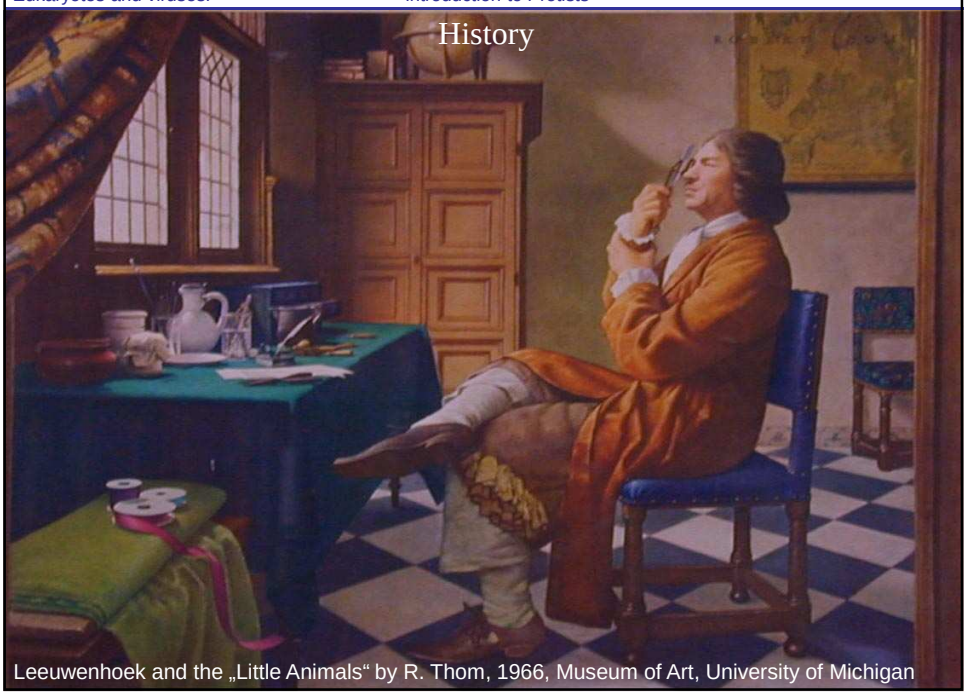
Eukaryotes and viruses:

Introduction to Protists

C. Beardsley, ICBM

08.01.2009

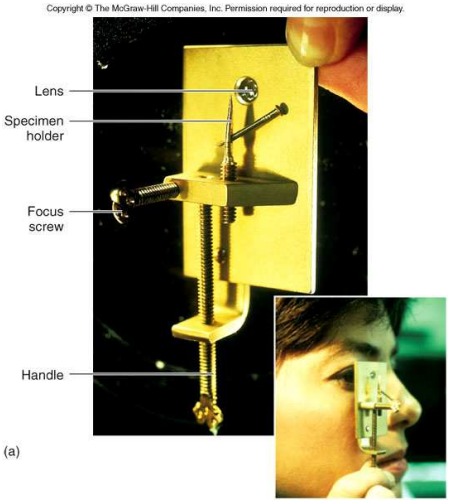
History



Leeuwenhoek and the „Little Animals“ by R. Thom, 1966, Museum of Art, University of Michigan

History

Antonie van Leeuwenhoek (1673) **Animalcula**

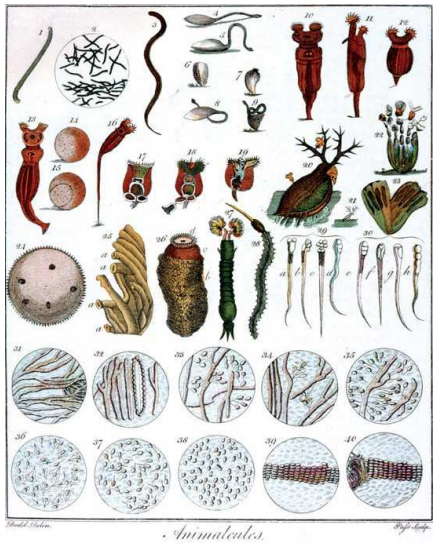


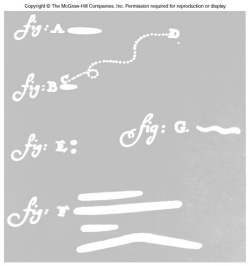
(a)

Microbes were first observed using a simple microscope and reported as “animalcules” to the Royal Society of London.

History

Antonie van Leeuwenhoek (1676) **Animalcula**

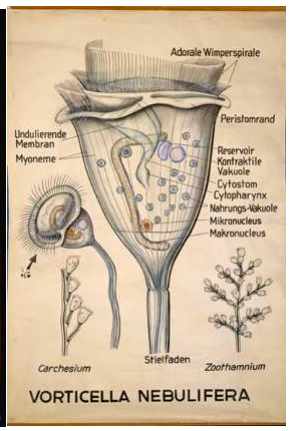


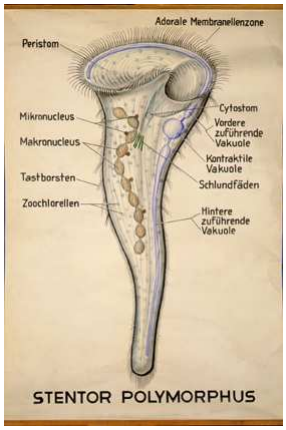


(b)

History

Martin Frobenius Ledermüller (1760/63) **Infusoria**
Lorenz Oken (1805) **Urthiere**

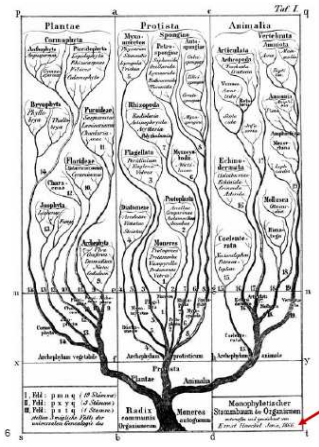




History

Georg August Goldfuss (1818) **Protozoa**
John Hogg (1861) **Protoctista**

Ernst Haeckel (1866) **Protista**

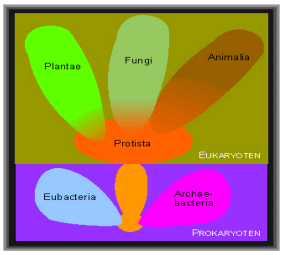


Tree of life - Haeckel (1866)

