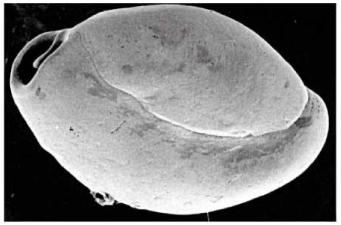
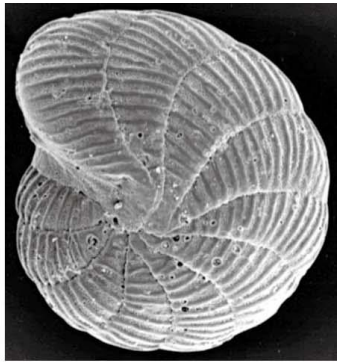
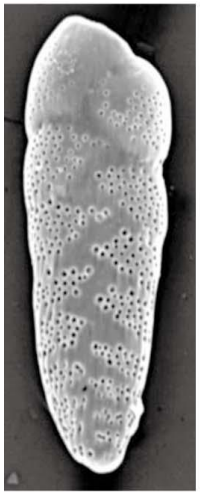


(c)

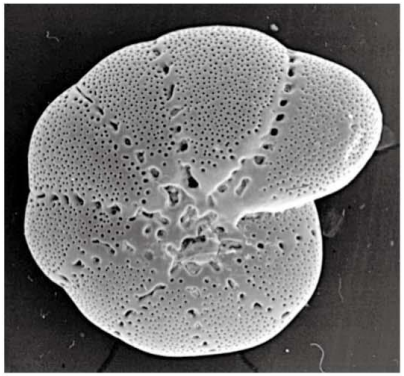


(d)

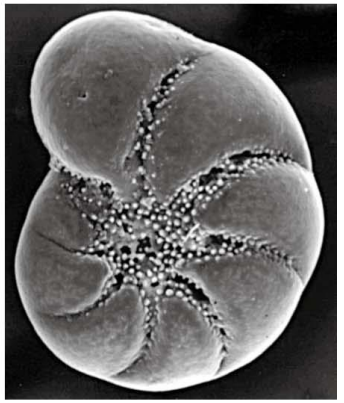


(e)

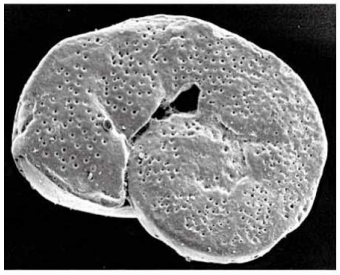
(f)



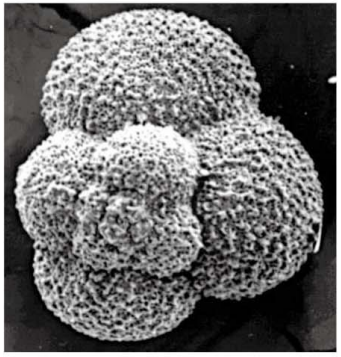
(g)



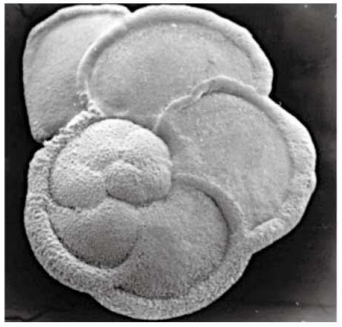
(h)



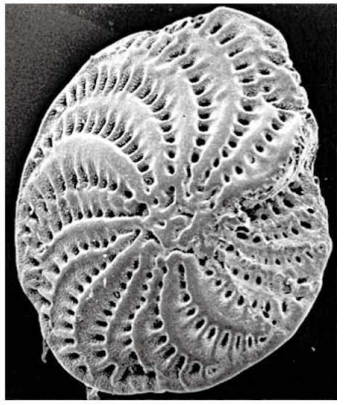
(i)



(j)



(k)



(l)

Test structure

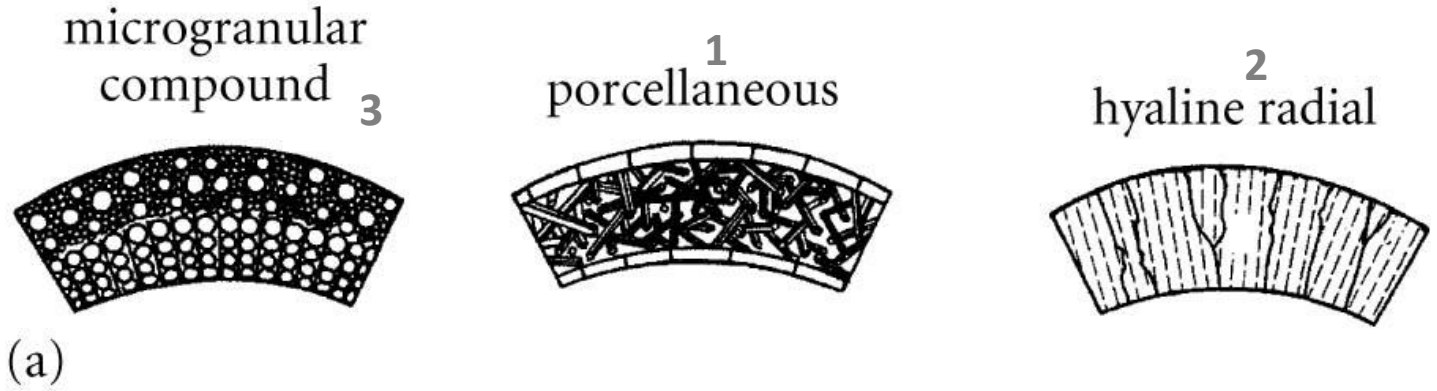
1. Porcelaneous imperforated test: Calcium crystals form a white opaque wall, the pseudopodia exit from an aperture

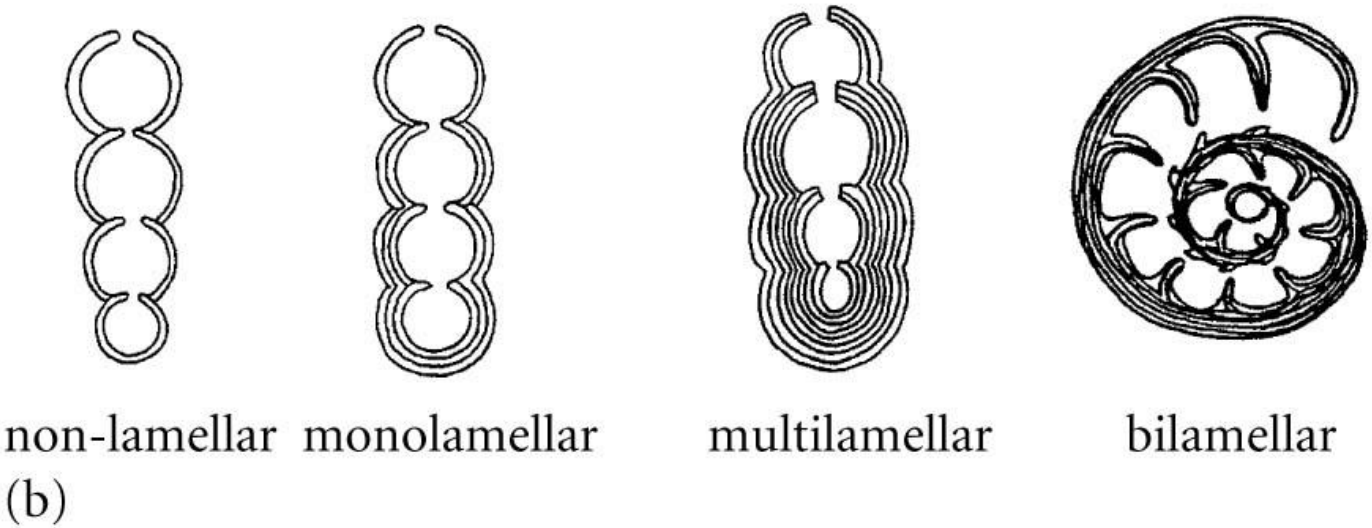
2. Hyaline perforated test: Calcium crystals form a transparent wall with pores from which the pseudopodia come out

3. Microgranular test: external imperforated layer, and internally thin laminated diaphragms forming chambers, developed during the Paleozoic

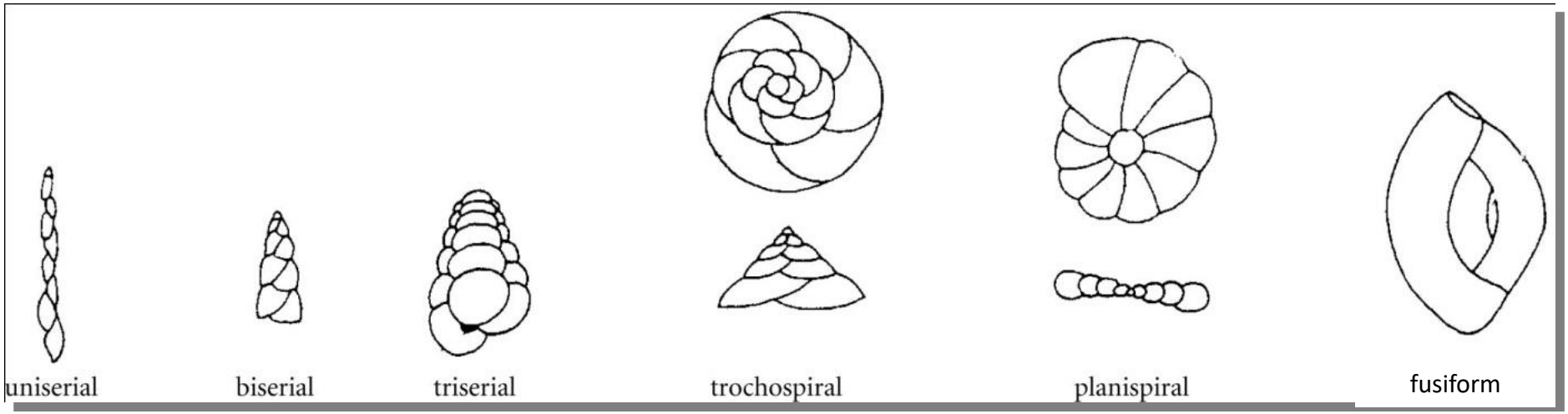
- At the same time, the shells are divided into non-lamellar, monolamellar, multi-lamellar, bilamellar (depending on the number of laminae that structure the test wall, in section)

