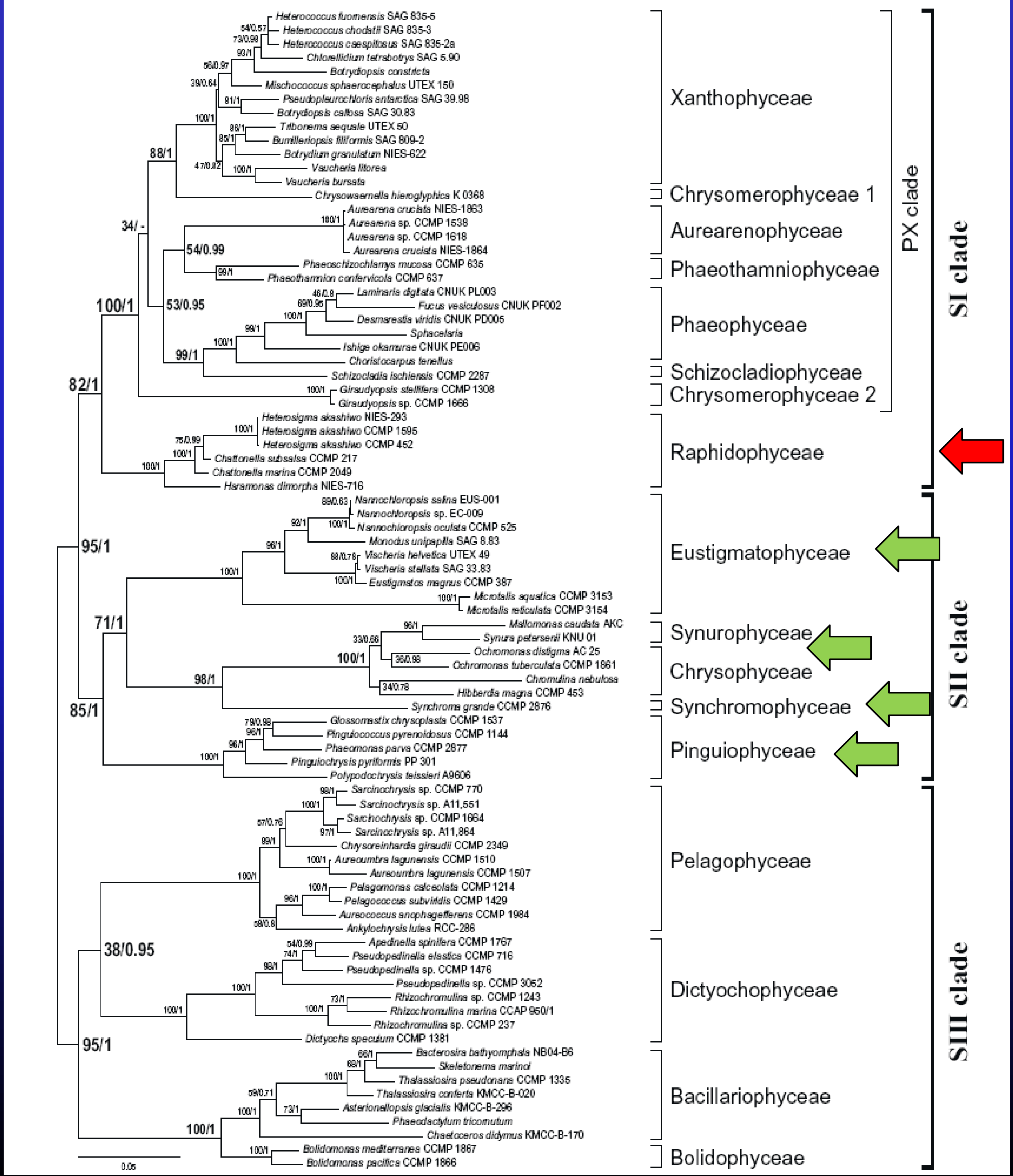
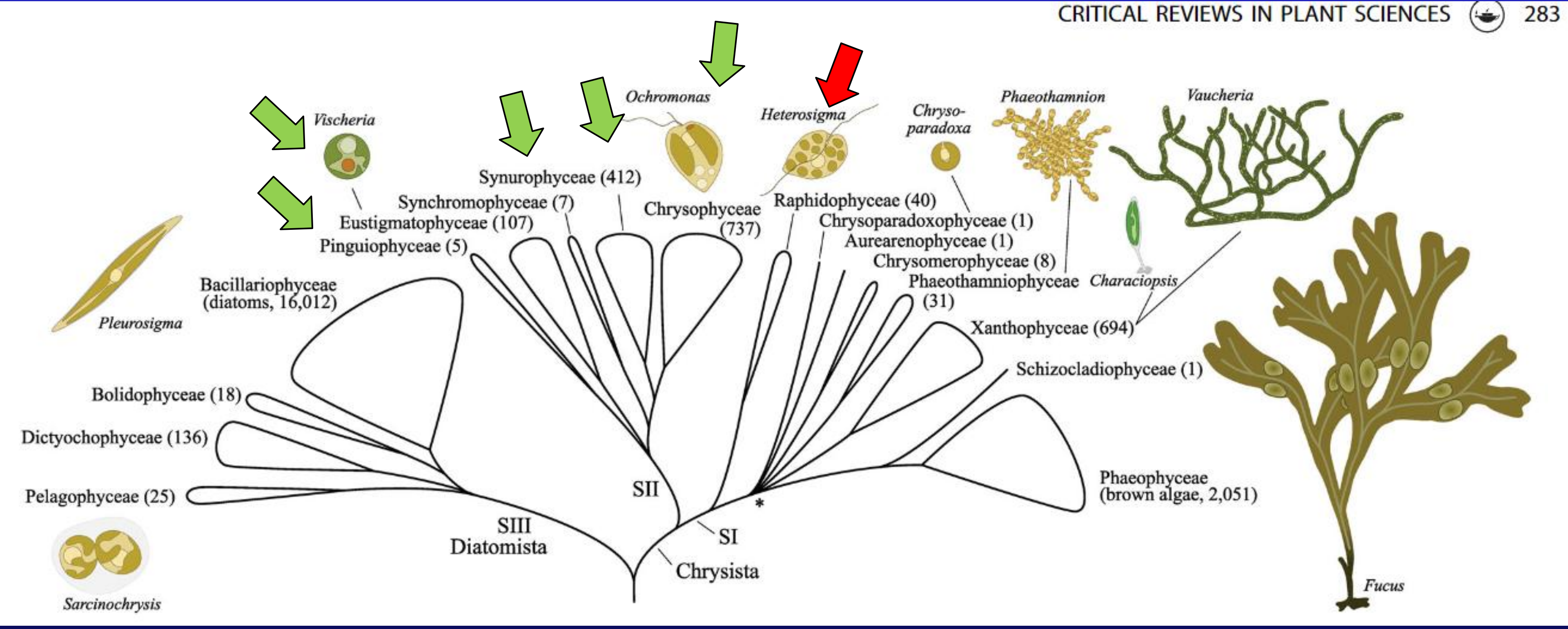


Yang et al. 2012

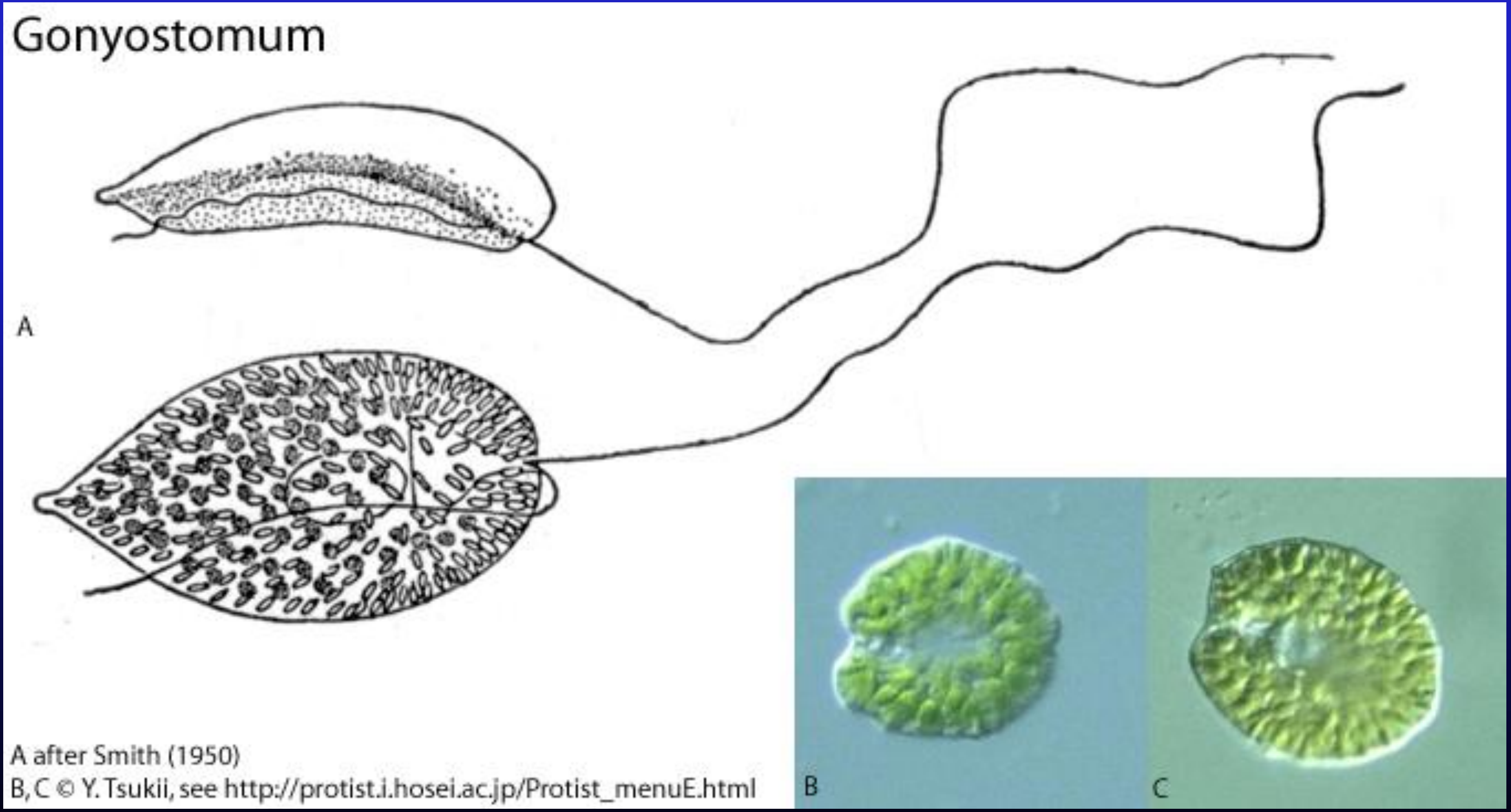
Summary diagram of phylogenetic relationships among the classes of photosynthetic heterokonts



(Bringloe et al, 2020)

Raphidophyceae

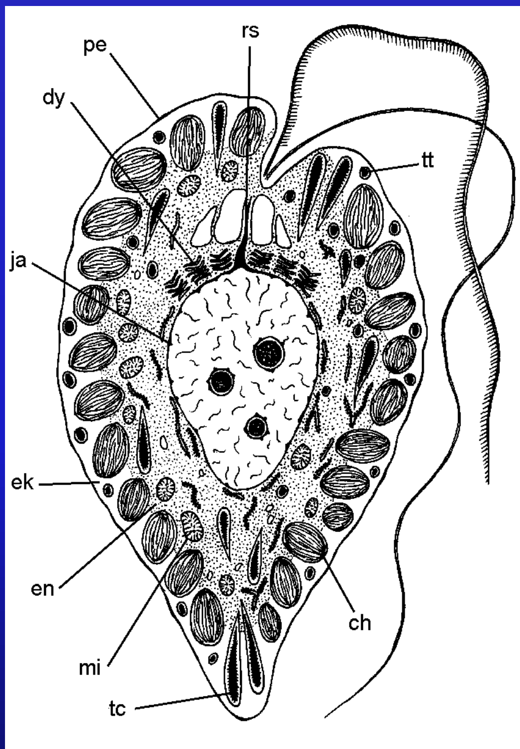
- Ch *a* and *c*, fucoxanthin (marine)
- four membranes of chloroplast
- tinsel anterior flagellum + naked posterior flagellum
- pyrenoids only in marine species
- reserve substances oil, chrysolaminarane

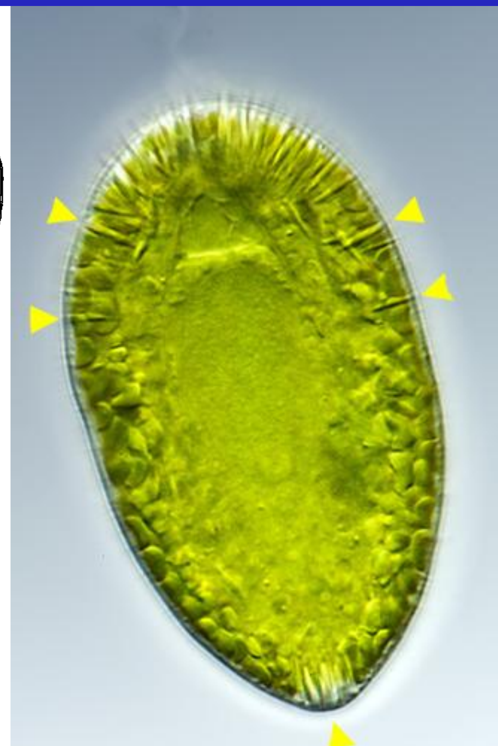


A after Smith (1950)
B, C © Y. Tsukii, see http://protist.i.hosei.ac.jp/Protist_menuE.html

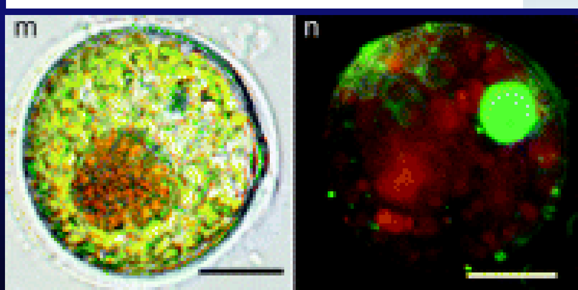
Gonyostomum semen 50-100μm
freshwater species

slime threads are up to 500 μm long





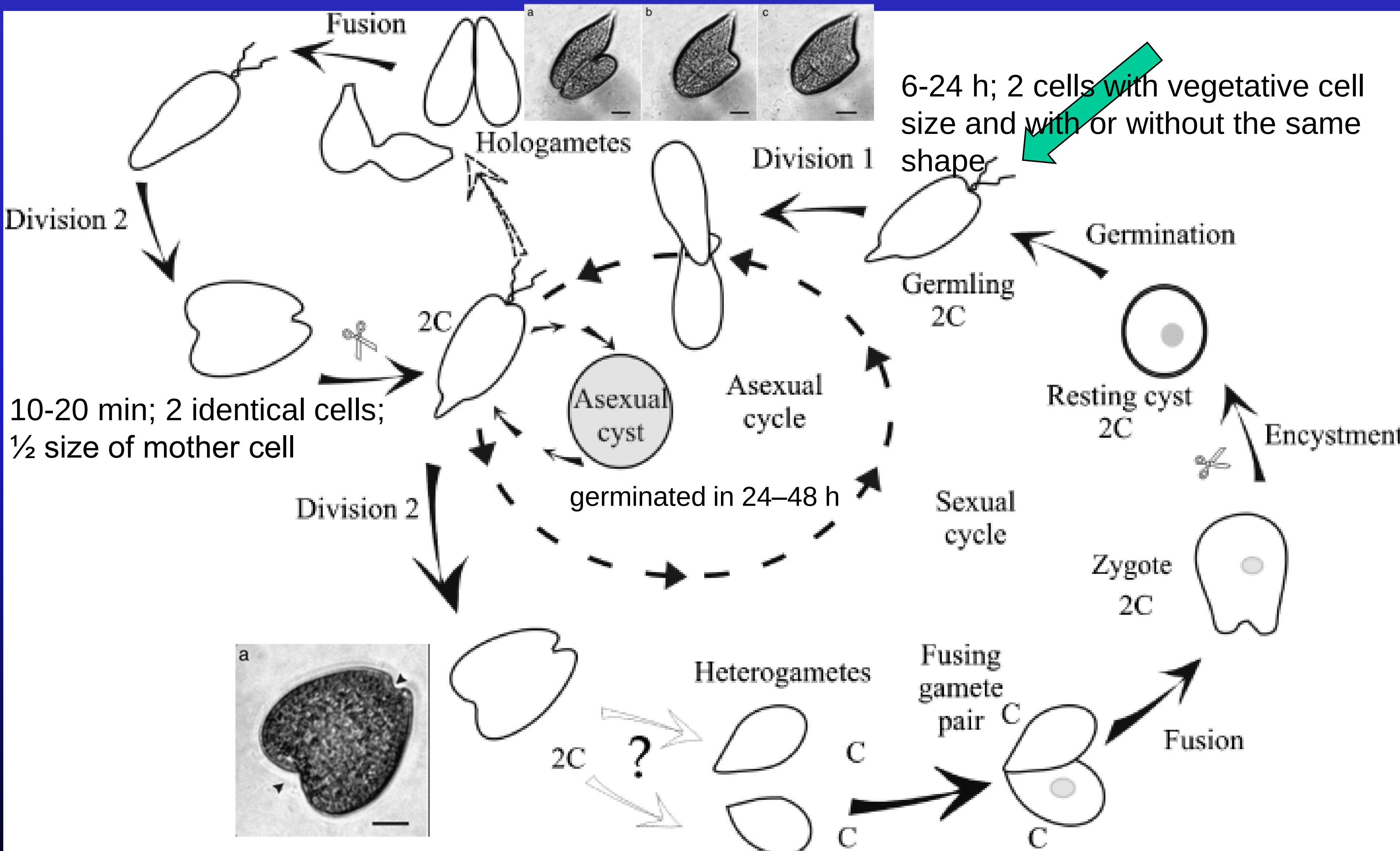
lakes and ponds rich in humic acids, invasive



Daphnia magna
– solely predator

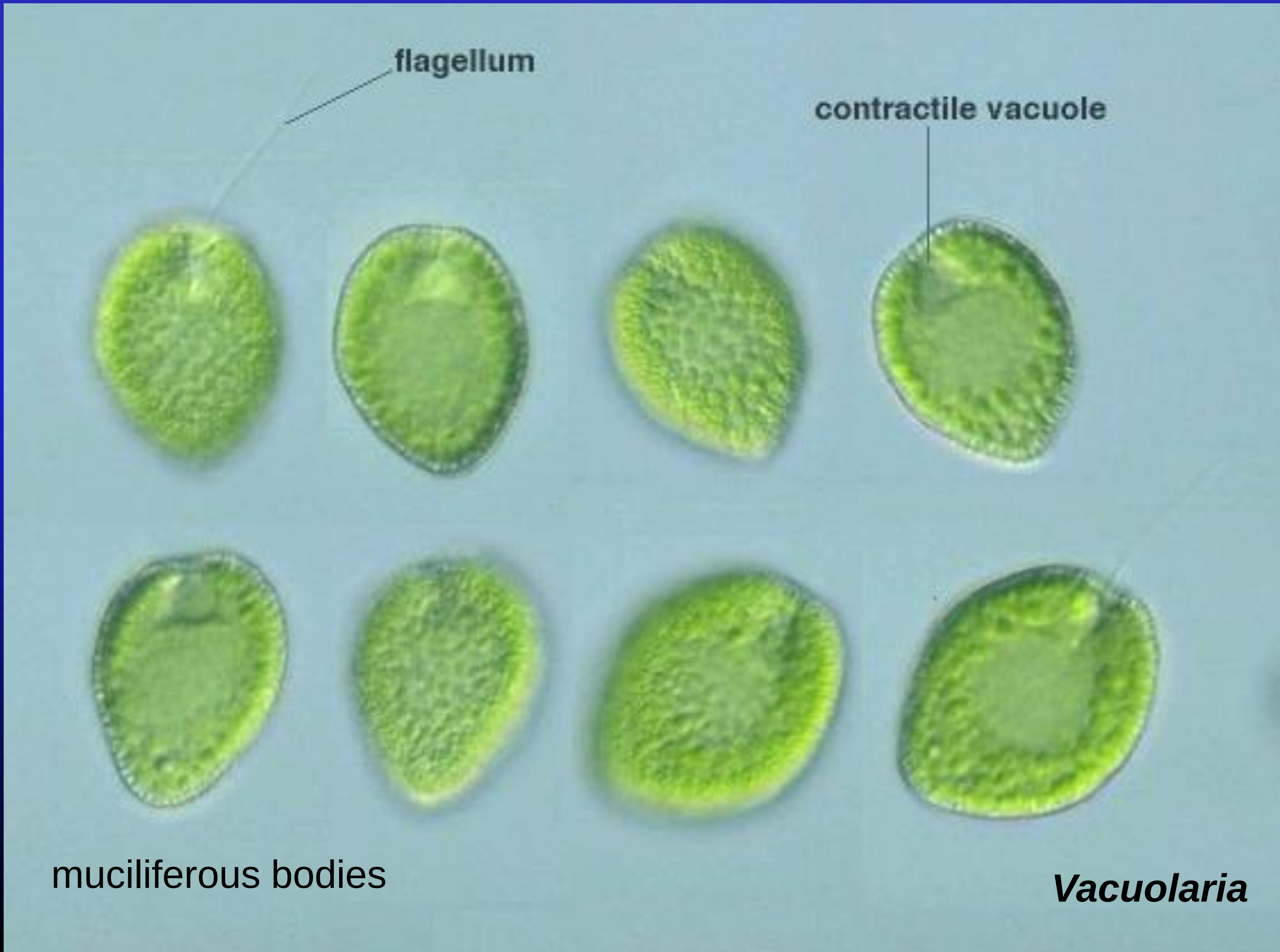
migration, predators infomol.
trichocysts, mixotrophy, resting cysts, lysis of enemies

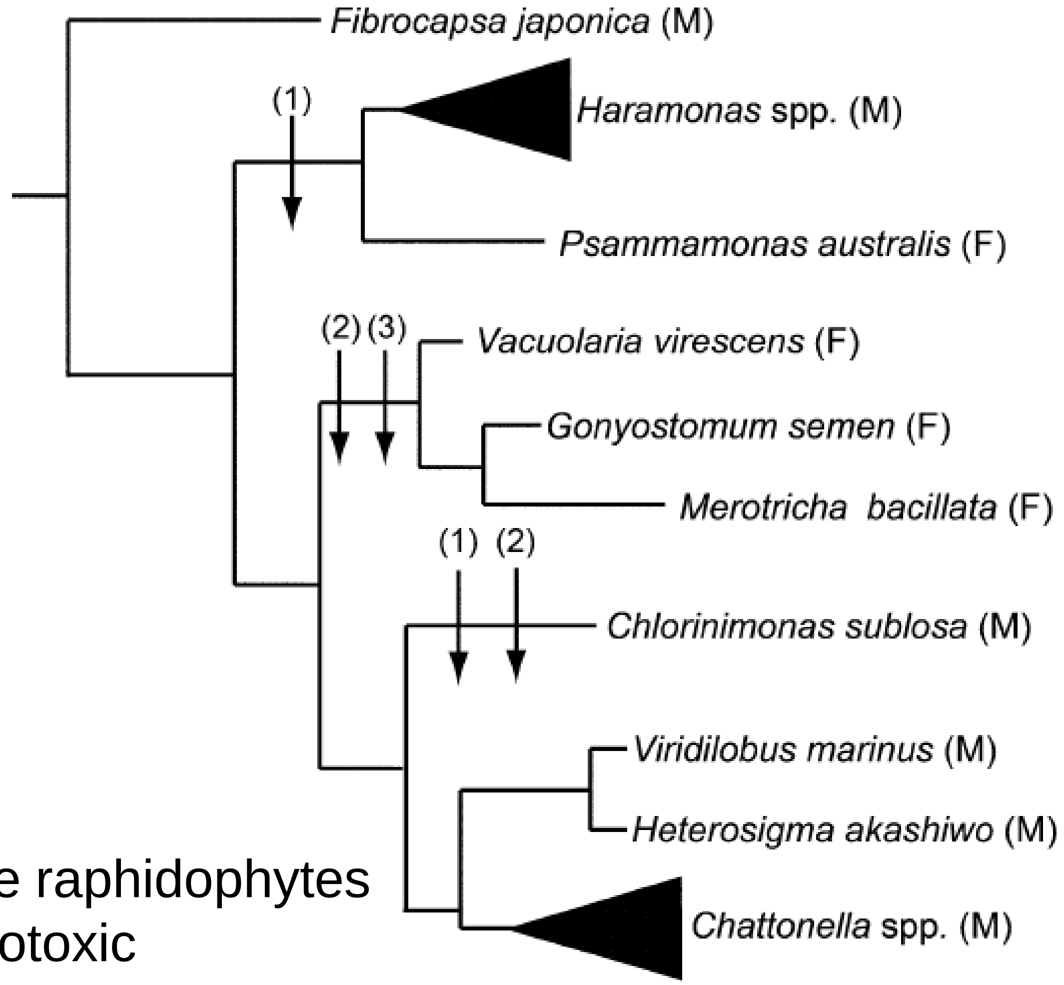
Life cycle of *Goniostomum semen*



(Figueroa et Rengefors, 2006)

Freshwater species



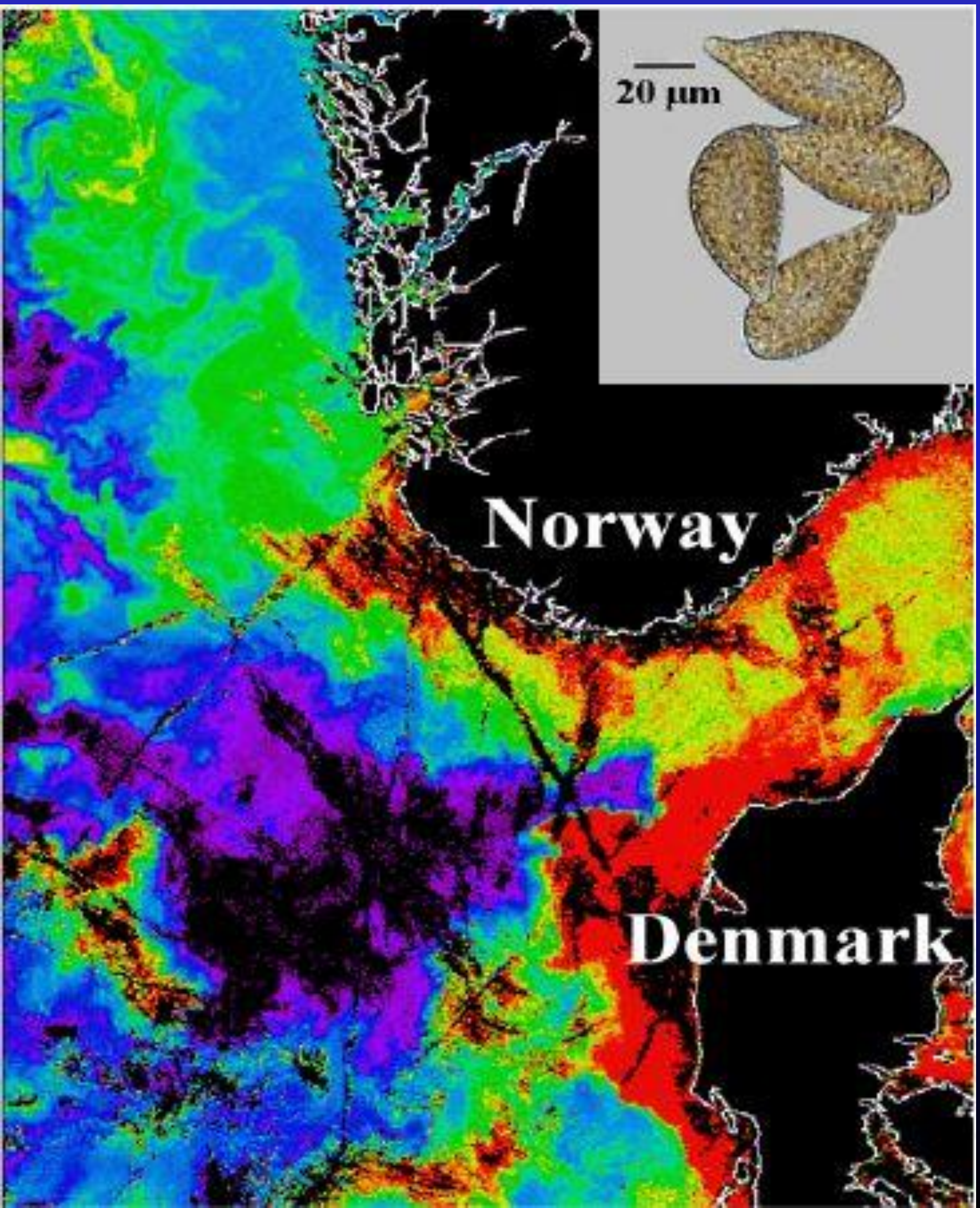


Marine raphidophytes
ichthyotoxic

Fig. 7 Schematic diagram depicting the evolutionary relationships between raphidophyte genera based on SSU rDNA phylogenies (see text). (*M*) marine species, (*F*) freshwater species. (*1*) Indicates gain of sand-dwelling habit. (*2*) Indicates loss of fucoxanthin and gain of diadinoxanthin. (*3*) Indicates gain of freshwater-dwelling habit

https://www.sciencephoto.com/media/921376/view/gonyostomum-semen-algae-light-microscopy-footage

Marine species



Brevetoxin - neurotic shellfish poisoning

Satellite images showing ***Chatonella verruculosa*** bloom outside the Norwegian and Danish coasts, May 1998 and *Chattonella* sp. cells.

Marine species

wide salinity tolerance, surviving in continuous darkness (up to 15 weeks), heterotrophy, resting cysts

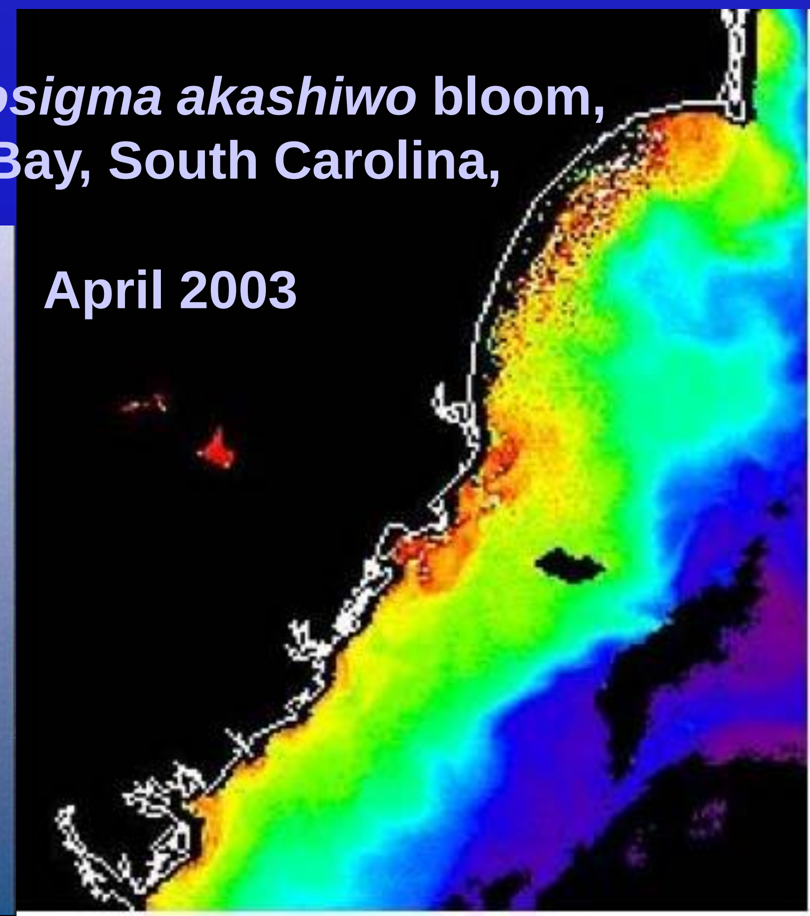
virus (HaV01) tested against *H. akashiwo* bloom (Nagasaki, 1999)

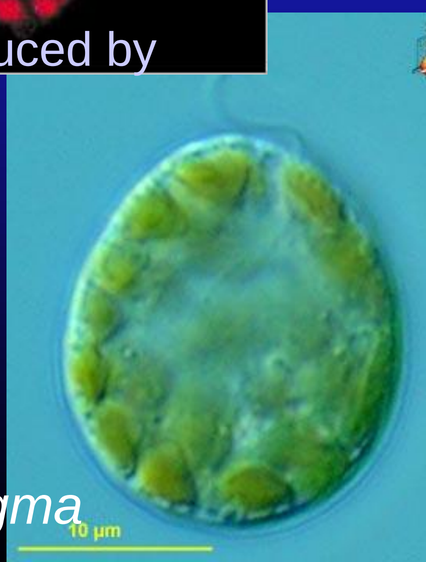
slime produced by mucocysts

dispersion in balast tanks??

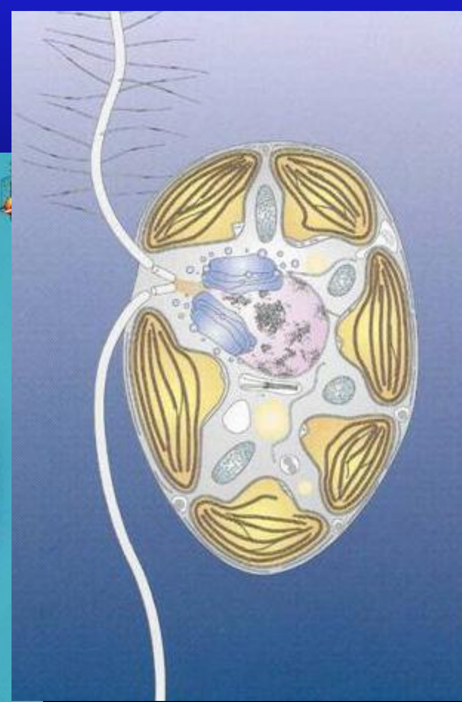
Heterosigma akashiwo **bloom, Bulls Bay, South Carolina,**

April 2003

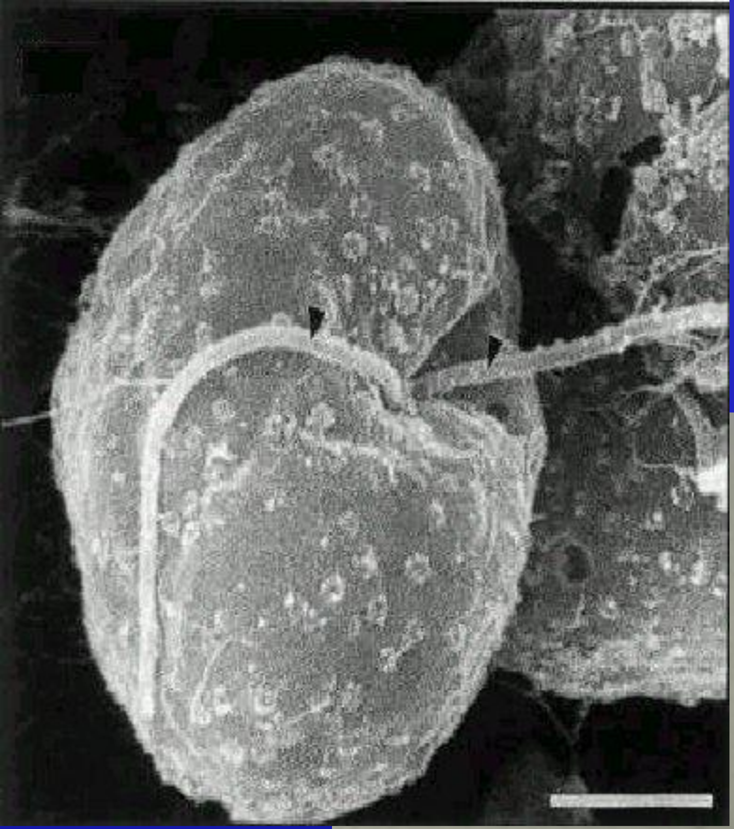




Heterosigma



Marine species



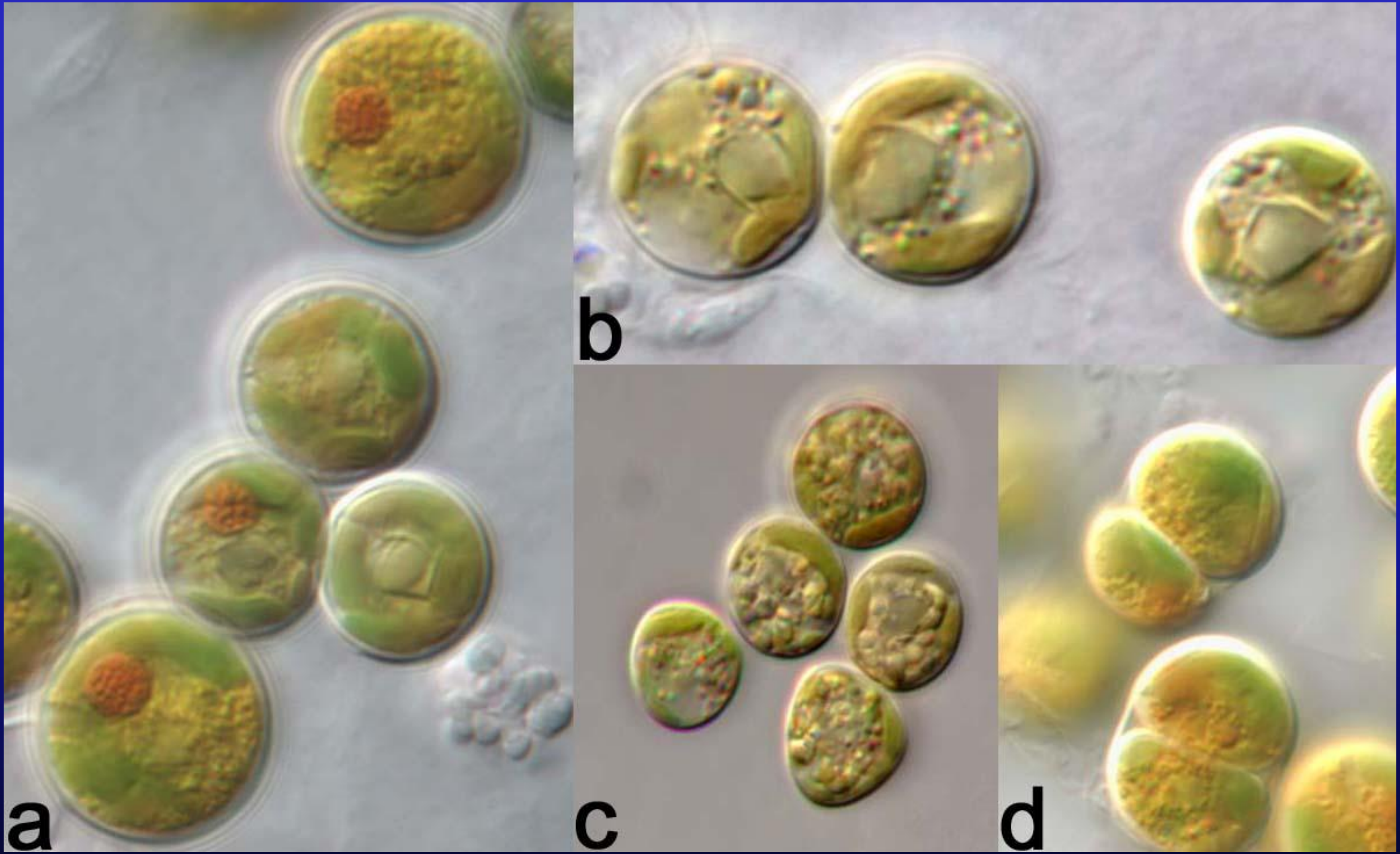
Fibrocapsa japonica

Ichtyotoxicity: ejection of mucocysts (clogging of fish gills); production of ROS (inducing gill asphyxia) and haemolytic compounds

Brevetoxins – neurotic shellfish poisoning

reduction of the heart rate - less oxygen to the gills - hypoxy

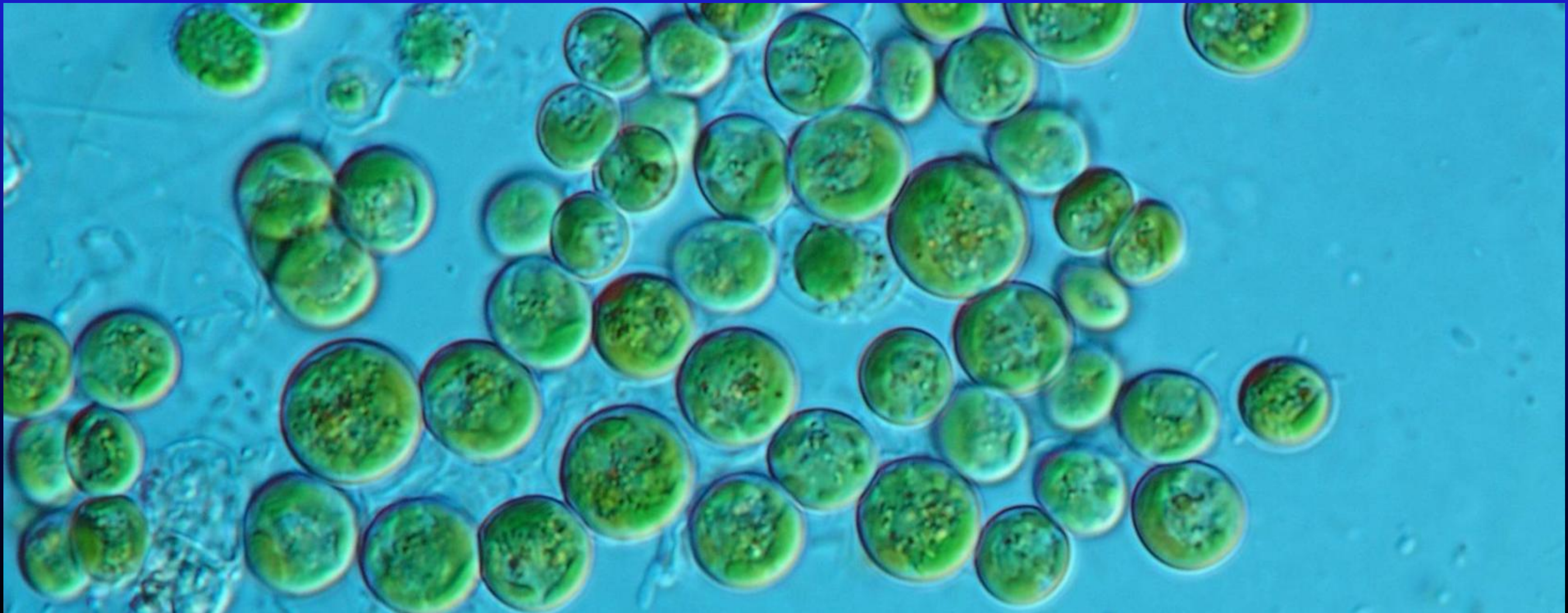
Eustigmatophyceae



Louise Lewis -**Biotic Crust Project**

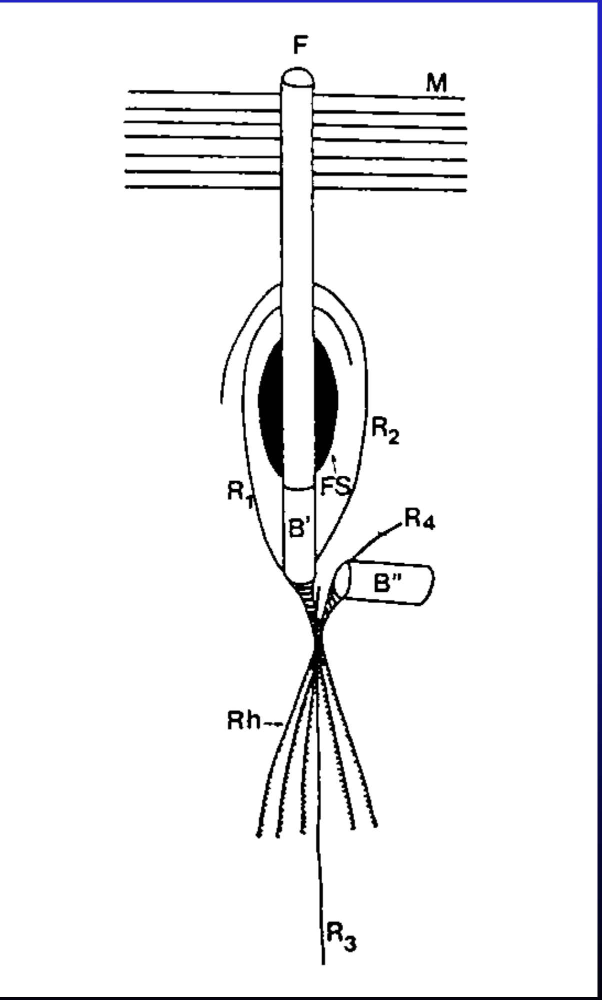
General characteristics

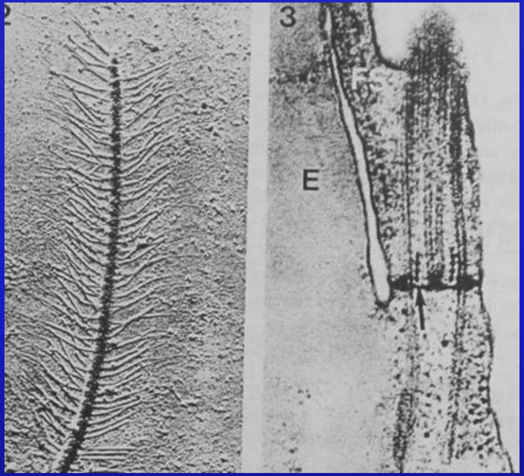
- class established in 1971, by separation from Xanthophyceae
- differences in submicroscopical structure of zoospores and vegetative cells (pyrenoid)
- only asexual reproduction
- freshwater, soil, some species in seawater

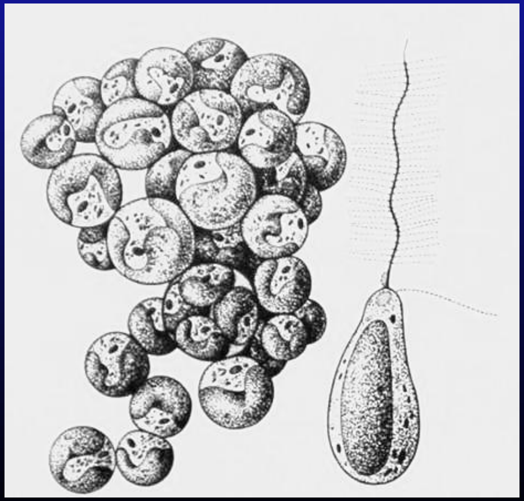


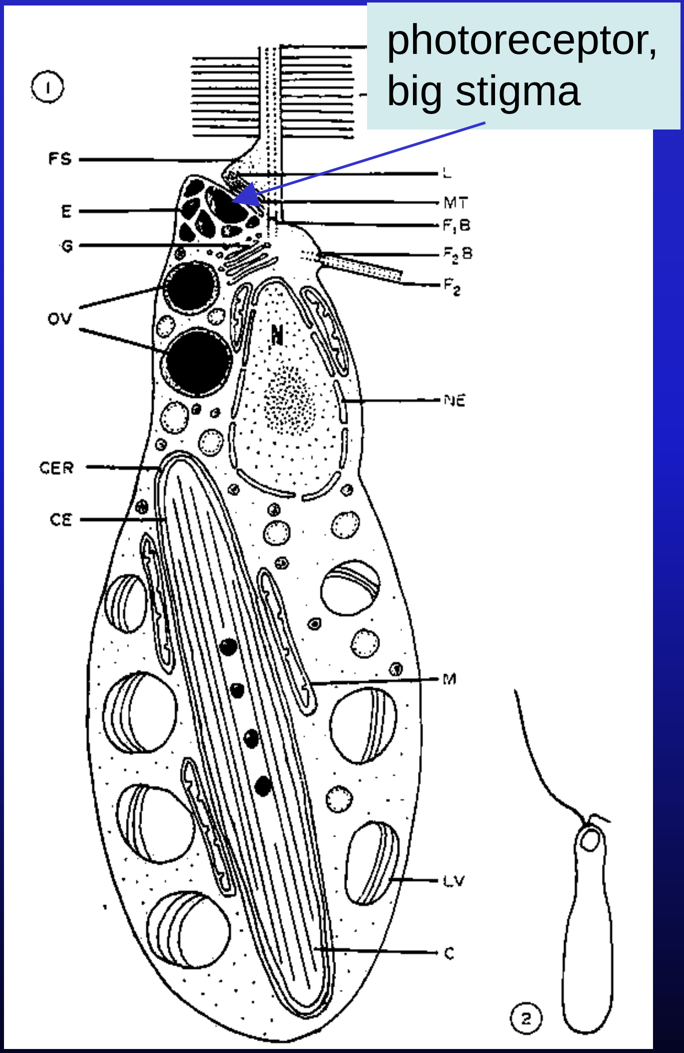
Zoospores

- 1 or 2 flagella (1 pleuronematic), 2 basal bodies
- large, extraplastidial stigma





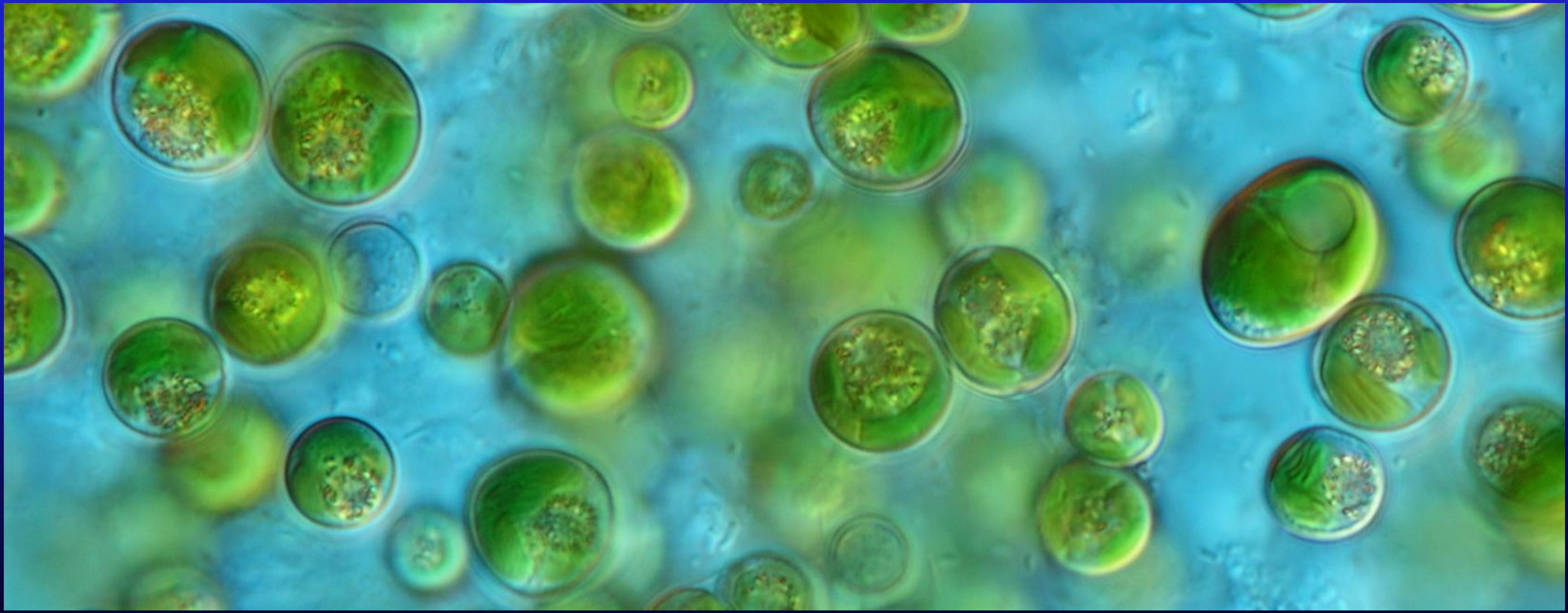




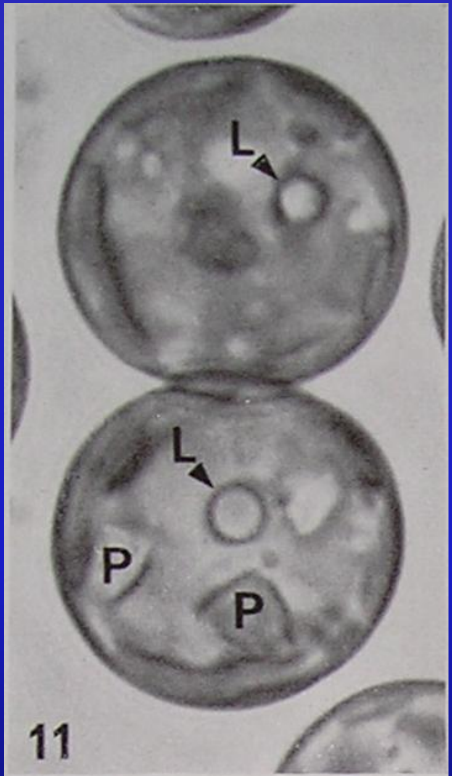
Pseudocharaciopsis – the only genus with two flagella