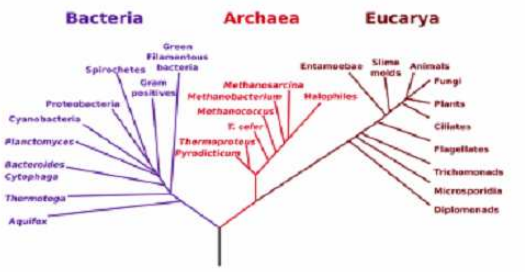
Ernst Haeckel (1834 - 1919)

Seven years after Darwin's "Origin of the species"

History



www.biologie.uni-hamburg.de/b-online



Linnaeus 1735	Haeckel 1866[1]	Chatton 1937[3]	Copeland 1956[5]	Whittaker 1969[7]	Woese et al. 1977[8]	Woese et al. 1990[9]
2 kingdoms	3 kingdoms	2 empires	4 kingdoms	5 kingdoms	6 kingdoms	3 domains
		Prokaryota	Monera	Monera	Eubacteria	Bacteria
					Archaebacteria	Archaea
(not treated)	Protista	Eukaryota	Protoctista	Protista	Protista	Eukarya
Vegetabilia	Plantae			Fungi	Fungi	
			Plantae	Plantae	Plantae	
Animalia	Animalia		Animalia	Animalia	Animalia	

Wikipedia.org
H. Cypionka. www.icbm.de/pmbio

Definition

Protista

Protists are a heterogeneous group of organisms, comprising those eukaryotes that are not animals, plants, or fungi. They are usually treated as the kingdom Protista or Protoctista. The protists are a paraphyletic grade, rather than a natural (monophyletic) group, and do not have much in common besides a relatively simple organization (unicellular, or multicellular without highly specialized tissues). Some call it the "left-overs" from the other eukaryotic kingdoms.

(Wikipedia)

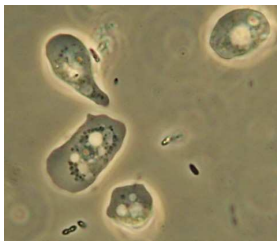
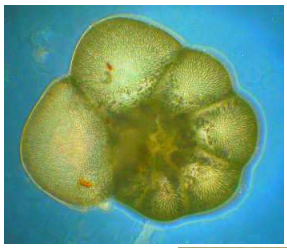
Mostly, but not exclusively, unicellular eukaryotic organisms.

What are taxonomic definitions based on?

Classification by Morphology & Physiology

Note: term classification is neutral and only means grouping by categories!

Cell membrane: Without, Silikate, Cellulose, Carbonate, Chitin, Proteins...

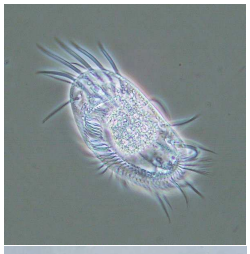





Fotos: H. Cypionka

Classification by Morphology & Physiology

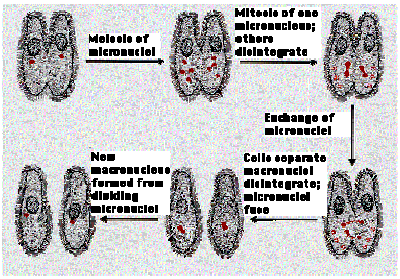
Movement: Pseudopodia, Flagella, Cilia, Sessile

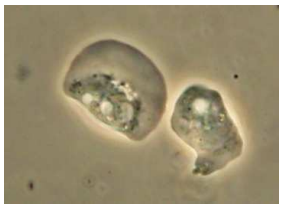




Fotos: H. Cypionka

Classification by Morphology & Physiology

Developmental stages: sexual and/or asexual reproduction





Fotos: H. Cypionka

Classification by Morphology & Physiology

Trophic life style: phototrophic, organoheterotrophic or mixotrophic

→ heterotrophic: phagotrophic or osmotrophic

→ phagotrophic: Filter feeding or Interception feeding

Fotos: H. Cypionka

What are taxonomic definitions based on?

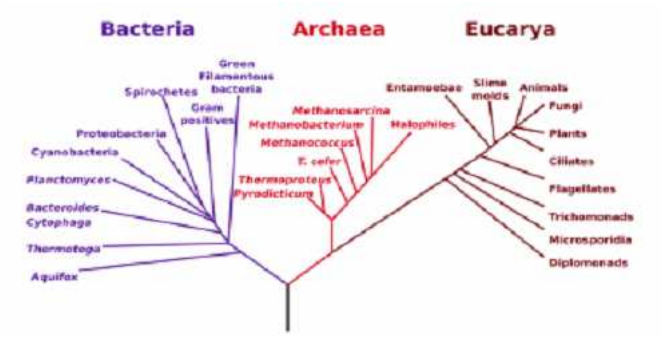
Traditionally, taxonomy was based on morphological and physiological similarities among organisms.

Concept: These similarities (or lack thereof) were inherited and "modified" by random mutation & natural selection - thus reflect phylogeny.

But within the heterogeneous group of protists no consistent classification arises from putting these phaenotypical trades into some kind of serial order!

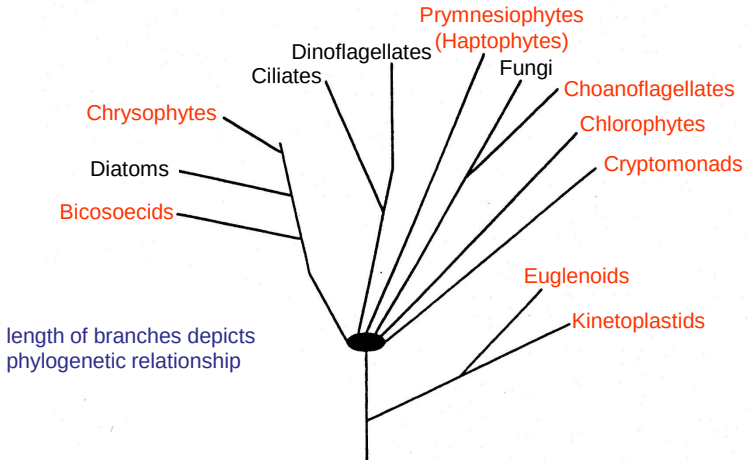
Classification by Phylogeny:

Tree of Life Based on SSU-rRNA Sequence Similarity



Classification by Phylogeny:

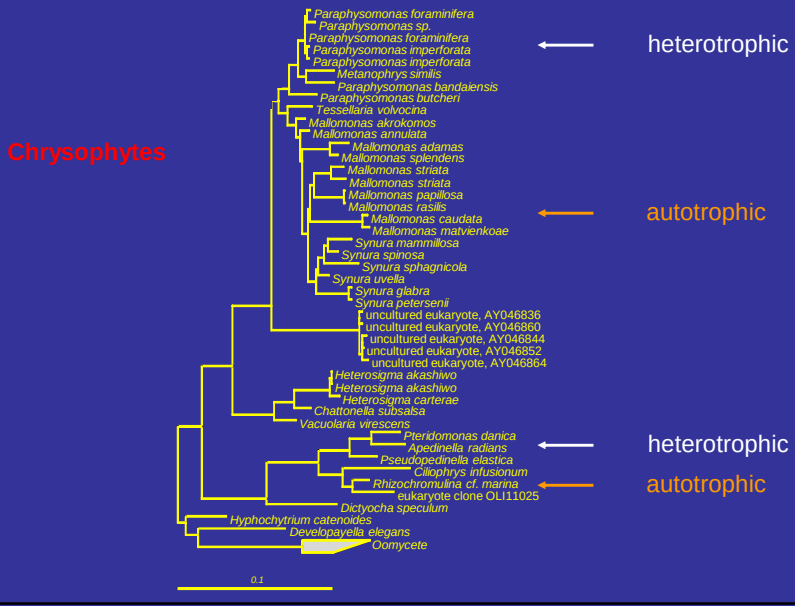
Phylogeny of Protists Based on 18S rRNA Sequence Similarity



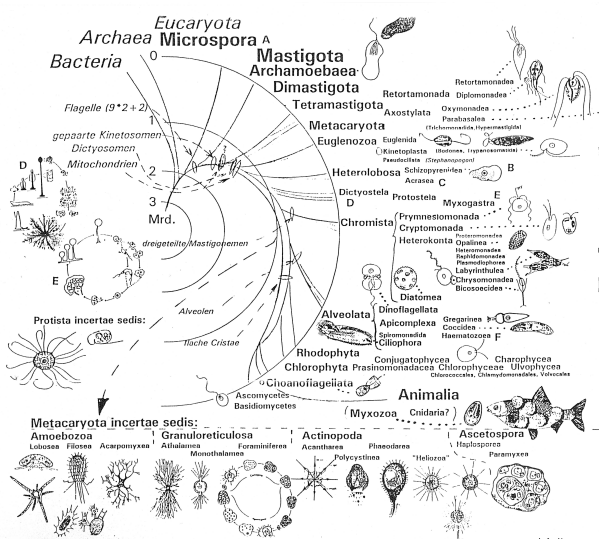
Groups with Heterotrophic Nanoflagellates

Sherr & Sherr 2000

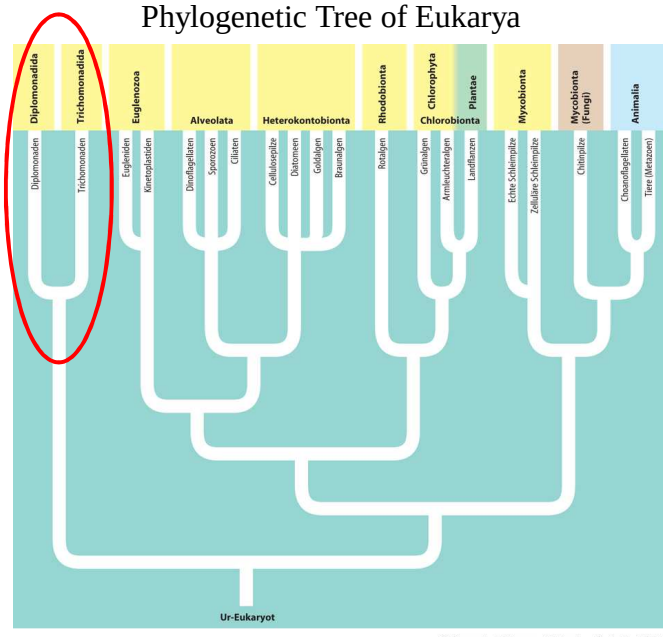
Phylogeny Does Not Reflect Trophic Life Style



Evolution



Phylogenetic Tree of Eukarya

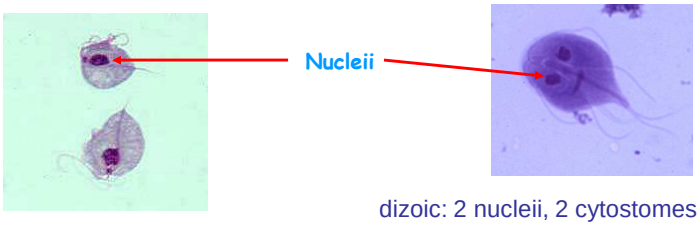


Trichomonads:

Trichomonas vaginalis

Diplomonads:

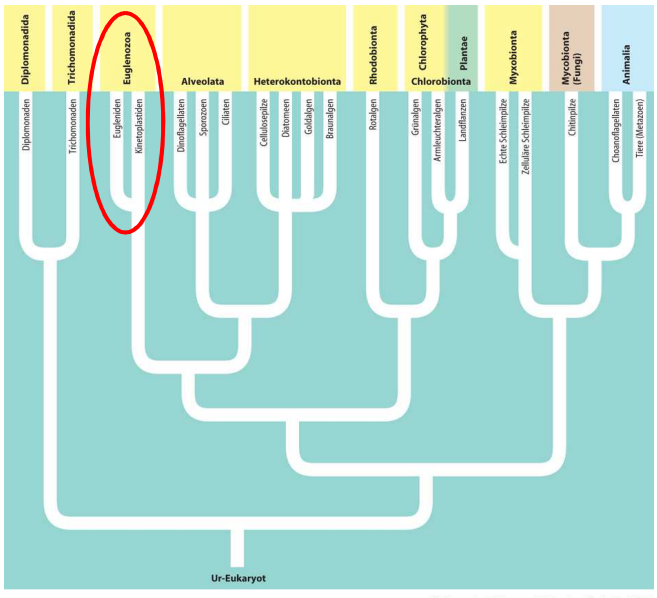
Giardia lamblia



dizoic: 2 nucleii, 2 cytostomes, 8 flagella

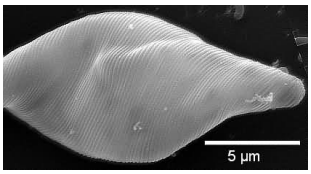
- deep branching group
- anaerobic without mitochondria (sekundary lost)
- *Trichomonas* is frequent in human vaginal flora (3 - 60 % of women), usually not pathogenic
- *Giardia*: causes diarrhea; builds cysts as resting stages