Test structure

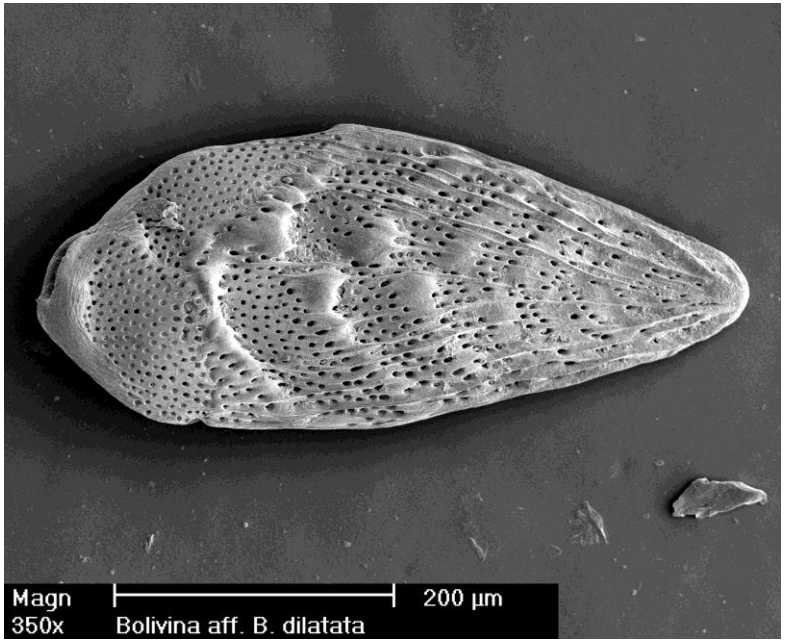




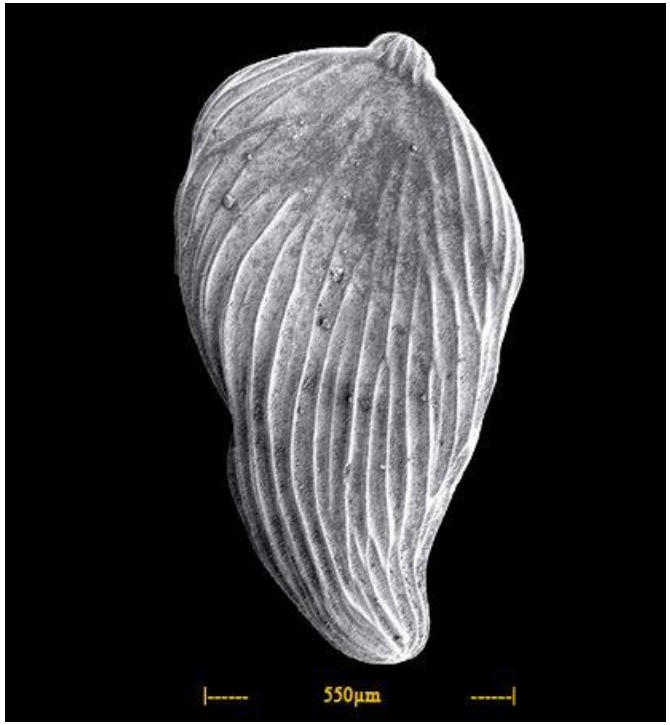
Chamber architecture



Test examples



Bolivina sp.
Biserial test



Frondicularia sp.
Uniserial, funshaped test

Test examples

Quinqueloculina seminula,
fusiform test

Robulus sp.
Involute test

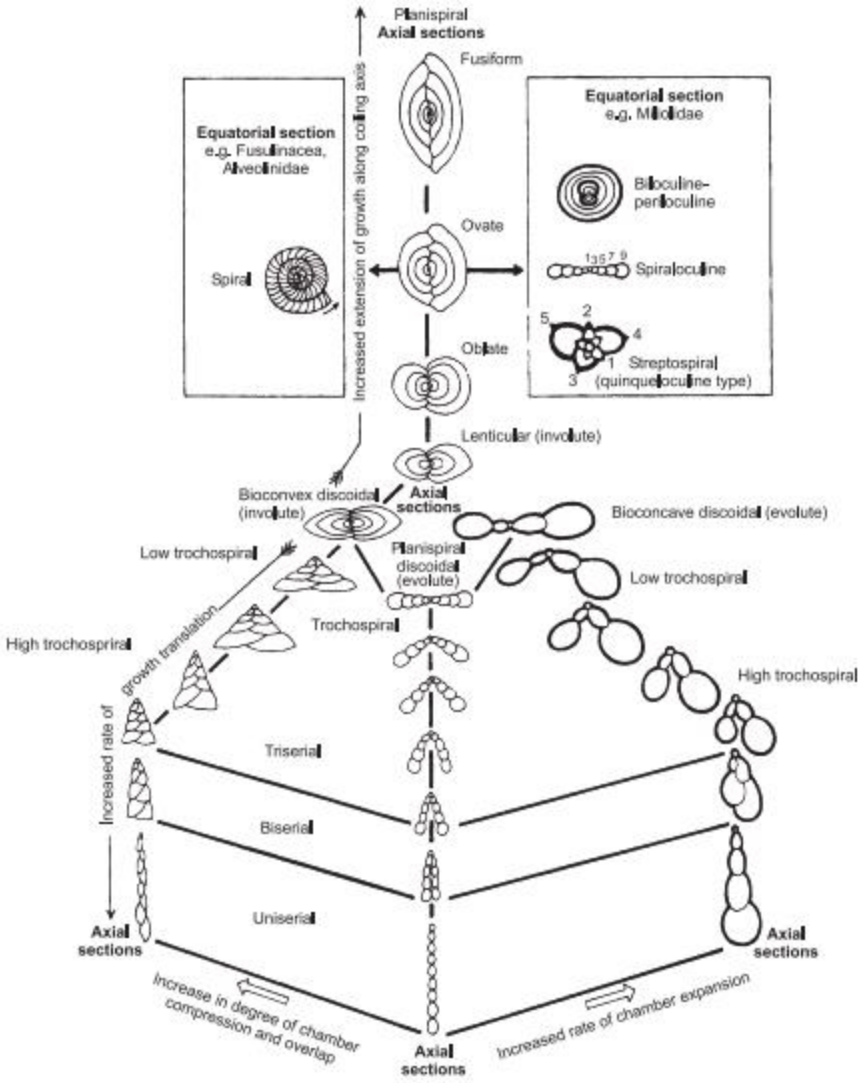
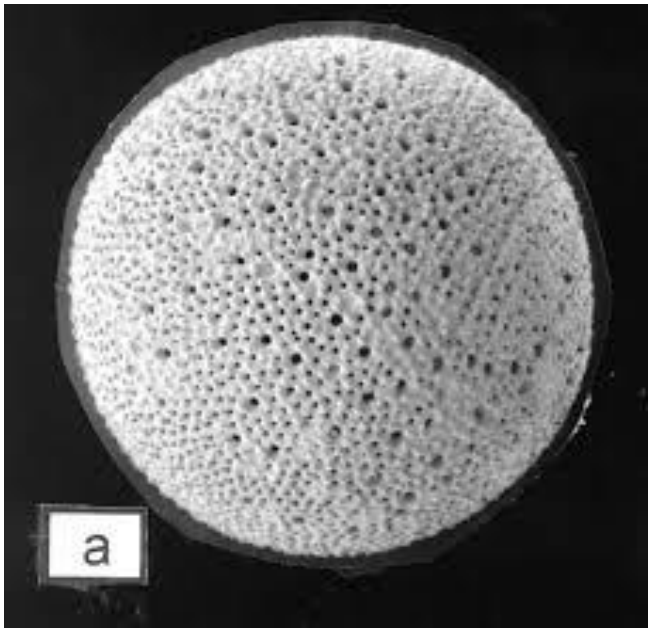


Fig. 15.6 The main growth forms in multilocular tests of foraminifera. Axial sections are those cut parallel to and including the main axis of symmetry and growth. Equatorial sections (*sensu lato*) are cut at right angles to this axis, at the widest point on the test.

