

# Determinace zelených kokálních řas

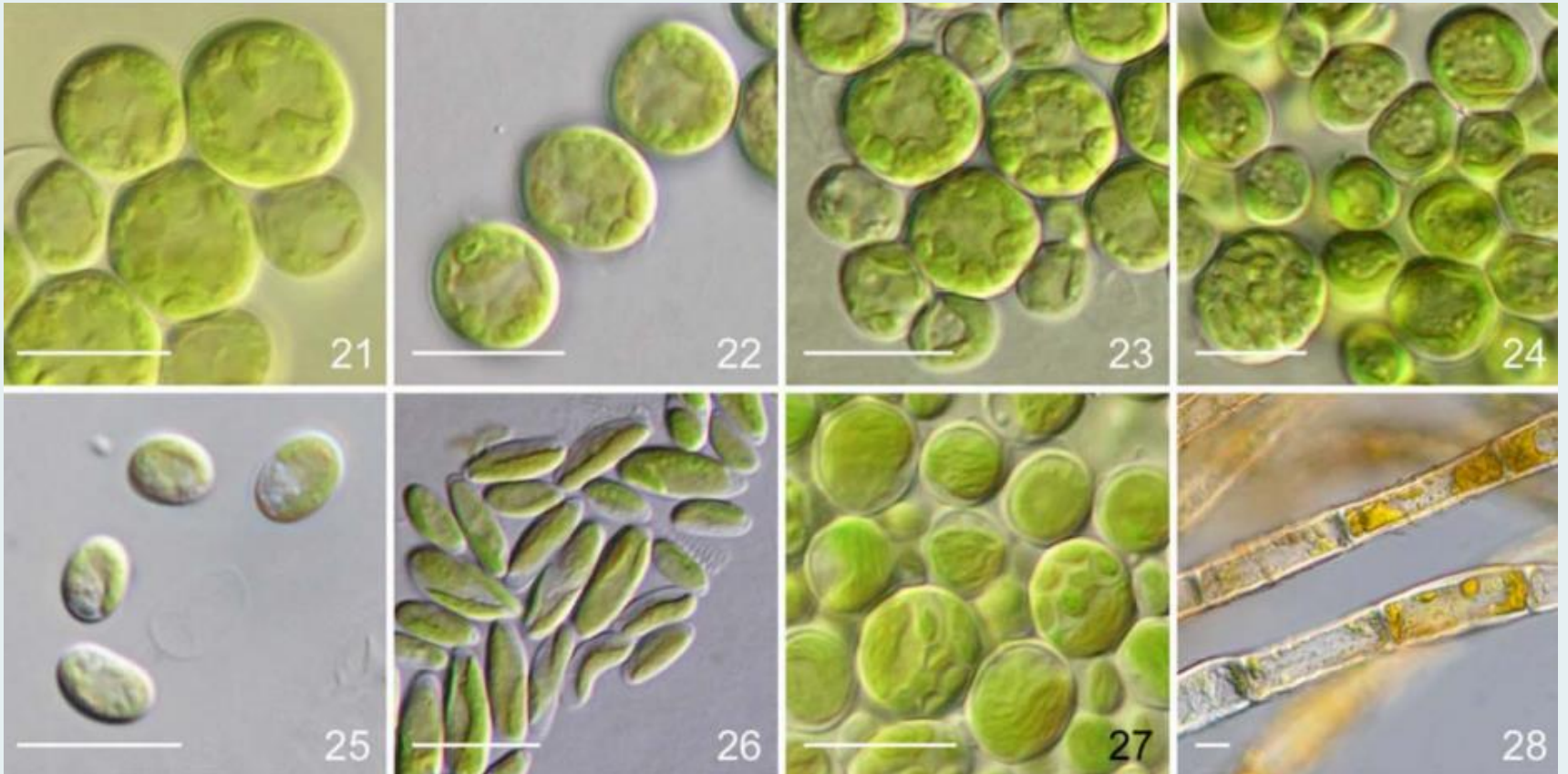


*Pavel Škaloud*

*Univerzita Karlova v Praze, Katedra botaniky*

# Systematika zelených kokálních řas

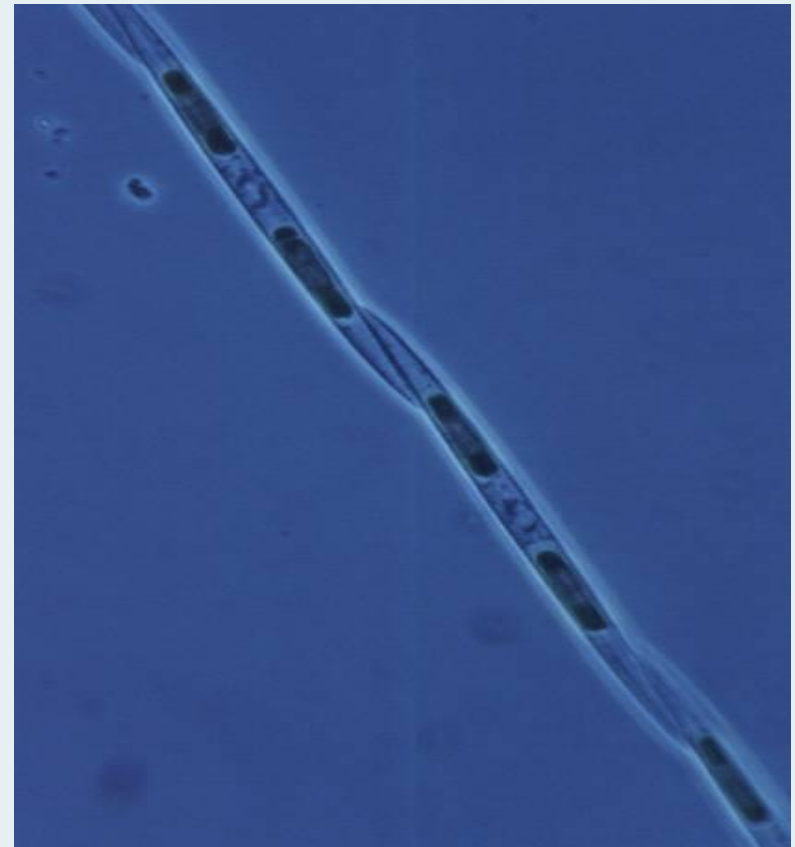
- starší systém založený na morfologických znacích je nahrazován moderní systematikou stavěnou na molekulárních datech



# Systematika zelených kokálních řas

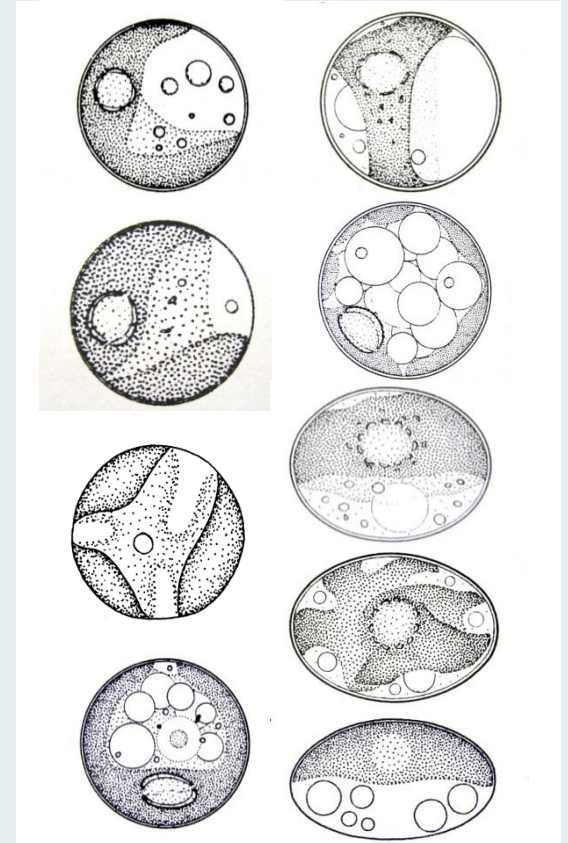
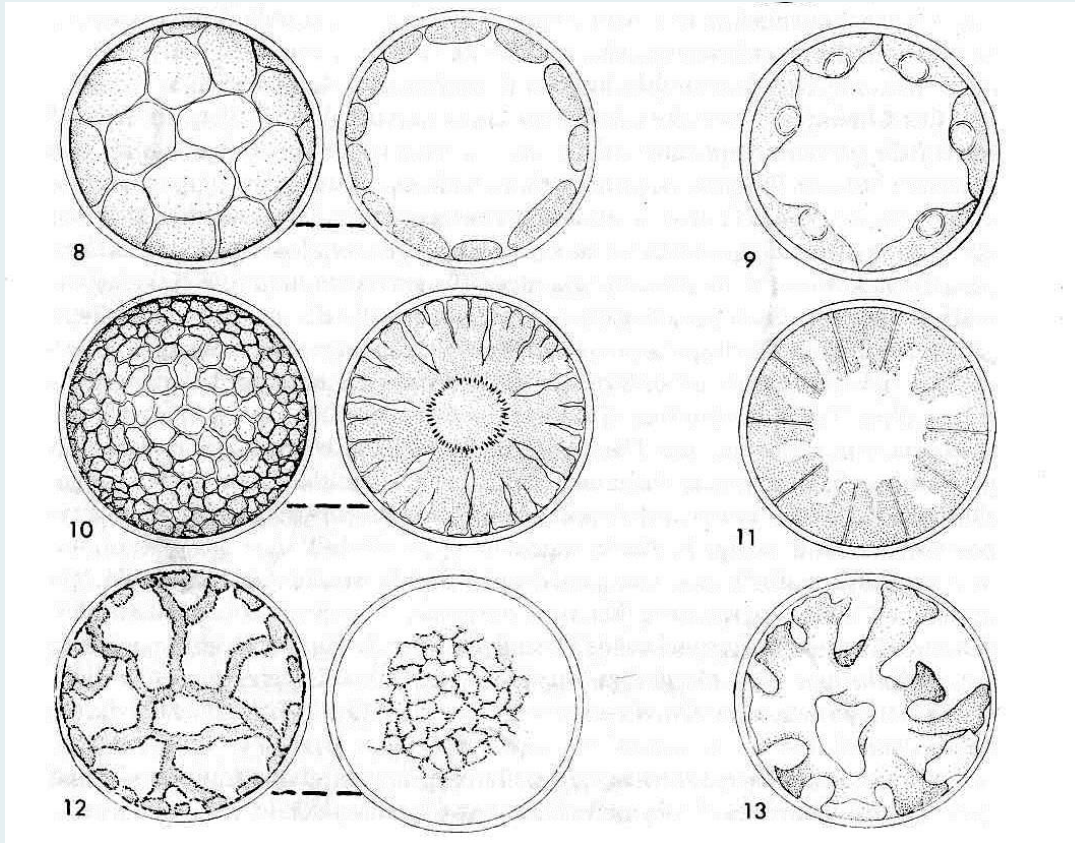
- biologický koncept druhu
  - u naprosté většiny zelených kokálních řas nebyl sex pozorován

Genotypes:	del1	del2	del3	pse1	pse2	pse3	pse4
No. of tested strains	34	25	5	17	4	2	8
del1	392	133	10	118	8	4	10
del2		723	16	52	-	12	16
del3			29	72	10	-	2
pse1				118	31	4	12
pse2					-	-	-
pse3						19	17
pse4							41



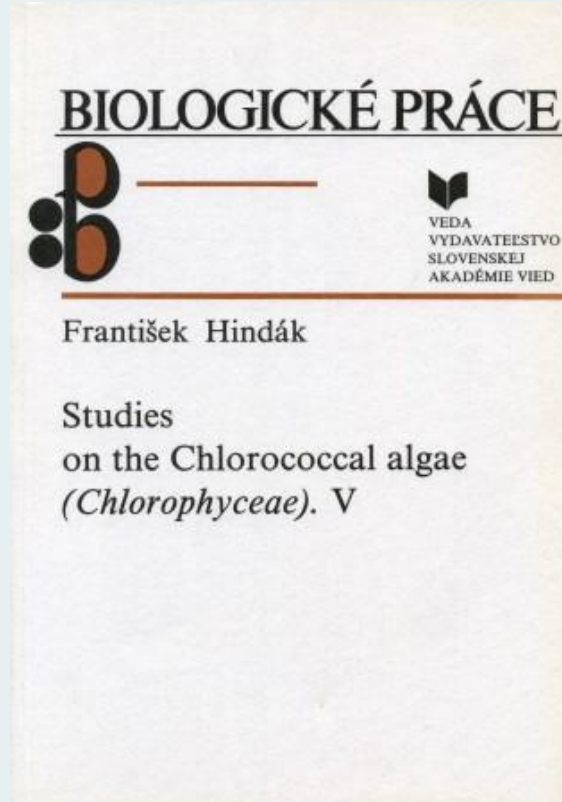
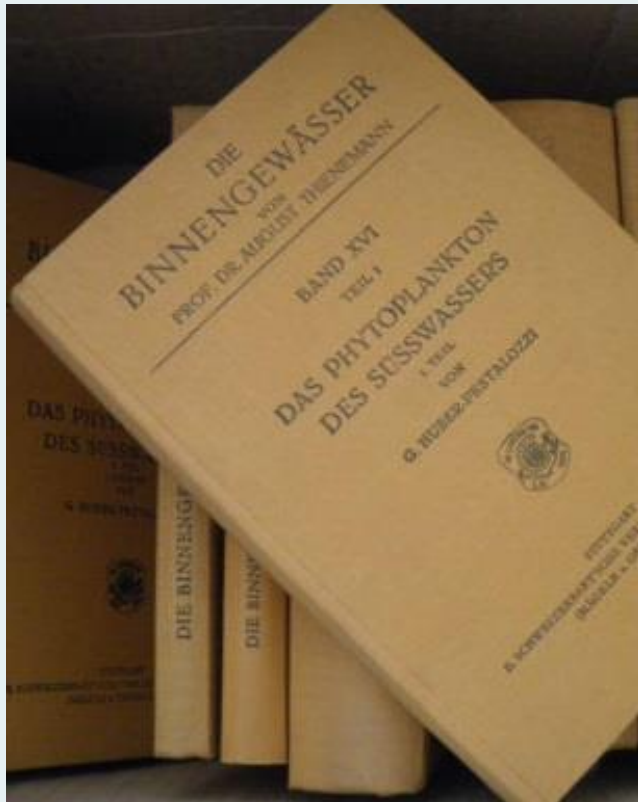
# Systematika zelených kokálních řas

- morfologický koncept druhu
  - druhy jako nejmenší morfologicky rozeznatelné skupiny organismů



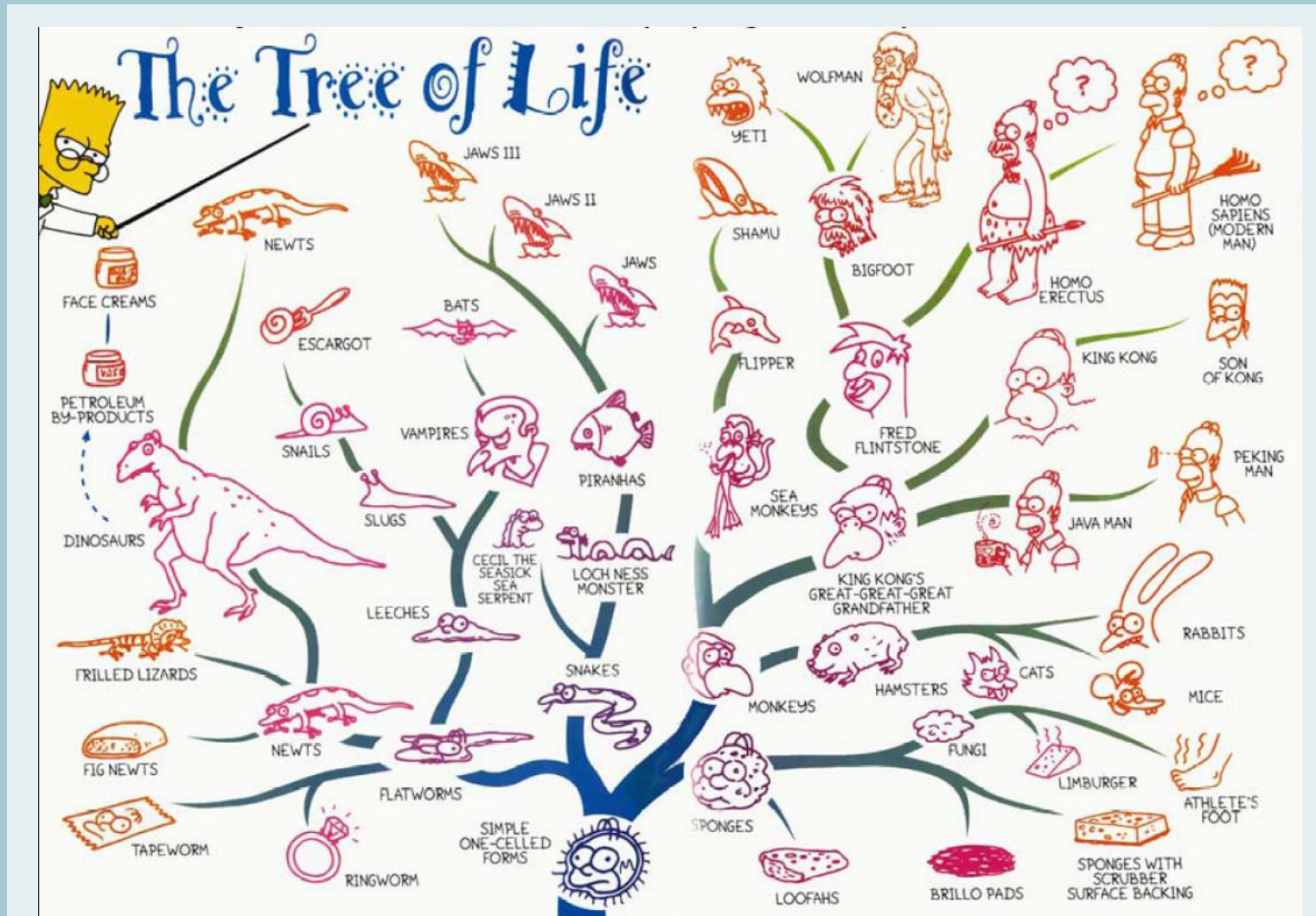
# Systematika zelených kokálních řas

- morfologický koncept druhu
  - proslulá Československá morfologická škola

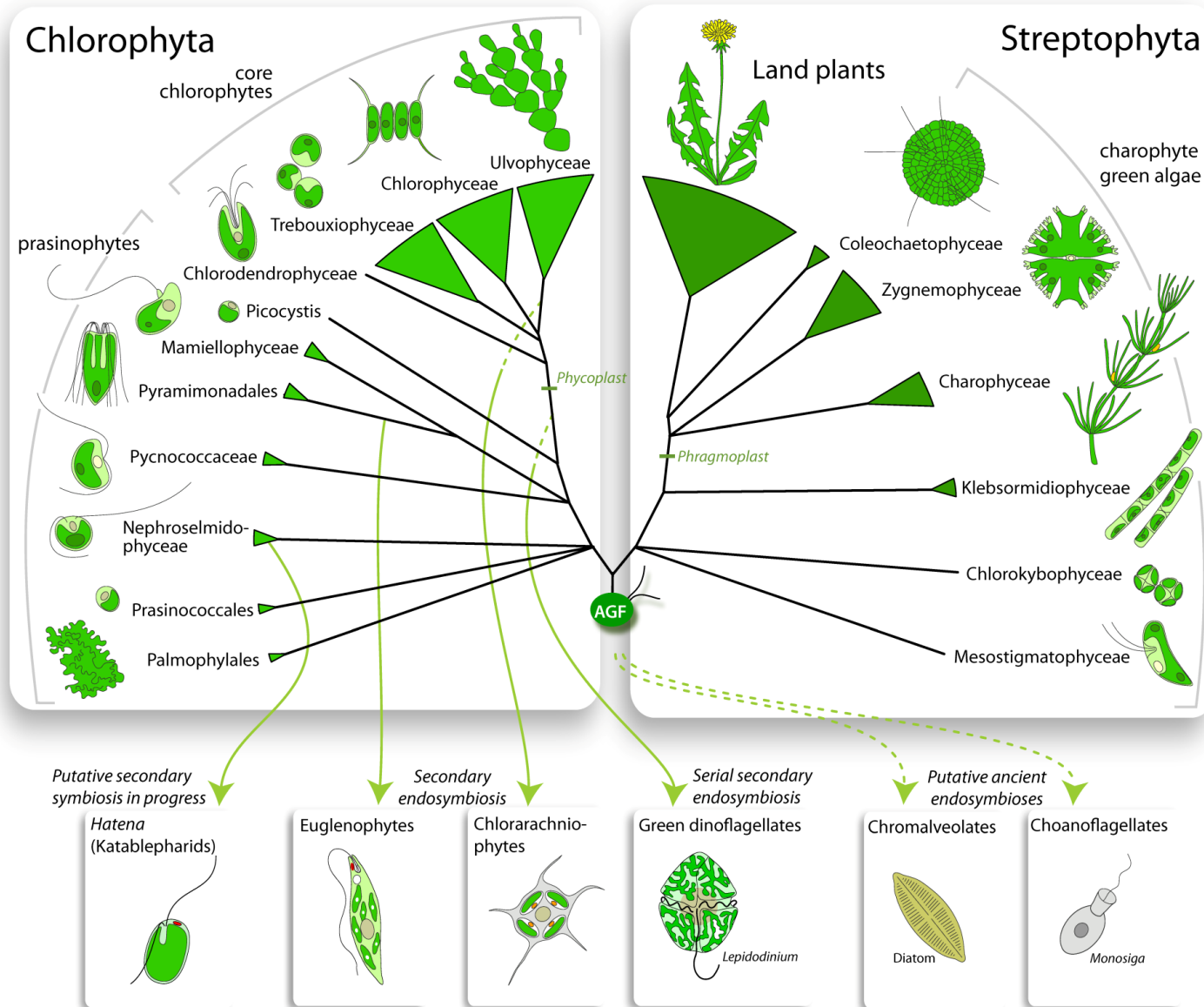


# Systematika zelených kokálních řas

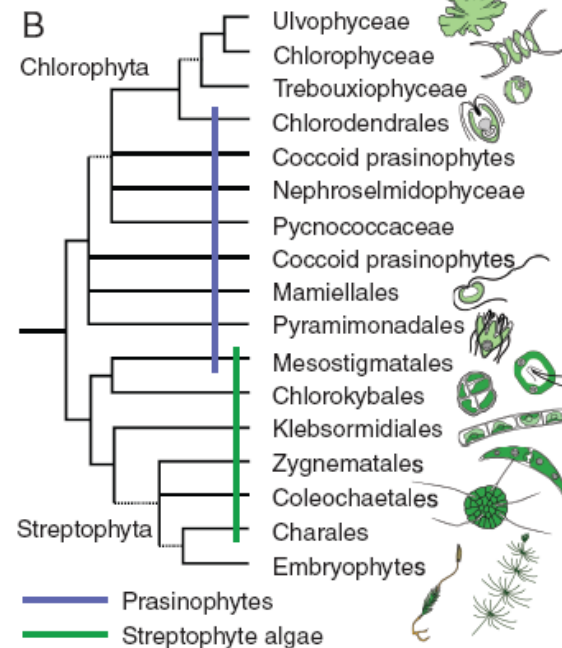
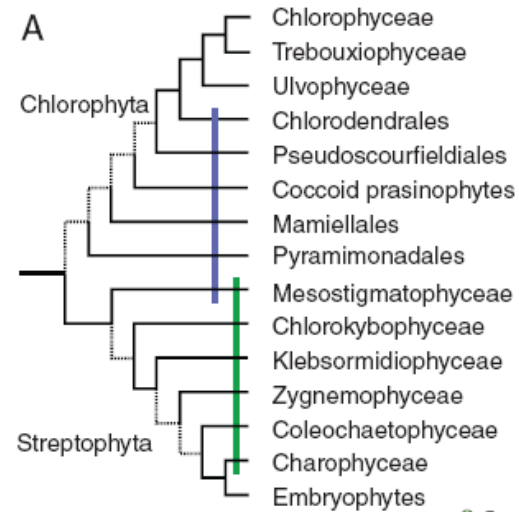
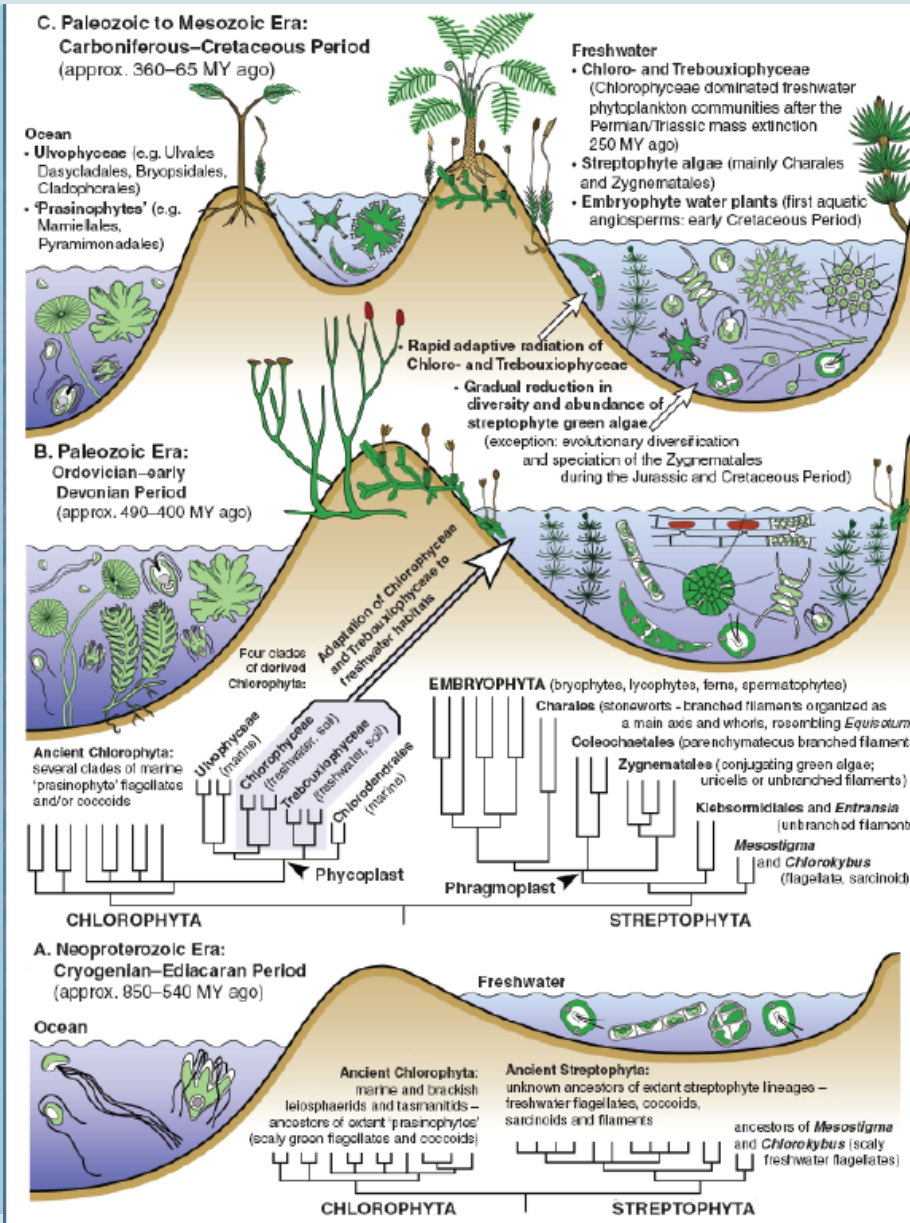
- fylogenetický druhový koncept
  - druh jako nejmenší skupina organismů sdílející unikátní kombinaci molekulárních znaků



# Systematika zelených kokálních řas

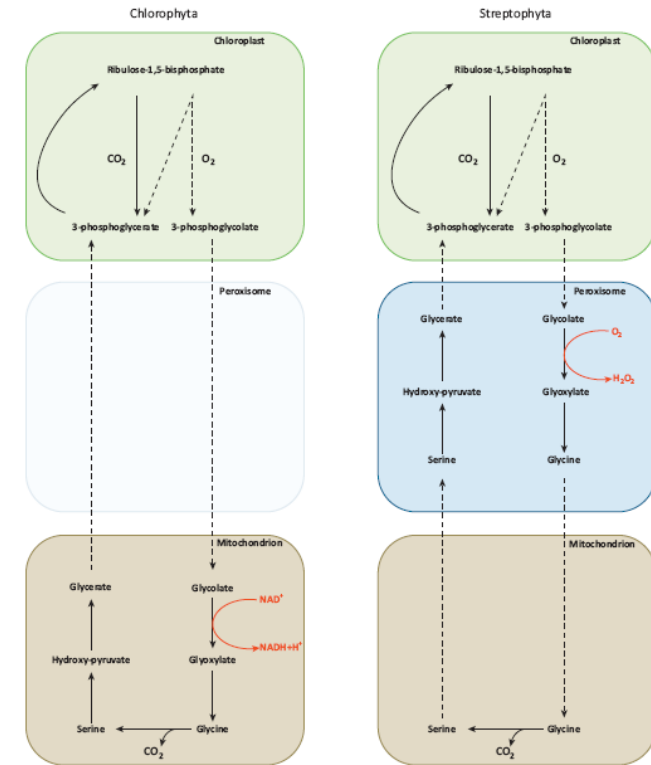
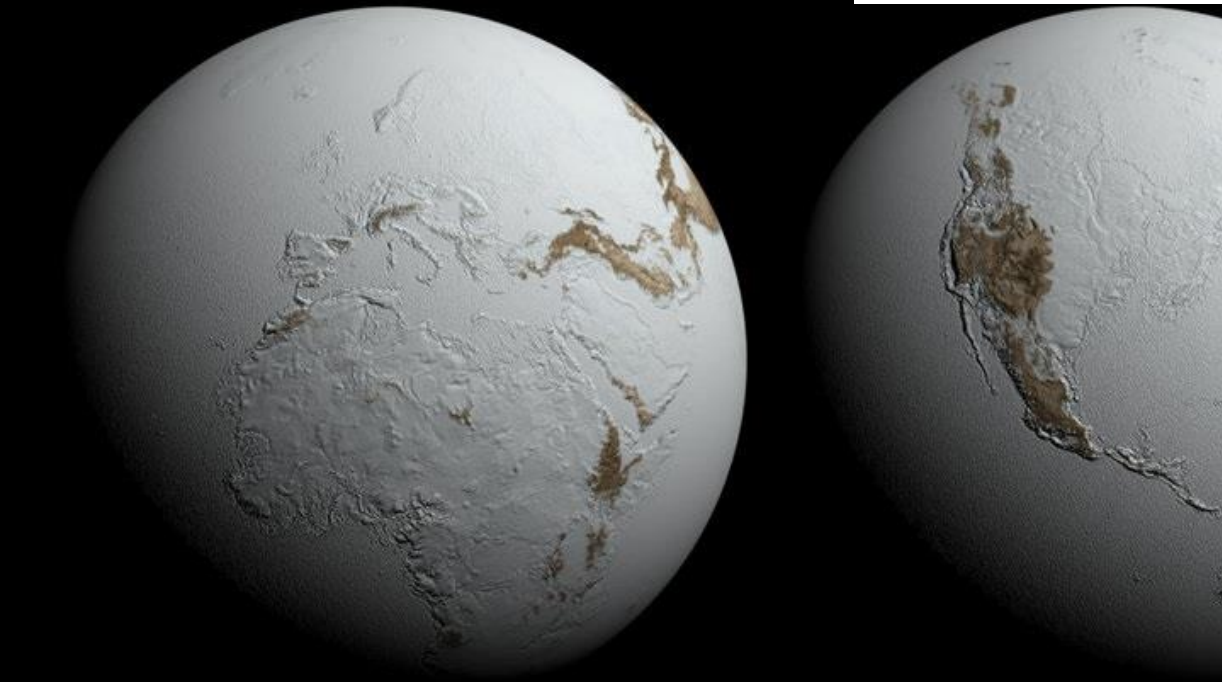
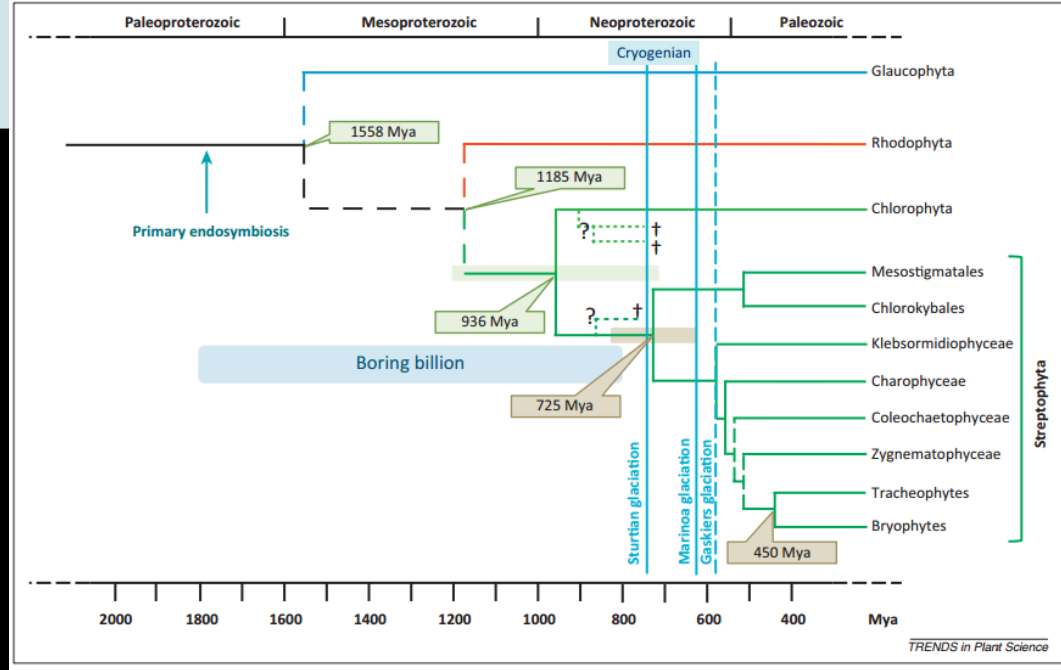