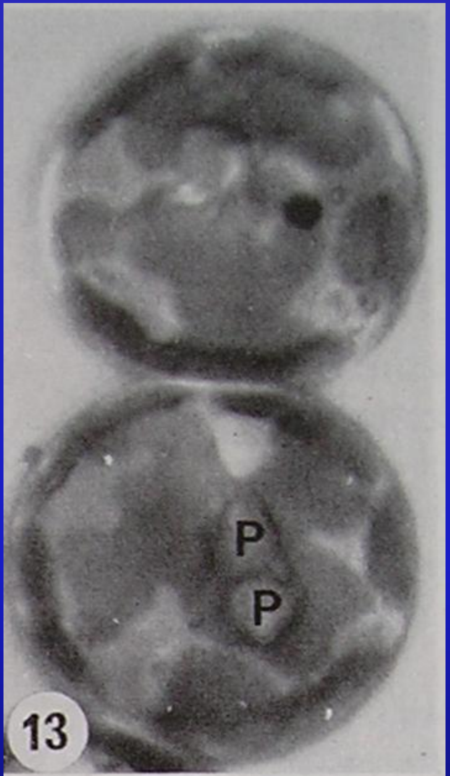
Plastids

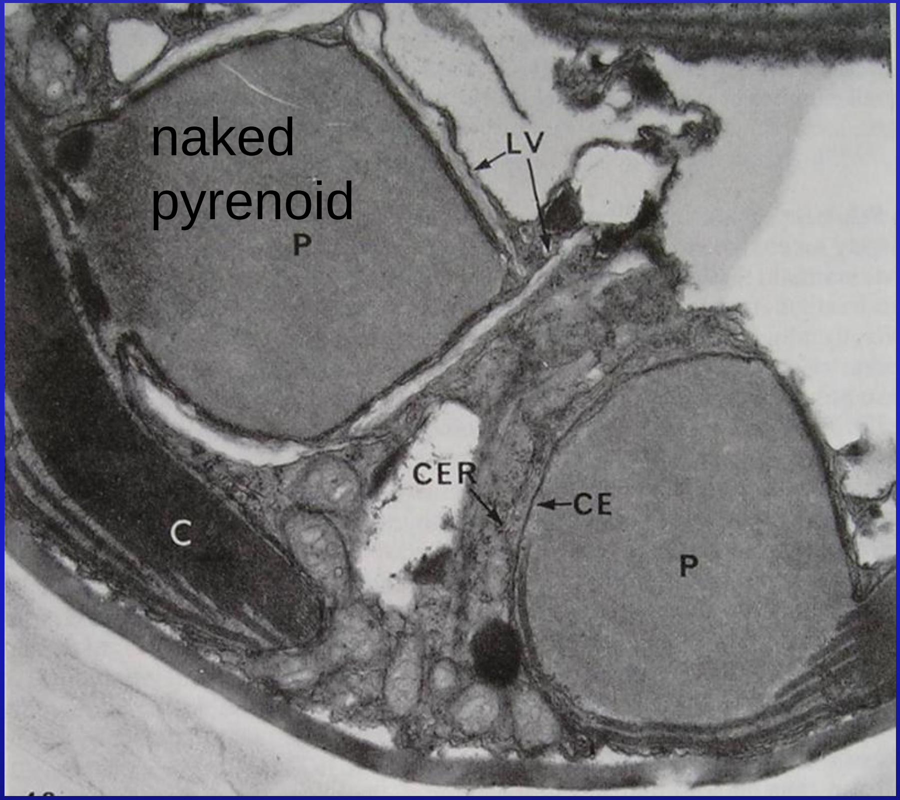
- single plastid (x *Paraeustigmatos*), only Ch *a*, yellow-green color,
- 4 membranes
- no girdle lamella

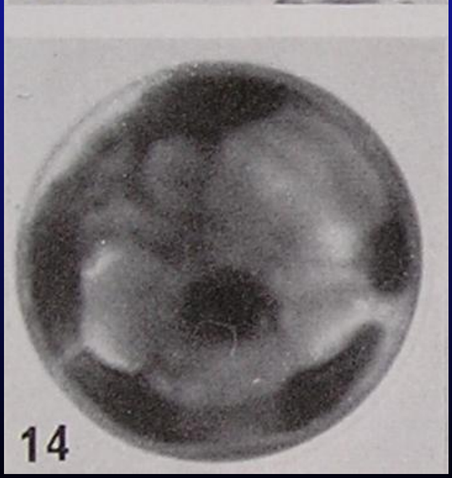


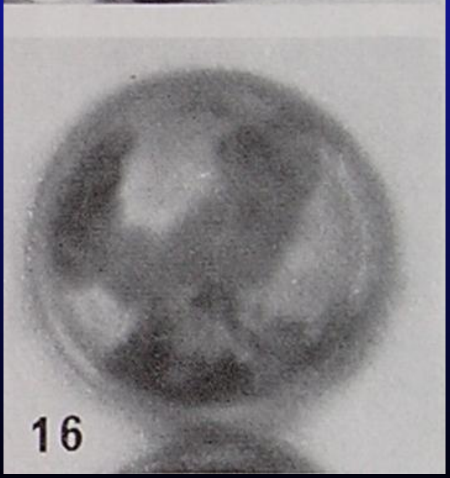
Plastids

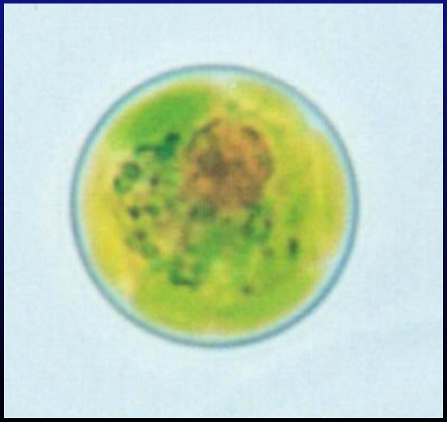


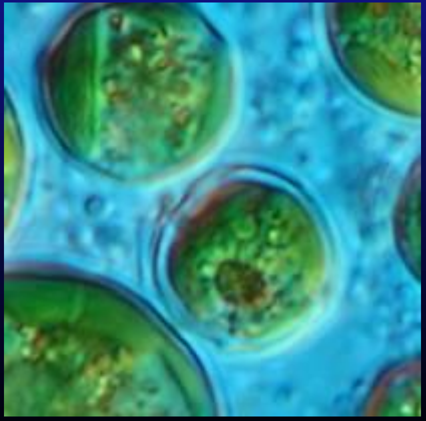




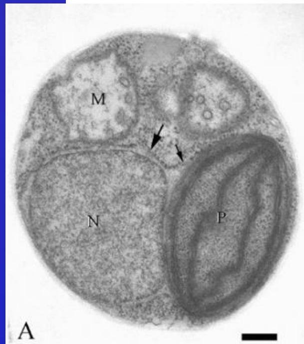


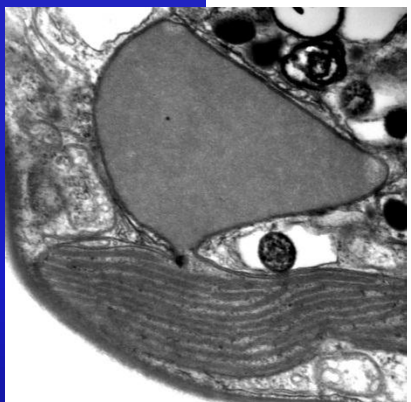


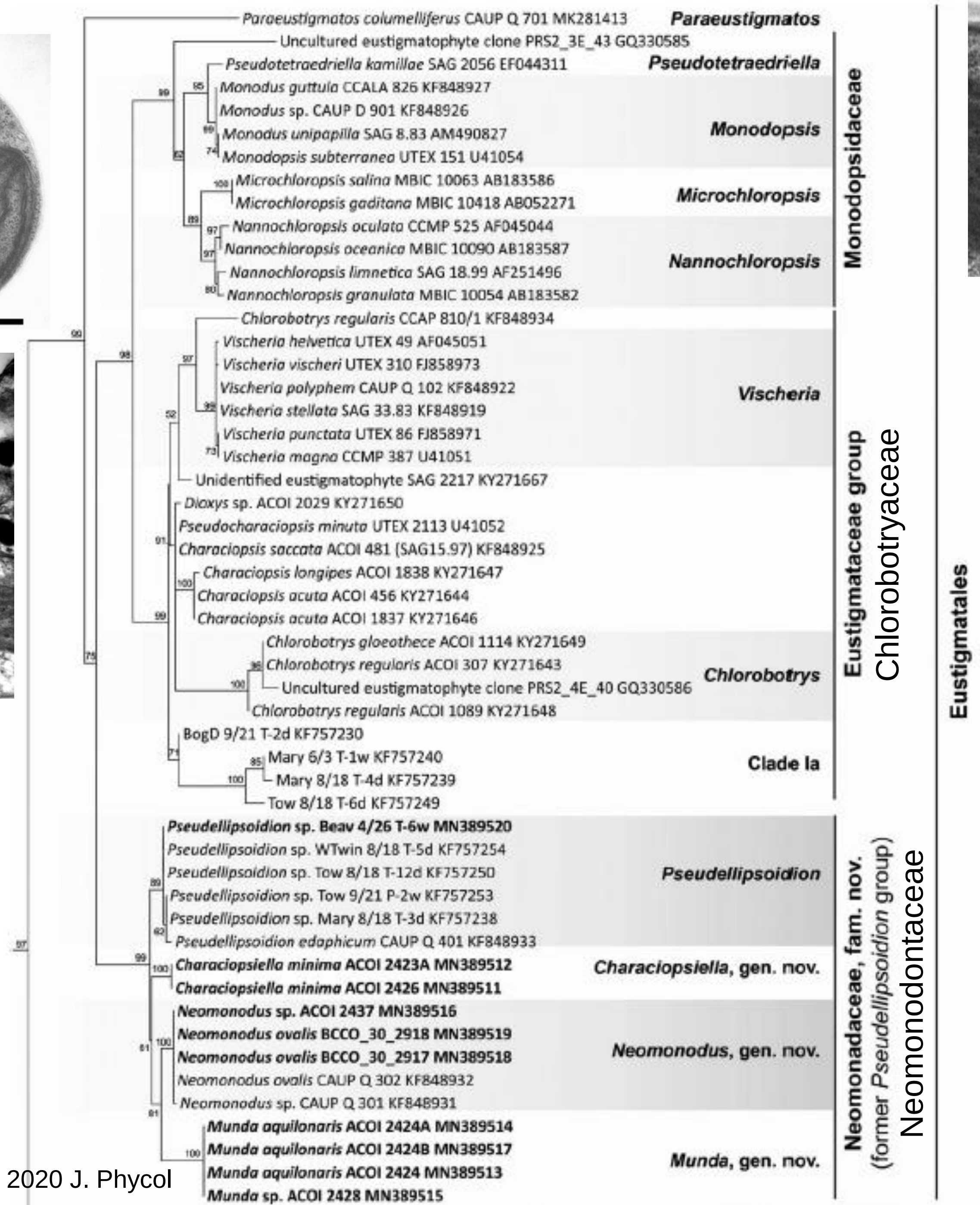


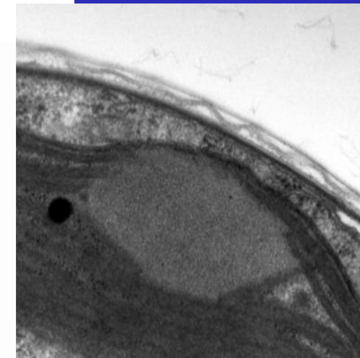


Eustigmatales









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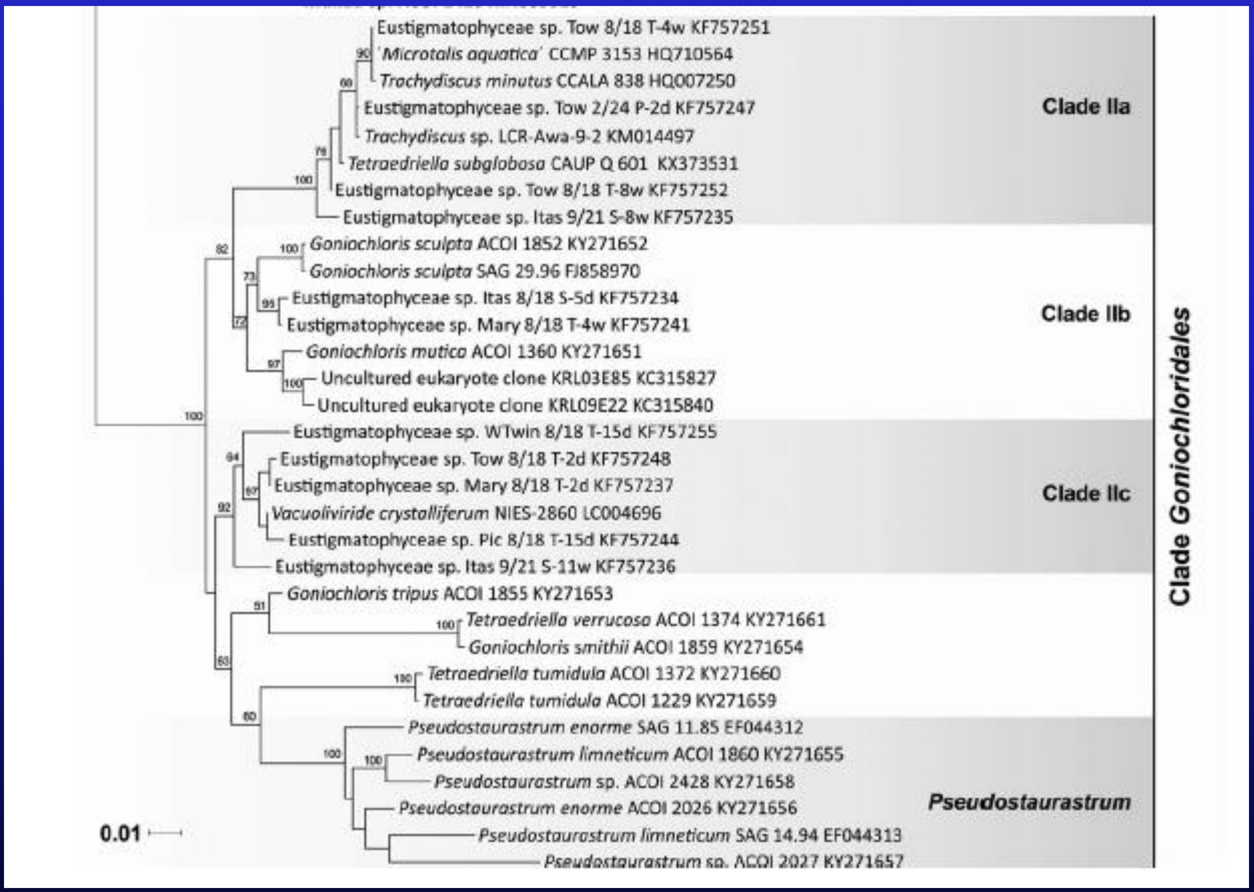
Goniochloridales



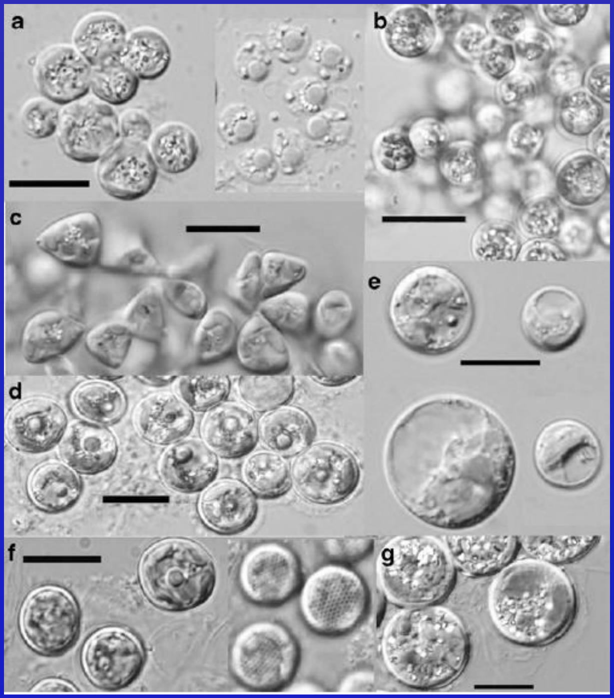


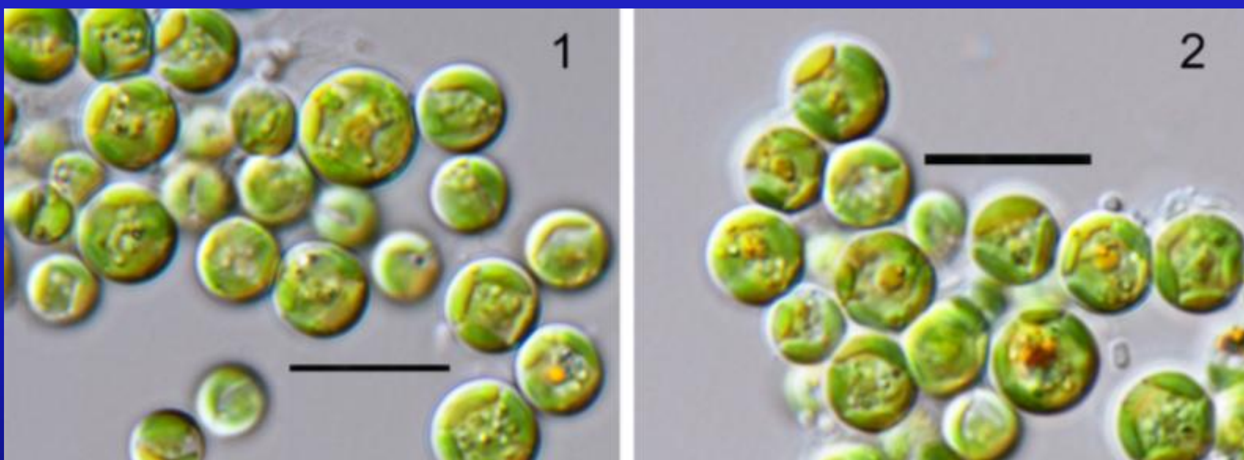
Fig. 2 a.Strain Mary 8/18 T-4d (Clade Ia) with refractive granules (left) and zoospores (right). b. Strain Mary 8/18 T-4w (Clade IIb), vegetative cells in clumps. c. Itas 8/18 S-5d (Clade IIb), angular vegetative cells similar to Goniochloris. d. Pic 8/18 T-15d (Clade IIc). e. Pic 9/21 T-1d (Clade IIc) vegetative cells. f. Chic 10/23 P-37w (Clade IIa) vegetative cells, with cell wall sculpting shown on the right. g. WTwin 8/18 T-15d (Clade IIc) vegetative cells with highly refractive granules. Scale bars = 10 μm

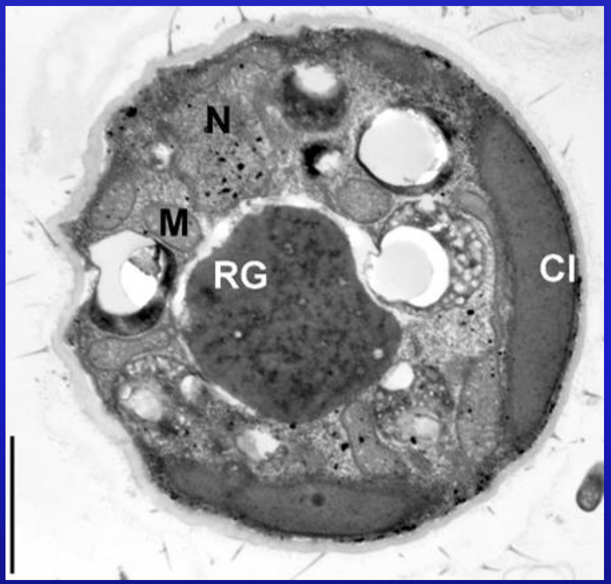
Amaral et al. 2020 J. Phycol

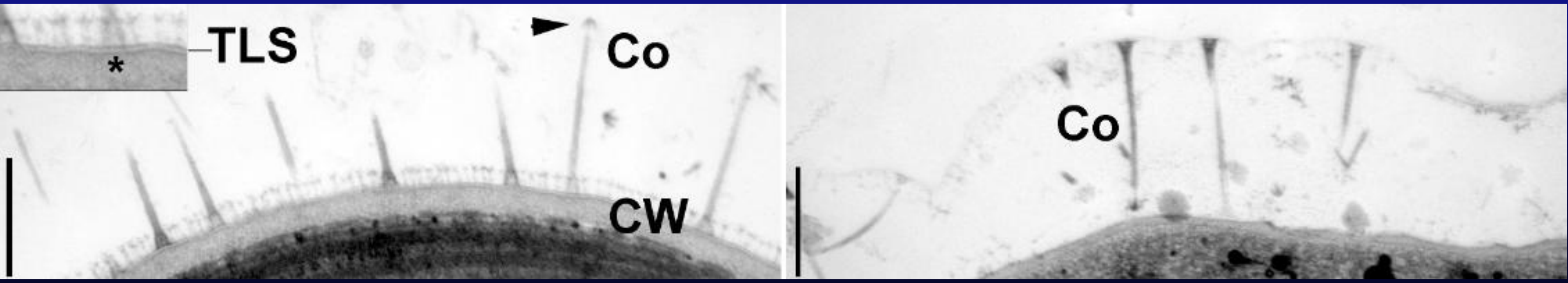
Fawley & al. 2014 J. Appl. Phycol.

Paraeustigmatos columelliferus – freshwater, isolated from Zygnema mats, small cells (3.7-7.8 µm), <u>multiple plastids,</u> reddish globule, lamellated vesicles, zoospores not observed

sister group to all Eustigmatales

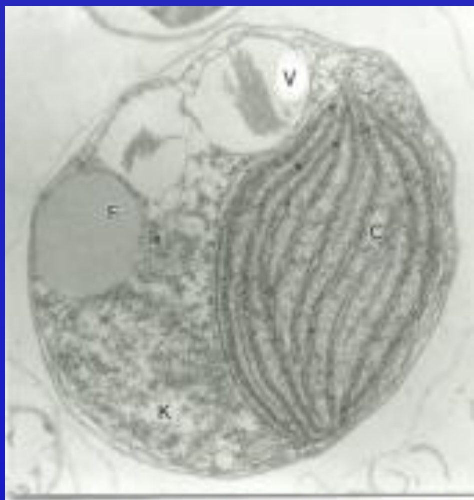


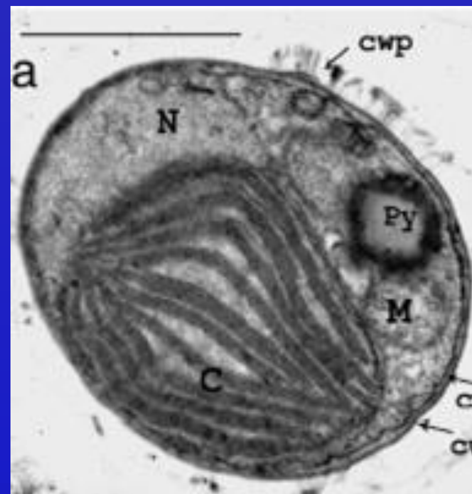


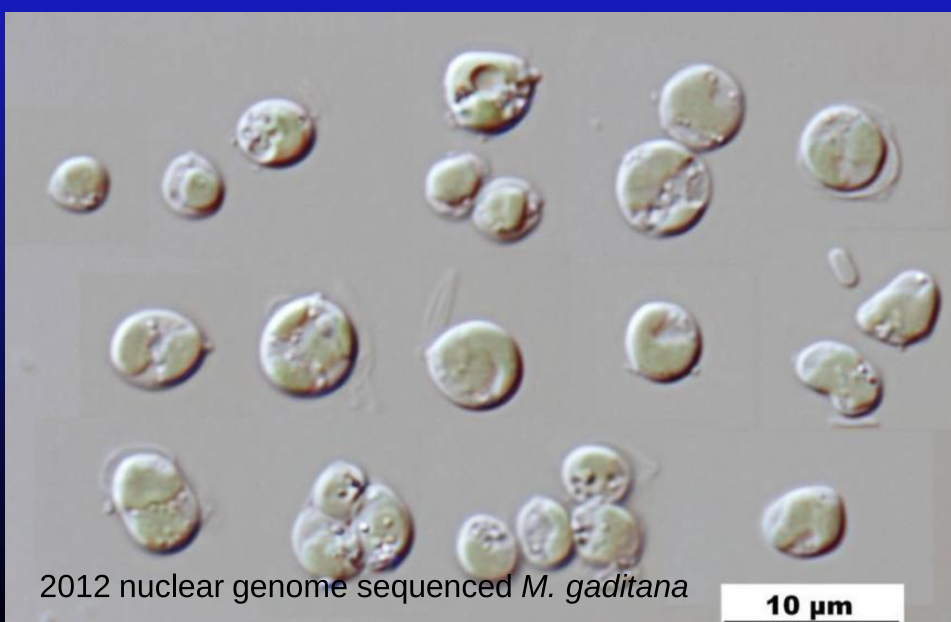


Eustigmatales - Monodopsidaceae

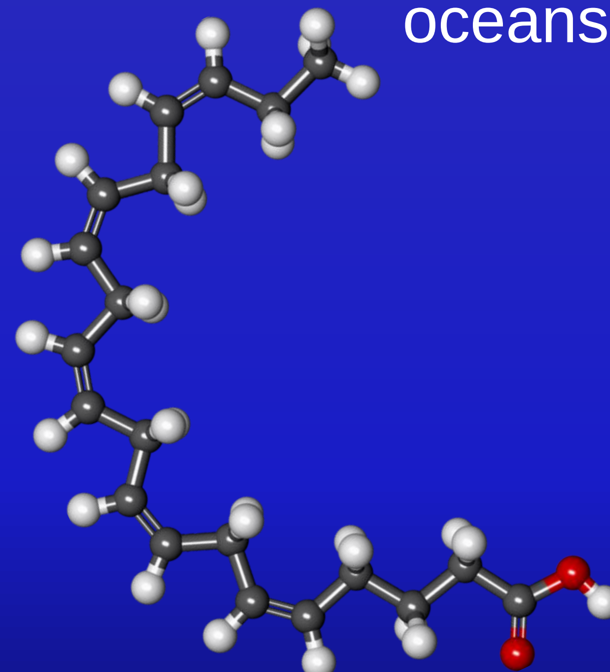
Nannochloropsis/Microchloropsis – picoplankton in surface oceans, EPA





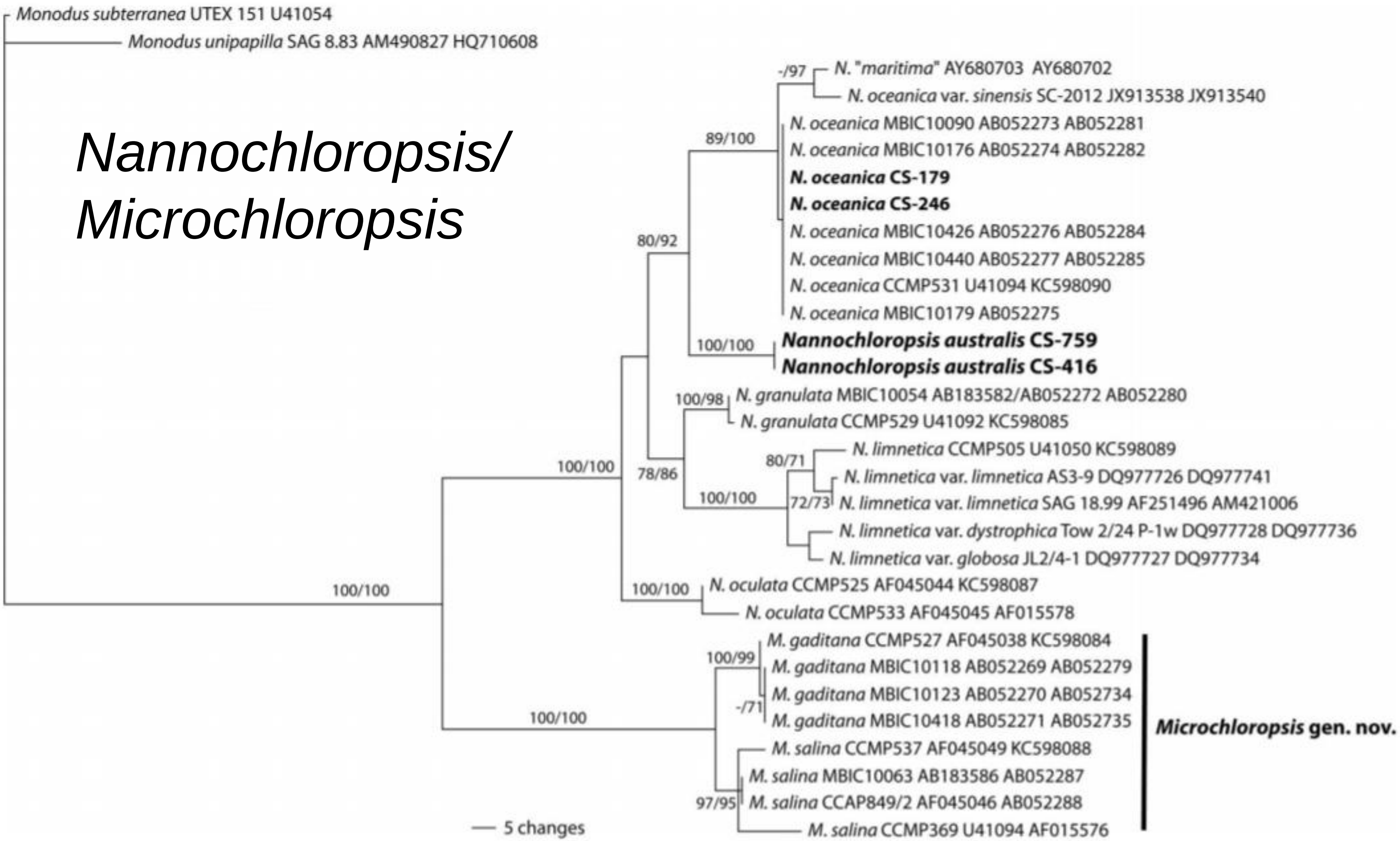


2012 nuclear genome sequenced *M. gaditana*

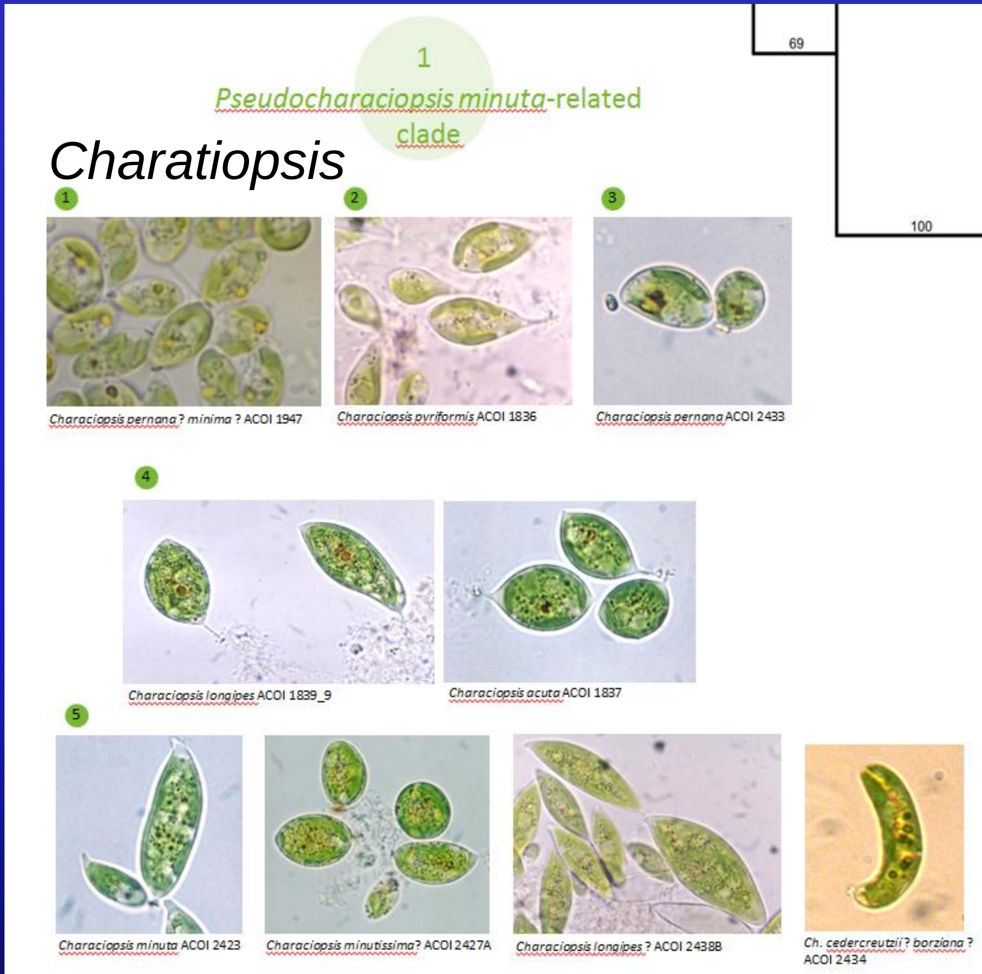


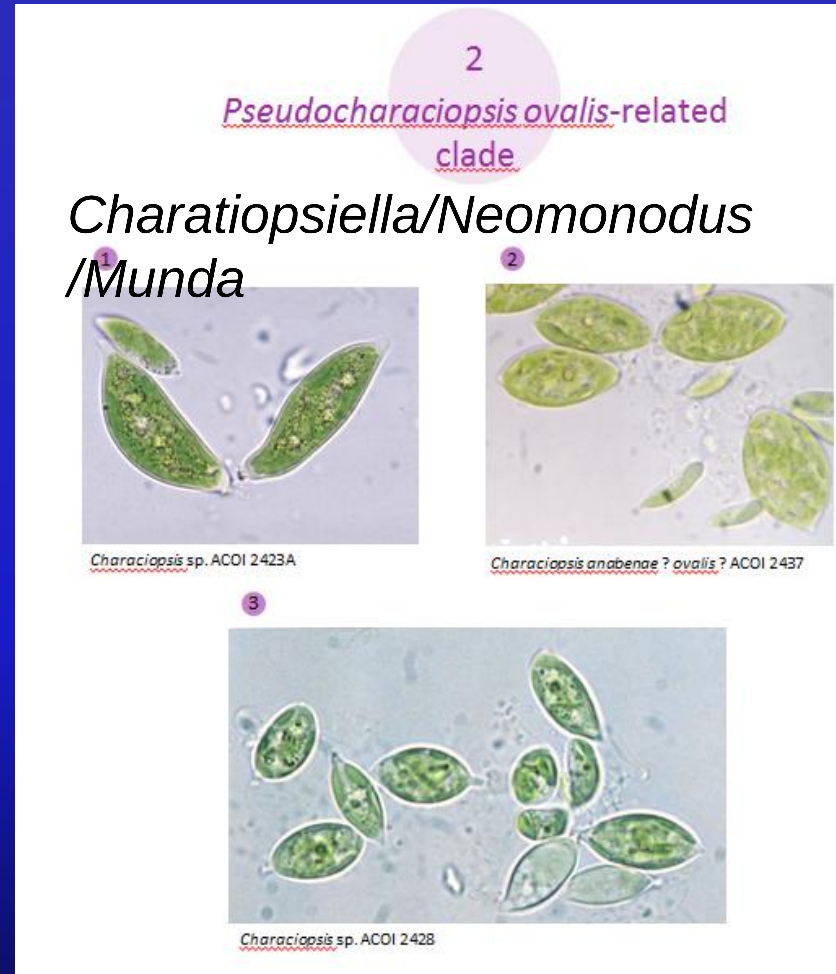
Decreases blood preasure, suppresses schizophrenia symtoms

Nannochloropsis/ Microchloropsis



Fawley et al. 2015



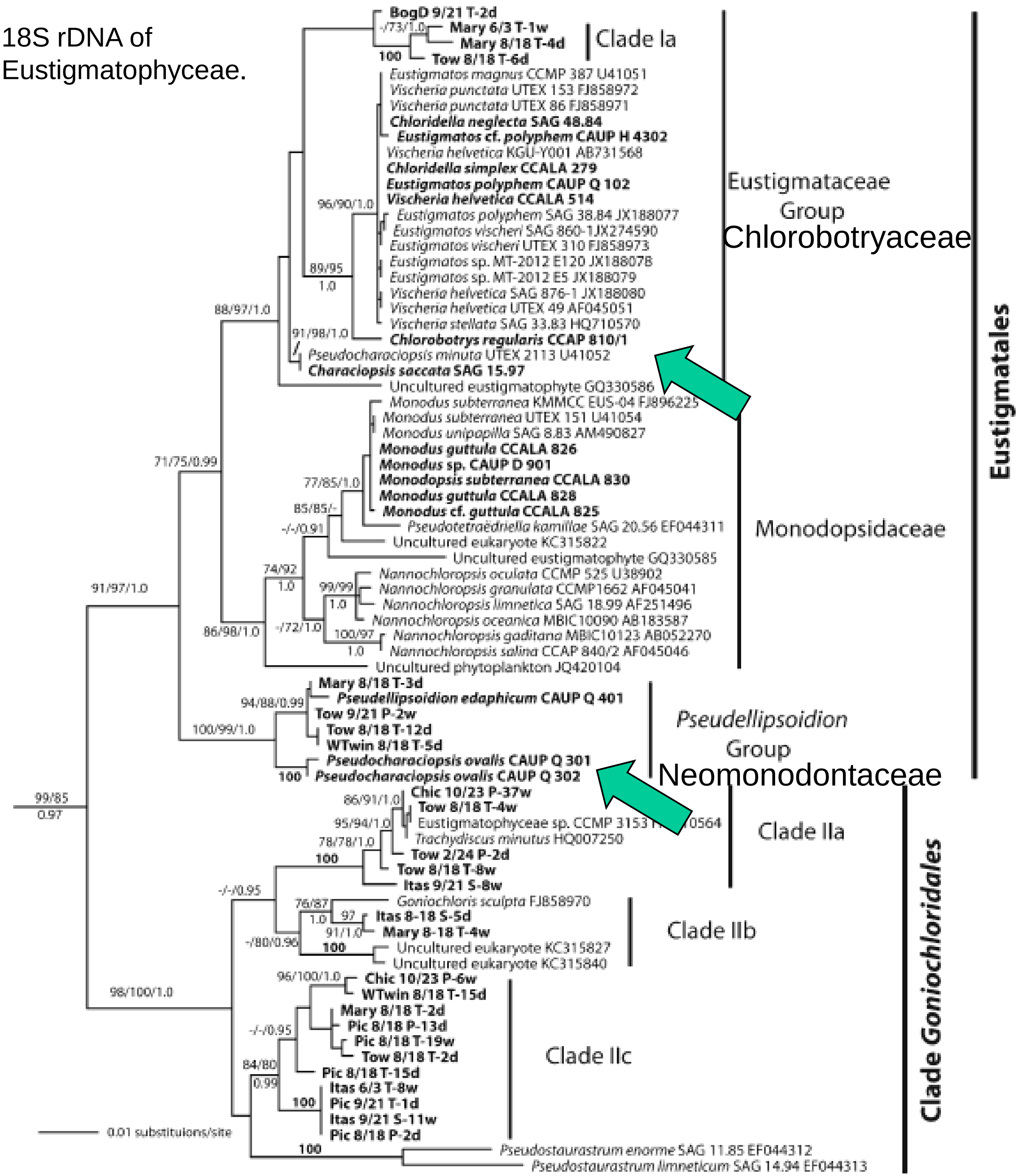


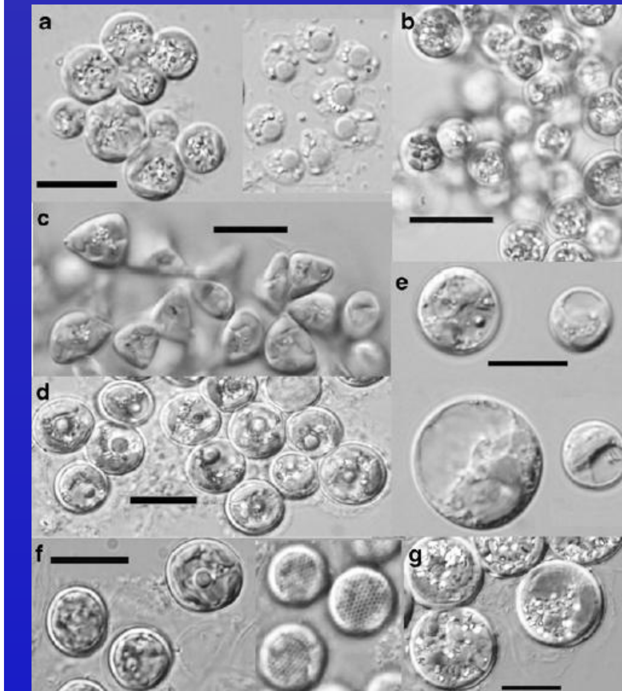
R. Amaral

Chlorobotryaceae
Stipitated py

Neomonodontaceae
No pyrenoid

18S rDNA of Eustigmatophyceae.





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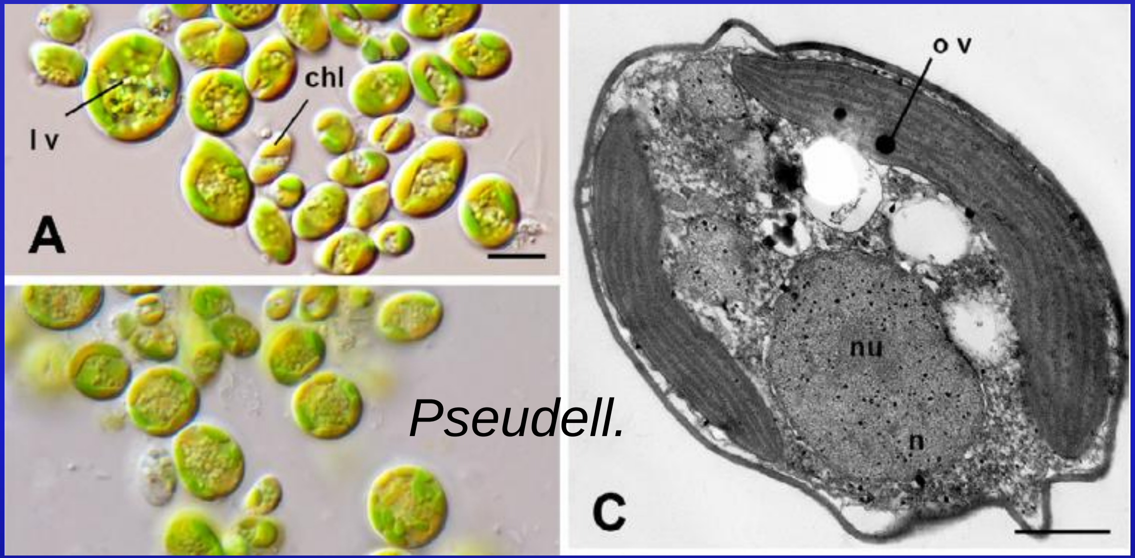
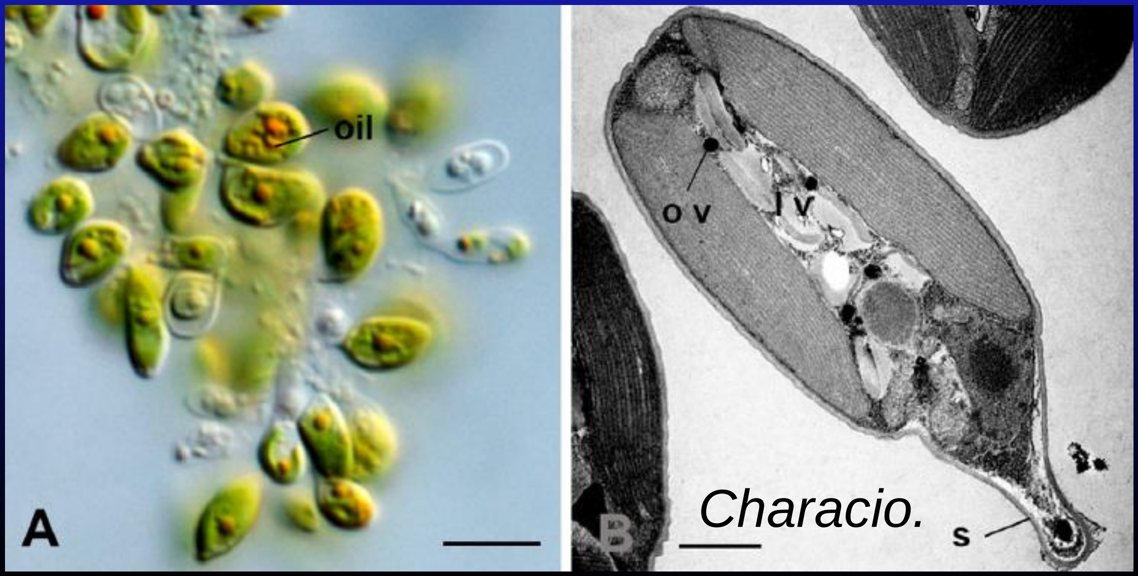
Fawley & al. 2014 J. Appl. Phycol.

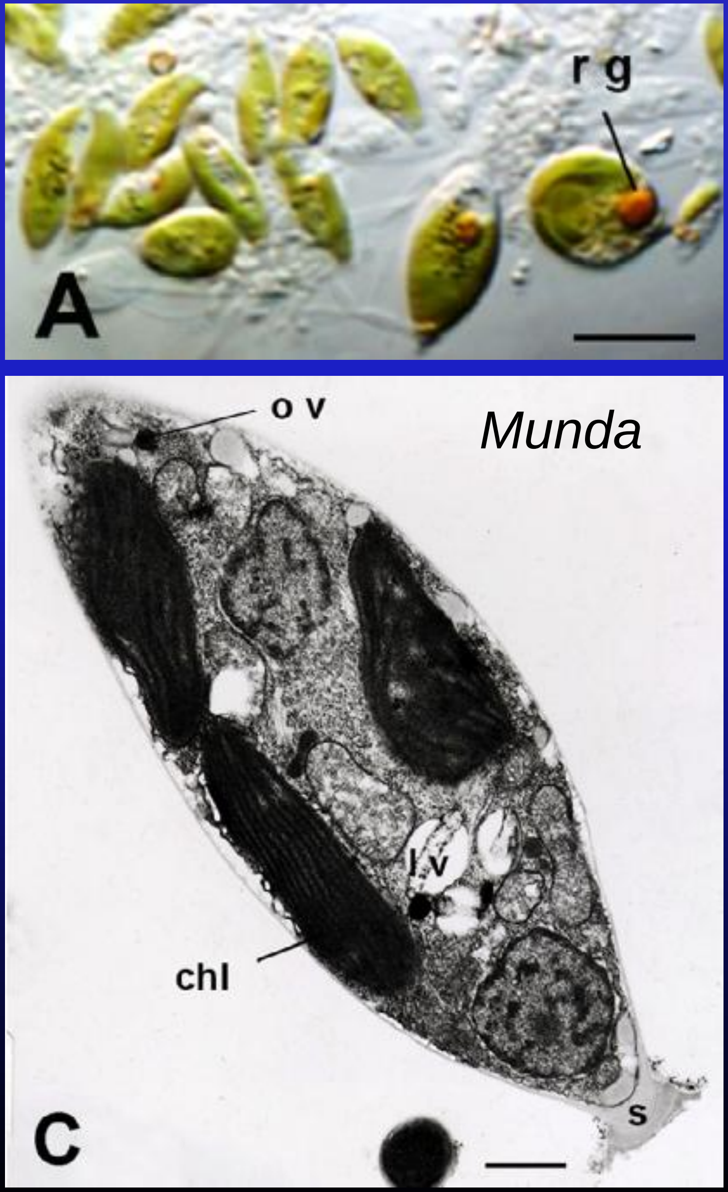
Neomonodontaceae

Neomonodus, Munda, Characiopsiella, Pseudellipsoidion freshwater

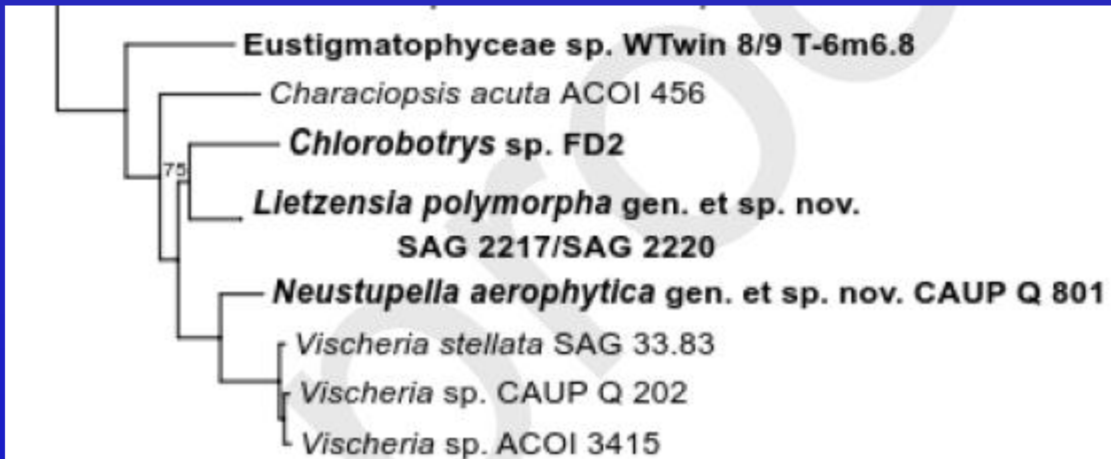
Amaral et al. 2020

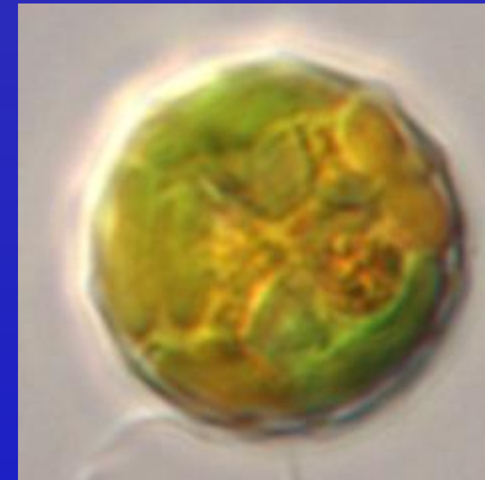




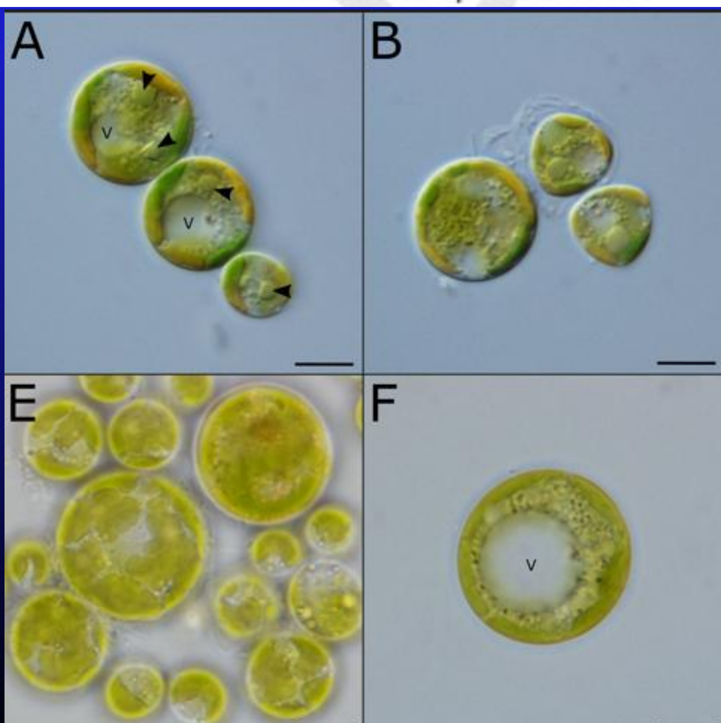


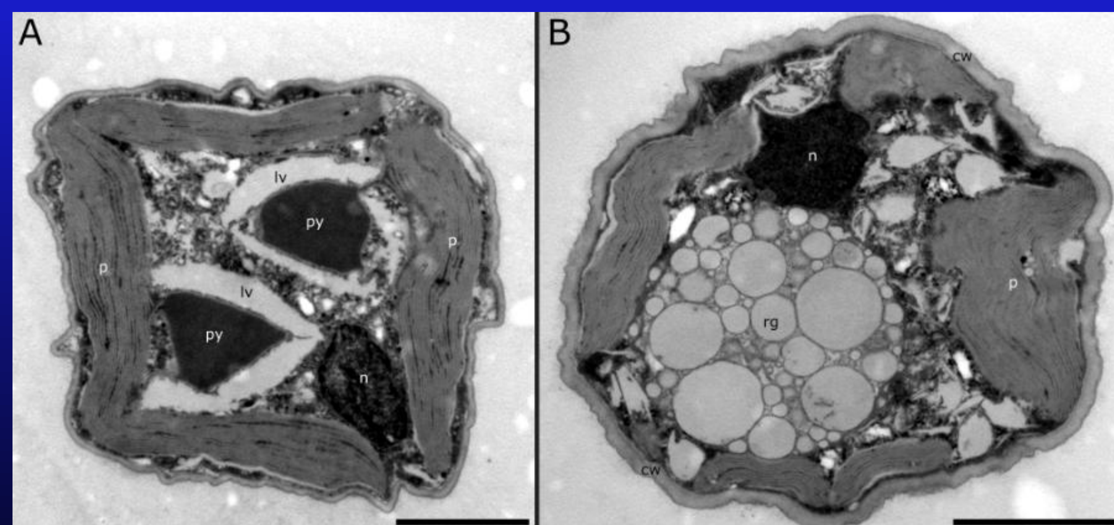
Chlorobotryaceae





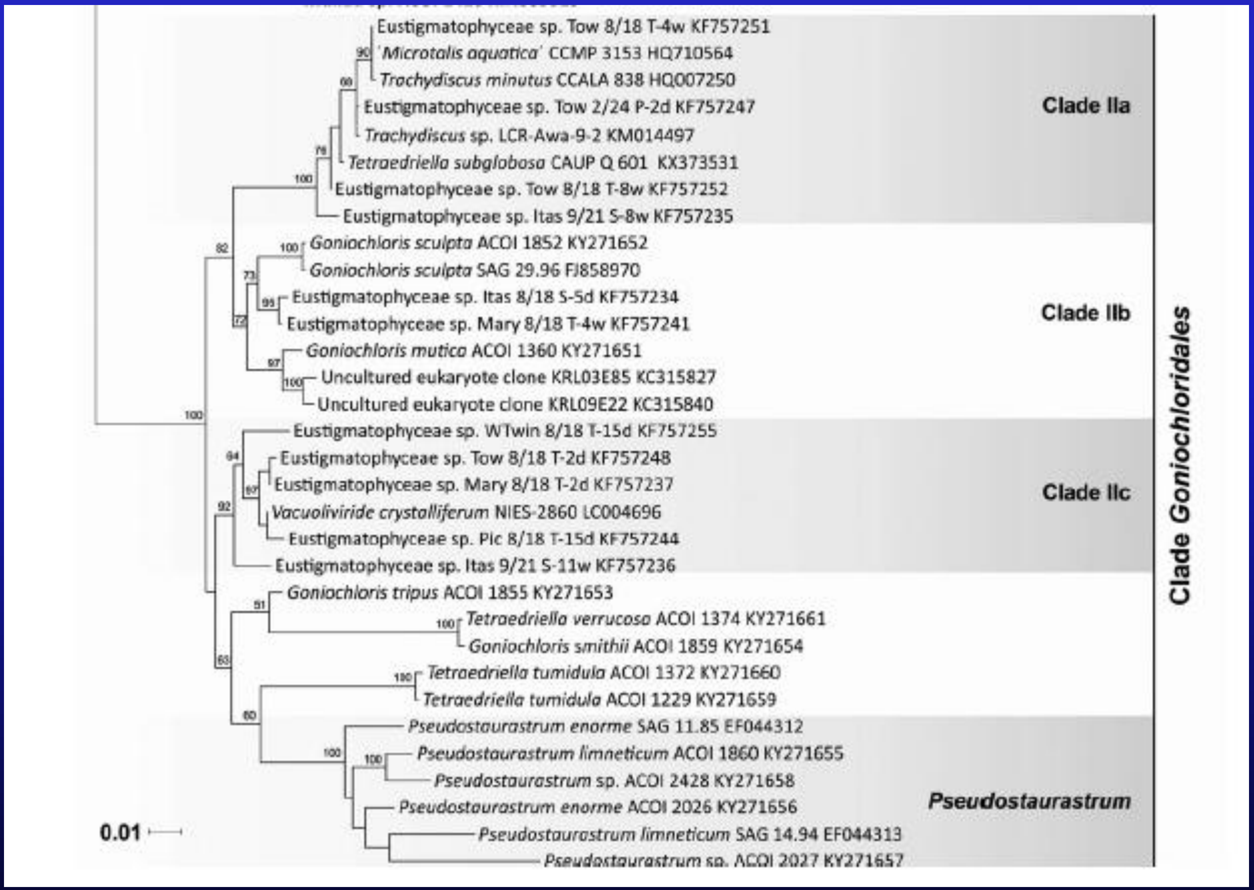
Vischeria stellata



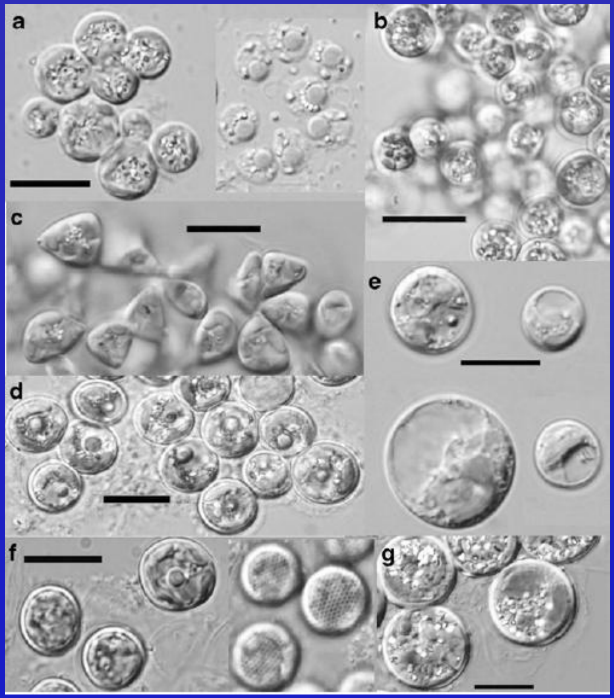


Neustupella aerophytica E4f

Goniochloridales



Amaral et al. 2020 J. Phycol



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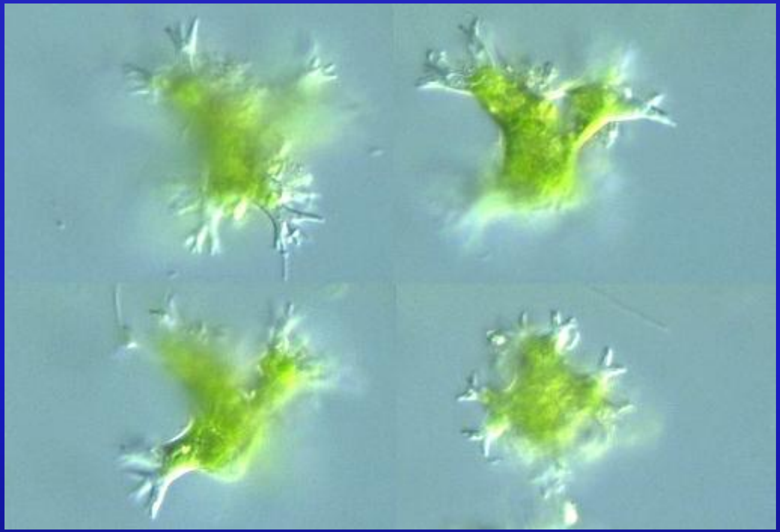
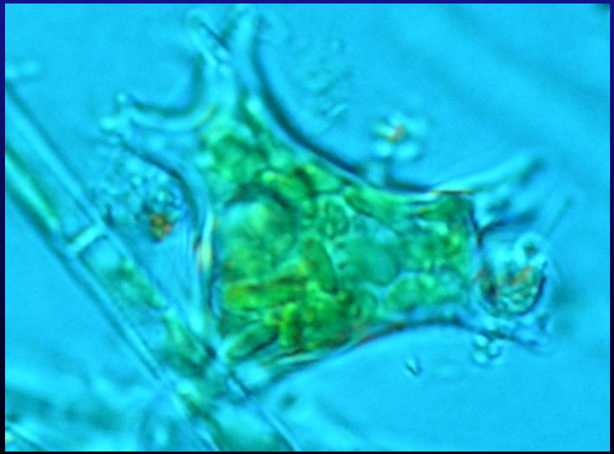
Goniochloridales

