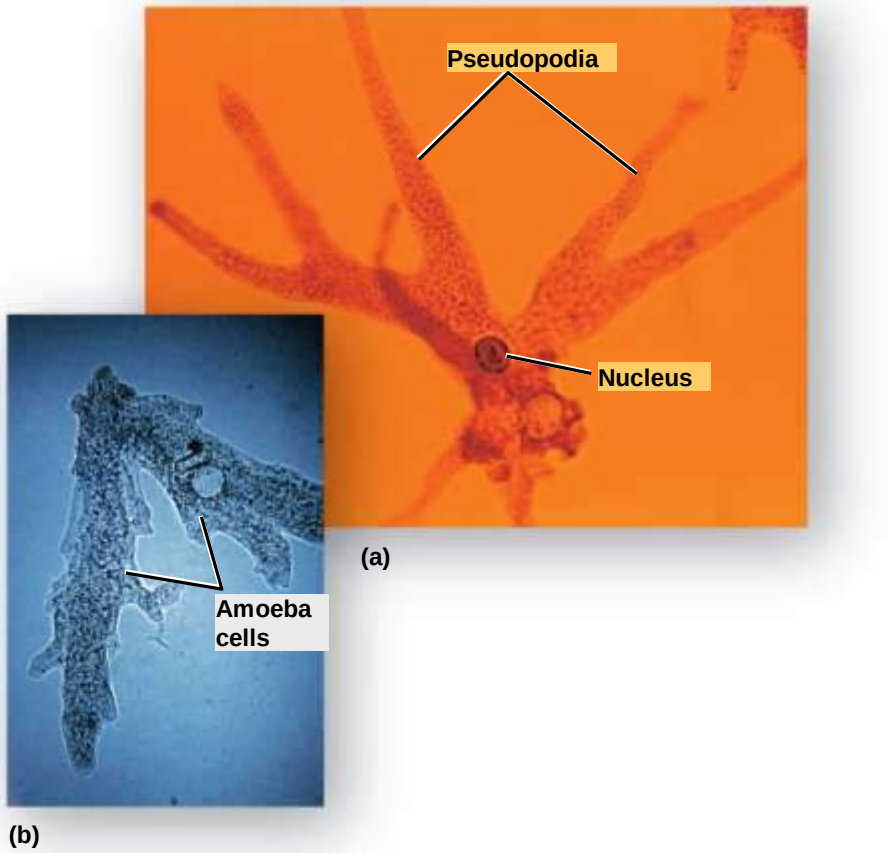
Lecture 6
Benthic Foraminifera

- Five phyla cannot yet be located on the protist phylogenetic tree.
- These five groups use their cytoplasm to aid movement.
  - Phylum Rhizopoda (amoebas)
  - Phylum Foraminifera (forams)
  - Phylum Actinopoda (radiolarians)
  - Phylum Acrasiomycota (cellular slime molds)
  - Phylum Myxomycota (plasmodial slime molds)

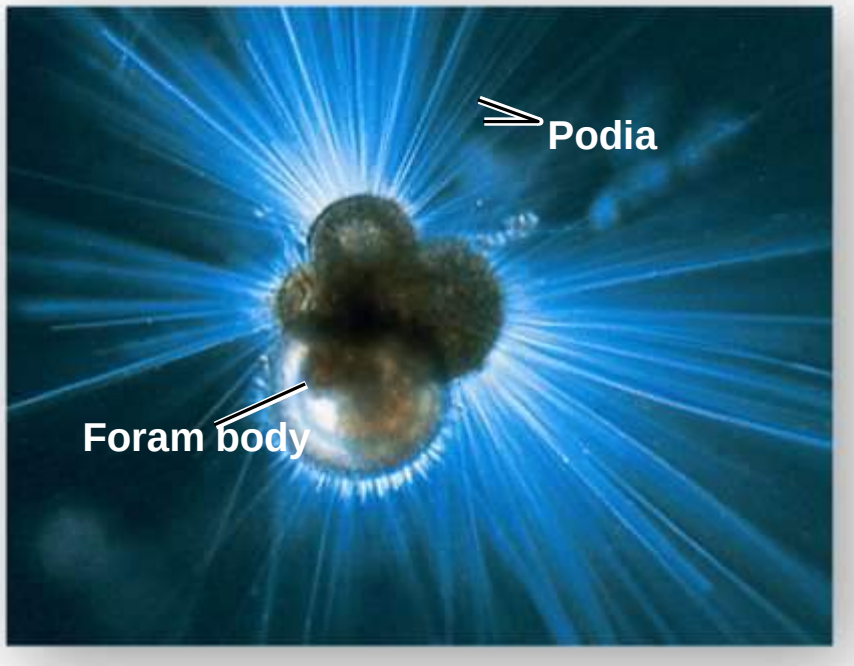
AMOEBAS (PHYLUM RHIZOPODA)

- Lack cell walls and flagella.
  - Move using **pseudopodia**, flowing projections of cytoplasm.
- Amoebas are abundant in soil and many are parasitic in animals.
- Reproduction is entirely asexual.



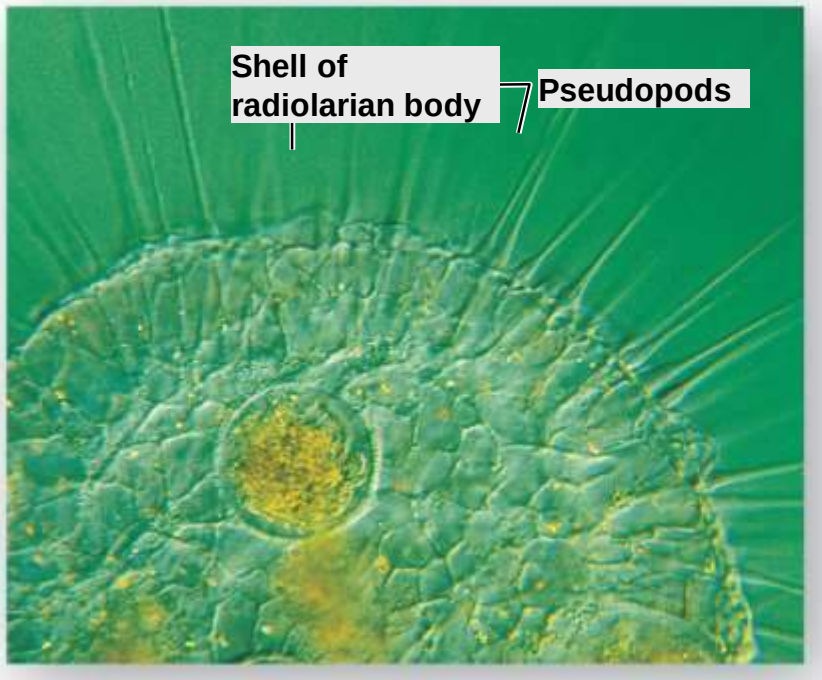
FORAMS (PHYLUM FORAMINIFERA)

- Possess rigid cells and move by **cytoplasmic streaming**.
- Marine protists with pore-studded shells called tests.
- Long, thin, cytoplasmic projections called podia radiate through the test pores and are used for swimming and capturing prey.



RADIOLARIANS (PHYLUM ACTINOPODA)

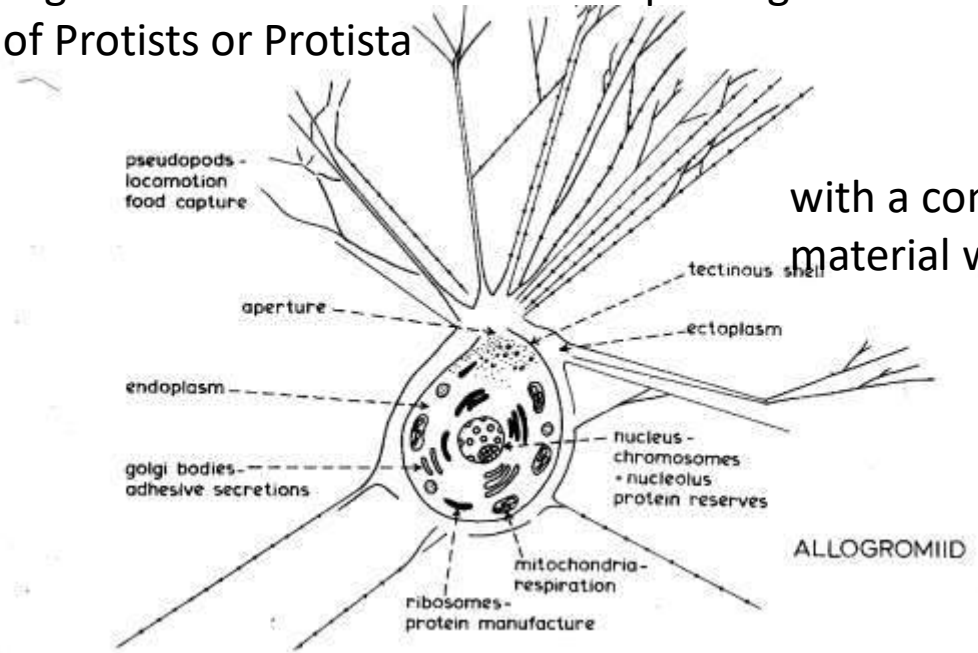
- Are amoeboid cells with a glassy skeleton made of silica.
- Have shells that are radially or bilaterally symmetrical.
- Have needlelike pseudopods that radiate out from the body.