# Evolve zelených řas

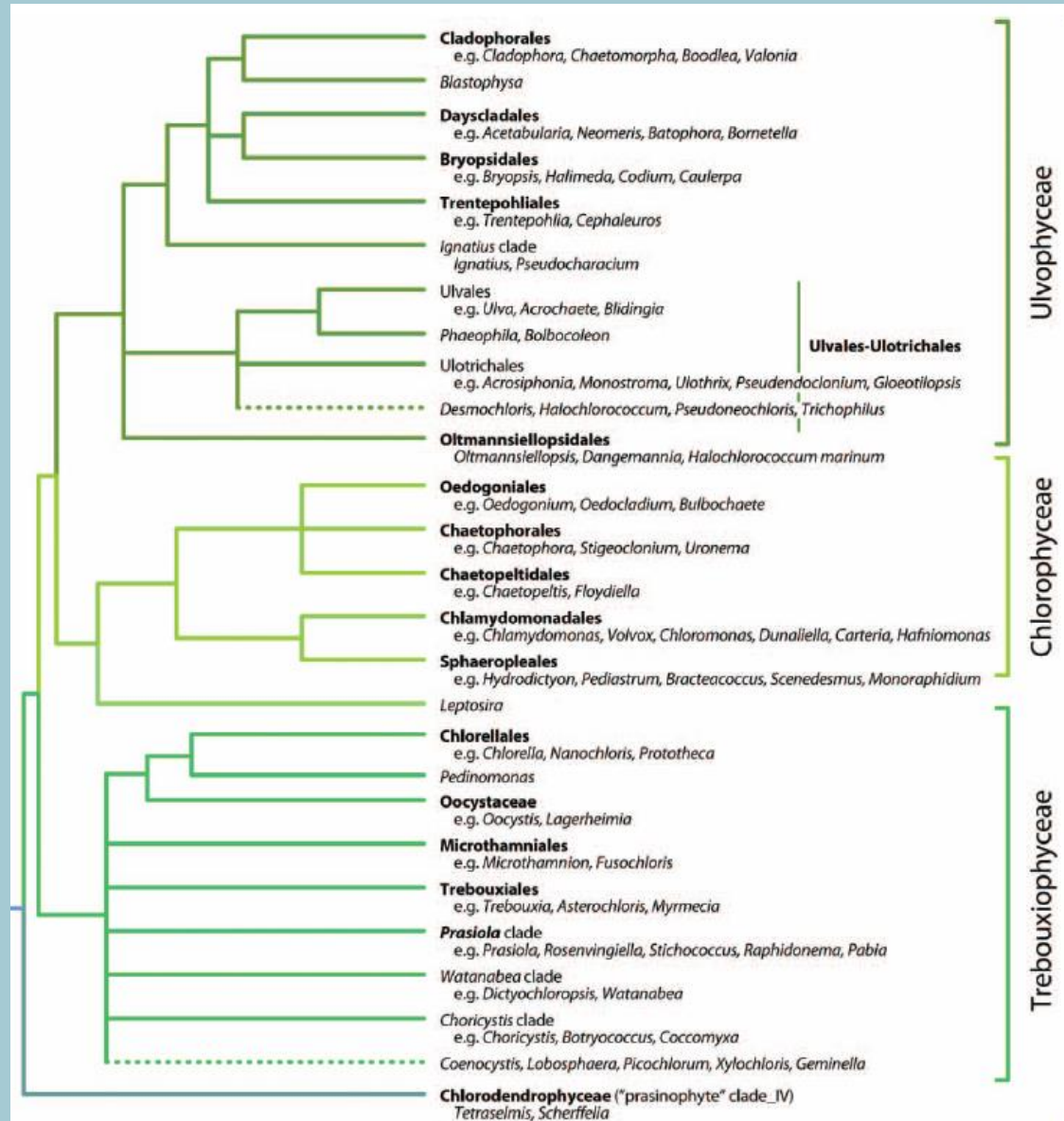
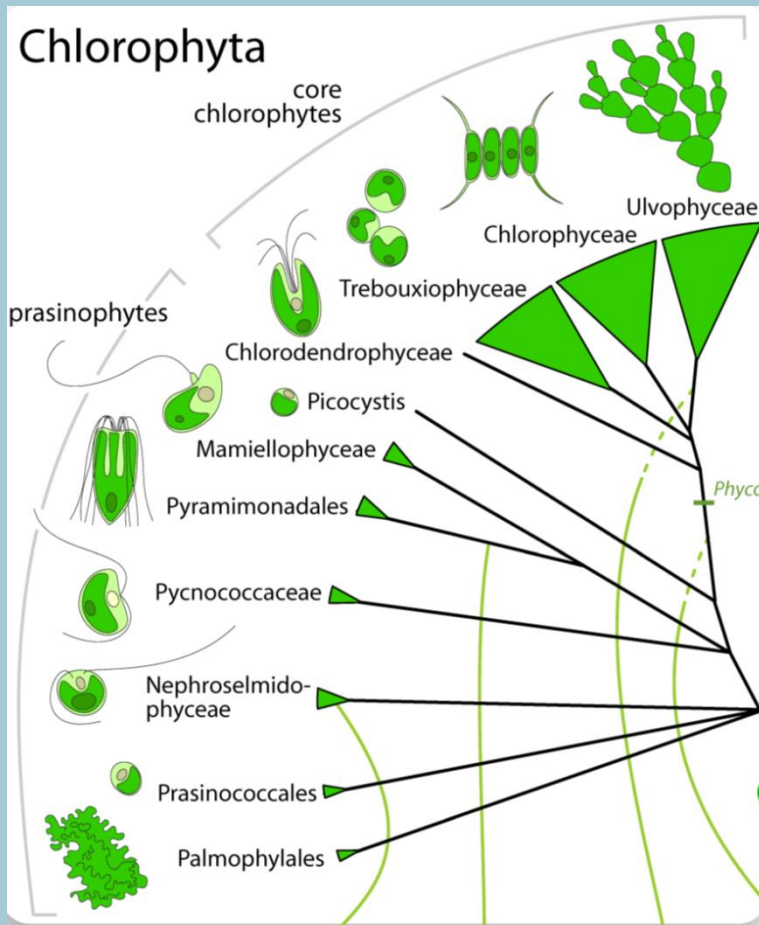




# Evoluce zelených řas

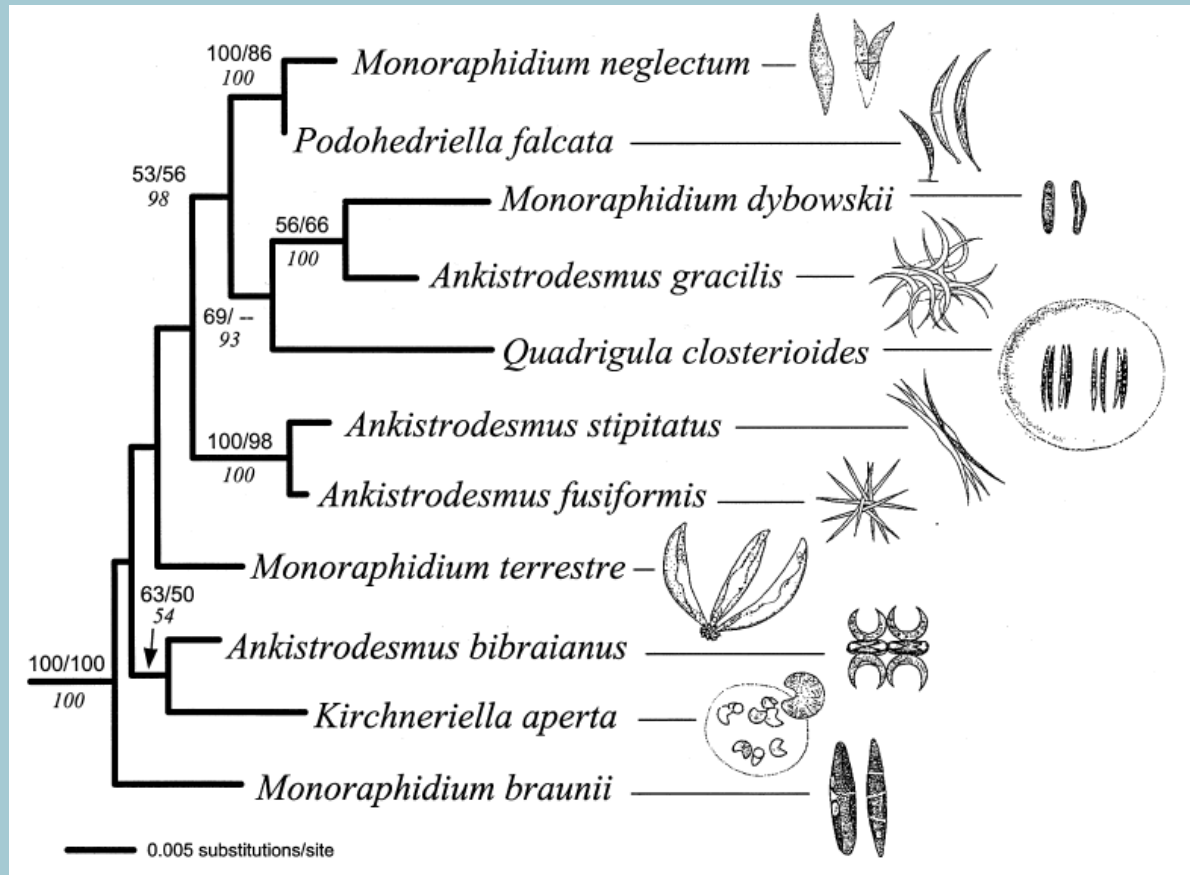


# Chlorophyceae



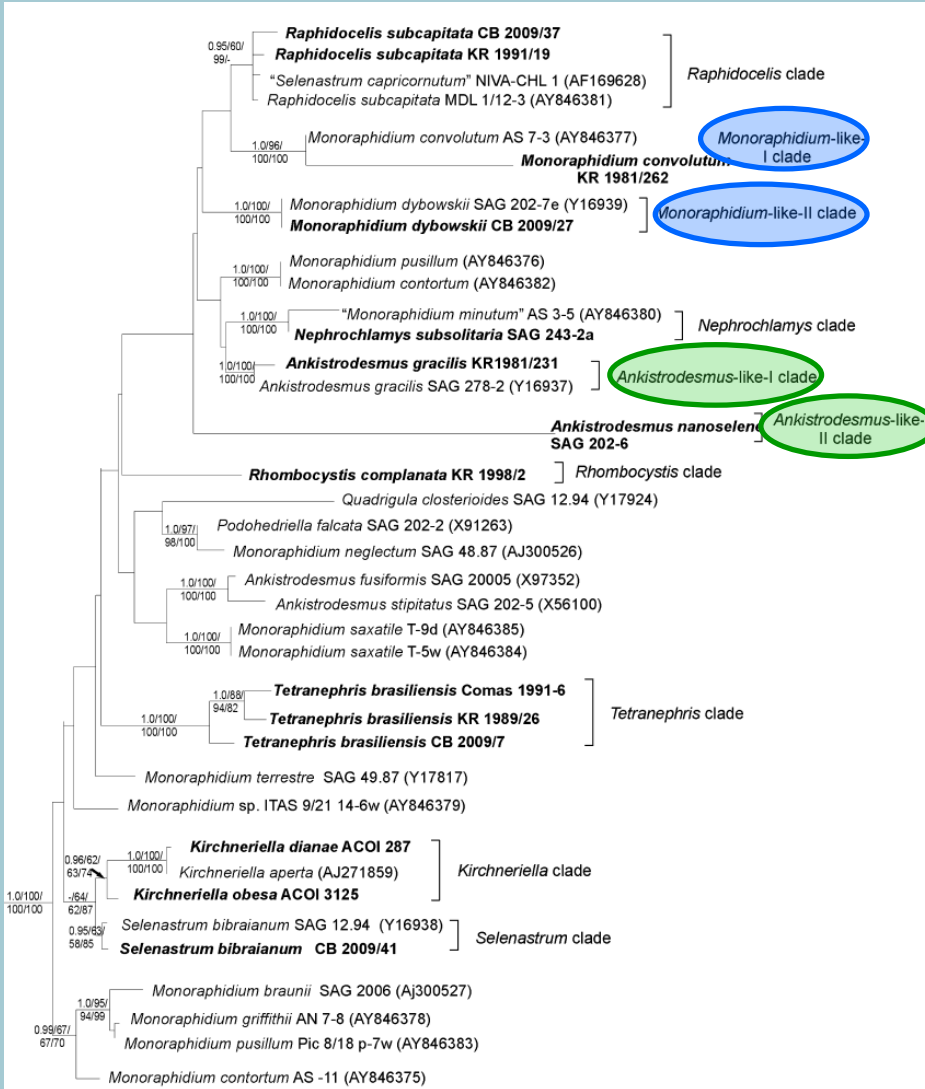
# Chlorophyceae, Selenastraceae

- protáhlé, jehlicovité buňky
- rody a druhy tradičně rozlišovány pomocí tvaru buněk a kolonií, uspořádání autospor, tvorby slizu, a přítomnosti pyrenoidů
- *Monoraphidium* a *Ankistrodesmus* polyfyletické



# Chlorophyceae, Selenastraceae

- počátek revize jednotlivých rodů



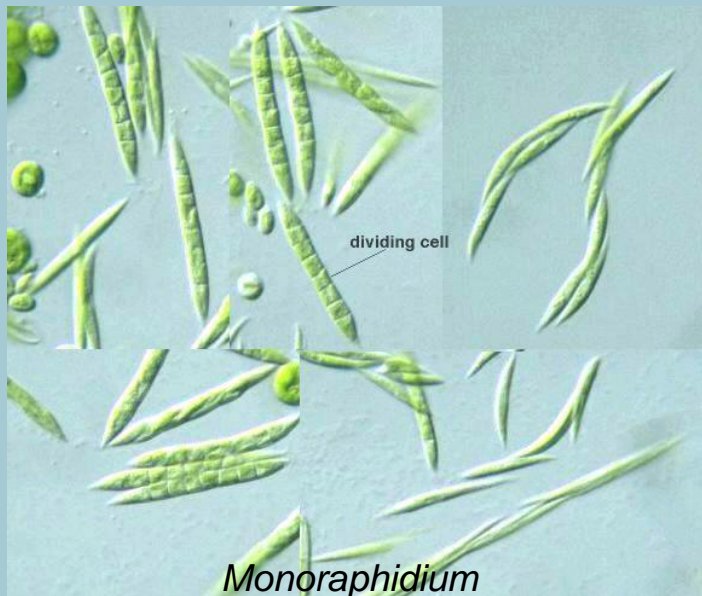
**Table 2** Genera of Selenastraceae confirmed by 18S rRNA gene phylogeny and their main diacritic morphological characteristics

Genus	Drawing	Main diacritic morphology
<i>Ankistrodesmus</i>		Needle-shaped cells, in colonies, parallel arrangement of autospores
<i>Kirchneriella</i>		Semilunate- to crescent-shaped cells, in colonies, serial arrangement of autospores
<i>Monoraphidium</i>		Needle- to rod-shaped cells, solitary, serial arrangement of autospores
<i>Nephrochlamys</i>		Semilunate-shaped cells, in colonies, serial arrangement of autospores, widening mother cell wall
<i>Podohedriella</i>		Needle-shaped cells, solitary, heteropolar, serial arrangement of autospores
<i>Quadrigula</i>		Cylindrical cells with rounded ends, in quadricellular colonies, parallel arrangement of autospores
<i>Raphidocelis</i>		Capricorn-shaped cells, arcuated, solitary or in irregular colonies, serial arrangement of autospores
<i>Rhombocystis</i>		Cells rhomboidal with slightly thickened poles, solitary or colonial, parallel arrangement of autospores
<i>Selenastrum</i>		Semilunate-shaped cells in regular colonies, parallel arrangement of autospores
<i>Tetranephris</i>		Bean-shaped cells in quadricellular colonies, touched at the poles, serial arrangement of autospores

Krienitz et al. (2011): *Journal of Phycology* **47**: 880–893

Krienitz & Bock (2012): *Hydrobiologia* **698**: 295 – 326

# Chlorophyceae, Selenastraceae



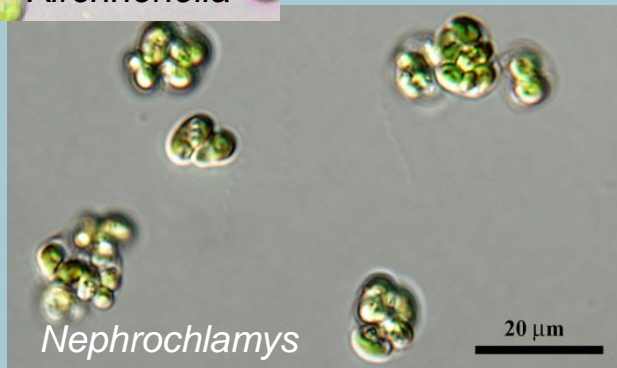
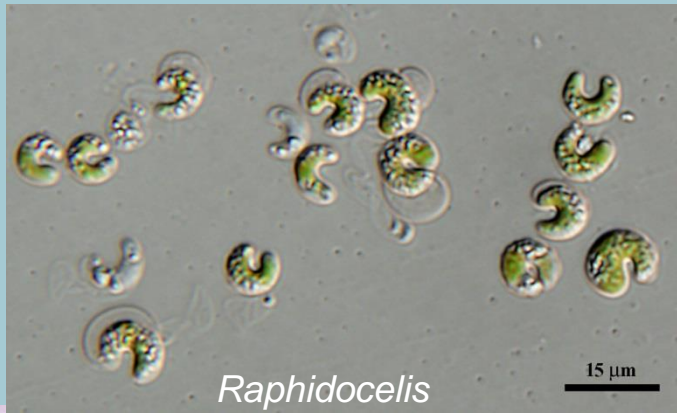
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# Chlorophyceae, Selenastraceae



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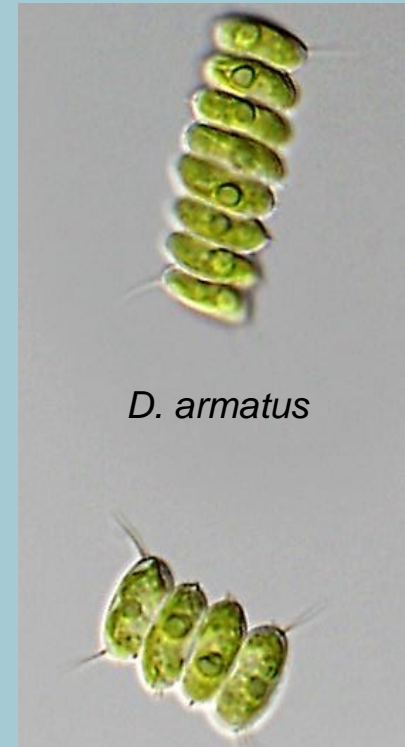
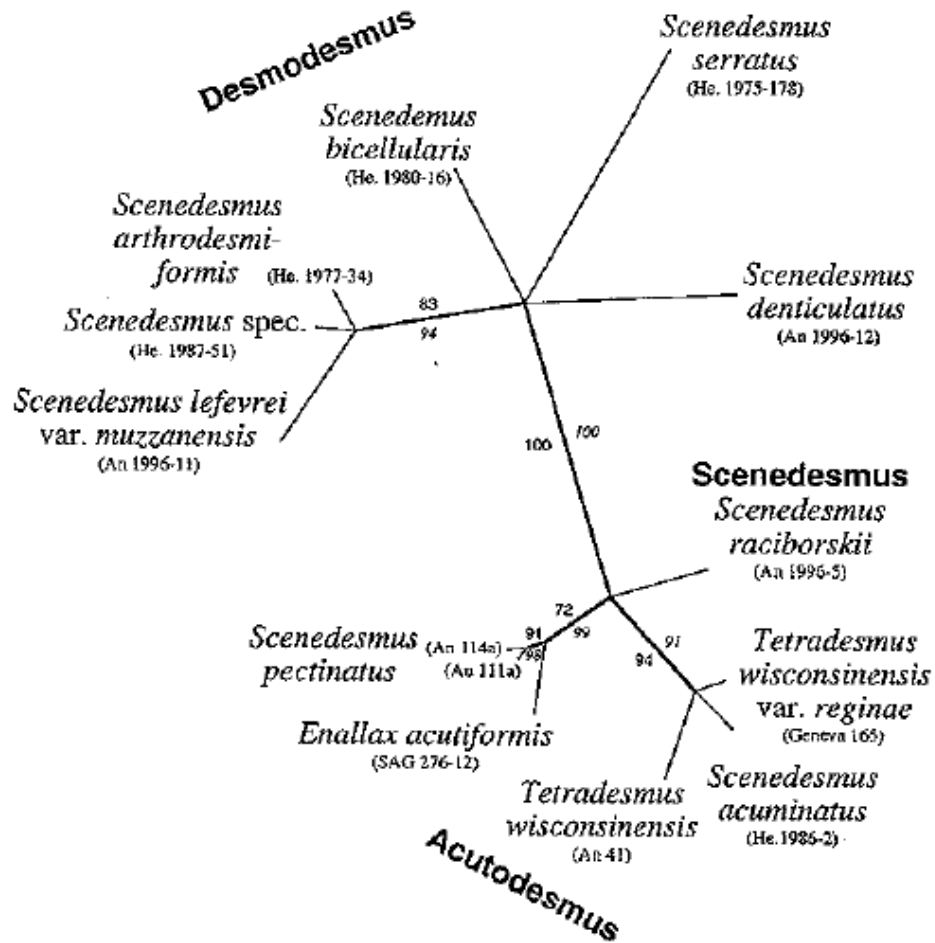
# Chlorophyceae, Scenedesmaceae

- *Scenedesmus* – popsáno přes 450 druhů a vnitrodruhových taxonů



# Chlorophyceae, Scenedesmaceae

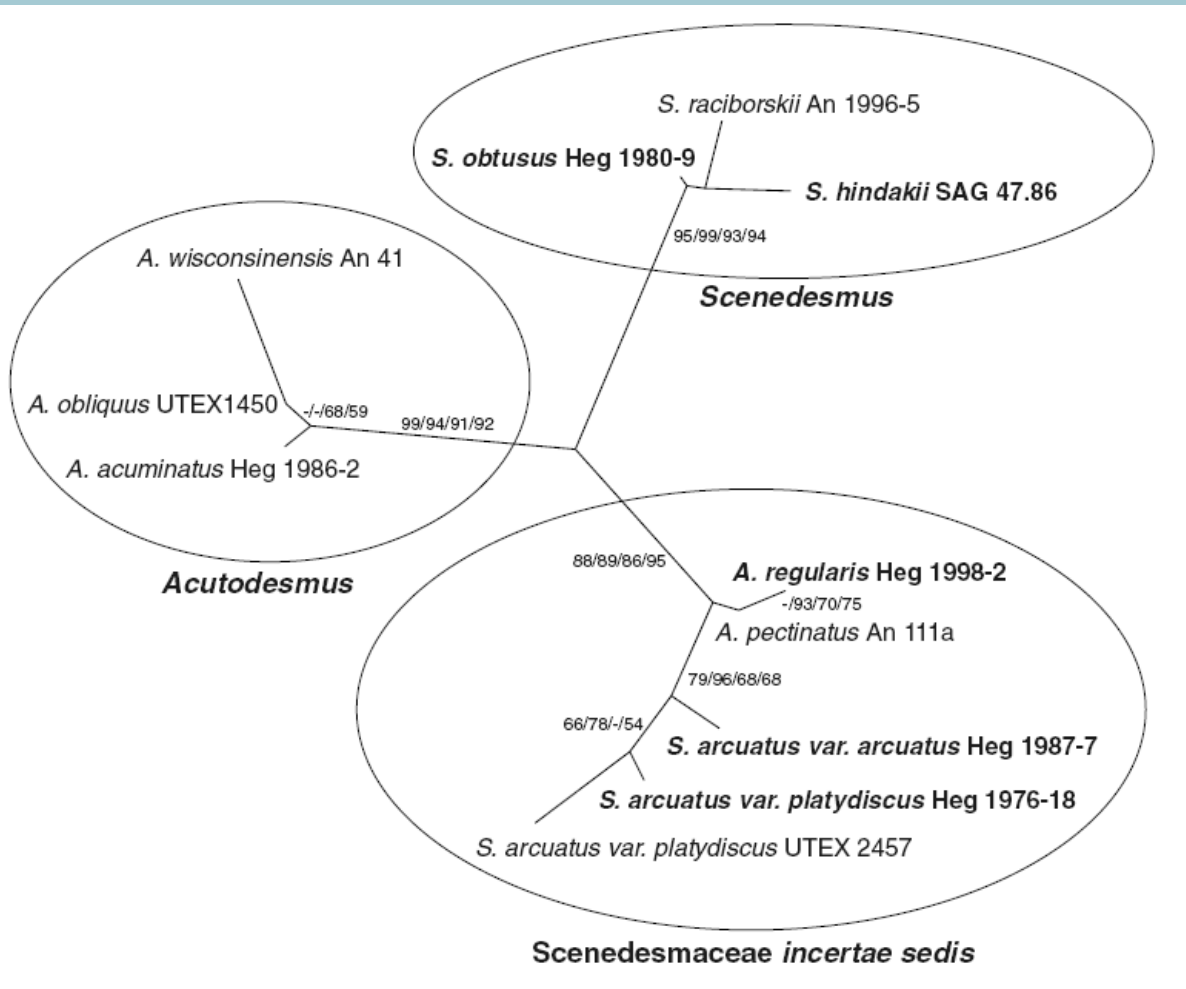
- *Scenedesmus* – hladká BS, sliz
- *Desmodesmus* – žebra, ostny, ...



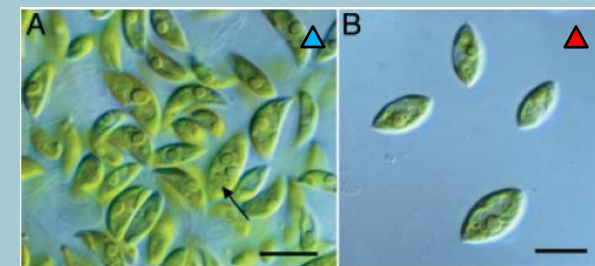


# Chlorophyceae, Scenedesmaceae

- *Acutodesmus* – hladké buňky, ostré konce buněk, bez slizu

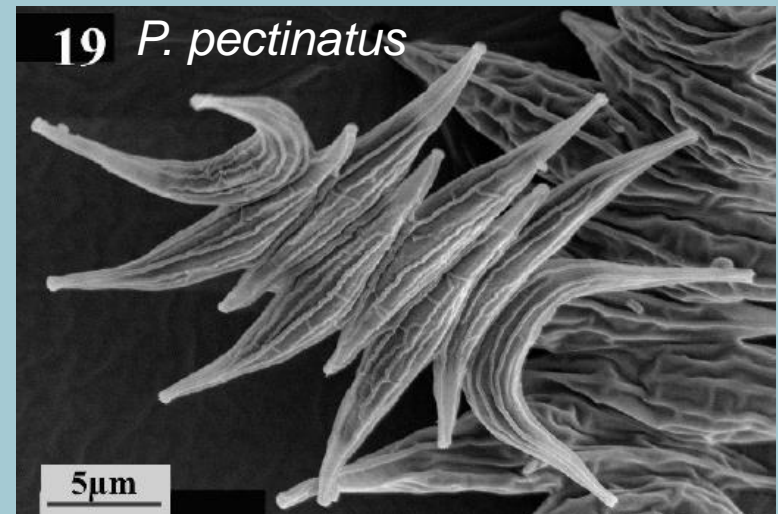
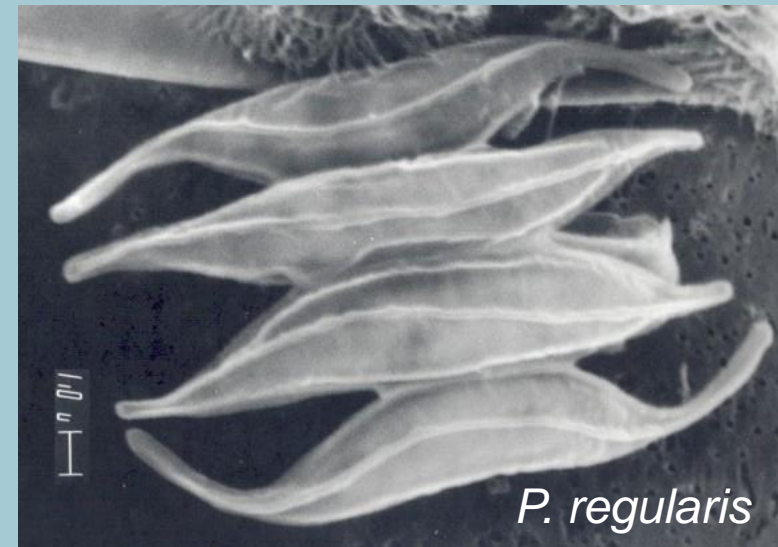
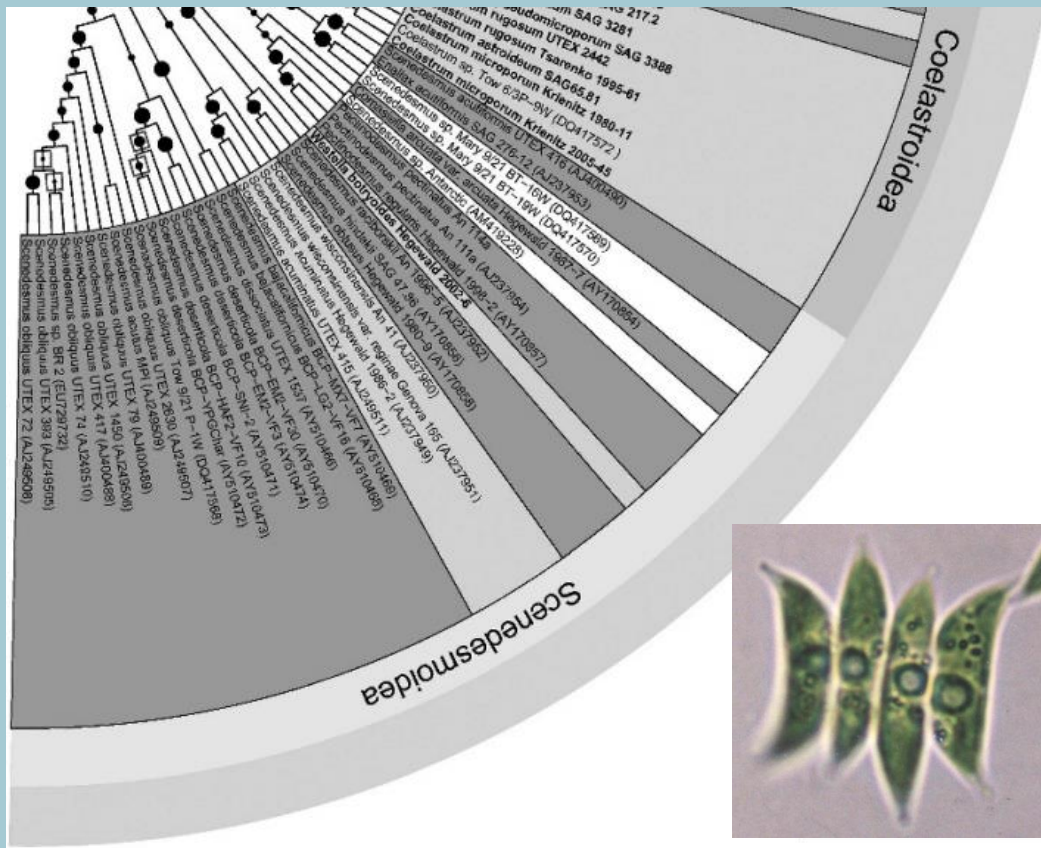