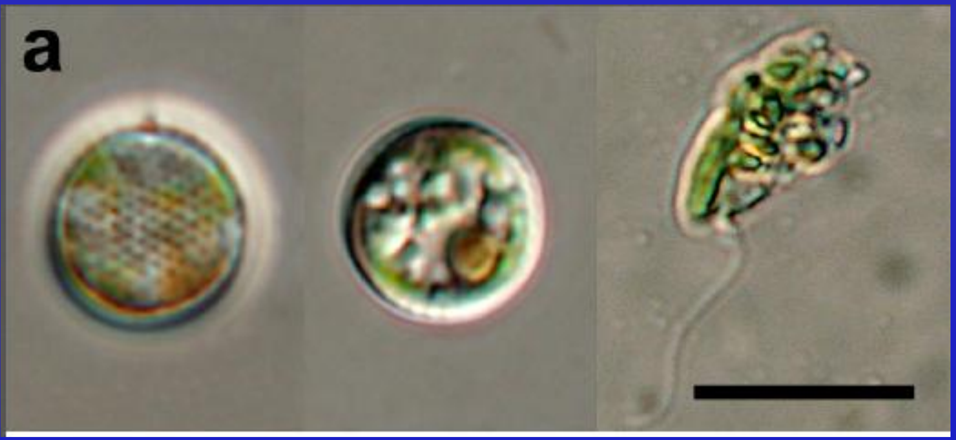
Pseudostaurastrum – plankton in freshwater

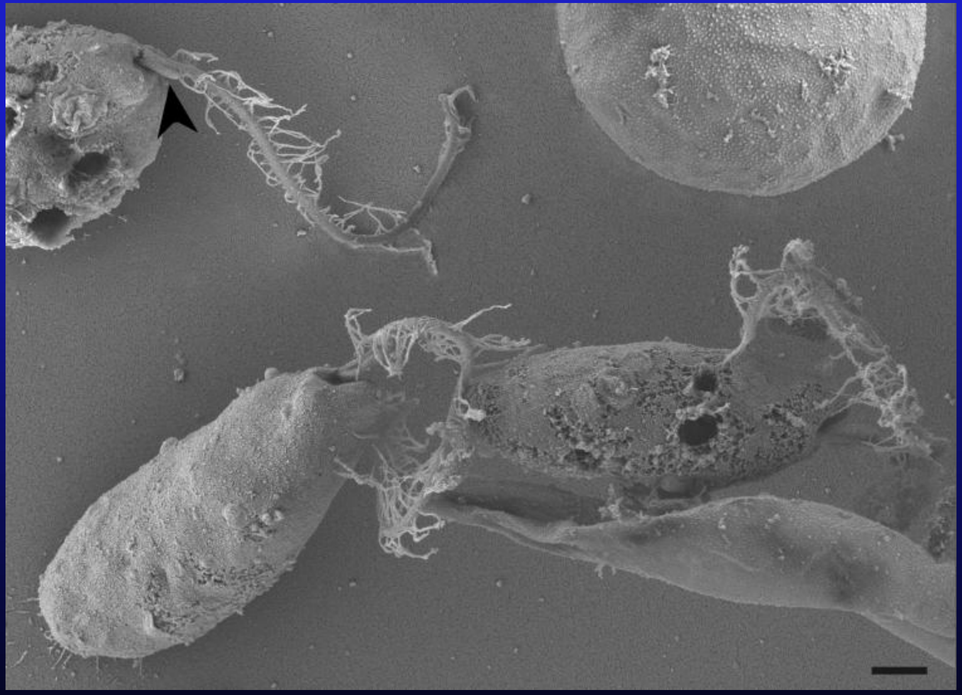




oligotrophic waterbodies

Trachydiscus

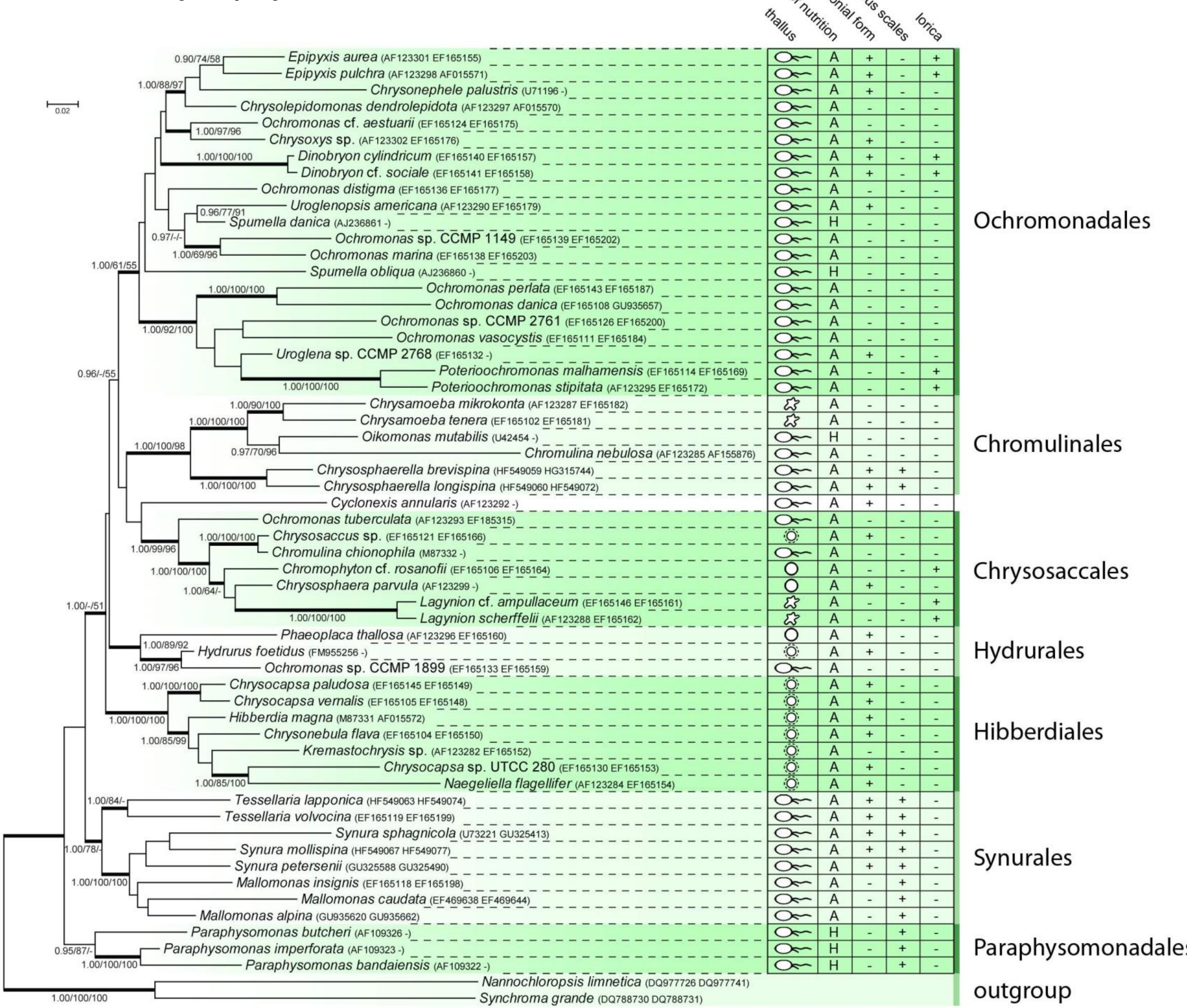




isolated from nuclear power plant Temelín cooling tower

biotechnologically important species - EPA (up to 35% of FA)

Chrysophyceae



- Differences in flagellar roots from typical chrysomonads are secondary simplifications caused by movement of the posterior basal body to be parallel to the anterior one and the cessation of phagotrophy involving root R1, associated with the evolution of autotrophy.
- The absence of chlorophyll c2 is certainly a simple secondary loss.
- Therefore, we no longer even treat Synurales as a separate class.

Cavalier-Smith et Chao 2006

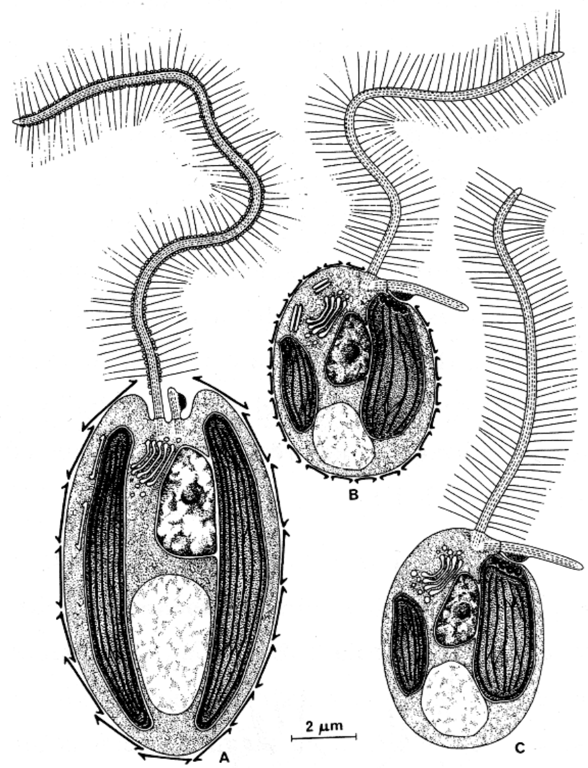


Fig. 2.41. Characteristic features of the Synurophyceae (A) versus the two chrysophycean families Paraphysomonadaceae (B) and Chromulinaceae (C). (Preisig & Hibberd 1986).

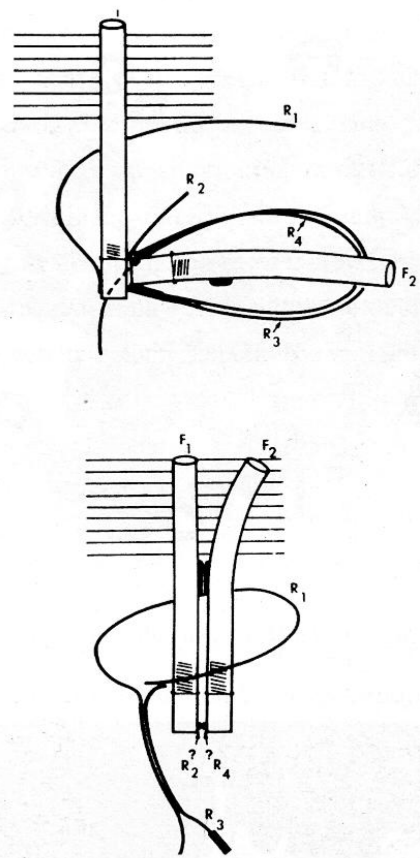


Fig. 2.42. Flagellar root systems in the Chrysophyceae (c) and in the Synurophyceae (f). (Andersen 1987). NB: The numbering of the roots has later been changed.

Andersen, 1987
Synurophyceae

Chrysophyceae

Most of the species are unicellular or colonial organisms, mostly flagellates; almost exclusivelly freshwater

Characteristics:

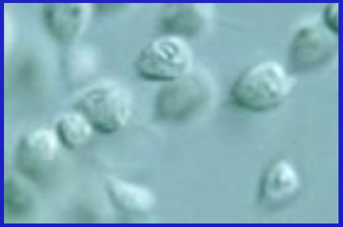
• Flagella inserted sub-apically
• photoreceptor apparatus (swelling on the short flagellum, stigma within a chloroplast)
• the transitional zone of each flagellum contains a „transitional helix“
• golden-brown chloroplasts (ch *a*, c_2), chlorophyll masked by fucoxanthin
• the chloroplast DNA arranged in ring-shaped nucleoid
• silica-walled stomatocysts formed endogenously within the SDV; some genera covered by silica scales
• open mitosis, the spindle is formed between two rhizoplasts

Nutrition

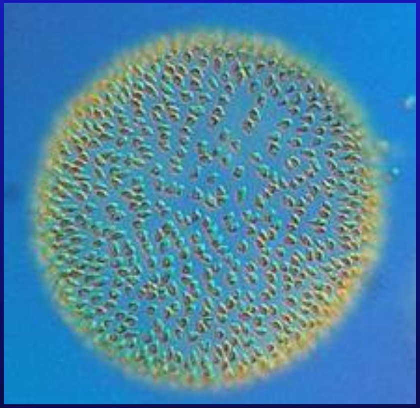
Mixotrophy – photoautotrophy combined with osmotrophy or phagotrophy or heterotrophy (some species aplastidic)

nutritional opportunists – switch between photoautotrophy, mixotrophy, and heterotrophy

Spumella – strict phagotroph, cannibalism

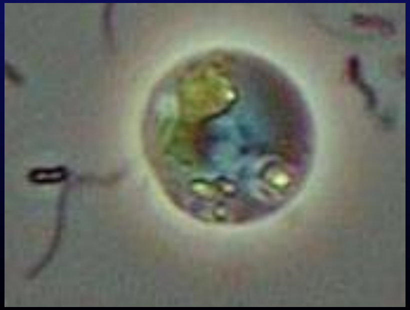


Ochromonas, Uroglena – obligatory phagotrophic and photoautotrophic (light is necessary)



Dinobryon – facultatively phagotrophic

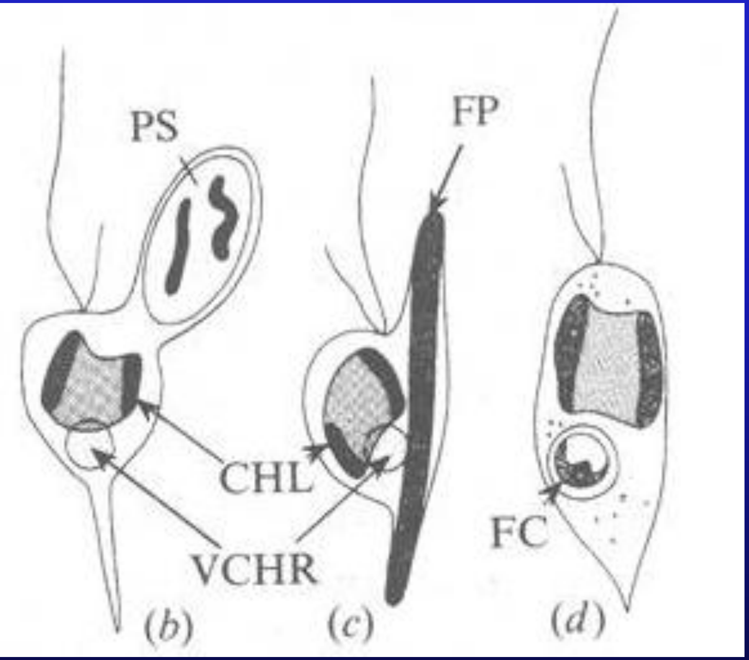
Poterioochromonas – strong tends toward phagotrophy; cannibalism rather than rely upon photosynthesis



Chrysophyte nutrition

Metabolic costs of mixotrophy
lower growth rates

Pseudopodia and food
vacuoles formation



Phagotrophy – main role in oligotrophic lakes, where dominate chrysophytes

Primary consumers of prokaryots (e.g. Dinobryon 3 bacteria/5min)

metalimnetic growth (7m)

consumption of bacteria (remove microorganisms that would compete for the same nutrients) more efficient than crustacea, ciliata and rotifera together

high requirement for iron (esential for cytochrome)

(b, c) *Ochromonas granularis* (d) *O. danica*. Phagotrophy
PS – pseudopodium; VCHR – chrysolaminaran vacuoles; FC – secondary vacuole; CH – chloroplast; FP – food particles

Chrysophyte nutrition

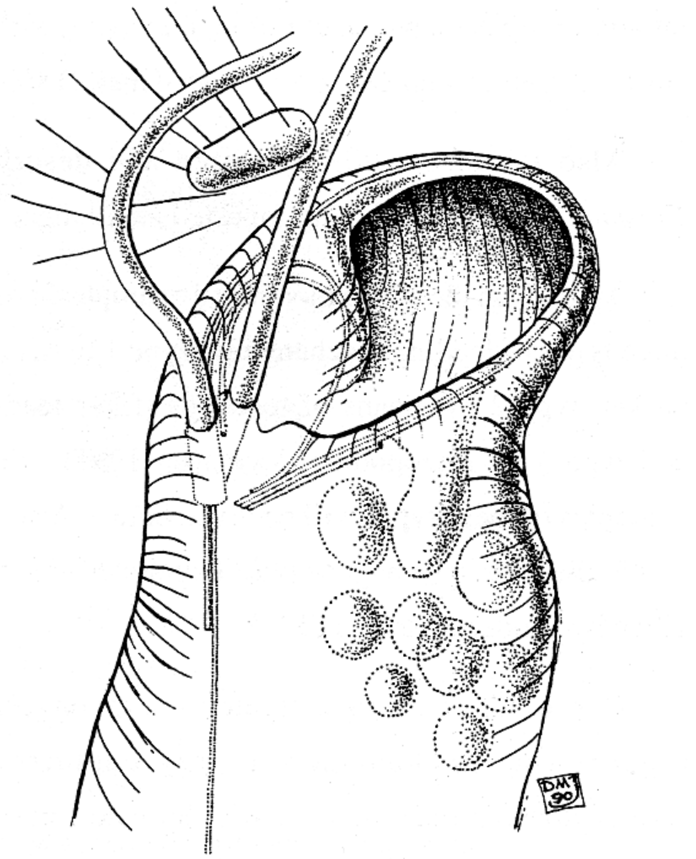


Fig. 3.3. The feeding basket of Epipyxis, ready for the prey which is being manipulated by the flagella. (Andersen & Wetherbee 1992).

Fig. 3.4. Feeding process in Epipyxis (Moestrup & Andersen 1991).

Fig. 3.5. Digestion vacuole in Dinobryon, containing bacteria and remnants of Synura scales. (JK).

Fig. 3.11. Paraphysomonas vestita, the digestion vacuole contains both bacteria and remnants of Synura scales. (JK).

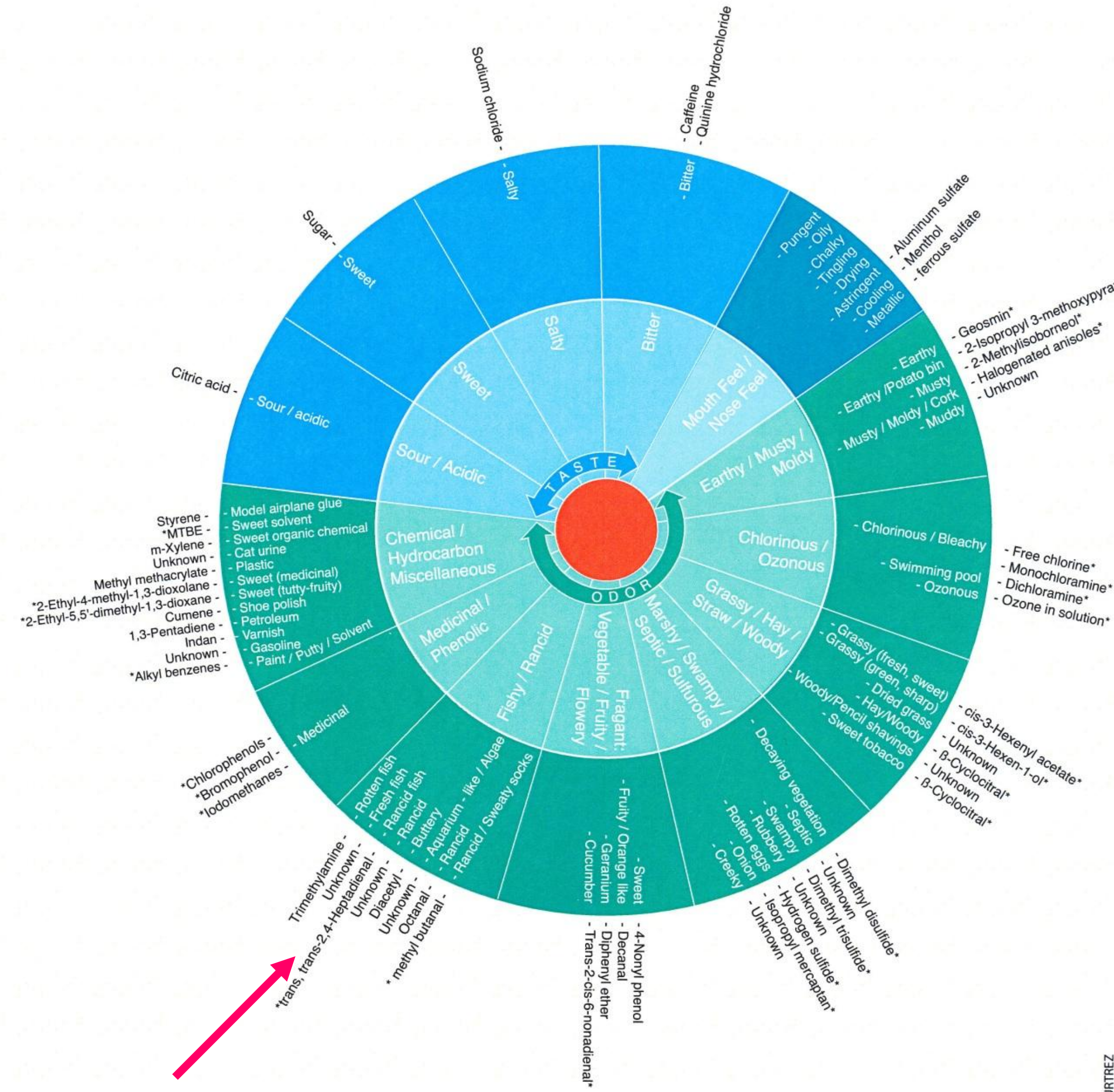
Bloom formation

Uroglena volvox – toxic fatty acids that affects fish

Uroglena, Dinobryon, Synura – aldehydes and ketones (n-heptanal, 2,4-heptandienal) – taste and odour of drinking water

rotten fish, rancid fish, buttery, cucumber, musk

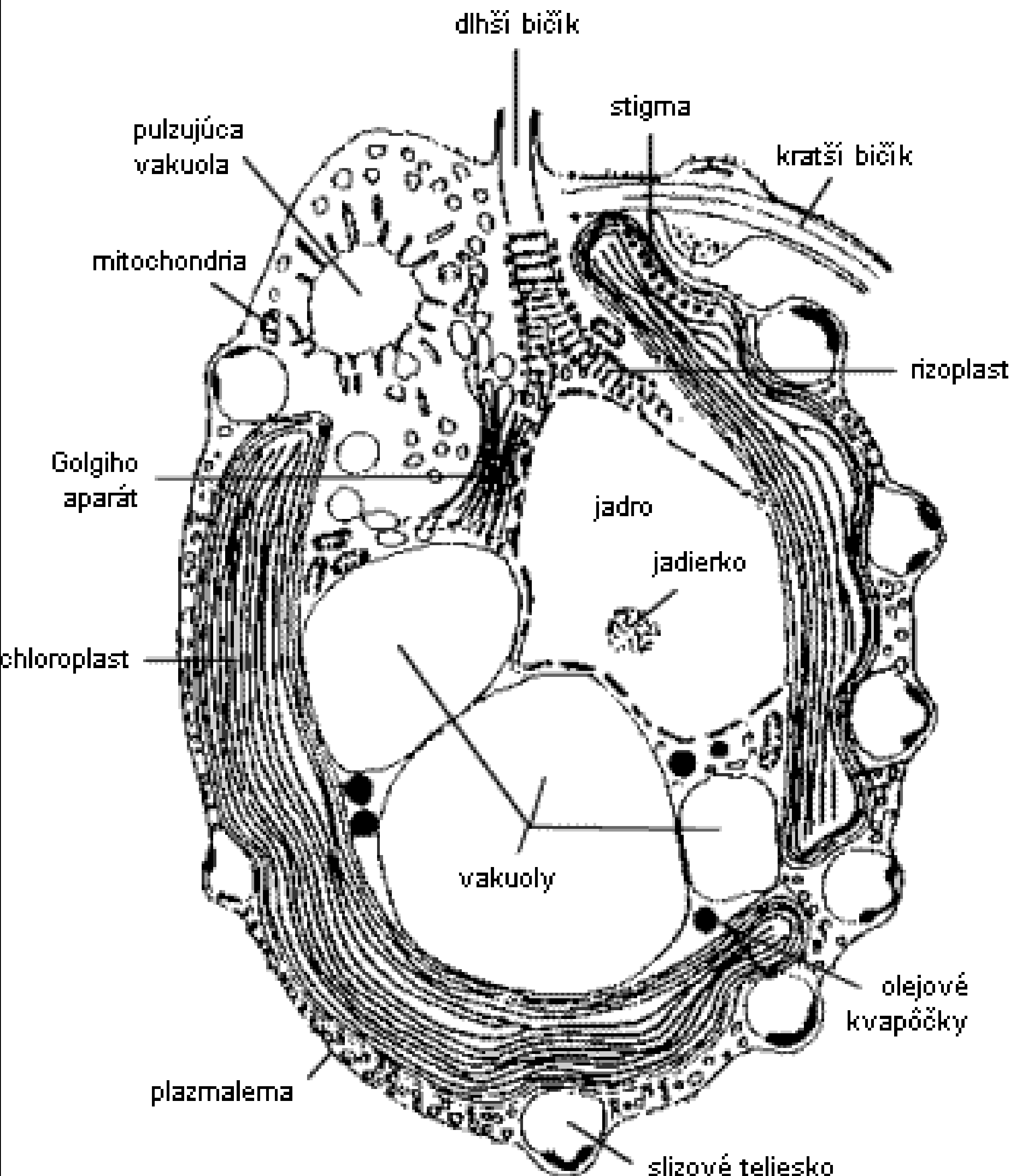
odor in the phase of population decline



Drinking Water 2006 Taste and Odor Wheel

Gary A. Burlingame

Philadelphia Water Department



Organels

Contractile vacuoles – osmoregulation

Golgi apparatus

Mucocysts, diskobolocysts

26 km/s

hydratation of mukopoly-saccharides

Sexual reproduction

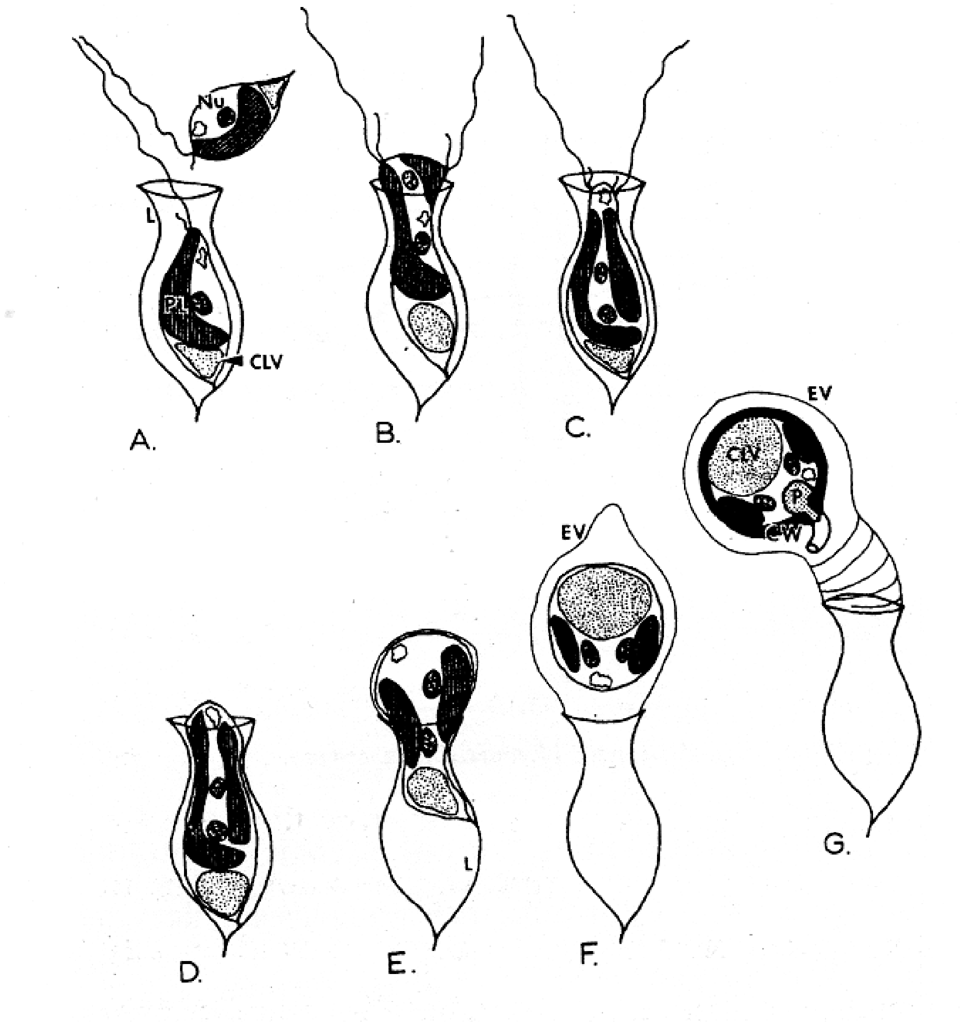


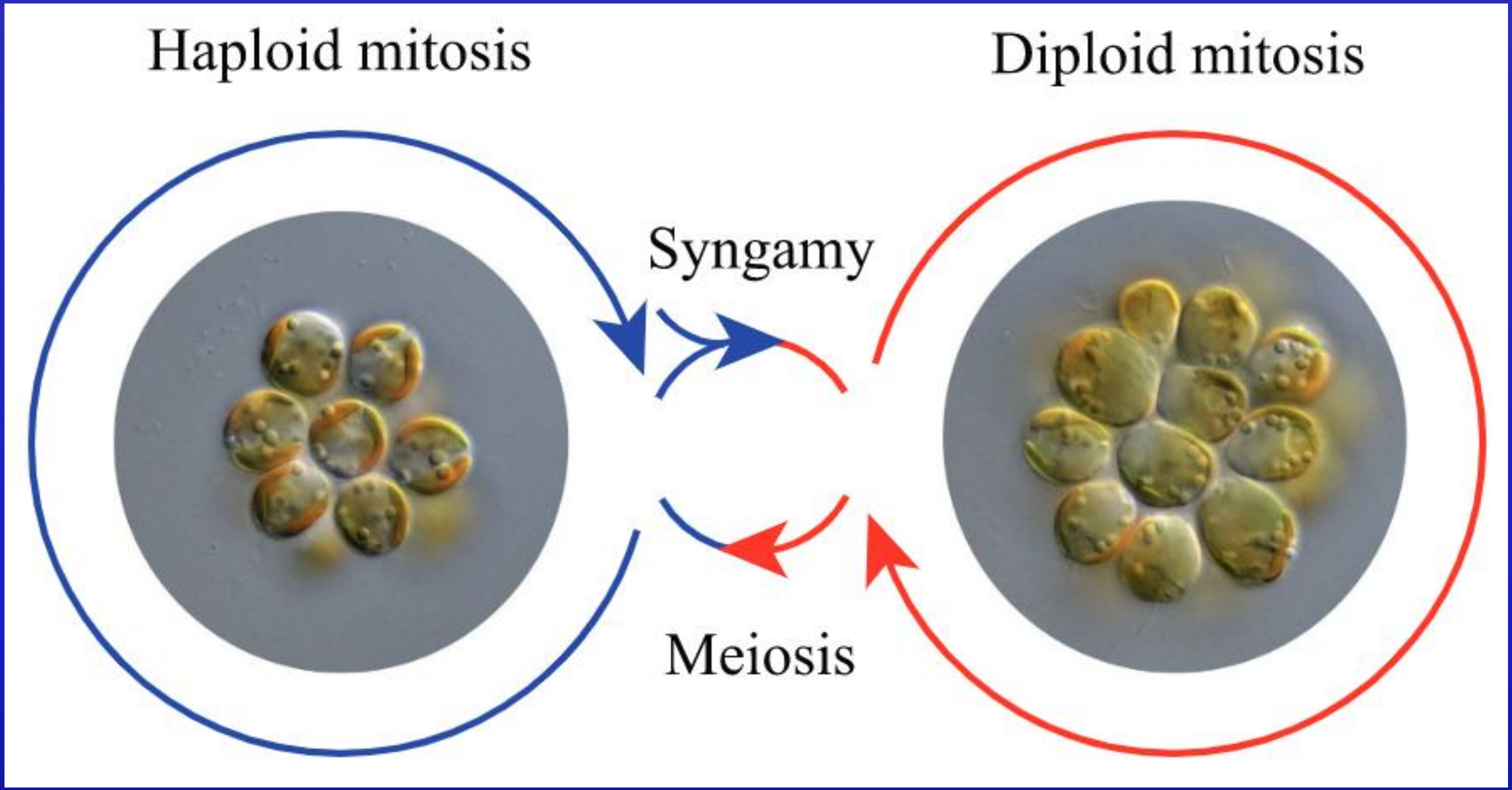
Fig. 1.29. Sexual reproduction in Dinobryon. (Sandgren 1981).

known in only few members

(e.g. Kephyrion, Chrysolykos, Dinobryon)

izogamy

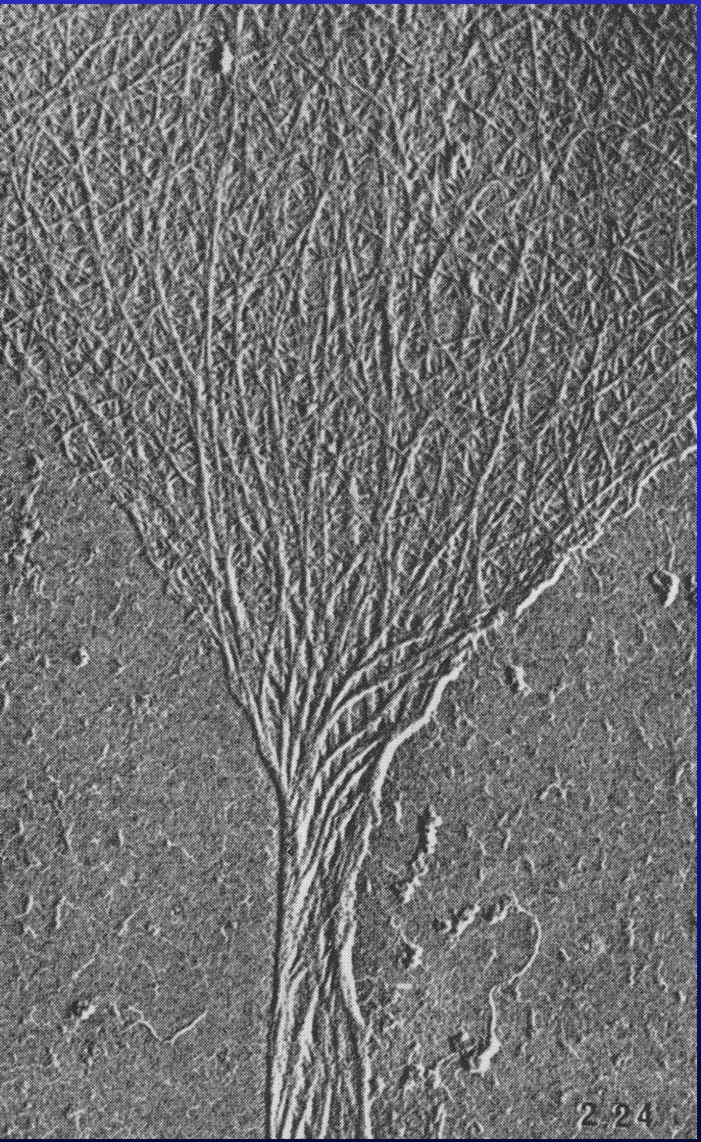
Dinobryon – feromones - atractants, male and female colonies



Alternating nuclear DNA content in chrysophytes provides evidence of their isomorphic haploid-diploid life cycle

(Čertnerová et al. 2022)

Loricae



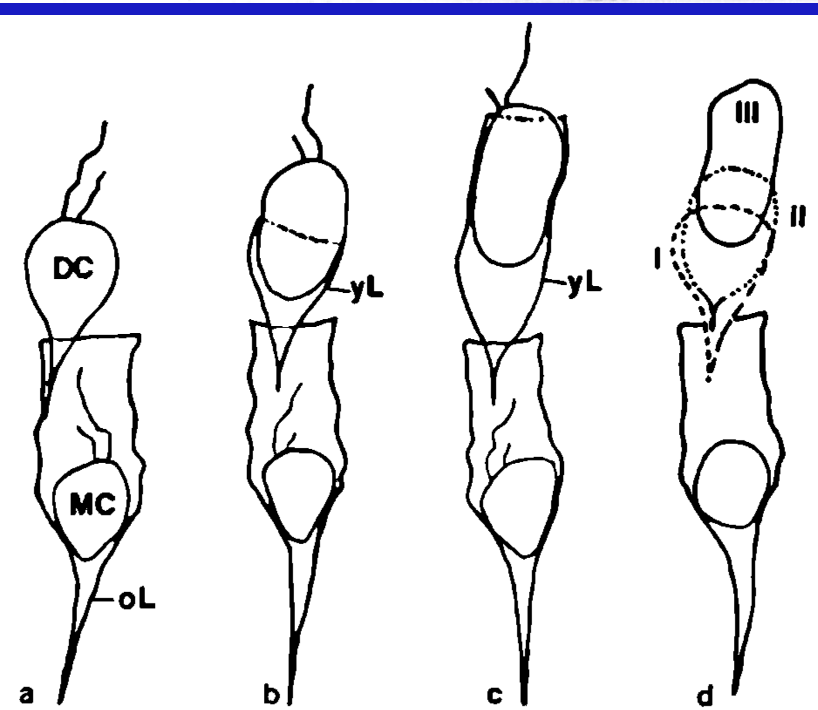
microfibrilar nature of the lorica
Poterioochromonas

Poterioochromonas

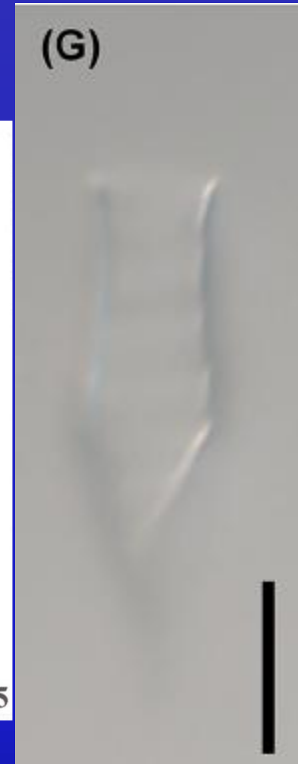
not connected with PM

fluorescence stain - Calcofluor white

Loricae



Dinobryon divergens



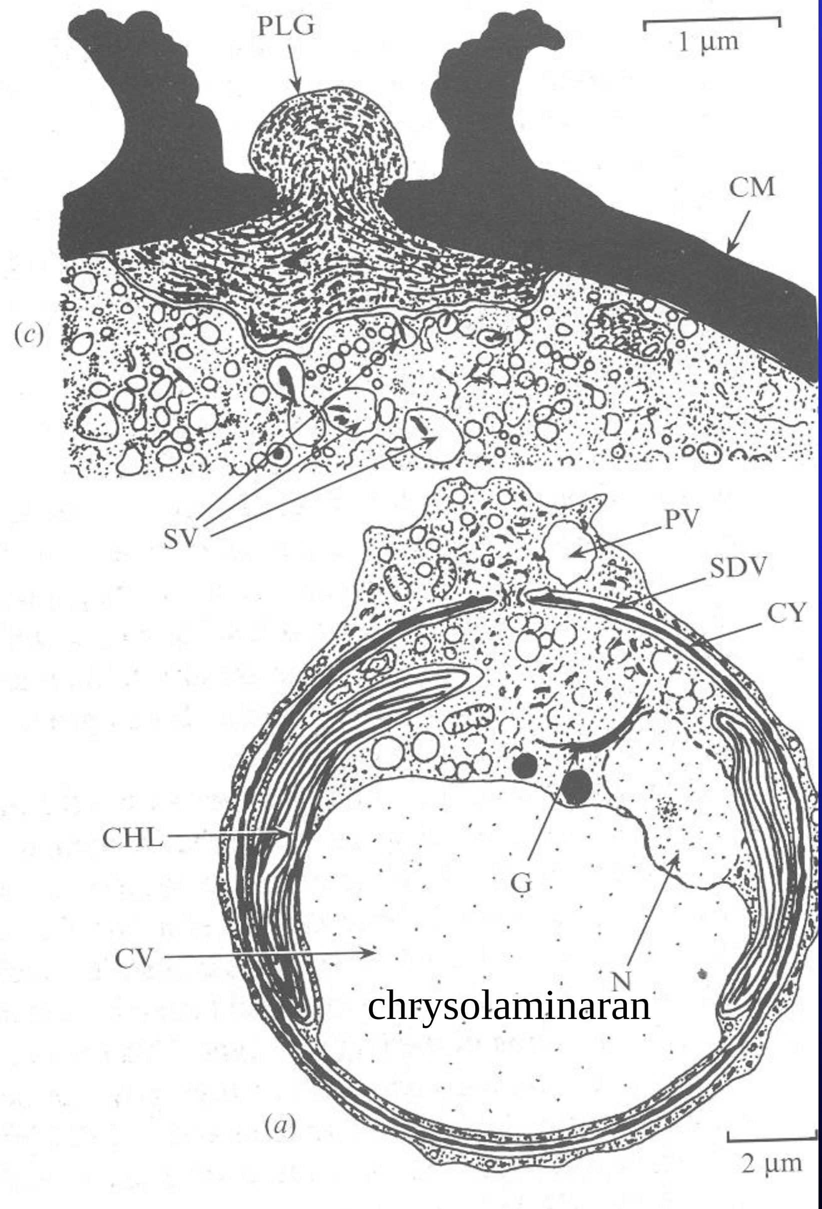
D. bavaricum

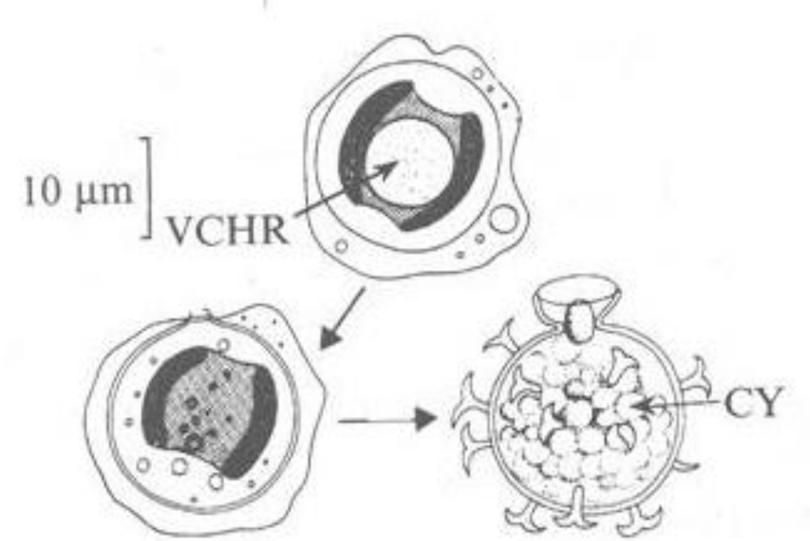
D. similis

Dinobryon divergens forming a lorica - 2 phases (nonrotative/rotative), cell shape

Stomatocysts (statospores)

stoma =mouth





Ochromonas fragilis

silica-walled stomatocysts formed endogenously within the SDV

cytoplasm outside degenerates, the pore is closed by a plug

stomatocysts –bottom sediments of lakes, survive for decades

Stomatocysts

Stomatocysts in SEM. Morphotypes defined on surface structures (papilae, ridges). Morphotypes are described according to International Statospore Working Group (ISWG) guidelines and defined by numbers.