Phylogenetic Tree of Eukarya



Euglenozoa: Euglenids

Euglena



Euglena

Throphic life style: most heterotrophic, but also phototrophic or mixotrophic

Chlorophyll a fluoresces under UV-light

Euglenids grazing on bacteria

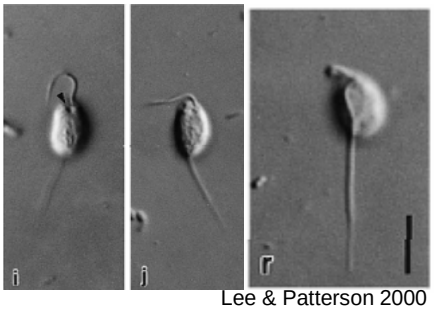
Images: www.mikrobiologischer-garten.de

Euglenozoa: Kinetoplastida

Bodo, Rhynchomonas

Throphic life style :

Free living heterotrophic

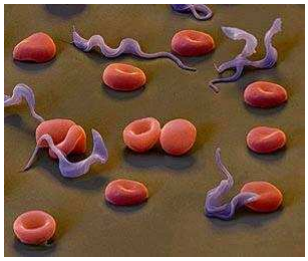


Lee & Patterson 2000

important bacteriovores

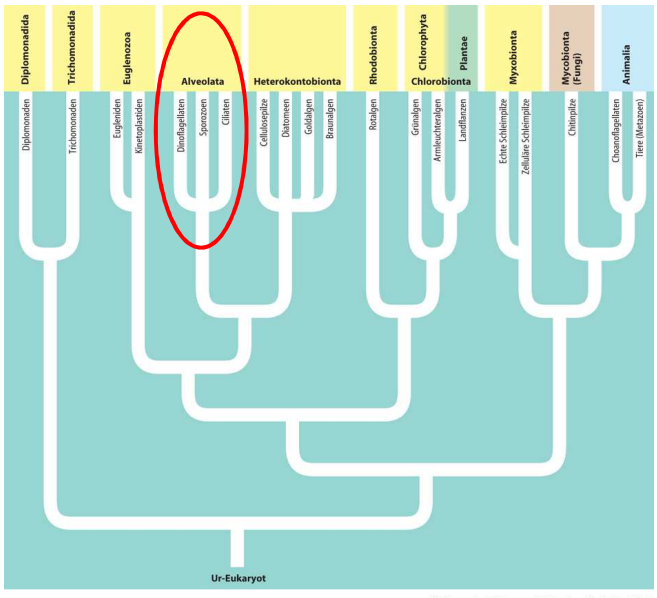
Trypanosoma

parasitic



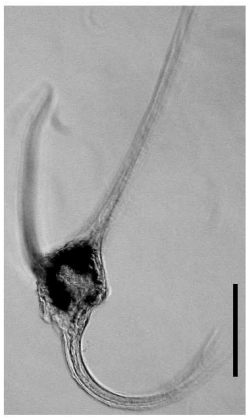
cause sleeping sickness

Phylogenetic Tree of Eukarya



Alveolata: Dinoflagellates

Throphic life style: phototrophic and/or heterotrophic: mixotrophic



- cellulose-plates
- 2 flagella: operate in a transverse constriction (girdle) & a longitudinal groove (= dinocont flagellation)

→ screw-like swimming movement

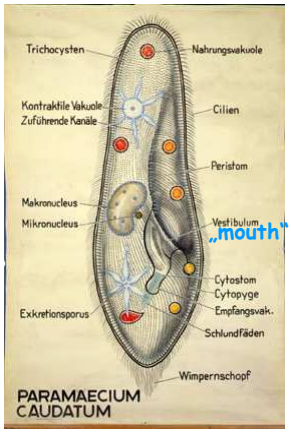
Major contributors to global marine photosynthesis!

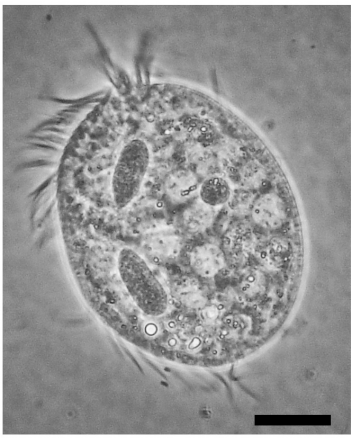
Red tide

Cypionka, Grundlagen der Mikrobiologie

Alveolata: Ciliates

- mostly heterotrophic filter- or interception feeders, but also photo- and mixotrophic species
- complex cell structures