- A. acuminatus* ▲
- A. reginae*
- A. obliquus*
- A. deserticola* ▲
- A. bajacalifornicus* ▲



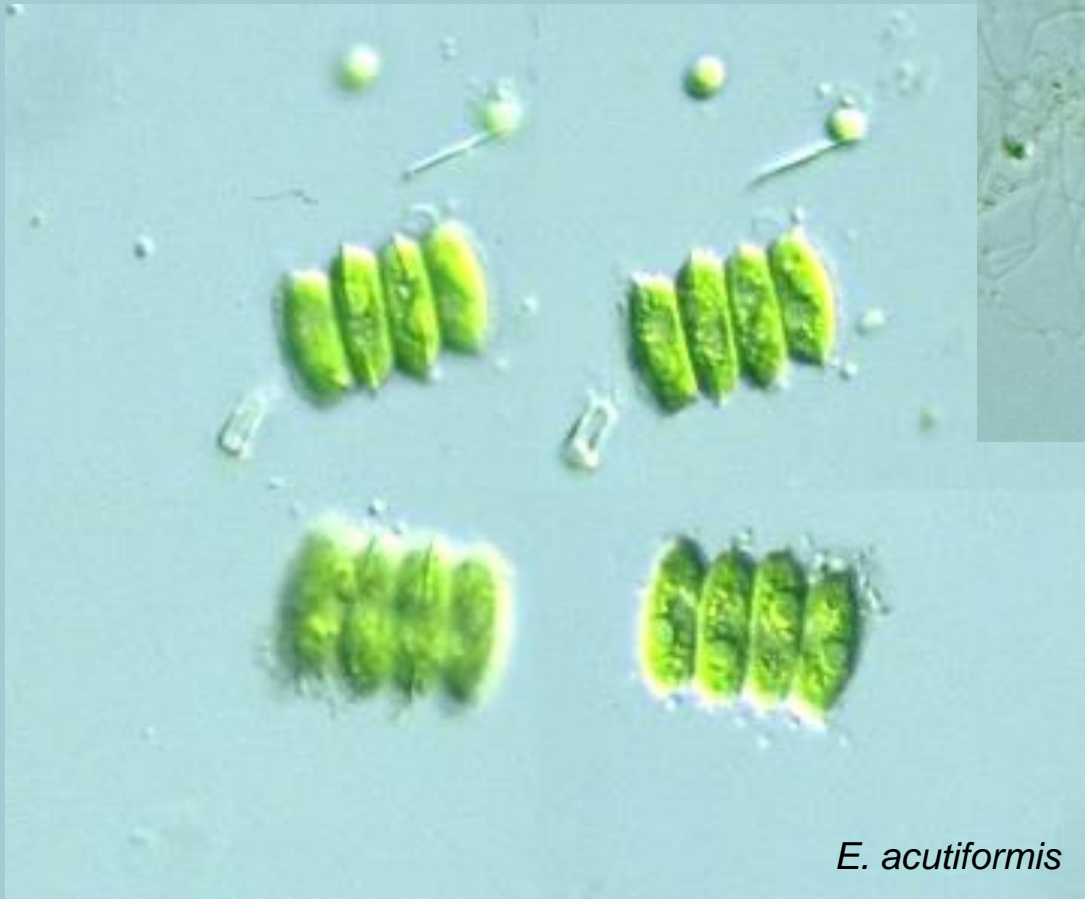
# Chlorophyceae, Scenedesmaceae

- *Pectinodesmus* – ostré konce buněk, podélná žebra na BS, bez slizu
  - *P. pectinatus*
  - *P. regularis*



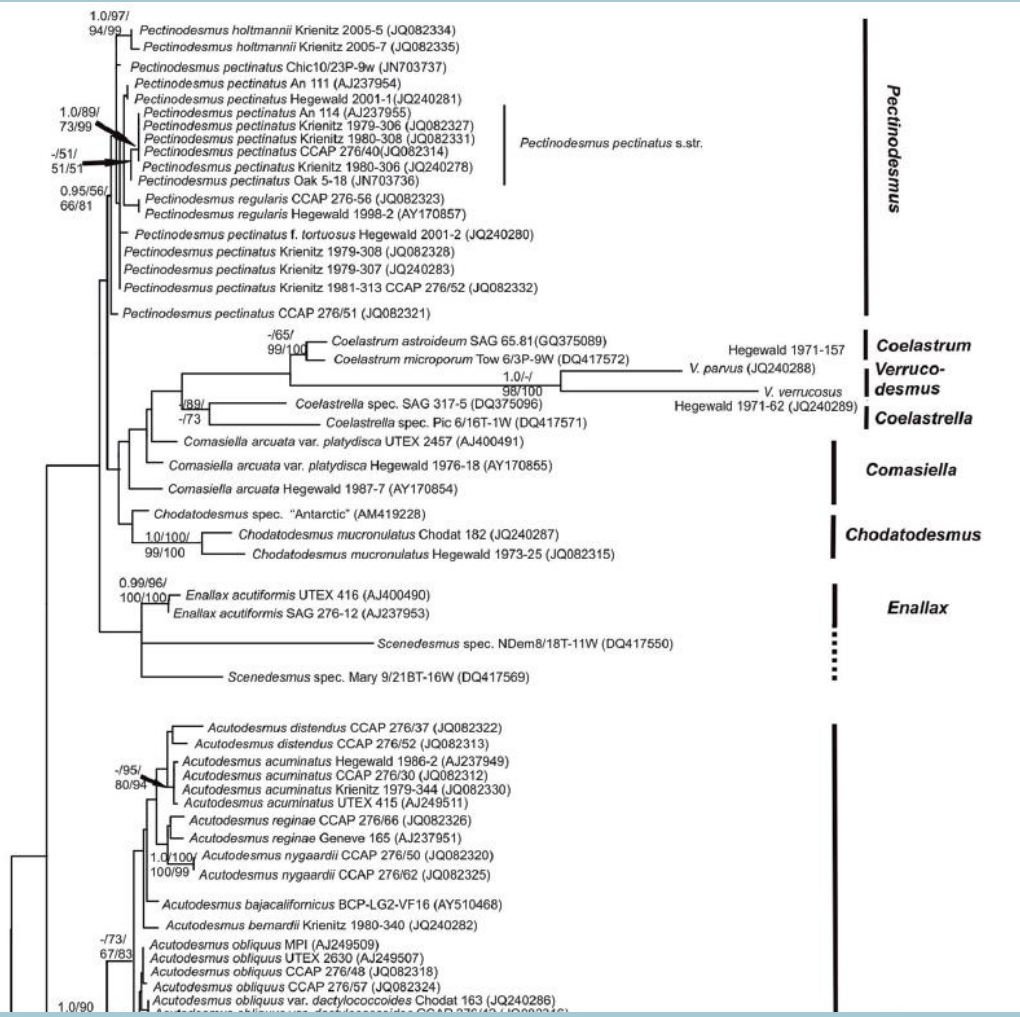
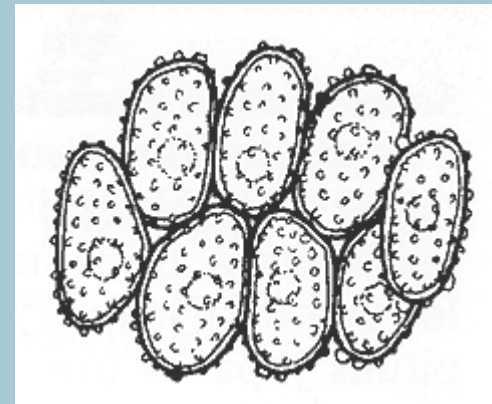
# Chlorophyceae, Scenedesmaceae

- *Enallax* – podélná žebra na BS, bez slizu, “coenobiální *Coelastrella*“
  - *E. acutiformis*
  - *E. coelastroides*, *E. costatus*



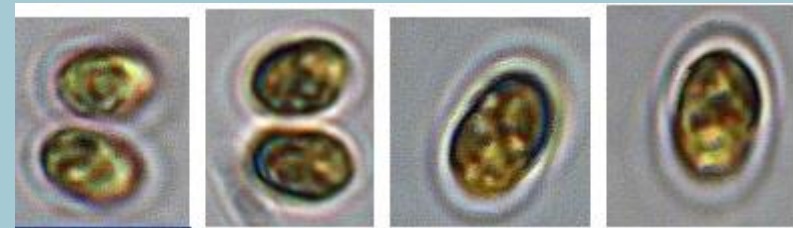
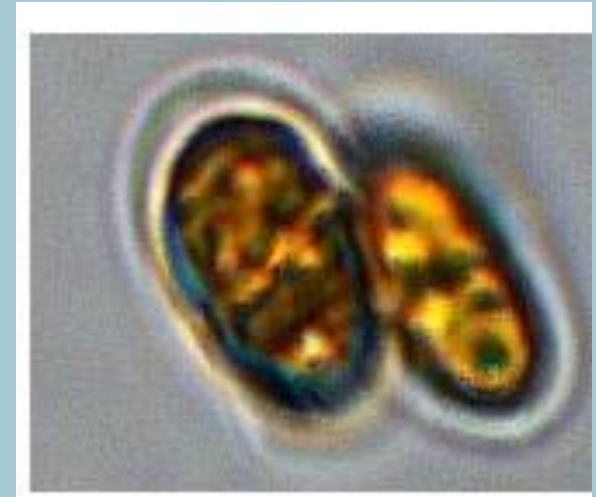
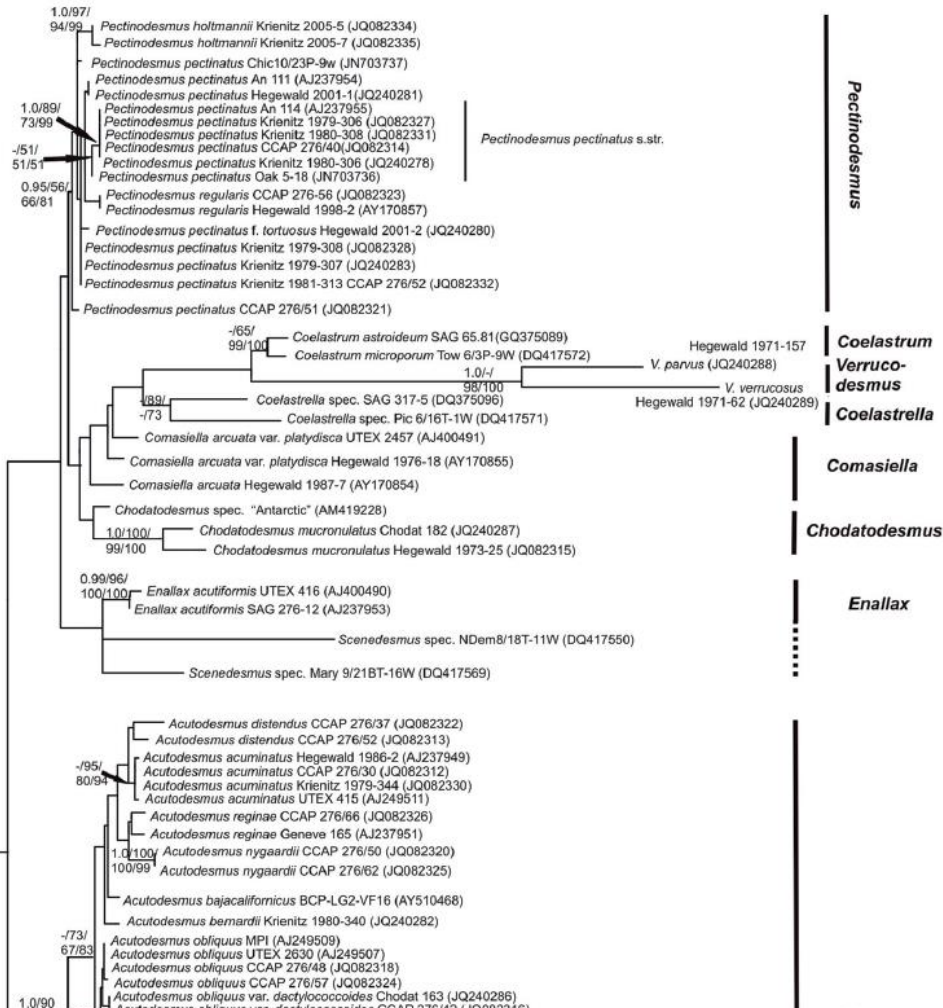
# Chlorophyceae, Scenedesmaceae

- *Verrucodesmus* – granulovaná buněčná stěna
  - *V. verrucosus*, *V. parvus*



# Chlorophyceae, Scenedesmaceae

- *Chodatodesmus* – jednobuněčný, eliptické, hladké buňky
  - *C. mucronulatus*



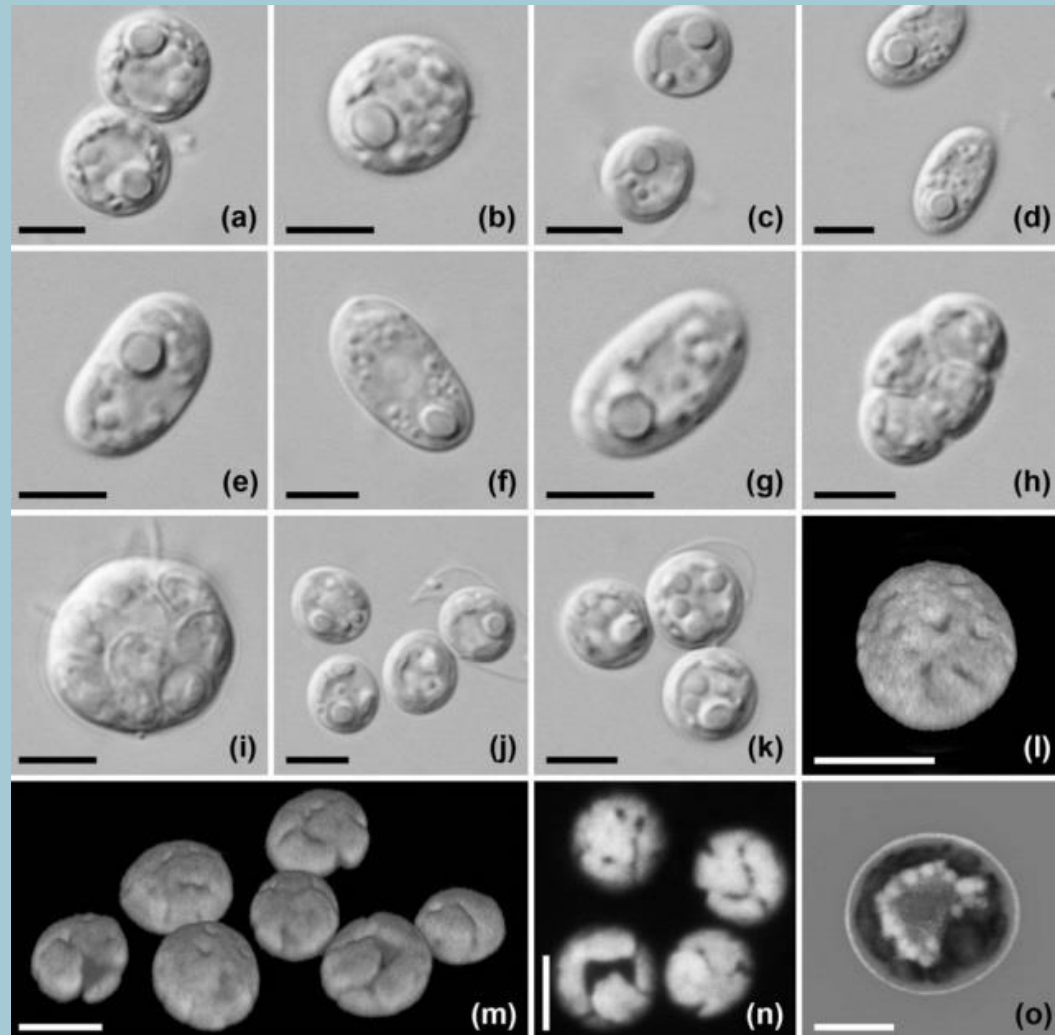
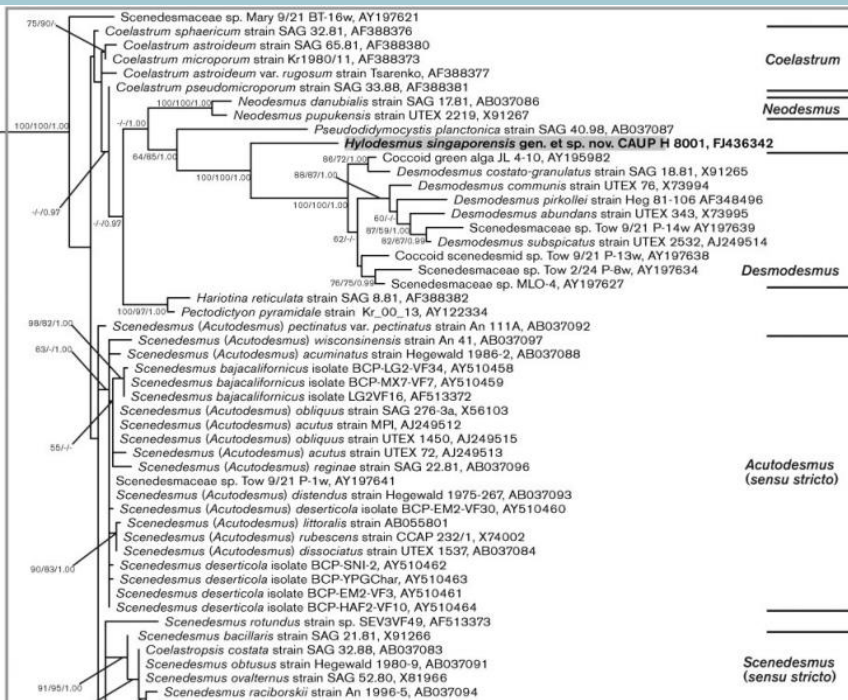
# Chlorophyceae, Scenedesmaceae

- *Neodesmus* – dvoj- či jednobuněčný, ledvinovité či kapkovité buňky
  - *N. danubialis*, *N. pupukensis*



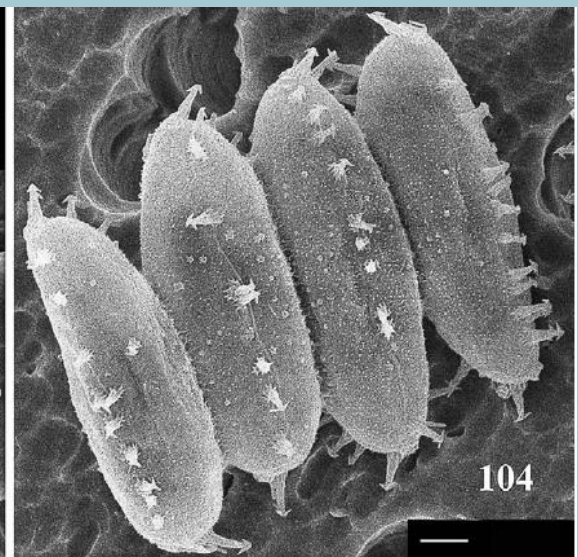
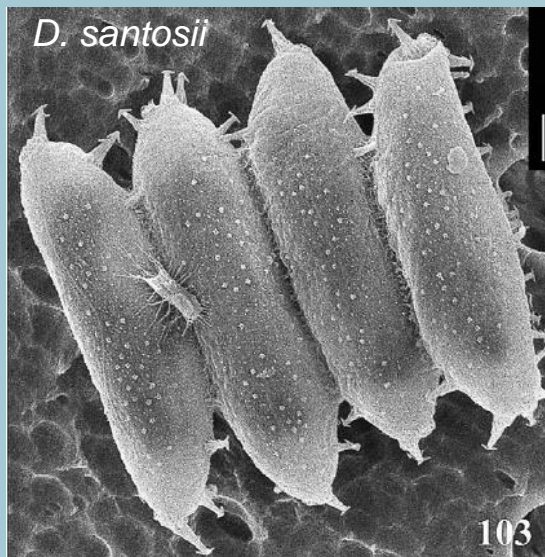
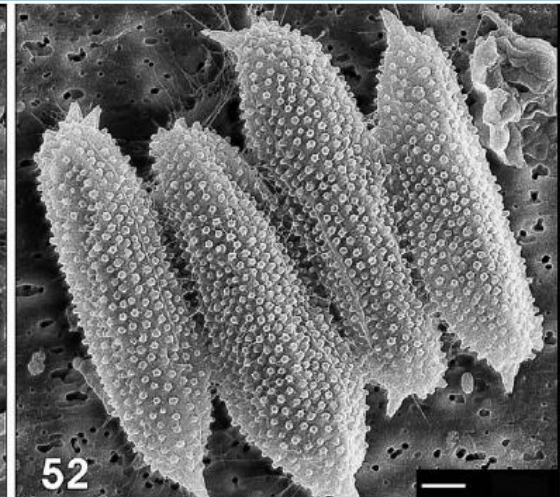
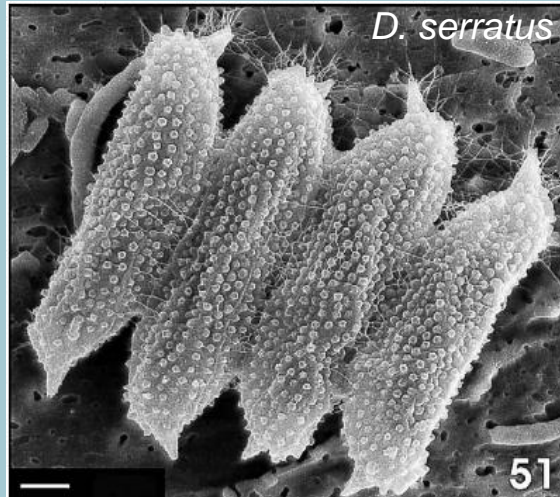
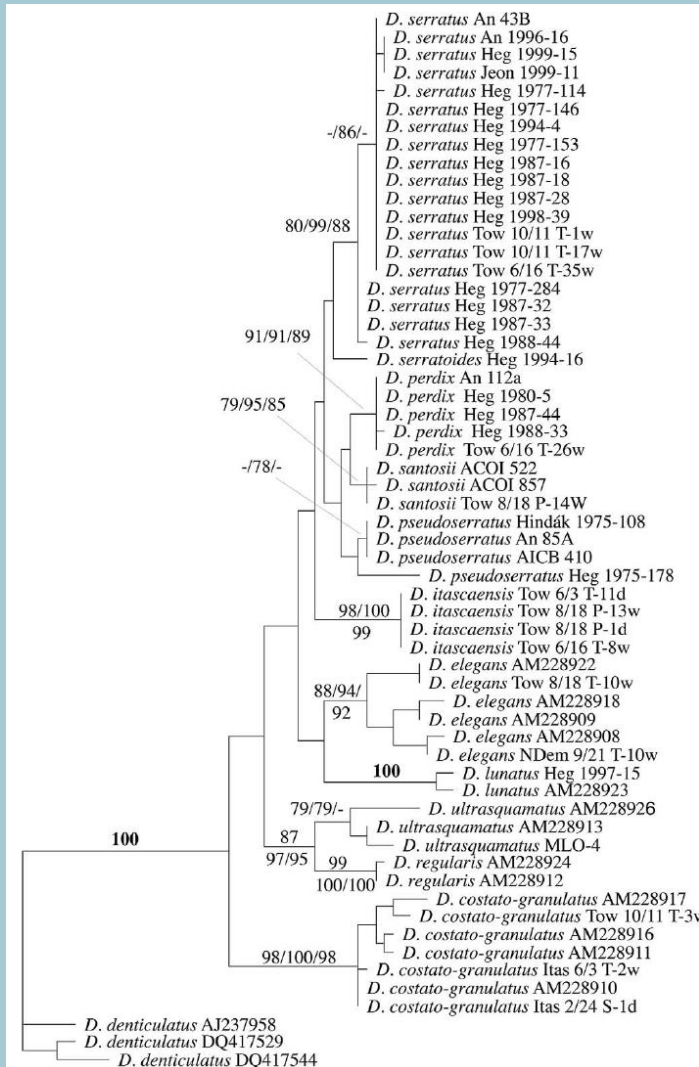
# Chlorophyceae, Scenedesmaceae

- *Hylodesmus* – jednobuněčný, kulaté či protáhlé buňky, kortikolní
  - *H. singaporensis*



# Chlorophyceae, Scenedesmaceae

- kryptická diverzita v rámci druhu *Desmodesmus serratus*

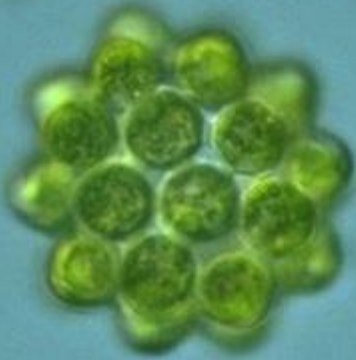




# Chlorophyceae, Scenedesmaceae

- *Coelastrum*

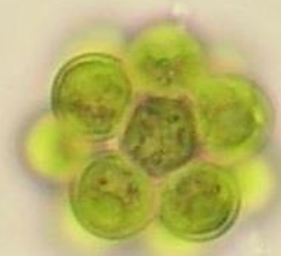
*C .astroideum*



*C .proboscideum*



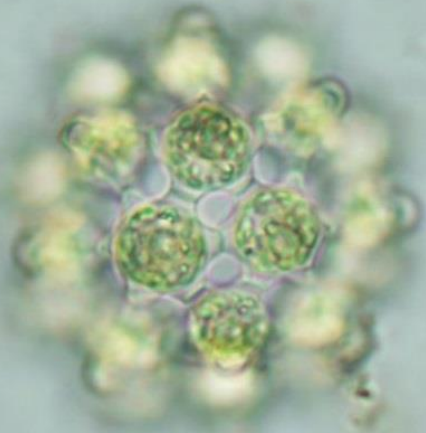
*C .microporum*



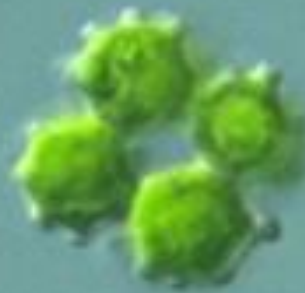
SINICE  
& RASY.cz

20 µm

*C .pulchrum*



*C .morus*

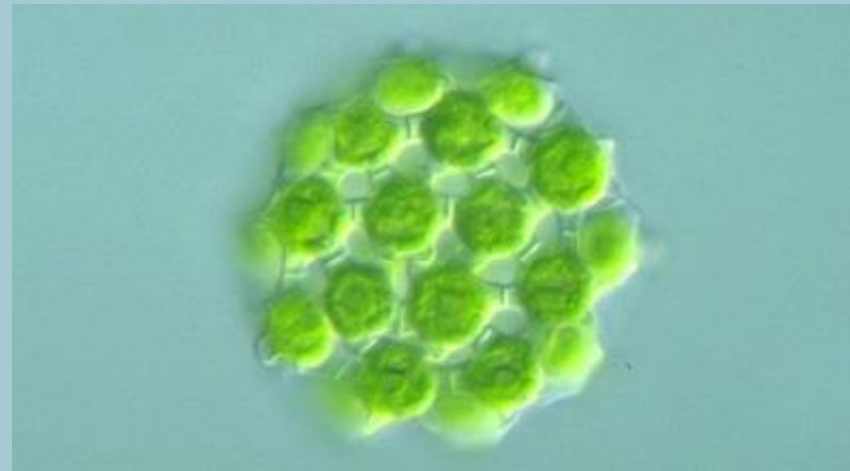
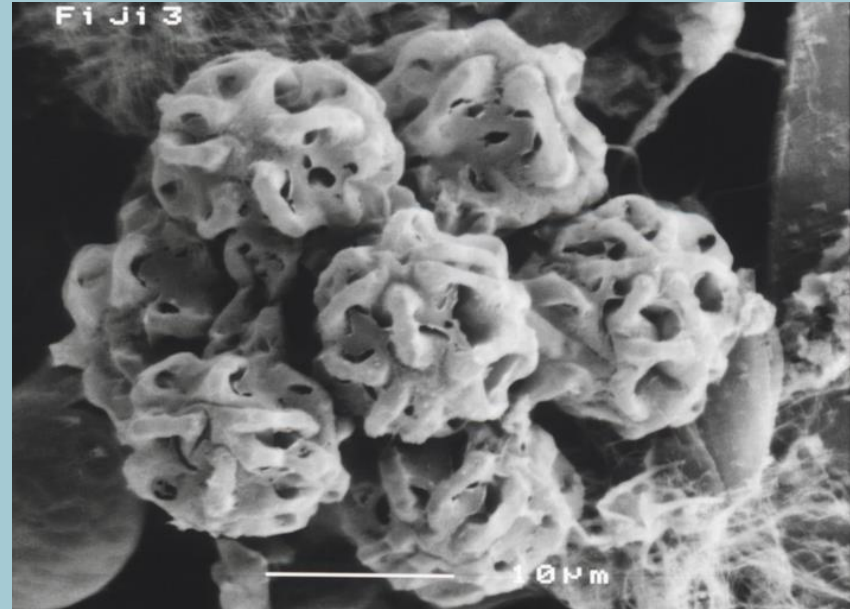


*C .pseudomicroporum*



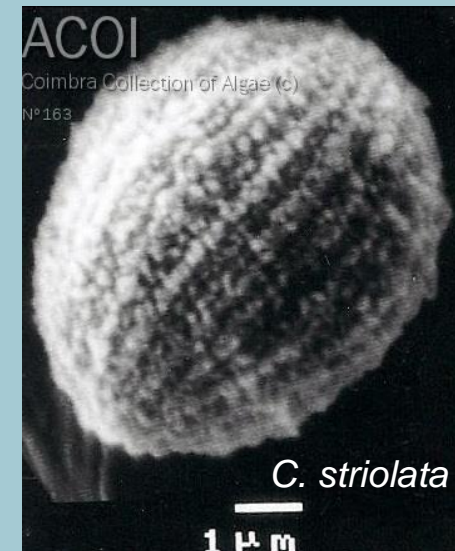
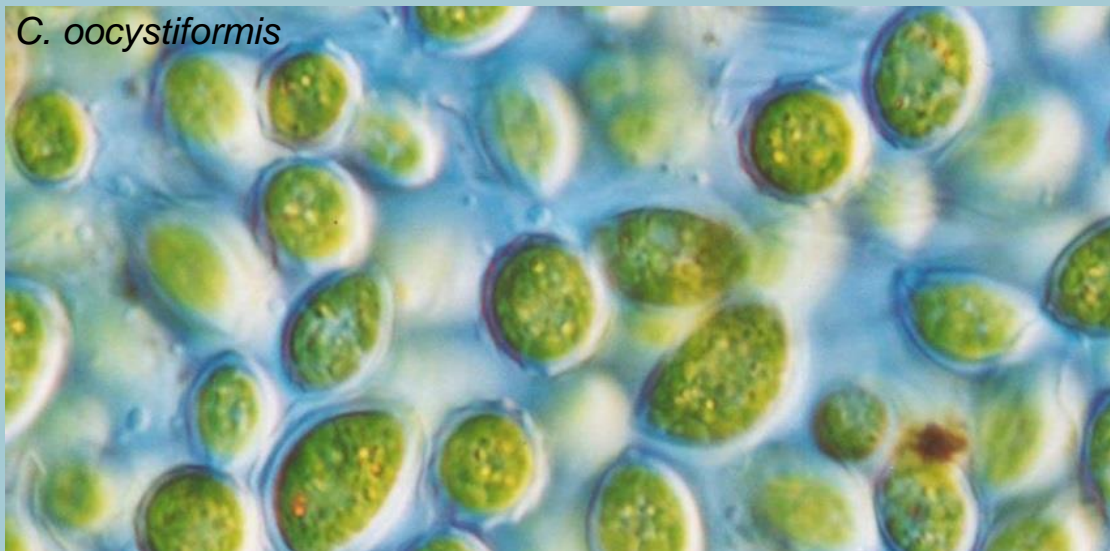
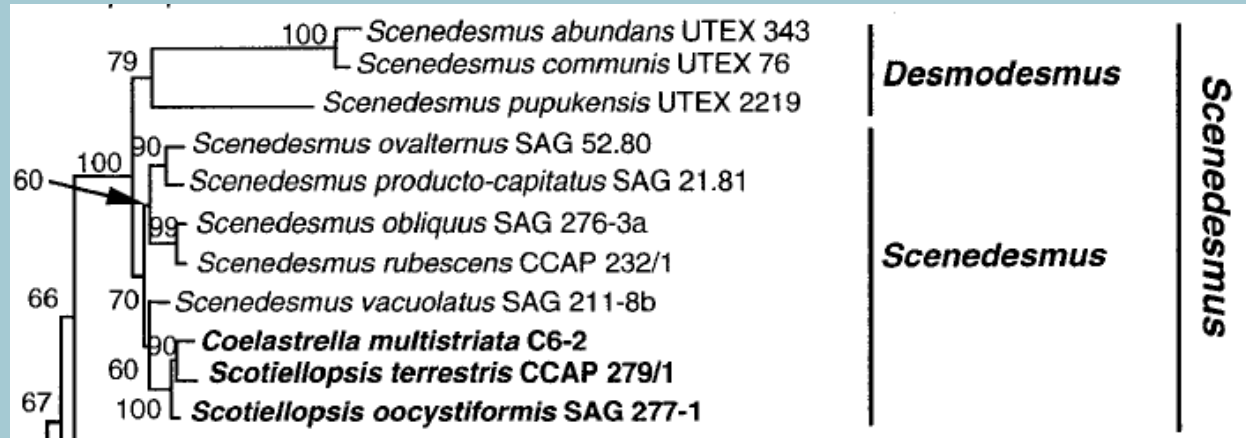
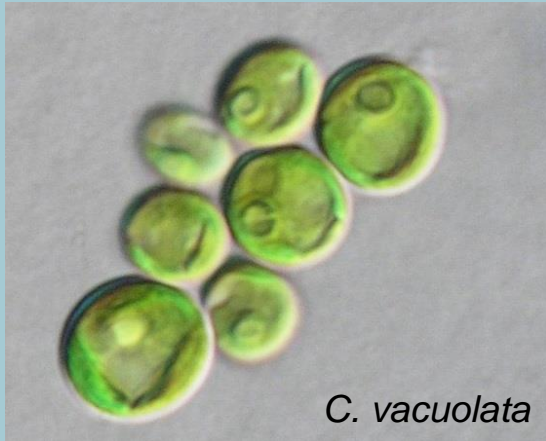
# Chlorophyceae, Scenedesmaceae