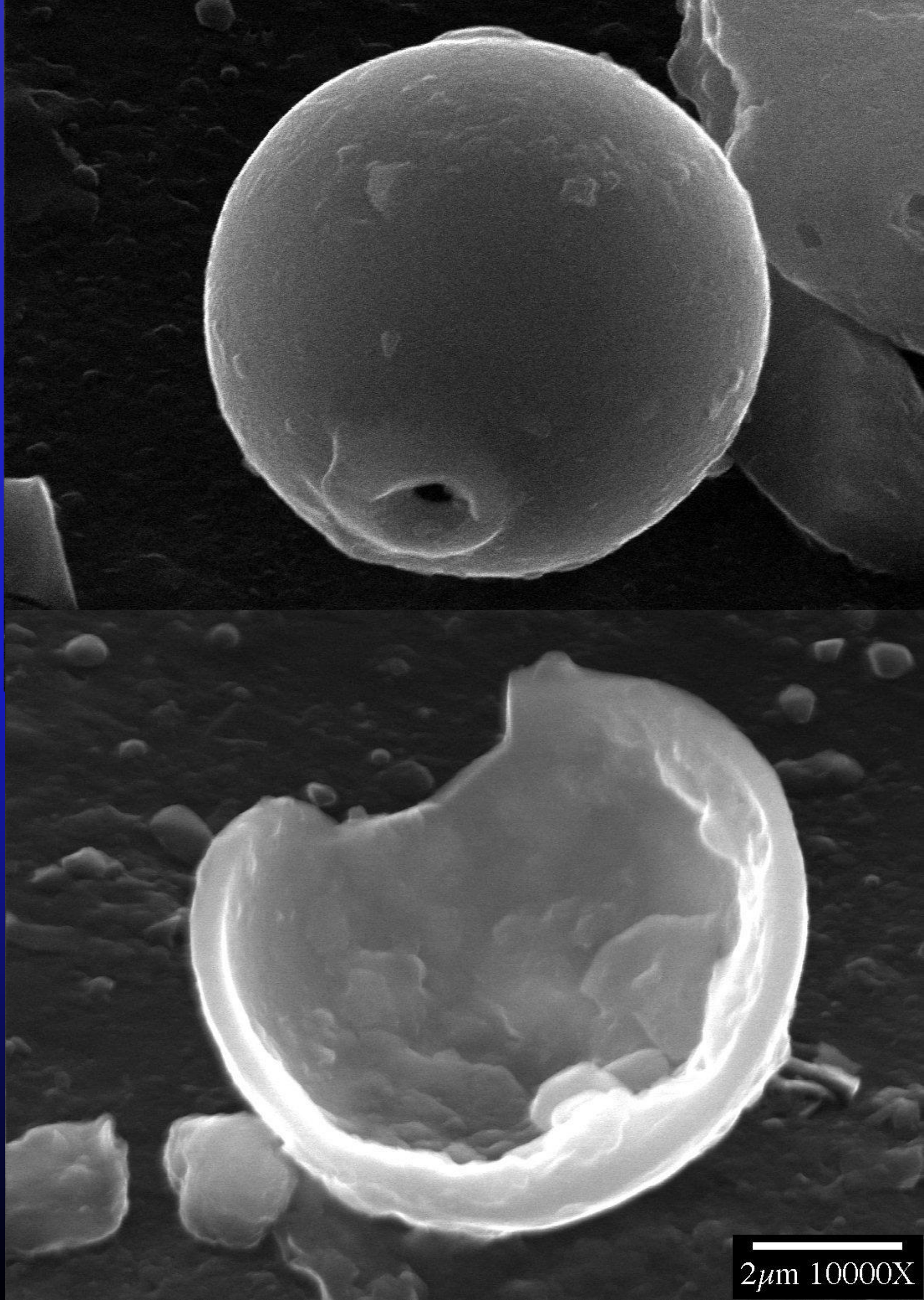
asexual or sexual reproduction

stomatocyst formation trigger??

cell density, production of chemical inducers, mass

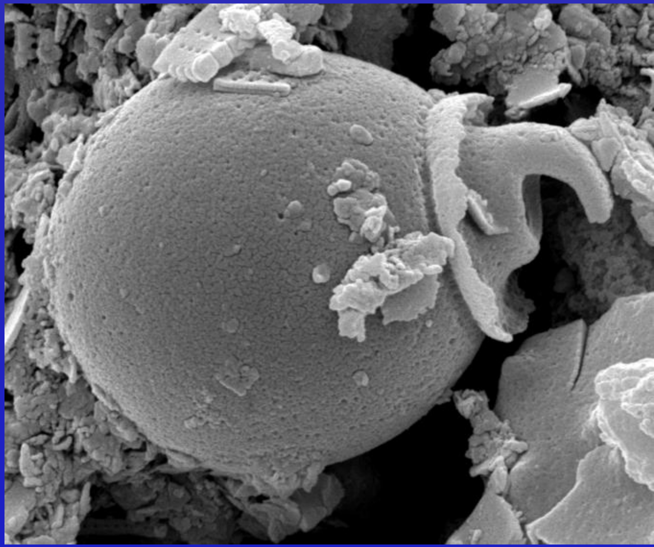
stomatocyst germination and excystment

continually small numbers



Stomatocysts

2-30 μm



Fossils back to lower Cretaceous (150 MY)

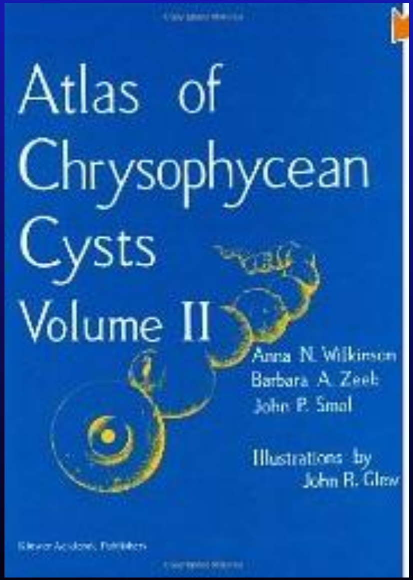
structually distinctive – deduction of environmental conditions at the time of sedimentary deposition

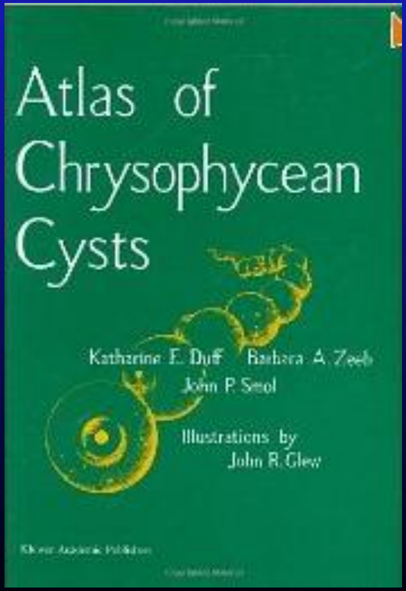
calibration sets

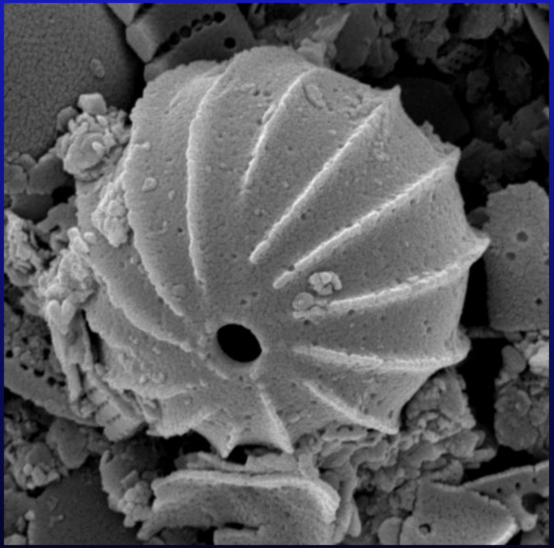
ancient samples-sediment coring devices

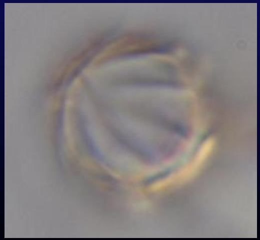
acidification, eutrophication, shifts of climate

Atlas of chrysophycean cyst I and II

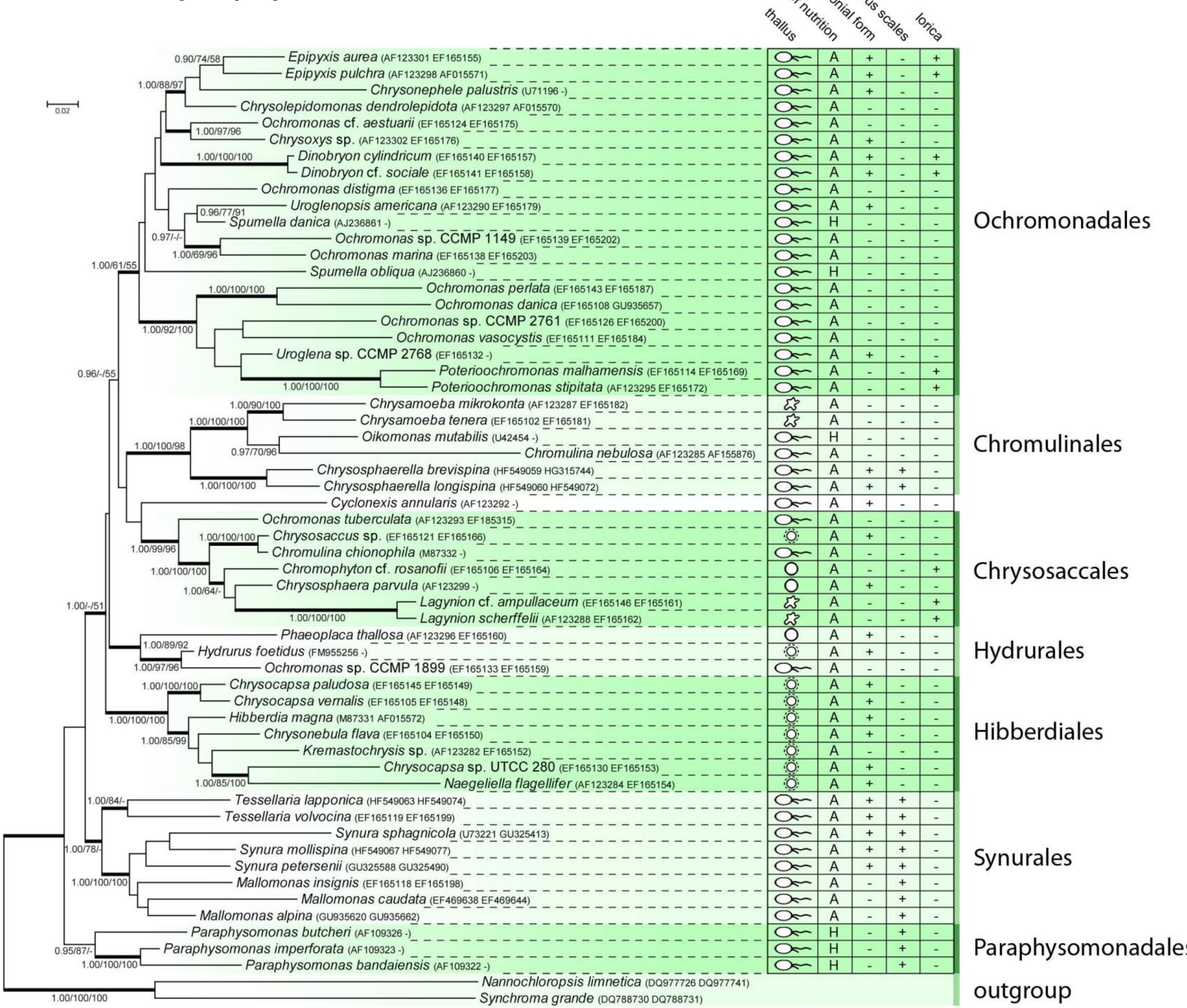








Chrysophyceae



Ochromonas

over 125 described species

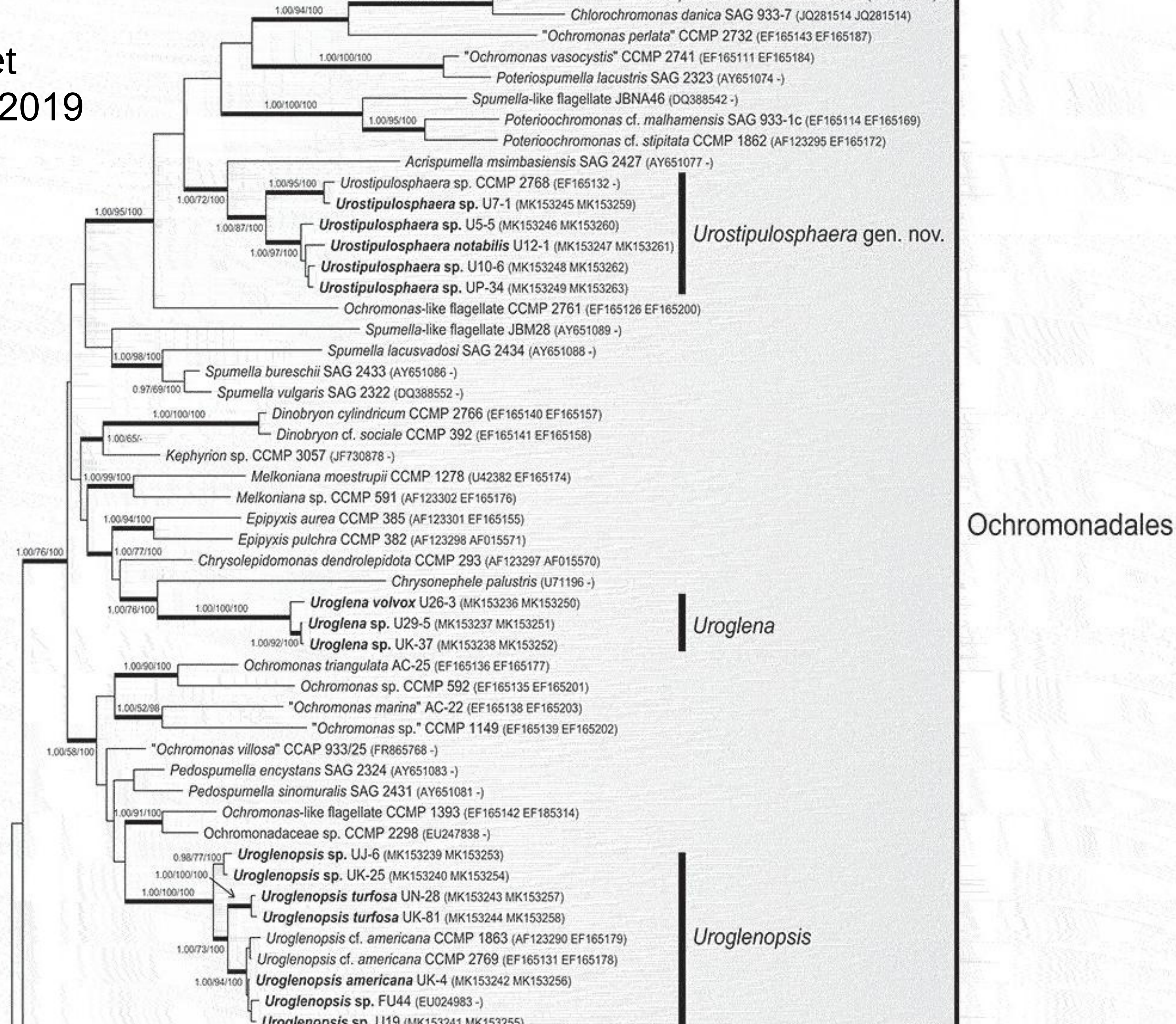
polyphyletic

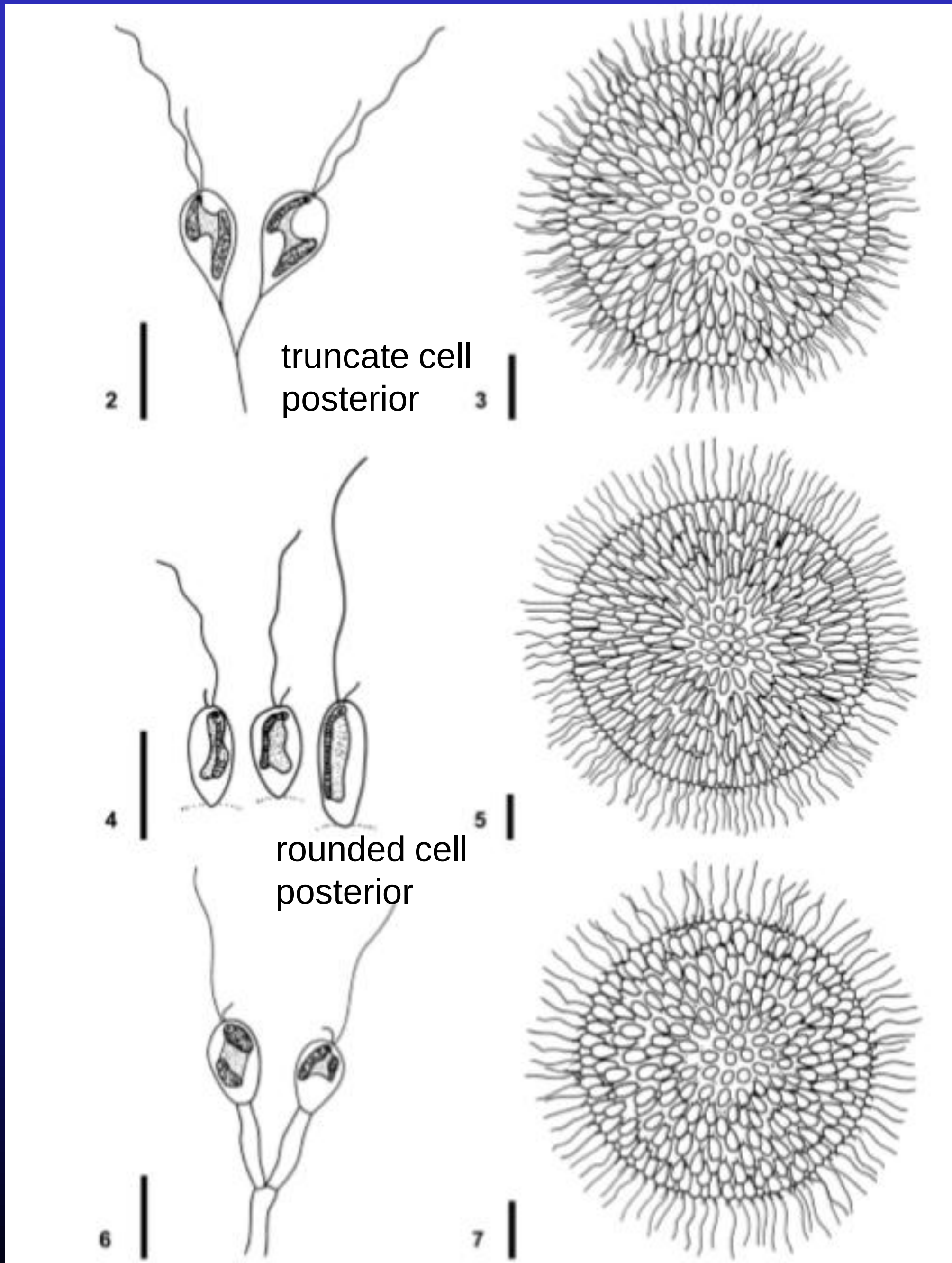
Determination complicated, stomatocysts may help

Andersen et al. 2017

the type species for a genus, was collected for only the second time, again from the type locality - Lake Veysove, a salt lake in the Donetsk region, Ukraine.

Pusztai et Škaloud 2019

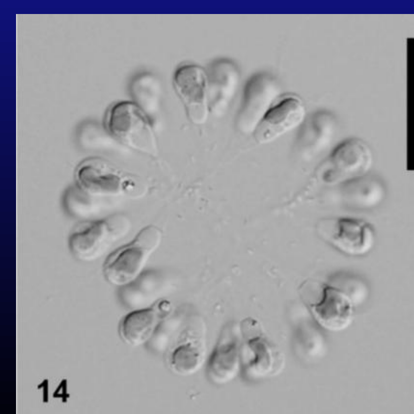




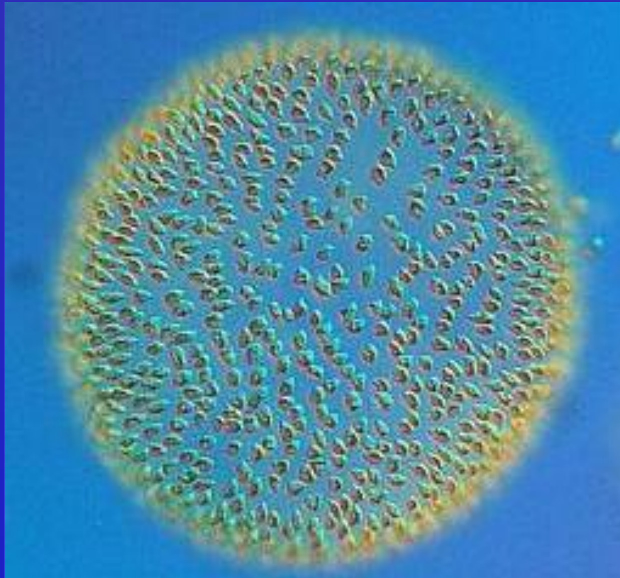
Uroglena

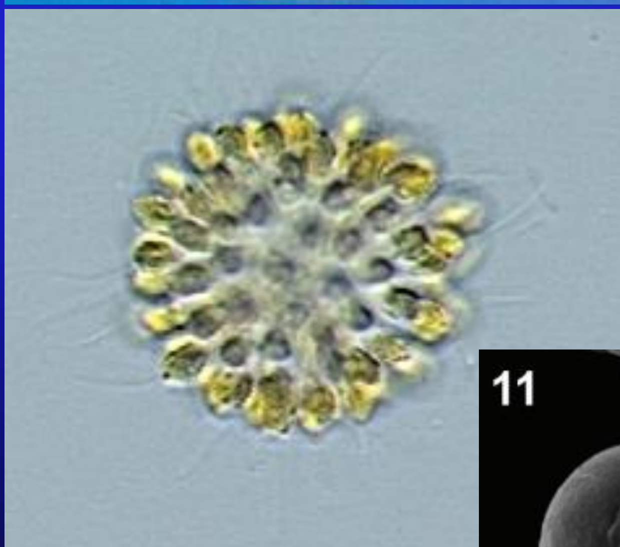
Uroglenopsis

Urostipulosphaera



thick
articulated
gelatinous
stalks,
merging in
the center

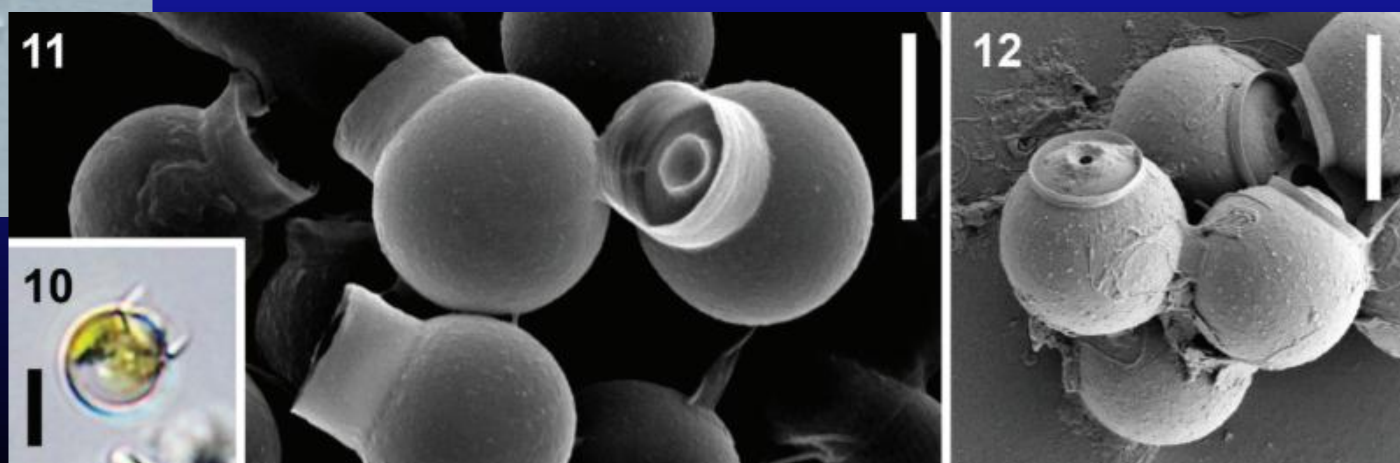




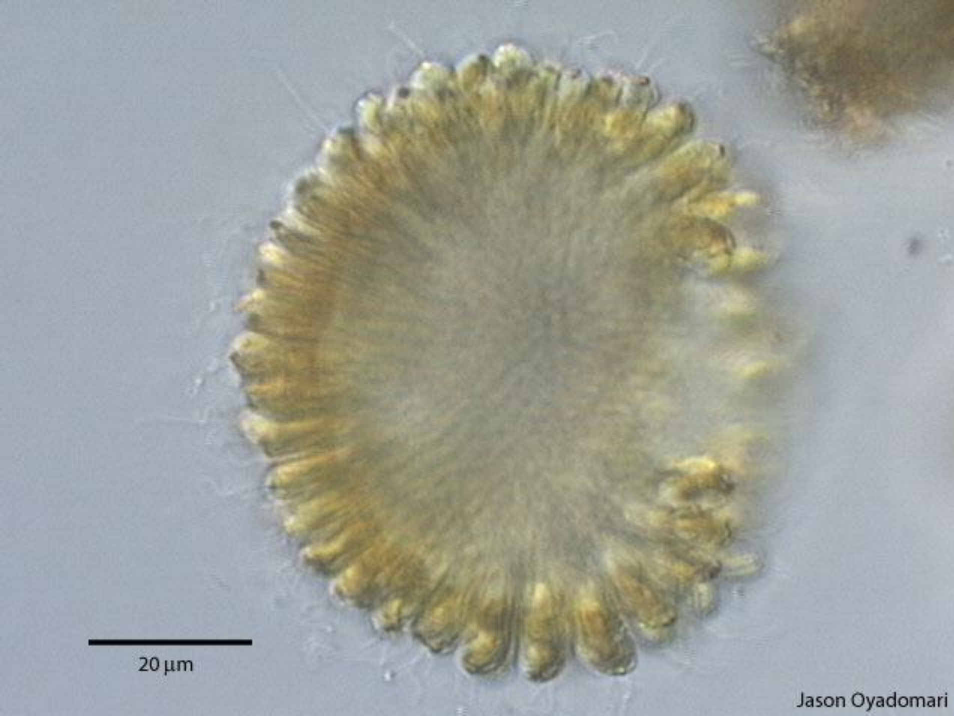
Uroglena

Colonial, uneven heterocont flagella.
Cells on the surface of the colony.
Bloom forming species – water taste and odor problems.

cells possessed pointed cell posteriors that continued as thin, probably cytoplasmic, threads

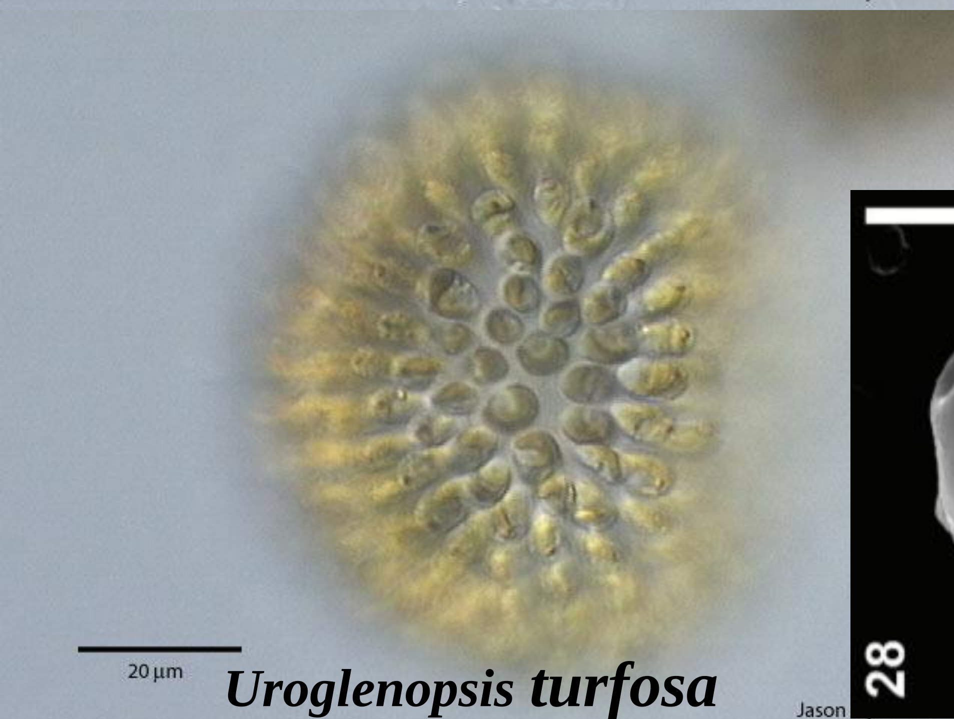


Uroglenopsis

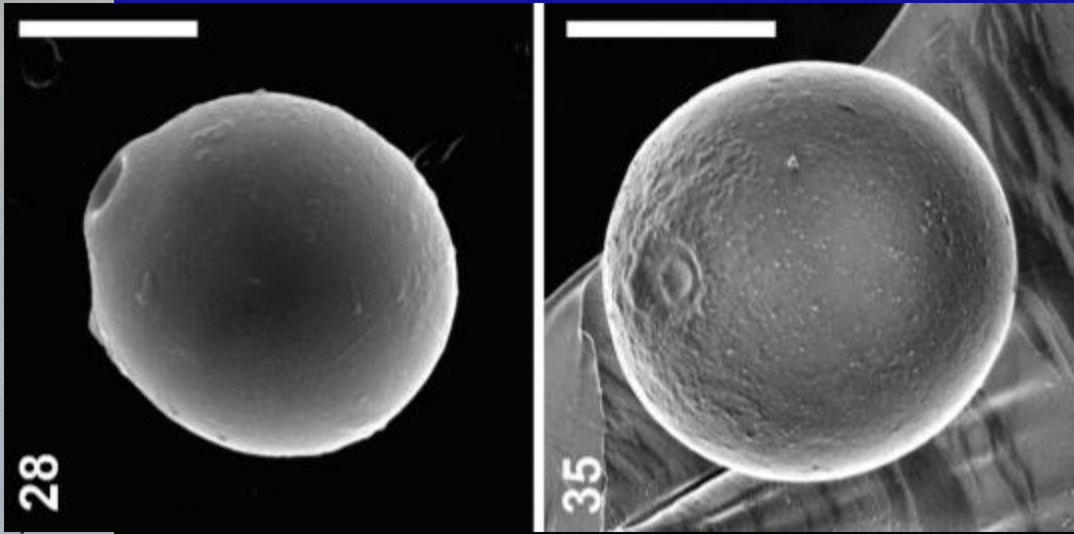


No branching system of any radially arranged thin cytoplasmic threads or thick gelatinous stalks was observed

late summer, especially in lakes of higher alkalinity

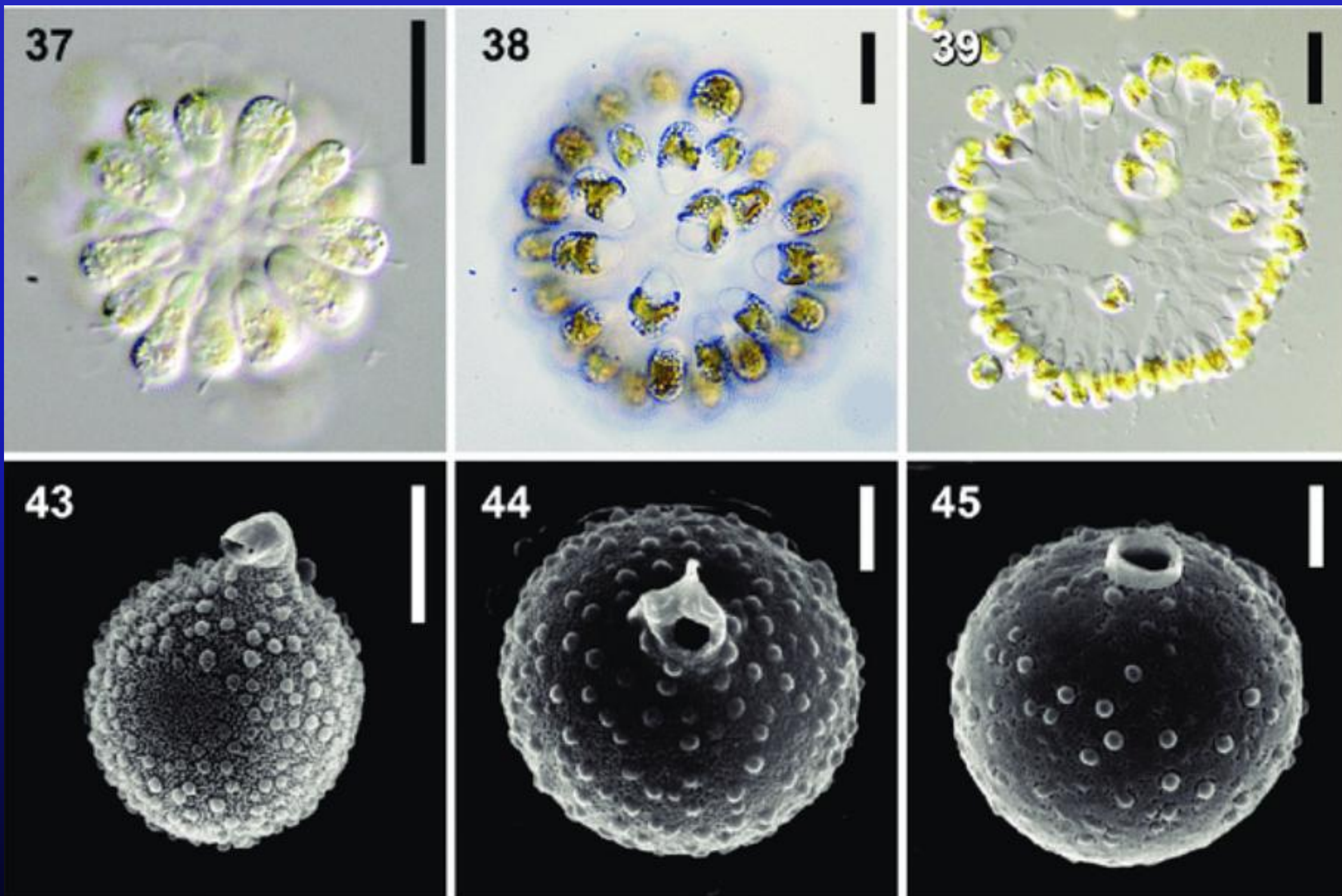


Uroglenopsis turfosa



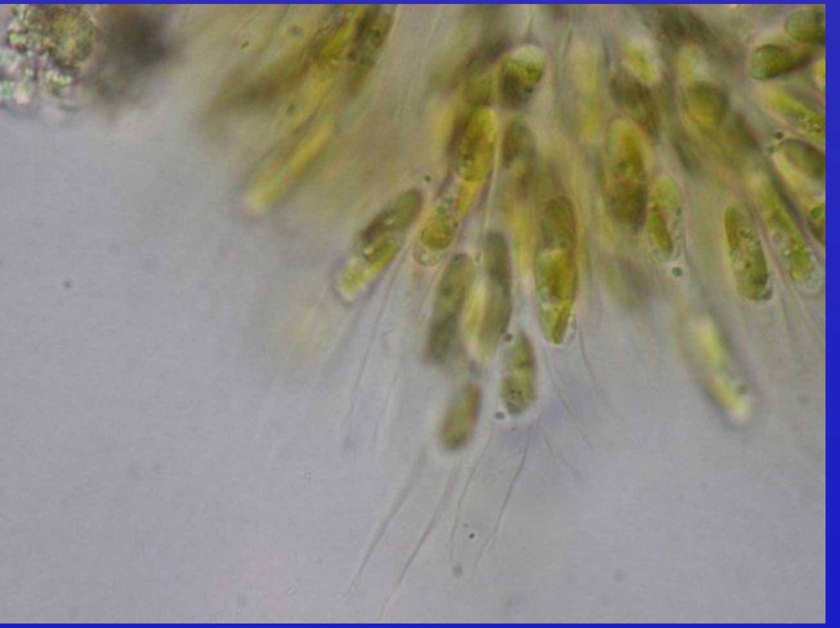
Urostipulosphaera

branching system of thick gelatinous stalks



Uroglenopsis turfosa

Epipyxis



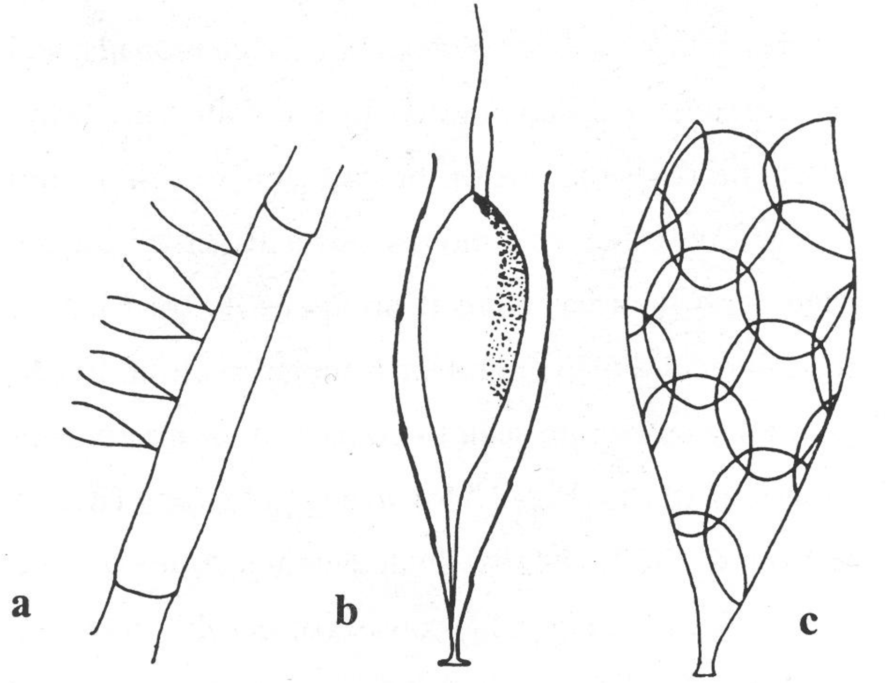
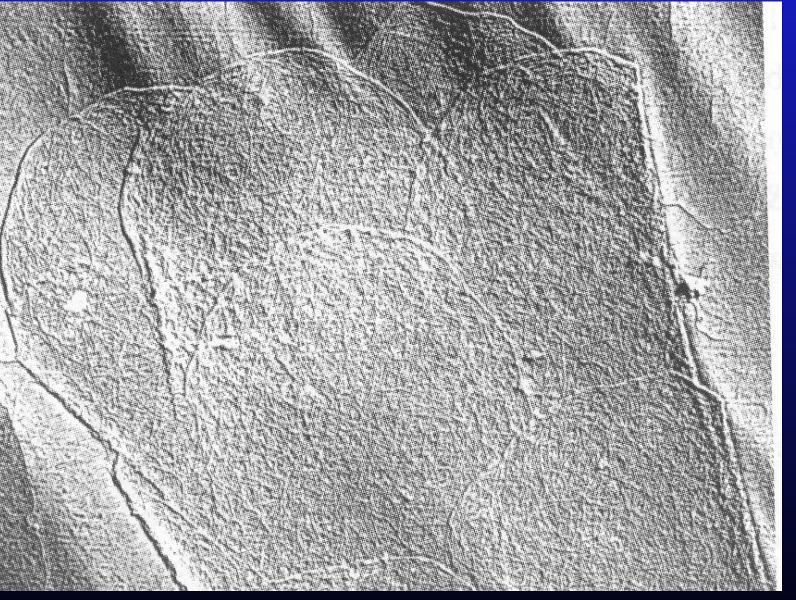
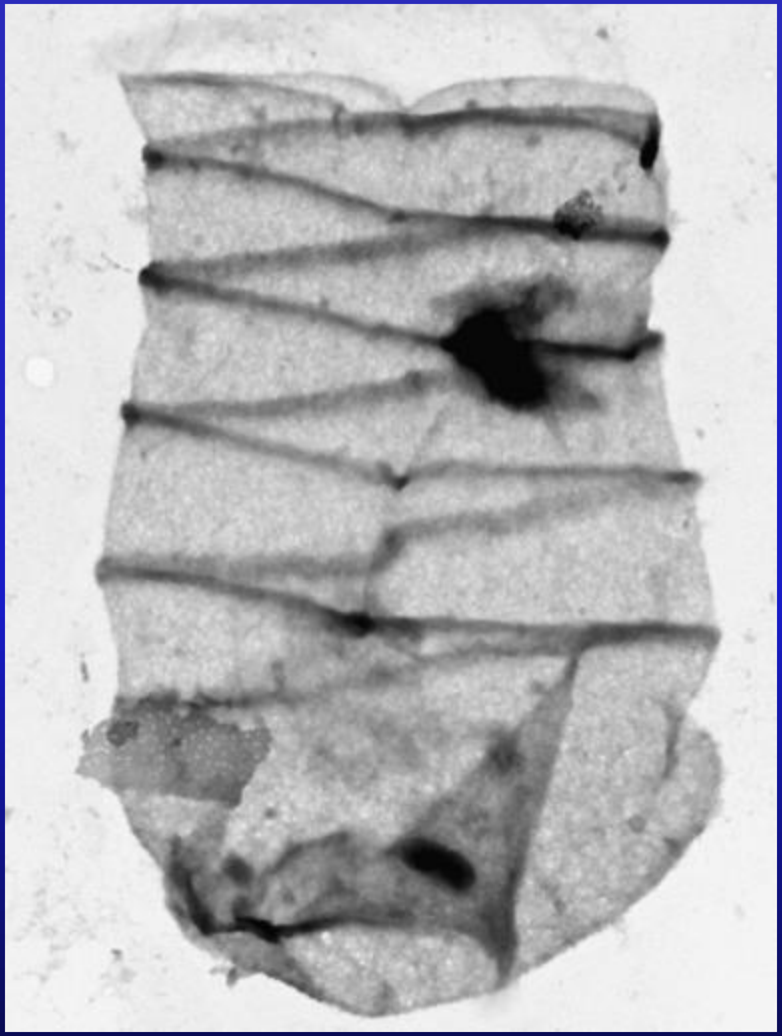


Fig.1.16. Epipyxis utriculus. a: empty loricas on an algal filament, b: single cell in its lorica, c: lorica construction of imbricate scales. LM. (Kristiansen & Preisig 2001).

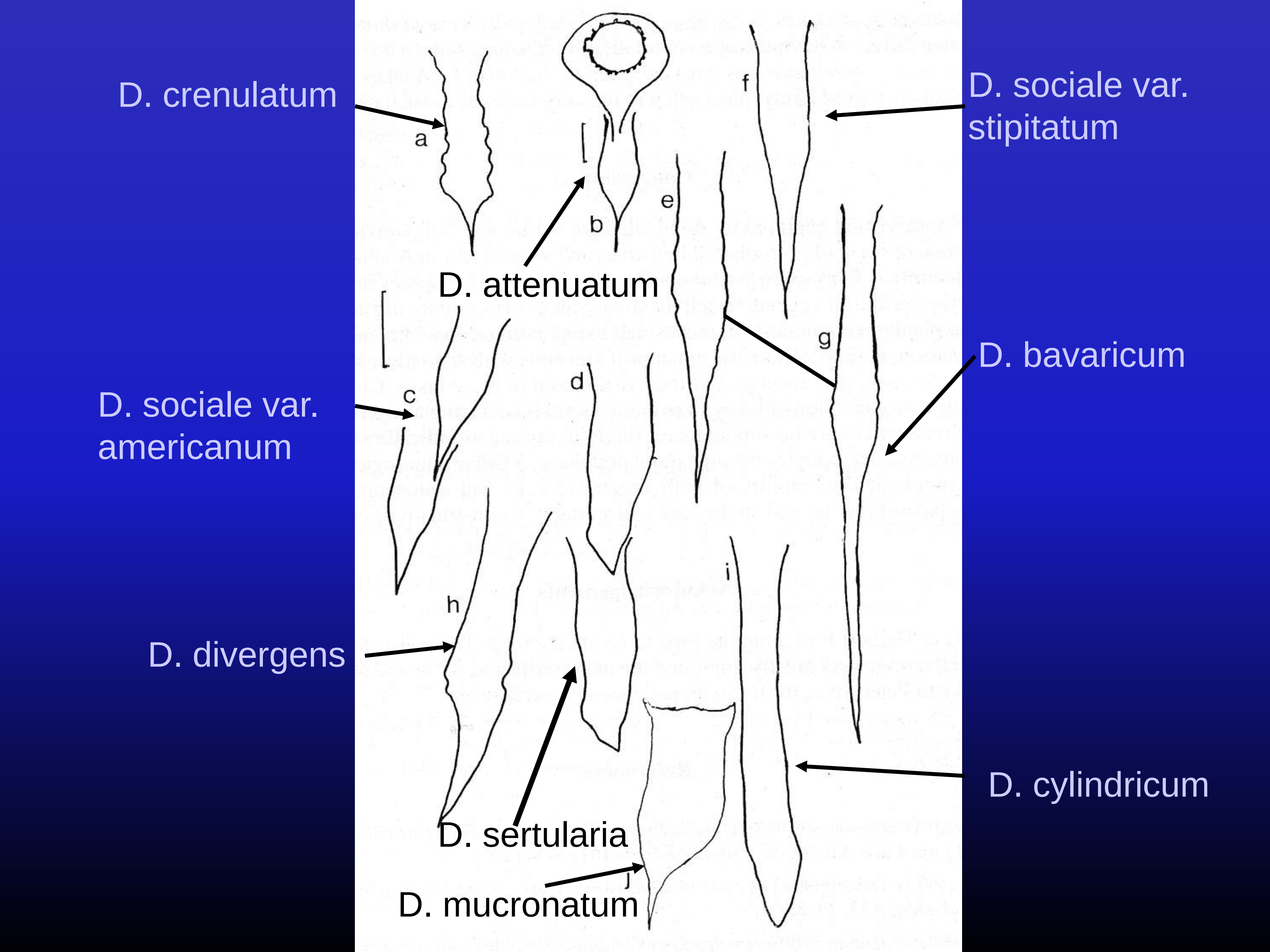


lorica

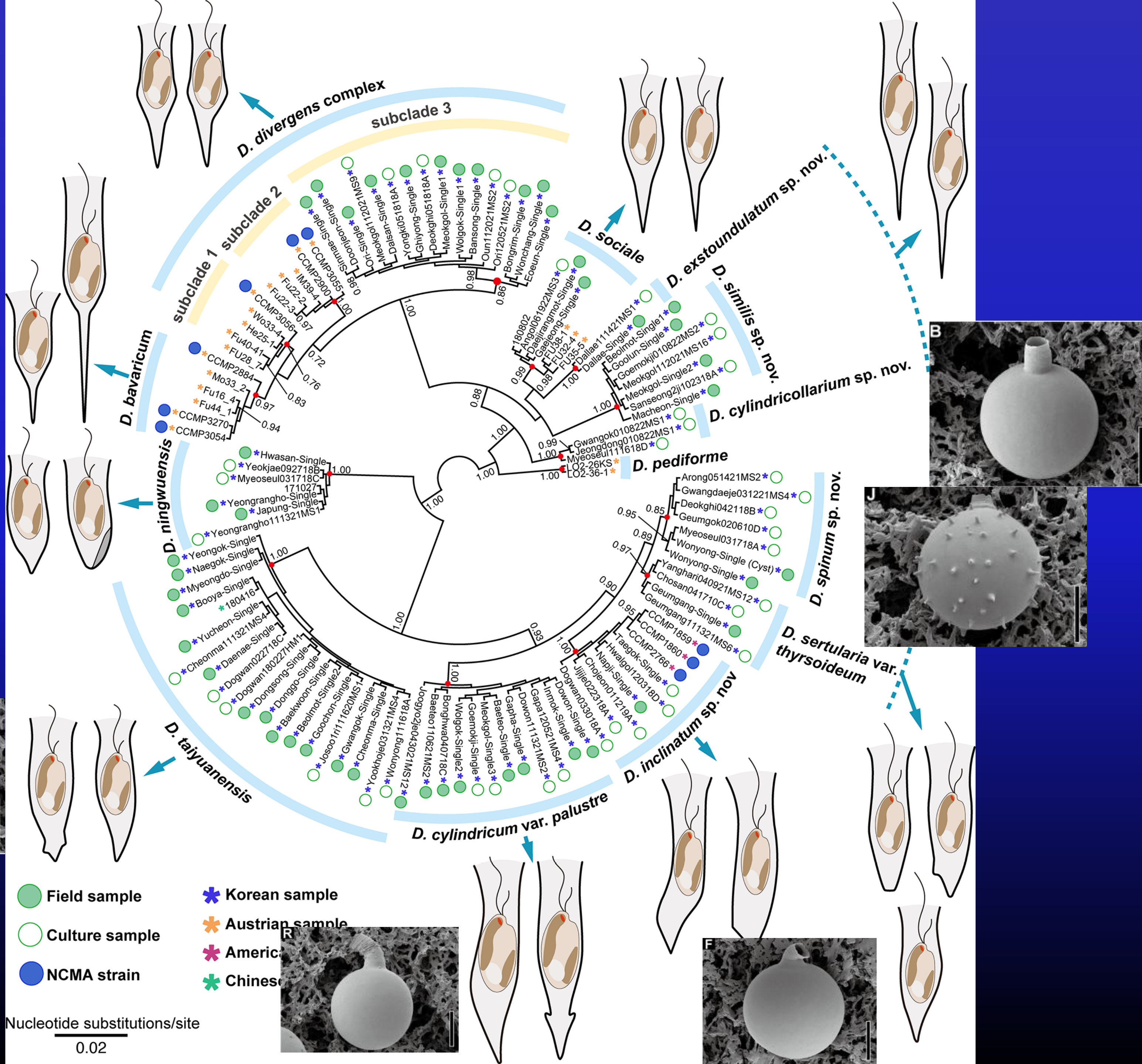
Kephyrion sp.

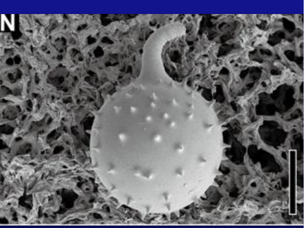


Akvitánie 2010



D. crenulatum
D. attenuatum
D. sociale var. stipitatum
D. bavaricum
D. sociale var. americanum
D. divergens
D. cylindricum
D. sertularia
D. mucronatum
a
b
c
d
e
f
g
h
i
j

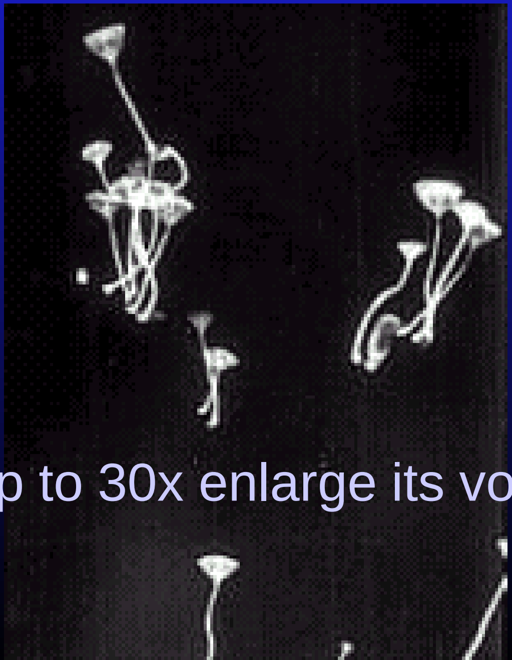




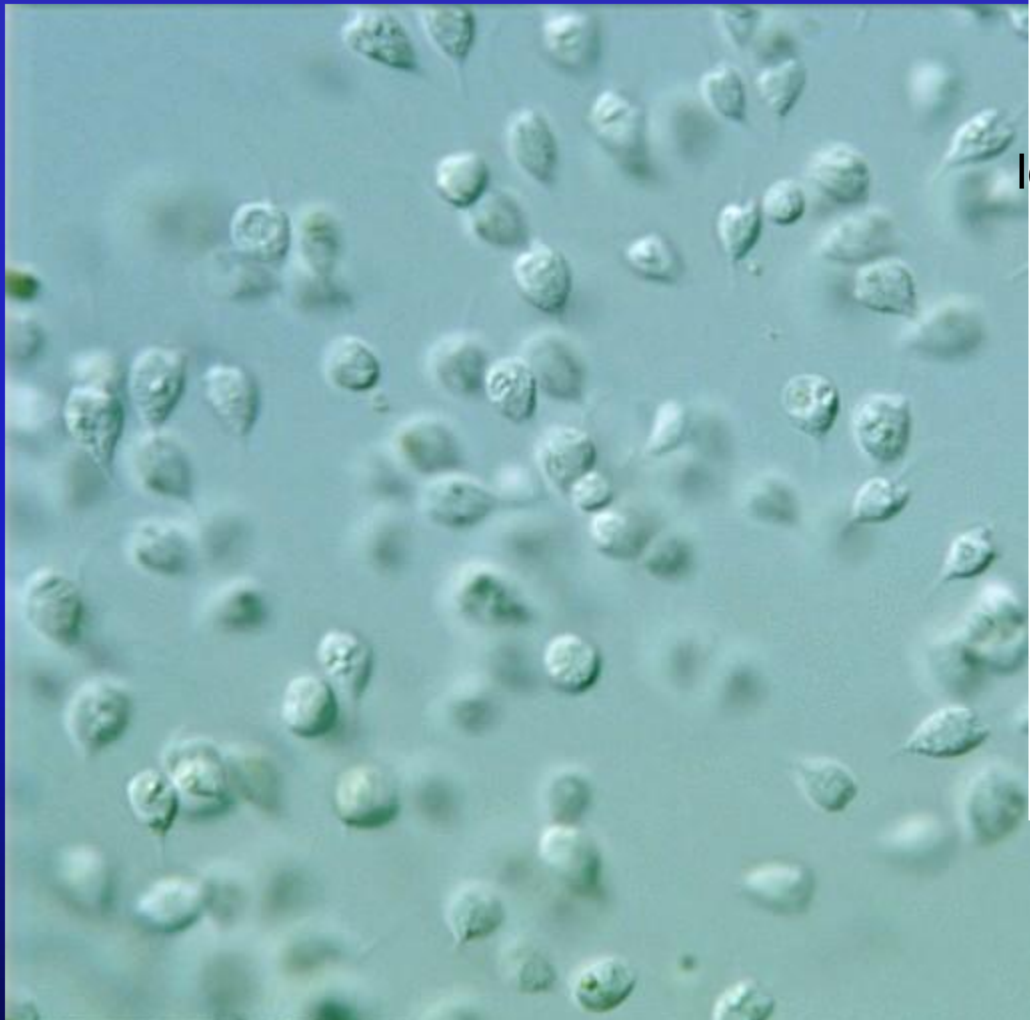
Jeong et al. 2023

Poterioochromonas

hemispherical or cone- to goblet-shaped lorica, a short or long stalk attaching to surfaces; lorica made up of interwoven microfibrils of chitin, the cells not attached to the lorica - easily becoming free when disturbed; 2 unequal flagella, 1-3 chloroplasts (occasionally without chloroplast); nutrition phototrophic and phagotrophic; often difficult to identify - cells escaped from lorica are then indistinguishable from Ochromonas spp.



cannibal; up to 30x enlarge its volume



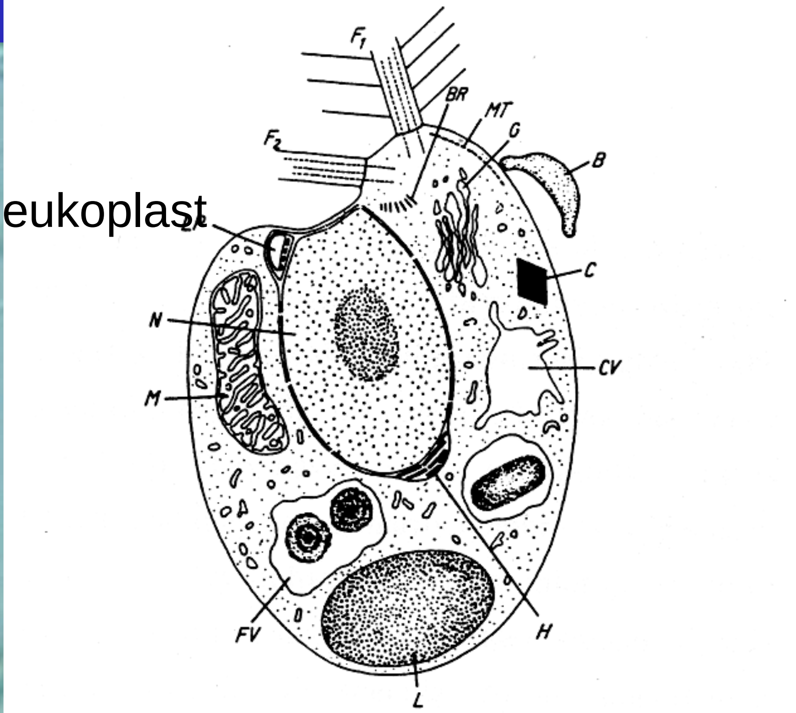


Fig. 3.12. Spumella, the chloroplast has been reduced to a minute leucoplast (lp). (Belcher & Swale 1976).

Spumella

Ochromonas -like, colour-less.

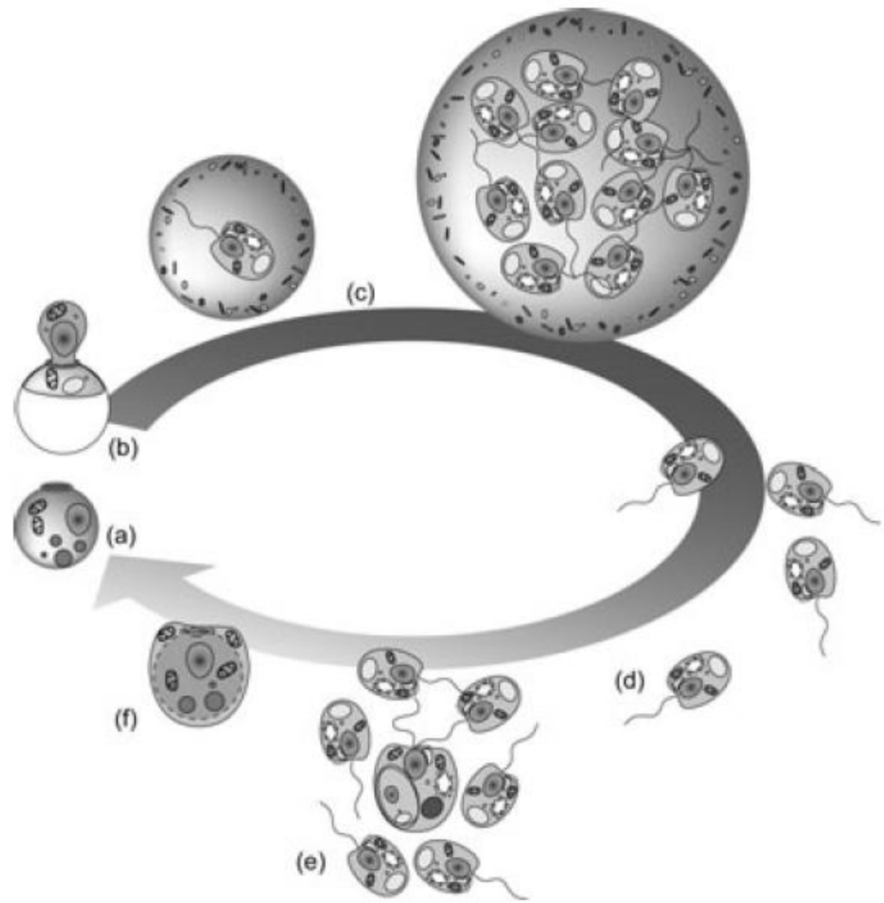
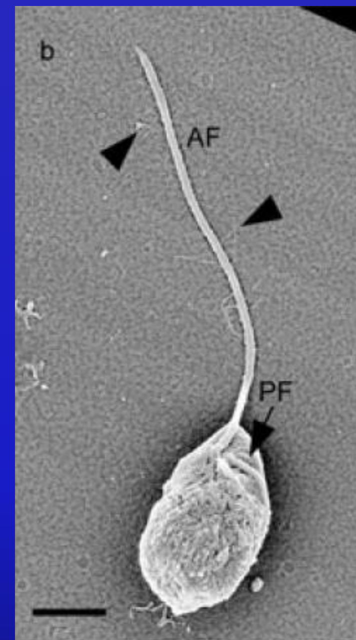
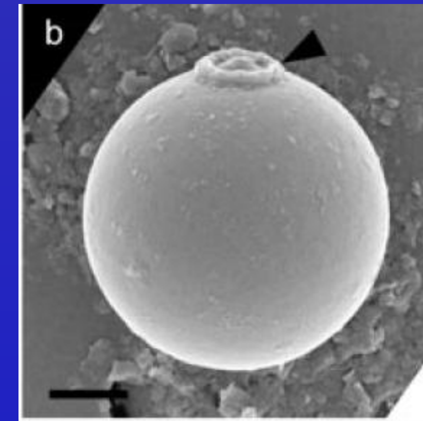
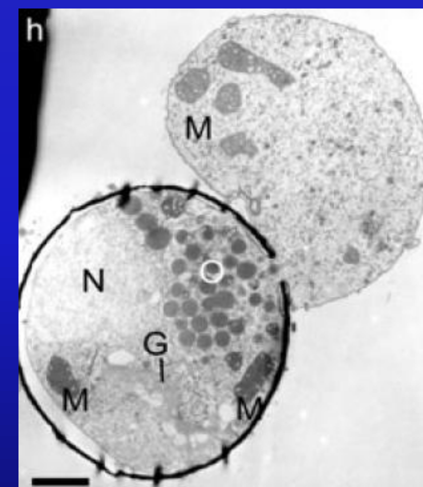


FIG. 5. Diagram of the life cycle of *Spumella* sp. showing (a) statospore, (b) germination of nonmotile cell through the pore, (c) cells in the gelatinous sphere, (d) swimming cells escaped from the gelatinous matrix, (e) giant cell with ingested sibling cell in the swarm, and (f) encystment of the giant cell.