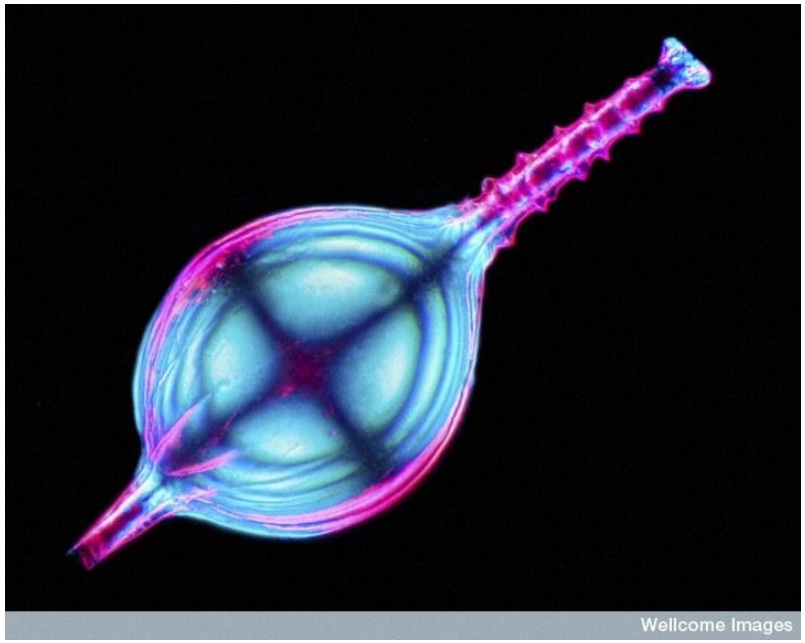
Test architecture

- Spherical (Orbulina)
- Hemispherical (Webbinella)
- Bottle shaped (Lagena)
- Cylindrical (Bathysiphon)
- Branched (Rhabdammina)
- Radiate (Astrorhiza)
- Patellate (Patellina)
- Conical (Textularia)
- Lenticular (Robulus)
- Arch shaped (Bolivina)
- Palm shaped (Frondicularia)
- Fun shaped (Pavonina)
- Dendroid (Dentrophina)
- Irregular (Polymorphina)
- Planispiral (Cornuspira)
- Spheroid (Shaeroidina)
- Triangular (Trifarina)
- Biconcave (Spiroloculina)