- *Hariotina* – žebra mezi buňkami
  - *H. polychorda*
  - *H. reticulata*



# Chlorophyceae, Scenedesmaceae

- *Coelastrella* – buněčná stěna s žebry
  - rod *Scotiellopsis* synonymní

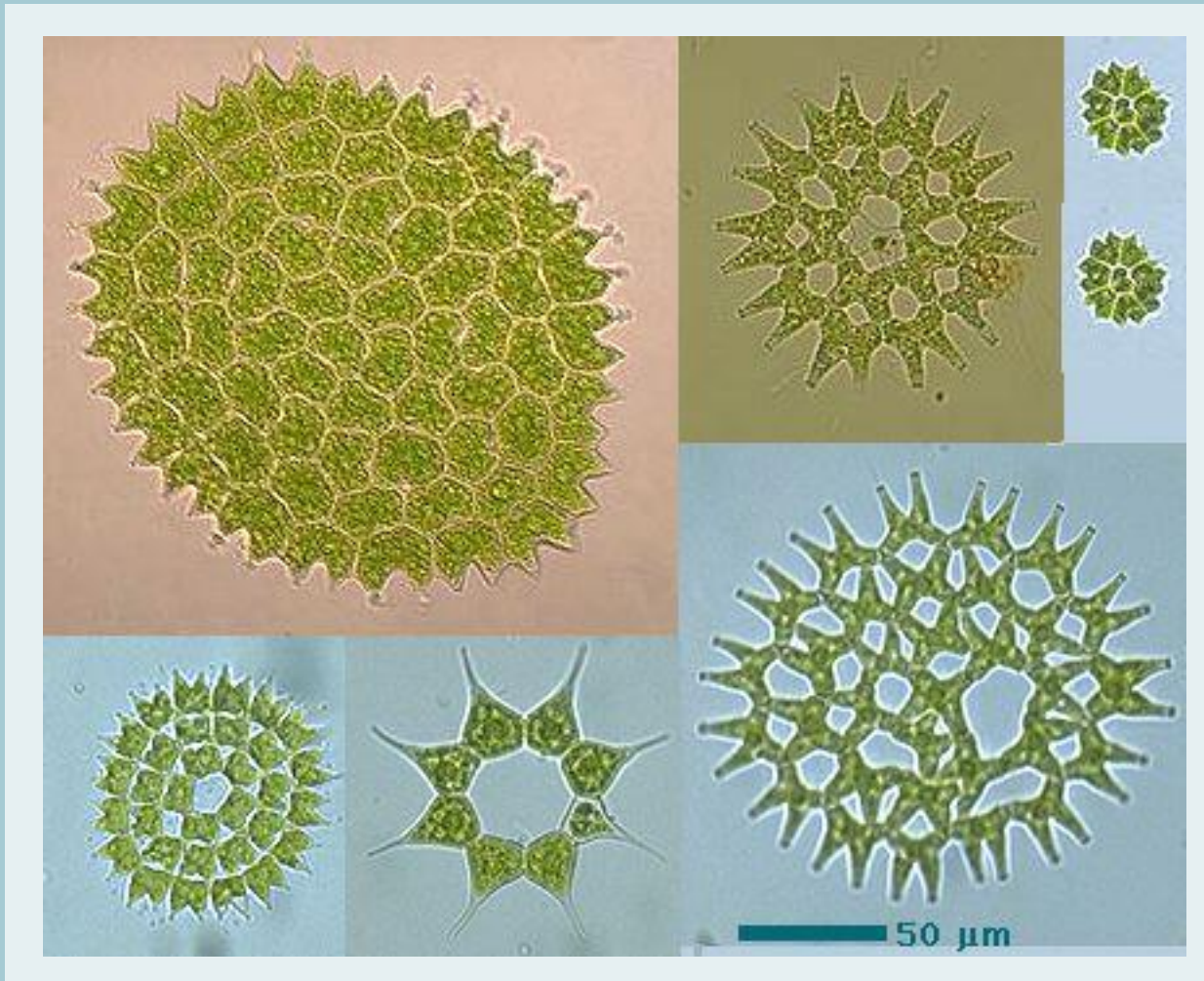


Hanagata (1998): *Journal of Phycology* **34**, 1049-1054

Kaufnerová & Eliáš (2013): *Nova Hedwigia* **97**, 415-428

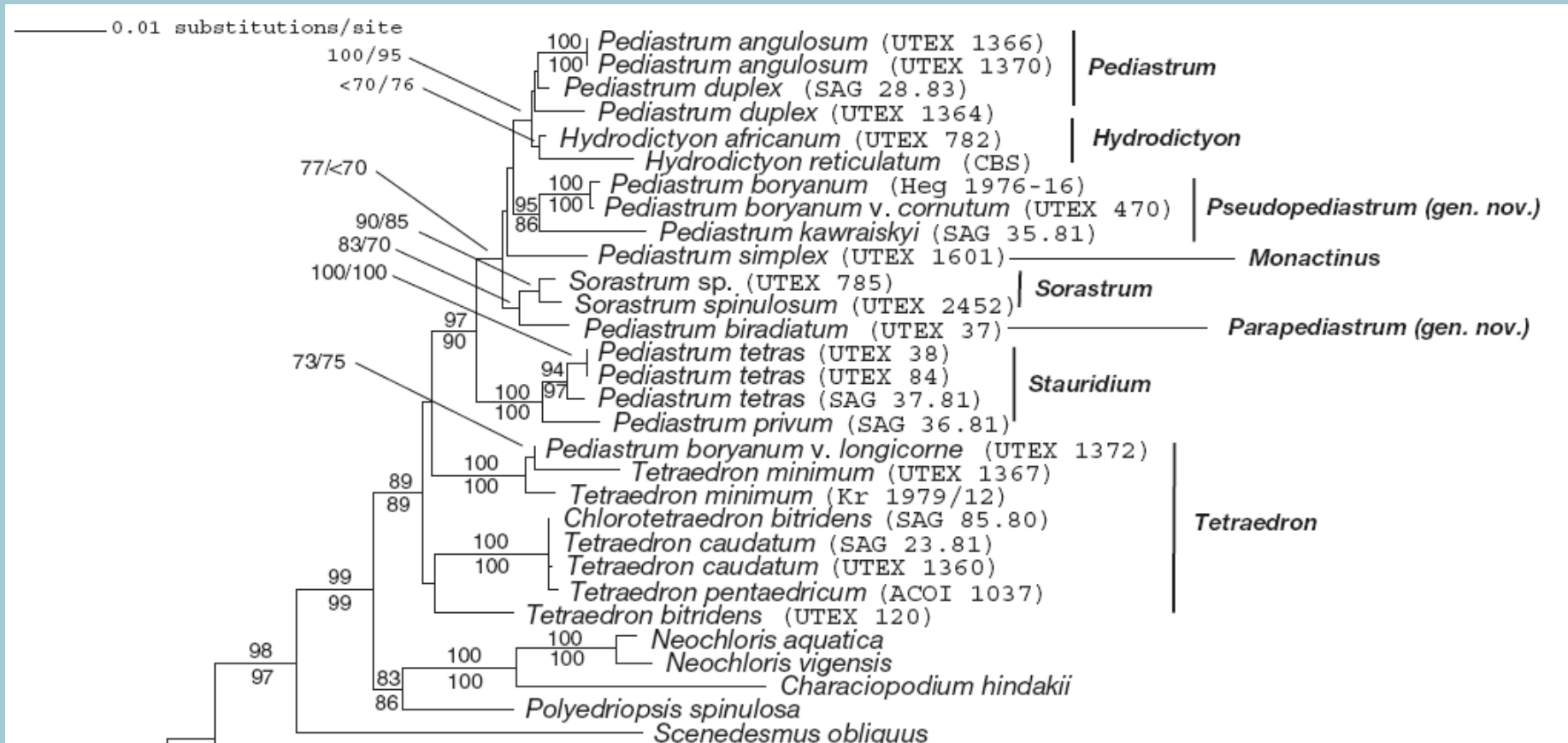
# Chlorophyceae, Hydrodictyaceae

- *Pediastrum* – popsáno přes 400 druhů a vnitrodruhových taxonů



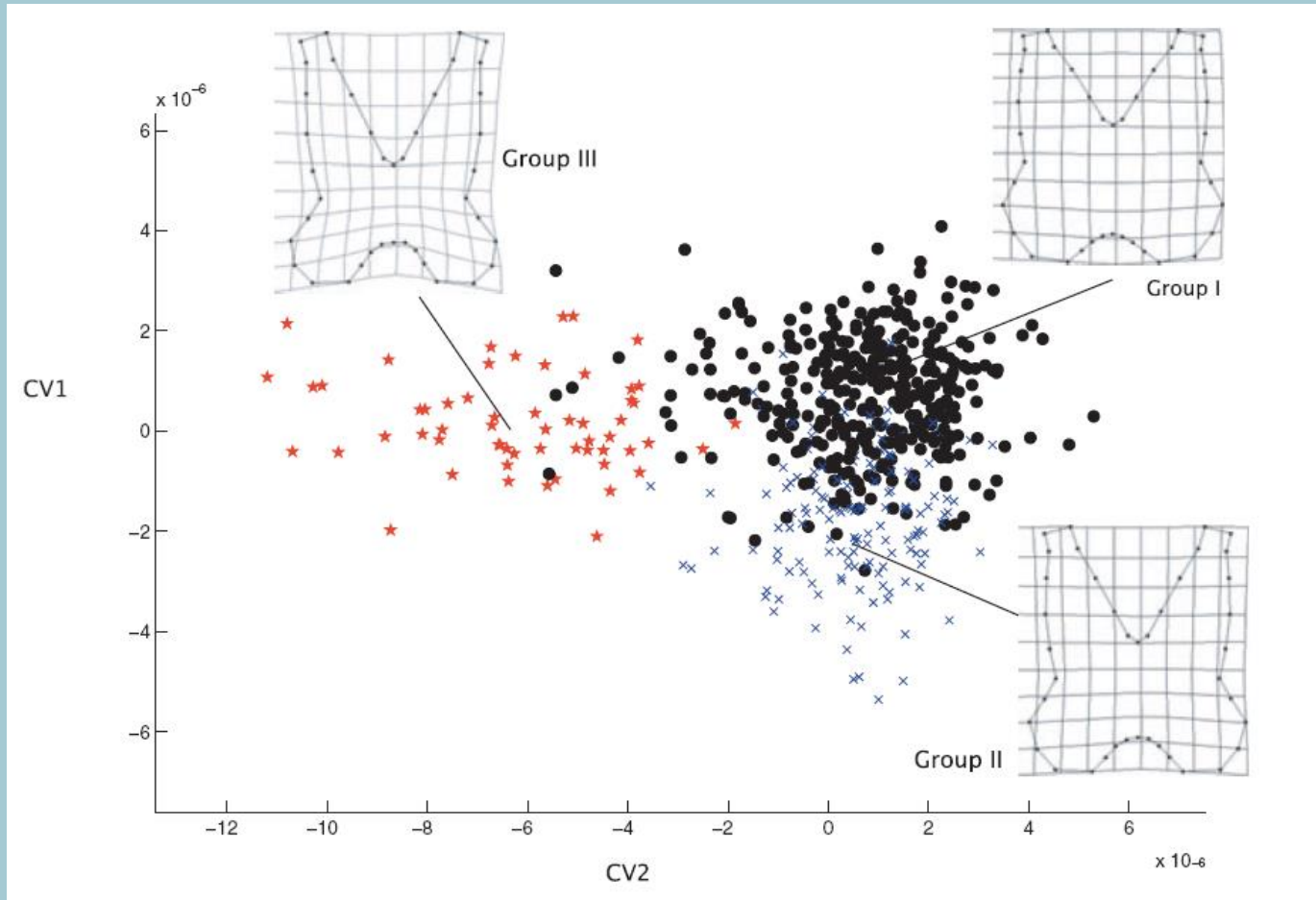
# Chlorophyceae, Hydrodictyaceae

- *Pediastrum* – parafyletický taxon, definice nových rodů
  - *Pseudopediastrum*, *Parapediastrum*, *Monactinus*, *Stauridium*



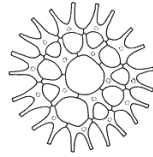
# Chlorophyceae, Hydrodictyaceae

- *Pediastrum* – parafyletický taxon, definice nových rodů
  - *Lacunastrum*

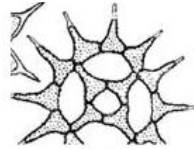


# Chlorophyceae, Hydrodictyaceae

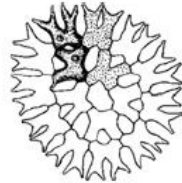
*Lacunastrum*



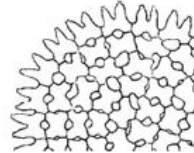
*Monactinus*



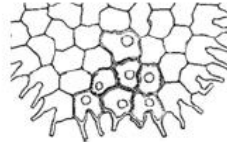
*Parapediastrum*



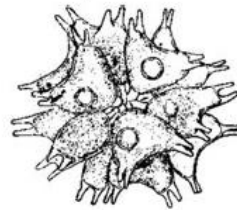
*Pediastrum*



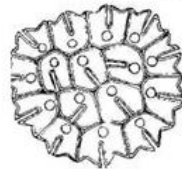
*Pseudopediastrum*



*Sorastrum*

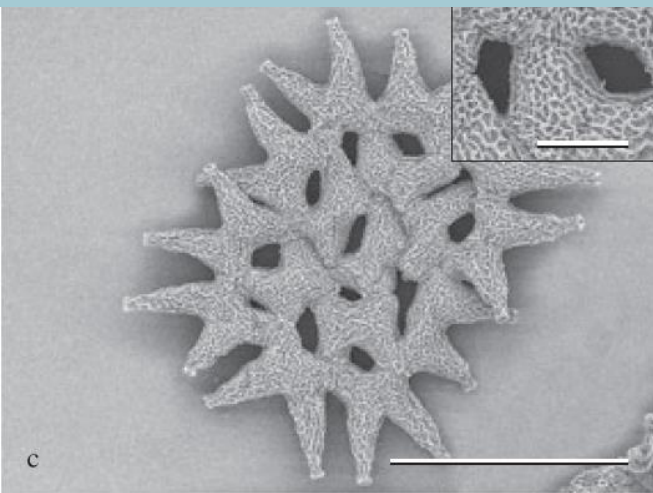


*Stauridium*

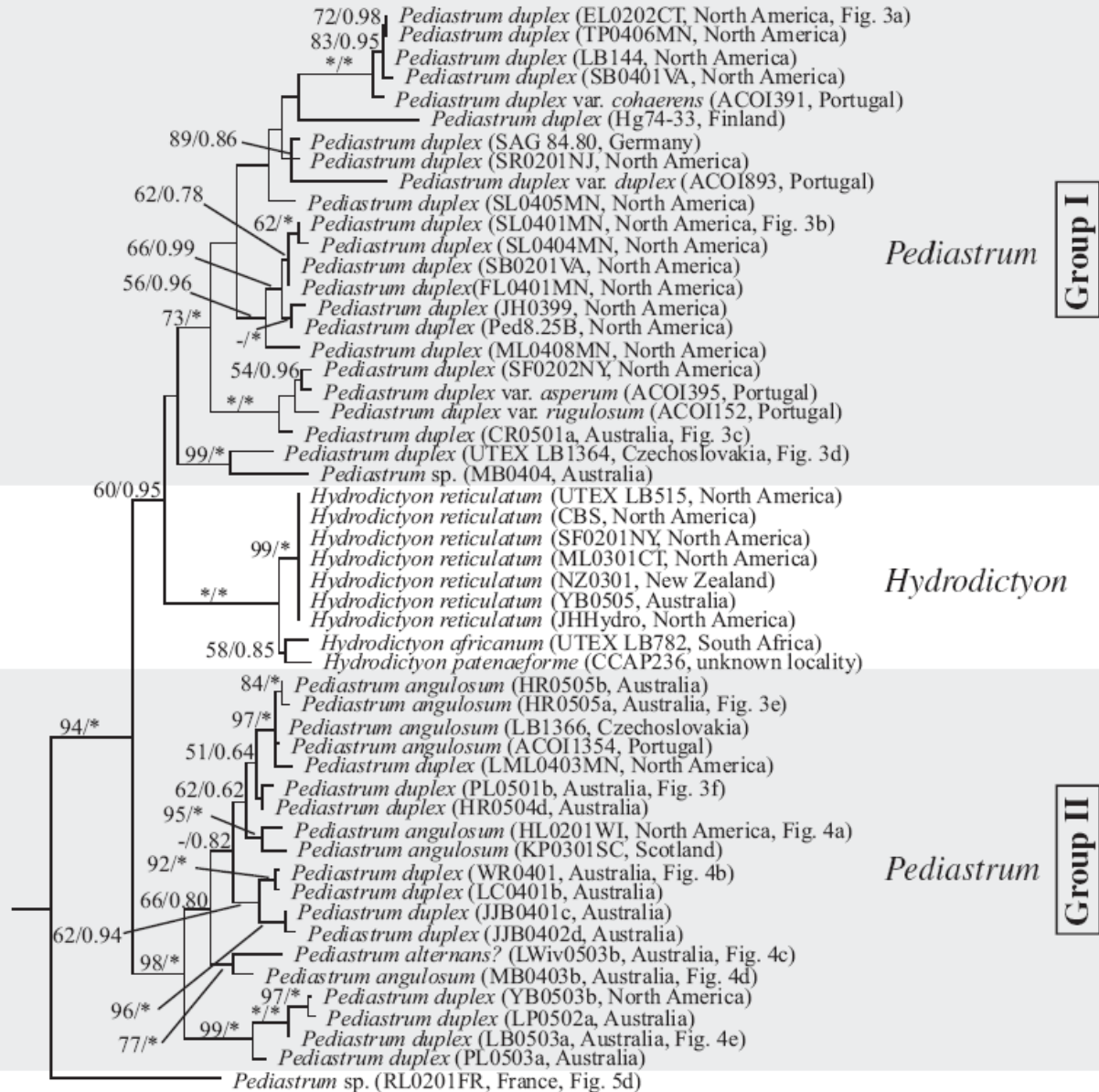
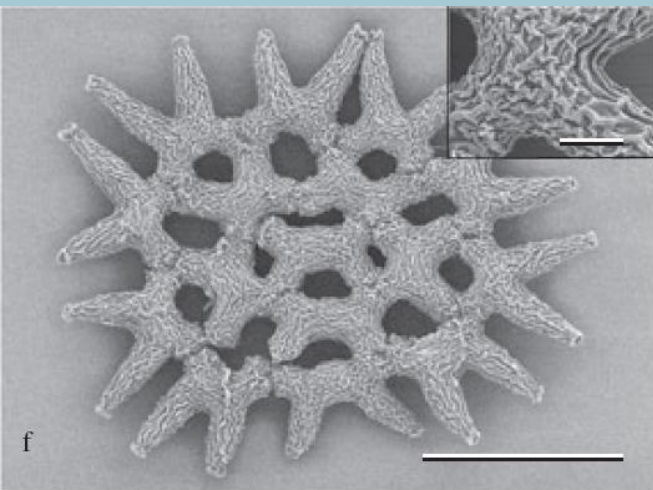


- **Lacunastrum**
  - *L. gracillimum*
- **Monactinus**
  - *M. simplex*
- **Parapediastrum**
  - *P. biradiatum*
- **Pediastrum**
  - *P. duplex*
  - *P. angulosum*
- **Pseudopediastrum**
  - *P. boryanum*
  - *P. kawraiskyi*
  - „*P. integrum*“
- **Sorastrum**
  - *S. spinulosum*
  - *S. americanum*
  - *S. biradiatum*
- **Stauridium**
  - *S. tetras*
  - *S. privum*

# Chlorophyceae, Hydrodictyaceae



- *Pediastrum* stále parafyletické!





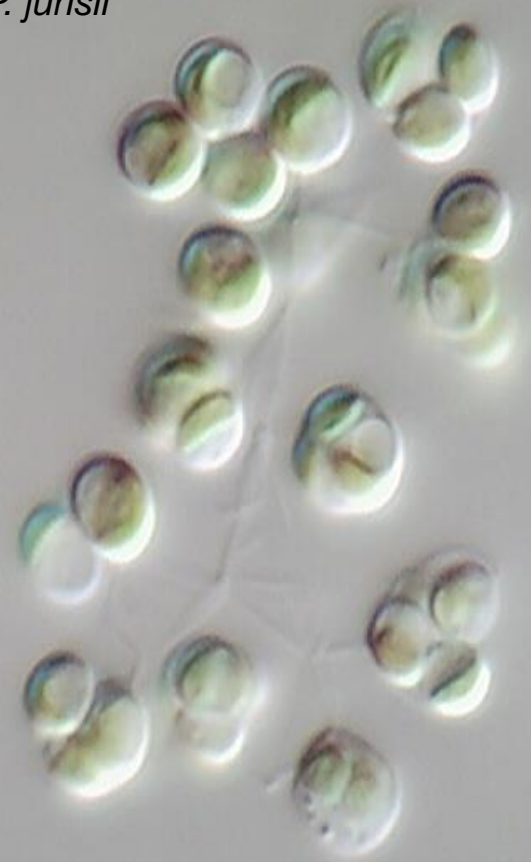
# Chlorophyceae, *Mychonastes*

- aerofytické řasy, pikoplankton, parietální chloroplast bez pyrenoidu
- *Mychonastes* – jednotlivé buňky
- *Pseudodictyosphaerium* – koloniální, buňky spojeny slizovými stopkami

*M. homosphaera*



*P. jurisii*

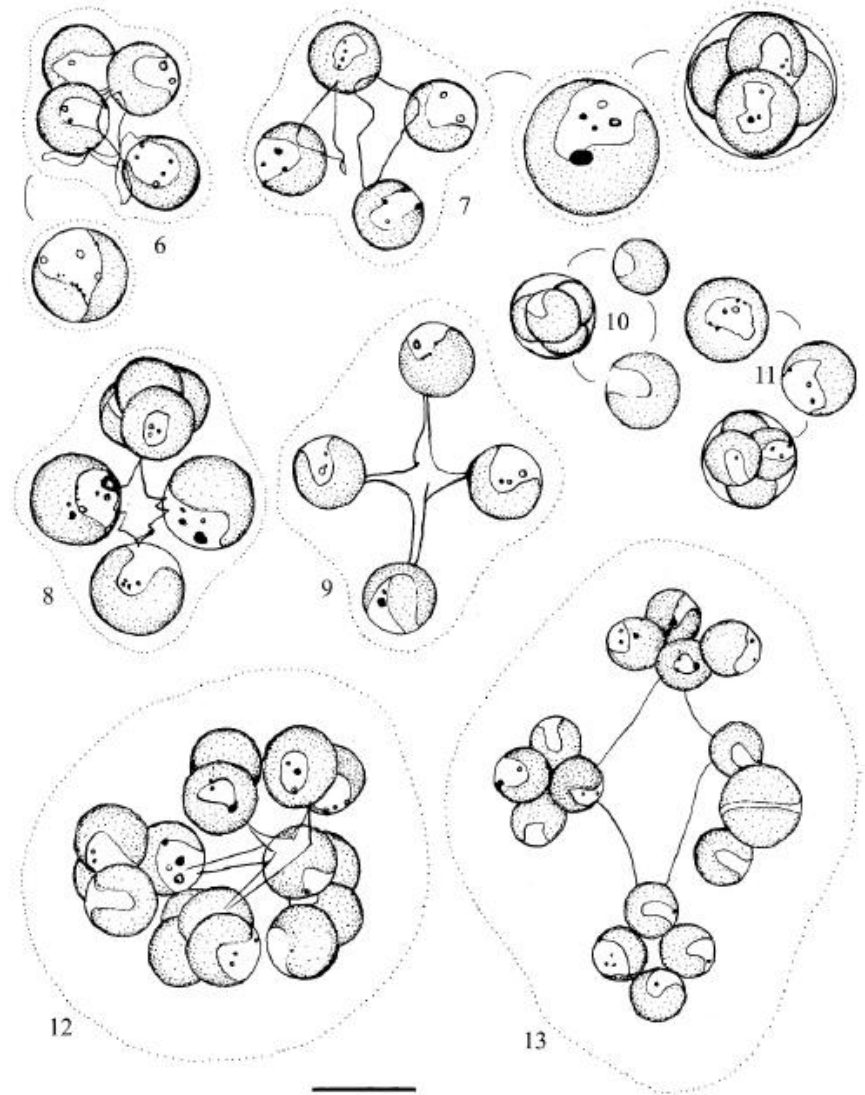
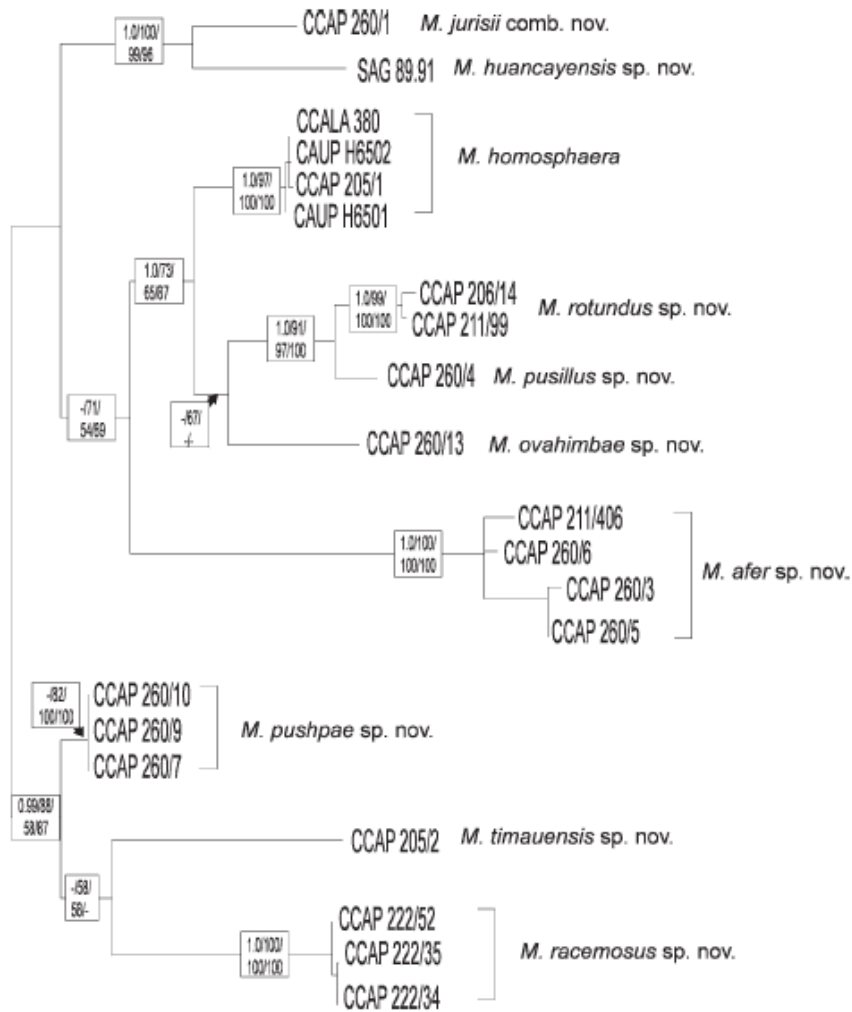


[botany.natur.cuni.cz/algo/CAUP/H6501\\_Mychonastes\\_homosphaera.htm](http://botany.natur.cuni.cz/algo/CAUP/H6501_Mychonastes_homosphaera.htm)



# Chlorophyceae, *Mychonastes*

- Pseudodictyosphaerium* synonymem rodu *Mychonastes* (nyní 10 druhů)

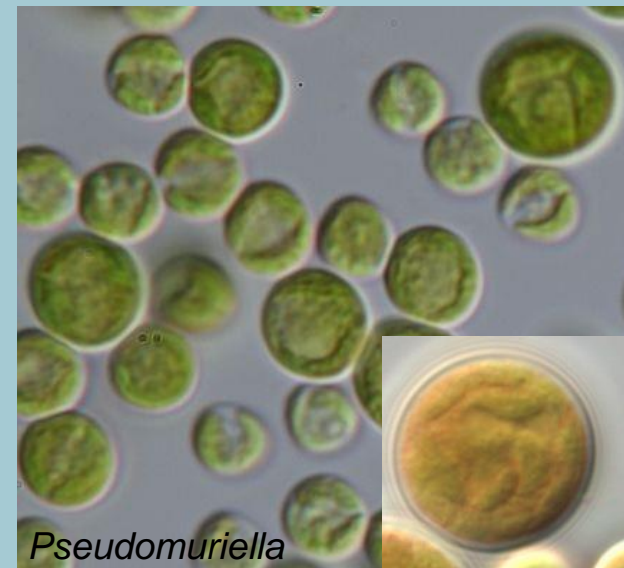
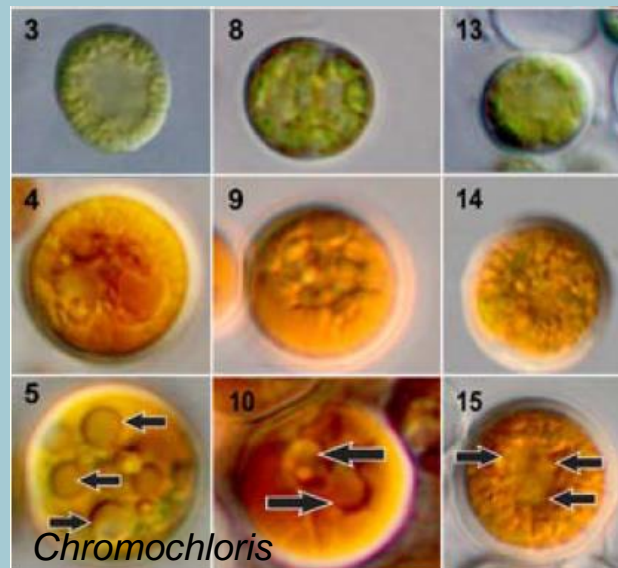
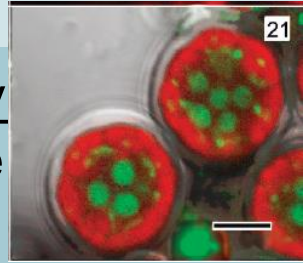


Figs 6-13. Iconotypes of newly described species of the genus *Mychonastes*. Scale bar = 5 µm (applies to all figures in plate).  
 Fig. 6. *M. afer*.  
 Fig. 7. *M. huancayensis*.  
 Fig. 8. *M. ovahimbæ*.