YUBUKI ET AL ■ 2008



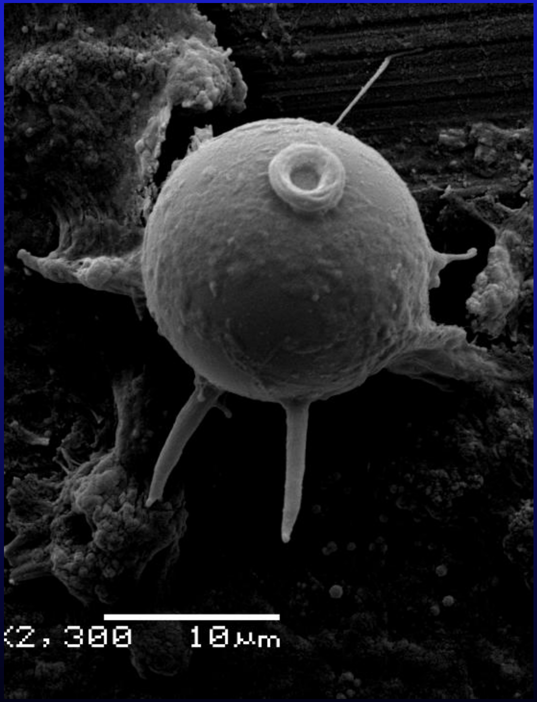


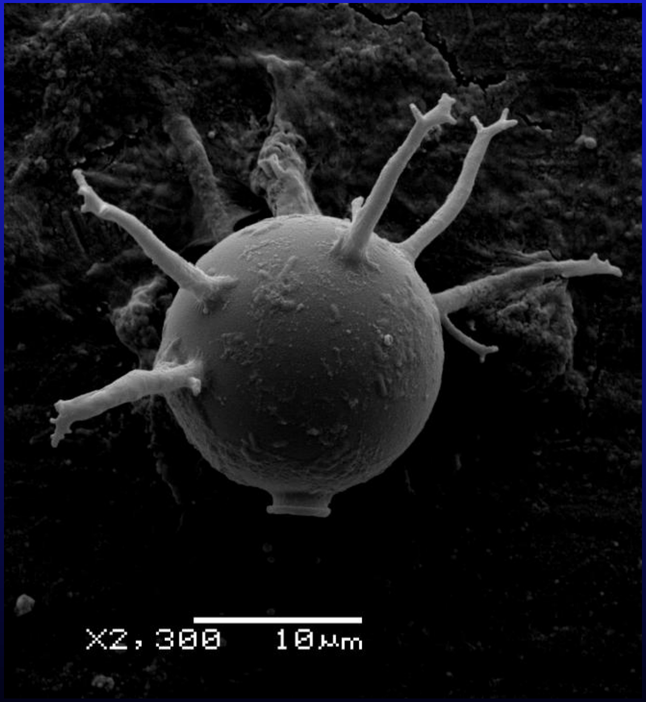


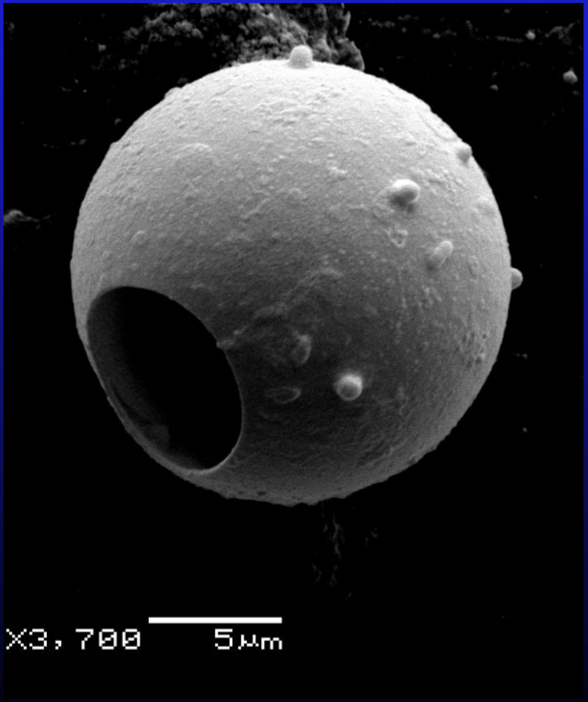
Cannibalism in Spumella

Chrysosaccales

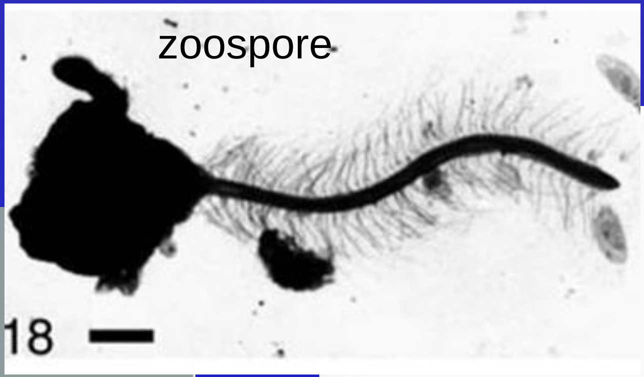
Ochromonas tuberculata

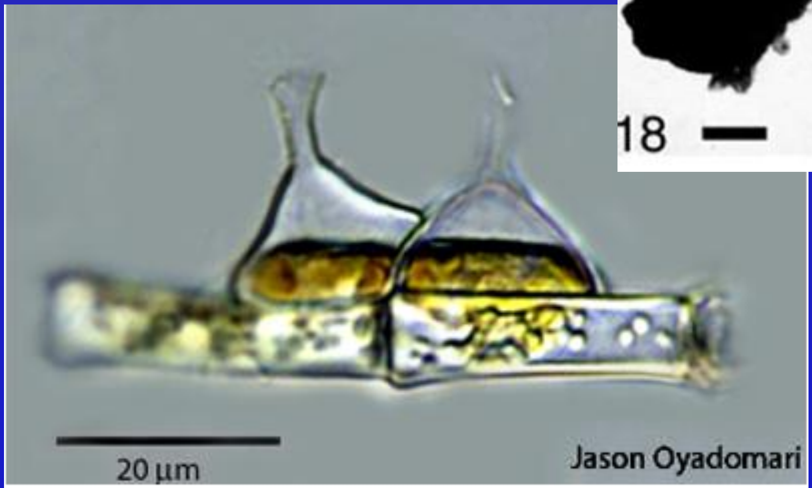


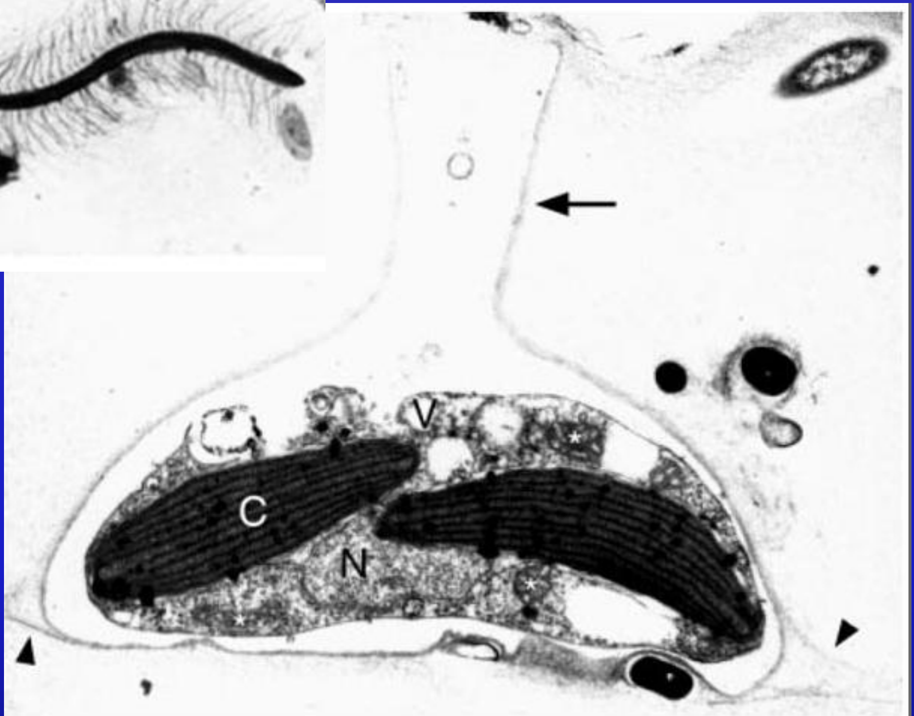




Lagynion



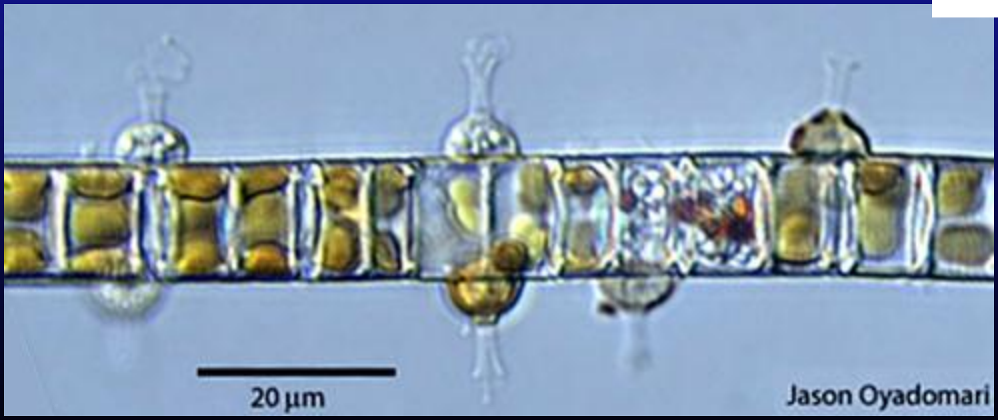




Lagynion delicatulum sessile loricate stage with a single rhizopodium from Lake Namunamu, New Zealand. Electron micrograph from O'Kelly, C., and D. Wujek 2010. Cell structure and asexual reproduction in Lagynion delicatulun (Stylococcaceae, Chrysophyceae). European J. Phycol.

Epiphytic. Lorica; rhizopodium

soft-water lakes

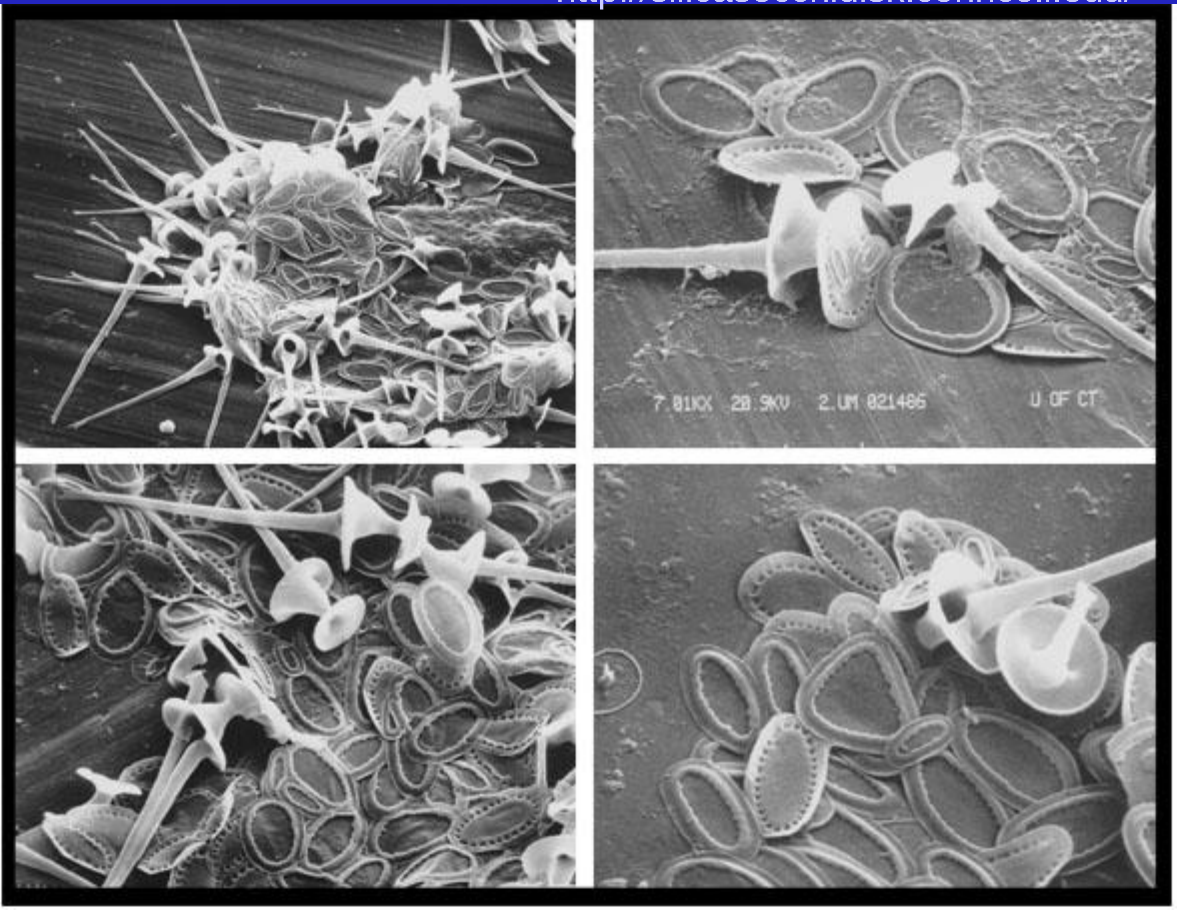


Chromulinales

Chrysosphaerella

Colonial, possesses chloroplast, cells connected by elongated stipe

http://silicasecchidisk.conncoll.edu/

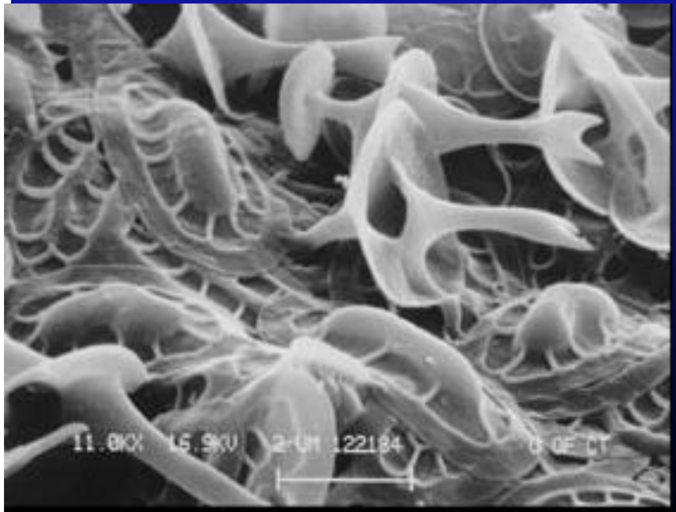


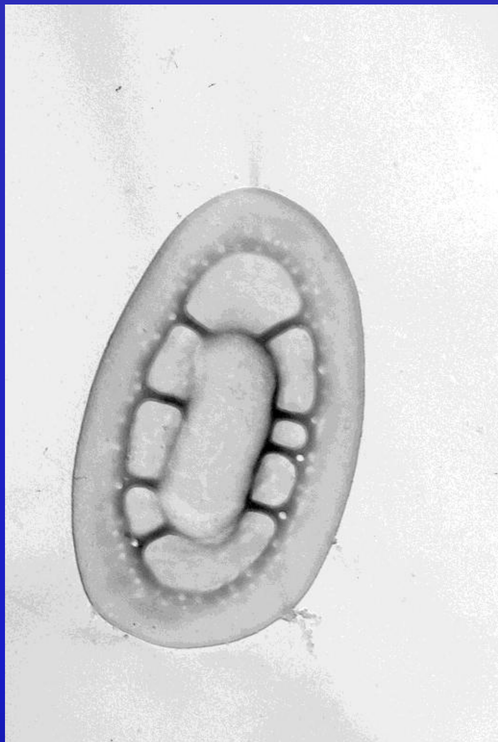
Chrysosphaerella brevispina

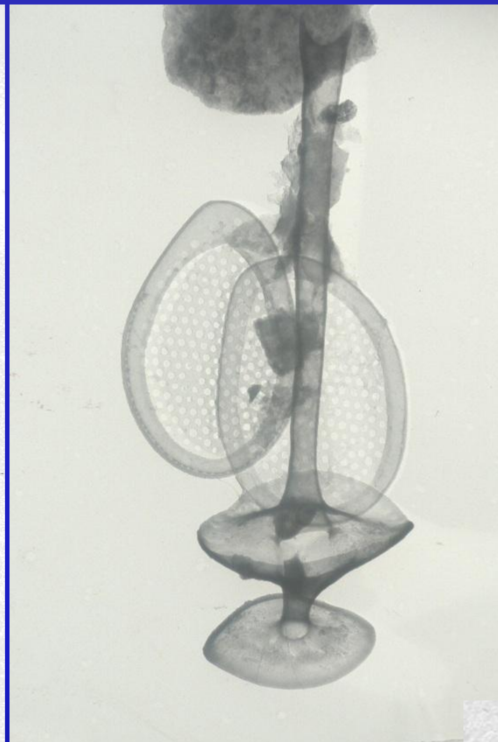
Korsh em. Harris and Bradley

Ch. brevispina – basal scale

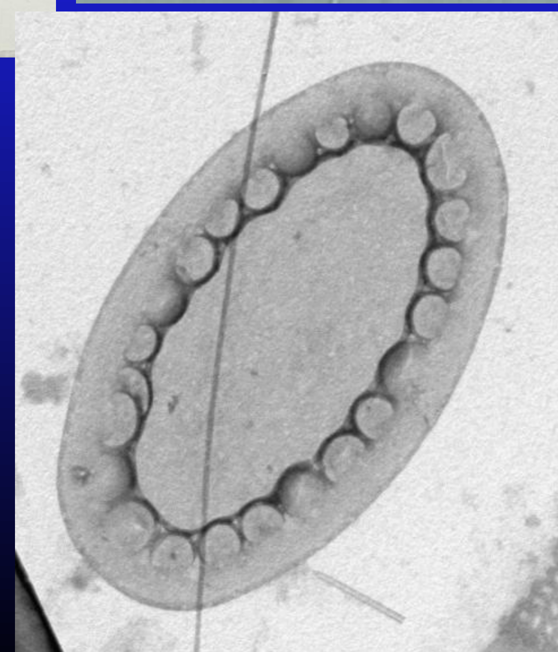
C. longispina

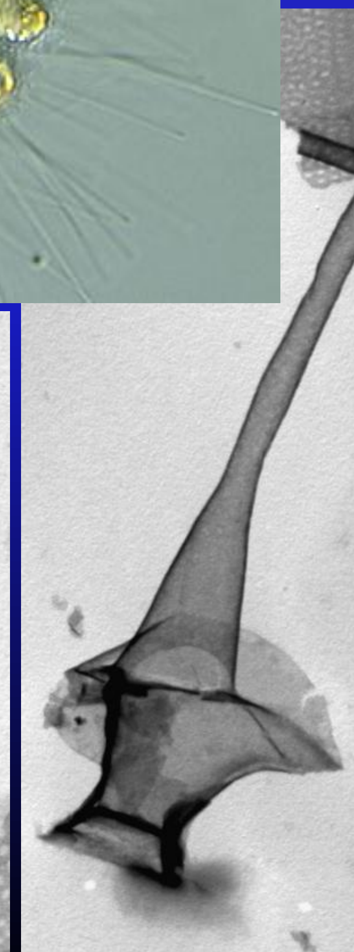






C. longispina

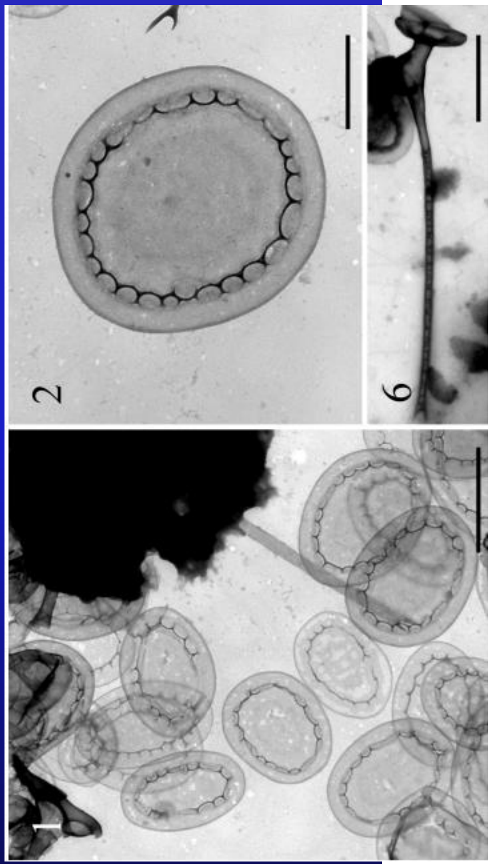


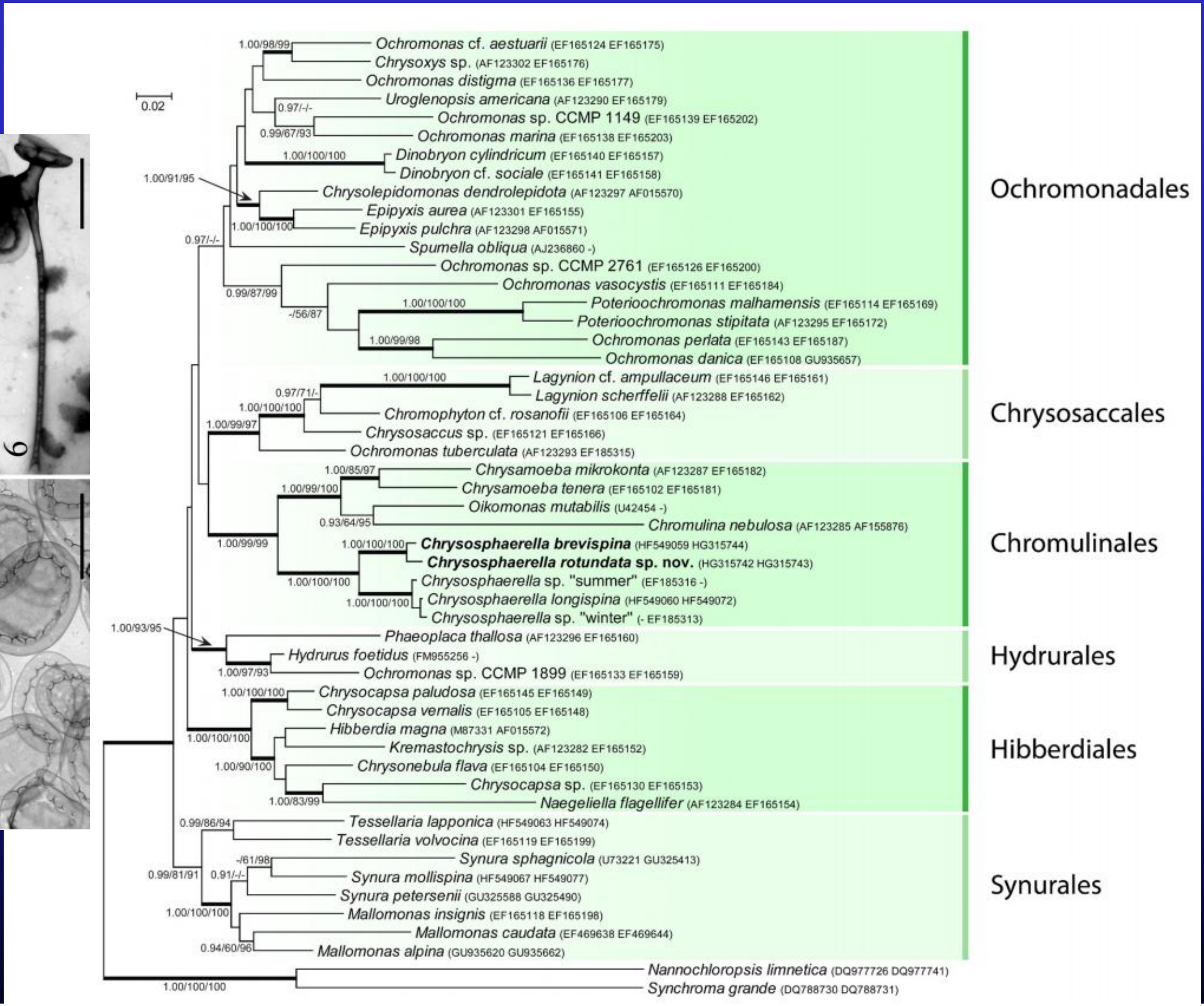


C. brevispina

C. rotundata

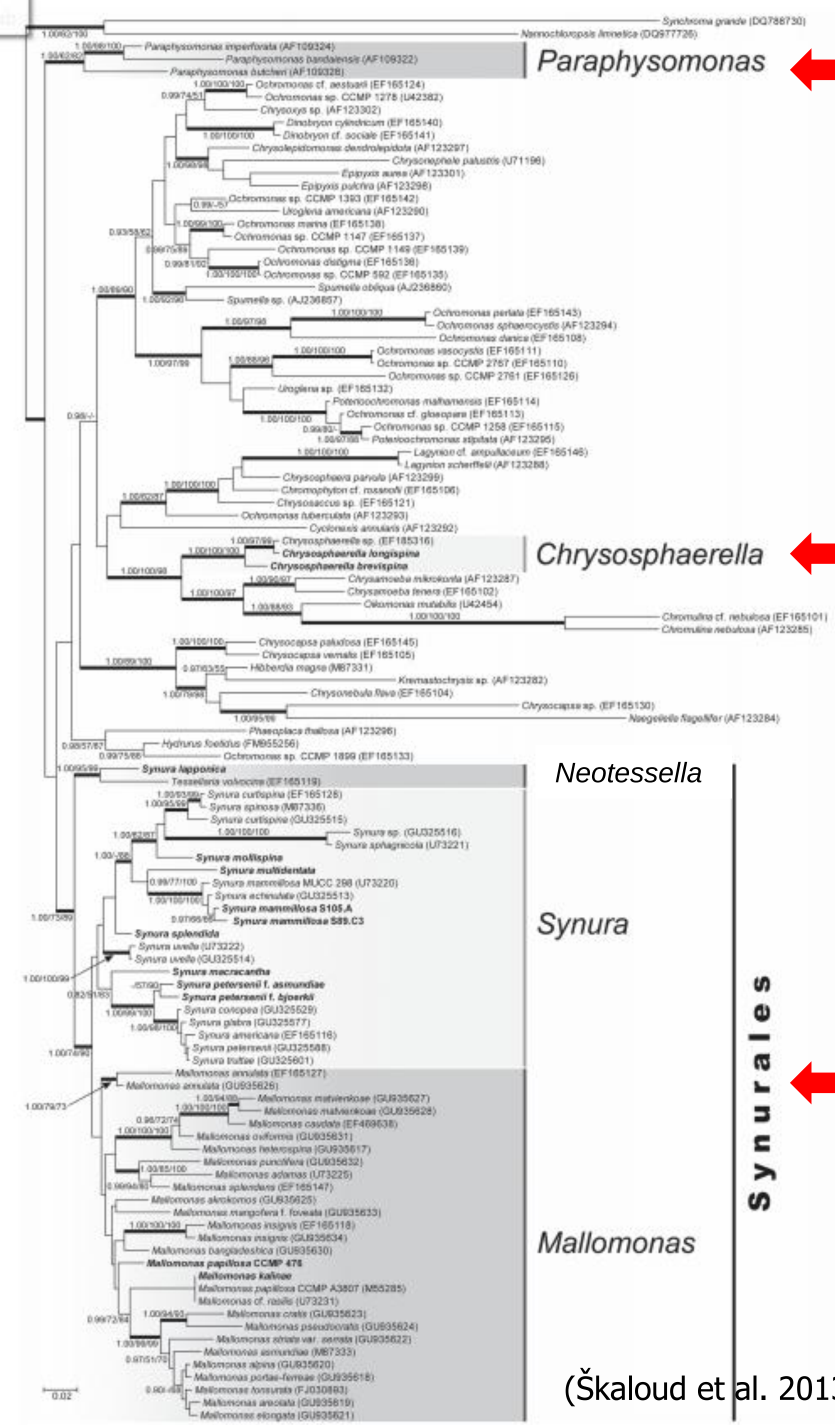
Škaloudová et
Škaloud 2013





Bayesian analysis of Chrysophyceae, based on the combined and partitioned SSU rDNA + *rbc*L dataset

Silica-scaled chrysophytes - phylogenetic relations



(Škaloud et al. 2013)

Spiniferomonas minuta – Gulf of Bothnia

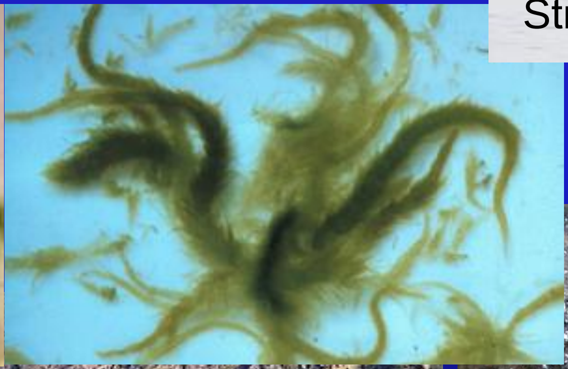
Silica-scales developed repeatedly

Hydrurales

Hydrurus

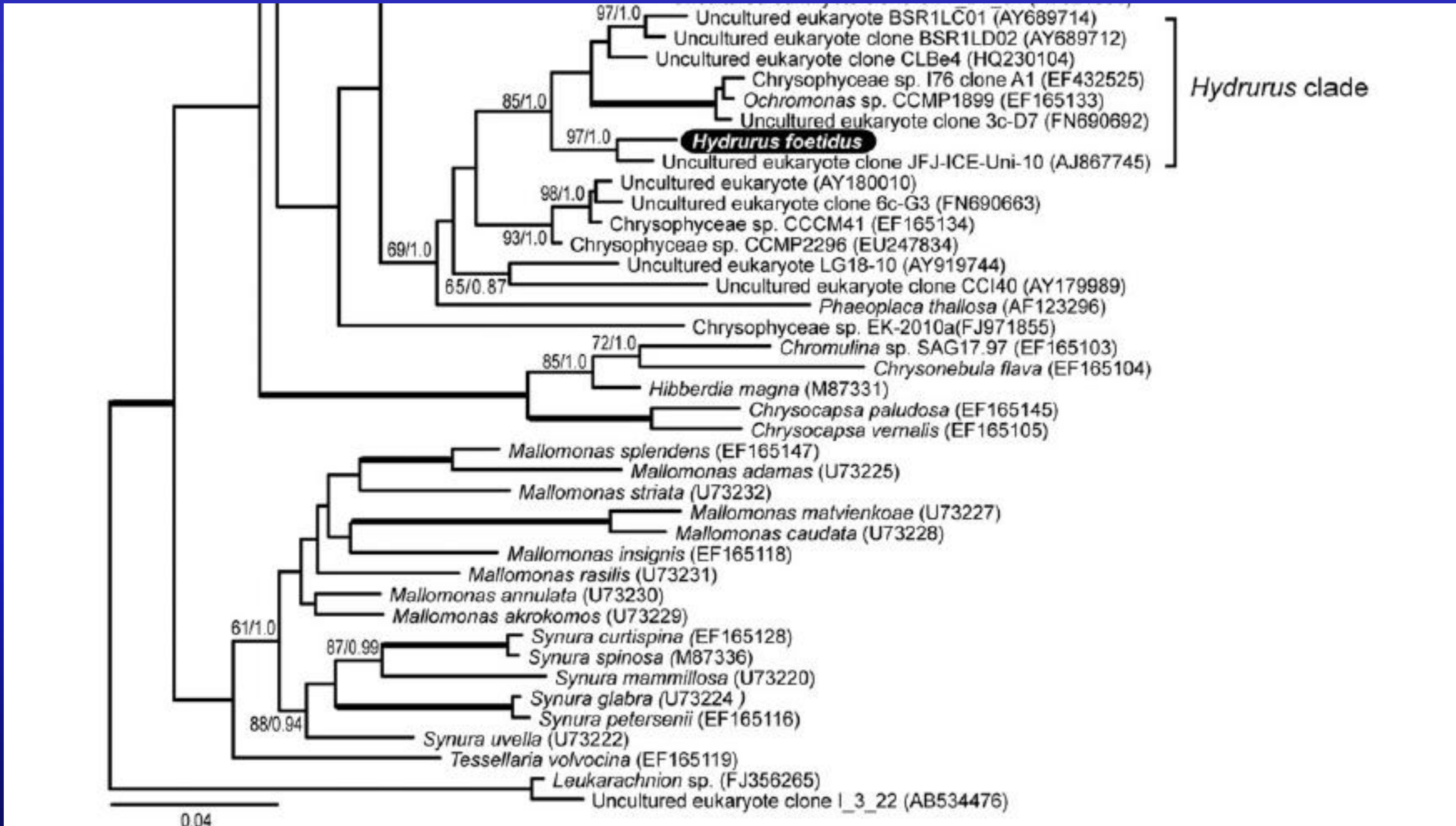
macroscopic up to 30 cm; palmelloid life form; growing apically,
inhabitates strong currents; the peculiar polysaccharide protecting the alga from disruption, epilithic

Finse Alpine Research Center Norway
Strøm 1926 *locus classicus*



limestone - karst, cold-water species

Hydrurus

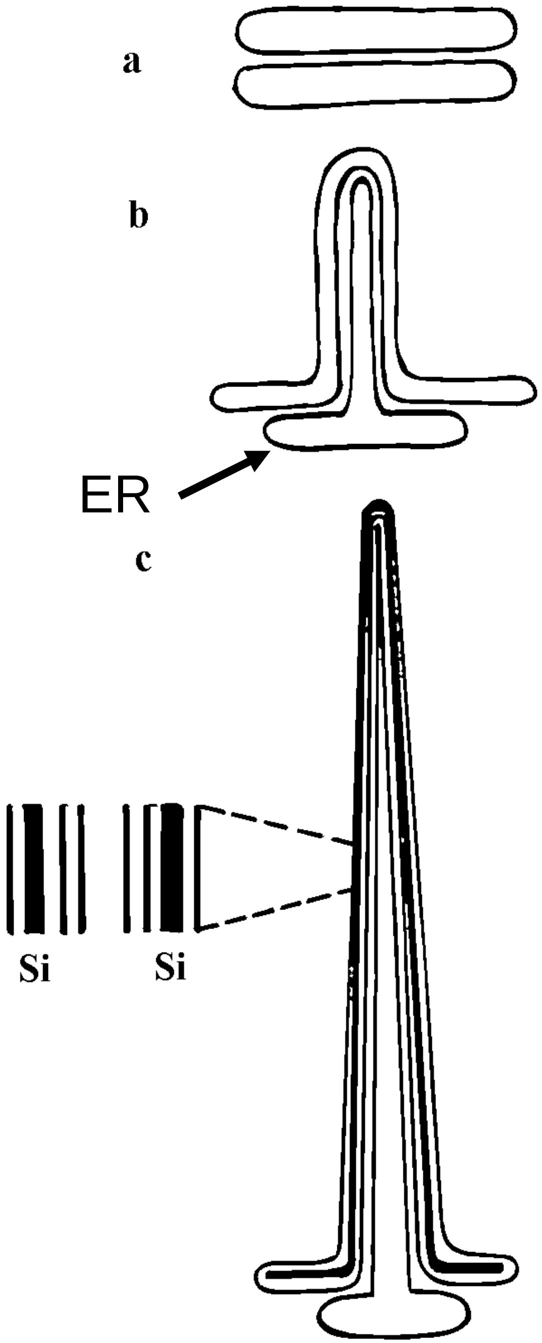


Klaveness et al. 2011

Hydrurus complex – not well defined

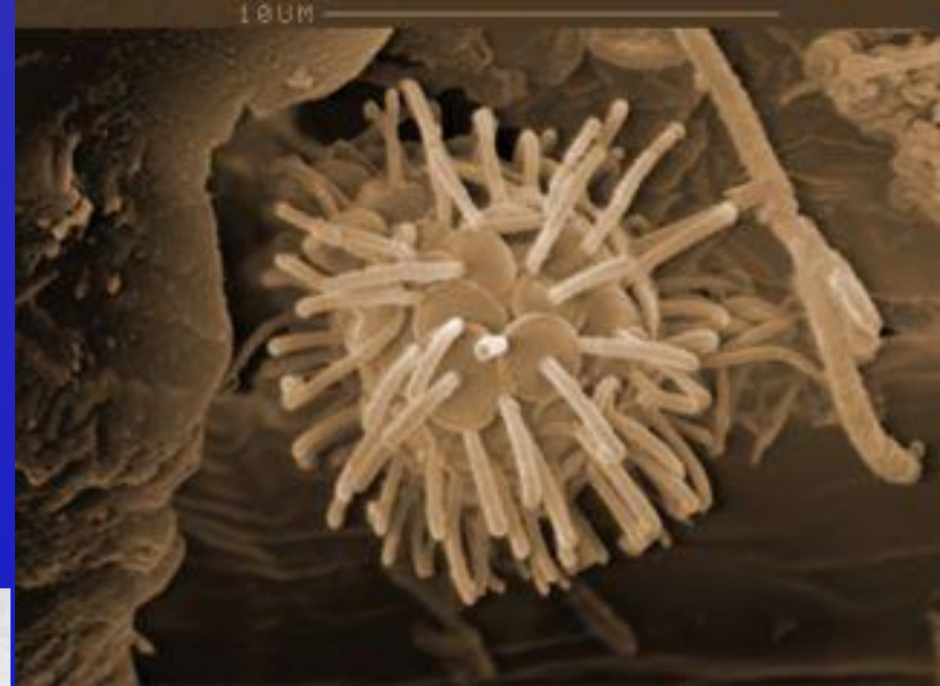
Paraphysomonas

Silica scales



Paraphysomonas /Lepidochromonas

Single cells, no chloroplasts (leukoplasts). Secondary lost. Connected to the substrate by a thin stipe or free living.



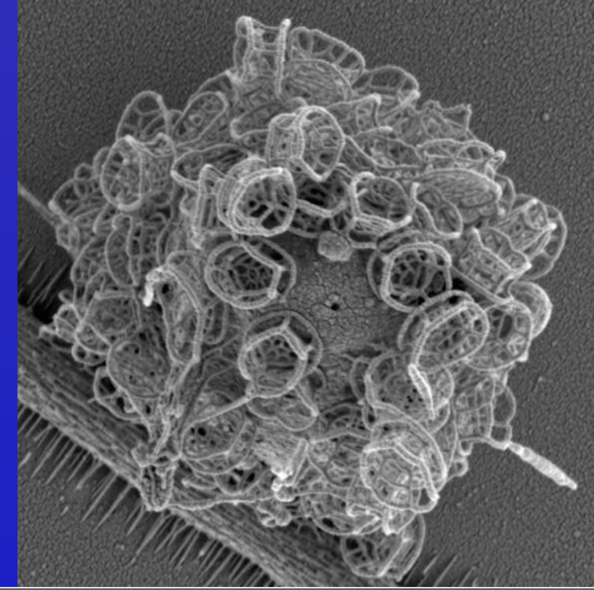
Lepidochromonas

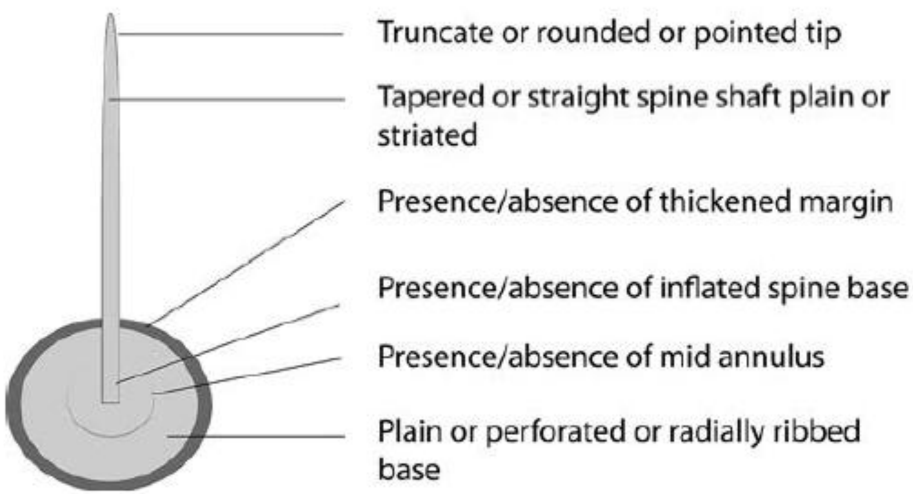
Available online at www.sciencedirect.com
ScienceDirect
European Journal of Protistology 50 (2014) 551–592
European Journal of PROTISTOLOGY
www.elsevier.com/locate/ejop

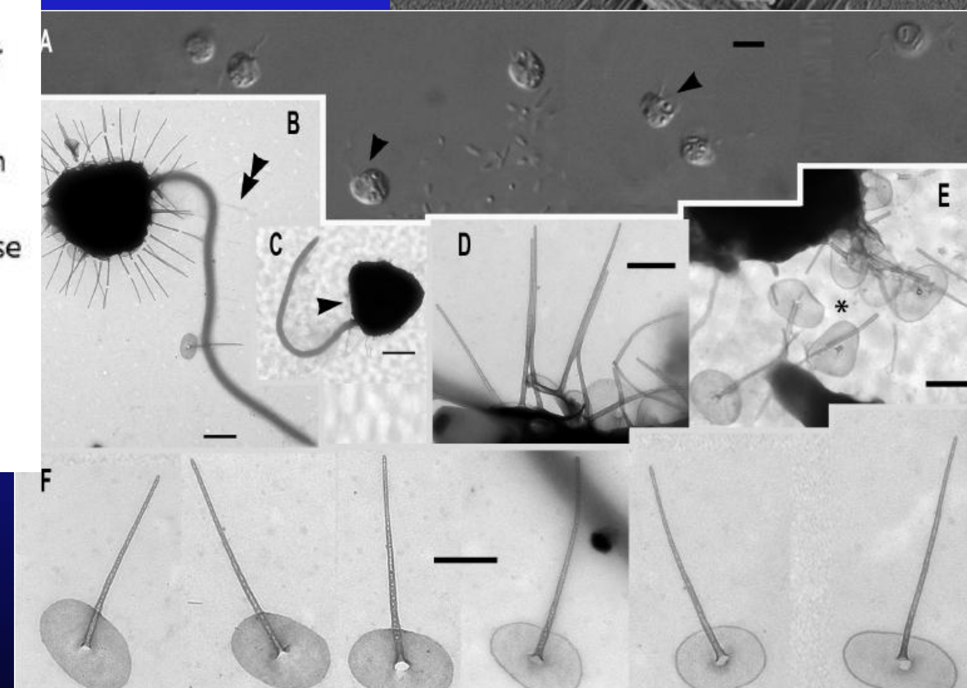
Scale evolution in Paraphysomonadida (Chrysophyceae): Sequence phylogeny and revised taxonomy of *Paraphysomonas*, new genus *Clathromonas*, and 25 new species

Josephine Margaret Scoble*, Thomas Cavalier-Smith

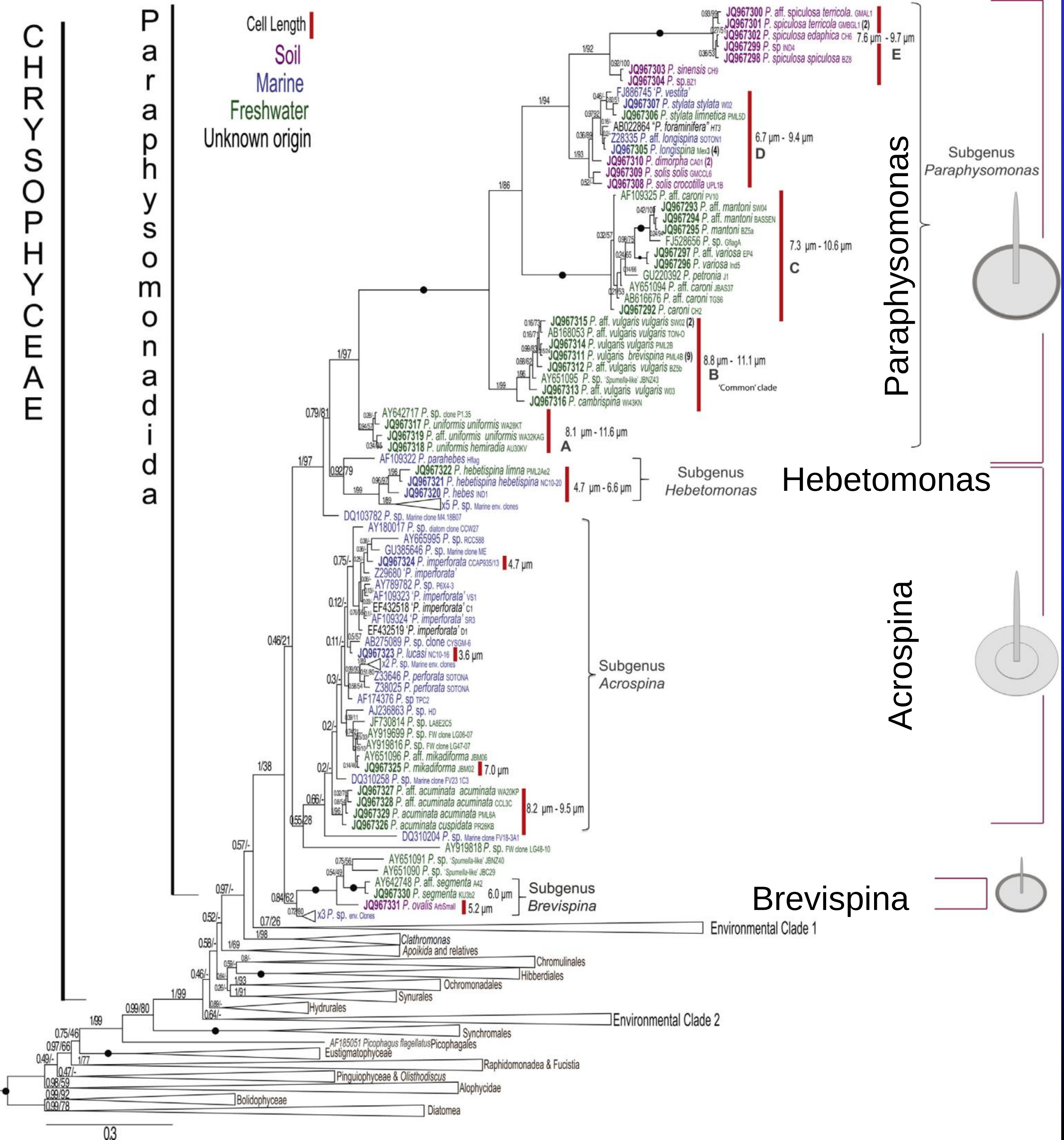
Lepidochromonas







Micrographs of two new species of subgenus *Brevispina*: *Paraphysomonas segmenta.*



4 subgenera

We cannot not precisely compare new species with the type species *P. vestita* because its scale type is unknown.