Foraminifera

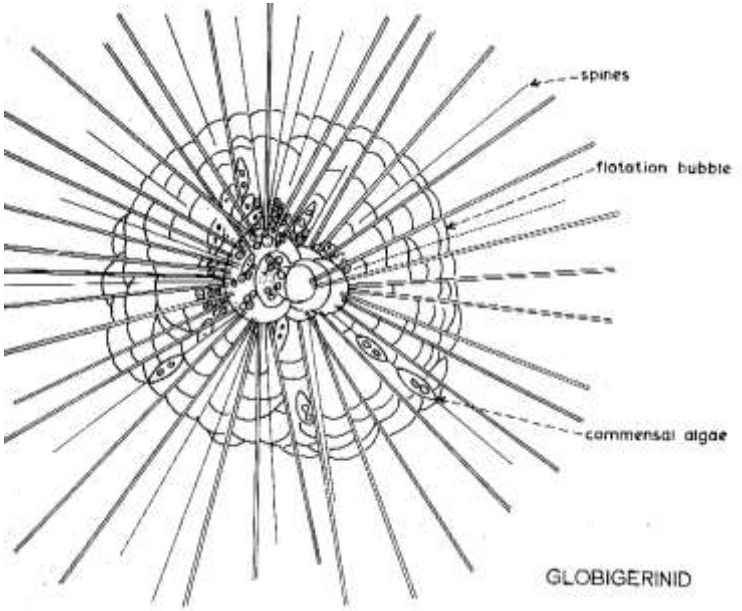
What are Foraminifera:

single-celled organisms (protists) Such organisms are classified in the Superkingdom of Protists or Protista



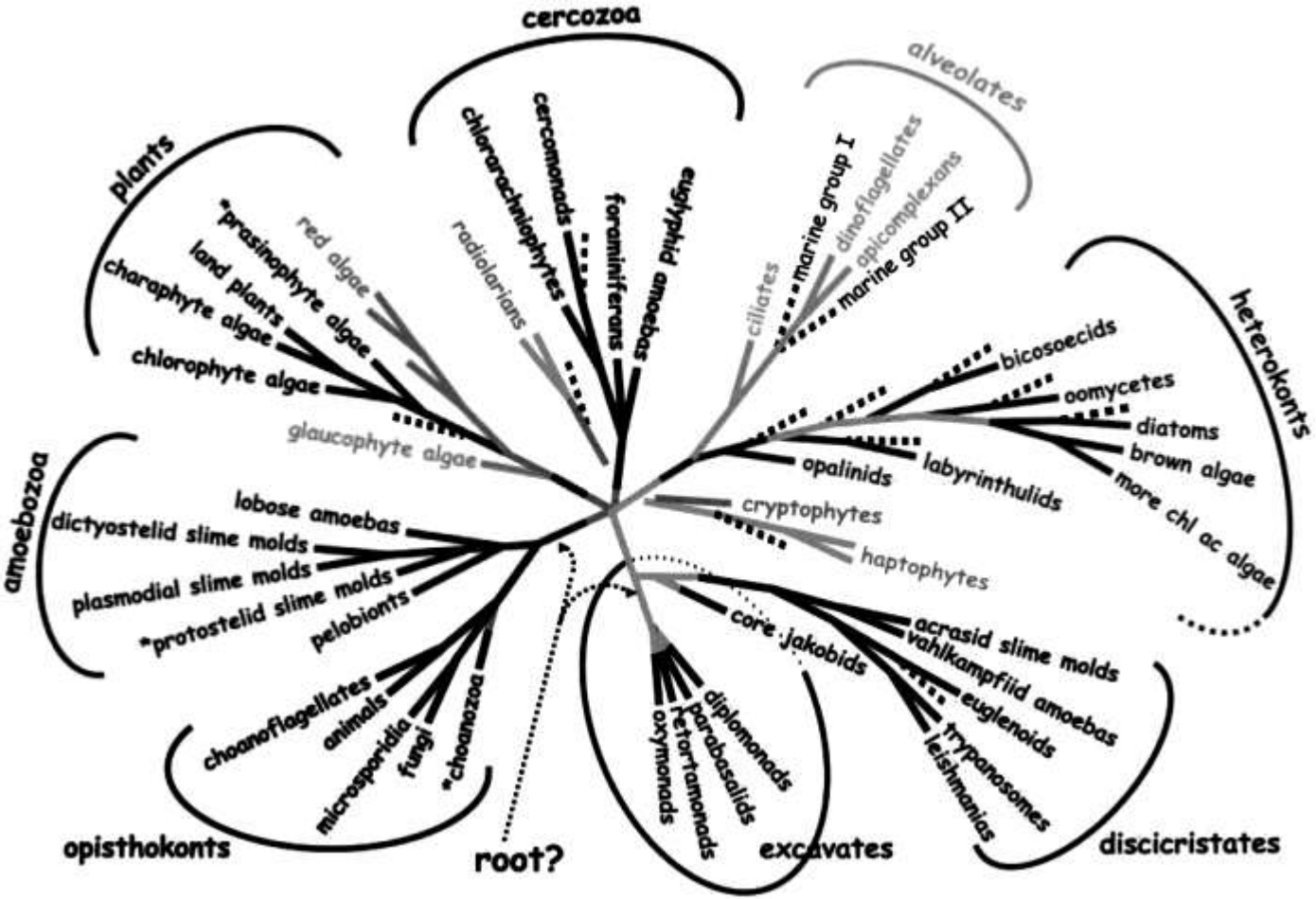
with a complex cell (**Eukaryotes**), and genetic material within a cell nucleus.

- with characteristic net-like pseudopodia called reticulopodia
- organic or shell-like, agglutinated or secreted outer protective layer, called a test



Cytoplasm is extruded as pseudopods through the aperture and any perforations in the test

Foraminifera are placed in the “Cercozoa”.
Cercozoans are amoebae with filose (threadlike)pseudopodia, often living within hard test

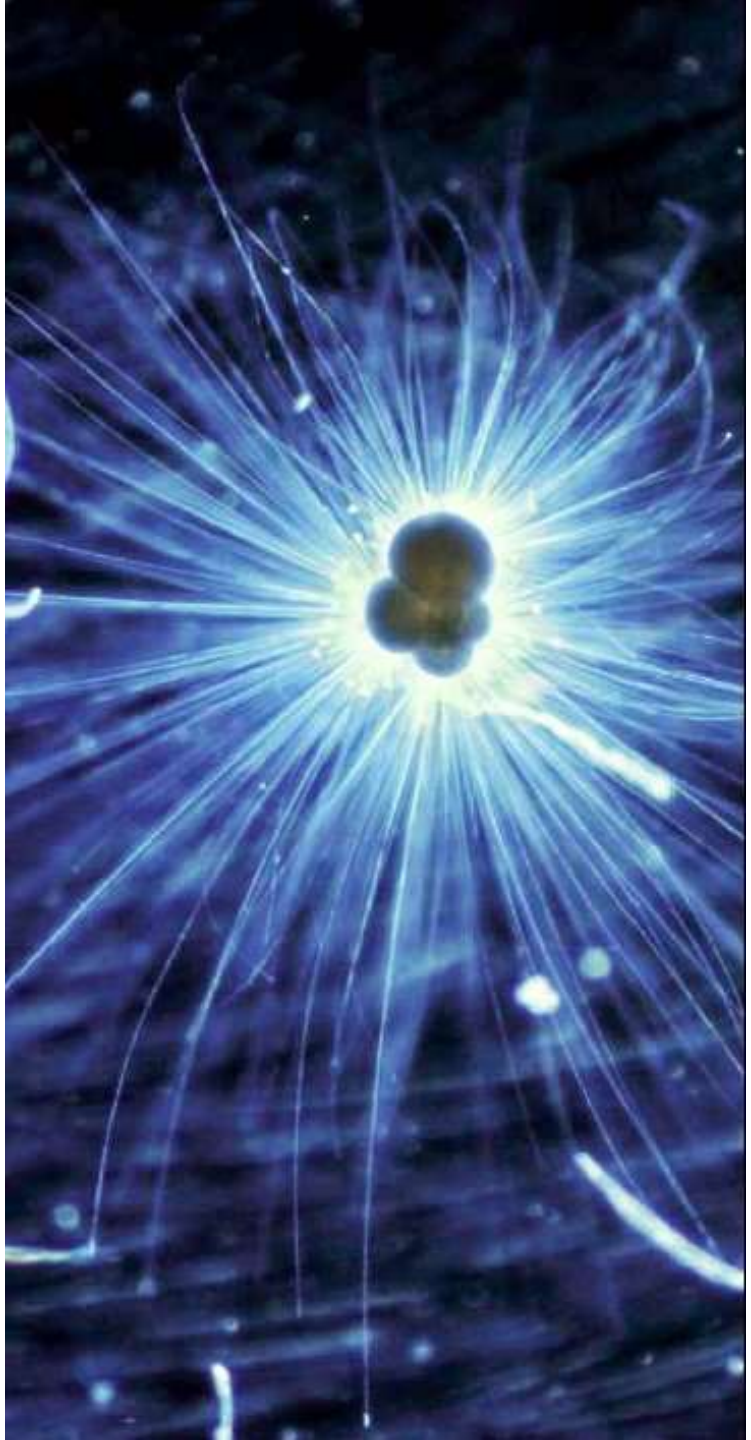


Most foraminifera grow an elaborate, solid calcite skeleton made of a series of chambers.