# Chlorophyceae, mnohojaderné rody

Mnohojaderné buňky, vícero chloroplastů bez pyrenoidů, zoospory

- *Bracteacoccus* – zelená barva starších buněk, dobrá penetrace fluorescenčních barev přes buněčnou stěnu
- *Chromochloris* – produkce sekundárních karotenoidů červené barvy
  - *C. zofingiensis* (= *C. cinnabarina*)
- *Pseudomuriella* – produkce sekundárních karotenoidů oranžové barvy
  - *P. engadiensis*
  - *P. aurantiaca*
  - *P. schumacherensis*



# Chlorophyceae, *Bracteacoccus*

- celkem 13 morfologicky nerozlišitelných druhů, fylogenetický koncept druhů

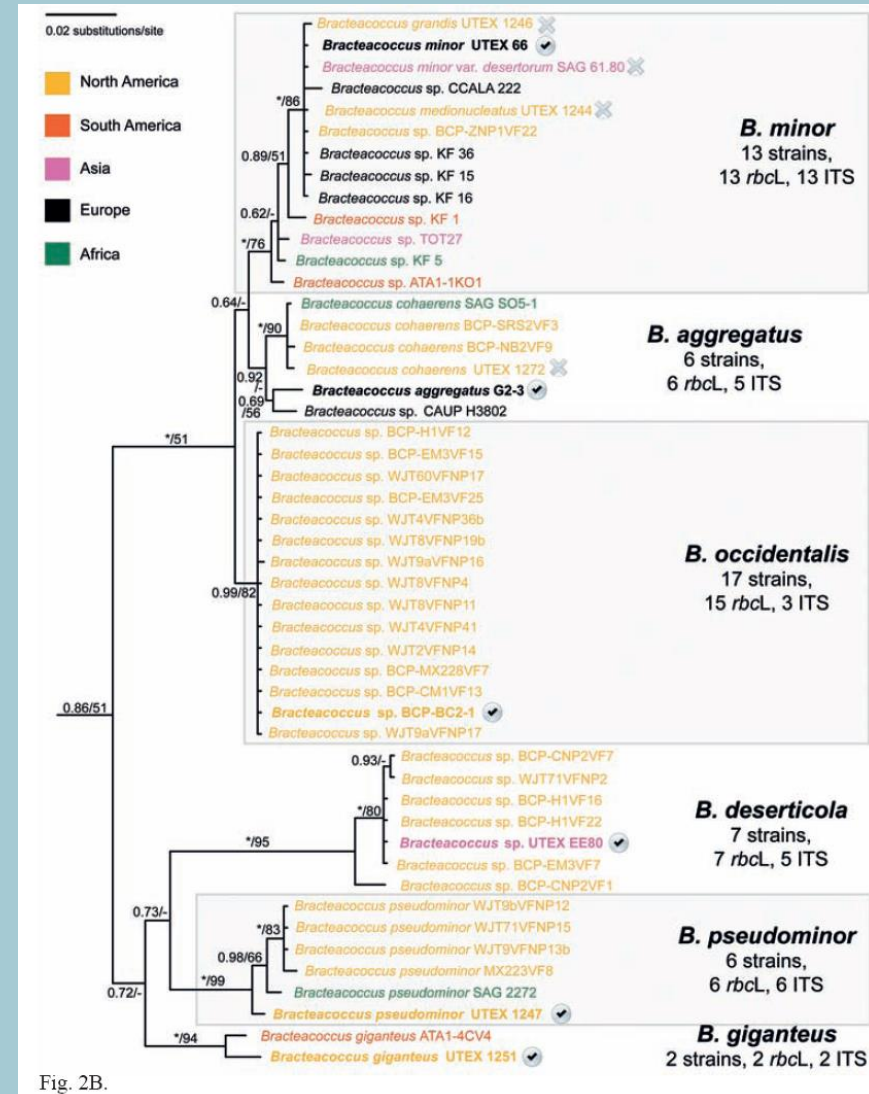
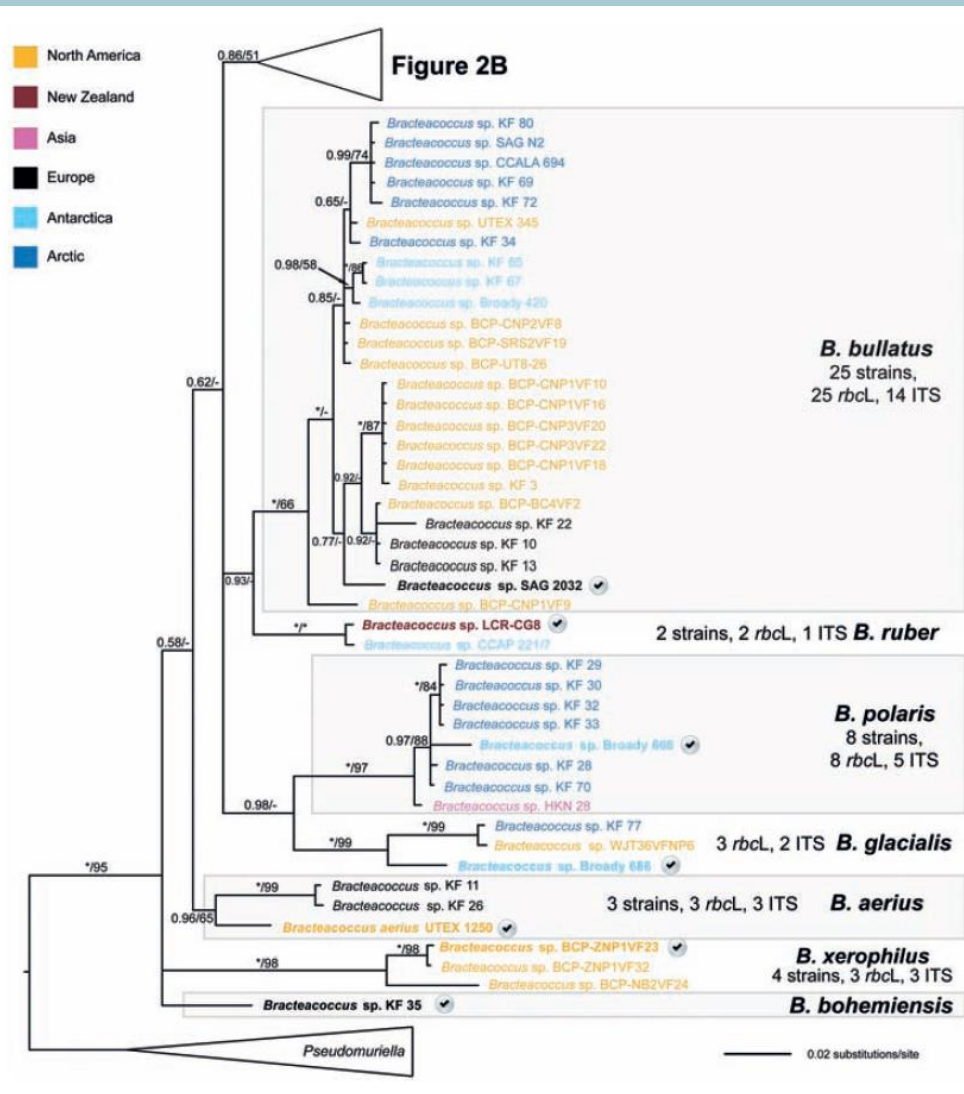


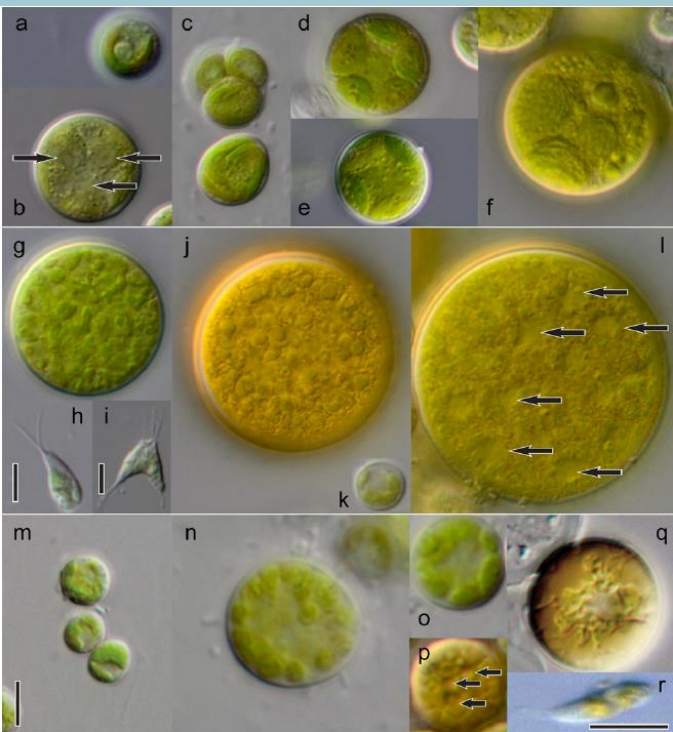
Fig. 2B.

# Chlorophyceae, mnohojaderné rody

Mnohojaderné buňky, vícero chloroplastů bez pyrenoidů, zoospory:

- *Bracteacoccus* – zelená barva, b. do 55 μm
- *Chromochloris* – červená barva, b. do 13 μm
- *Pseudomuriella* – oranžová barva, b. do 13 μm
- *Rotundella* – oranžovo-hnědá barva, b. do 20 μm
- *Tumidella* – zlato-oranžová barva, b. do 33 μm
- *Bracteamorpha* – oranžová barva, b. do 24 μm

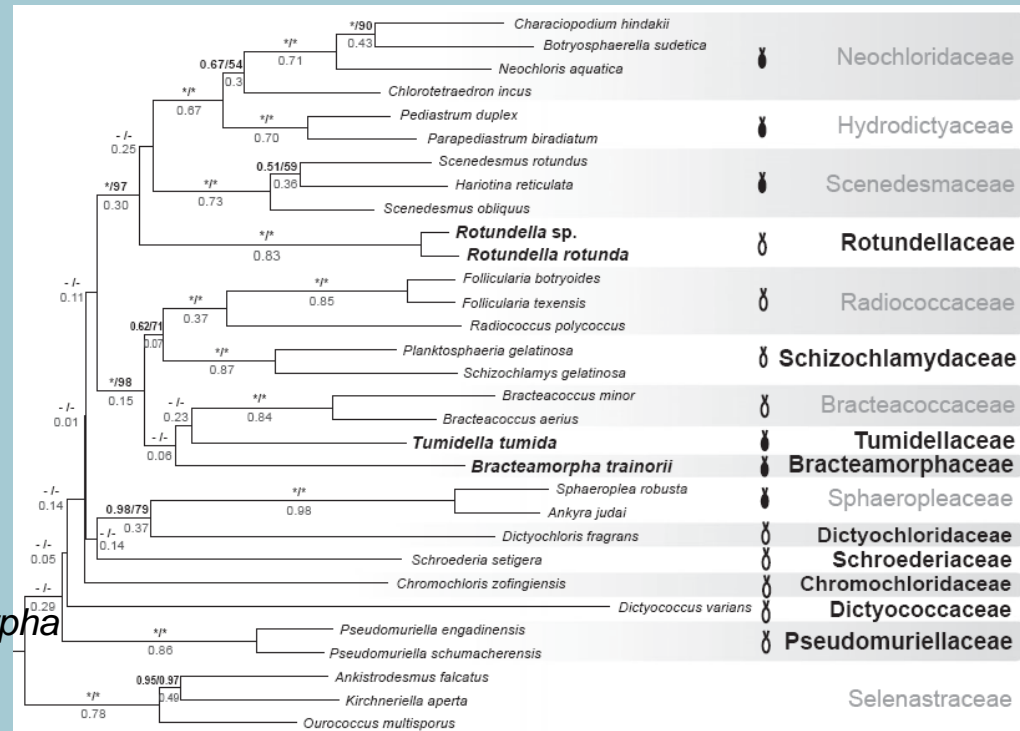
kryptické rody



*Rotundella*

*Tumidella*

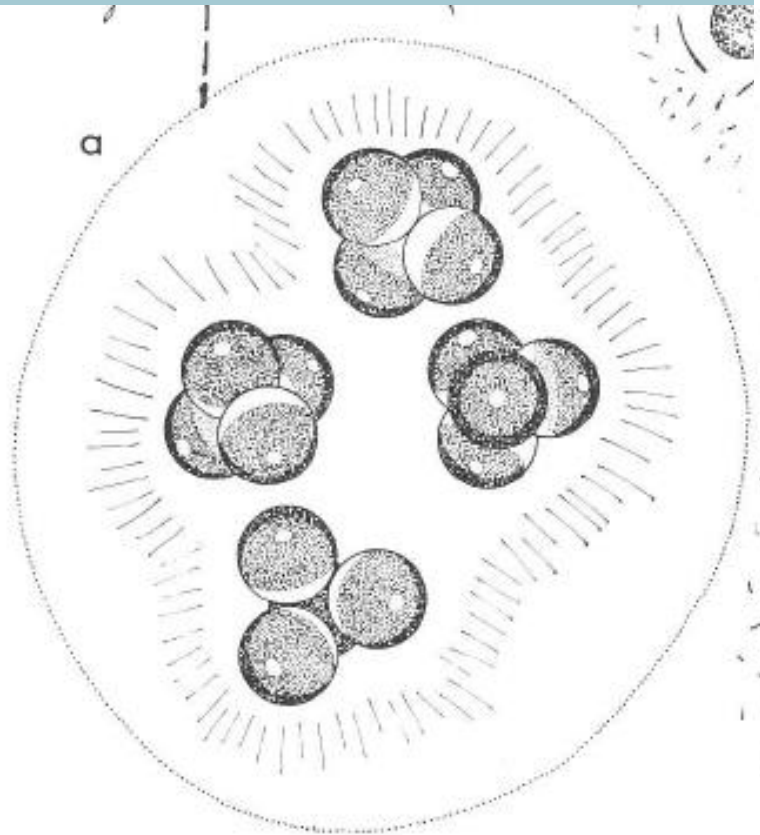
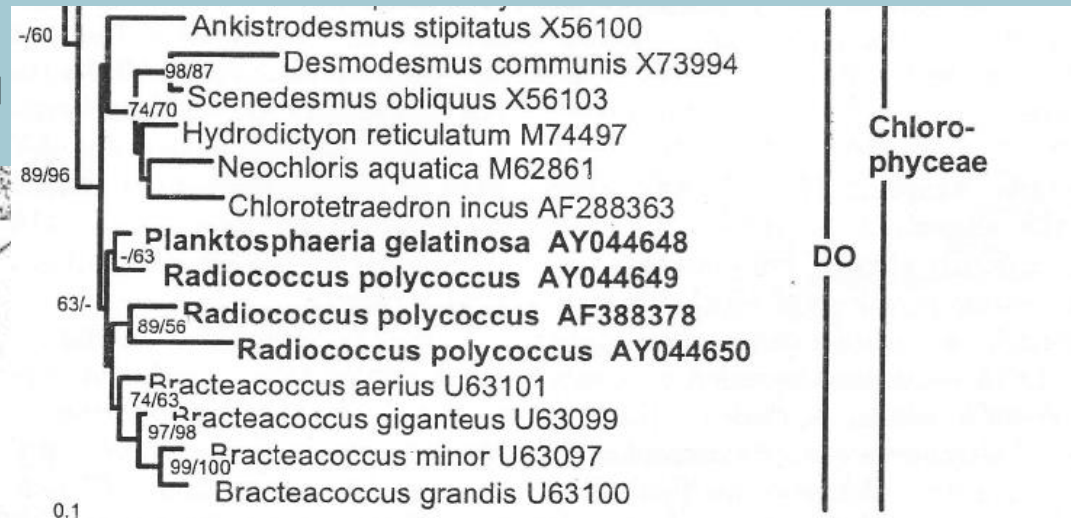
*Bracteamorpha*



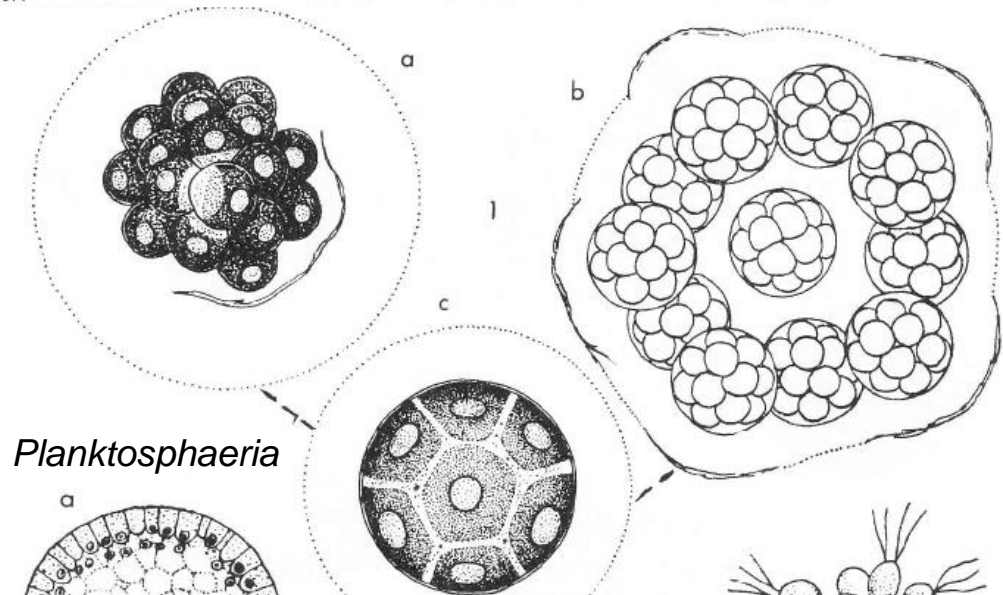
# Chlorophyceae, mnohojaderné rody

Mnohojaderné buňky, chloroplasty s pyrenoidy, zoospory:

- *Radiococcus* – 1 plastid
- *Planktosphaeria* – více plastidů



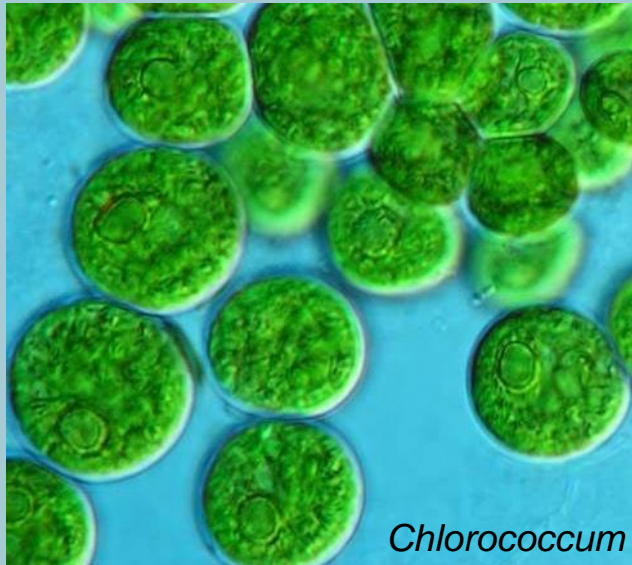
*Radiococcus*



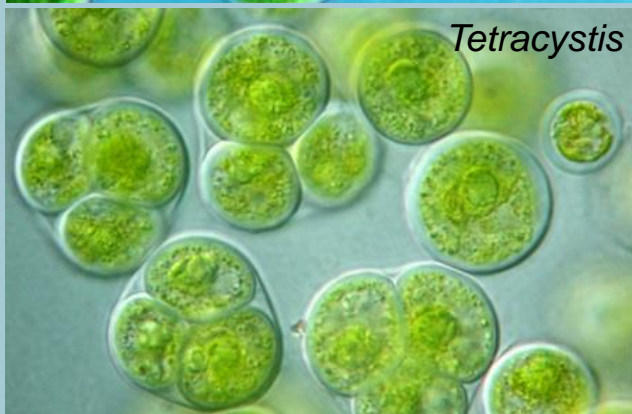
# Chlorophyceae, nepohyblivé chlamydomonádní rody

Složitý, často perforovaný chloroplast, kontraktilní vakuoly

- *Asterococcus* – monofyletický rod, koncentrický sliz
- *Chlorococcum*, *Tetracystis* – polyfyletické rody

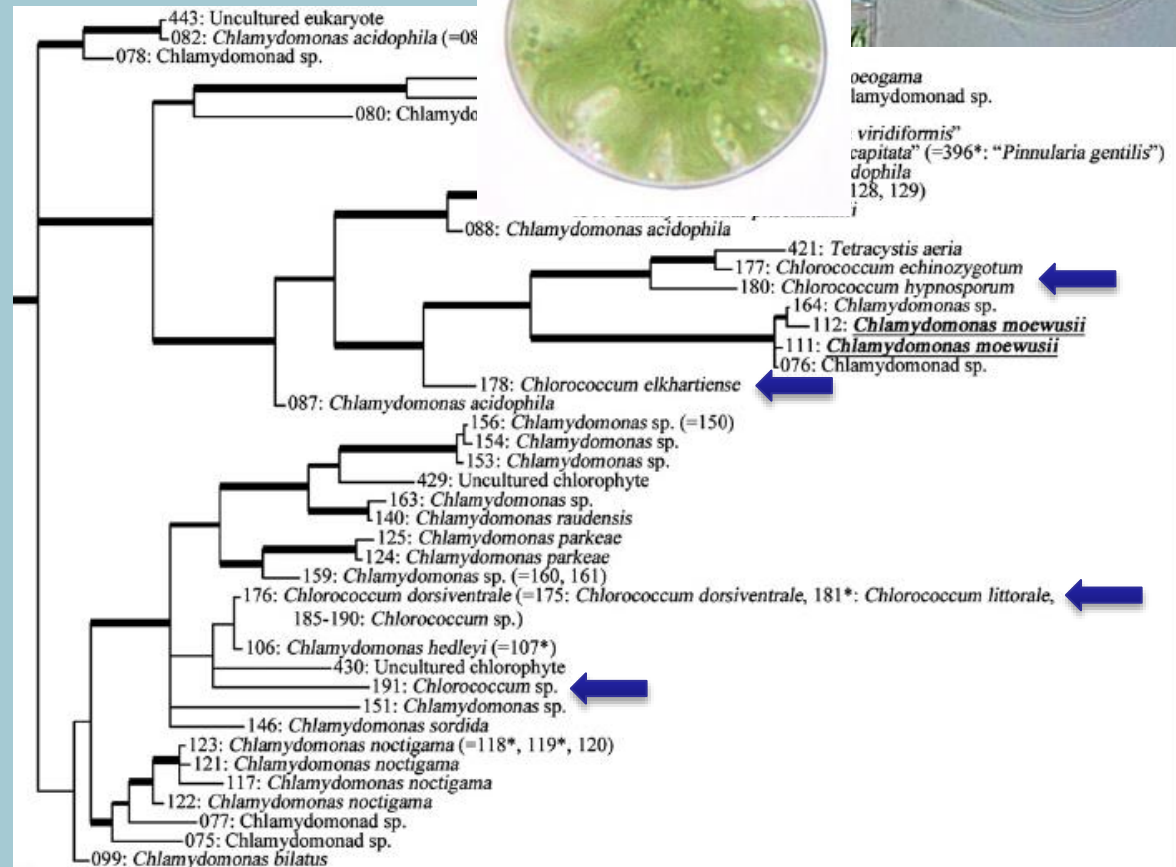
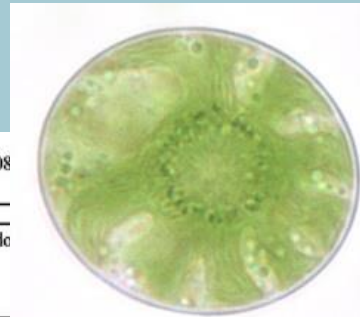


*Chlorococcum*



*Tetracystis*

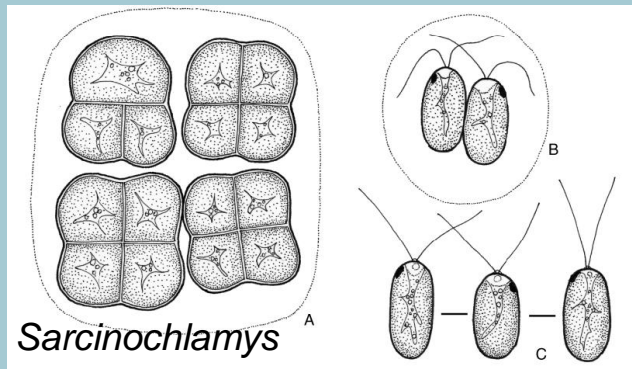
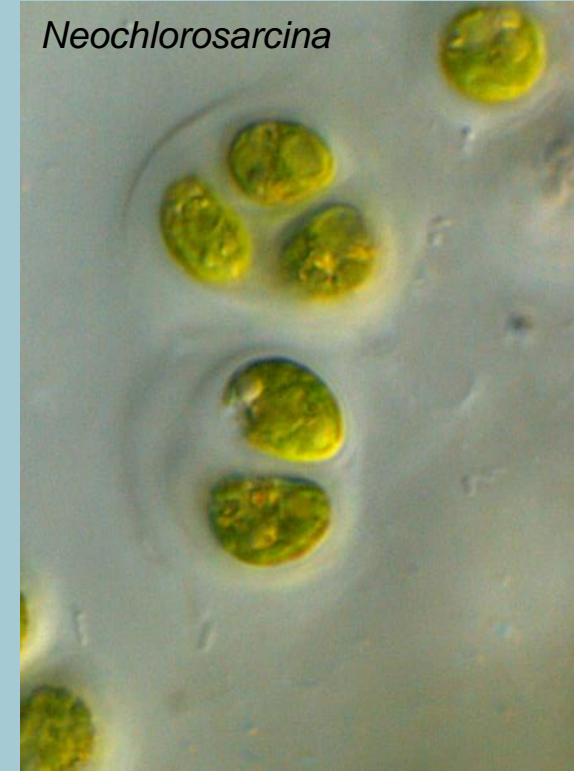
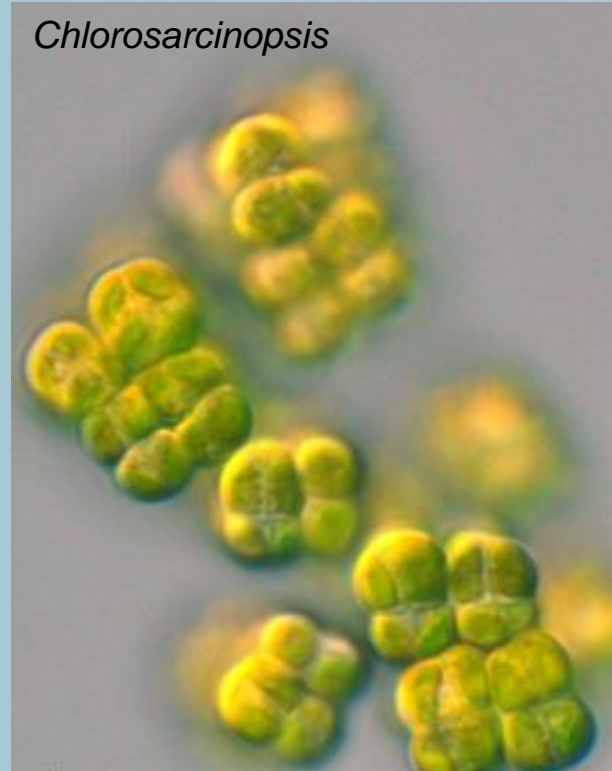
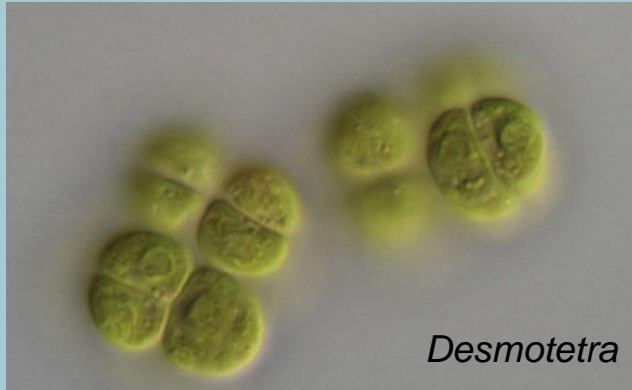
- *Radiosphaera*



# Chlorophyceae, nepohyblivé chlamydomonádní rody

## Sarcinoidní morfologie:

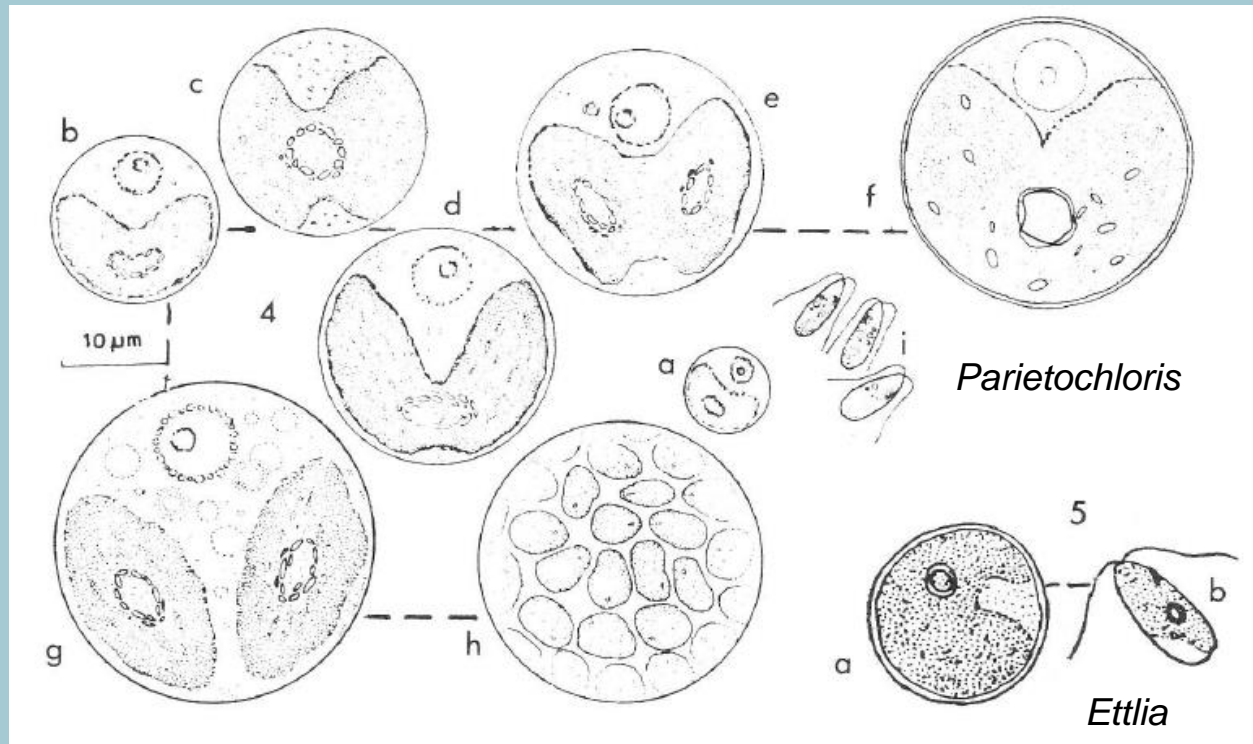
- *Chlorosarcinopsis* – nahé zoospory, pyrenoid, polyfyletický rod!
- *Desmotetra* – nahé zoospory, pyrenoid
- *Sarcinochlamys* – zoospory s BS, bez pyrenoidu
- *Neochlorosarcina* – zoospory s tenkou BS, pyrenoid





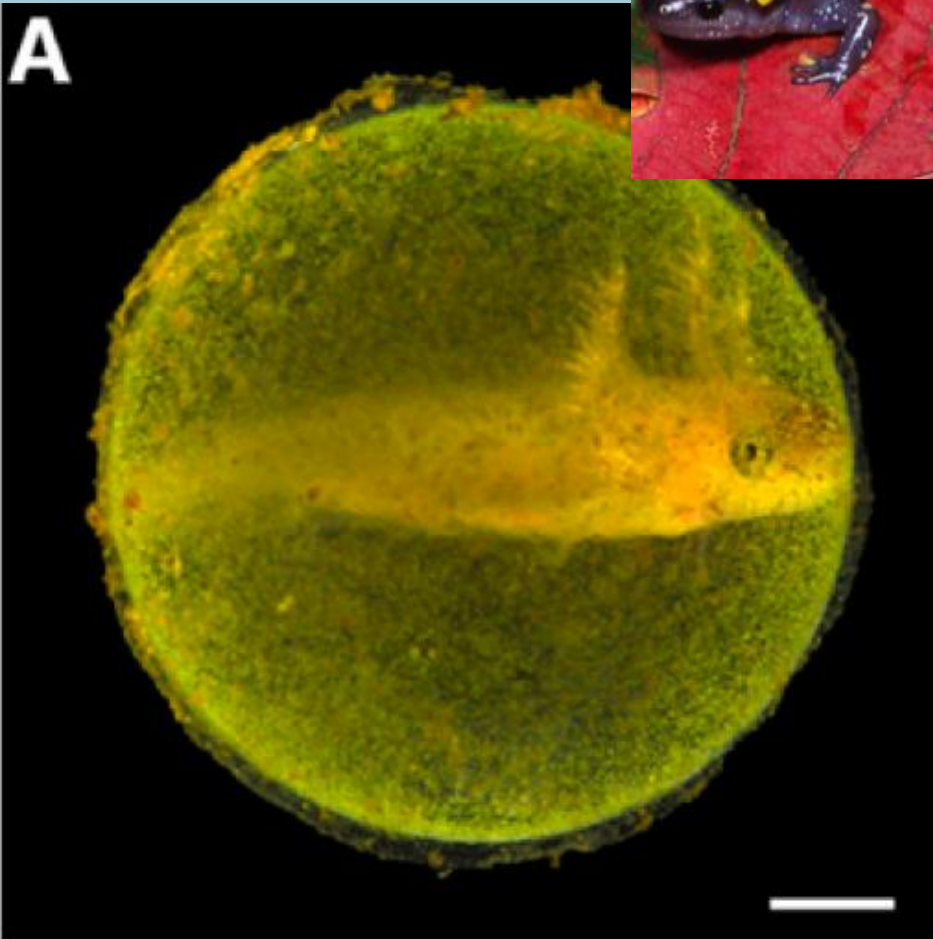
# Chlorophyceae, *Neochloris*

- parietální chloroplast, nahé zoospory, mnohoaderné buňky
- jednojaderné buňky:
  - *Ettlia* – CW: příbuzná rodu *Haematococcus*
  - *Parietochloris* – CCW: Trebouxiophyceae