Ideally we would have liked to establish a neotype to end that confusion, but no isolate was sufficiently similar (by light microscopy) to Stokes'

MrBayes covarion tree for 329 ochrophyte 18S rDNA sequences showing only the branching order of *Paraphysomonas* sensu strictoin detail (1672 nucleotide positions).

species with basket scales
Scoble et Cavalier-Smith (2014)

basal

spine

crown-scales

Lepidochromonas

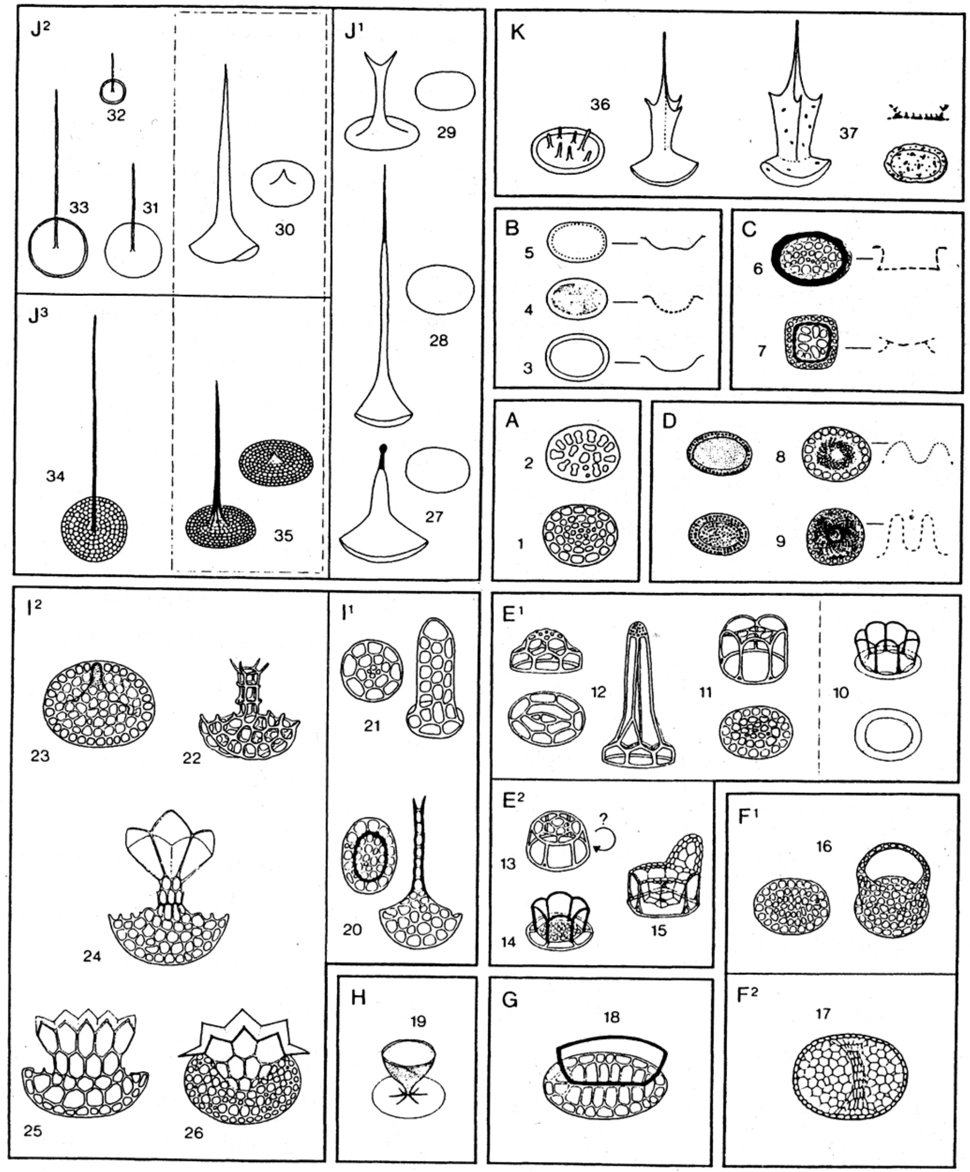
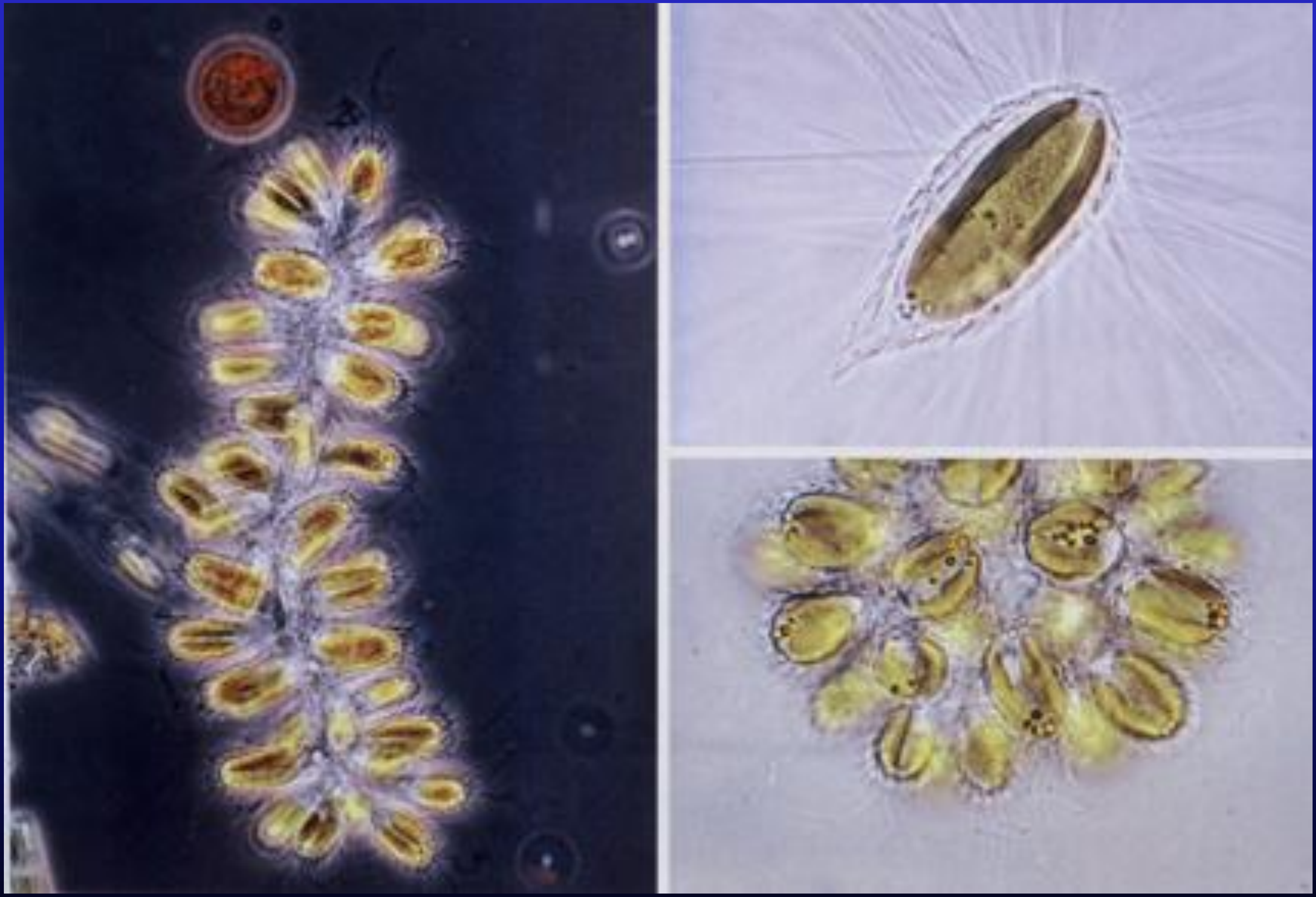
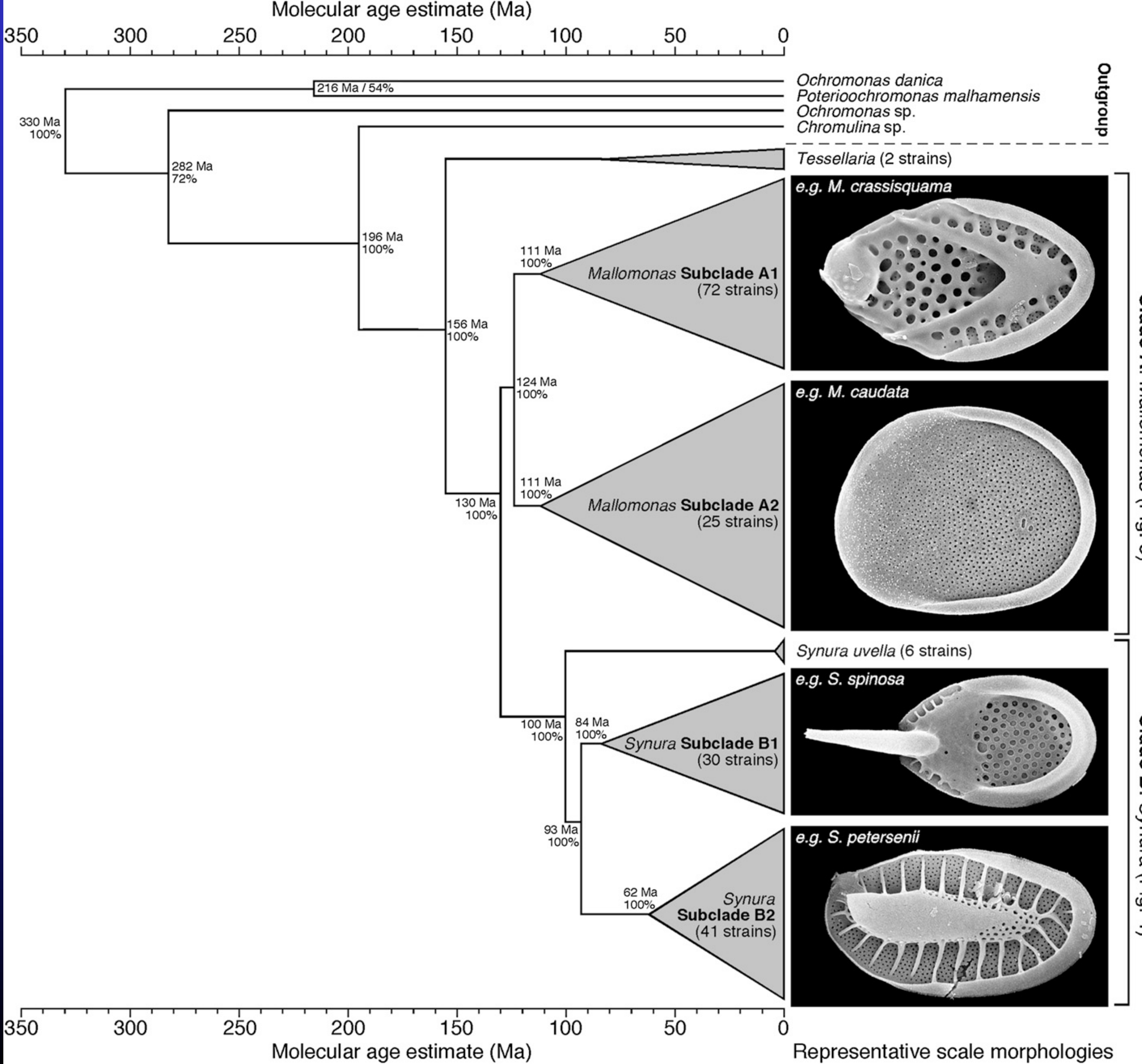


Diagram illustrating some of the possible relationships between all of the known species of *Paraphysomonas*. Species with similar scales are included in groups and subgroups (see text). The scales are not drawn at the same magnification and for those shown in perspective or sectional view the bottom of the diagram is considered to be proximal. 1 : *P. homolepis*, 2: *P. subrotacea*, 3: *P. circumvallata*, 4: *P. punctata*, 5: *P. limbata*, 6: *P. runcinifera*, 7: *P. subquadrangularis*, 8: *P. undulata*, 9: *P. ignivoma*, 10: *P. diademifera*, 11: *P. butcheri*, 12: *P. cribosa*, 13: *P. corbidifera*, 14: *P. stephanolepis*, 15: *P. morchella*, 16: *P. sigillifera*, 17: *P. canistrum*, 18: *P. sideriophora*, 19: *P. cylicophora*, 20: *P. eiffelii*, 21: *P. faveolata*, 22: *P. quadrispina*, 23: *P. cancellata,*, 24: *P. poteriophora*, 25: *P. coronata*, 26: *P. stelligera*, 27: *P. corynephora*, 28: *P. bourrellyi*, 29: *P. capreolata*, 30: *P. gladiata*, 31: *P. imperforata*, 32: *P. bandaiensis*, 33: *P. vestita*, 34: *P. foraminifera*, 35: *P. takahashii*, 36: *P. acantholepis*, 37: *P. caelifrica*.

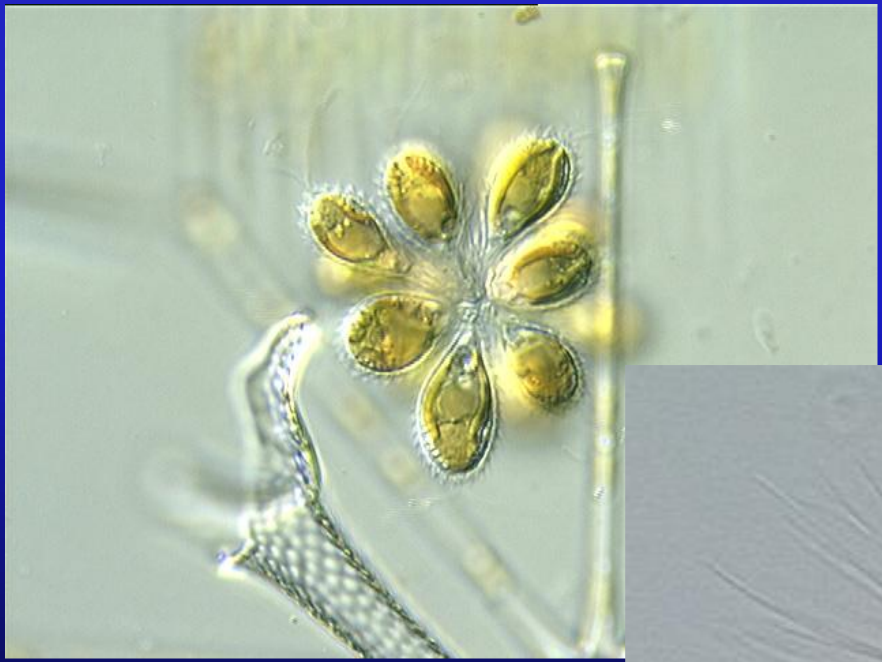
Synurales

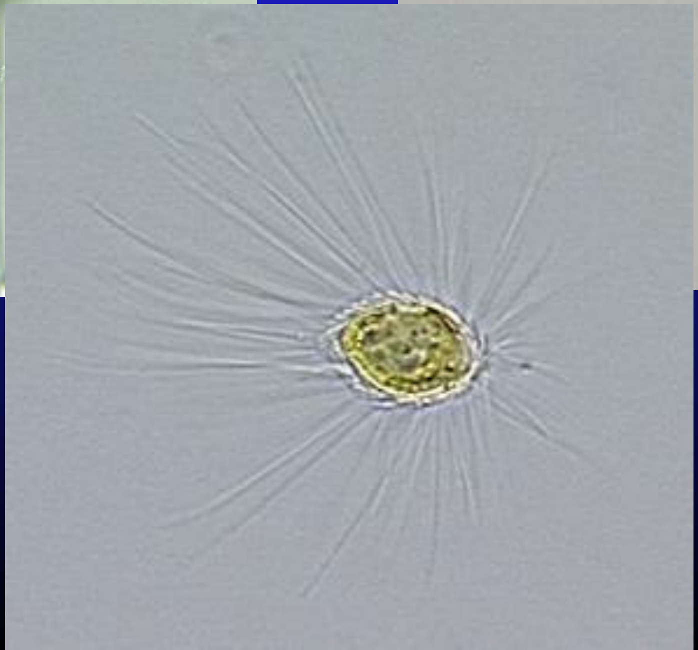




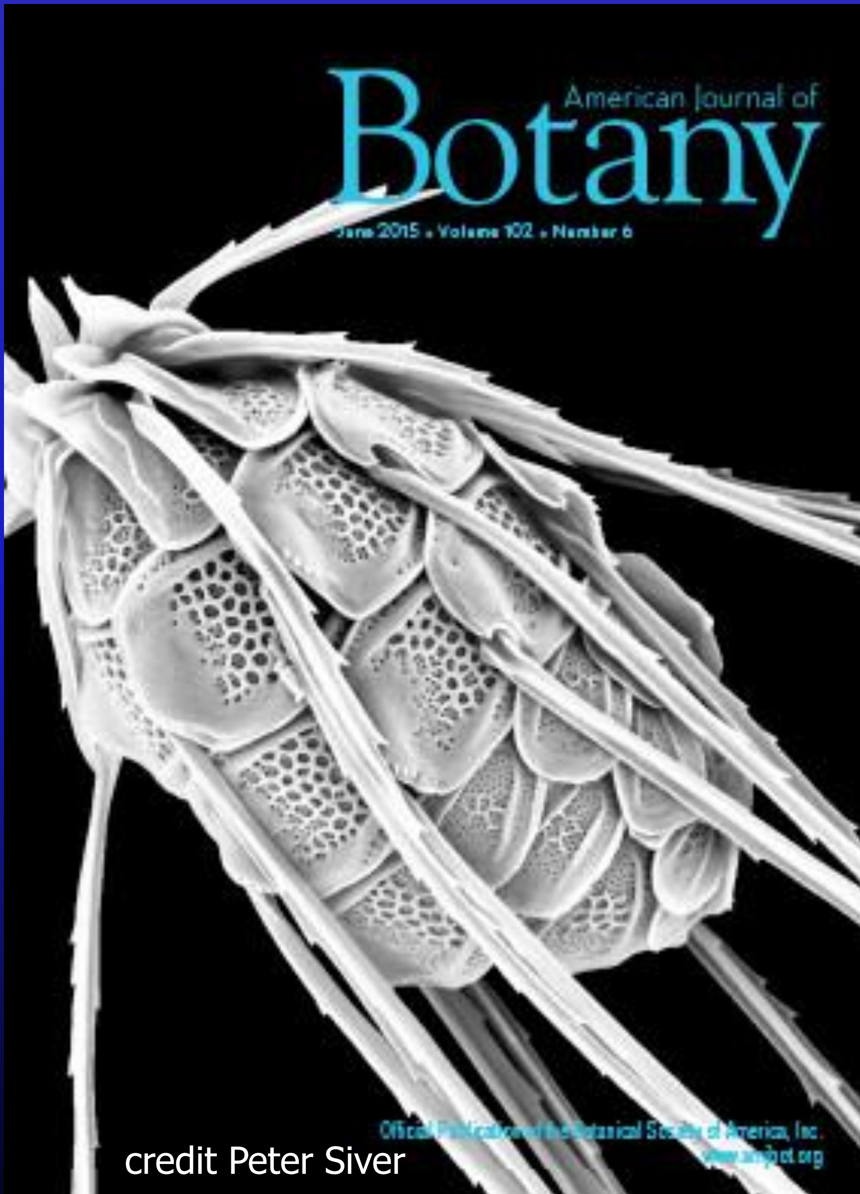
Molecular age estimate (Ma)
350 300 250 200 150 100 50 0
Ochromonas danica
Poterioochromonas malhamensis
Ochromonas sp.
Chromulina sp.
Outgroup
216 Ma / 54%
330 Ma 100%
282 Ma 72%
196 Ma 100%
156 Ma 100%
130 Ma 100%
124 Ma 100%
111 Ma 100%
111 Ma 100%
100 Ma 100%
93 Ma 100%
84 Ma 100%
62 Ma 100%
Tessellaria (2 strains)
e.g. M. crassisquama
Mallomonas Subclade A1 (72 strains)
e.g. M. caudata
Mallomonas Subclade A2 (25 strains)
Clade A: Mallomonas (Fig. 3)
Synura uvella (6 strains)
e.g. S. spinosa
Synura Subclade B1 (30 strains)
e.g. S. petersenii
Synura Subclade B2 (41 strains)
Clade B: Synura (Fig. 4)
Representative scale morphologies

single living or colonial freshwatwr flagellates - **photoautotrophy**
recently 3 genera:
Mallomonas, *Synura*, *Neotessella* (Jo et al. 2016)

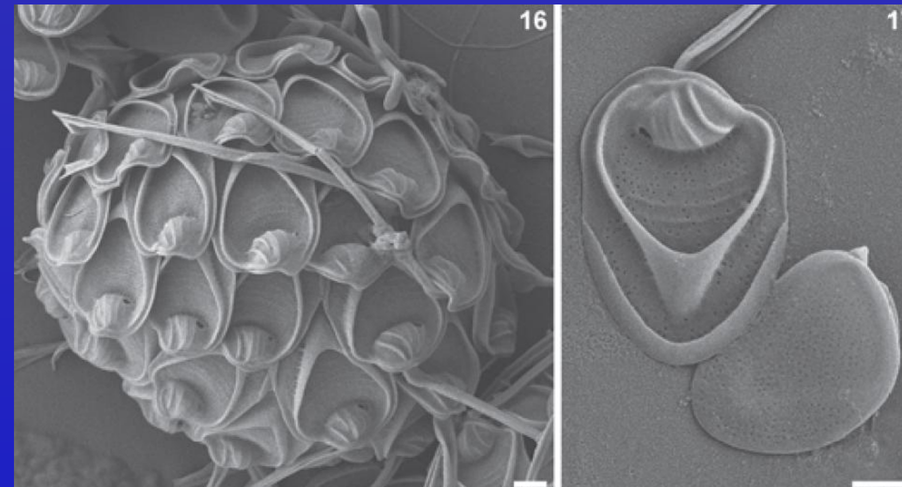




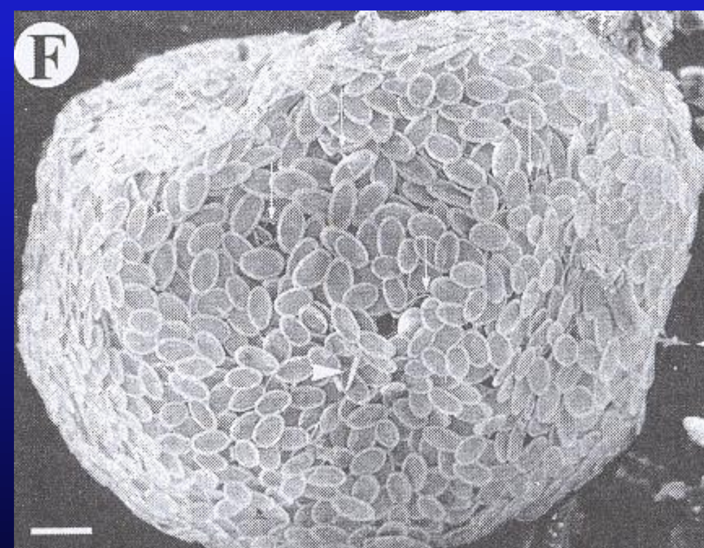
Bristles in *Mallomonas*

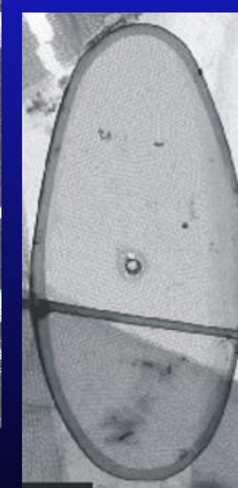


credit Peter Siver



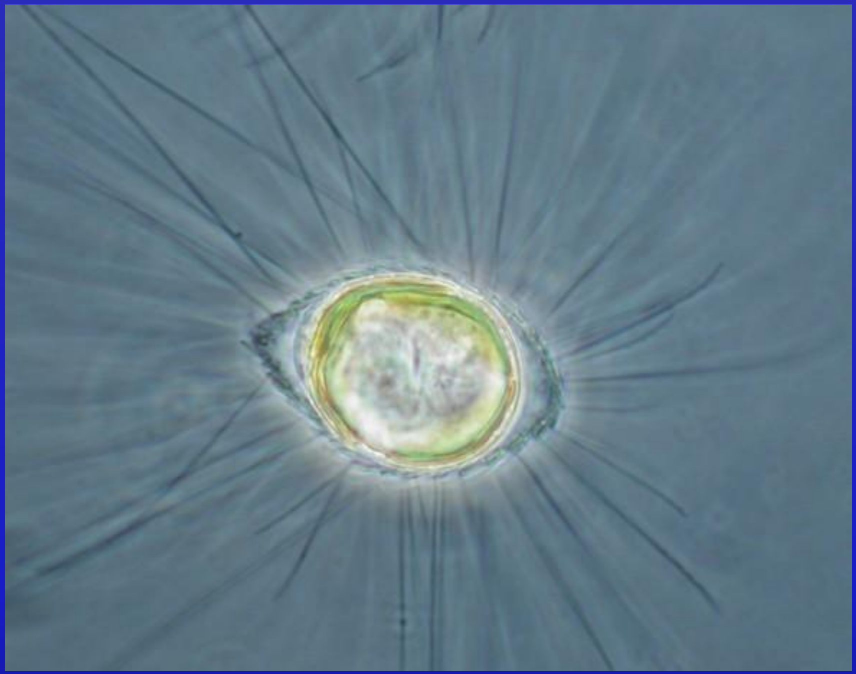
Scales in *Neotessella*





secondary structures???

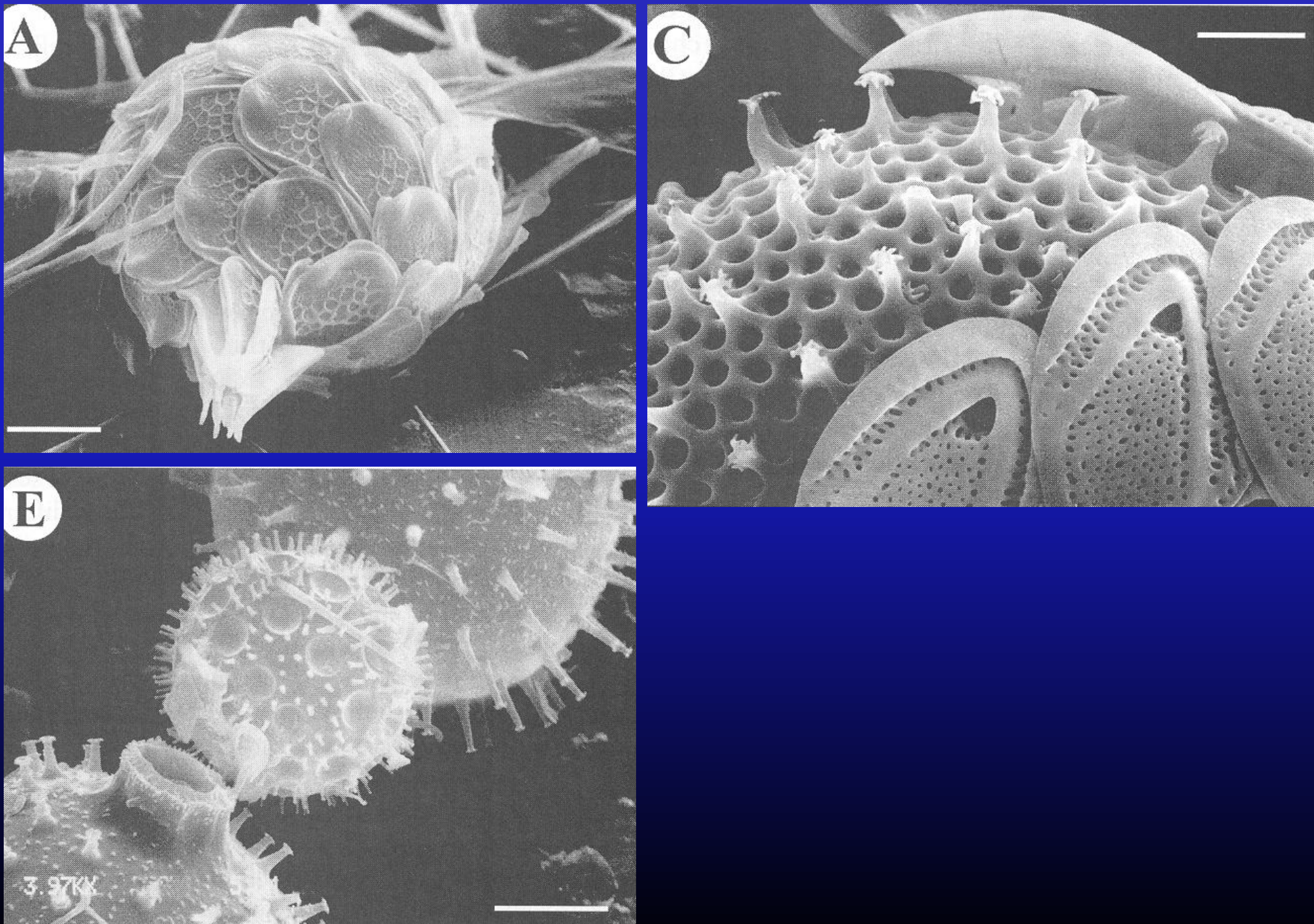
Stomatocysts



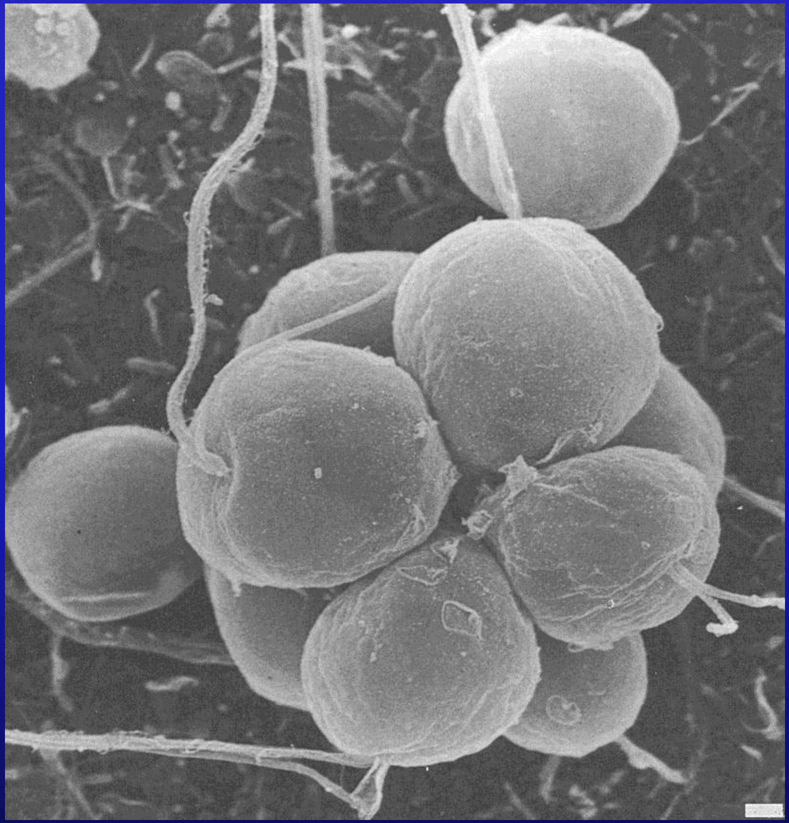
M. punctifera - cysta

Mallomonas caudata - cysta

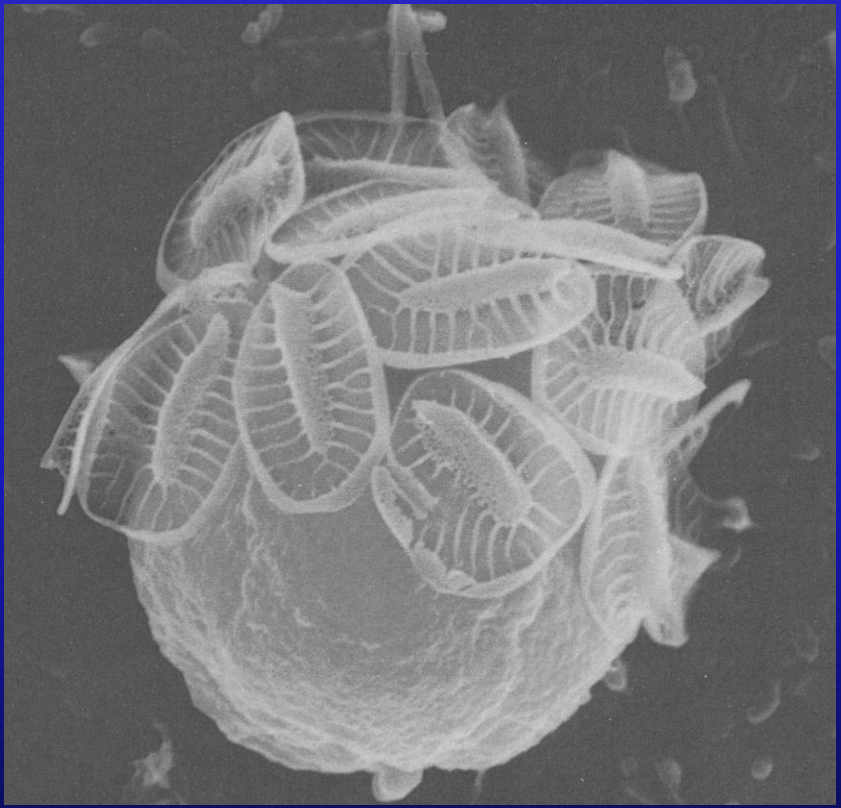
Stomatocysts in SEM



Do they need silica?

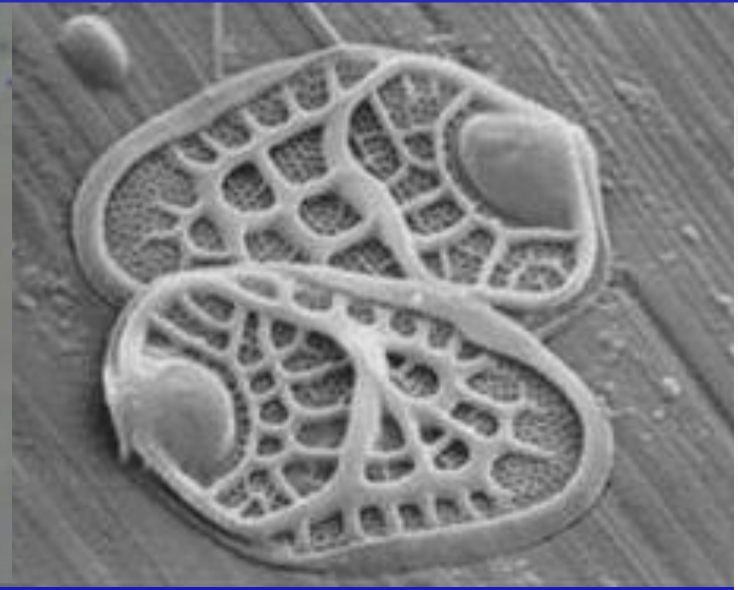
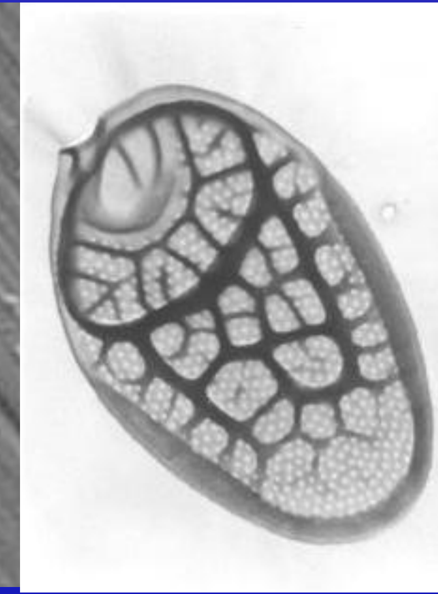


Sangren et al. 1996



diatoms x Synurales

Scale determination

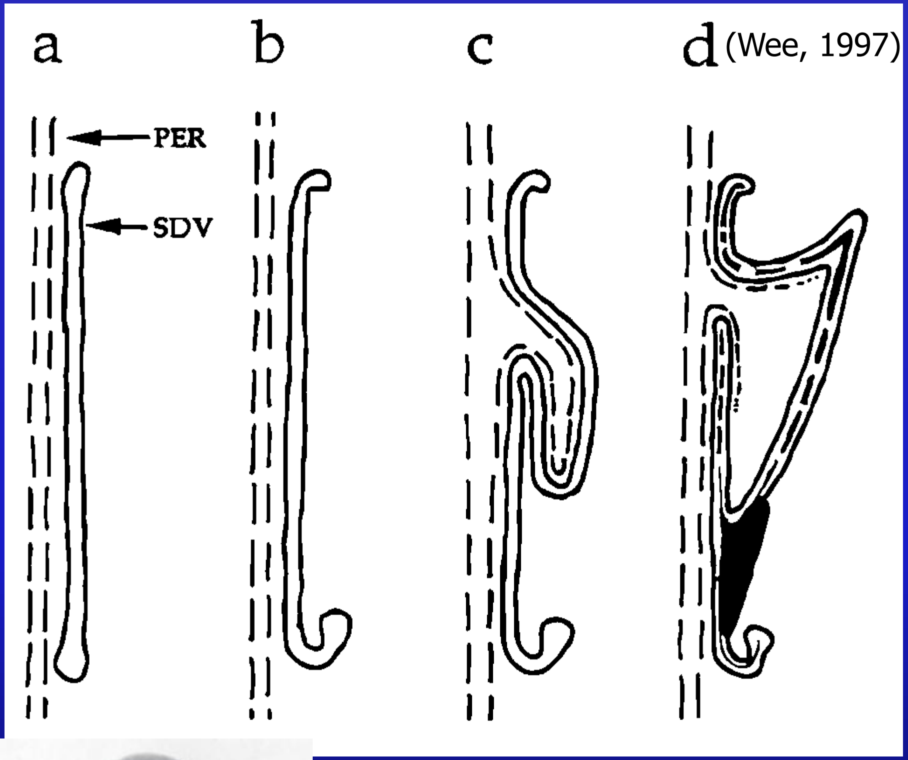




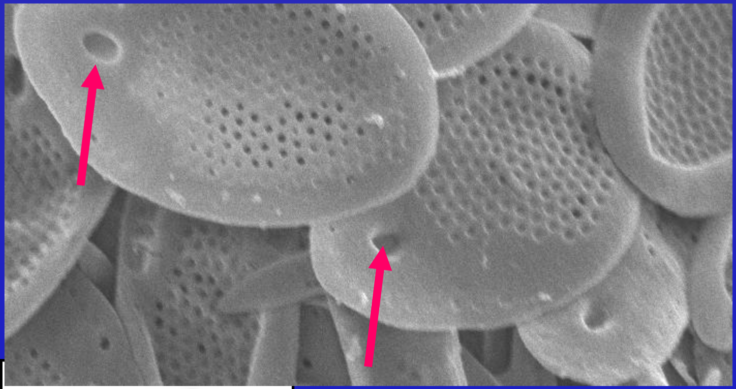
light microscope

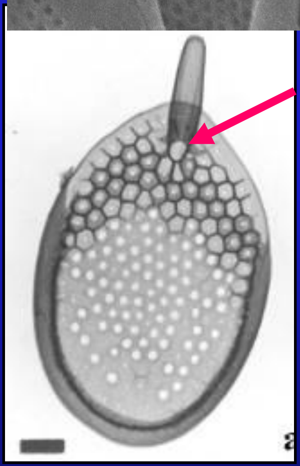
Scanning and transmision electron microscope
M. heterospina

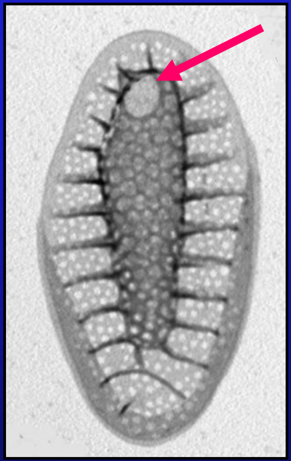
Morphology studied by means of TEM or SEM is necessary for the **right identification** of synurales species. Scales of some species may be observed in LM in Pleurax preparations (same as diatoms frustules)

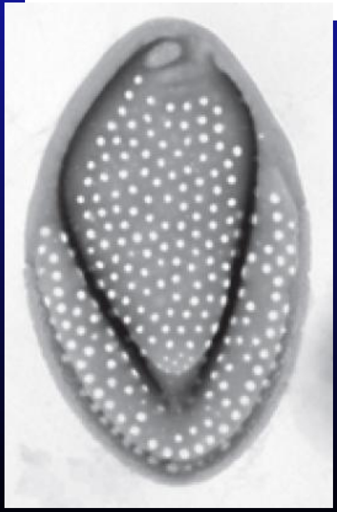
Silica scale biogenesis

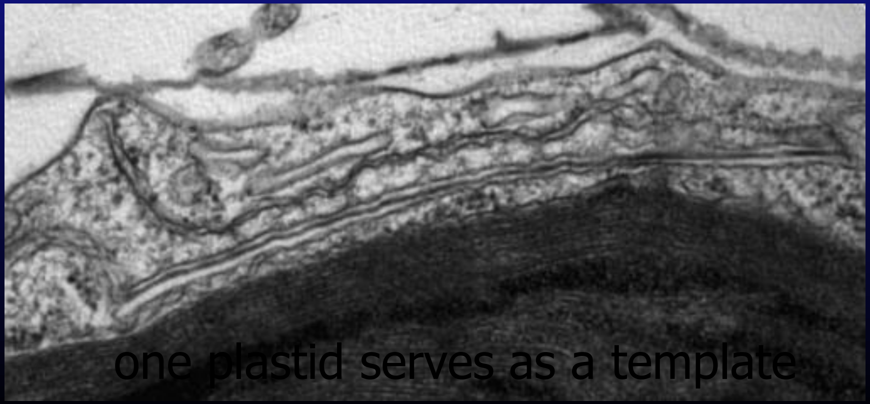


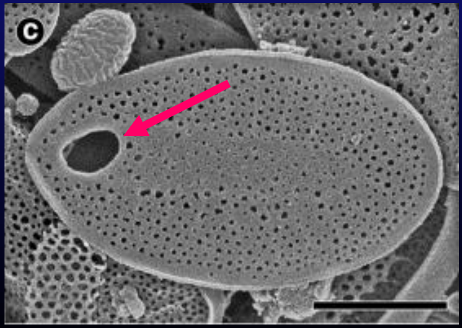






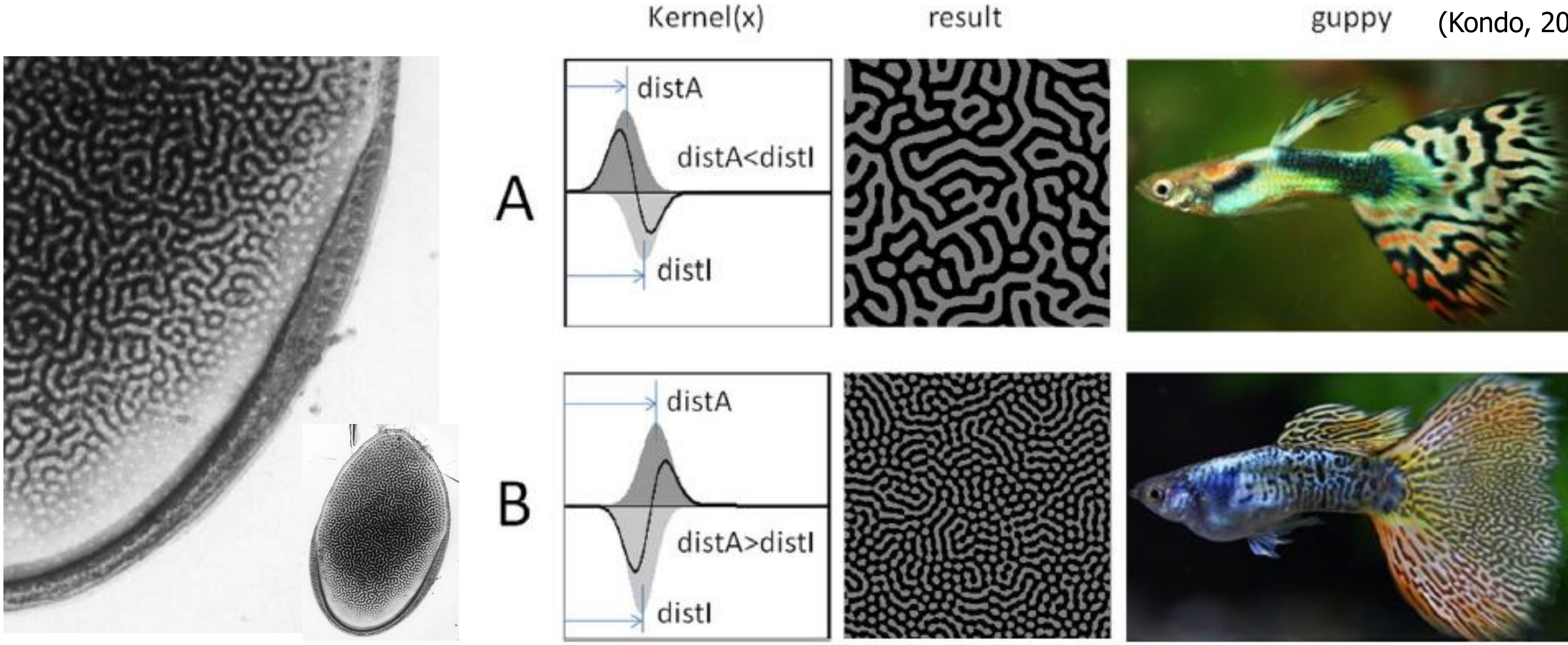






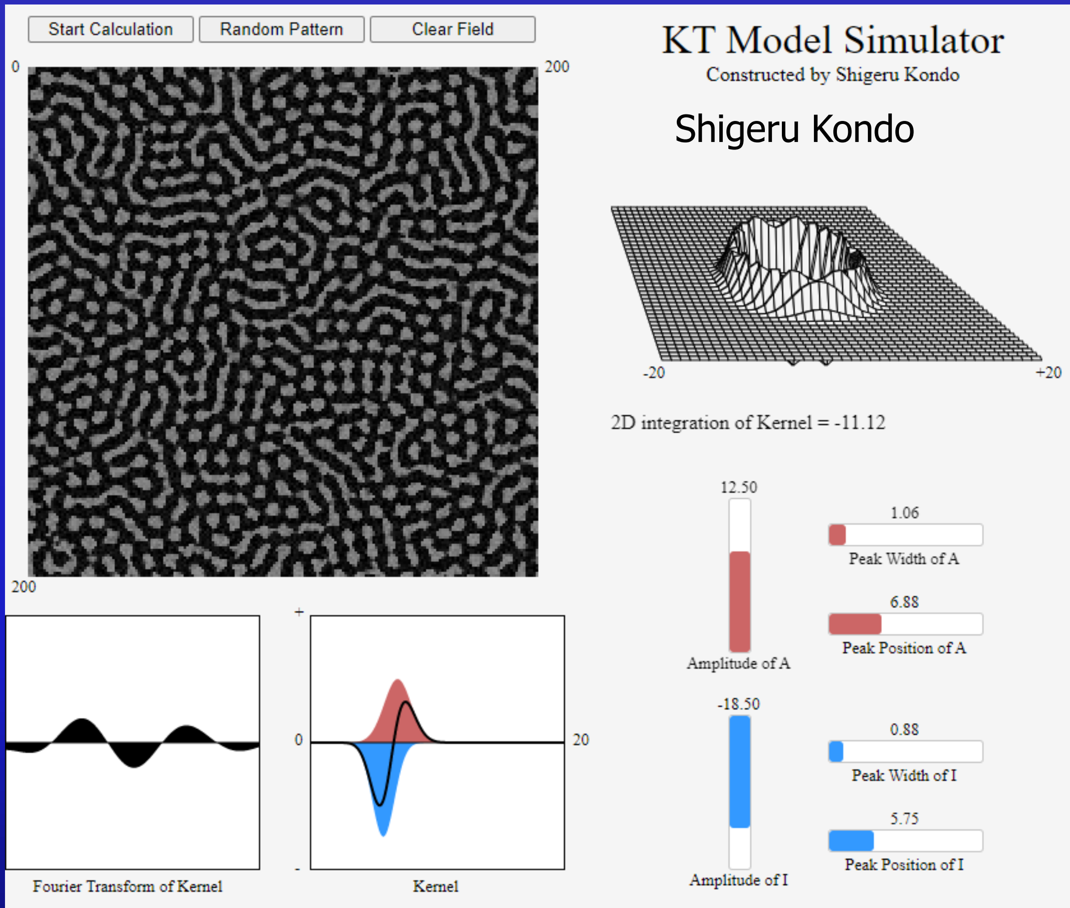
Turing Model – biological pattern formation

(Kondo, 2017)

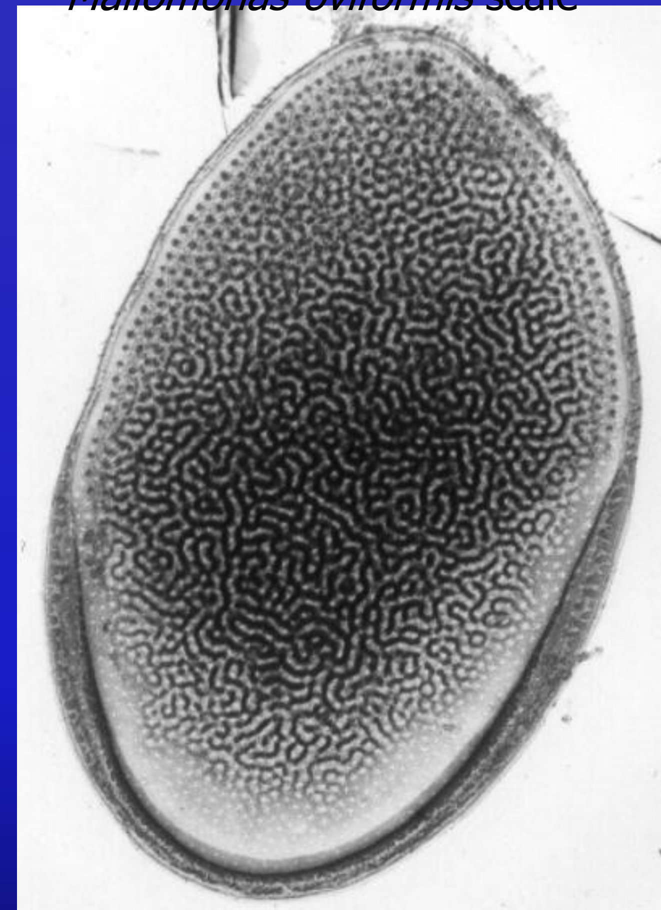


The reaction-diffusion (RD) model (Alan Turing, 1952) is a theoretical mechanism to explain how spatial patterns form autonomously in an organism.

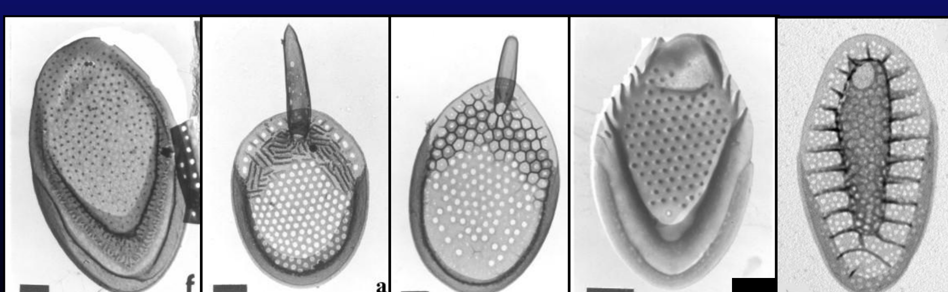
Behaviour of a system in which two diffusible substances interact with each other - wavelike patterns are the chemical basis of morphogenesis



Mallomonas oviformis scale



Kernel-based Turing Model model is improved RD model

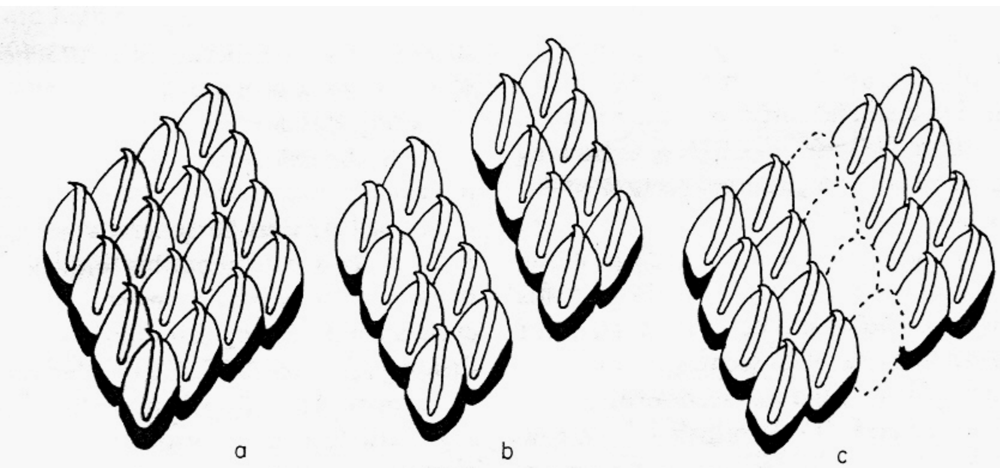


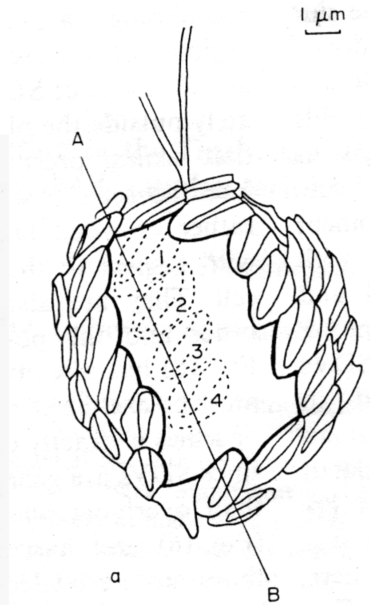
All these patterns can be made by KT model or classic Turing model with some modification

Exocytosis of chrysophyte scales

Synura petersenii

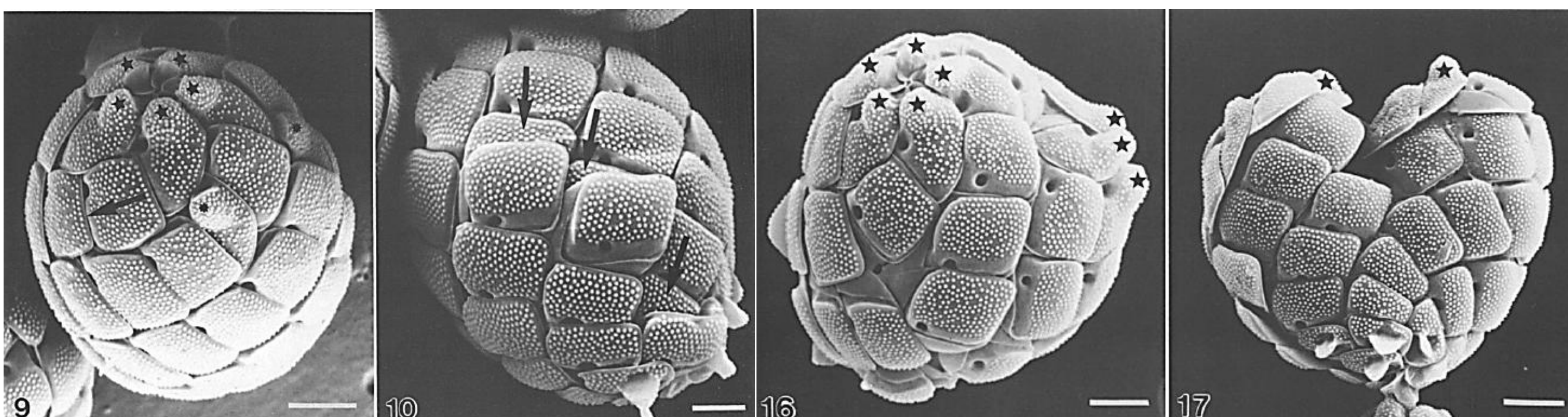
Leadbeater, 1990





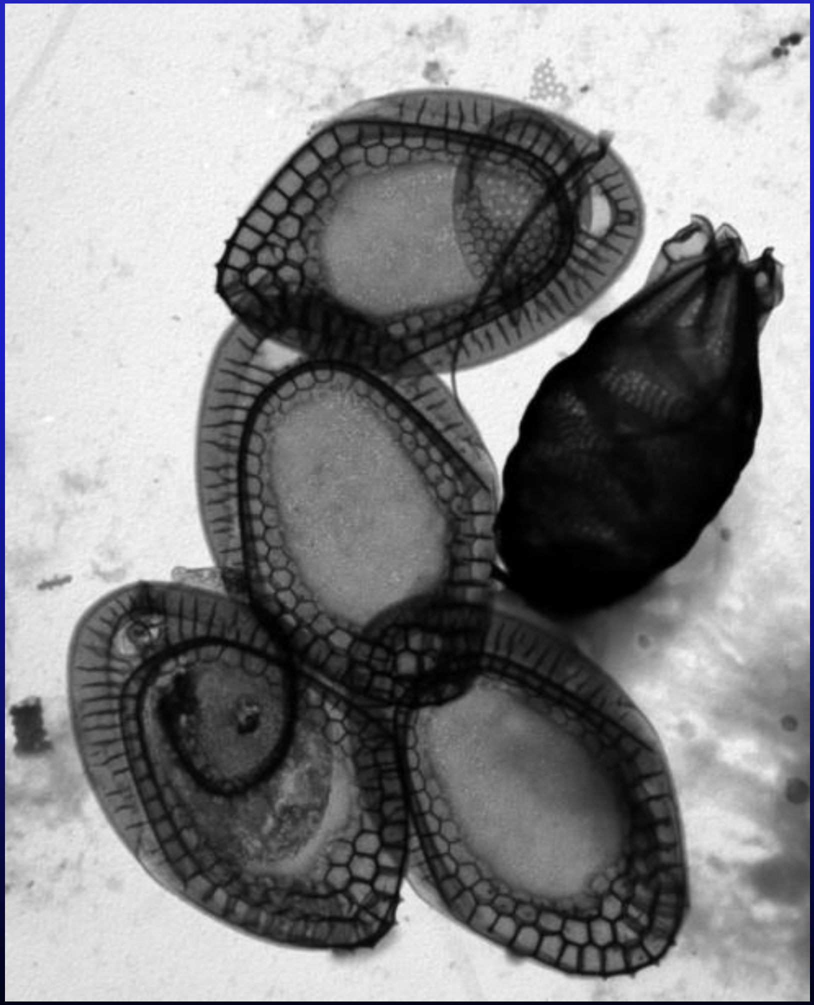
Lavau et Werherbee, 1994

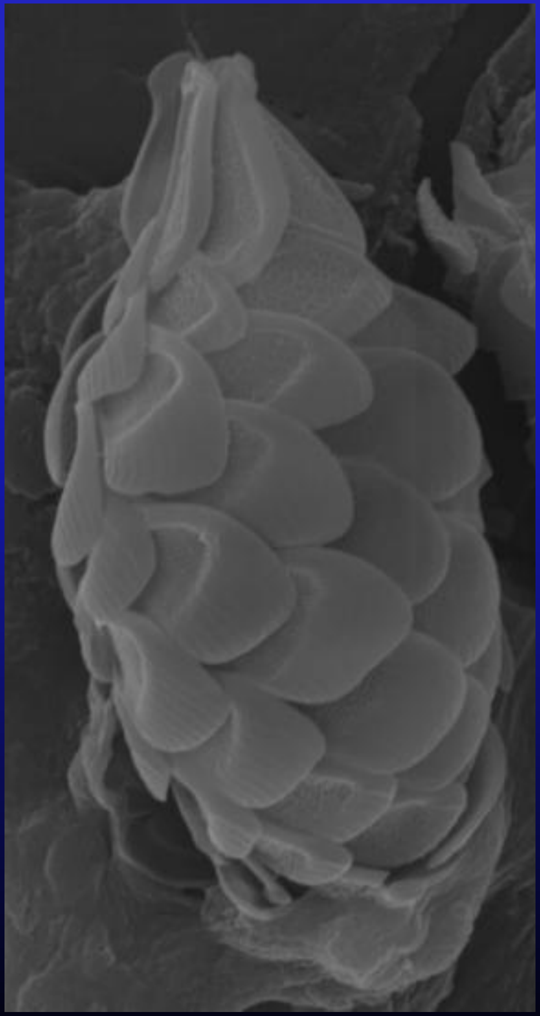
Mallomonas adamas



Genus: *Mallomonas*

ca. 180 taxa described. Species differ in size and ecological requirements. However the main distinguishing chracter provide species-specific silica scales

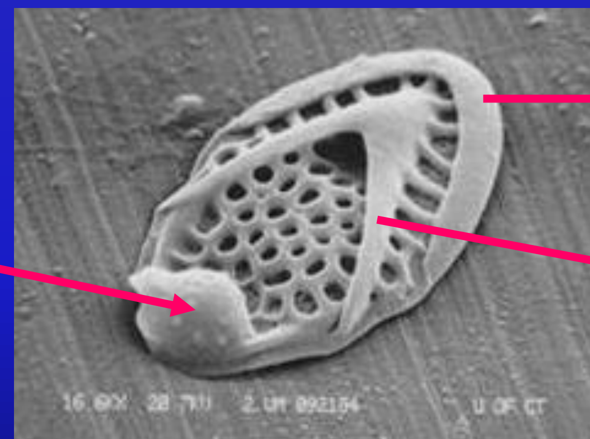




Scale shape

Bilaterally (or almost) summetric scales. Size and shape differ according to position within a scale-case. Apical (anterior) - body - caudal (posterior)

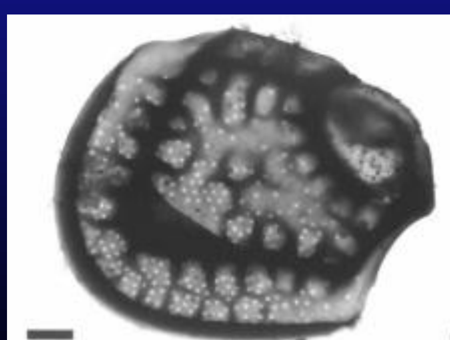
M. crassisquama



posterior rim

dome

V-rib



apical

body

posterior

(Jo et al. J. Phycol. 2011)

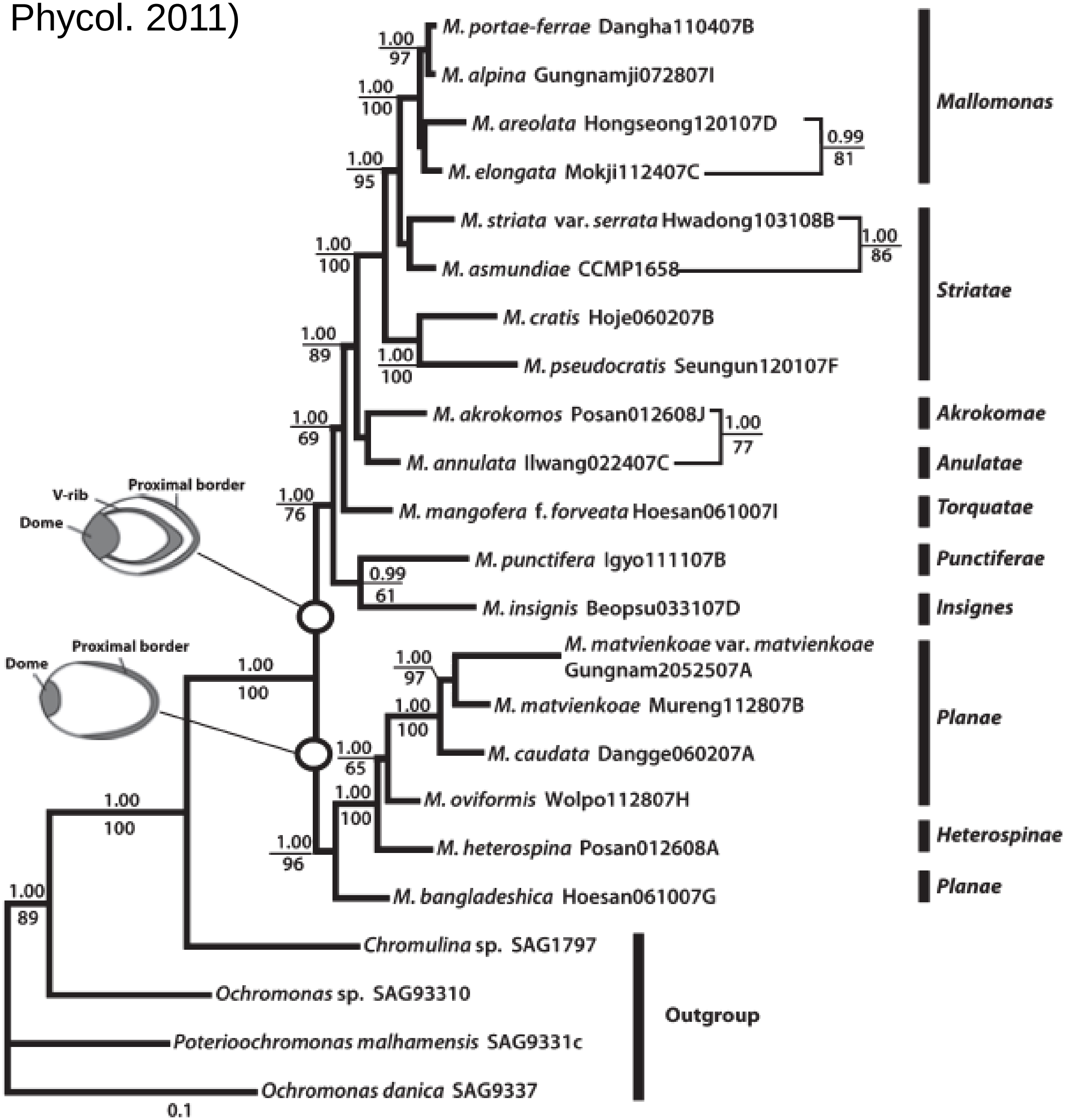


FIG. 4. Consensus Bayesian tree of 18 strains of the genus *Mallomonas* species based upon the combination of nuclear SSU and LSU rDNA and *rbc*L sequence data. Numbers indicate the posterior probability above the branches and the maximum likelihood below the branches.