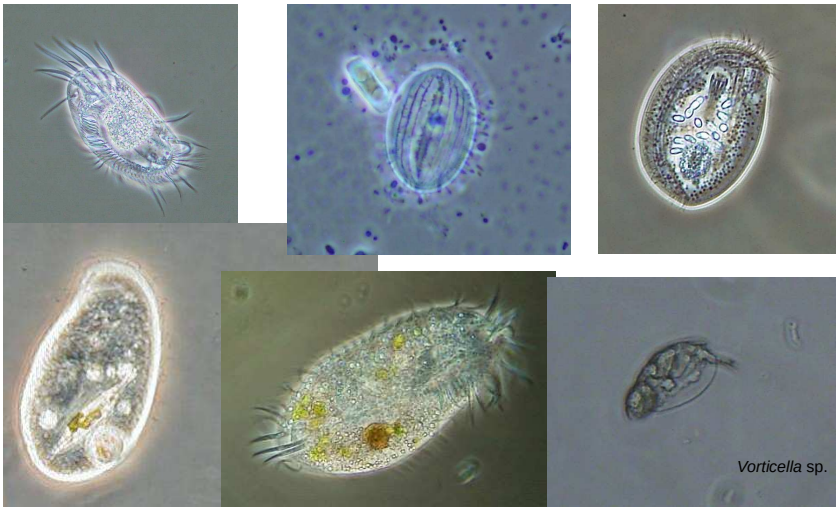




Cypionka, Grundlagen der Mikrobiologie

Alveolata: Ciliates

- Rows of cilia originating from the kinetosomal bases
- Nucleii dimorphism



Fotos: H. Cypionka

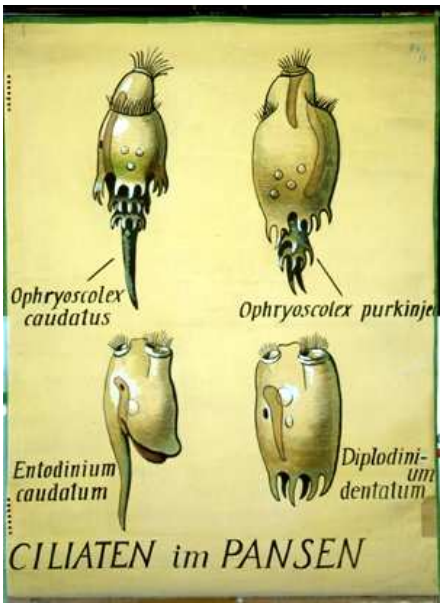
Alveolata: Ciliates

Vorticella: filter feeder

www.mikrobiologischer-garten.de

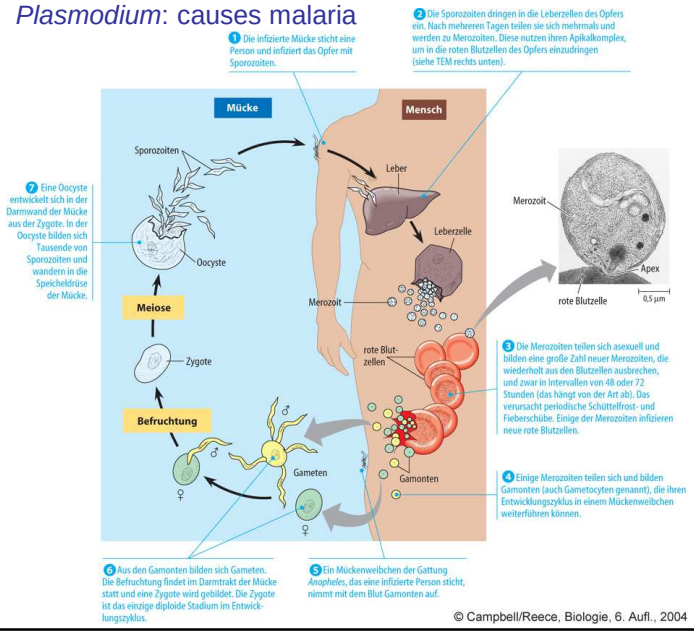
Alveolata: Ciliates

Obligate anaerobic ciliates !



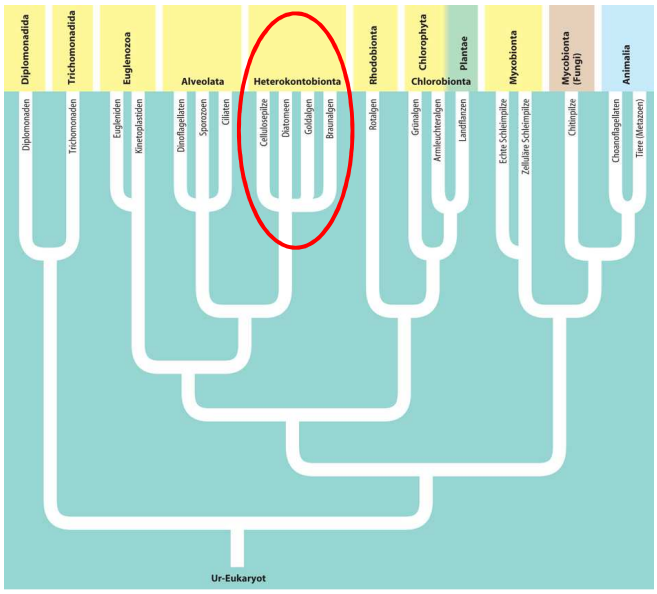
Alveolata: Apicomplexa

Plasmodium: causes malaria



- obligate parasitic
- alternation of generation and of host
- >>100 Mio. people per year

Phylogenetic Tree of Eukarya



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Heterokontobionta: 2 flagella (1 short and 1 long & hairy)

Heterokonts:
- Diatoms (Bacillariophyceen)

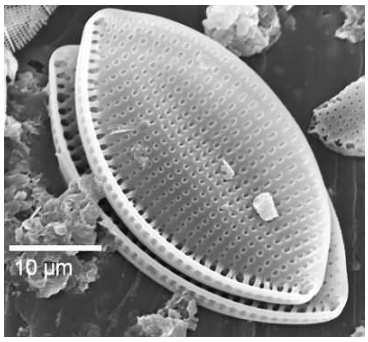
- Chrysophyceae / Chrysomonads (Gold algae)

- Phaeophyceae (Brown algae)

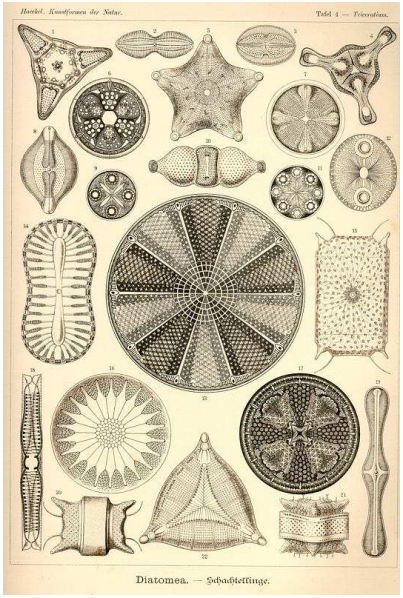
Oomyceta:
- Cellulose molds

Heterokontobionta: Diatoms

- Phototrophic
- no flagella
- silica containing cell walls

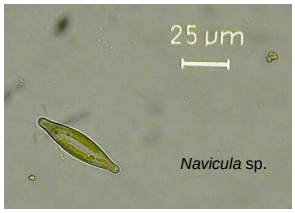


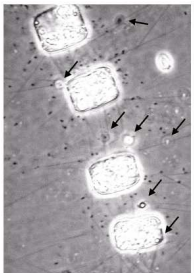
REM of a diatom cell wall (Foto Renate Kort, Erhard Rhiel).

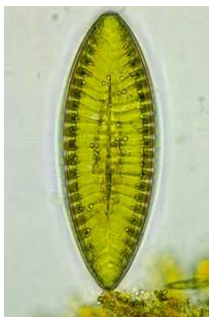


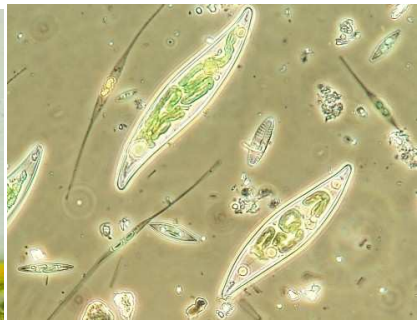
Heterokontobionta: Diatoms

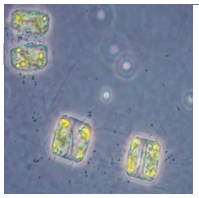
Pennate und central forms









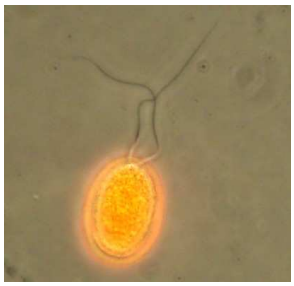


Fotos: H. Cypionka

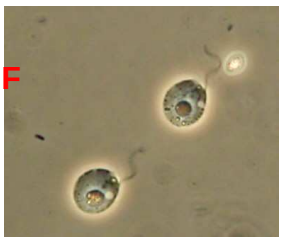
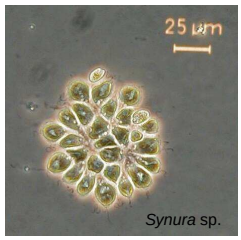
Heterokontobionta: Chrysomonads