Test shapes



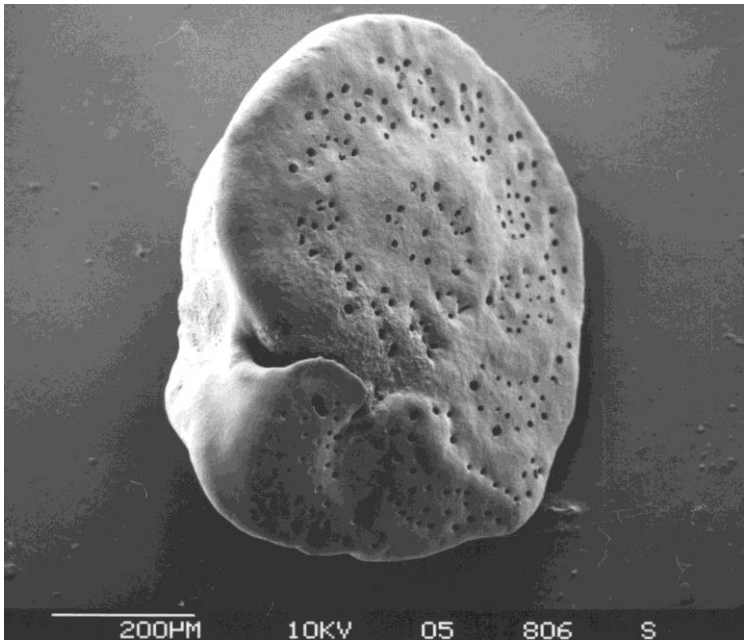
Orbulina sp.
spherical



Lagena sp.
Bottle shaped

Test shapes

Sphaeroidina sp.
spheroid

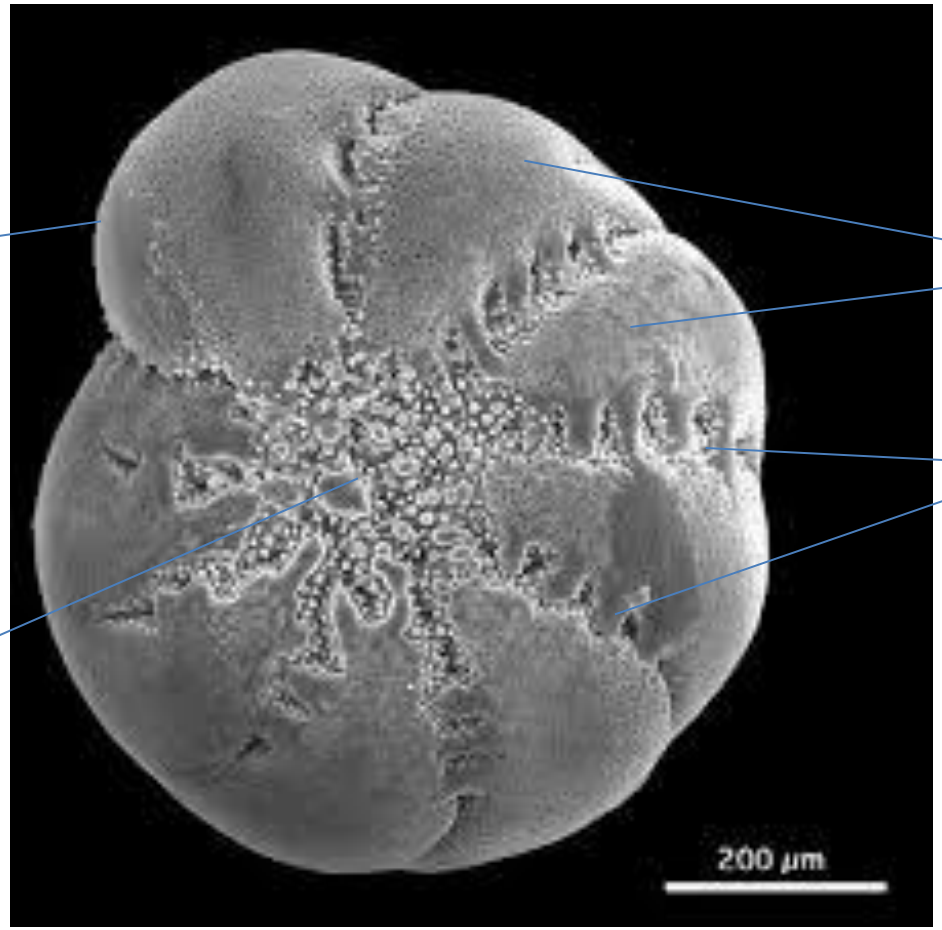


Cibicides sp.
Hemispherical

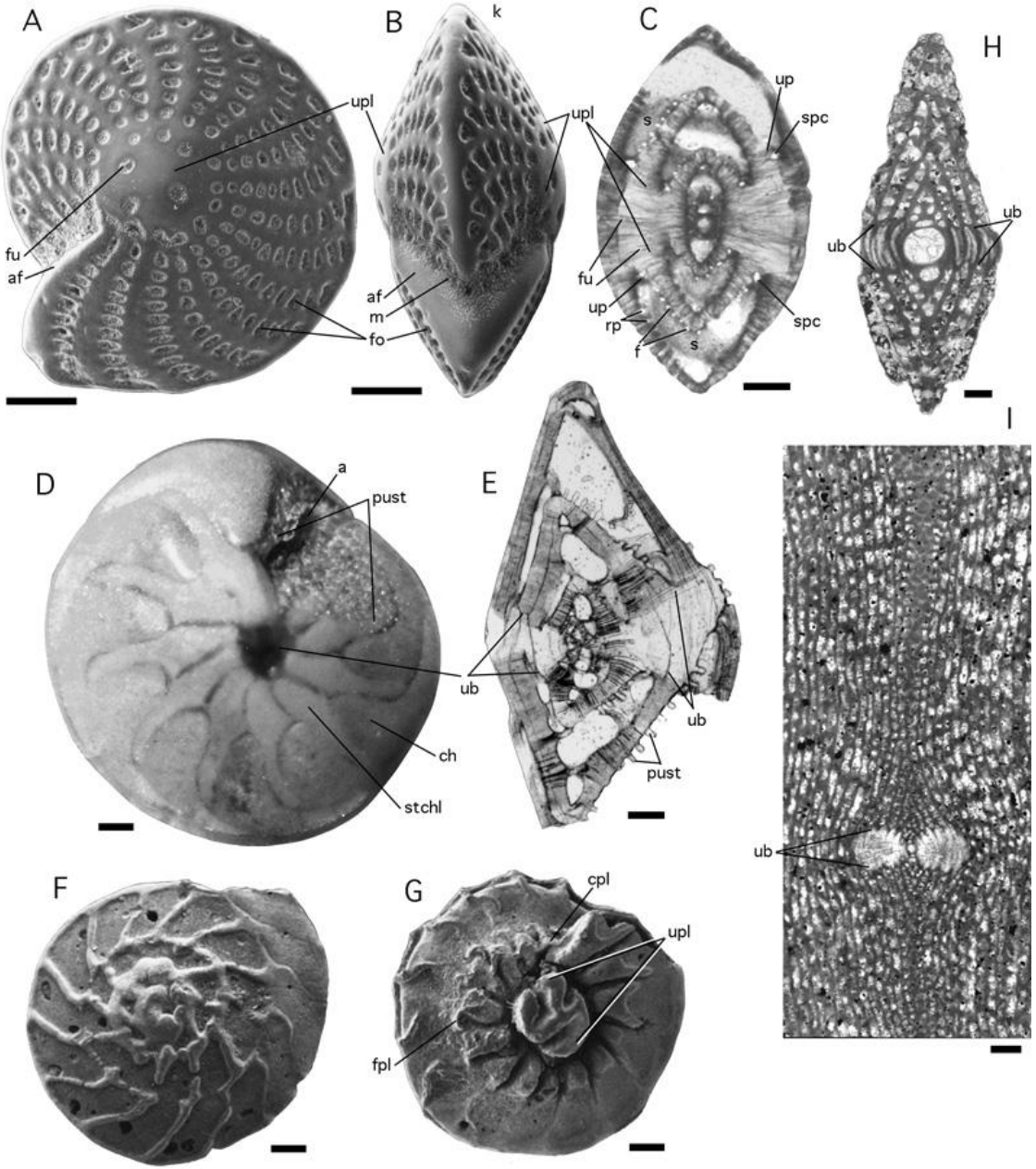
Morphological characters

- Proloculus
- Chambers
- Septa
- Suture lines
- Umbilicus
- Keel
- Aperture

Morphological characters of *Ammonia sp. test*



Ammonia sp., Umbilical view


A
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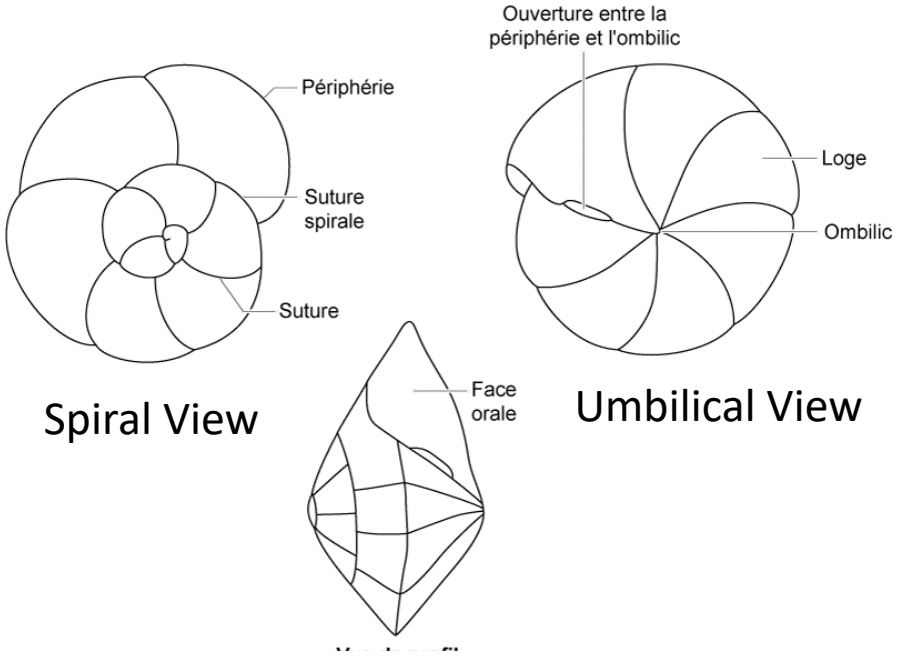
Test views

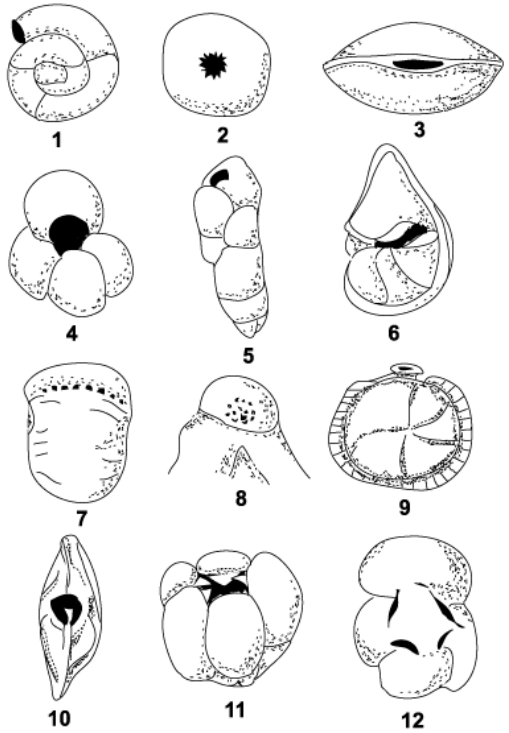


Spiral View

Umbilical View

Lateral View

Types of Aperture



Principle types of aperture. 1, open end of tube; 2, terminal radiate; 3, terminal slit; 4, umbilical; 5, loop shaped; 6, interiomarginal; 7, interiomarginal multiple; 8, areal crbrate; 9, with phialine lip; 10, with bifid tooth; 11, with umbilical teeth; 12, with umbilical bulla. Redrawn from Loeblich and Tappan 1964.

Types of Aperture

- Terminal (Cornuspira, Nodosaria, Oolina)
- Subterminal (Parafissurina, Cassidulina)
- Marginal
    - At the whorl plane (Epistominella)
    - At the base of the last chamber (Nonion)
    - At the edge of the last chamber(Robulus)
    - Marginal (Quaraltina)
- Interiomarginal
    - Around the umbilical area (Globorotalia)
    - Umbilical (Globigerina)

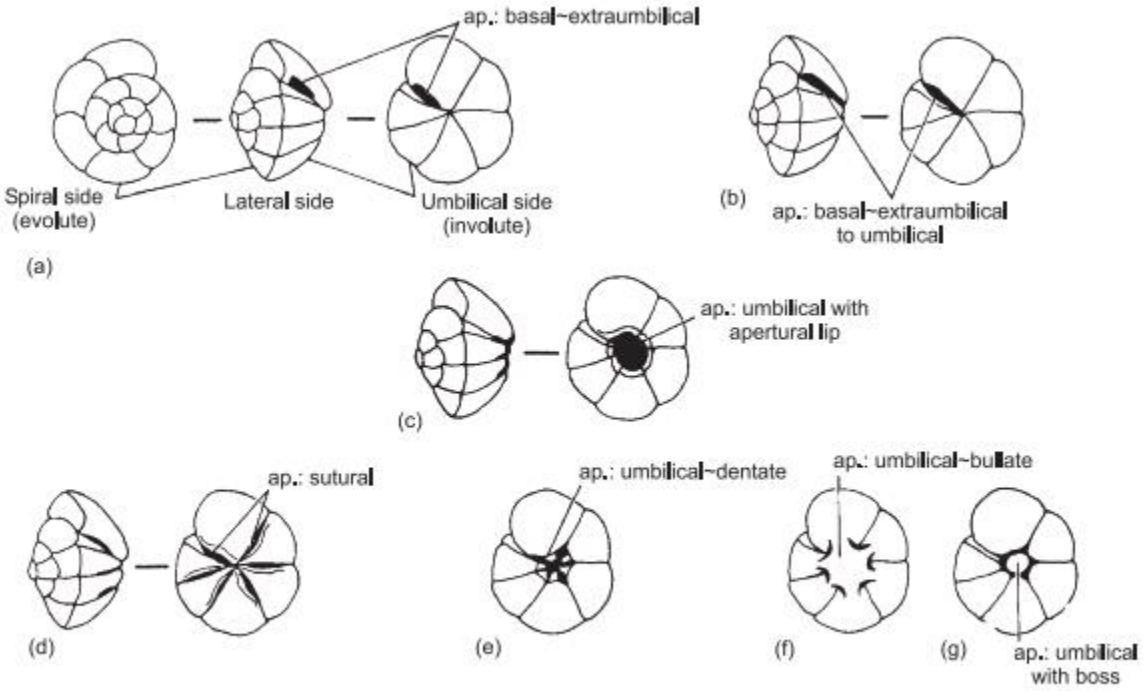


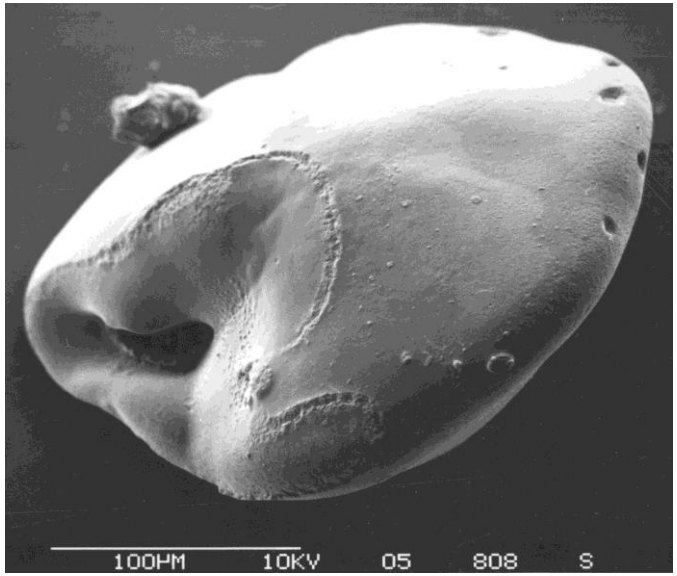
Fig. 15.8 (a)–(g) Trochospiral tests with different kinds of aperture (ap).