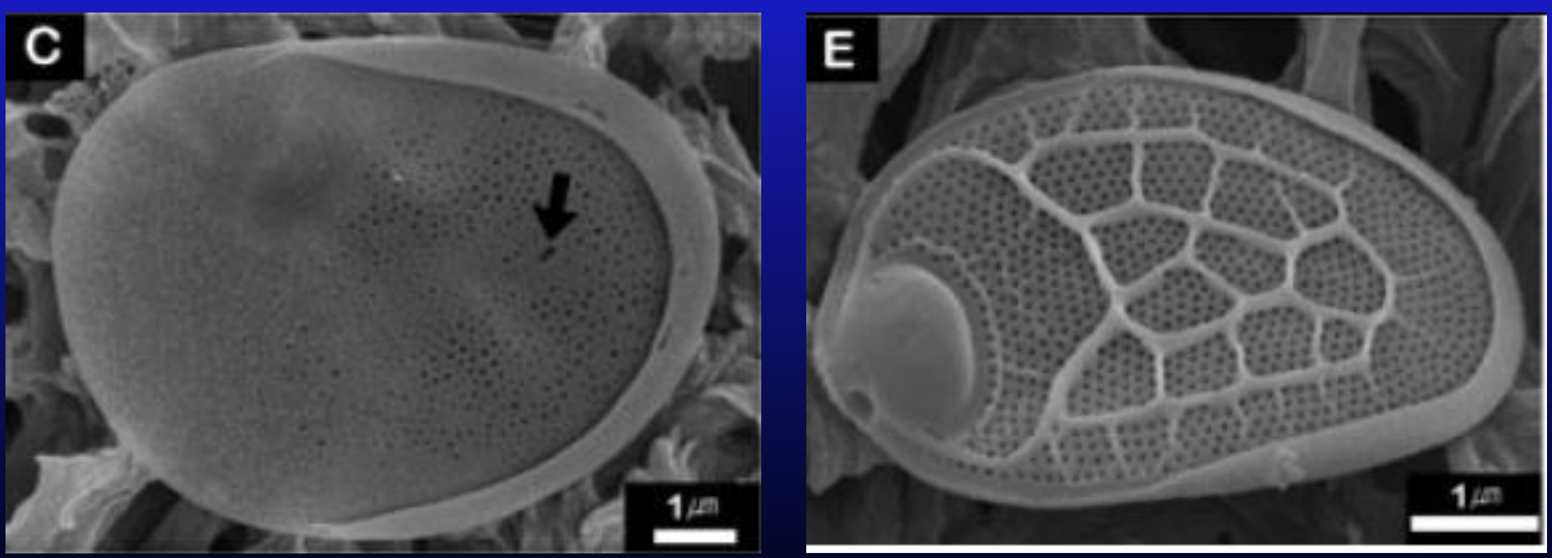
(Jo et al. J. Phycol. 2011)

• two well-supported clades, possessing V-rib x lacking V-rib

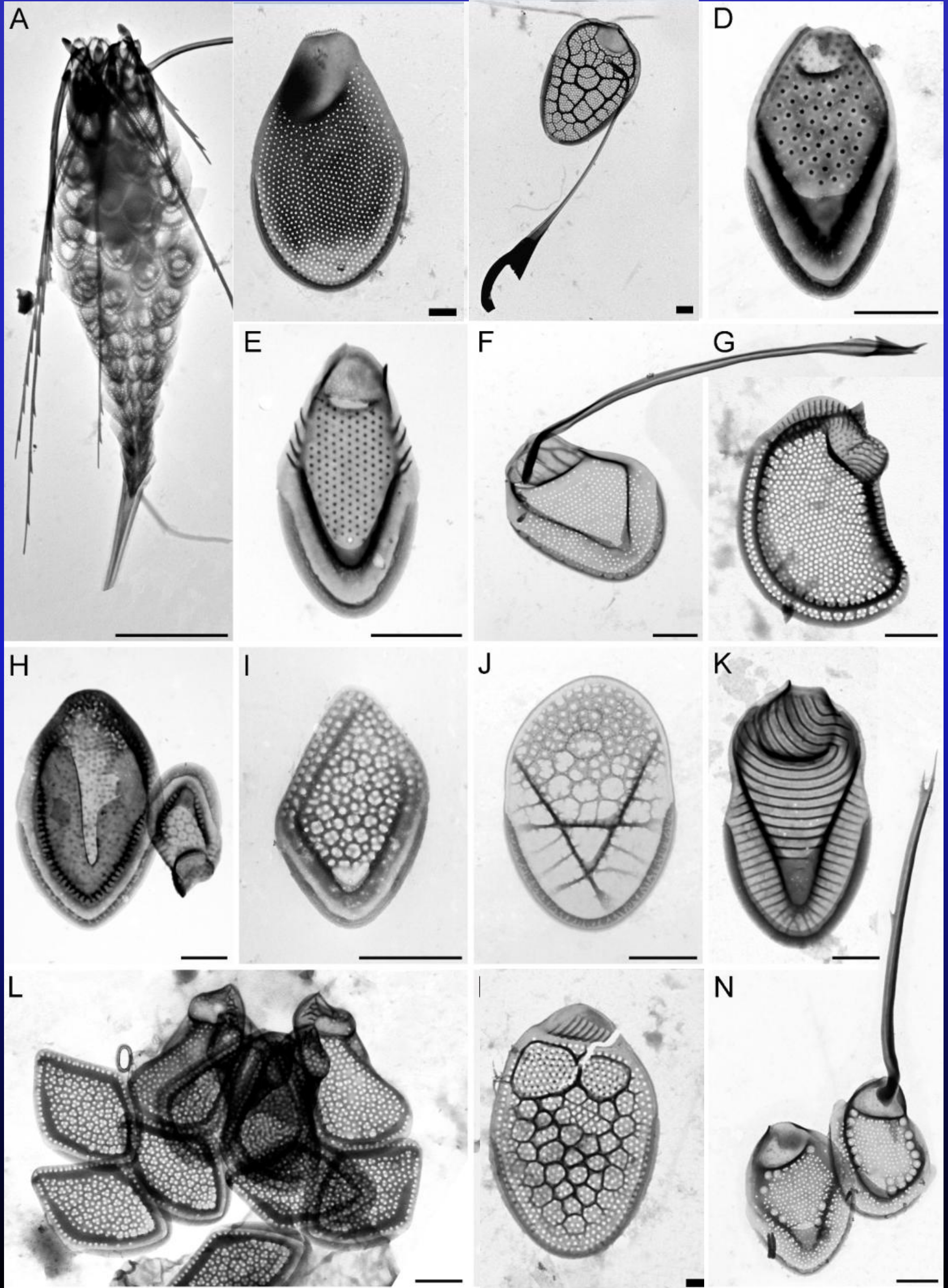
• V- rib was an important event in the evolution

• scales with a dome in both clades - synapomorphy (possibly evolved multiple times)

• more complex scales and scale-case arrangement are not always derived (e.g. *M. caudata* - simplest scale type, more derived position relative to e.g. *M. heterospina*)

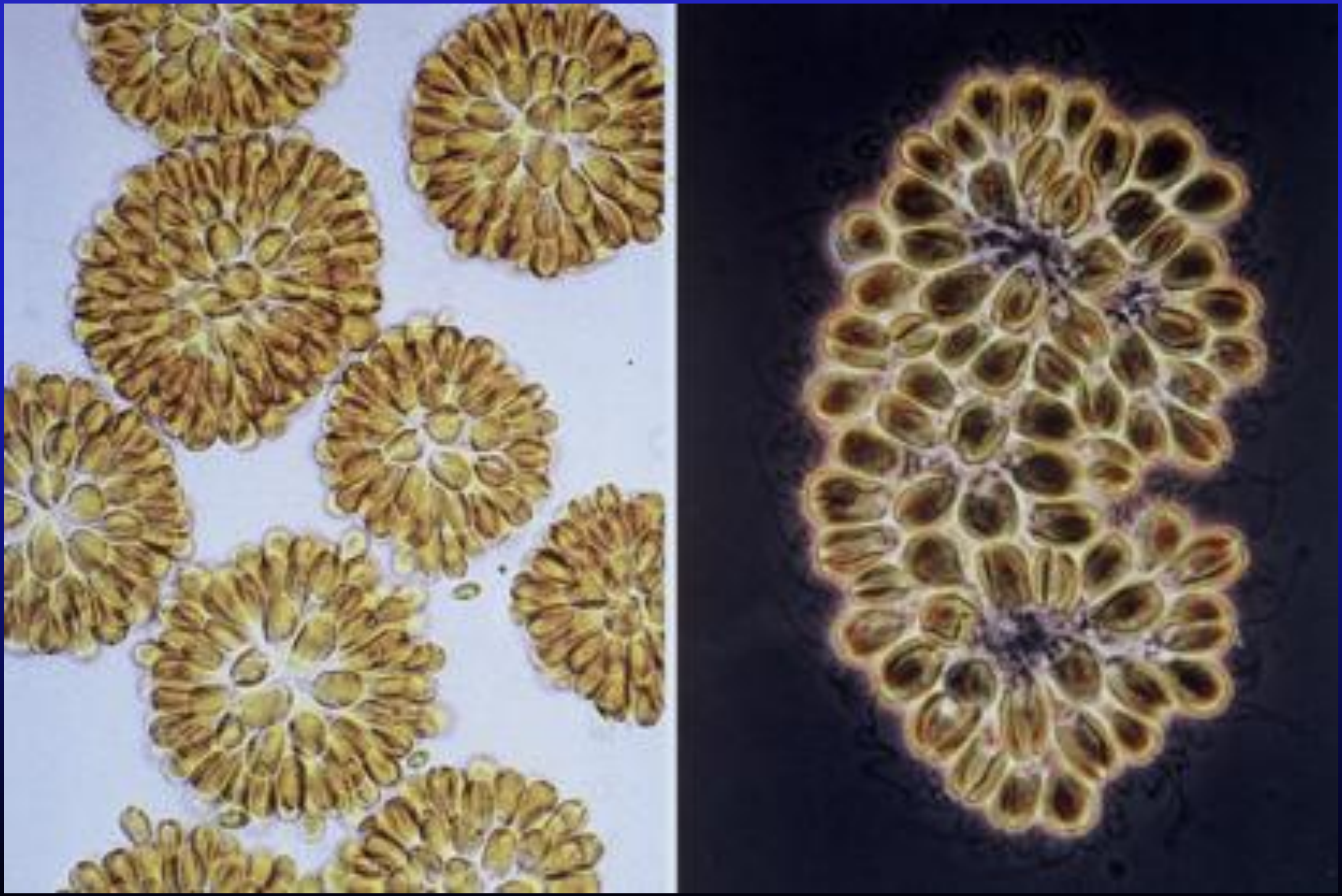


Scales of *Mallomonas*



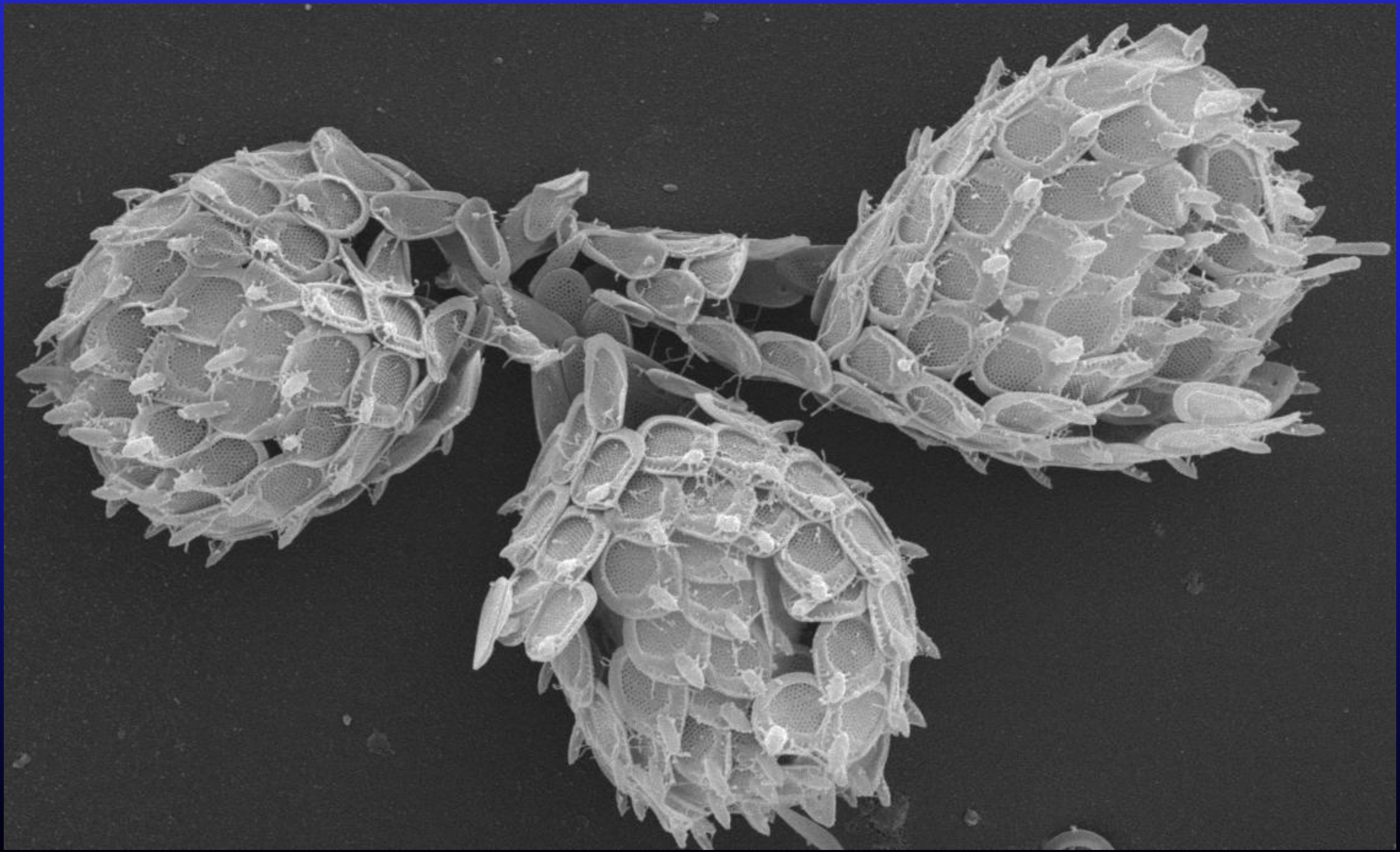
Genus: *Synura*

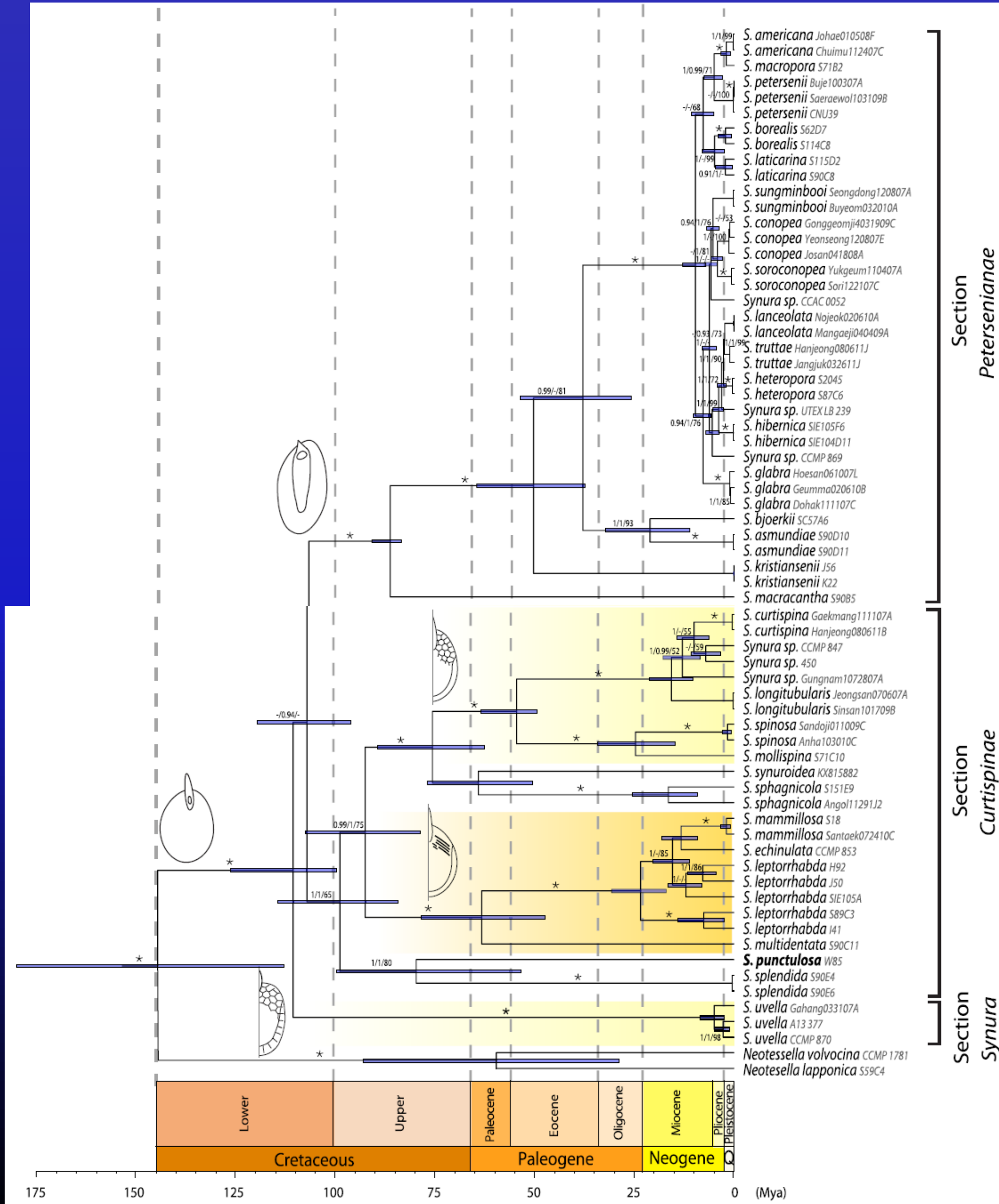
c.a. 35 taxa. Colonies rounded, ellipsoidal or elongated. Several to several tens of cells, free apical part, connected (stalks) in the middle of the colony.

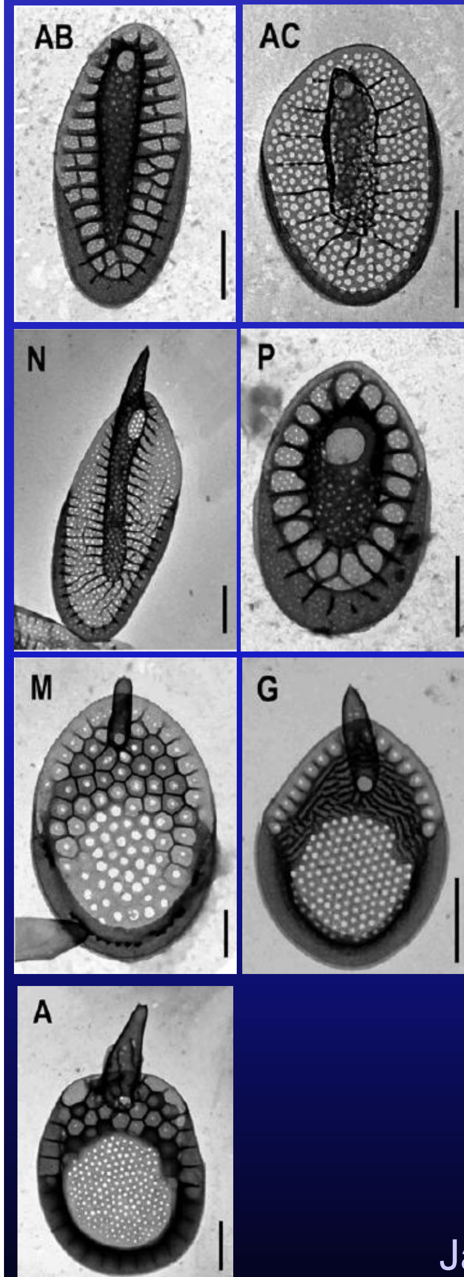


Silica scales

Spines are well developed in the apical part of the cell and they point out from the colony. Spines are reduced where the neighbouring cells touch.



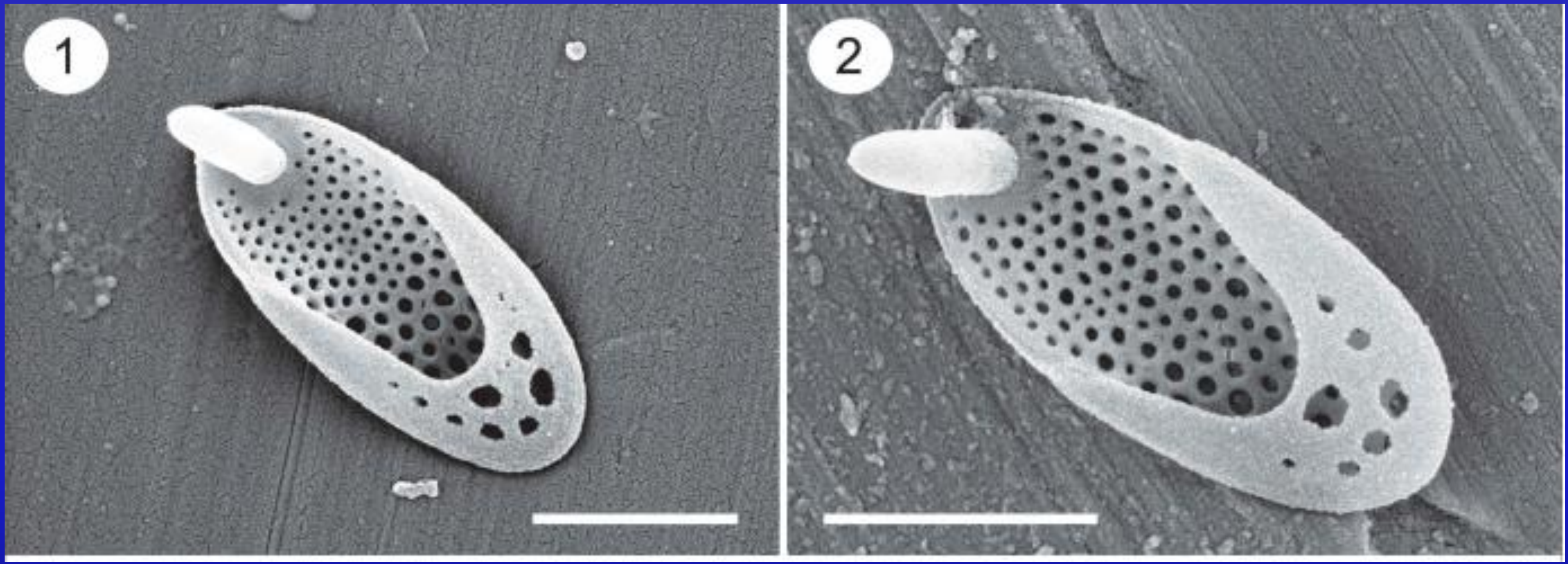


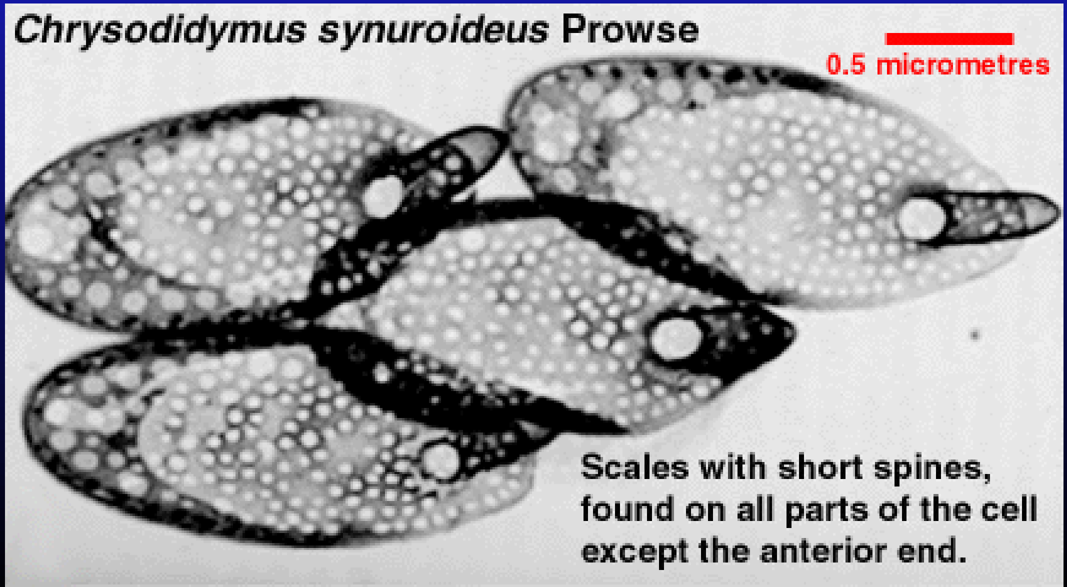


Jadrná et al. 2021

Genus: *Chrysodidymus* = *Synura synuroidea* Curtispinae

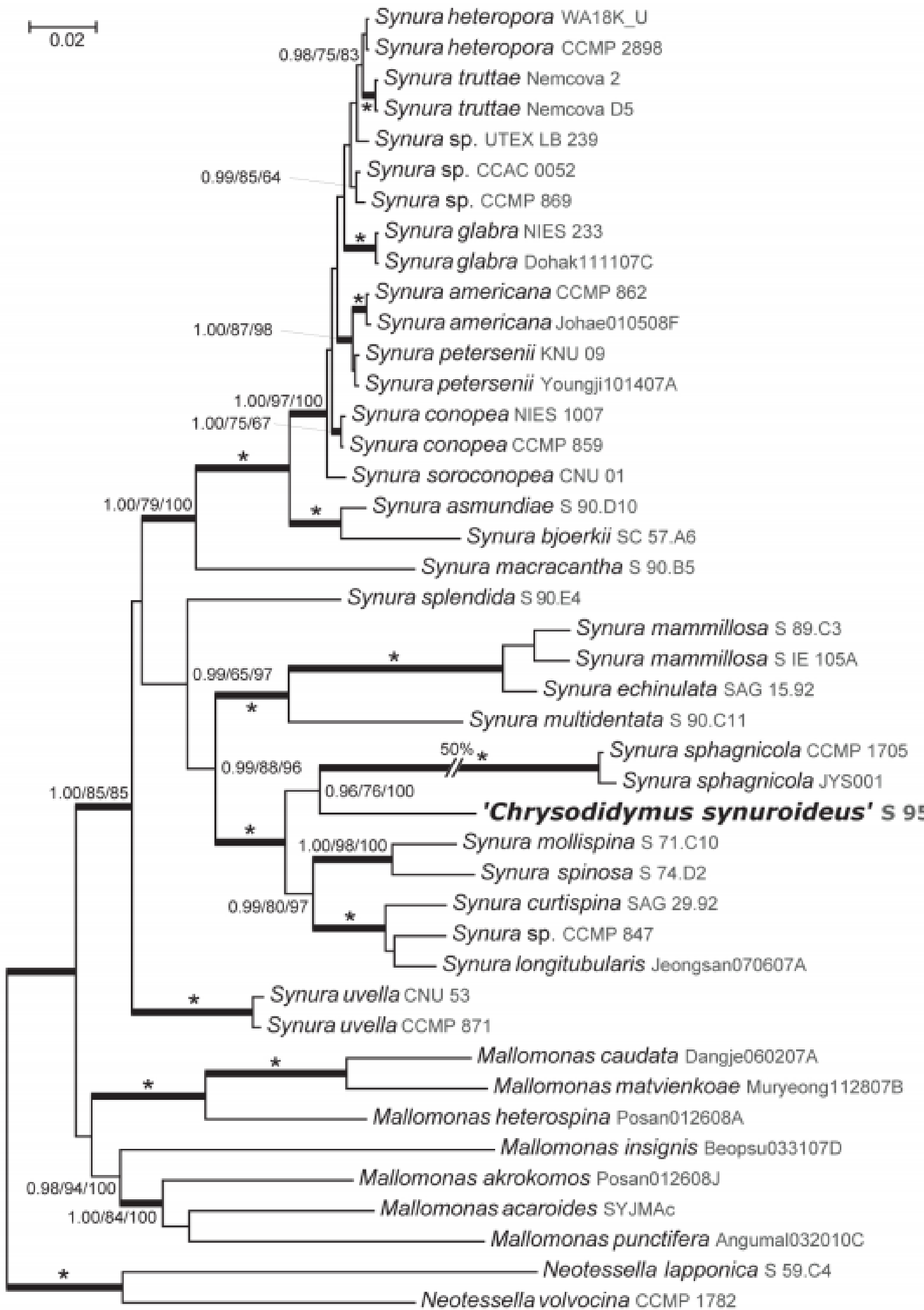
Two-celled colonies, cells connected by posterior ends.

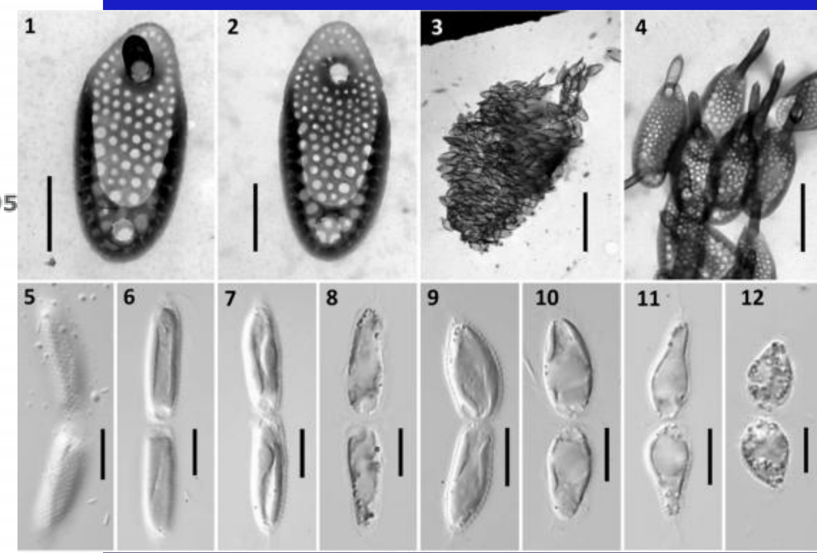




Elucidating the phylogeny and taxonomic position of the genus *Chrysodidymus* Prowse (Chrysophyceae, Synurales)

Synura synuroidea

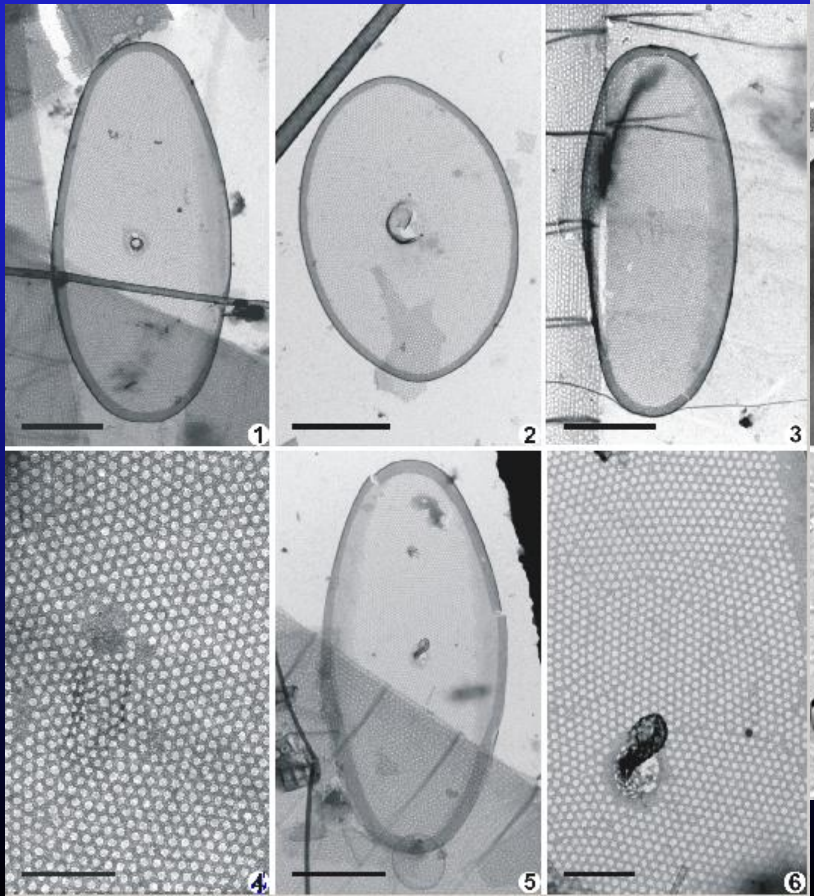


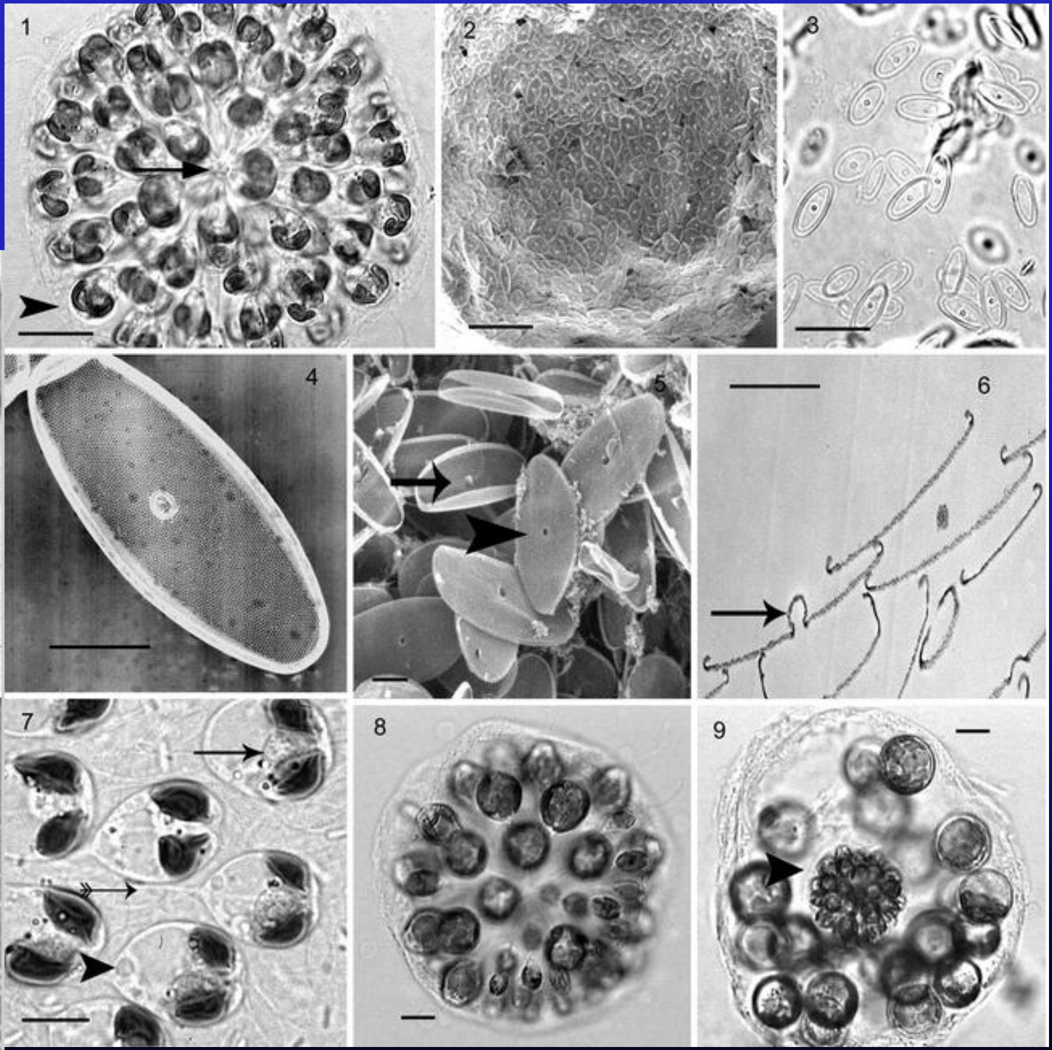


Pusztai et al. 2016

Neotessella lapponica

transferred to *Neotessella* according to molecullar data and morphology

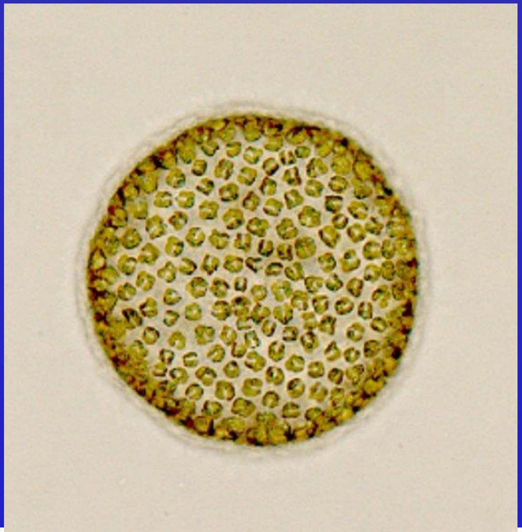


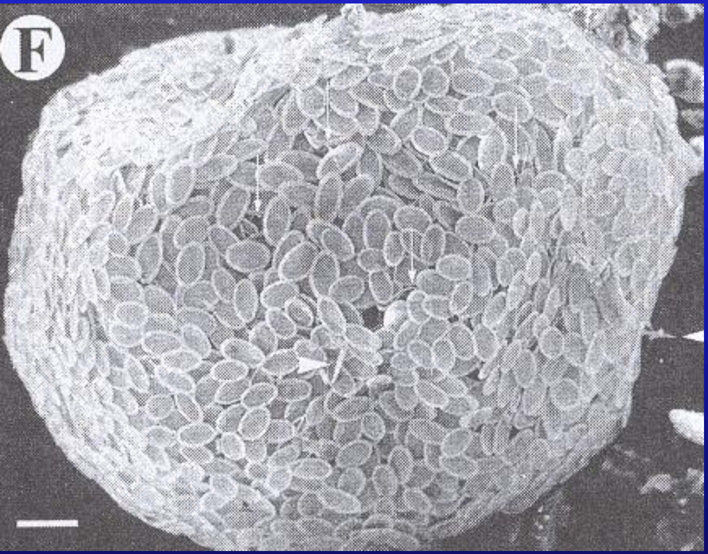


Goldstein etal. 2005

Neotessella

Colonies with several hundreds of cells (25 - 200µm in diameter). Scales cover the whole colony in several layers. *Neotessella volvocina*, australien endemit.





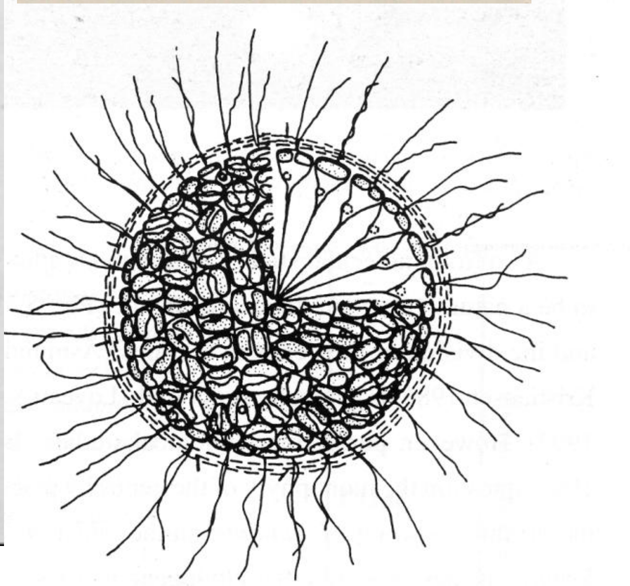
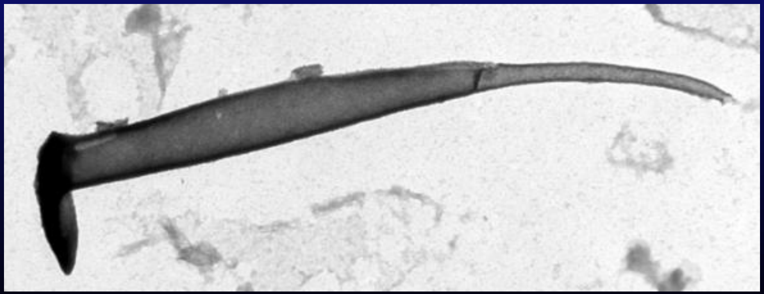
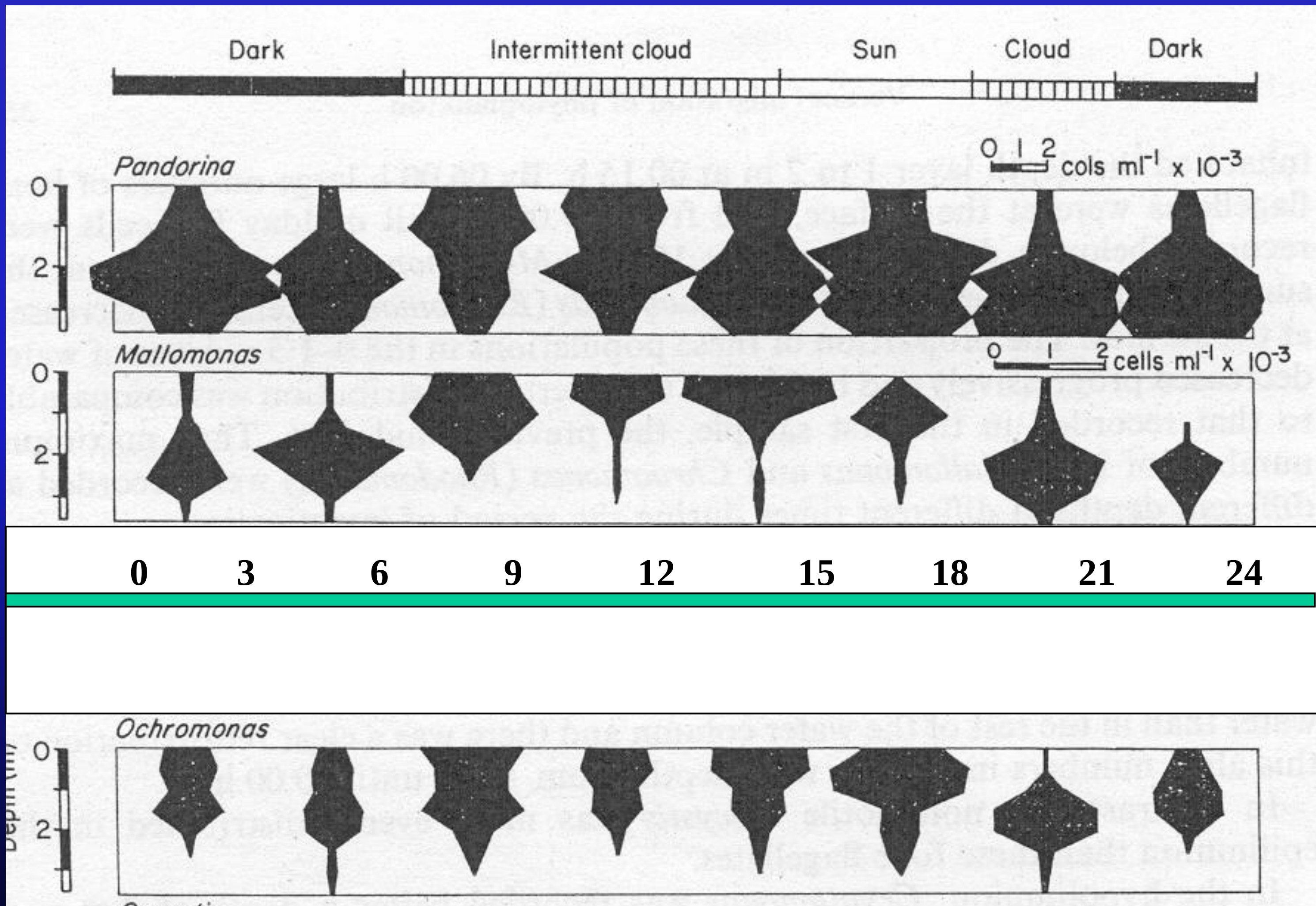


Fig. 5.27. Tessellaria, colony. (Kristiansen & Preisig 2001, from Andersen & Preisig 2002 b).