Most **foraminiferal tests** are sand-sized (>61 mm in diameter)

Both living and fossil foraminifera

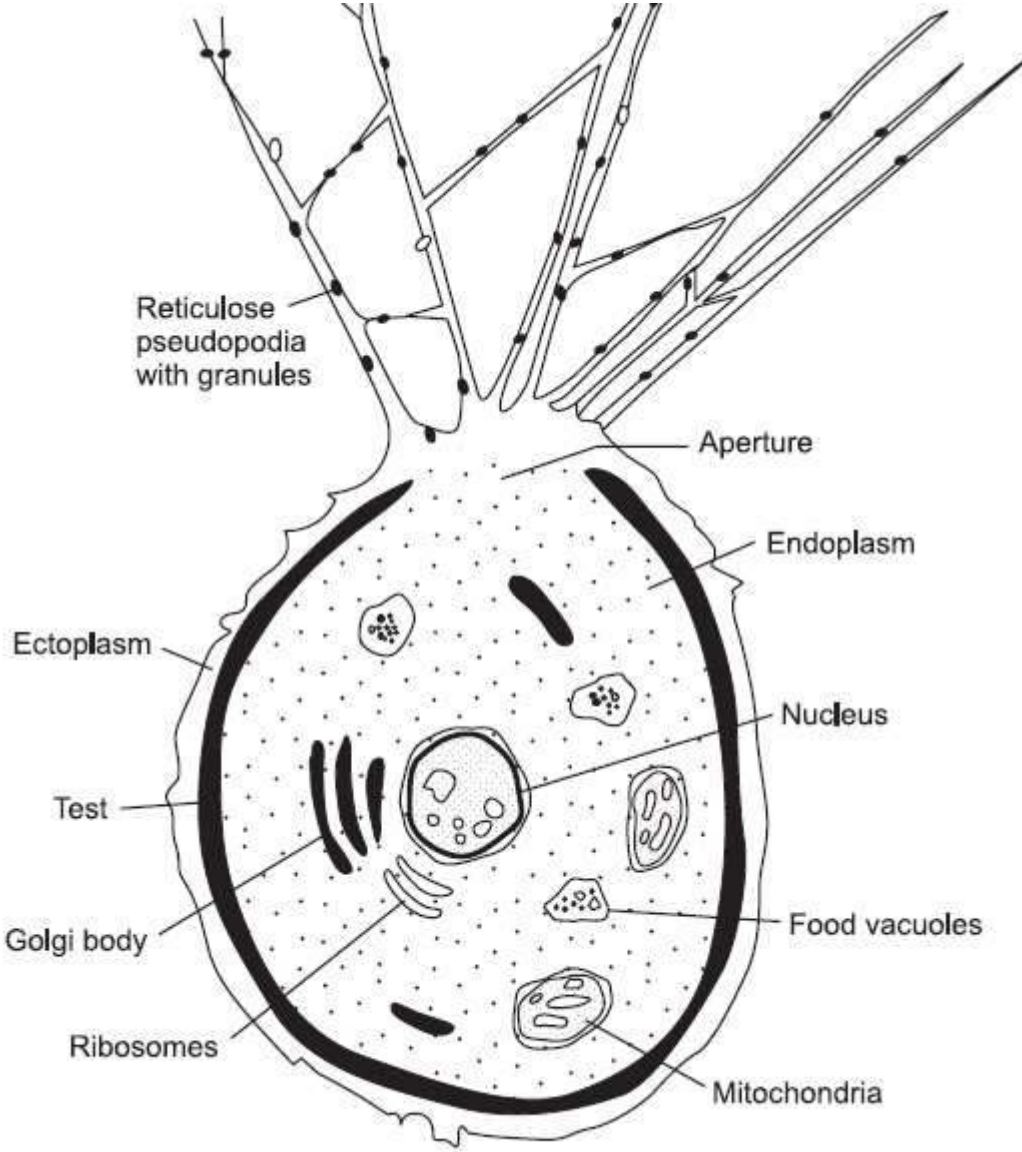
- inhabited the oceans.
- They are extremely abundant in most marine sediments
- in many different environments, from live in marine to brackish habitats
- near shore to the deep sea,
- and from near surface to the ocean floor



- Some foraminifera live in oligotrophic reef associated with algae.

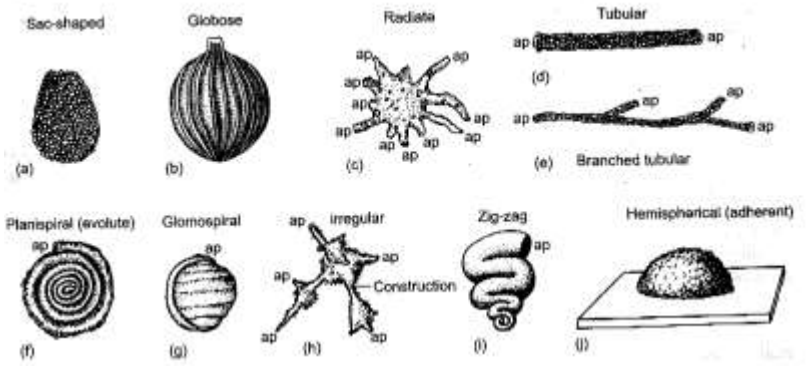
- An oligotroph is an organism that can live in an environment that offers very low levels of nutrients.
- Oligotrophs are characterized by slow growth, low rates of metabolism, and generally low population density.
- They may be contrasted with copiotrophs, which prefer nutritionally rich environments.

- The test is commonly divided into chambers which are added during growth
- The test is thought to reduce biological, physical and chemical stress
- The size of the test is associated with amount of the cytoplasm.
- Feeding adds to the bulk of the cytoplasm, therefore, the test has to enlarge.