Apertures

Nodosaria sp.
Terminal

Cassidulina sp.
Subterminal

Apertures



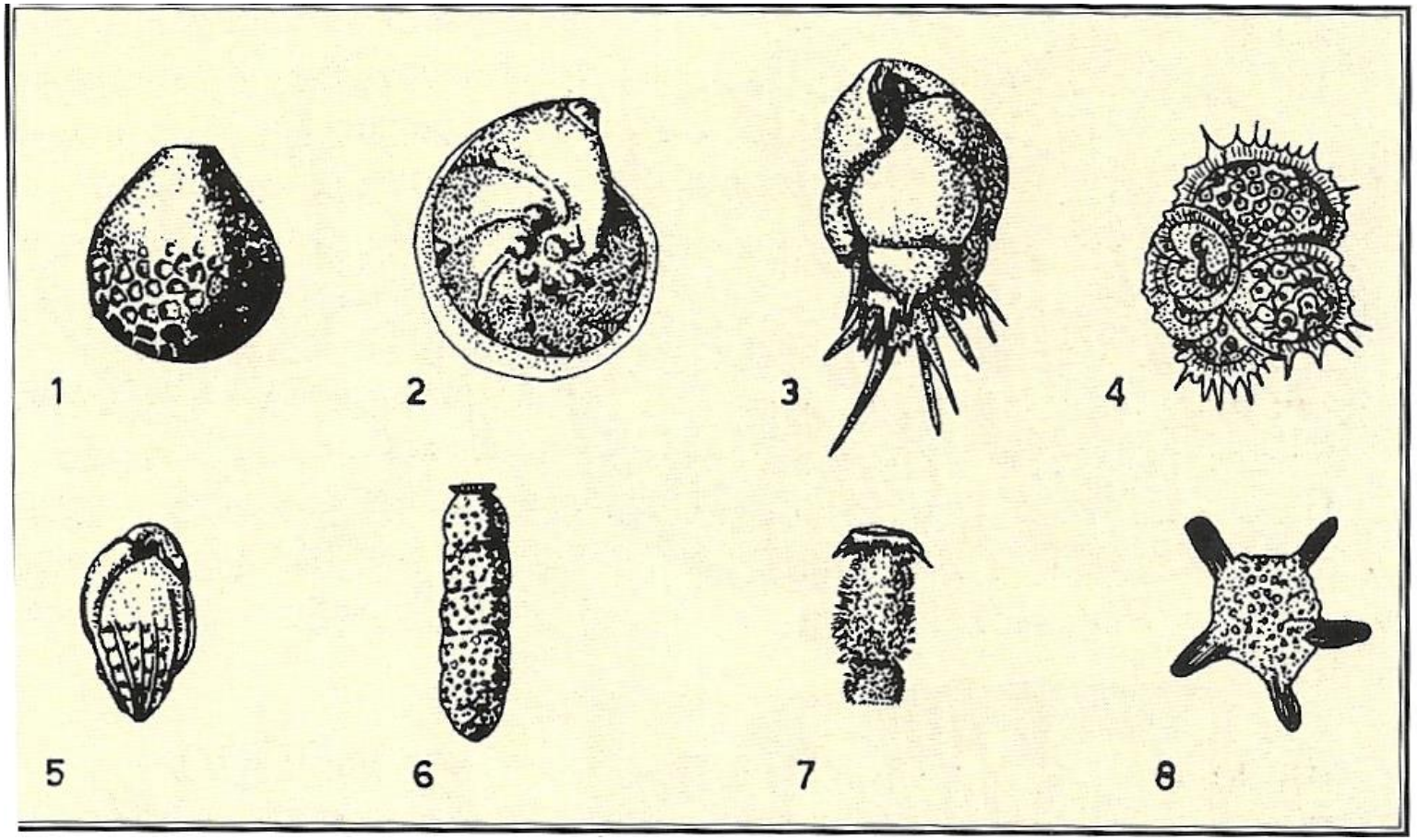
Epistominella sp.
At the whorl plane

Globorotalia sp. Interiomarginal
Around the umbilical area

Sculpture

- Carinate
- Striate
- spines
- Rugose
- Costate
- Granulate
- Reticulate

Sculpture



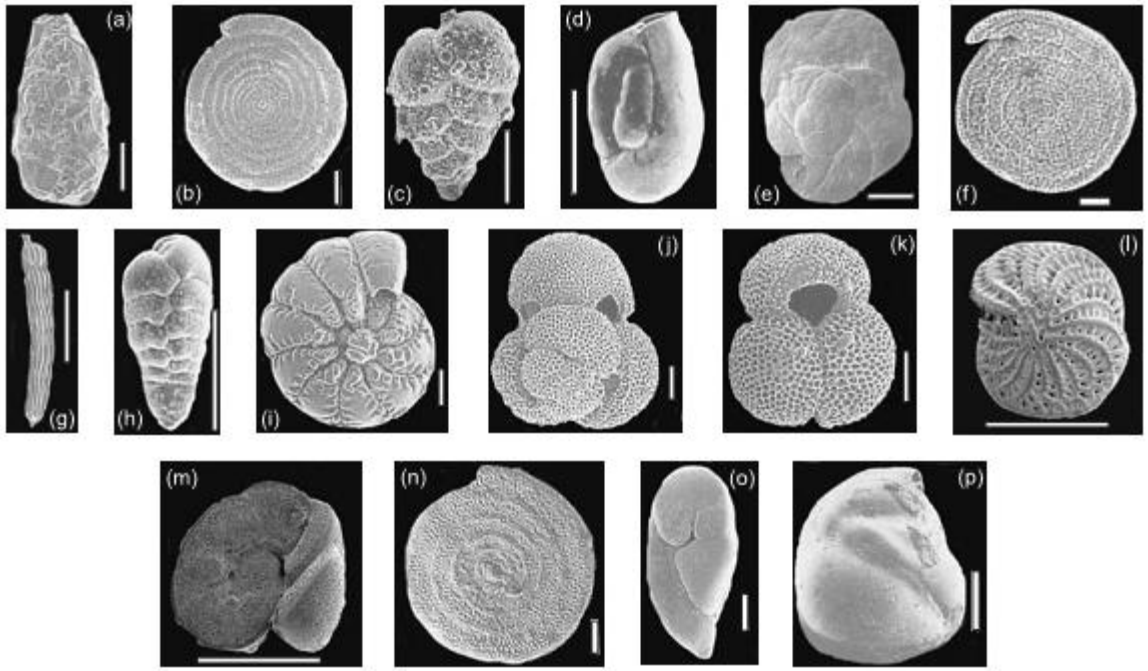
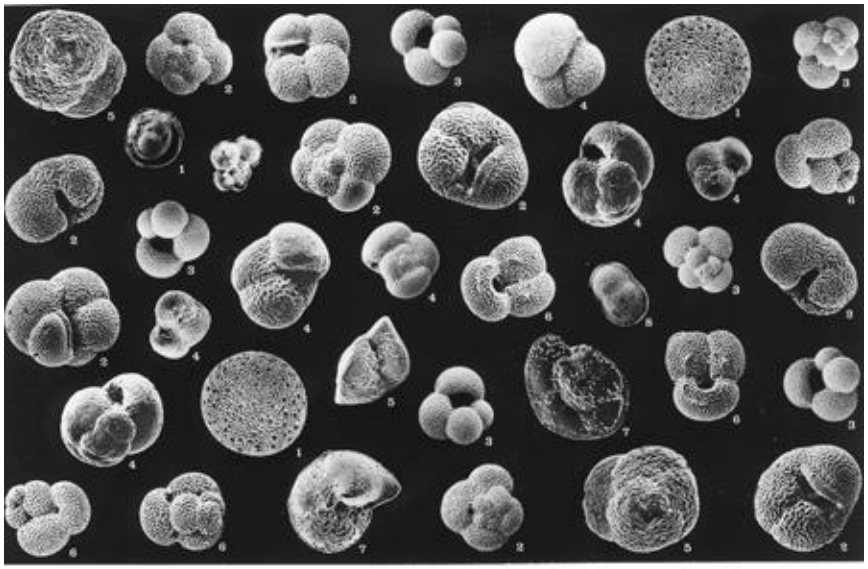


Fig. 15.31 Electron photomicrographs of selected foraminifera. (a) *Saccammina* (Textulariina). (b) *Ammodiscus* (Textulariina). (c) *Siphotextularia* (Textulariina). (d) *Miliolinella* (Miliolina). (e) *Carterina* (Carterinina) dorsal view. (f) *Spirillina* (Spirillinina). (g) *Dentalina* (Lagenida). (h) *Bolivina* (Buliminida). (i) *Ammonia* (Rotaliacea) ventral side. (j), (k) *Globigerinoides* (Globigerinina) spiral and umbilical views. (l) *Elphidium* (Rotaliina). (m) *Cibicides* (Rotaliina). (n) *Planispirillina* (Involutinina). (o) *Robertinoides* (Robertinina). (p) *Milammellus* (Silicoloculinina). Scale bars = 500 μm in (b), (g), (l), (m); = 100 μm in all others. ((a), (h), (i) From Sen Gupta 1999 after Platon; (b), (f), (g), (j), (k) from Sen Gupta 1999; (c) from Sen Gupta 1999 after Jones; (e) from Sen Gupta 1999 after Deutsch & Lipps; (n) from Sen Gupta 1999 after Piller; (o) from Sen Gupta 1999 after Resig (reproduced with the permission of Kluwer Academic Publishers).)