- phototroph und/oder heterotroph: mixotroph
- HNF: important bacterivores

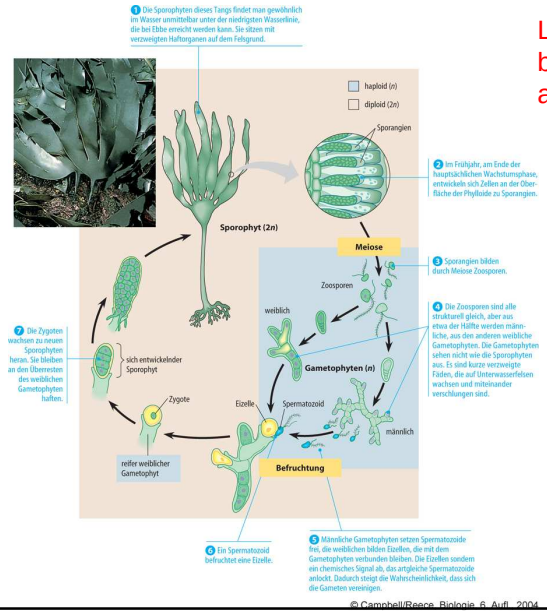
Fotos: H. Cypionka

HNF

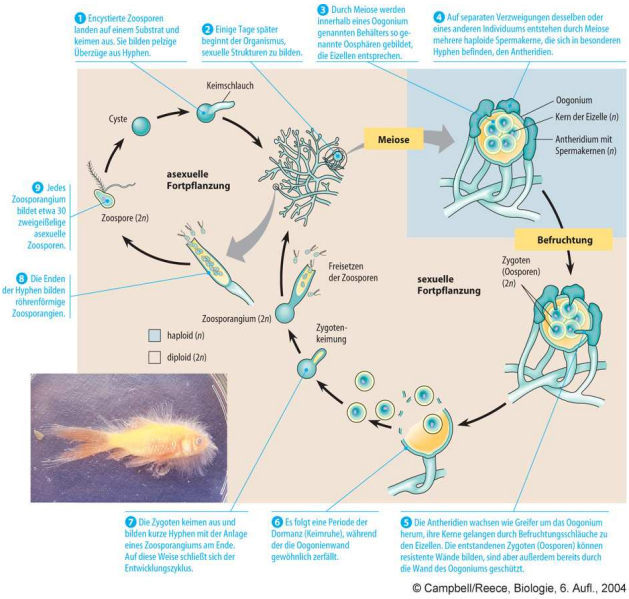



Heterokontobionta: Phaeophyceae



Laminaria (kelp):
by definition
a protist !

Heterokontobionta: Oomycetes



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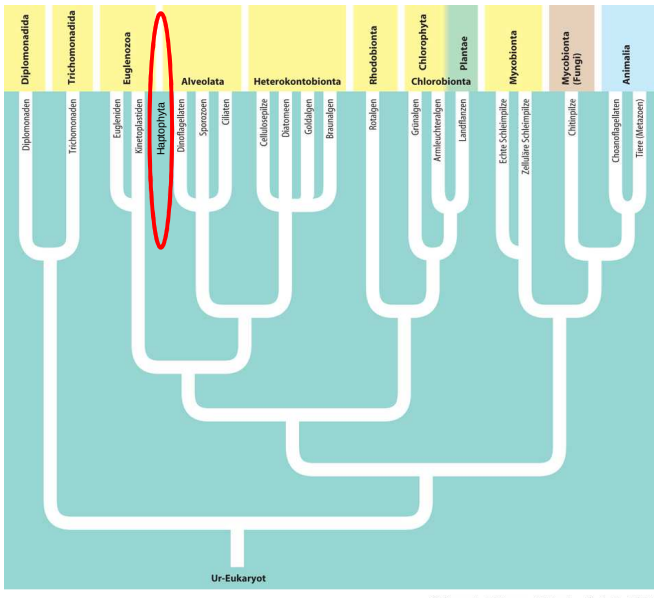
- mostly free living in water; some live in soils or as parasites
- heterokont biflagellated spores depend on water
- cellulose molds: cell walls consist of Cellulose and Glucane
  - •(ß-(1-3) and ß-(1-6) glycosidic bonds
- potatoe disease in Ireland (1845-49)

Phylogenetic Tree of Eukarya



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Haptophyta (Prymnesiophyta)

Coccolithophorids

Cell size: 2-20 µm

Cell wall: $CaCO_3$ coccoliths or scales

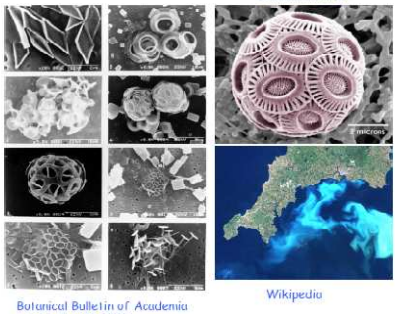
Chloroplasts: none, single thylakoid membrane

Photo-pigments: chlorophyll a & c, carotenoids

Reproduction: simple cell division, rarely sexual reproduction

Ecological roles: biflagellated, produce chalk deposits

Common genus: *Emiliania*



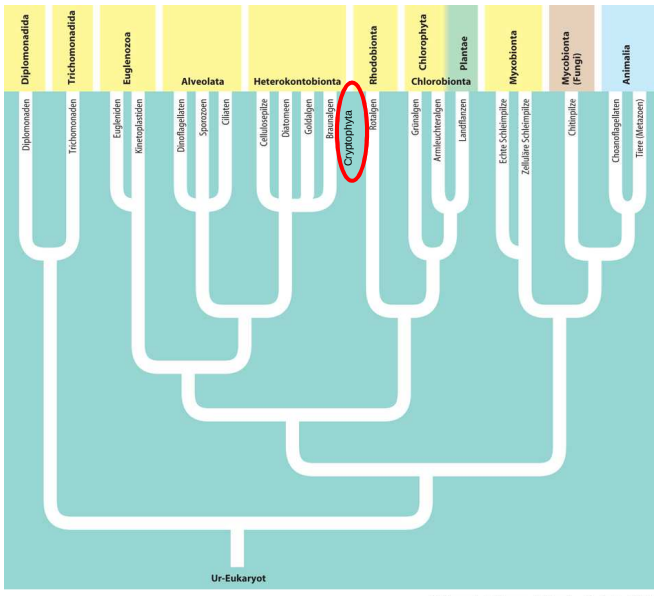
Botanical Bulletin of Academia Sinica, Vol. 42, 2001