Both living and fossil foraminifera come in a variety of shapes and sizes

the simplest forms are open tubes or hollow spheres

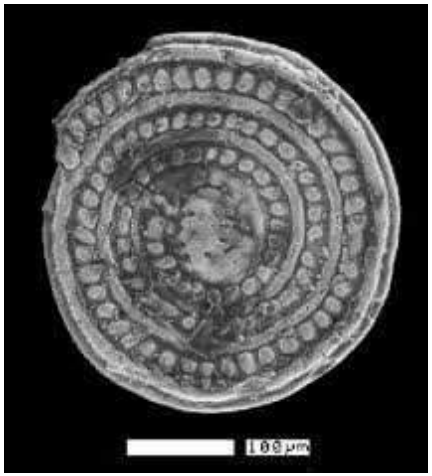


Lagena

reticulation

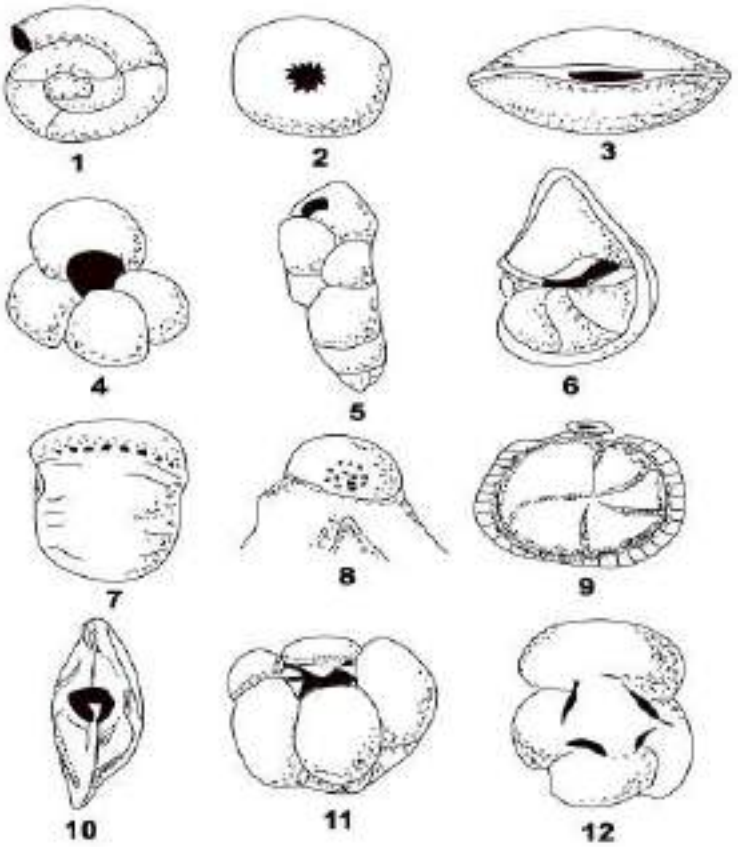
Undivided chamber

Spirillina

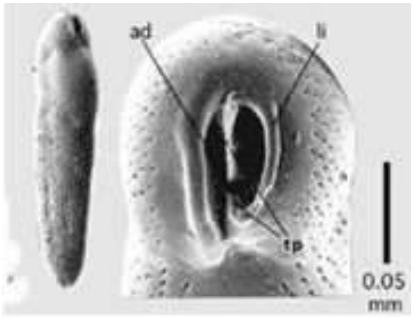


Planispiral, evolute, undivided tube

Chamber: cavity containing cytoplasm. Chambers separated by septa; connected by foramina (holes) in septa. Foramen in last chamber is called aperture



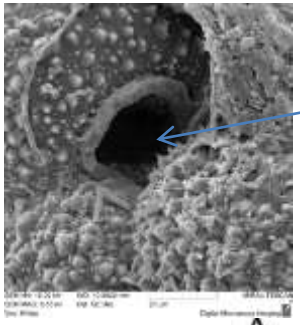
Principle types of aperture. 1, open end of tube; 2, terminal radiate; 3, terminal slit; 4, umbilical; 5, loop shaped; 6, interiomarginal; 7, interiomarginal multiple; 8, areal crbrate; 9, with phialine lip; 10, with bifid tooth; 11, with umbilical teeth; 12, with umbilical bulla. Redrawn from Loeblich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



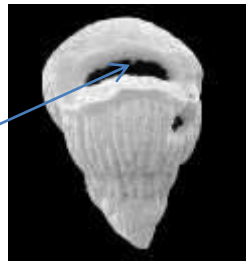
Loxostomina.

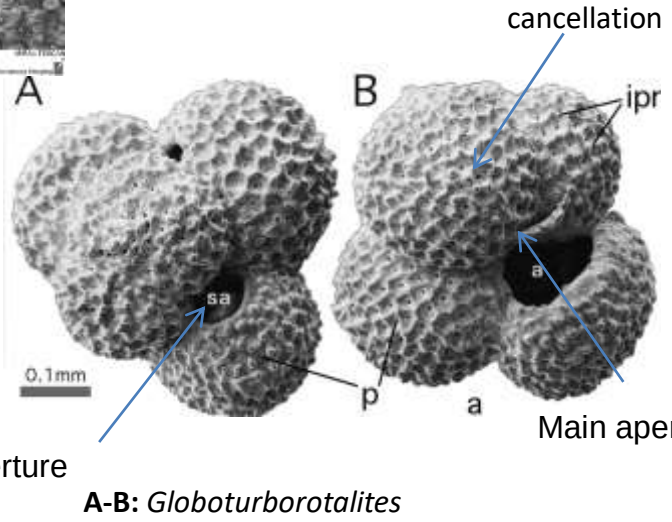
a: aperture; **ad:** adapertural depression; **li:** lip; **tp:** toothplate with its serrated margin.

Carpenteria



aperture

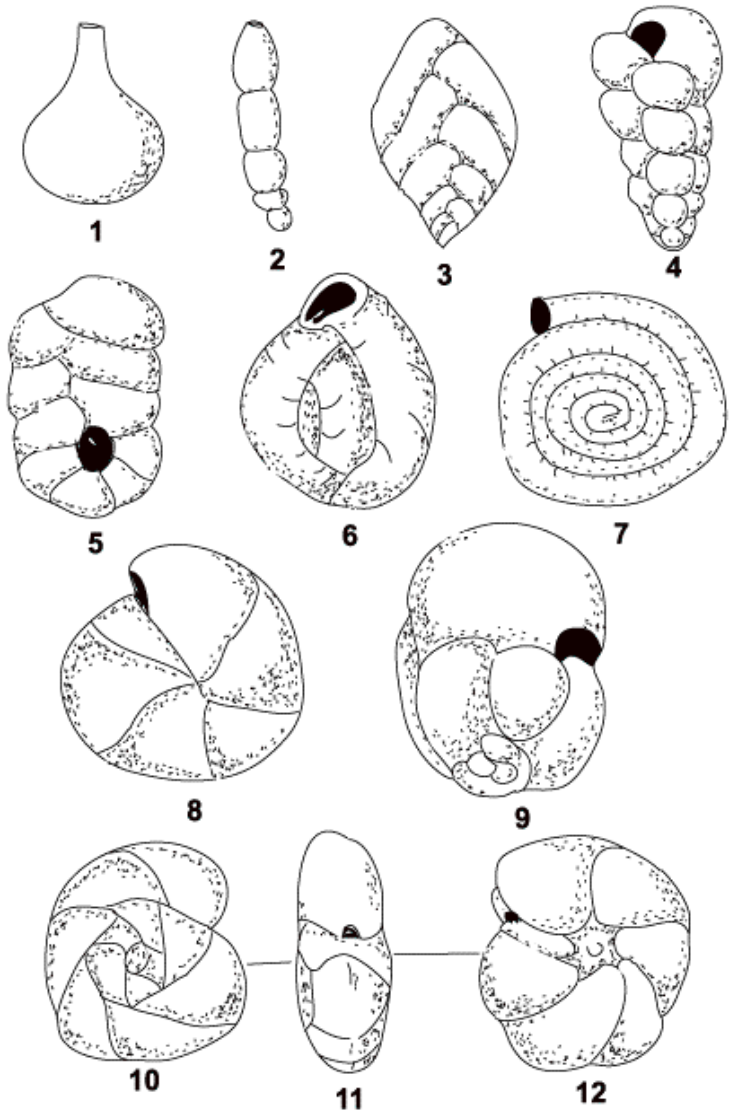




A-B: *Globoturborotalites*

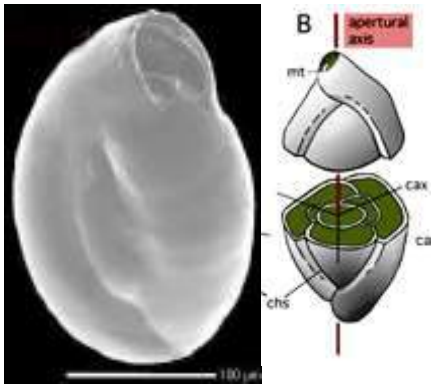
The shape, or morphology, of the test is extremely important in the taxonomy of foraminifera.

To date, more than 2140 benthic (ocean floor dwelling) species have been recognized



Principle types of chamber arrangement. 1, single chambered; 2, uniserial; 3,biserial; 4, triserial; 5, planispiral to biserial; 6, milioline; 7, planispiral evolute; 8, planispiral involute; 9, streptospiral; 10-11-12, trochospiral (10, dorsal view; 11, edge view; 12, ventral view). Redrawn from Loeblich and Tappan 1964.

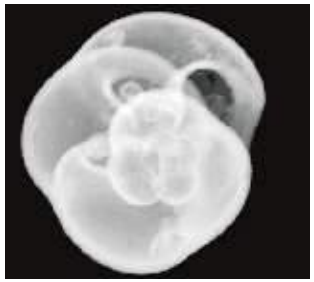
milioline



Quinqueloculina

biserial

Heterohelix



streptospiral

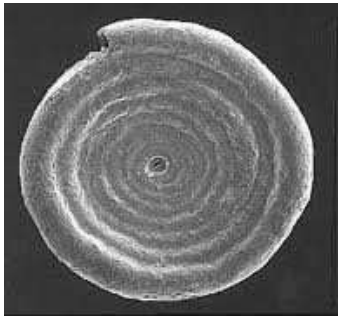
Pulleniatina

trochospiral

Ammonia

Planipiral involute

Elphidium



Planipiral evolute

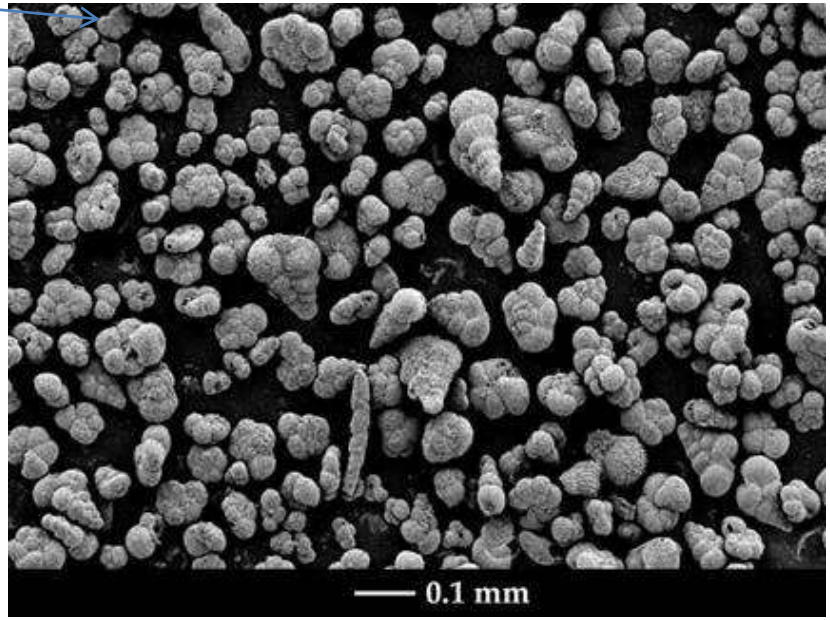
Spirillina

What are fossil foraminifera?