Ecology



(a)

(b)

Ecology

- Benthic and pelagic
  Mostly marine but also some costal lacustrine
  In all marine zones, most of them benthic down to 200m. Most pelagic from100-300m.
  Some stenotopic other eurytopic
  They are affected by: depth, temperature, pressure, light, turbidity, currents, salinity, alkalinity
  Several of them are good palaeo-ecological biomarkers

- Physical factors
  Temperature
  Hydrostatic pressure
  Light
  Water turbidity
  Currents

- Chemical factors
  Salinity
  Alkalinity
  Trace elements
  nutritional needs

  Biological agents
  Symbiotism-parasitism

Geographical expansion factors

- Temperature
- depth

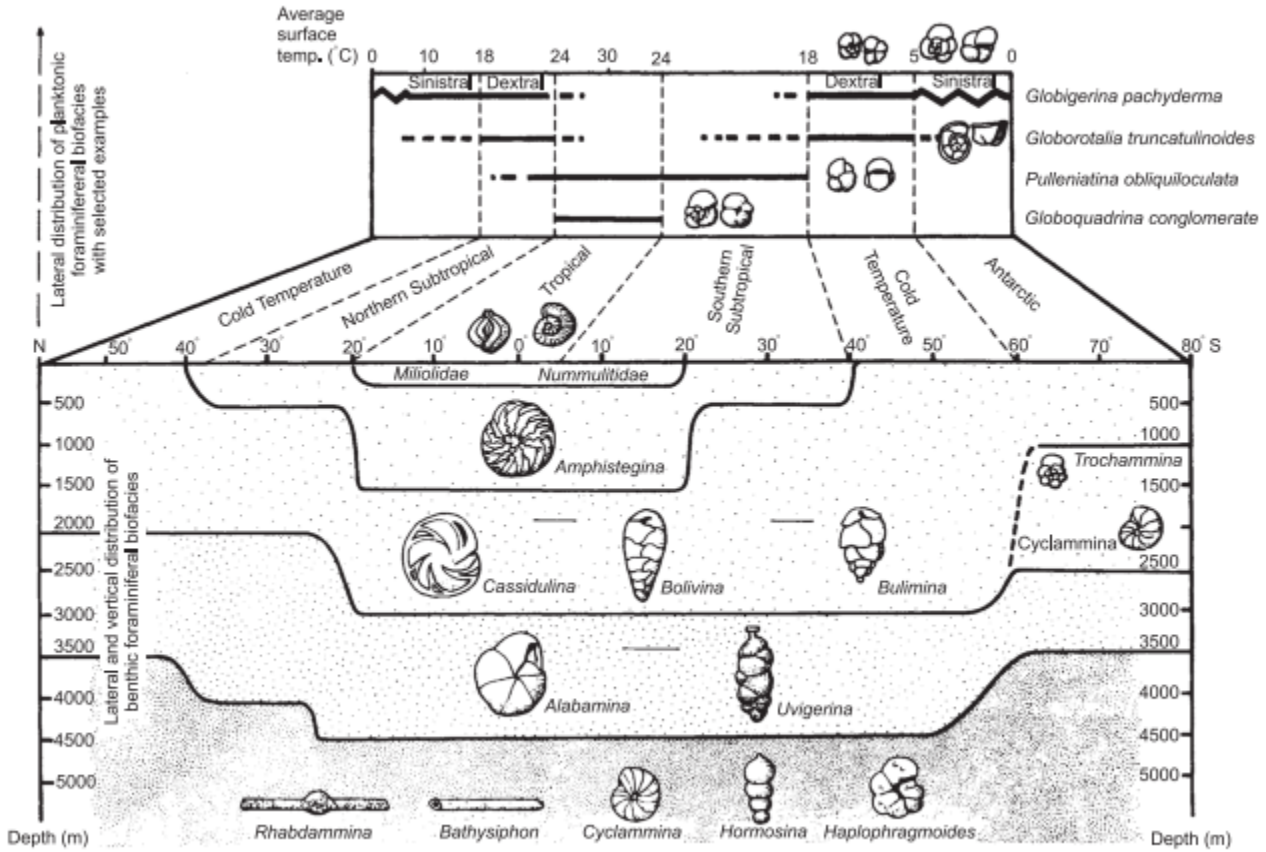


Fig. 15.10 How benthic and planktonic foraminiferid abundance and general composition change with depth and salinity. Some typical genera are shown.

Clasification

Class Monothalamea

Order Allogromiida (Chitinous)

Class Globothalamea

Order Rotaliida

- Suborder Textulariina (agglutinated)
- Suborder Rotaliina (multichambered, hyaline)
- Suborder Globigerinina (hyaline, bubble-shaped, all planktonics)

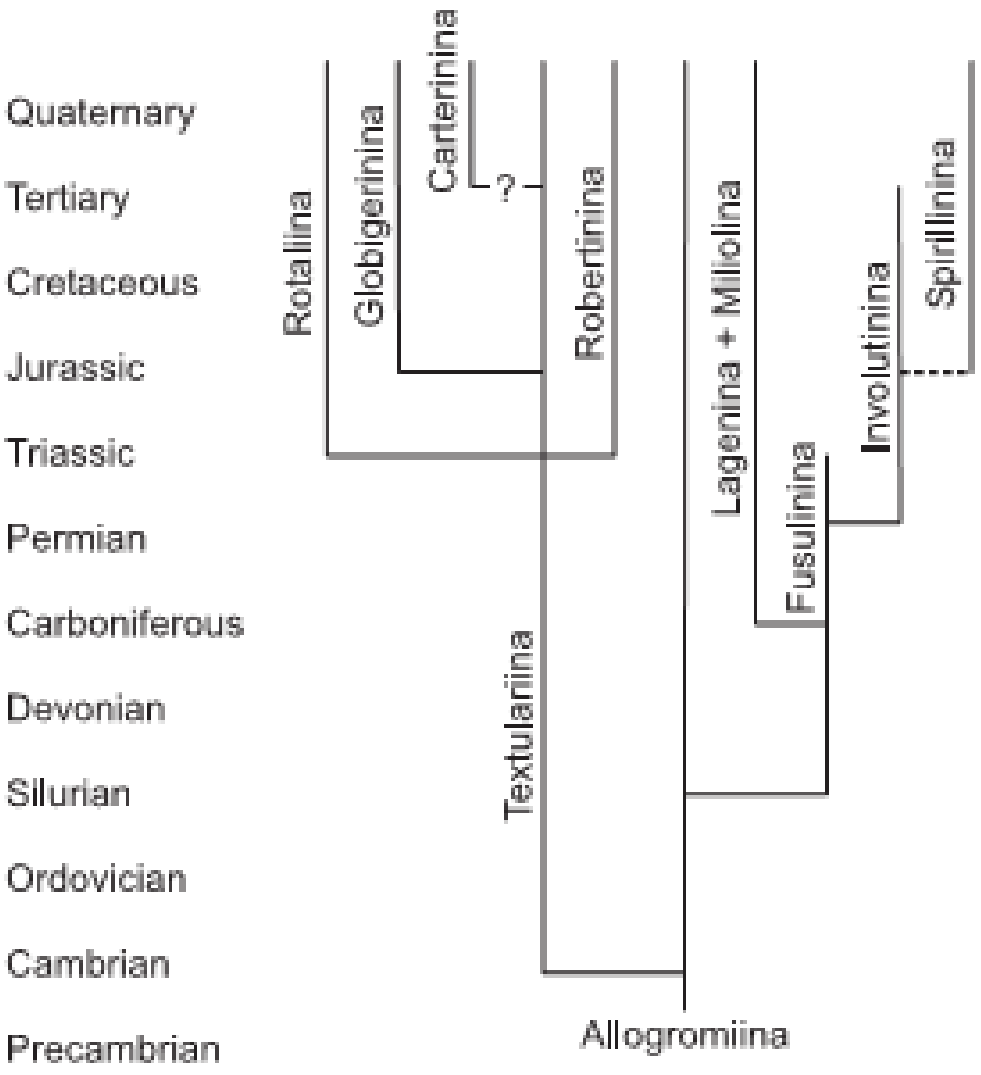
Order Fusulinida (granular, Palaeozoic)

Order Lagenina (uniserial, bottle-shaped)

Class Tubothalamea

Order Miliolida (porcelaneous)

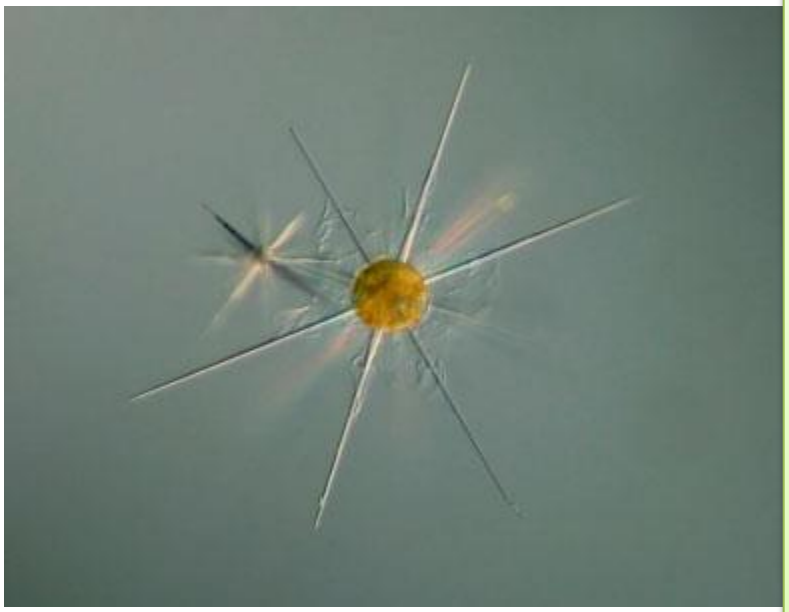
Clasification



Radioralia

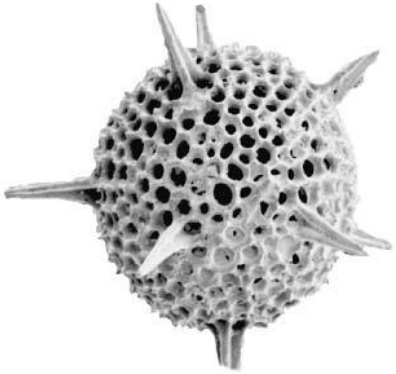
- They appeared in the Precambrian
  Useful in Biostratigraphy
  Small, medium to deep, warm and cold water
  Their name from their radial pseudopodia
  Dimensions 0.1 - 0.5 mm
  Manufacturers of silicate layers (radiolarites, 1cm / 1000 years)