Wikipedia

lat. coccus = round, gr. lithos = stone, gr. phorein = carry

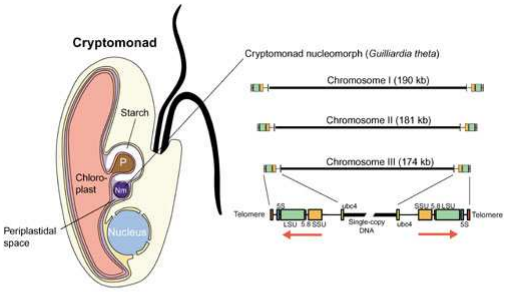
14

Phylogenetic Tree of Eukarya

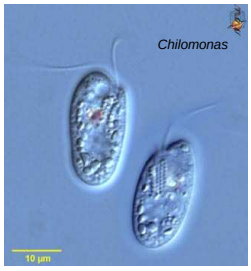


Cryptophyta

- 2 flagella
- some organelles not free in cytoplasm but surrounded by an additional double membrane
- protein plates



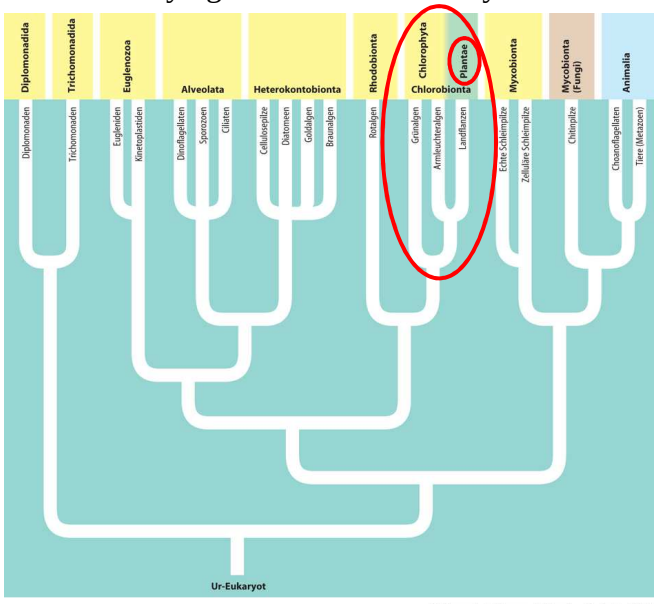
phototrophic



saprophytic

www.glerl.noaa.gov

Phylogenetic Tree of Eukarya



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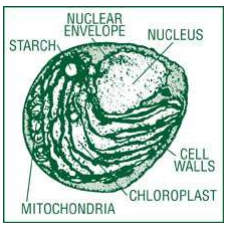
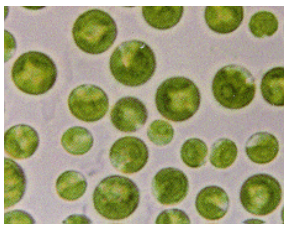
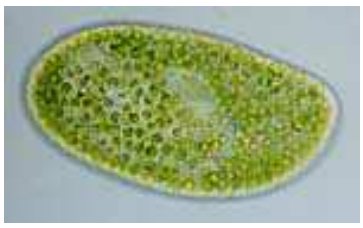
Chlorobionta: Chlorophyta

Chlorella

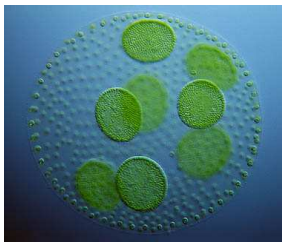






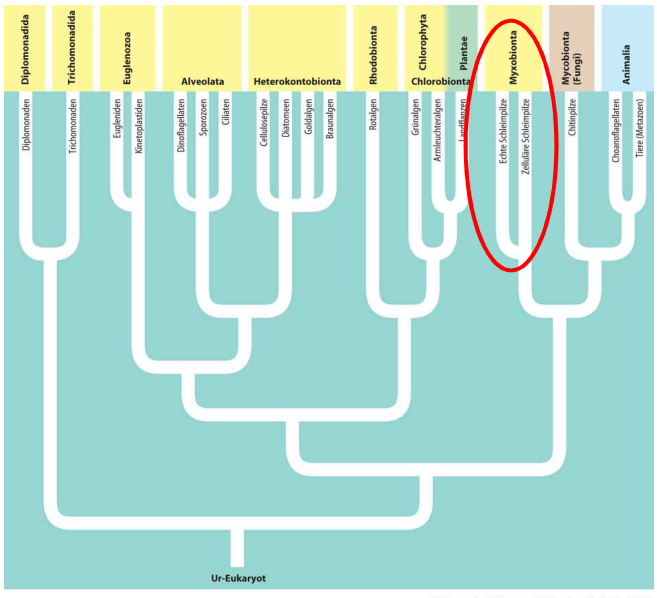
- 2, 4 or no flagella
- Autotrophic
- related to plants

Acetabularia, a unicellular organism



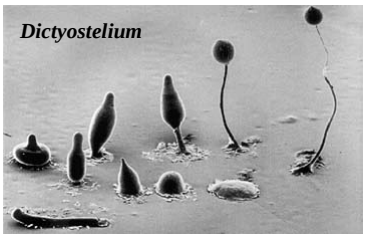
Volvox

Phylogenetic Tree of Eukarya



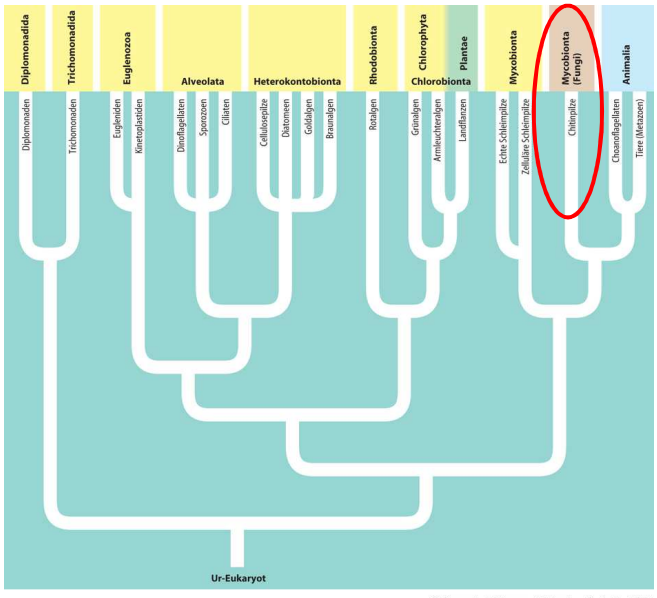
Myxobionta (Heterolobosae)

- Do not confuse with **Myxobakteria**!
- Myxomycota: True Slime Molds (Plasmodium)
- Acrasiomycota: Cellular Slime Molds (Pseudoplasmodium)



aggregation of cells = pseudoplasmodium
→ production of fruiting boddies

Phylogenetic Tree of Eukarya



Mycobionta: Yeast

→ by definition NOT a protist
but a fungi (Ascomycete) !