Most foraminifers construct tests (shells) covering the cell body.
Fossil foraminifera are the remains of their tests (shells).

They have inhabited the oceans for more than 500 million years and found fossilised in most type of sedimentary rocks.

Fossils can be microscopic
or
a few centimeters long



Fully grown individuals range in size from about 100 micrometers to almost 20 centimeters long.

relatively small size of tests (shells)

makes foraminifera

much more useful than larger fossils

For,

biostratigraphic,

palaeo/environmental, palaeoceanographical

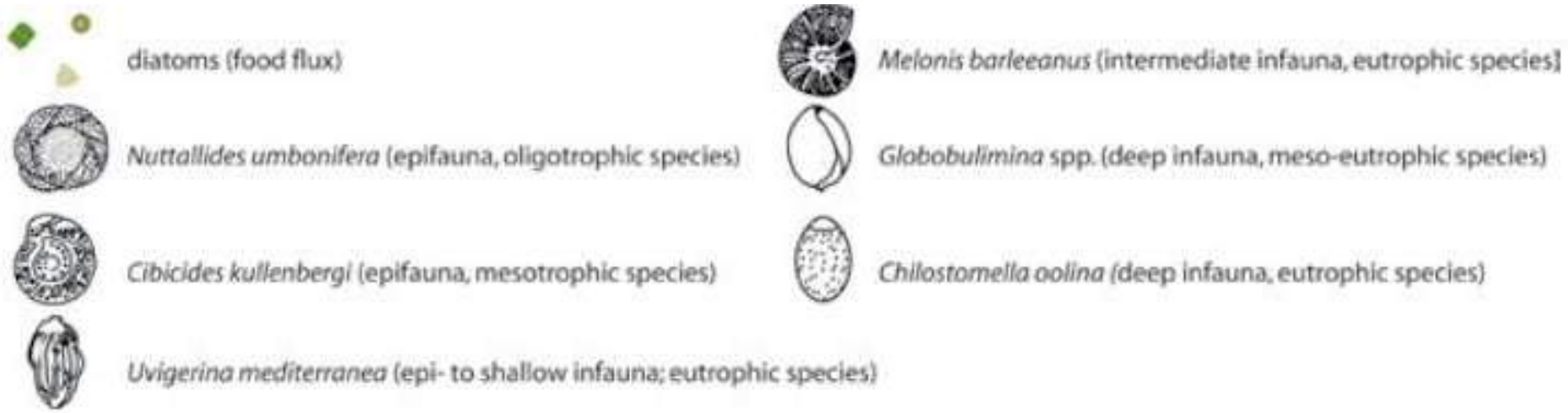
and **palaeoclimatological reconstruction**

or petroleum exploration applications

because there can be thousands of specimens in a small sediment sample.

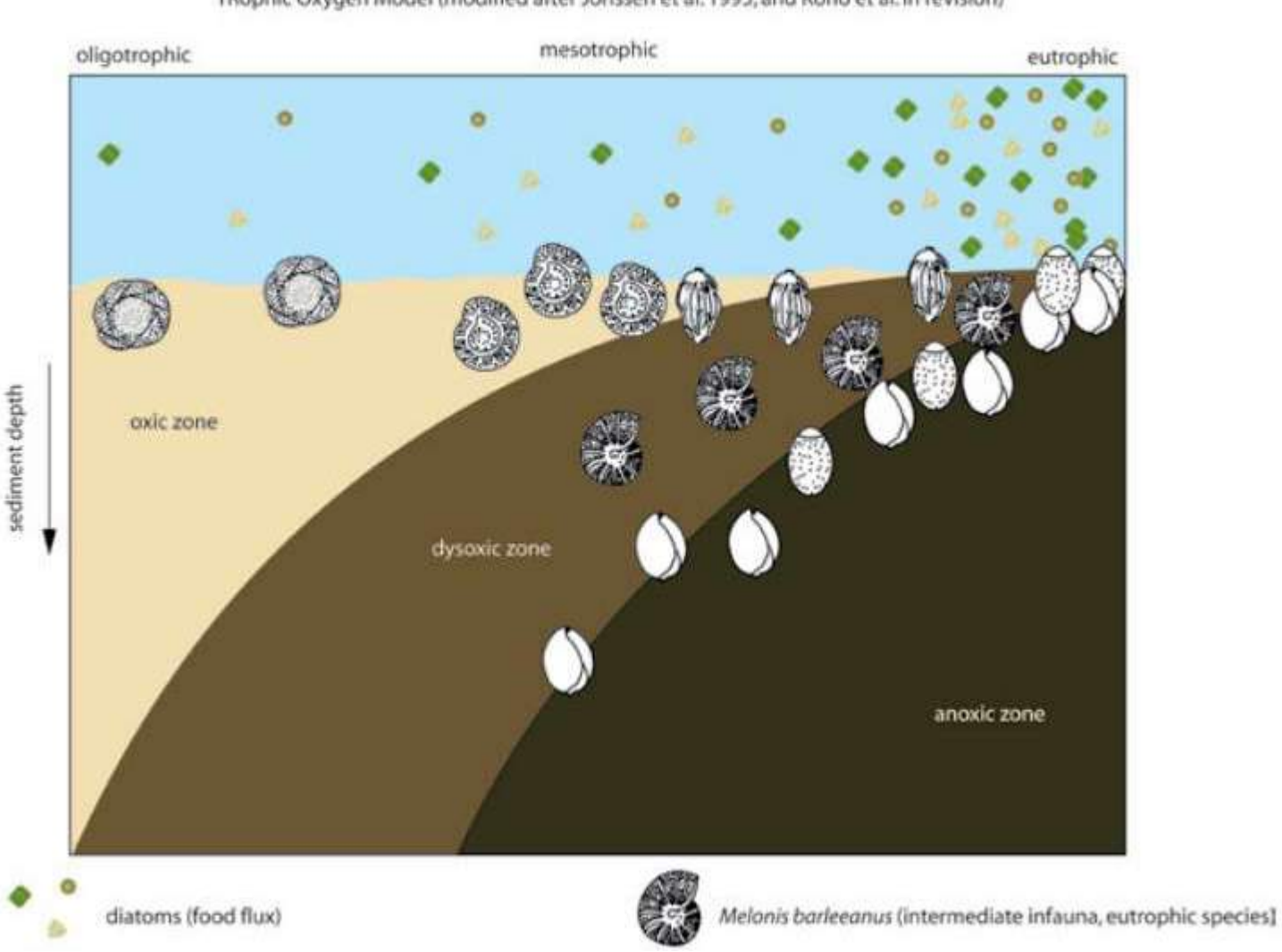
Benthic foraminifera: ecological indicators of past and present oceanic environments

- changes in foraminiferal morphology can be used as an analogue for the past distributions recorded in sediments.
- Nowadays, it is commonly believed that deep sea foraminiferal assemblages are mainly controlled by two parameters: oxygen and food availability.
- in food-limited and well oxygenated environments, foraminiferal communities are restricted to the surficial sediments due to low food supply, and consist of epifaunal, or surface dwelling, taxa specialized to live in oligotrophic regions.
- In eutrophic environments, where food is abundant and the pore water oxygen content is often reduced, the foraminiferal assemblage is dominated by infaunal taxa.



- the Trophic Oxygen model. The model outlines both lateral and in-sediment changes in foraminiferal distribution. Foraminiferal numbers are highest in the most eutrophic sediment and lowest in the oligotrophic setting. However, the in-sediment distribution is also related to pore water oxygen content as well as the food abundance. In the eutrophic sites, only infaunal species are found which can tolerate low oxygen conditions. In contrast in the oligotrophic sites, only epifaunal species are present, restricted to the surface sediments due to low food supply. In the mesotrophic situation, relatively diverse foraminiferal communities can be found, comprising of both epi- and infaunal taxa.