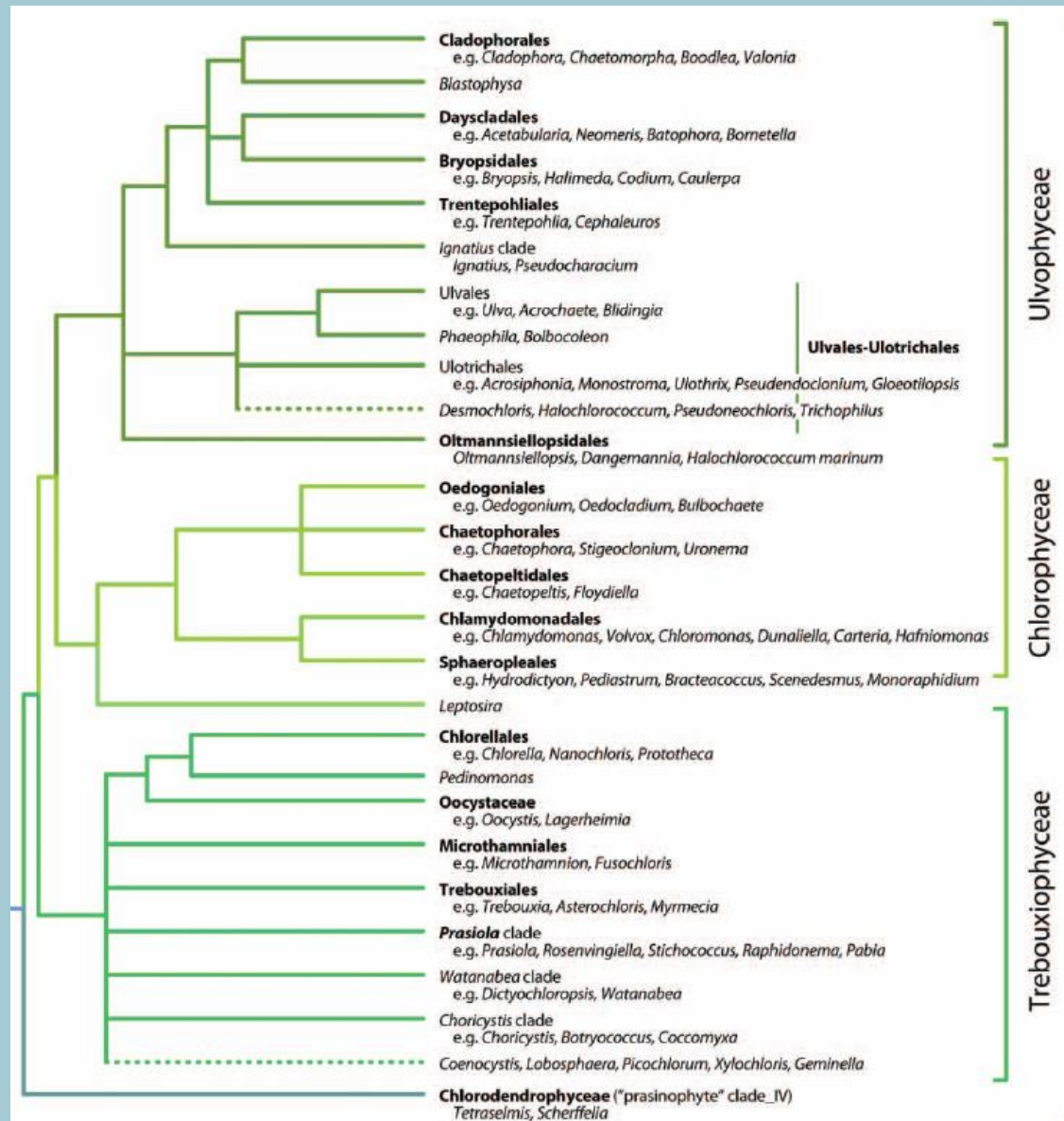
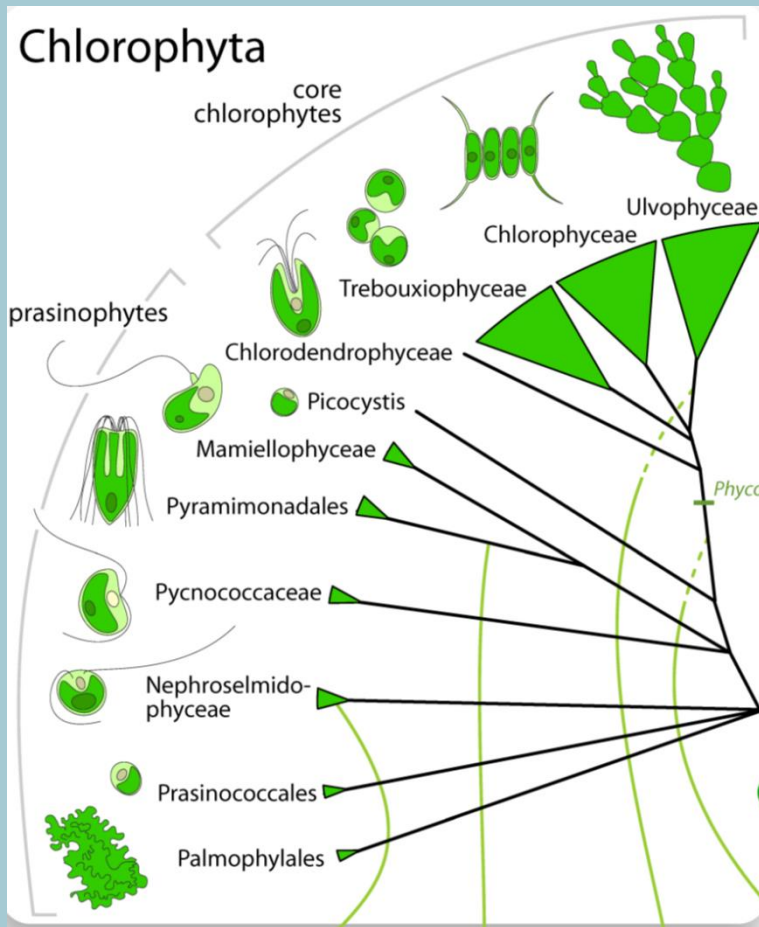


# Chlorophyceae, *Oophila*

- zelená vajíčka mloků



# Trebouxiophyceae

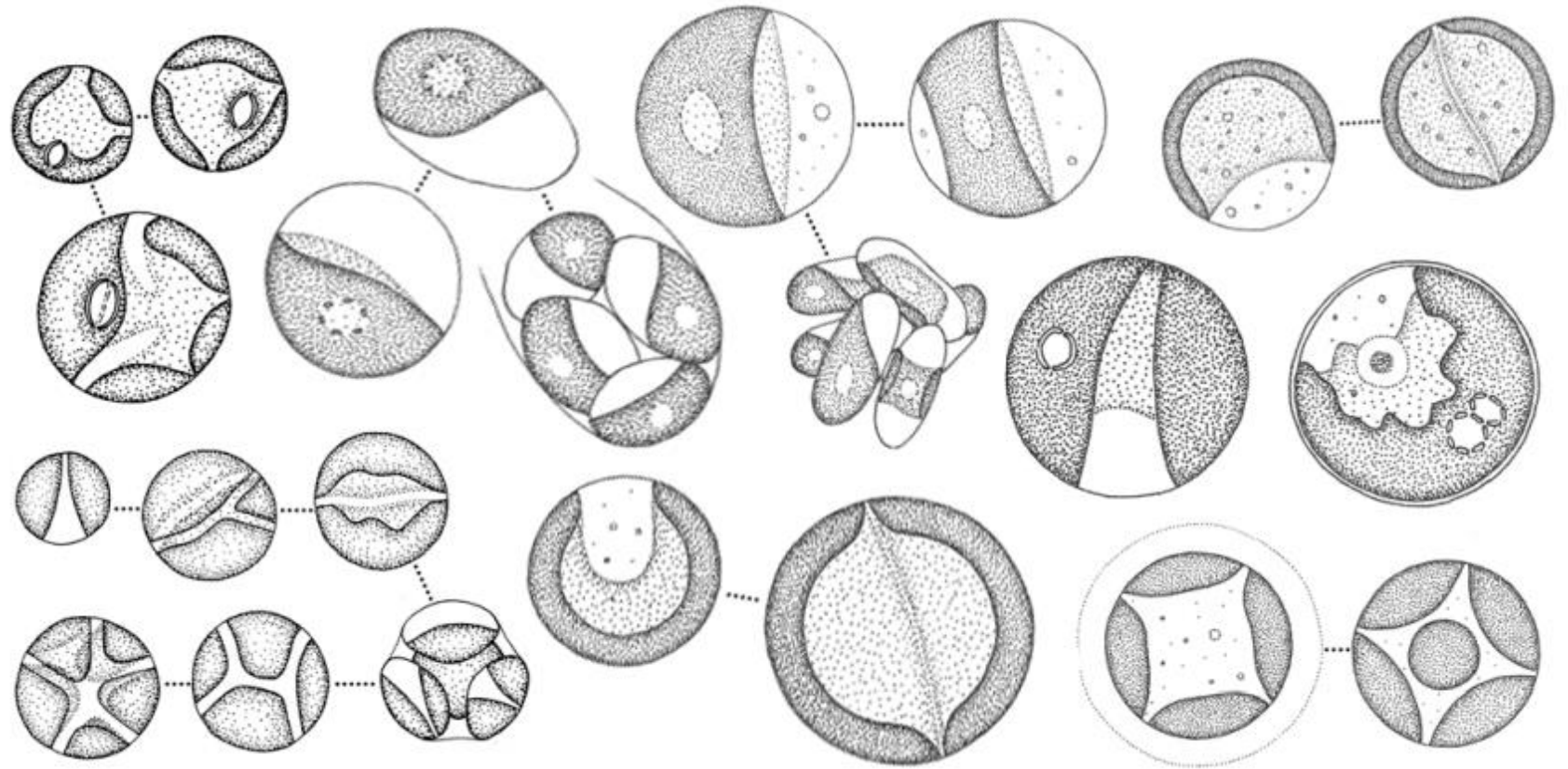


# Trebouxiophyceae, *Chlorella*

- *Chlorella* – autosporinní zelená kulička s jedním pyrenoidem
- Beijerinck (1980):

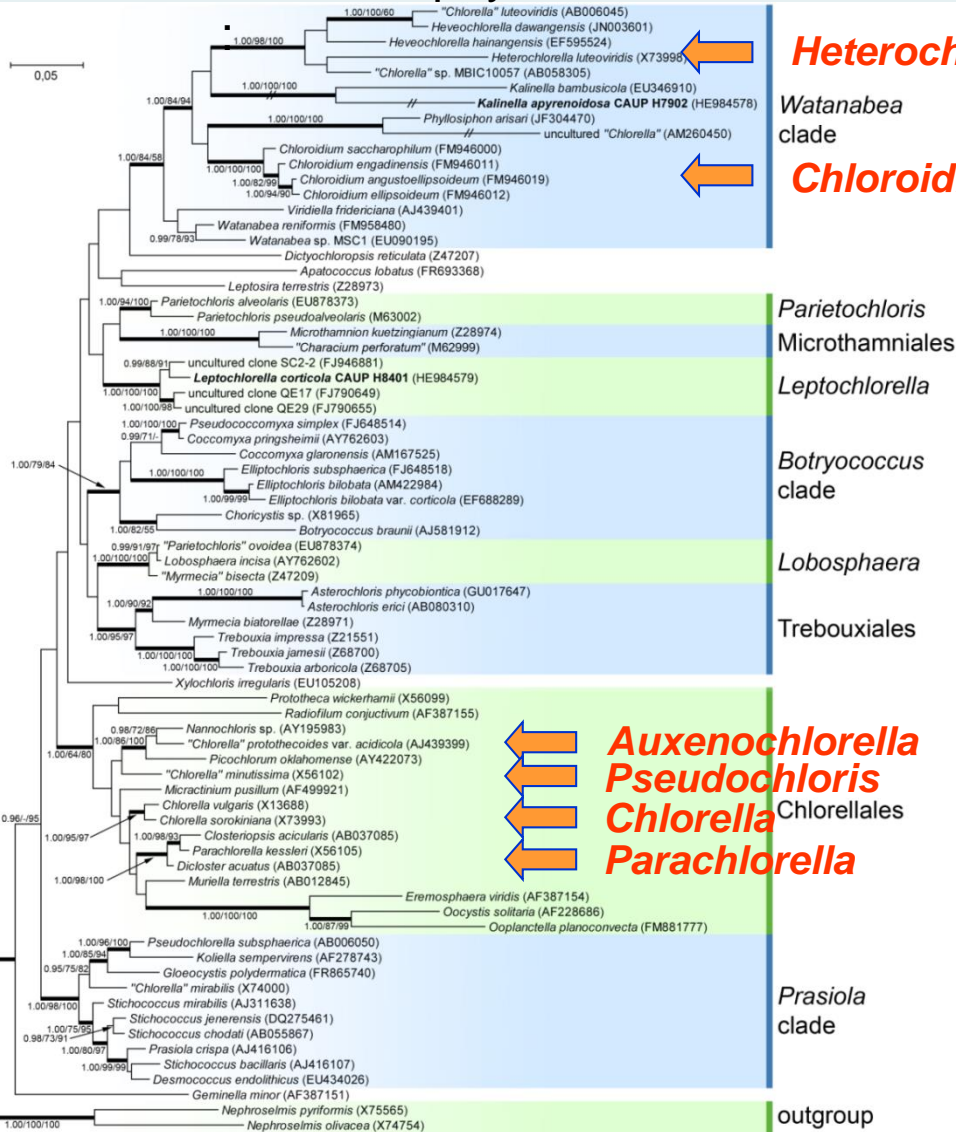
„... ich werde unten die Algen derart beschreiben, dass jeder dieselben leicht erkennen kann.“

„... nyní popíšu řasu takovým způsobem, že ji každý bude moci lehce rozeznat.“



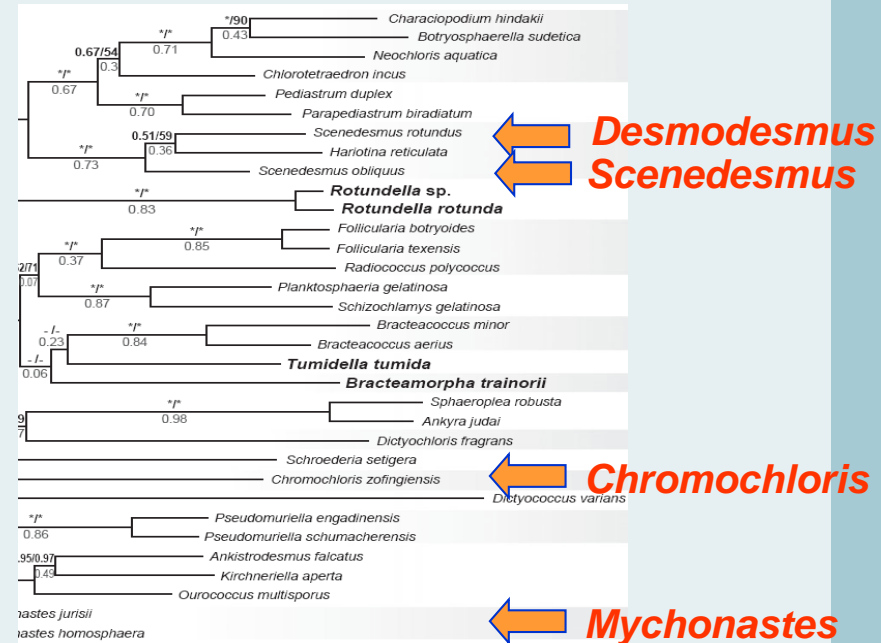
# Trebouxiophyceae, *Chlorella*

## Trebouxiophyceae

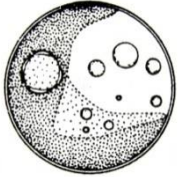
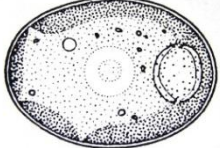
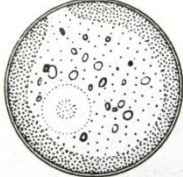
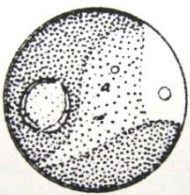
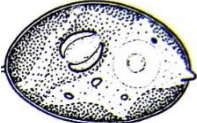
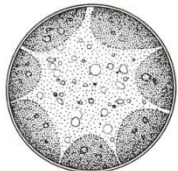
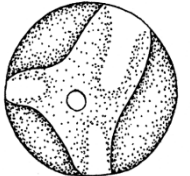
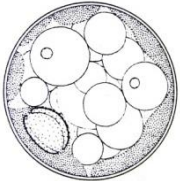

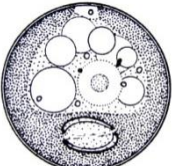
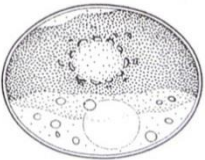


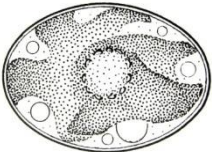
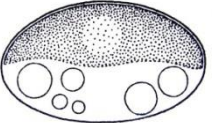


- V aerofytických podmínkách tlak na jednoduchou kokální morfologii
- Tradiční druhy rodu *Chlorella* spadají do 10 separátních linií/rodů

## Chlorophyceae:



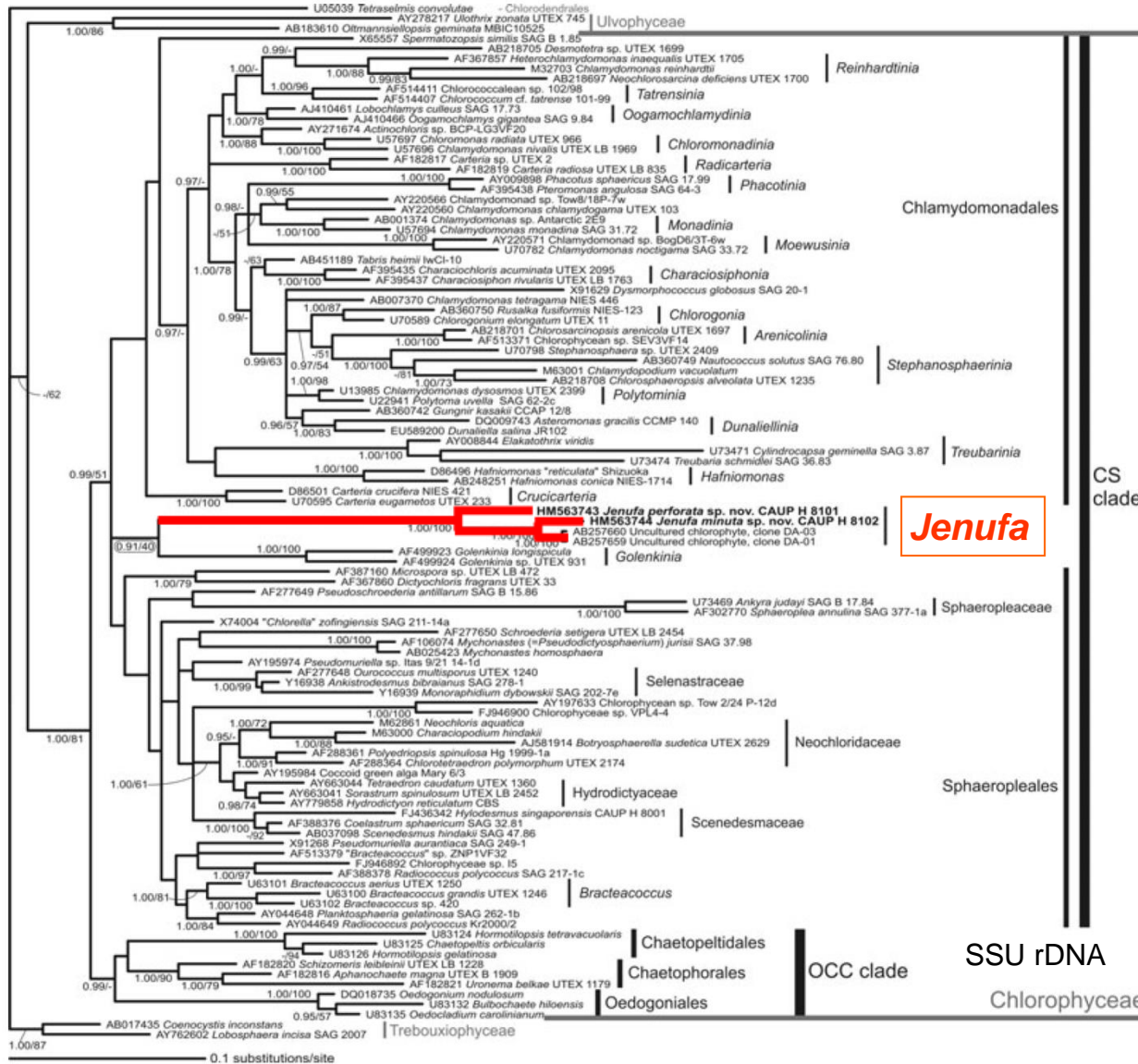
# Trebouxiophyceae, *Chlorella*

	<p><b>glukosamin</b> <i>Chlorella vulgaris</i></p>		<p><i>Desmodesmus abundans</i> (<i>Ch. fusca</i>, v. <i>fusca</i>) (<i>Scen. abundans</i>)</p>		<p><i>Mychonastes homosphaera</i> (<i>Ch. homosphaera</i>, <i>Ch. minutissima</i>)</p>
	<p><i>Chlorella sorokiniana</i> (<i>Ch. vulgaris</i>)</p>		<p><i>Scenedesmus rubescens</i> (<i>Ch. fusca</i>, v. <i>rubescens</i>) (<i>Halochlorella rubescens</i>)</p>		<p><i>Chromochloris zofingiensis</i> (<i>Ch. zofingiensis</i>)</p>
	<p><i>Chlorella lobophora</i></p>		<p><i>Scenedesmus vacuolatus</i> (<i>Ch. fusca</i>, v. <i>vacuolata</i>) (<i>Graesiella vacuolata</i>)</p>		<p><i>Auxenochlorella protothecoides</i> (<i>Ch. protothecoides</i>)</p>
	<p><i>Parachlorella kessleri</i> (<i>Ch. kessleri</i>)</p>		<p><i>Chloroidium ellipsoideum</i> (<i>Ch. ellipsoidea</i>)</p>		<p><i>Pseudochloris wilhelmii</i> (“<i>Ch. minutissima</i>”)</p>
	<p><i>Heterochlorella luteoviridis</i> (<i>Ch. luteoviridis</i>)</p>		<p><i>Chloroidium ellipsoideum</i> (<i>Ch. trebouxiioides</i>)</p>		
			<p><i>Chloroidium saccharophilum</i> (<i>Ch. saccharophila</i>)</p>		

An et al. (1999), Huss et al. (1999), Krienitz et al. (2004), Darienko et al. (2010), Neustupa et al. (2009), Fučíková & Lewis (2012), Somogyi et al. (2013)

# Trebouxiophyceae, *Chlorella* – kryptické rody

## Chlorophyceae:



**Jenufa**

CS clade

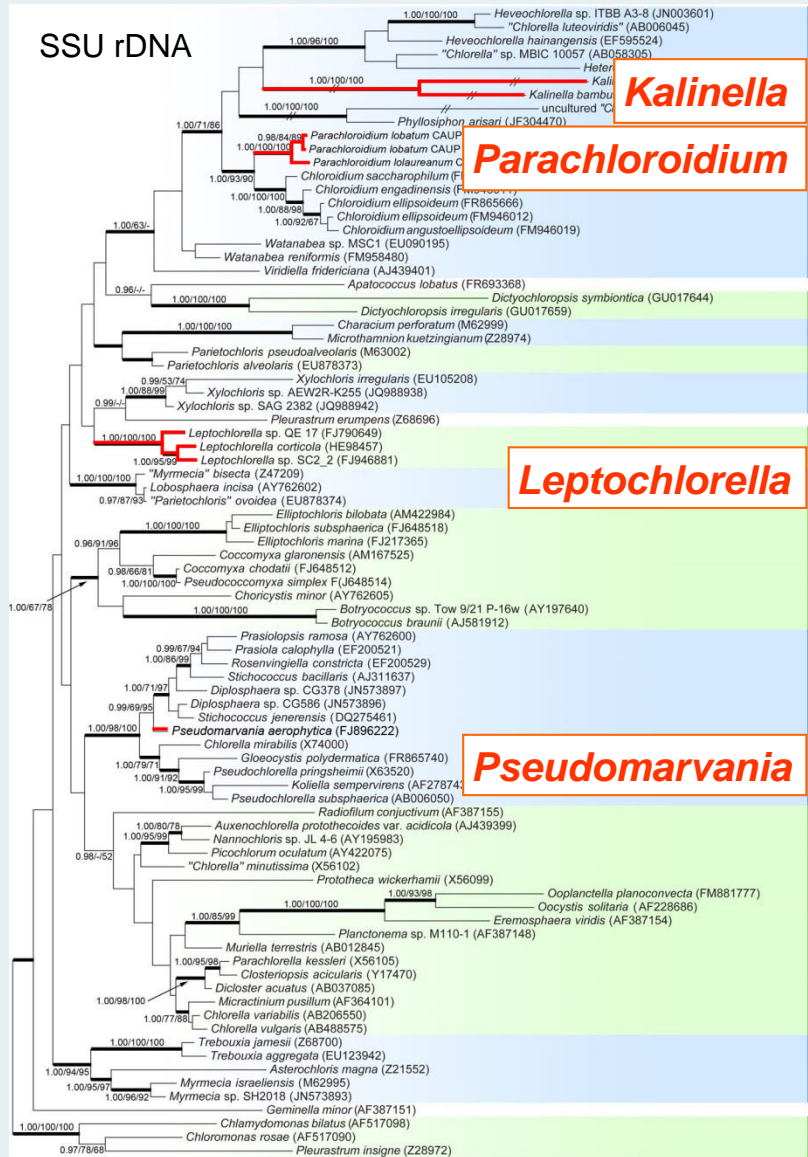
SSU rDNA

OCC clade

Chlorophyceae

# Trebouxiophyceae, *Chlorella* – kryptické rody

SSU rDNA



## Trebouxiophyceae:

*Watanabea*  
clade

*Dictyochloropsis*  
*Microthamniales*

*Parietochloris*  
*Xylochloris*

*Leptochlorella*  
*Lobosphaera*

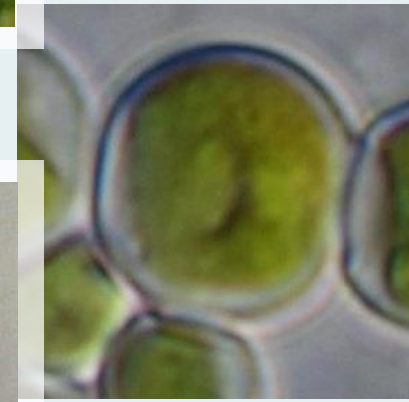
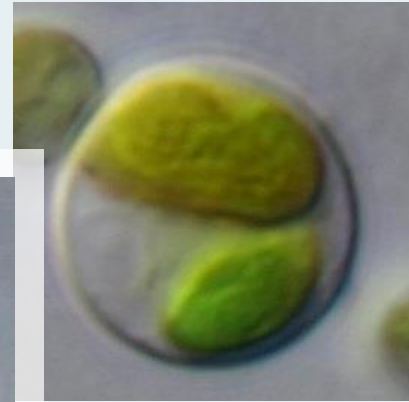
*Botryococcus*  
clade

*Prasiola*  
clade

Chlorellales

Trebouxiales

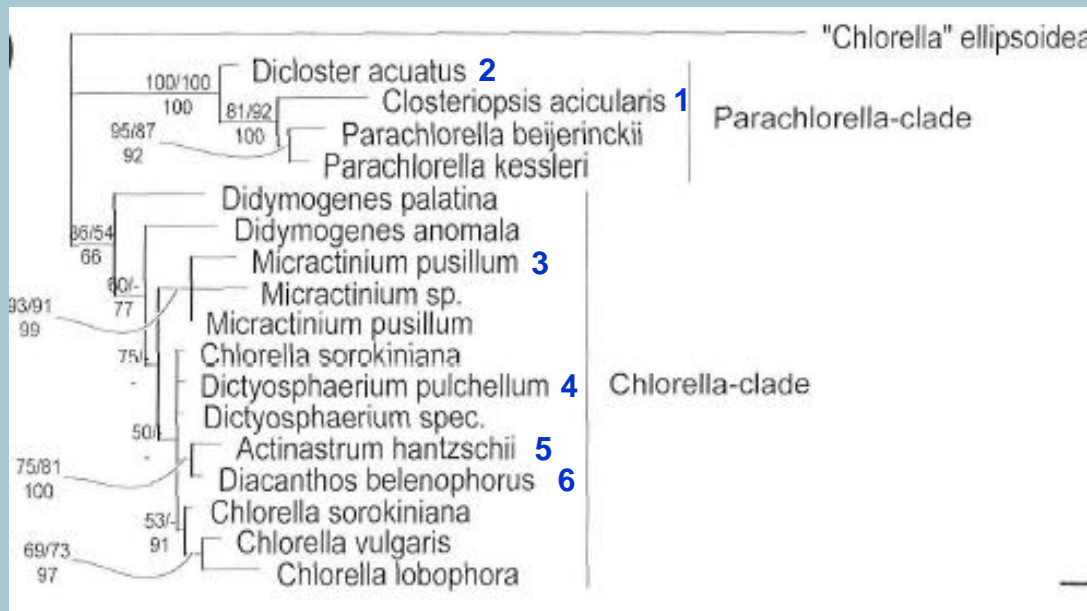
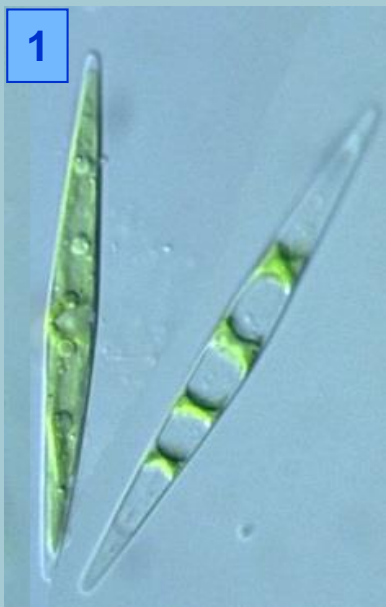
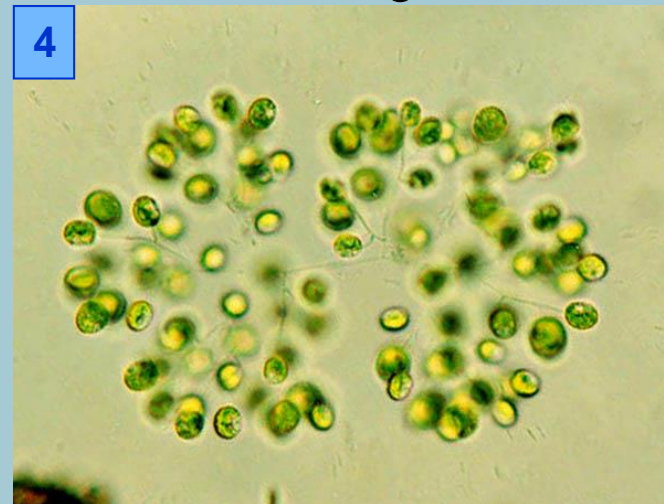
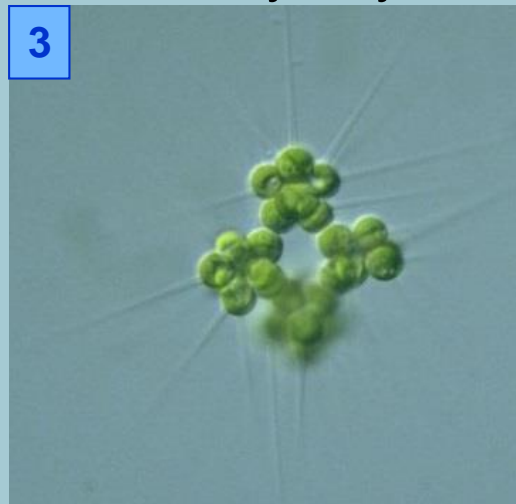
outgroup