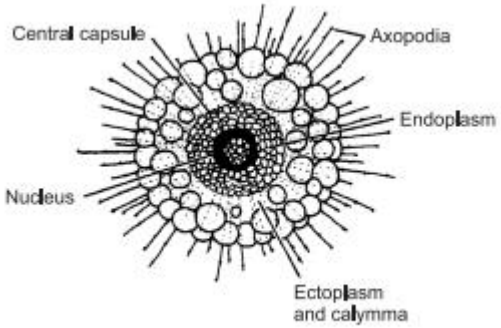
The living cell



- The protoplasm is divided into two parts by a pseudo-chitin formation, the central capsule.
- The exterior the ectoplasm (secretes the skeleton or capsule)
- the internal the endoplasm (contains the nucleus and various organelles)
- The central capsule may consist of one, two or three layers
- The protoplasm forms outer radial pseudopodia of two types:
- Filipodia (simple protuberances of ectoplasm)
- Axopodia (protrusions that grow around an "axoplast" or spine)

Spumellaria





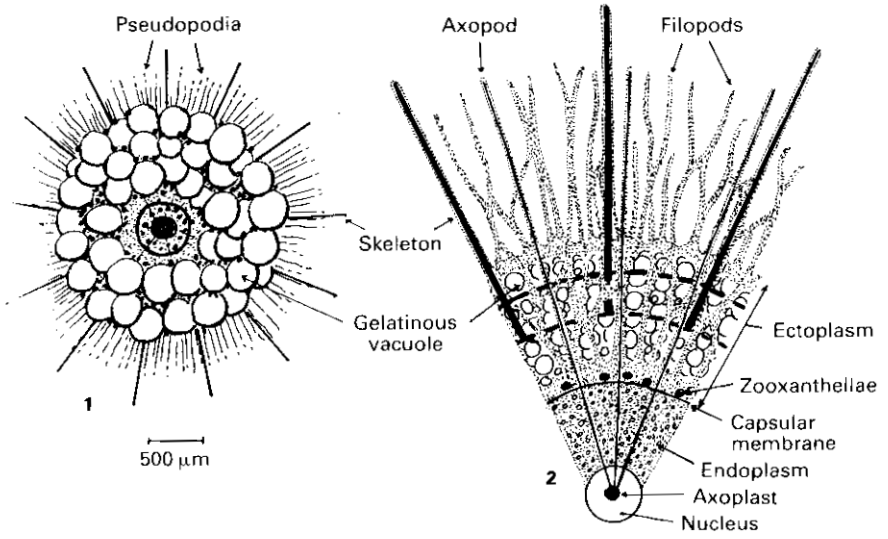
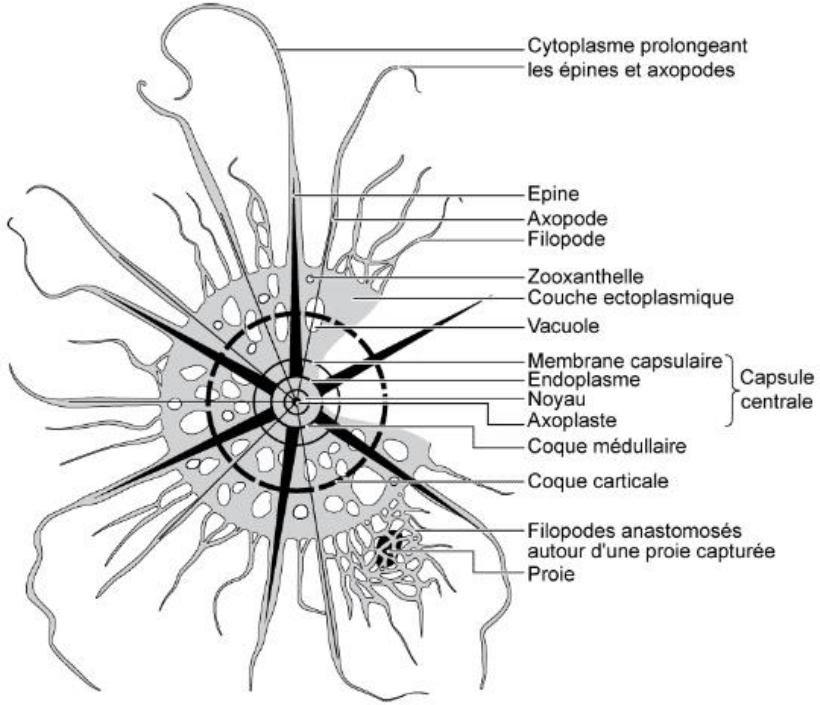
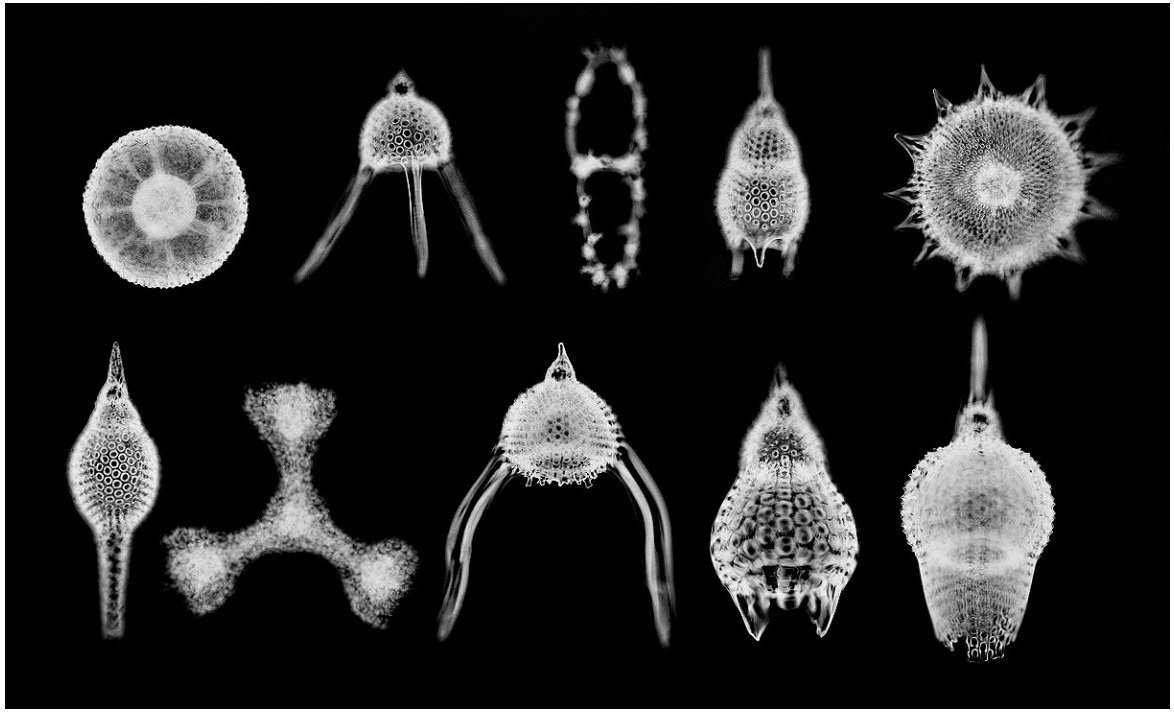


Fig. 8.1 External appearance and optical section of a living spumellarian polycystine radiolarian (×14)

Fig. 8.2 Diagram of part of a section of a spumellarian, the skeleton of which is formed from two concentric shells, trabeculae and radial spines



Radiolaria



The skeleton

- It is formed inside or outside the central capsule
  It consists of silicate spines or needles
  It is located in the protoplasm
  The shape varies, in the primitive simple needles, later ductile, spherical, ellipsoid, disc-shaped, cylindrical, tapered, etc.
  The growth mechanism is unknown

Classification-1200 genera and more than 7000 species

- Order Albaillellaria (Ordovician– Silurian)

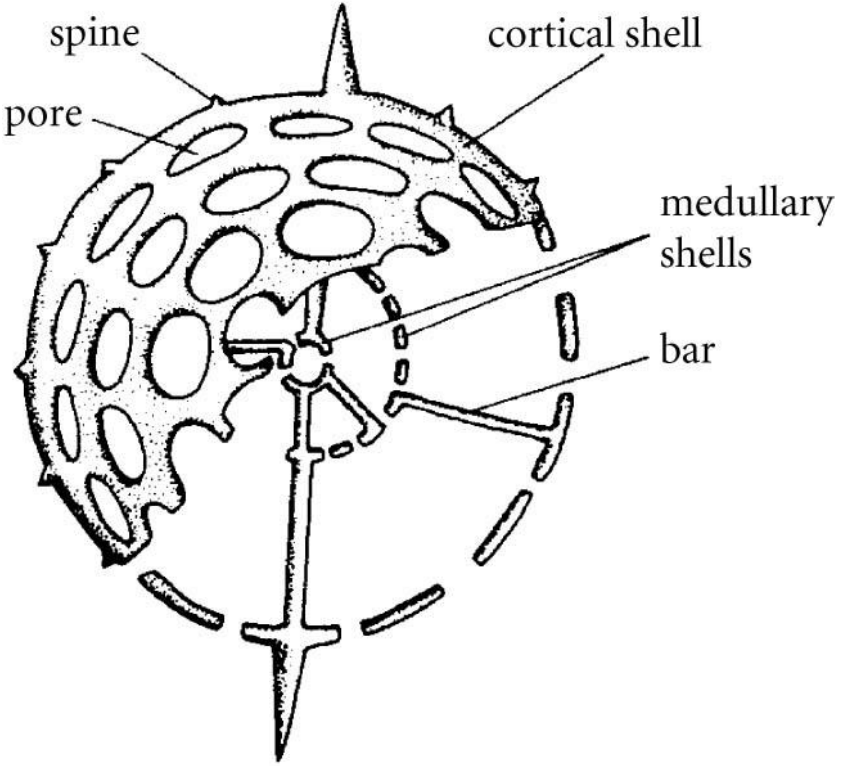
Class Polycystina

- Order Archaeospicularia (Cambrian– Silurian)
- Order Latentifistularia (Carboniferous– Permian)
- Order Entactinaria (Ordovician– Today)
- Order Spumellaria (Palaeozoic– Today)
- Order Nassellaria (Triassic– Today)