Dysoxic : Having a very low oxygen concentration (i.e. between anoxic and hypoxic).



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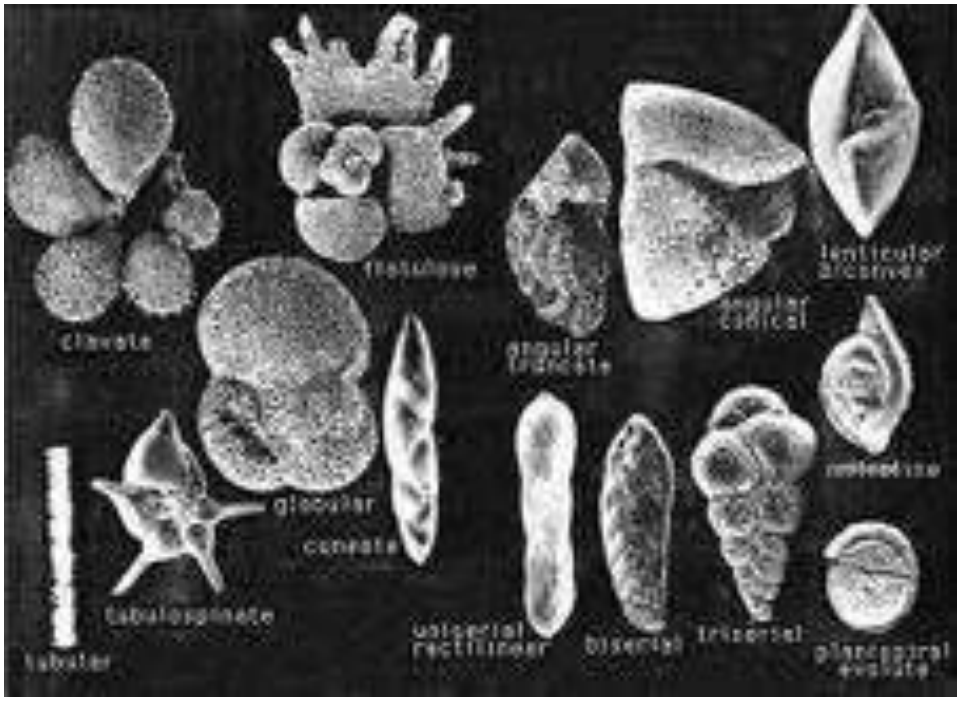
Life strategy

Planktonic foraminifera

Float in the surface of the open ocean
and sea water column
Wide distribution
Rapid evolution + short stratigraphic range
= excellent index fossil



Benthic foraminifera

Live attached or free
At all depth
marine, brackish and freshwater habitats
sea-floor

Small

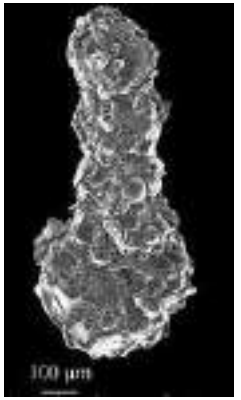
Larger

Benthic foraminifera

- Benthic foraminifera are bottom dwelling forms that can be either sessile or vagile.

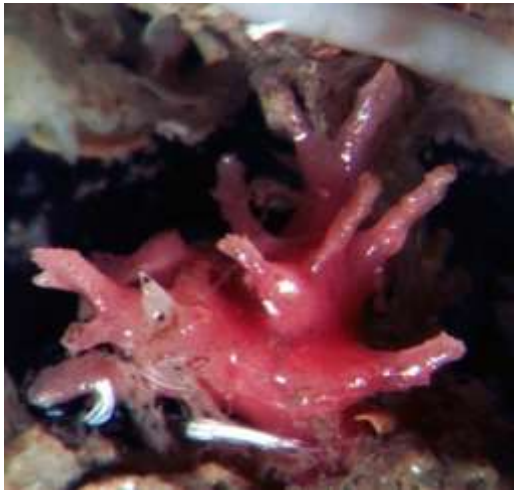
•**Vagile** (mobile) foraminifera are free to move along the sea floor and/or in its substrate

Cassidulina



Ammobacculites

•**Sessile** foraminifera are permanently attached or fixed (not free-moving)



Miniacina

Benthic foraminifera

include two major groups of foraminifera

Small benthic foraminifera

with simple internal structures

live, attached or free, at all depths, in most marine environments, as well as in brackish, marginal marine environment with low alkanity.

Larger benthic foraminifera

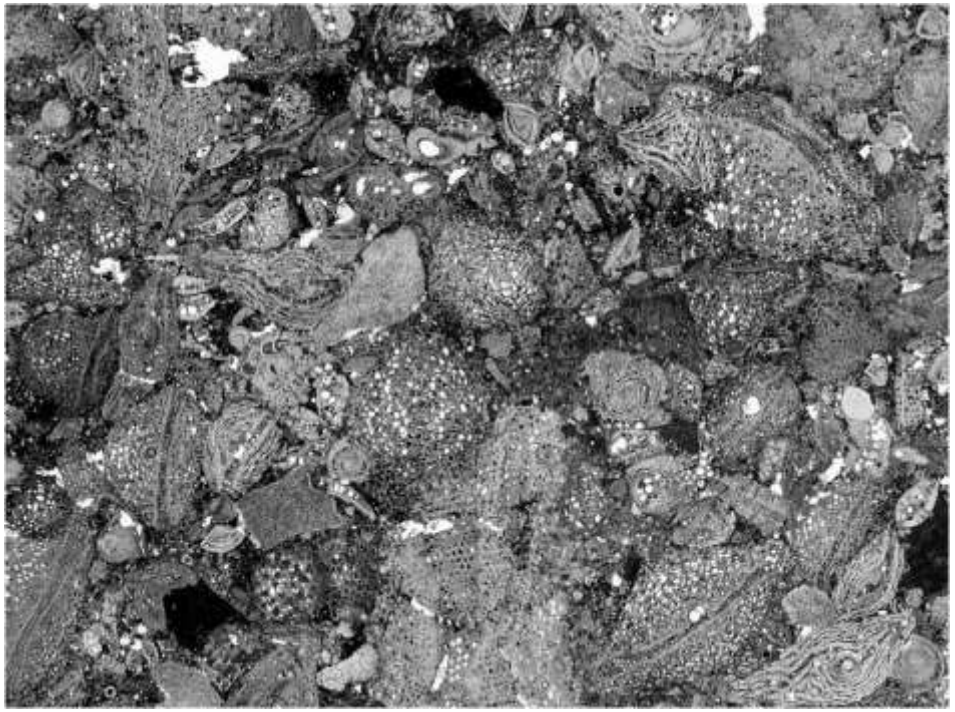
with complicated internal structures

occur abundantly in the shelf regions of most tropical and subtropical shallow marine, especially in carbonate-rich, environments

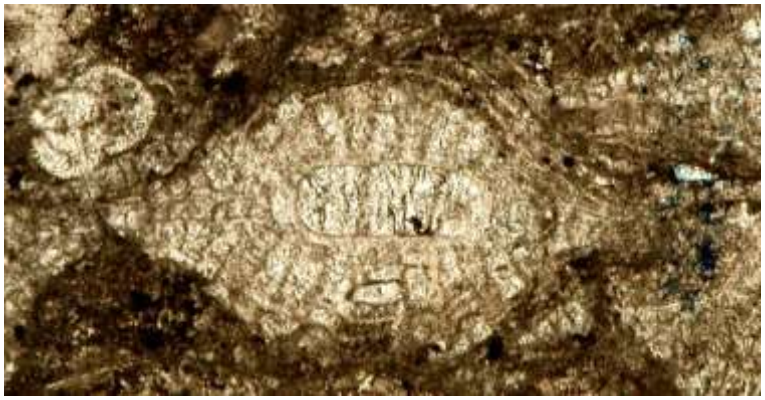
•Benthic foraminifera are an important component of the deep-sea biomass in the present oceans, adapted to its cold, dark, and extremely oligotrophic environments.

•Larger benthic foraminifera are important shallow marine rock builders

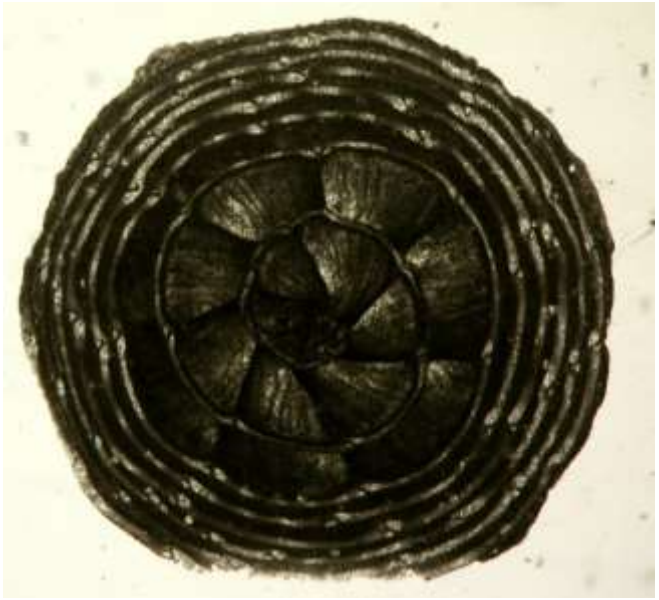
• Faunas are highly diverse, and many species have a cosmopolitan distribution.