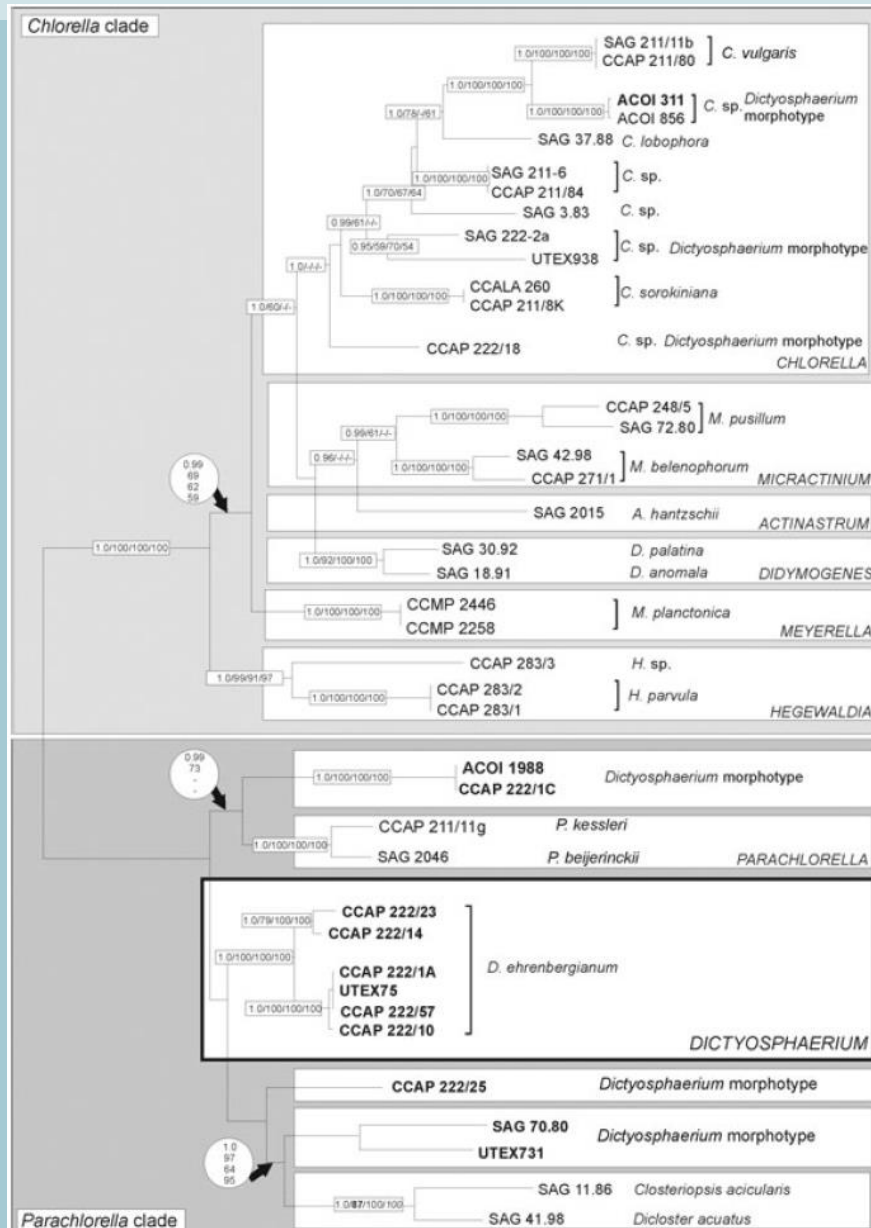
# Trebouxiophyceae, Chlorellaceae

- ke chlorelám spadají planktonní řasy s výrazně odlišnou morfologií



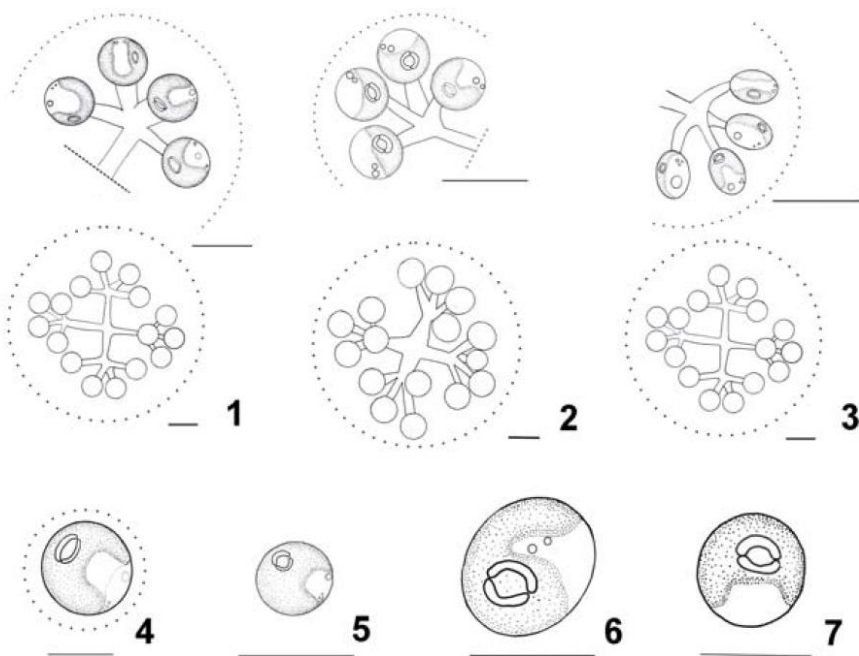
# Trebouxiophyceae, Chlorellaceae

- Chlorella-clade + Parachlorella-clade
- *Dictyosphaerium* – výrazně polyfyletický rod

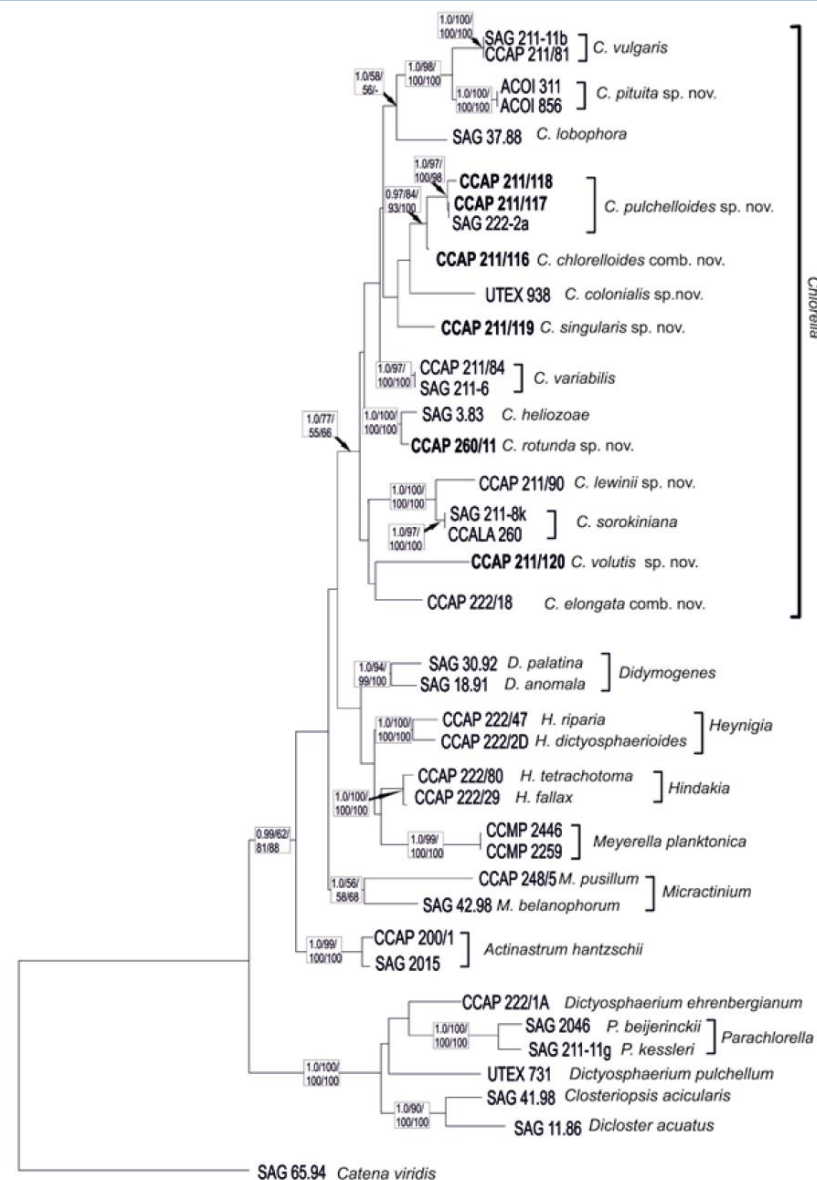


# Trebouxiophyceae, Chlorellaceae

- Chlorella-clade
  - Chlorella* - jednobuněčné i koloniální (*Dictyosphaerium*-like) druhy



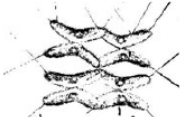
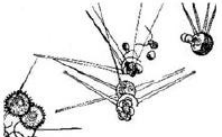
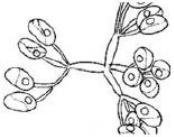
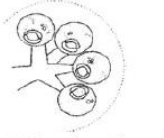
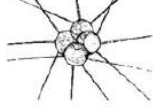



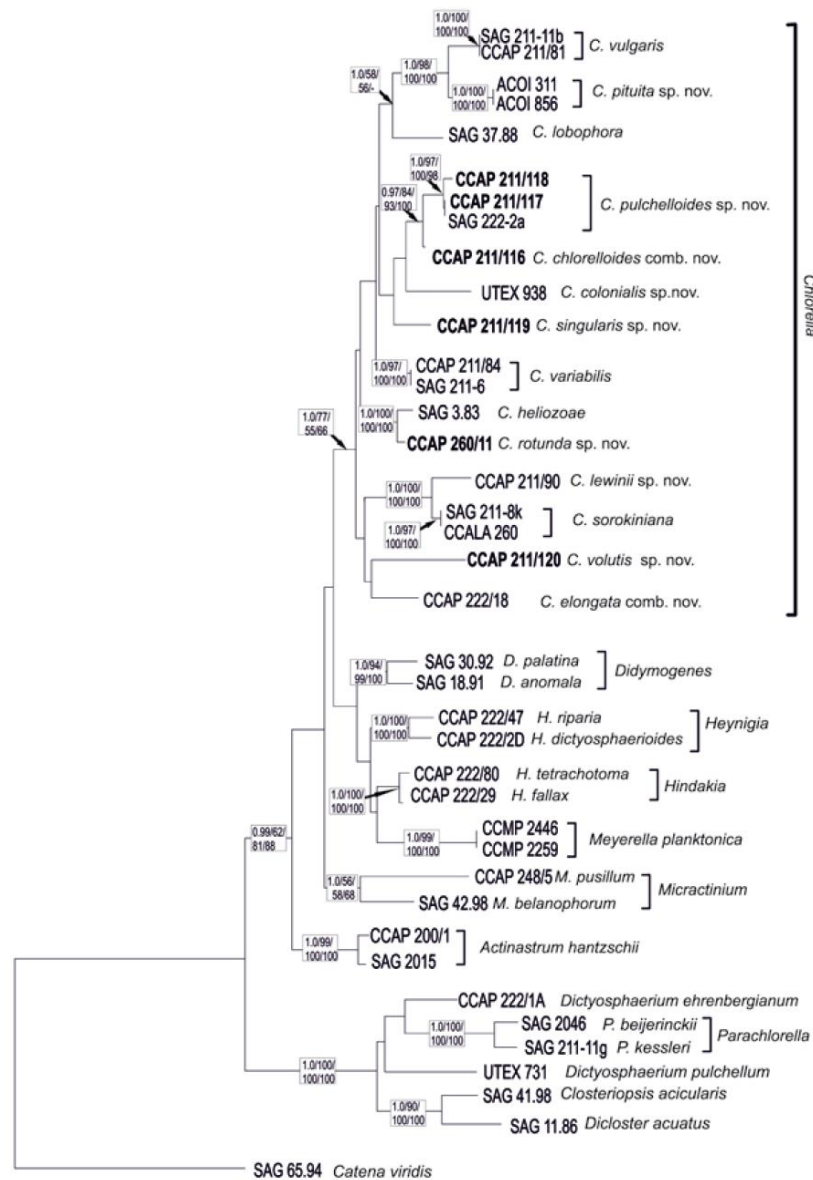
Figs 1–7. Drawings of light microscopical characters of *Chlorella* species. Iconotypes: (1) *Chlorella pituita*, authentic strain ACOI 311; (2) *Chlorella pulchelloides*, authentic strain CCAP 211/118; (3) *Chlorella coloniales*, authentic strain UTEX 938; (4) *Chlorella singularis*, authentic strain CCAP 211/119; (5) *Chlorella rotunda*, authentic strain CCAP 260/11; (6) *Chlorella lewinii*, authentic strain CCAP 211/90; (7) *Chlorella volutis*, authentic strain CCAP 211/120. Scale bars 10 µm.



# Trebouxiophyceae, Chlorellaceae

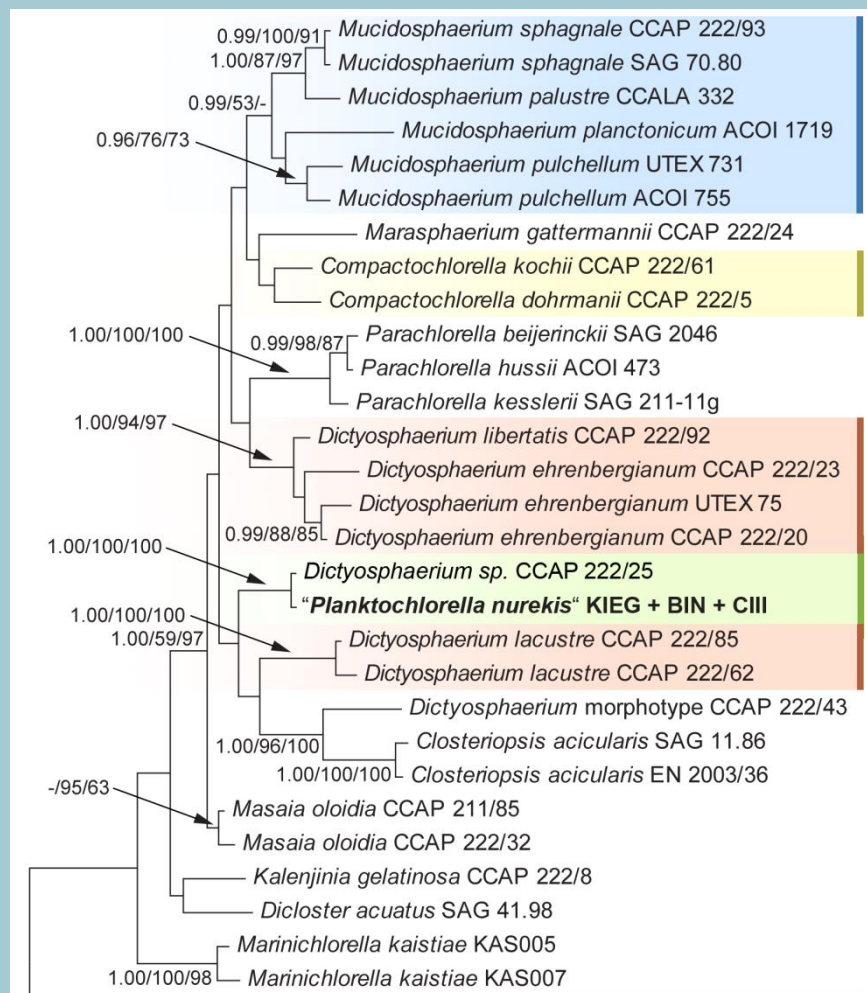
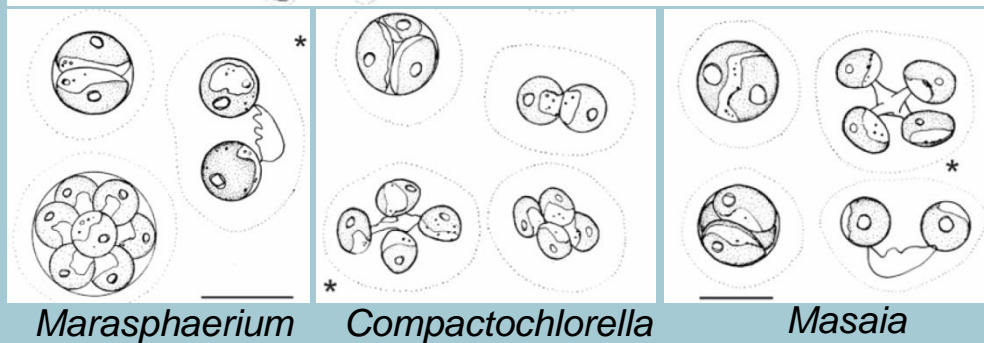
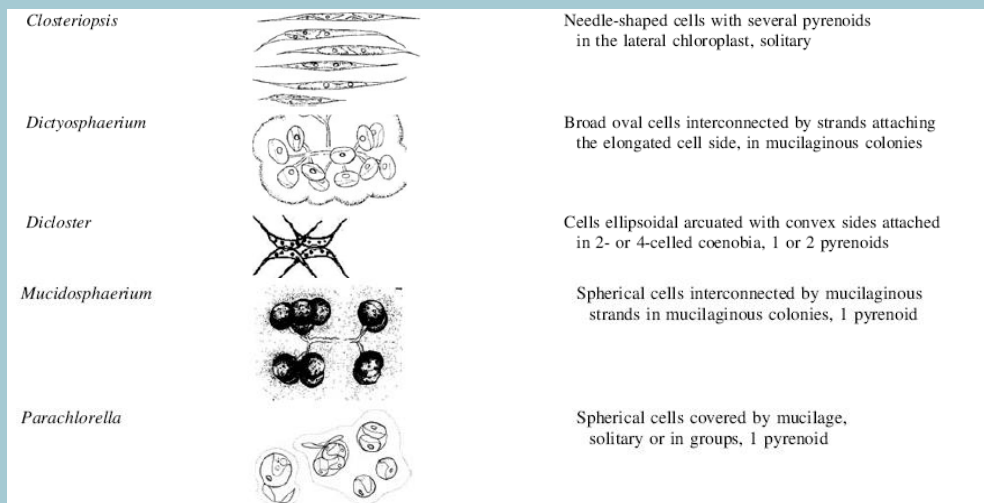
## Chlorella-clade

Genus	Drawing	Main diacritic morphology
<i>Actinastrum</i>		Cells rod-shaped, elongated, radially arranged in coenobia
<i>Chlorella</i>		Spherical or broad oval cells, with one pyrenoid, solitary or in mucilage covered colonies
<i>Didymogenes</i>		Cells cylindrical curved with convex side attached in 2-, 4- or 16-celled coenobia, one pyrenoid, spines
<i>Hegewaldia</i>		Spherical cells with or without bristles, solitary or in colonies, 1 pyrenoid, facultative oogamy
<i>Hindakia</i>		Broad oval cells interconnected by strands attaching the apical pole, in mucilaginous colonies, 1 pyrenoid
<i>Heynigia</i>		Spherical cells interconnected by mucilaginous strands in mucilaginous colonies, 1 pyrenoid
<i>Micractinium</i>		Spherical cells with long bristles, in colonies, 1 pyrenoid
<i>Meyerella</i>		Cells short cylindrical, small, without mucilage, solitary, pyrenoid missing



# Trebouxiophyceae, Chlorellaceae

## Parachlorella-clade



Krienitz & Bock (2012): *Hydrobiologia* **698**, 295 – 326; Krienitz et al. (2012): *Fottea* **12**, 231-253; Škaloud et al. (2014): *Fottea*, in press

# Trebouxiophyceae, Chlorellaceae

- Parachlorella-clade
  - Marinichlorella kaistiae*

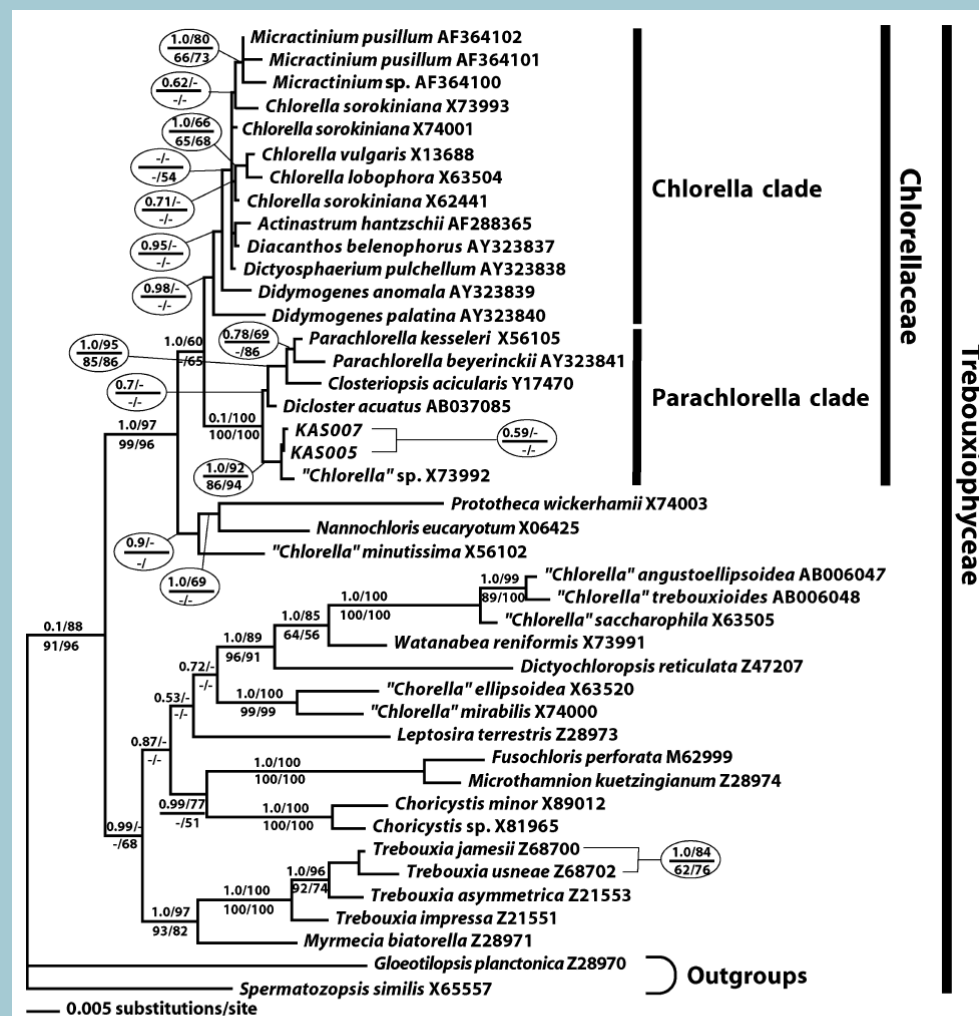
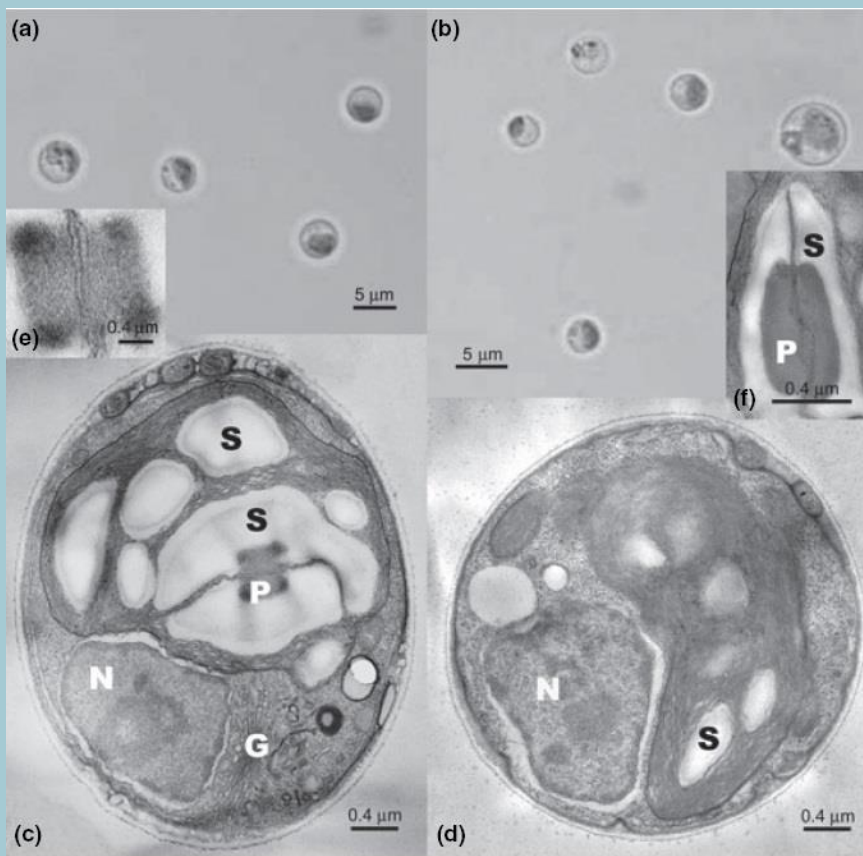
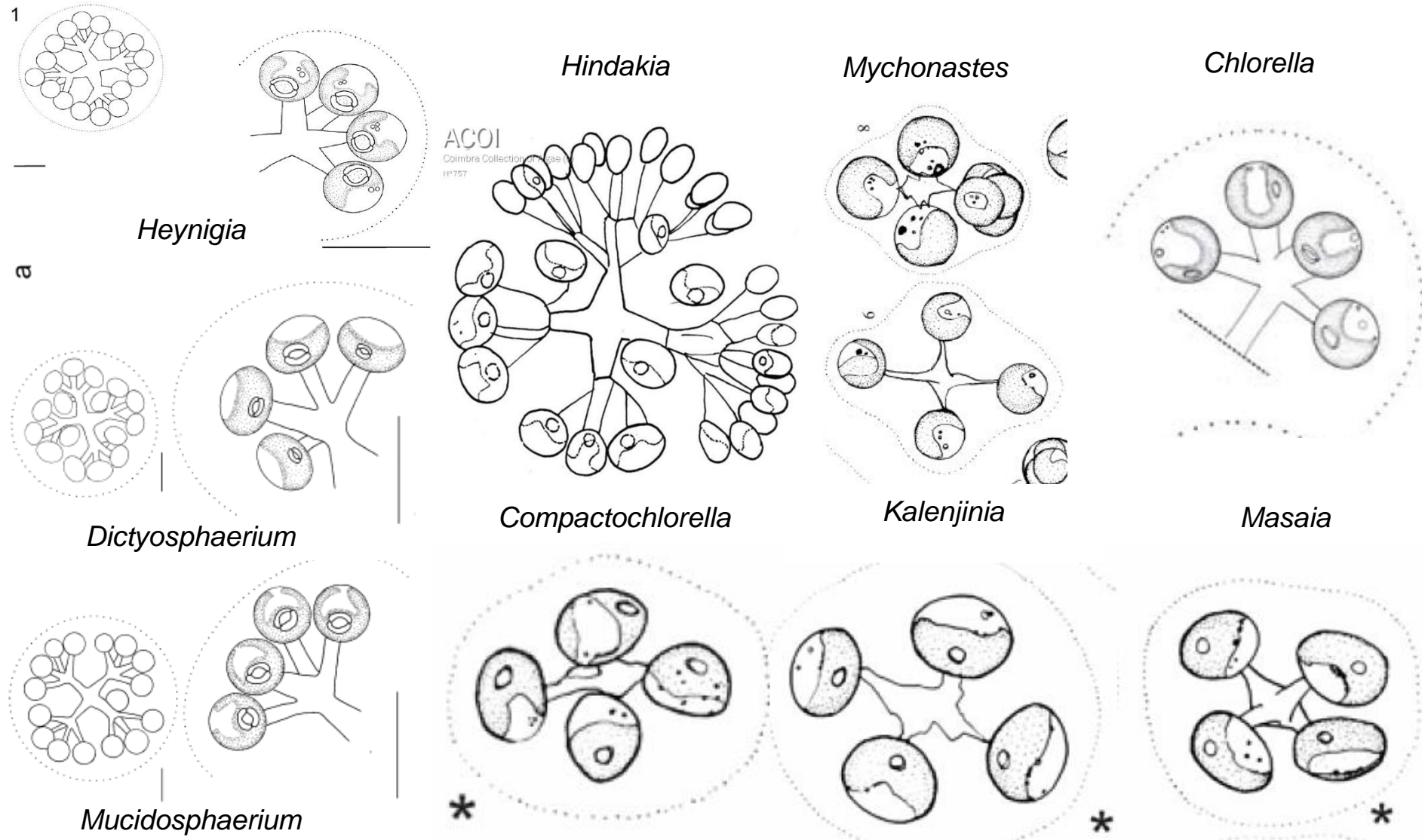


FIG. 2. Maximum-likelihood (ML) tree inferred from 18S rRNA gene sequences, with *Gloettilopsis planctonica* and *Spermatozopsis similis* as outgroup taxa. The numbers above each branch show posterior probabilities (0.50 and higher) of Bayesian analysis (1,000,000 generations, left) and bootstrap values (50% or more) of ML (500 replicates, right). The numbers below each branch show bootstrap value (50% or more) of ML distance (1000 replicates, left) and maximum parsimony (1000 replicates, right). Some duplicate strains of some genera are not included in the tree because they have the same sequences. Branch lengths correspond to evolutionary distances. A distance of 0.005 is indicated by the scale.