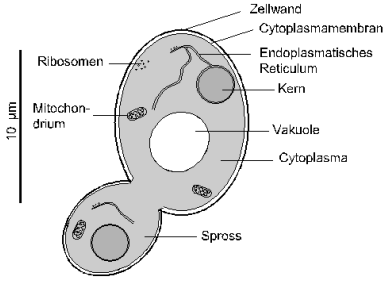
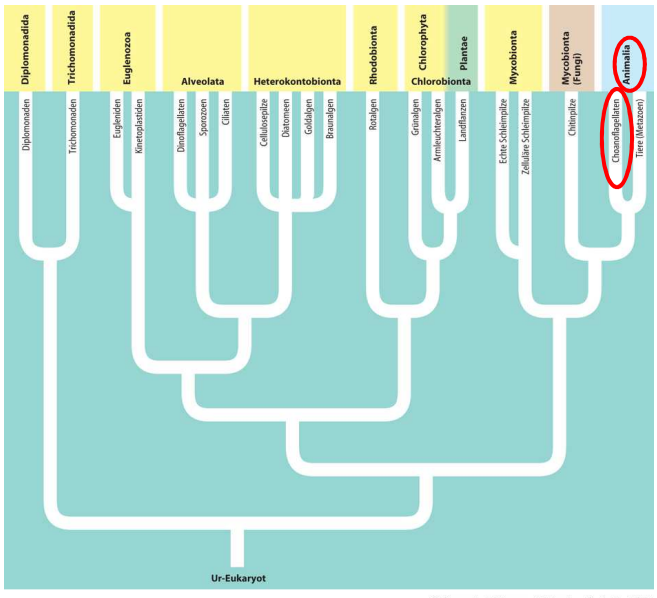


Abb. 4.4. Hefezellen. *Links* der Aufbau einer sprossenden Zelle schematisch, *rechts* ein Präparat unter dem Mikroskop. Im differenziellen Interferenzkontrast (s. Kap. 6) erscheinen die Zellen und innere Strukturen reliefartig räumlich. Maßstab = 10 µm

Phylogenetic Tree of Eukarya



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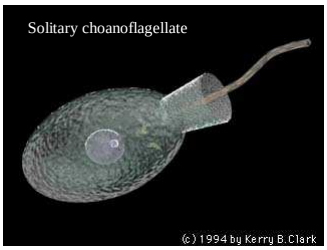
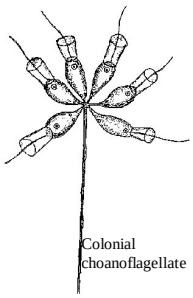
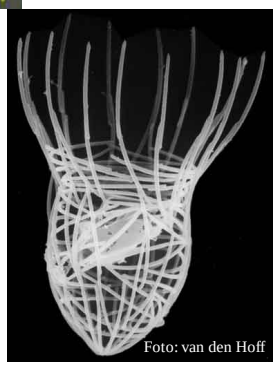
Choanoflagellates



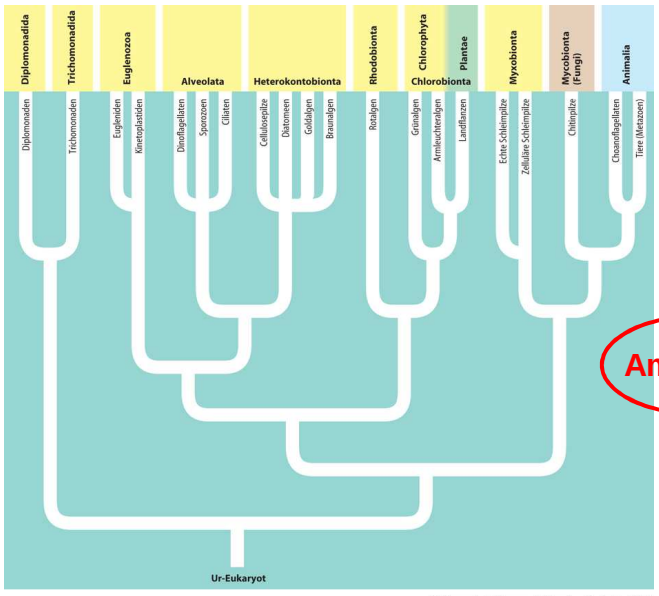
- bacteriovores
- unique: collar (microvilli)
- 1 flagellum



Acanthocorbis



Phylogenetic Tree of Eukarya



Amoeba ?

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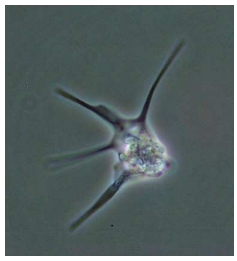
Protists *incertae sedis:* **Protozoa with pseudopodia**

- Phylogenetic classification still debated
- Only monophyletic within each group:

  - Rhizpoda: Amoeba
  - Actinopoda: Radiolaria, Heliozoa
  - Foraminifera

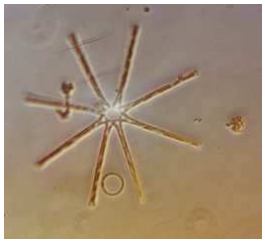
Rhizpoda: Amoeba



Fotos: H. Cypionka

- pseudopodia: movement by alternating new formation and retraction
- with shells (tests) or without (naked)
- uni- or multinuclei
- size: few micrometer up to 5 mm (*Chaos carolinense*)

Actinopoda: Radiolaria



Fotos: H. Cypionka

- radiating axopodia, stiffened by microtubular bundles

→ for locomotion & food capture

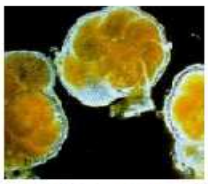
Foraminifera

- calcified shells
- single- or multichambered
- protoplasm in chamber

- > 4000 recent species

lat. *foramen* = Loch, lat. *ferre* = tragen

Foraminiferen, Kammerlinge, Klasse der Rhizopoda (Wurzelfüßer)



Foraminifera

- > 30000 ancient species

- chalk skeletons of ancient foraminifera used as indicators for marine palaeo-temperatures