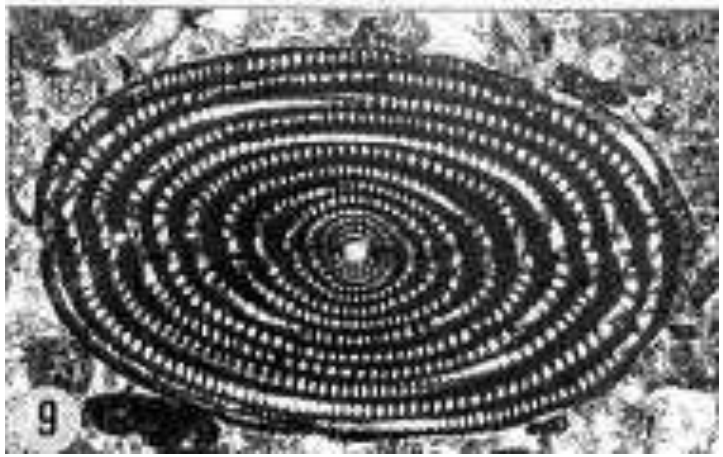


•In addition to their interest as indicator species living in the largest habitat on earth, their tests have been used extensively in isotope and trace element analysis aimed at reconstruction of past environments.



Larger Foraminifera with test sizes from 2mm up to 13cm are characteristic organisms inhabiting shallow water subtropical and tropical environments today.





Alveolina

NUTRITION

❖The food of foraminifera includes:

- unicellular algae, especially diatoms,
- other protozoans and
- small metazoans including crustaceans such as copepods.

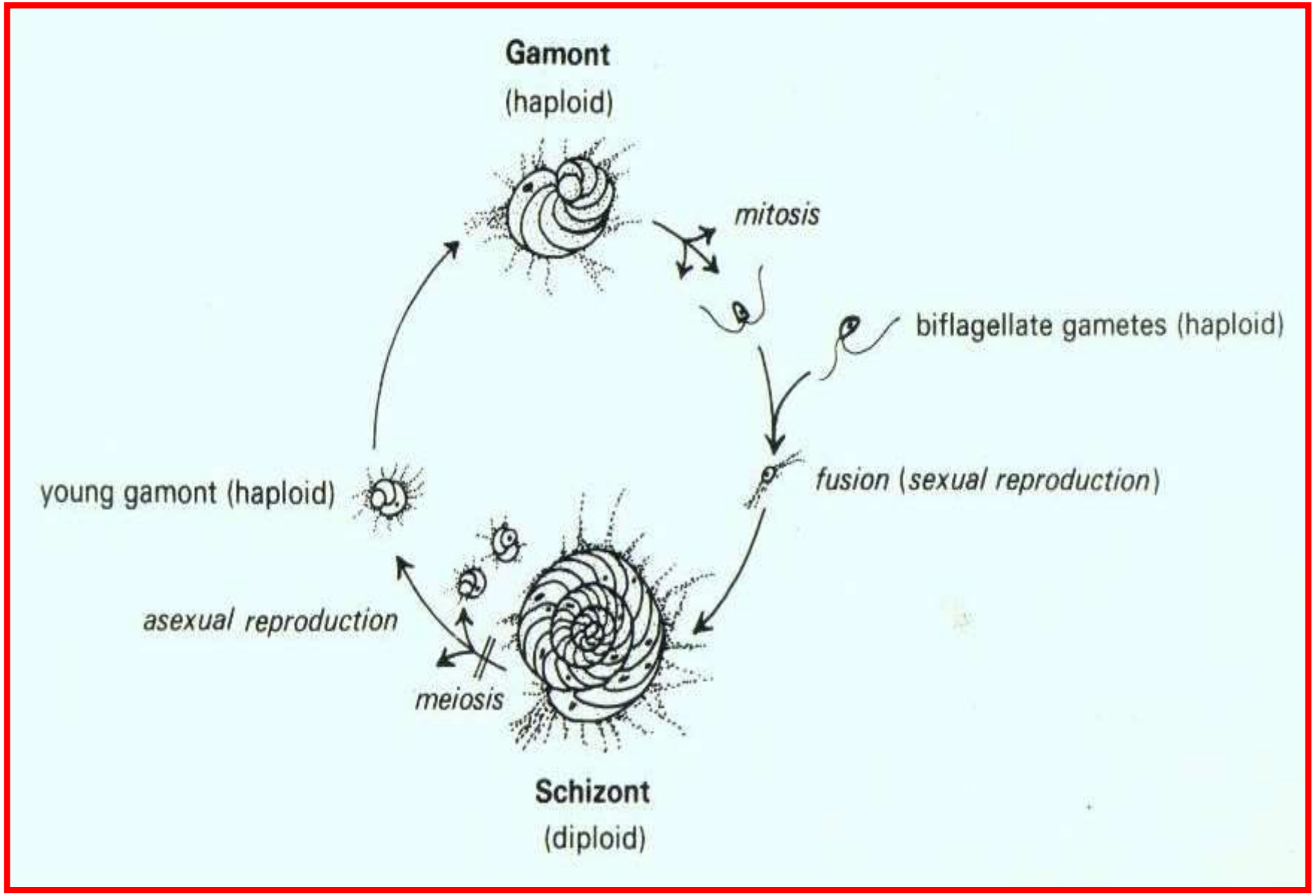
❖Solid food may be carried through the aperture and digested with the help of enzymes secreted by the lysosomes or partly digested in place.

REPRODUCTION

•A life cycle is termed heterophasic when it characteristically contains two different phases, or types of reproduction and maturation.
•Among some foraminifera there is alternation of an asexual followed by a sexual generation.
•The young gamonts with the larger proloculus are termed the megalospheric (haploid) generation, while the individuals with smaller proloculi are called the microspheric (diploid) generation. Thus the two morphologically distinct tests are termed dimorphism. proloculus The initial chamber of a foraminiferid (Foraminiferida) test

•**Dimorphic pairs are found among smaller and larger benthic foraminifera, but have not been recognized in planktonic genera.**

•The microspheric generation with the smaller proloculus is termed B form, whereas the megalospheric phase (with larger proloculus) is called the A form.



Foraminiferid life history (diagrammatic)