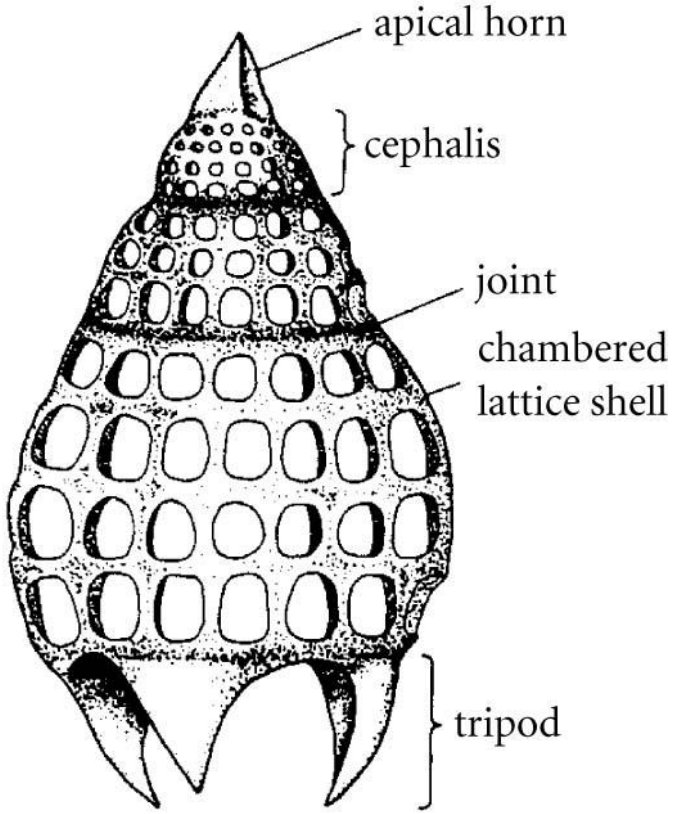
Class Acantharia

Class Phaeodaria

Morphological features

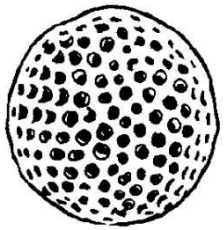


Spumellaria

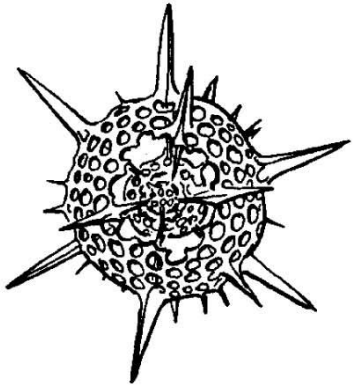


Nassellaria

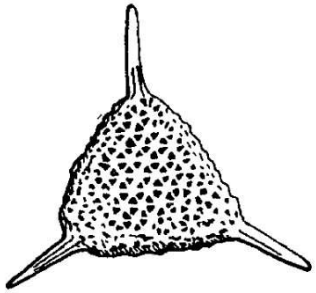
SPUMELLARIA



Lenosphaera

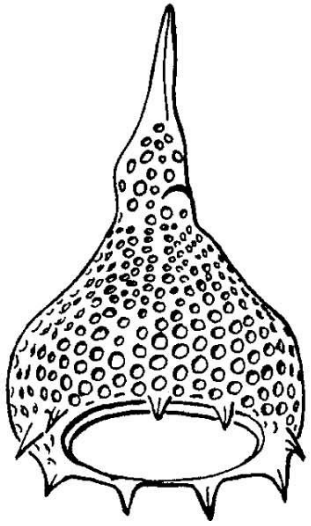


Actinomma

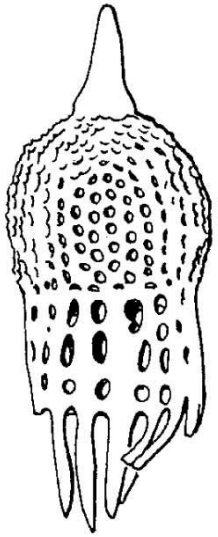


Alievium

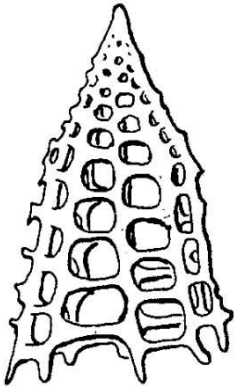
NASSELLARIA



Anthocyrtidium



Calocyclas



Peripyramis

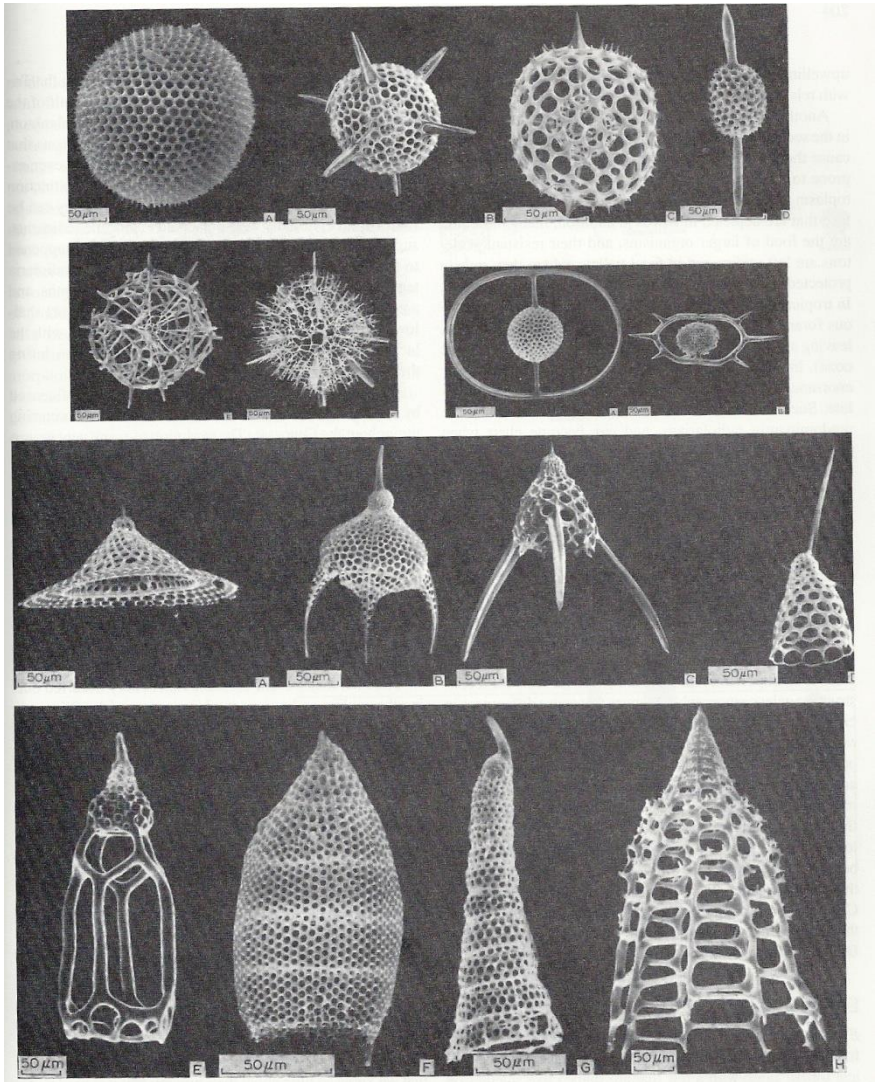


figure 11.12 Radiolarians exhibit a great variety of test shapes. The top two rows are all spumellarians, which tend to be radially symmetrical around a central point. The bottom two rows are nassellarians, which are symmetrical around an axis, so they tend to be shaped like cones, cylinders, bells, or helmets. The top row consists of actinommid spumellarians, as are the two on the left of the second row. The two on the right of the second row are the appropriately named saturnalins. All in the two bottom rows are

Ecology

- They live for about a month
  They feed on small game like diatoms and coppers
  Reproduction by splitting, one descendant holds the original skeleton and the second one produces a new one with gyrocentric growth
  Intra-specific dimorphism has been observed, with different stages in their development cycle

Ecology

- Stenohaline (salinity> 30 ‰)
  Pelagic faunas present a maximum growth at 100m.
  Abyssal faunas in deep bottoms
  Zonal faunas at different depths
  The temperature affects the shape and size, in the cold waters they have larger tests
  The tests of those living in surface waters smaller and thinner than in the deep
  Sensitive to climate change, they prefer calm waters
  When environmental conditions change, they migrate