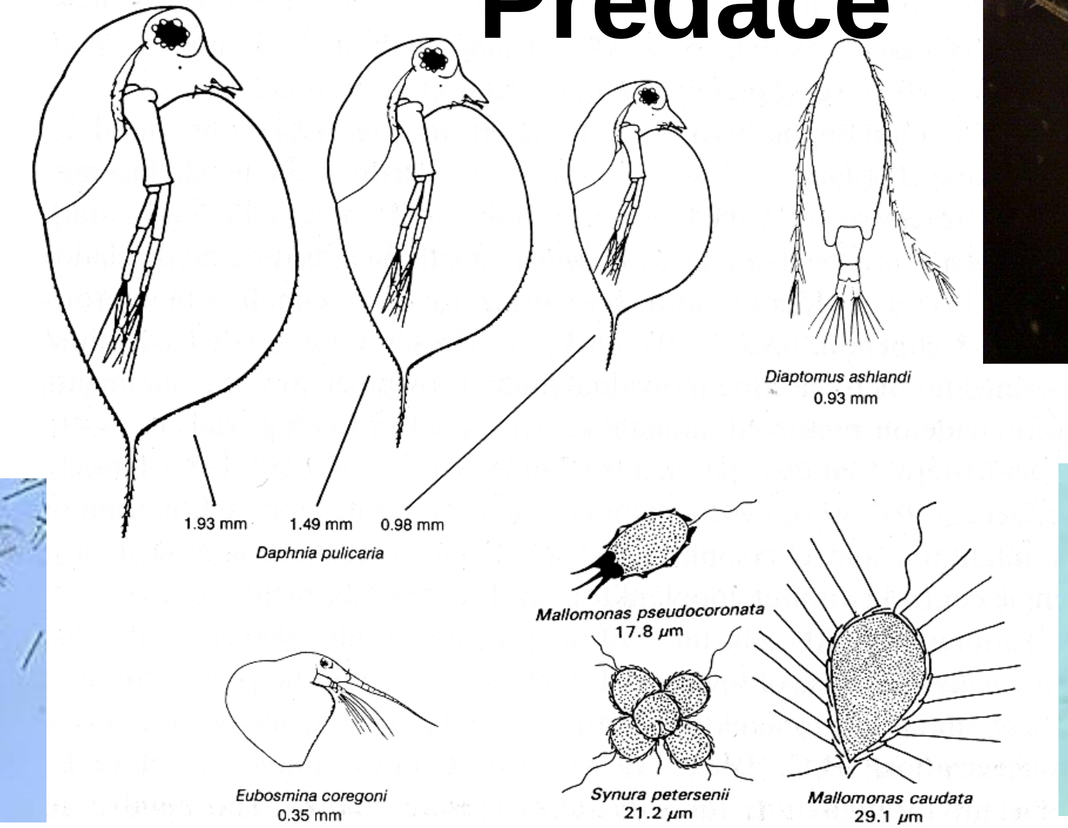


Diurnal migration



Happey-Wood, 1976

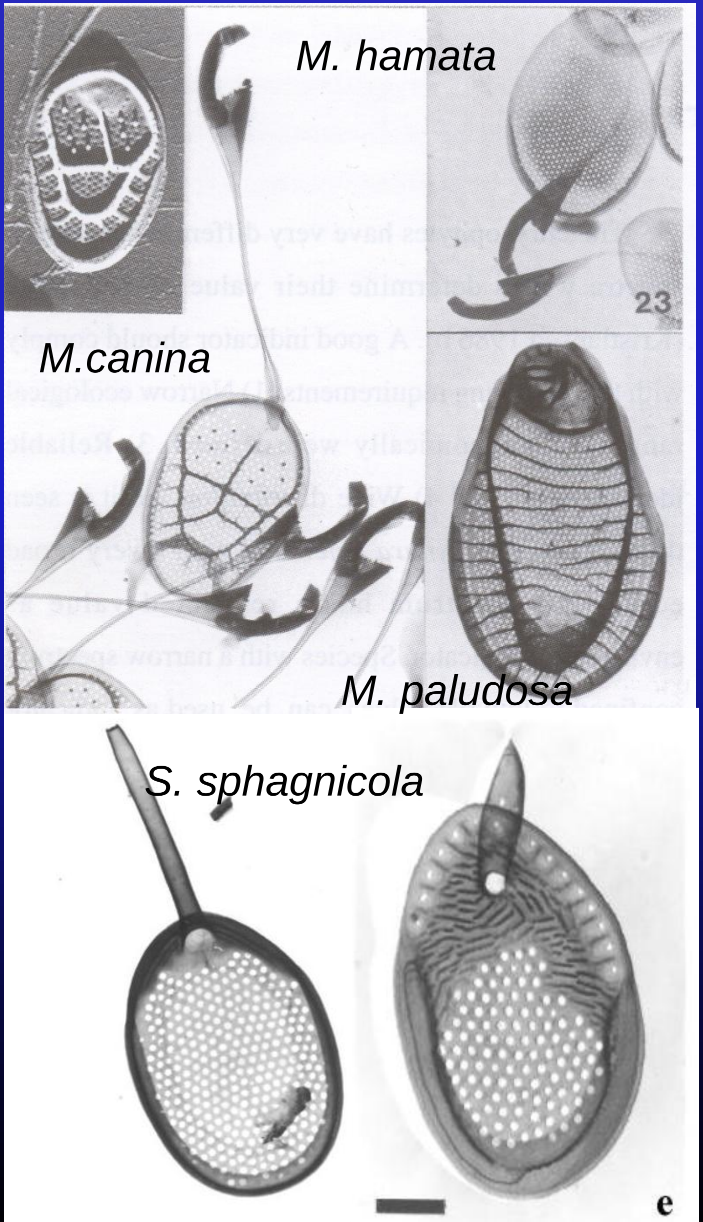
Predace

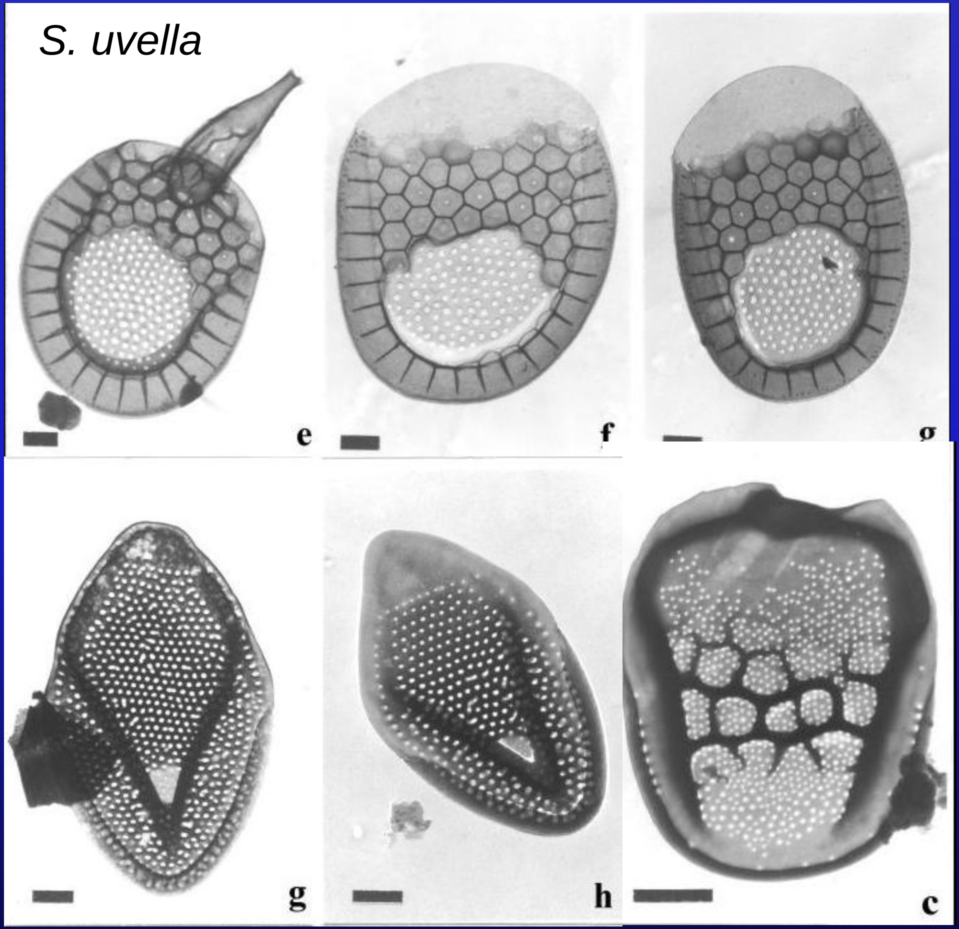


Species	μ_{MAX}(days^{-1})	G (days^{-1}) Daphnia pulicaria 1.9mm	Daphnia pulicaria 1.5mm	Daphnia pulicaria 0.9mm	Eubosmina 0.4mm	Diaptomus 0.9mm
Synura petersenii	0.76	-0.45	-0.20	-0.04	-0.03	-0.01
Mallomonas pseudocoronata	0.50	-0.31	-0.18	-0.05	-0.04	-0.05
Mallomonas caudata	0.30	-0.38	-0.32	-0.04	-0.01	-0.02

Bioindicators

indicators of acidic environm. indicators of alkaline environm.



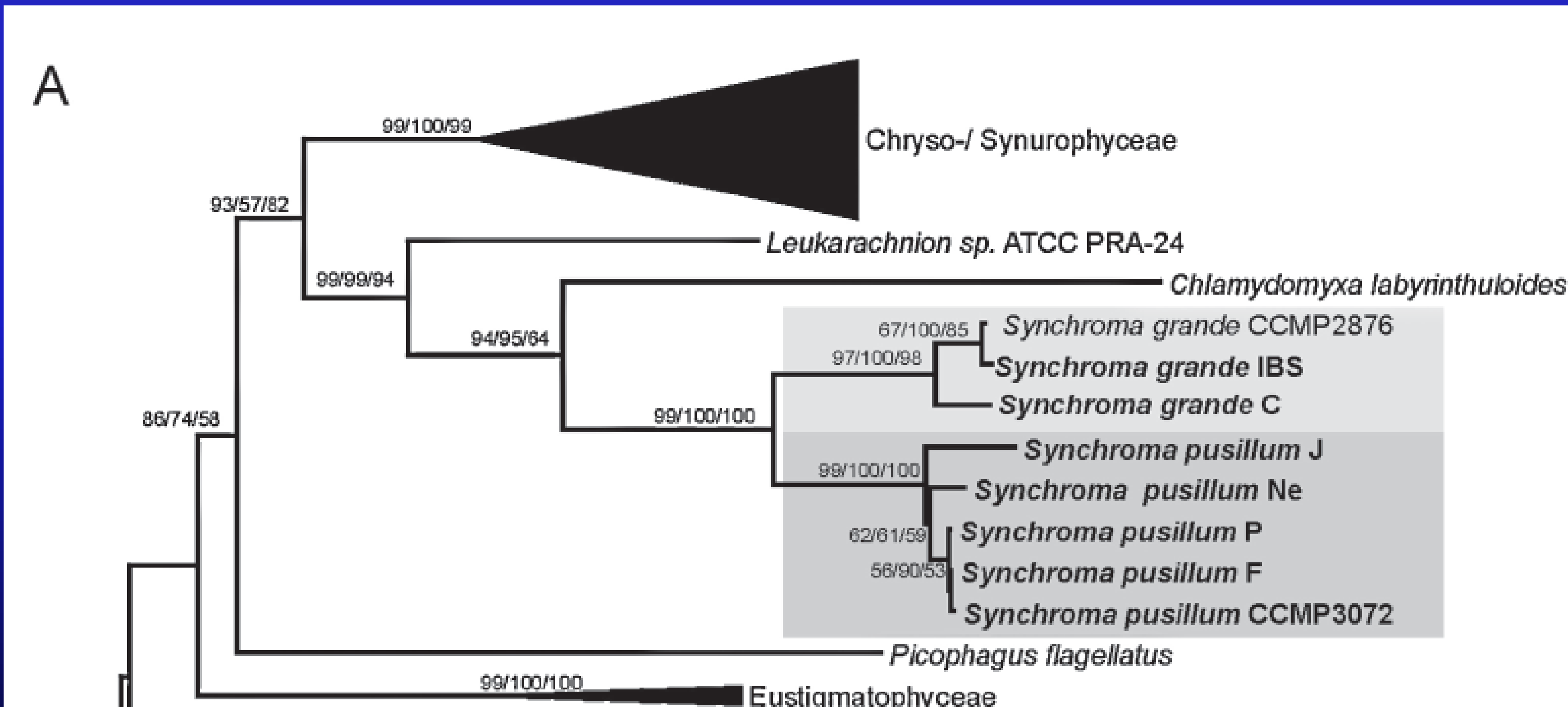


M. tonsurata M. punctifera

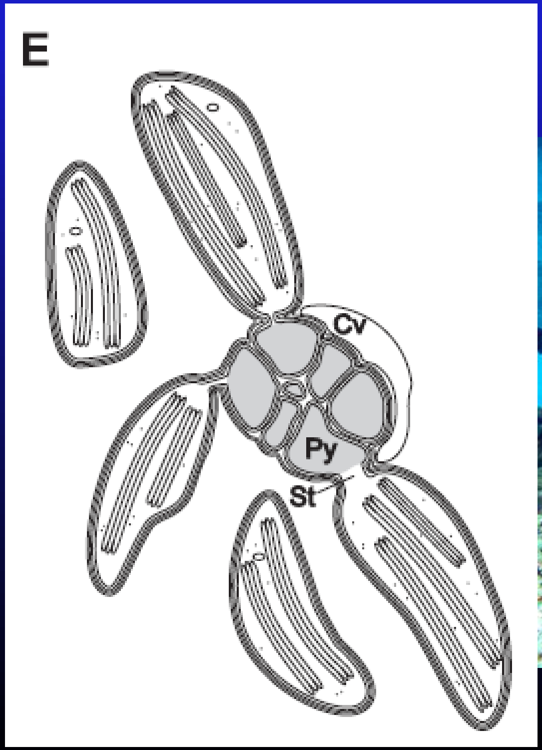
S. echinulata

Synchromophyceae

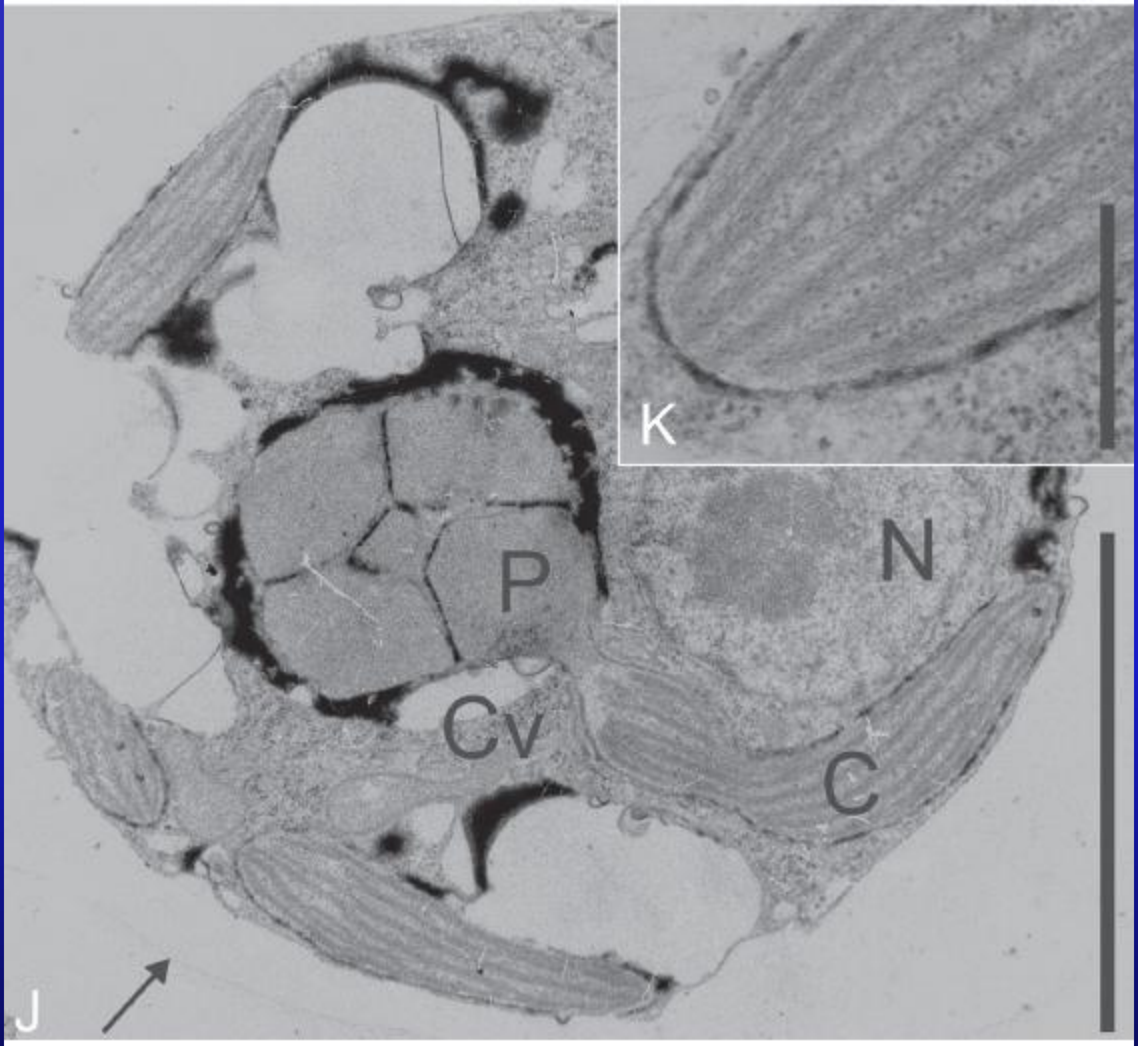
- closely related to Chrysophyceae
- amoebae, plastids with joint outer membrane



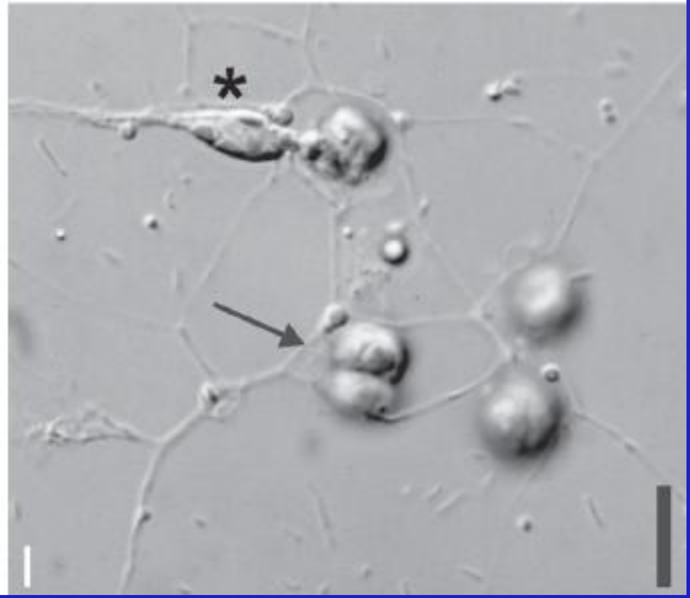
Schmidt et al. 2012. Phylogenetic tree of 18S rDNA of stramenopiles with a focus on Synchromophyceae.



coral reefs Columbia



TEM overview of a sessile amoeba of *S. pusillum* CCMP3072 with a surrounding lorica (arrow).



arrow: two amoebae inside one lorica after binary division) incorporated into a meroplasmodial network as well as migrating amoebae (asterisk: migrating amoeba shortly after hatching).

Synchroma pusillum

Life cycle of *Synchroma grande*

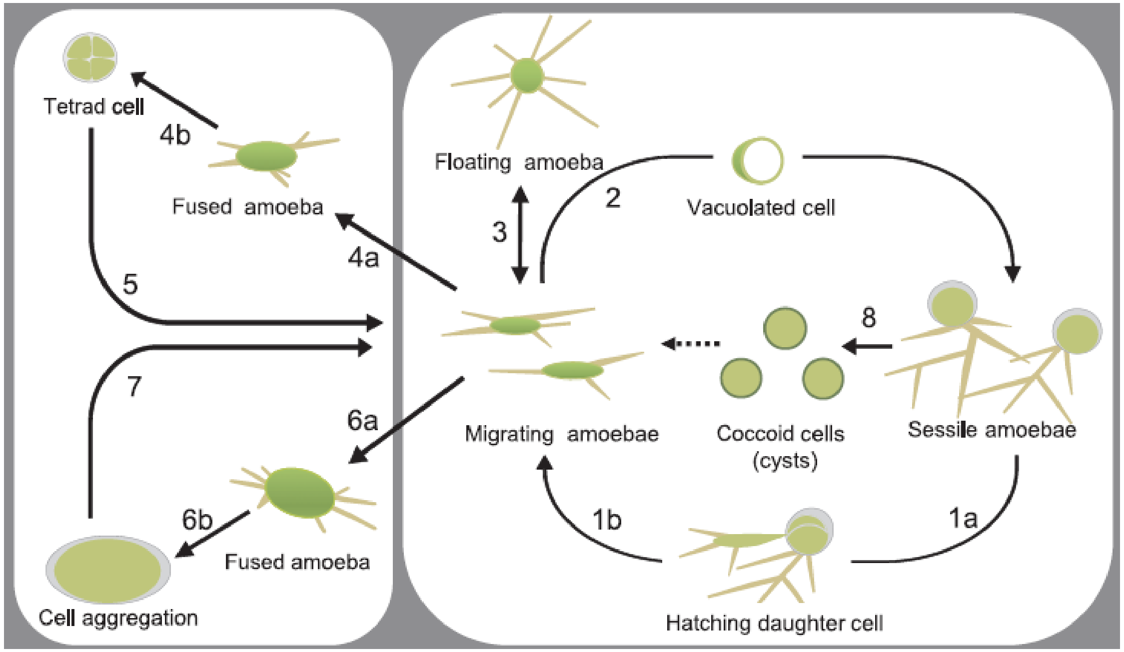


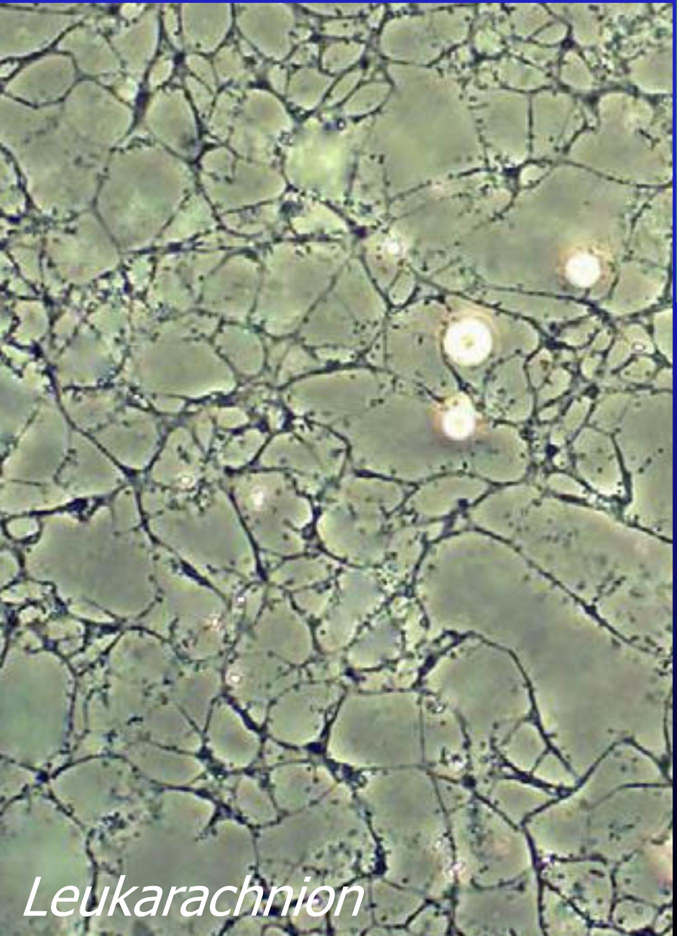
Fig. 2. Schematic life cycle of *S. grande* integrating all observed morphological cell types: (1a) binary cell division of sessile amoeboid cells; (1b) one daughter cell hatches out of the lorica and becomes a migrating amoeba (sessile amoebae can also leave their lorica under certain circumstances); (2) migrating amoebae become sessile through the formation of a lorica including a vacuolated cell stage; (3) migrating amoebae can detach from the substrate and become floating cells and *vice versa*; (4a) cell fusion (with karyogamy) of two migrating cells; (4b) lorica and tetrad formation; (5) hatching of three (alternatively four) migrating amoeboid cells; (6a) cell fusion of several cells; (6b) formation of lorica and meroplasmodium; (7) hatching of several (more than four) migrating amoebae; (8) cell wall formation after prolonged stress conditions.

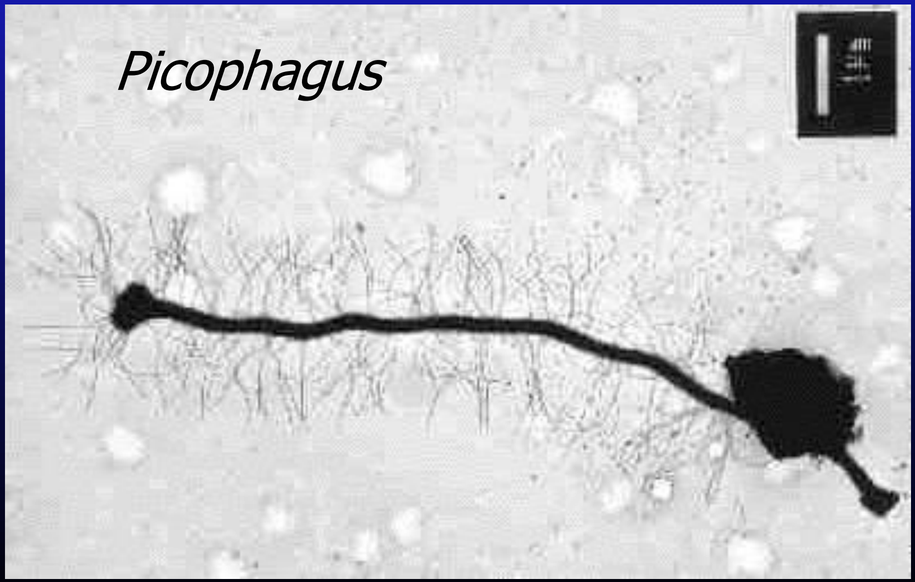
(Koch et al. 2011)

Synchromophyceae / Picophagea

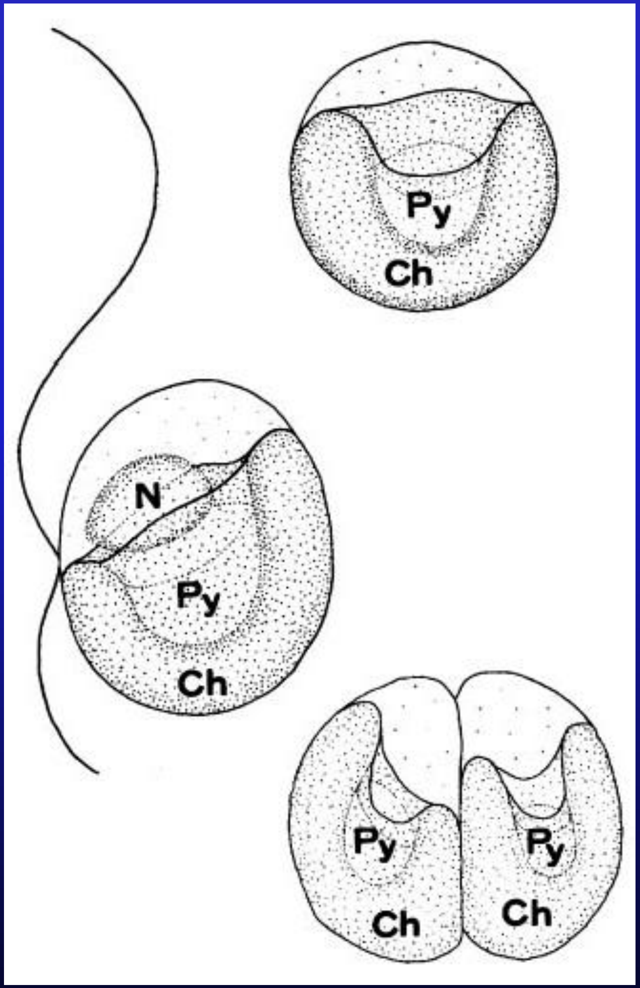
basal group – reduced plastid, not found any unambiguous candidate for a plastid organelle by TEM

novel form of a relict plastid organelle



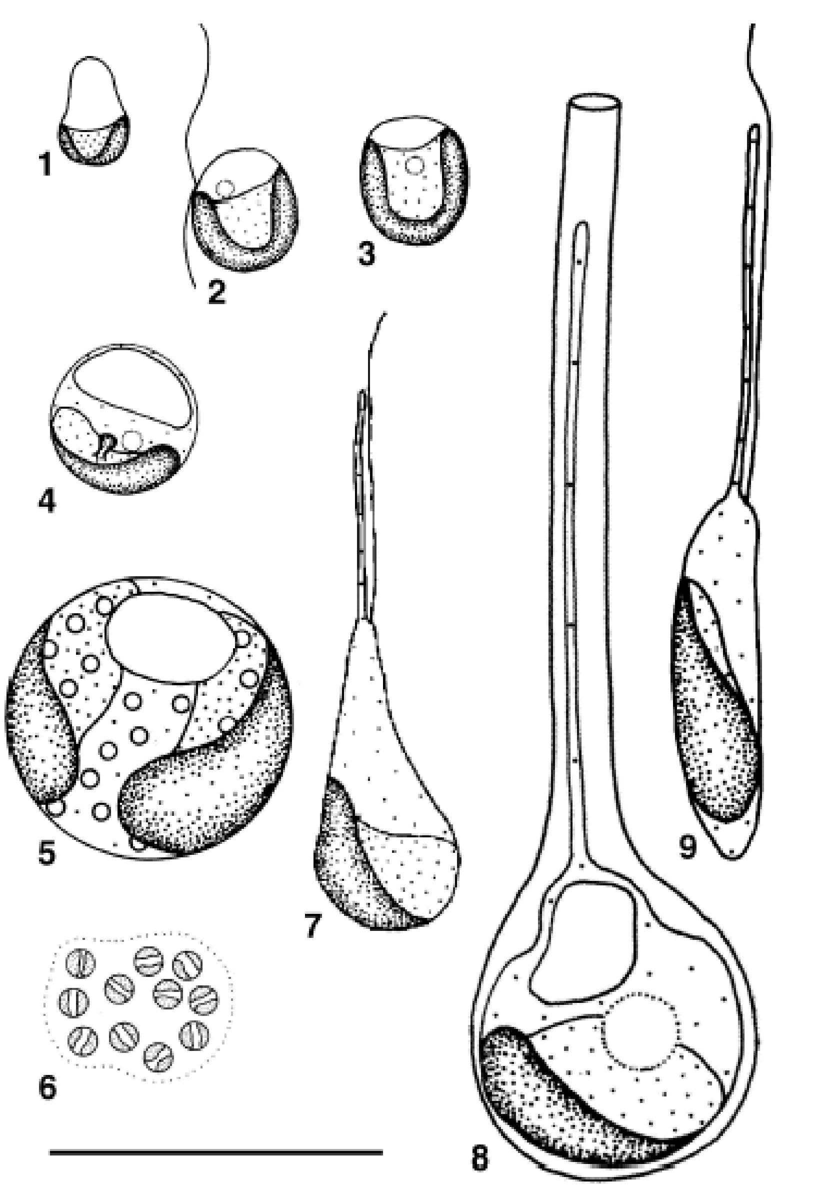


Pinguiophyceae

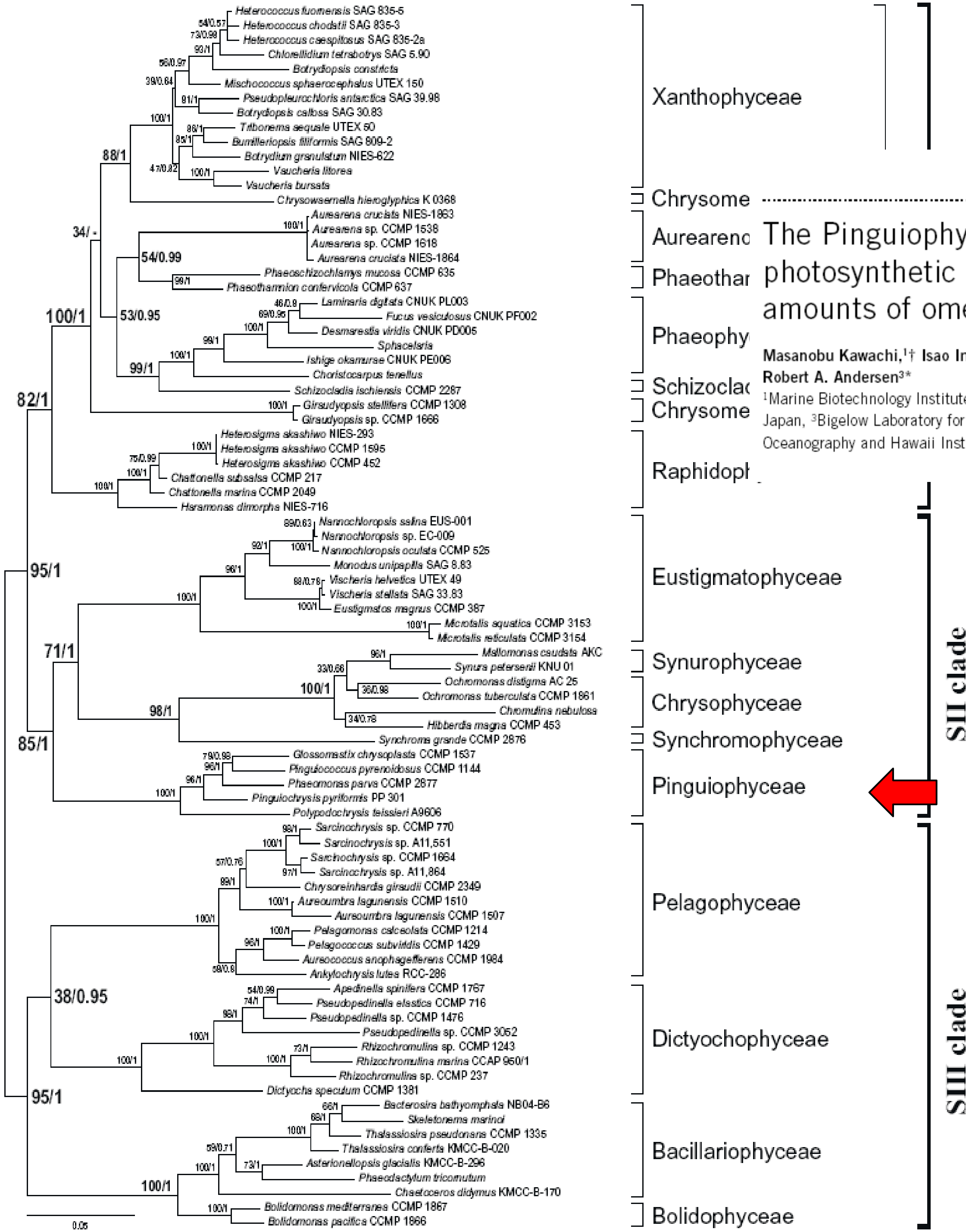


Pinguiophyceae

- described in 2002
- named according to the high content of fatty acids in the cells
- heterokont plastid, flagella
- marine picoplanktonic algae



Figs 1–9. Illustrations of Pinguiophyceae taxa. 1. *Pinguiochrysis pyriformis*. 2,3. *Phaeomonas parva*; swimming cell (2); non-motile cell (3). 4. *Pinguiococcus pyrenoidosus*. 5–7. *Glossomastix chrysoplasta*; vegetative cell (5); colony (6); zoospore (7). 8,9. *Polypodochrysis teissieri*; loricate vegetative cell (8); zoospore (9). Scale bar = 10 µm (1–5,7–9) or = 1 µm (6).



Phycological Research 2002; **50:** 31–47

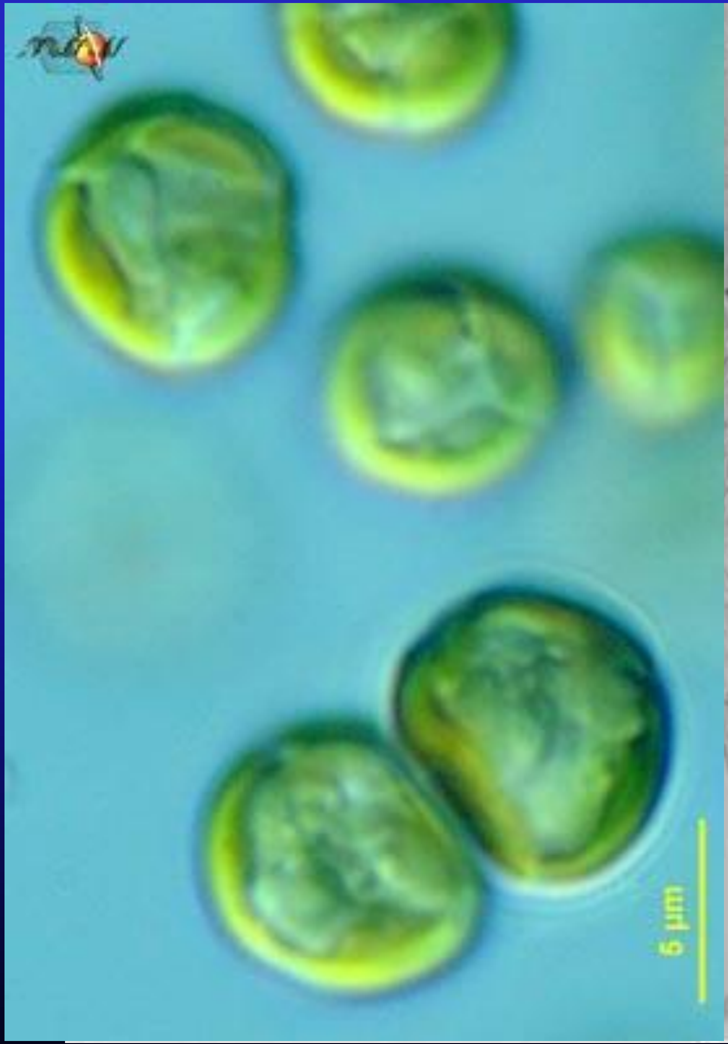
The Pinguiophyceae *classis nova*, a new class of photosynthetic stramenopiles whose members produce large amounts of omega-3 fatty acids

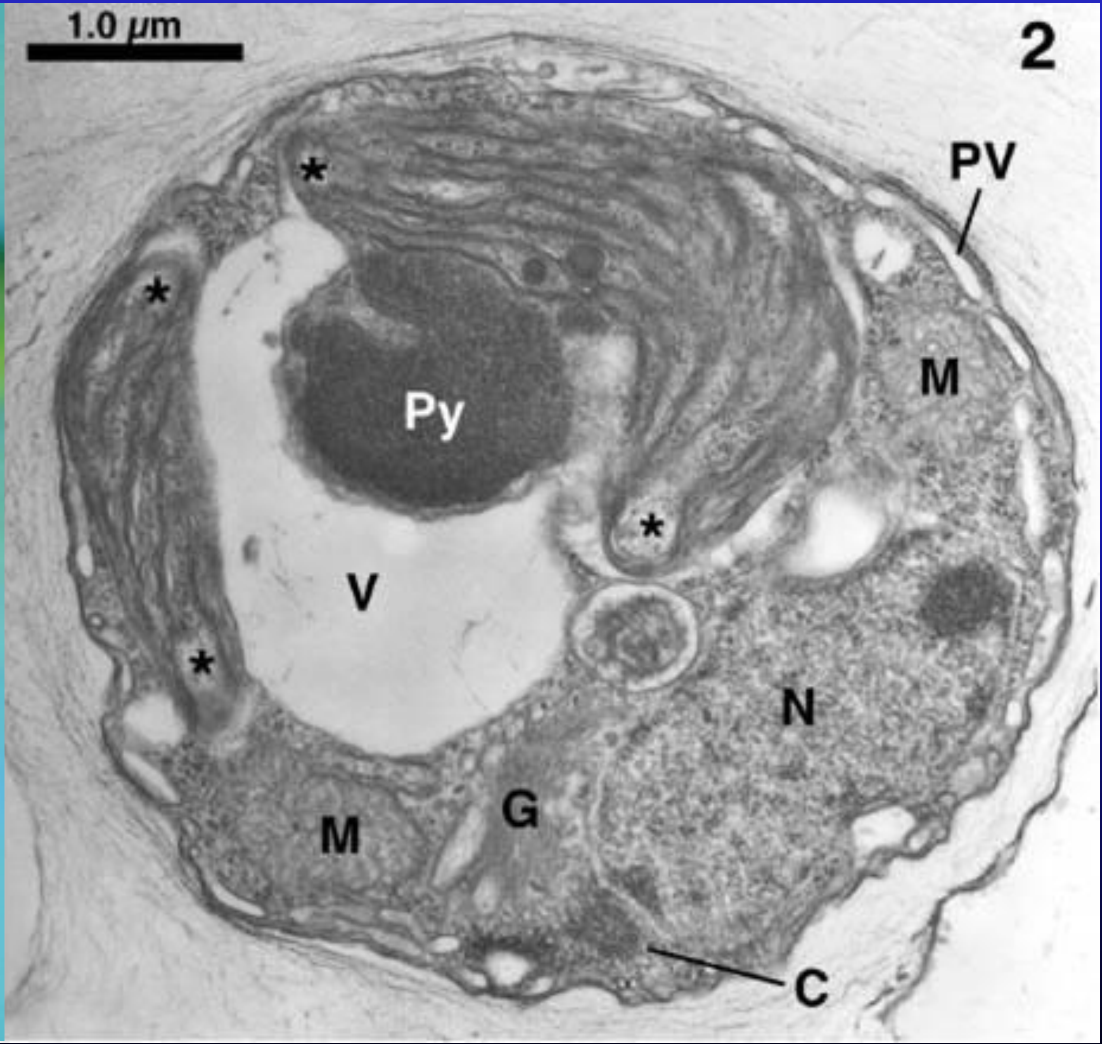
Masanobu Kawachi,[1]† Isao Inouye,[2] Daiske Honda,[2]‡ Charles J. O'Kelly,[3] J. Craig Bailey,[3]§ Robert R. Bidigare[4] and Robert A. Andersen[3]*

[1]Marine Biotechnology Institute Co. Ltd, Kamaishi Laboratory, Kamaishi 026-0001, Japan, [2]Tsukuba University, Tsukuba, Japan, [3]Bigelow Laboratory for Ocean Sciences, West Boothbay Harbor, ME 04575, USA, and [4]Department of Oceanography and Hawaii Institute of Marine Biology, University of Hawaii, HI 96822, USA

Pinguiophyceae

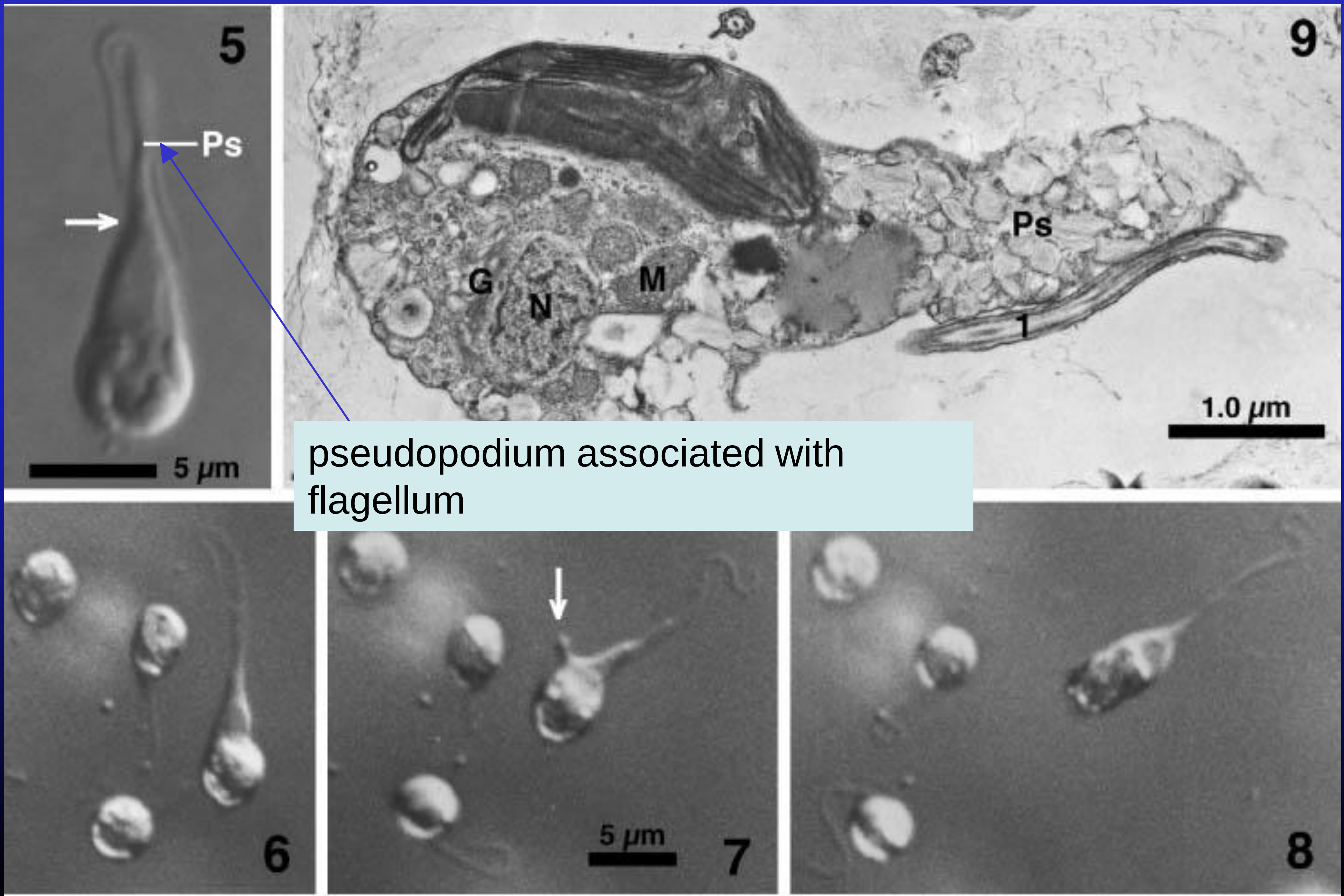
Glossomastix – capsal thallus, zoospores woth 1 flagellum





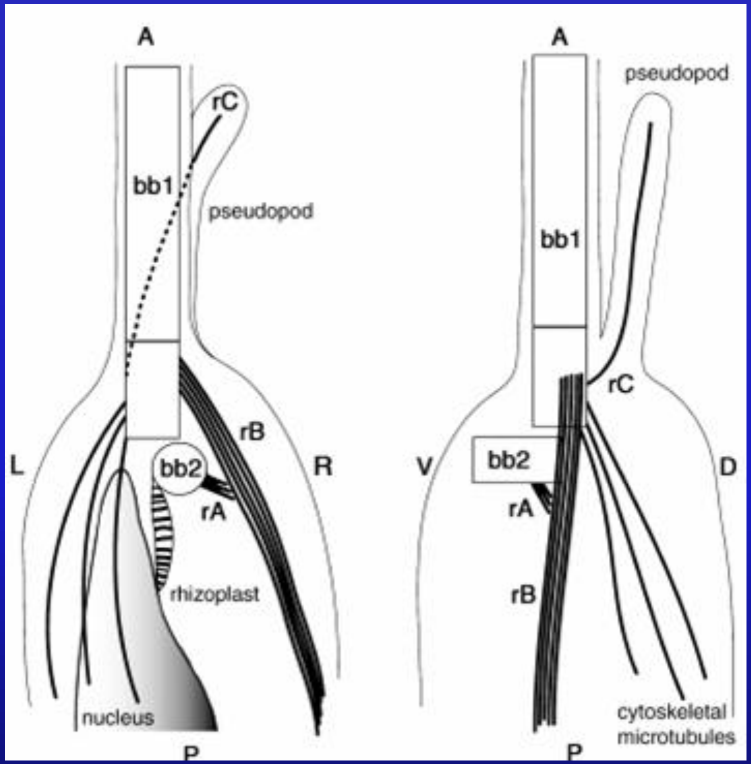
Pinguiophyceae

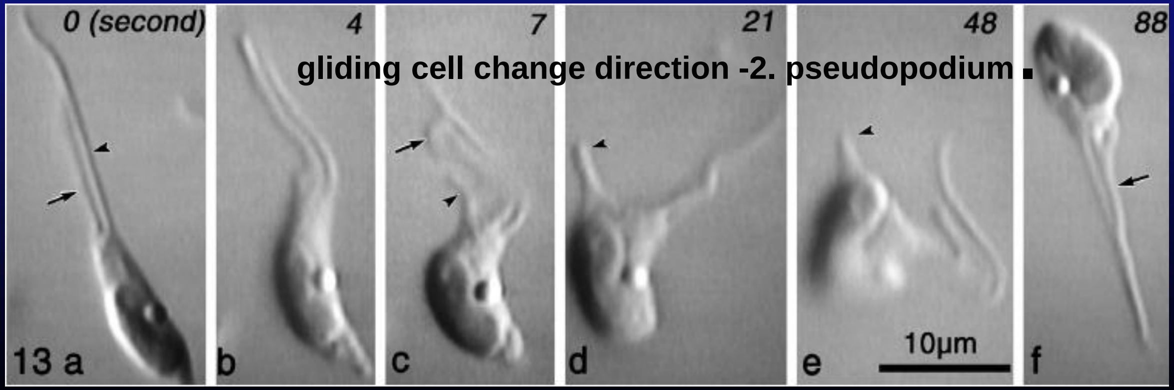
Glossomastix – capsal thallus, zoospores with 1 flagellum



Pinguiophyceae

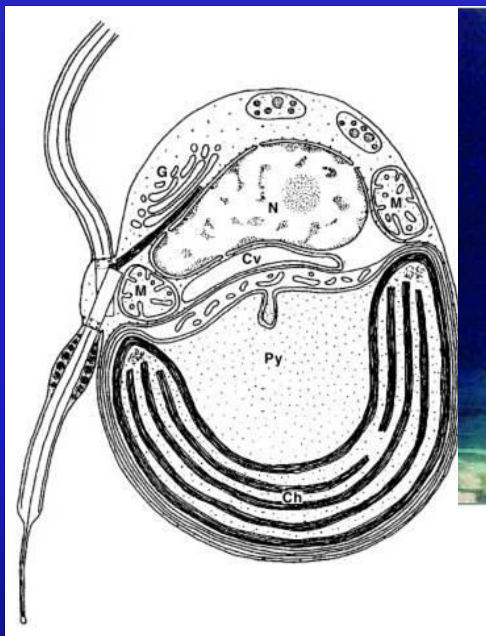
Polypodochrysis – coccoid cells in lorica, zoospores with 1 flagellum



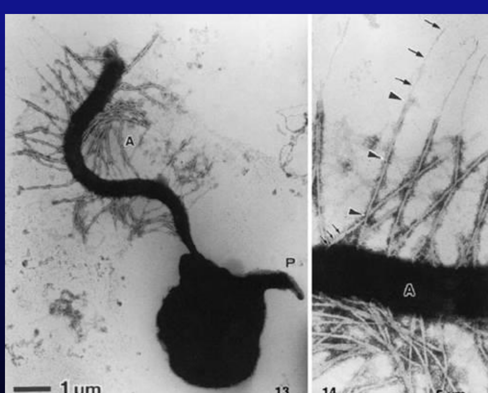


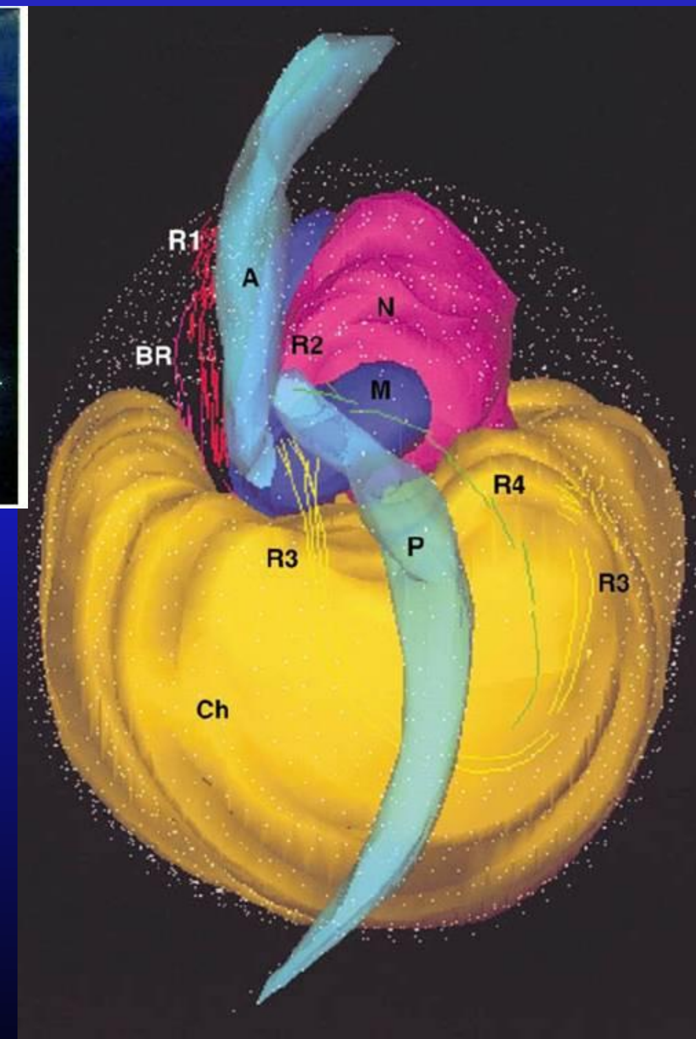
Pinguiophyceae

Phaeomonas – 2 heterokont flagella, no pseudopodium



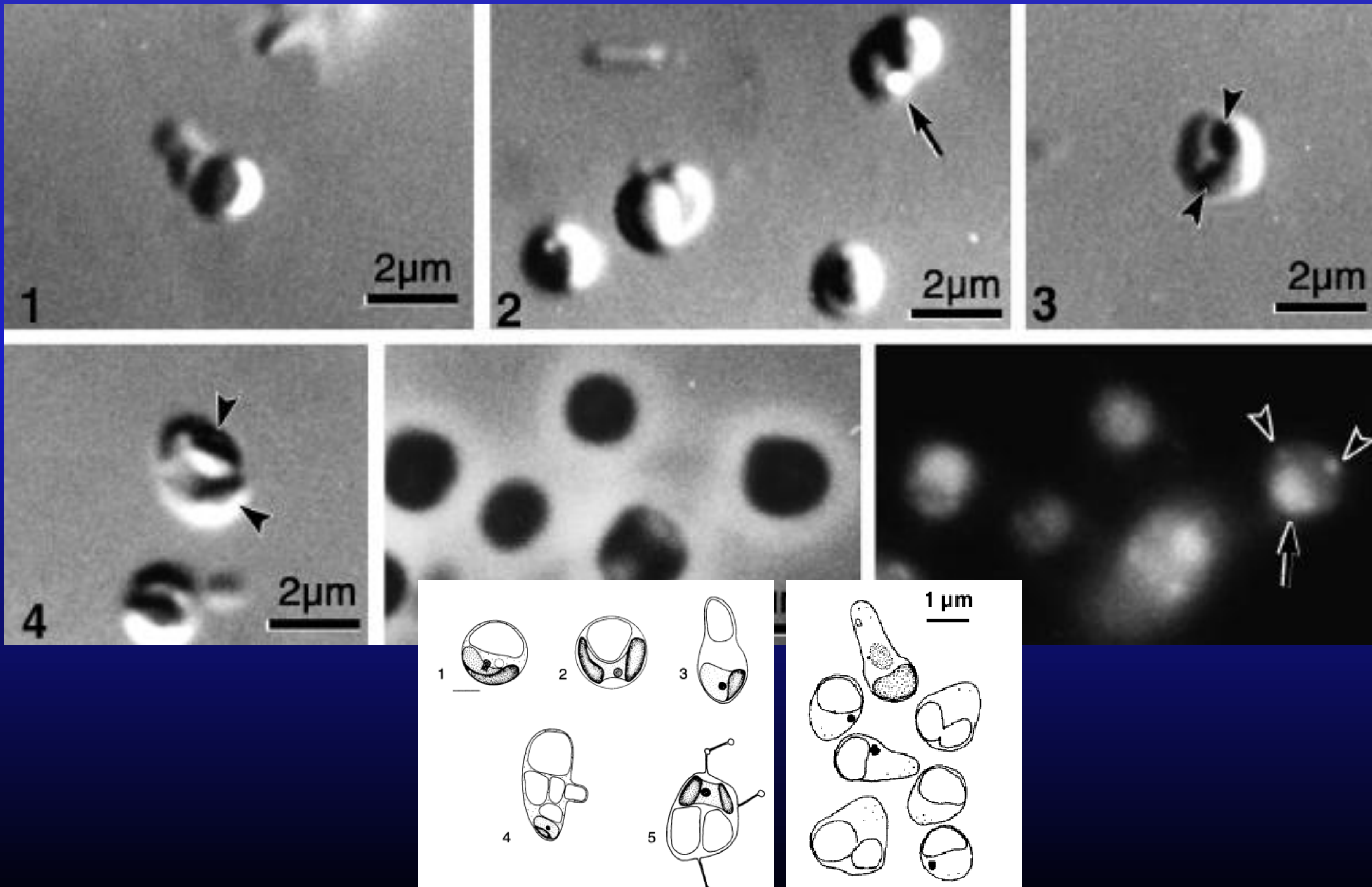
ocenic plankton





Pinguiophyceae

Pinguiococcus, *Pinguiochrysis* – coccoid



Organisms Diversity & Evolution (2022) 22:327–341
https://doi.org/10.1007/s13127-022-00554-y

ORIGINAL ARTICLE

Phylogenetic and functional diversity of Chrysophyceae in inland waters

Christina Bock[1] · Jana L. Olefeld[1] · Janina C. Vogt[2] · Dirk C. Albach[2] · Jens Boenigk[1]

a substantial diversity, i.e., Paraphysomonadida Scoble and Cavalier-Smith 2014, Synurales Andersen 1987, Chromulinales Pascher 1910, Chrysosaccales Bourrelly 1954, Hydrurales Pascher 1931, Hibberdiales Andersen 1989, Segregatales Boenigk and Grossmann 2016, Ochromonadales Pascher 1910 and Apoikiida Boenigk et Grossmann 2016b (Andersen, 1987, 1989; Brodie & Lewis (2007); Grossmann