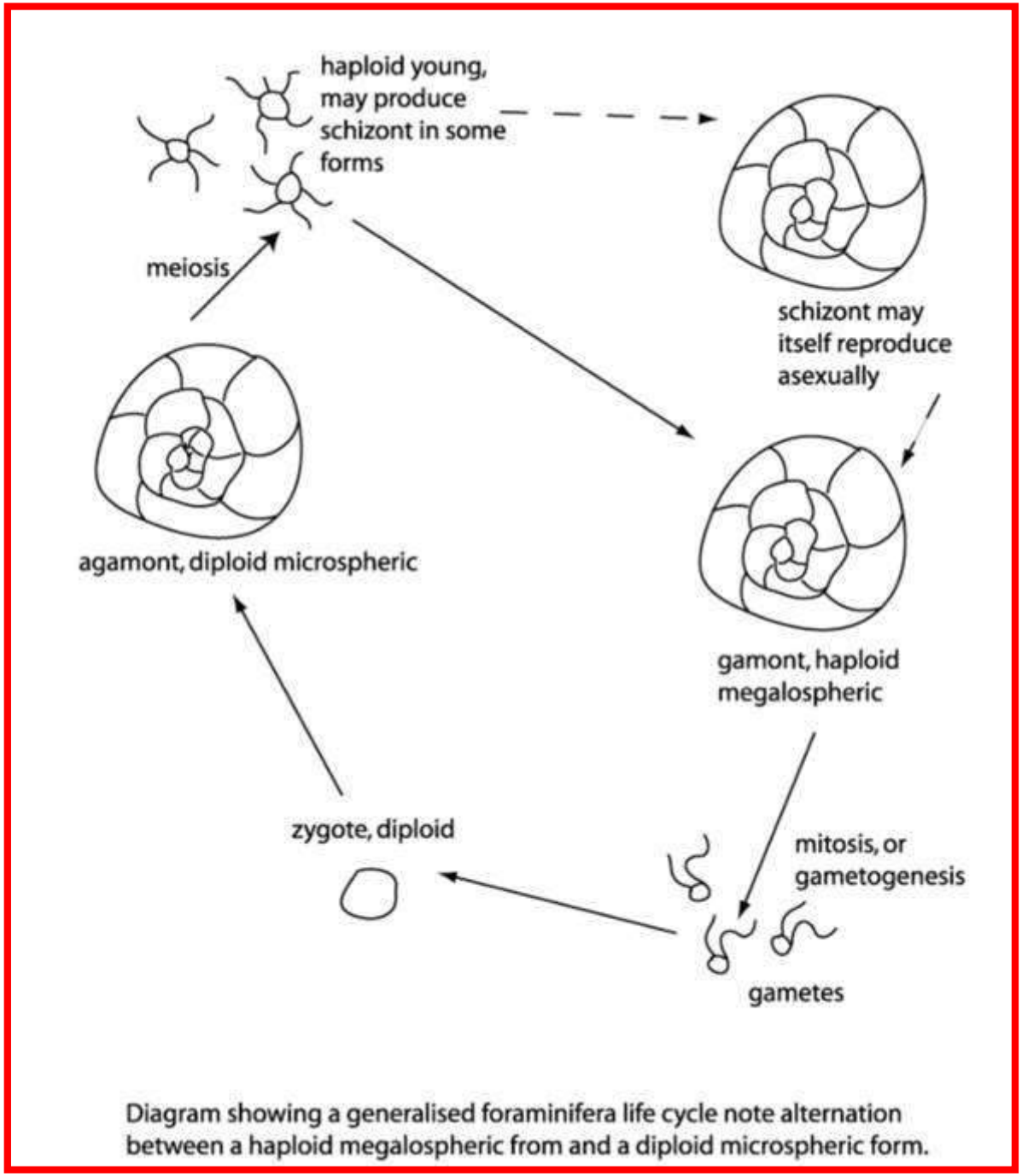
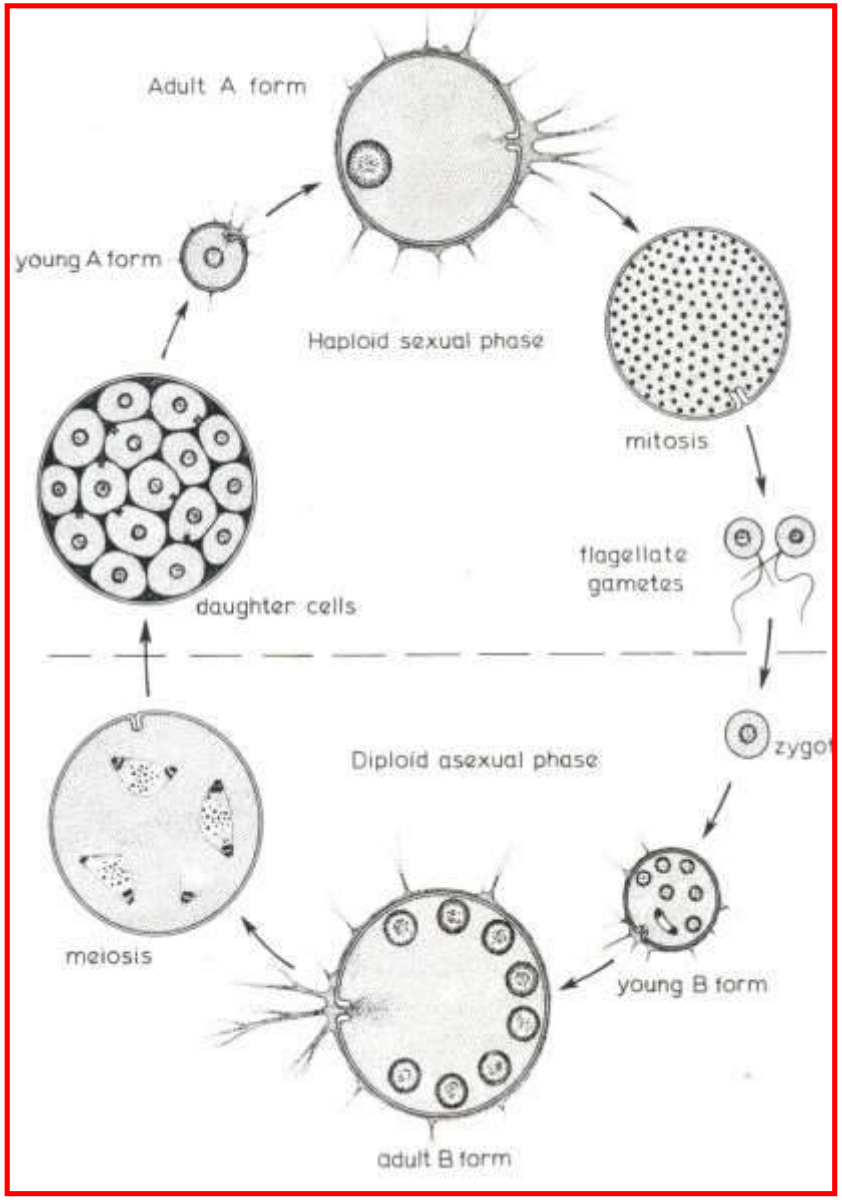
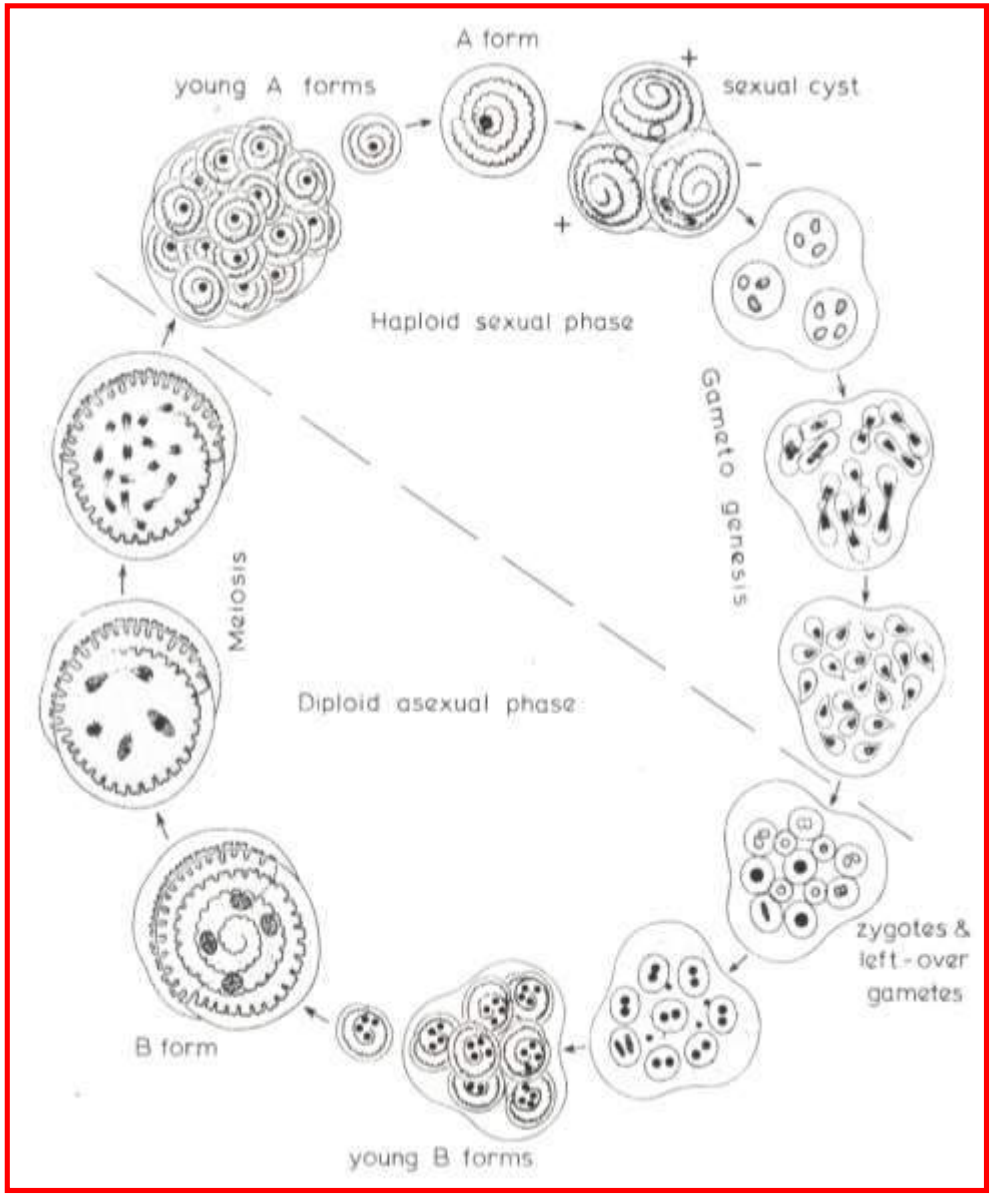


Diagram showing a generalised foraminifera life cycle note alternation between a haploid megalospheric from and a diploid microspheric form.



Alternation of generations in *Myxotheca arenilga* after Grell (1973)



Alternation of generations in *Patellina corrugata* after Grell (1973)