# Dictyosphaerium

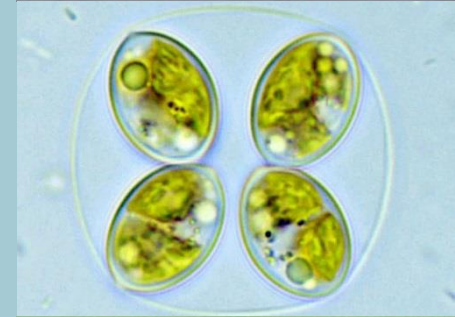
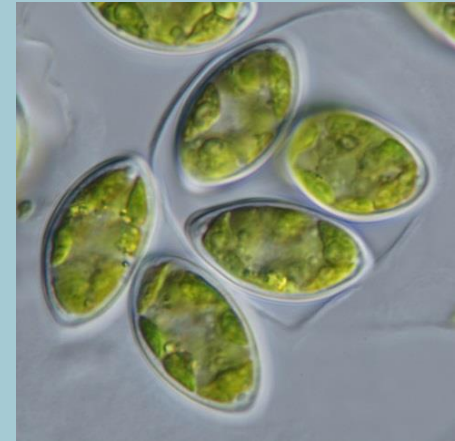
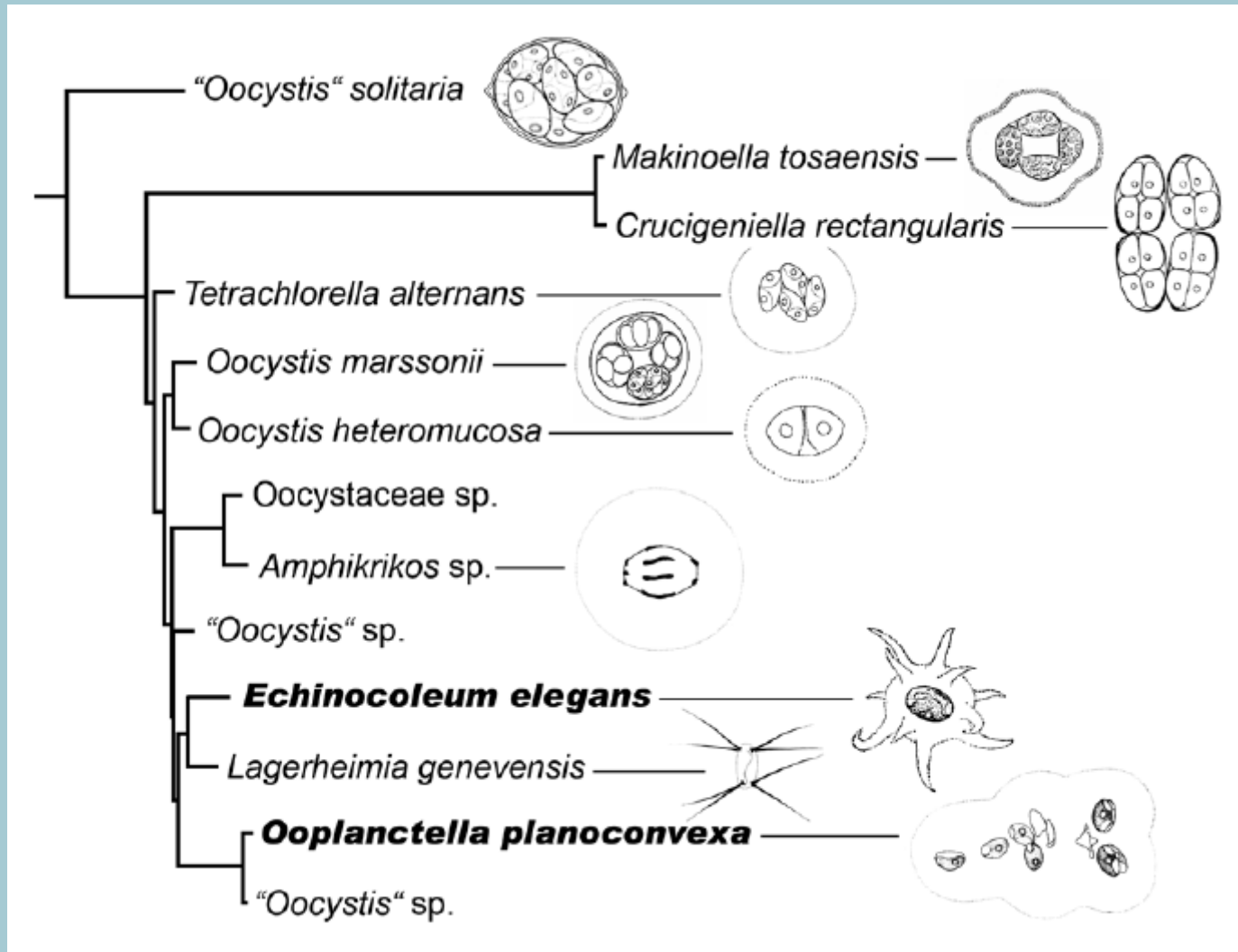
- 9 kryptických rodů



Krienitz et al. (2012): *Fottea* **12**, 231-253; Bock et al. (2010): *European Journal of Phycology* **45**, 267-277; Bock et al. (2011): *Journal of Phycology* **47**, 638-652; Krienitz et al. (2011): *Phycologia* **50**, 89-106

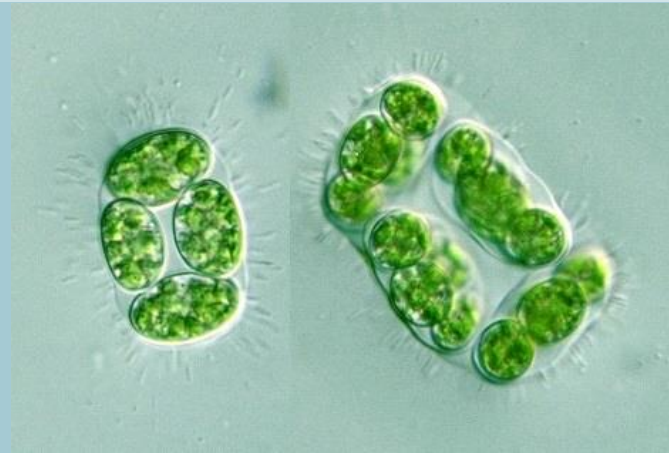
# Trebouxiophyceae, Oocystaceae

- *Oocystis* – polyfyletický rod





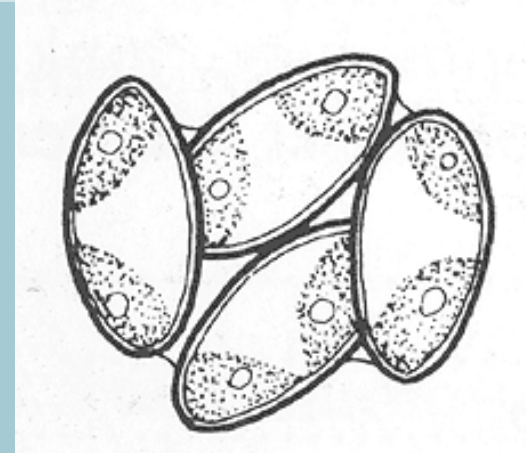
# Trebouxiophyceae, Oocystaceae



*Makinoella*



*Crucigeniella*



*Tetrachlorella*



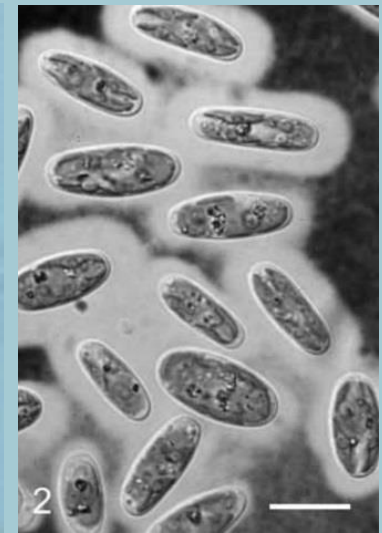
*Amphikrikos*



*Lagerheimia*



*Echinocoleum*



*Elongatocystis*

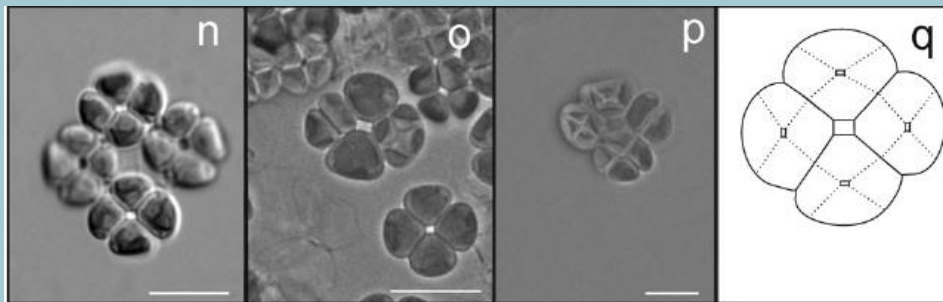
# Trebouxiophyceae, Oocystaceae

- *Eremosphaera*

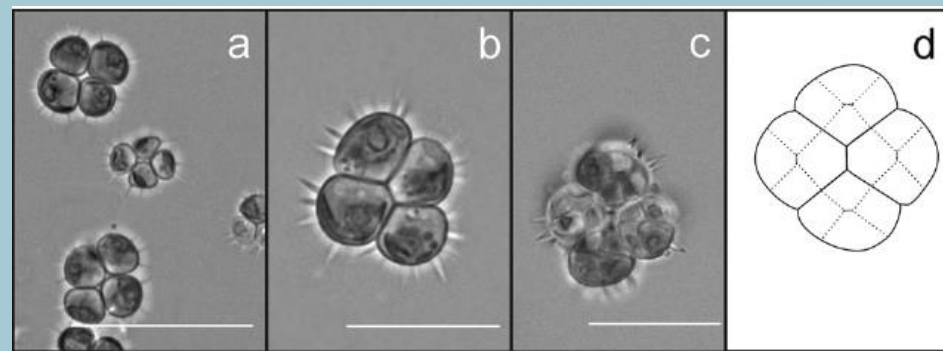


# Trebouxiophyceae, tetraedrické kolonie

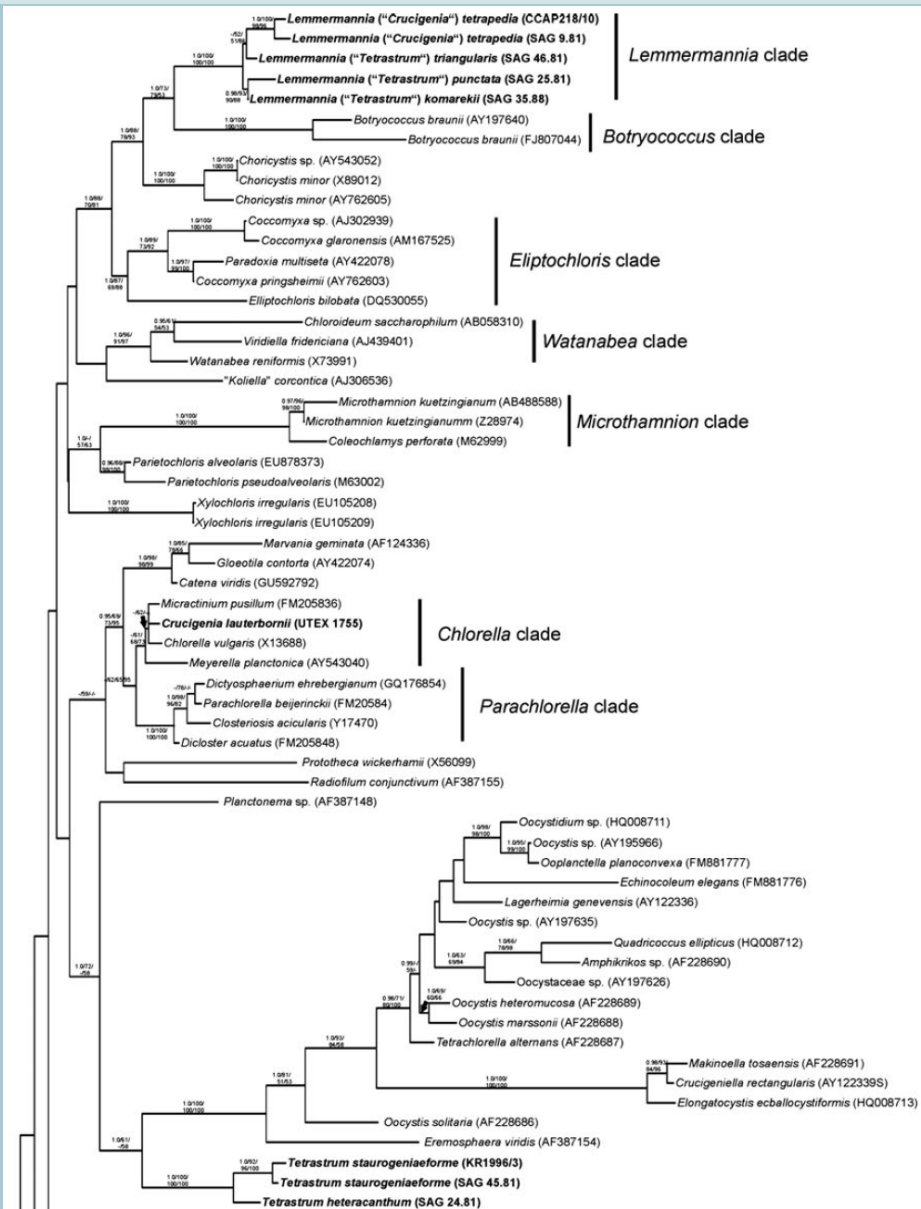
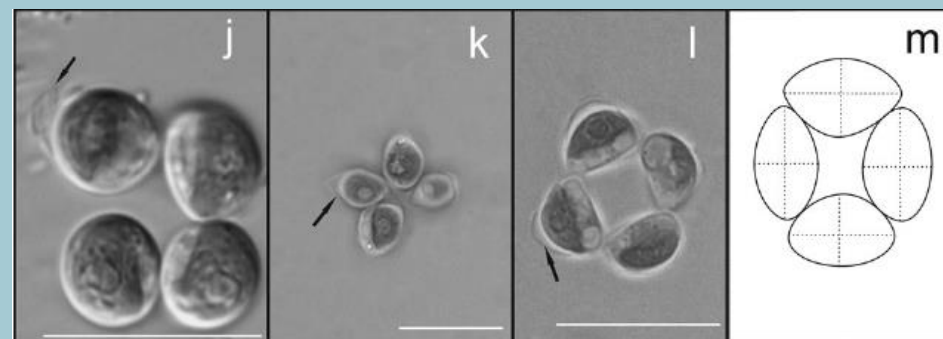
*Lemmermannia* – hladké kolonie, malý otvor



*Tetrastrum* – chlupaté kolonie

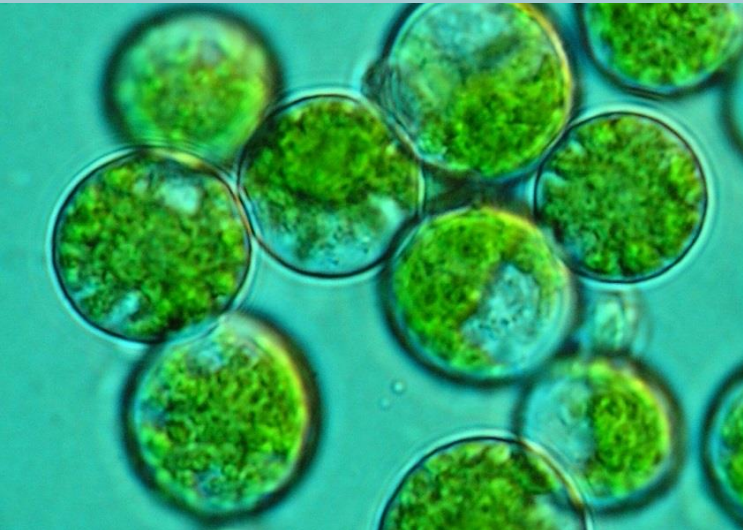


*Crucigenia* – hladké kolonie, velký otvor, zbytky BS

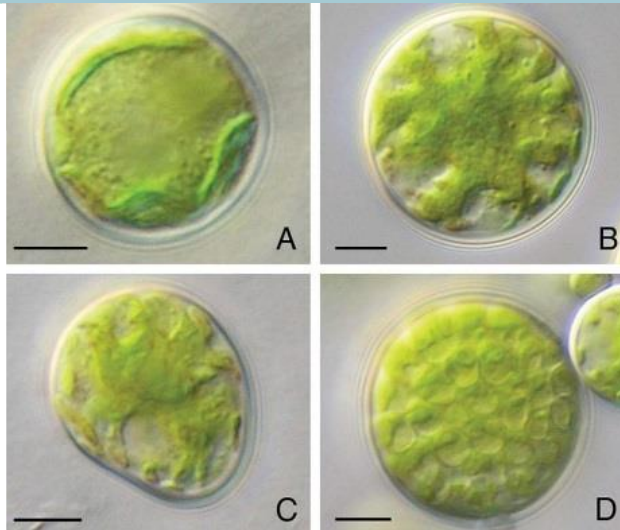


# Trebouxiophyceae, Trebouxiales

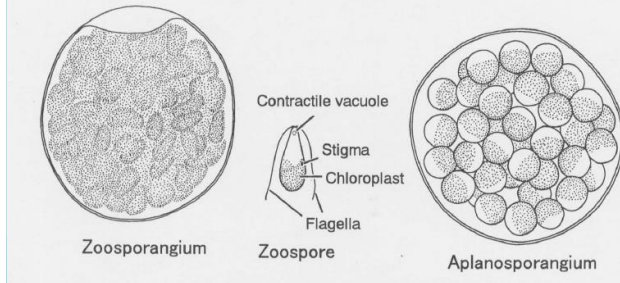
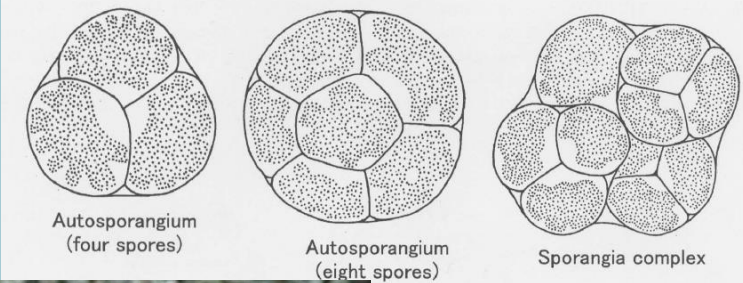
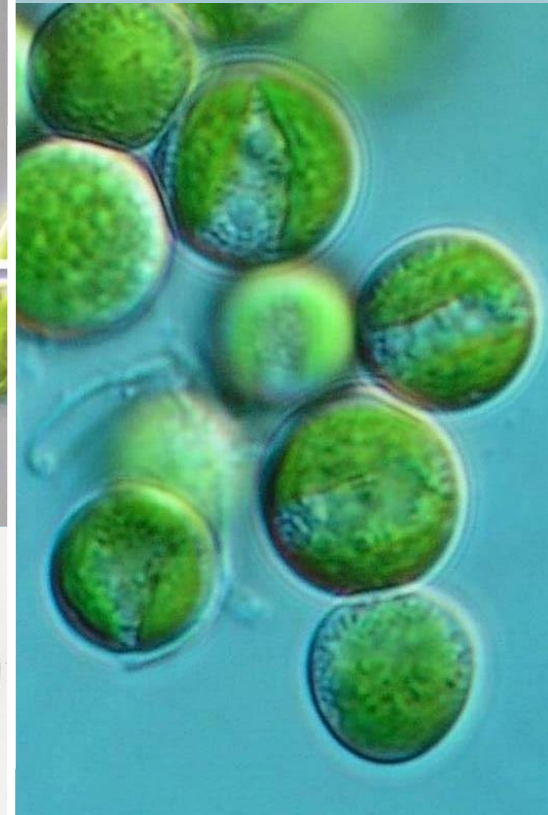
*Trebouxia*



*Asterochloris*



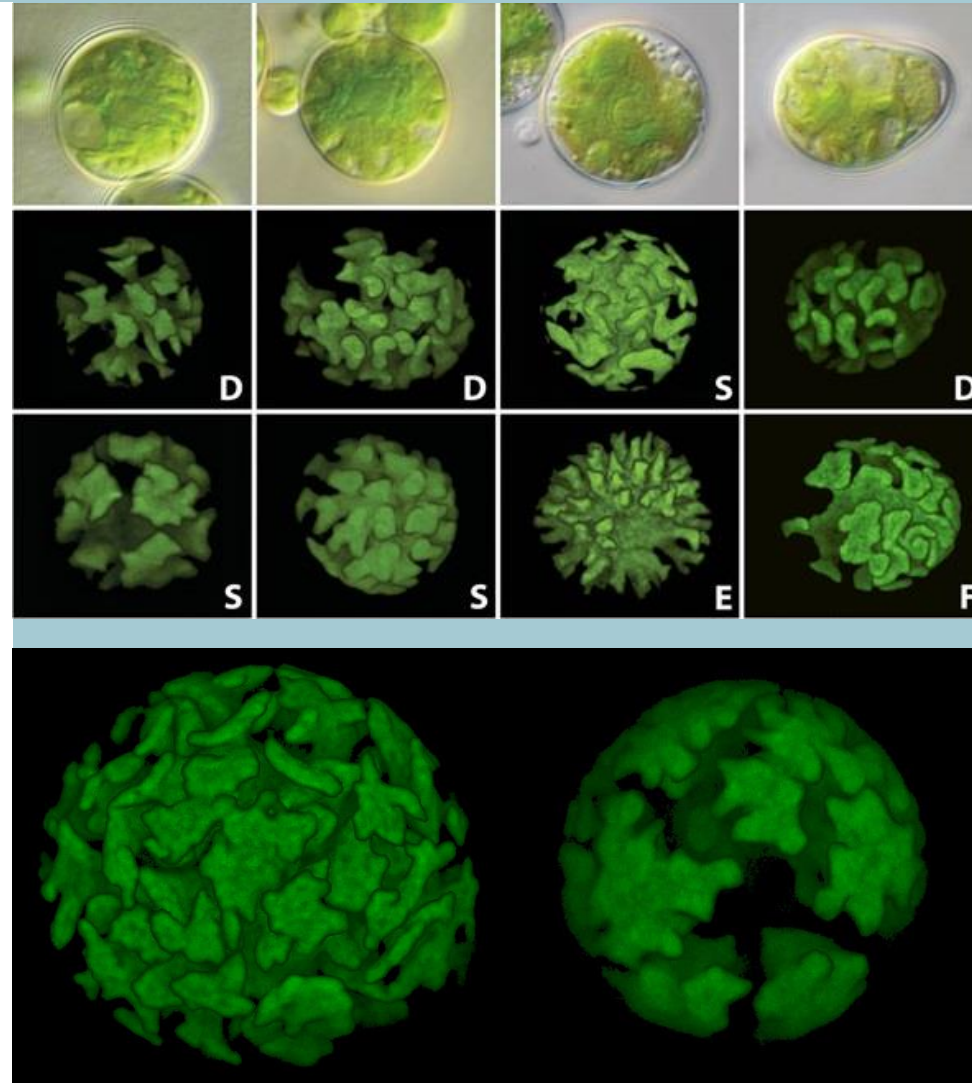
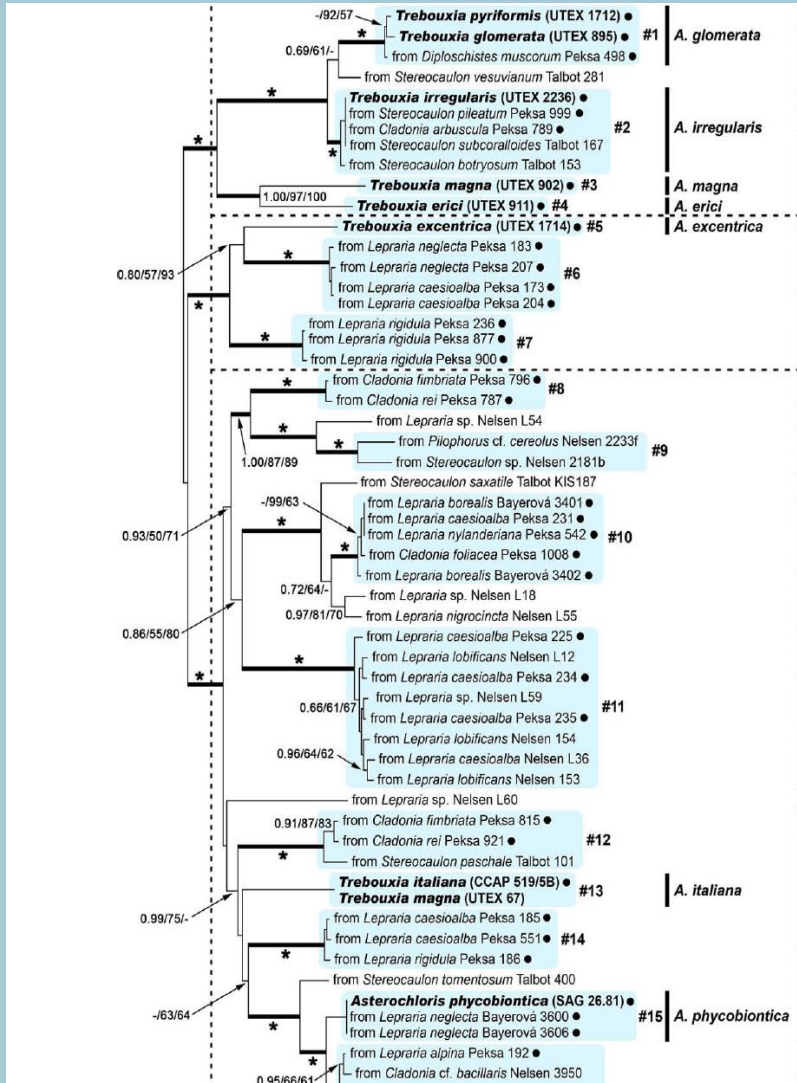
*Myrmecia*



*Bacidia*

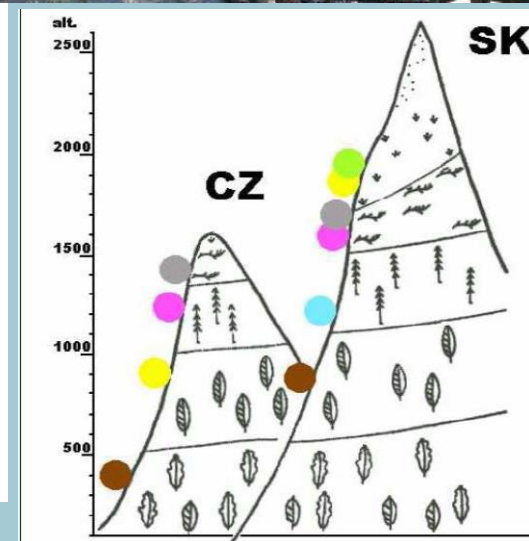
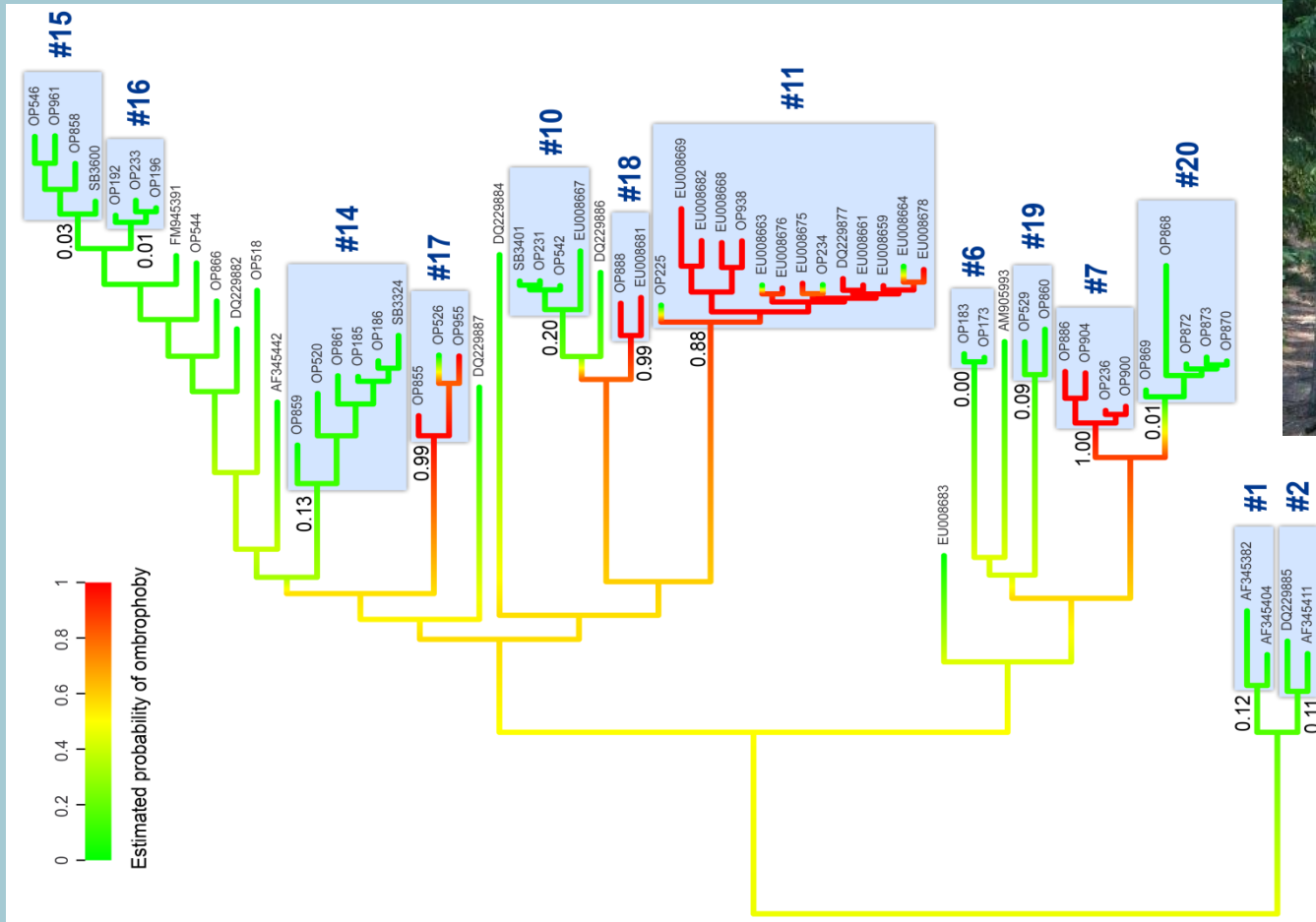
# Trebouxiophyceae, Trebouxiales

- Asterochloris* – kryptická diverzita



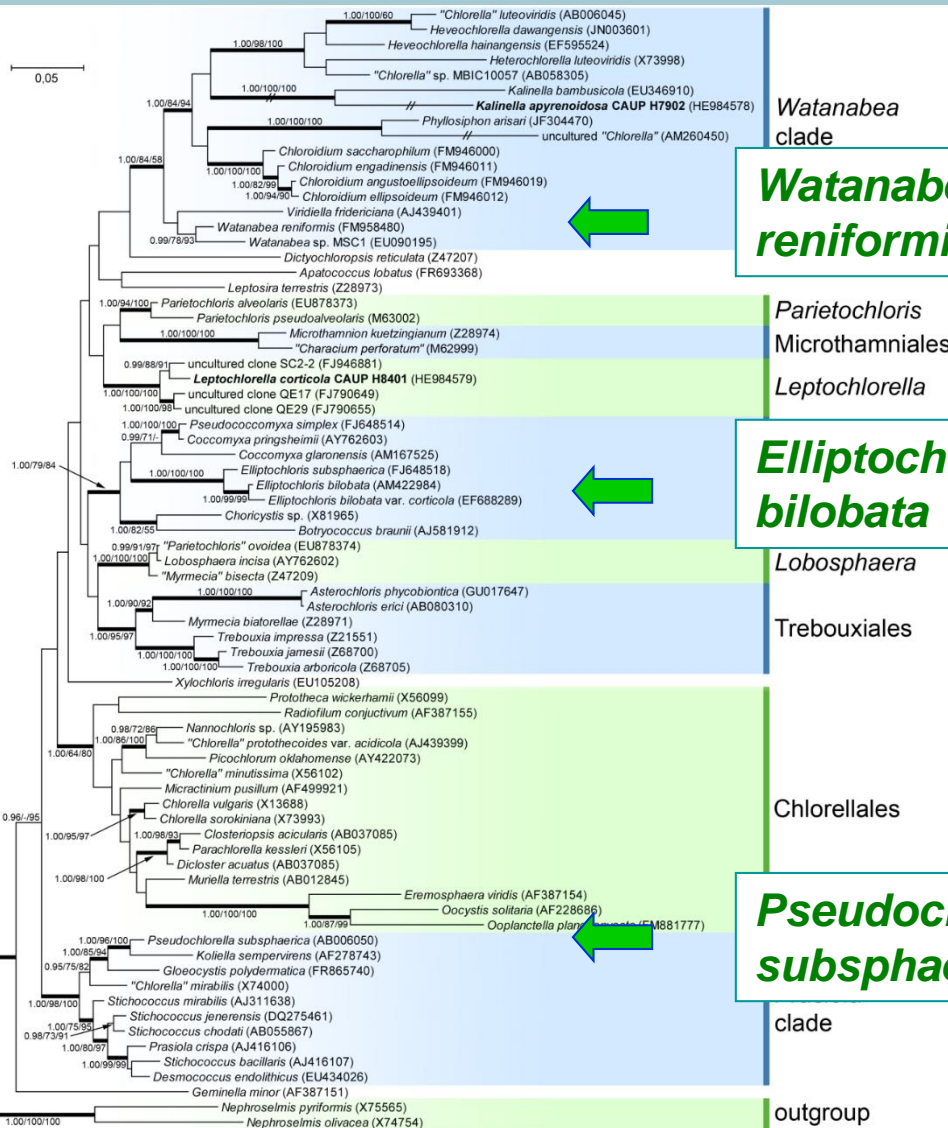
# Trebouxiophyceae, Trebouxiales

- Asterochloris* – kryptická diverzita, ekologická diferenciacie druhů



# Trebouxiophyceae, *Elliptochloris*

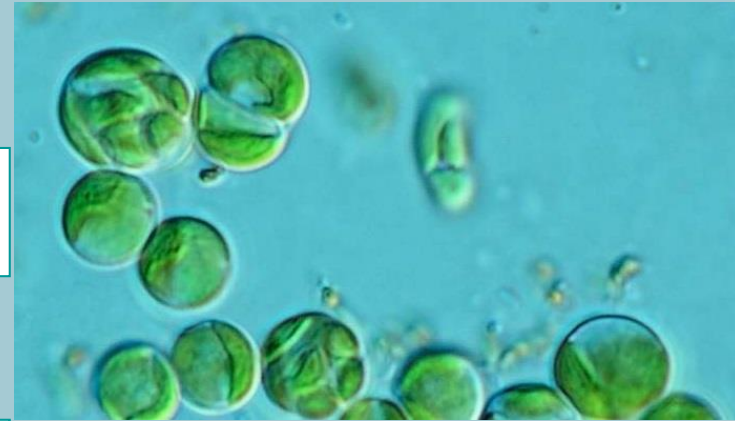
- 2 typy autospor, nezávislý vznik ve 3 nepříbuzných liniích



**Watanabea reniformis**

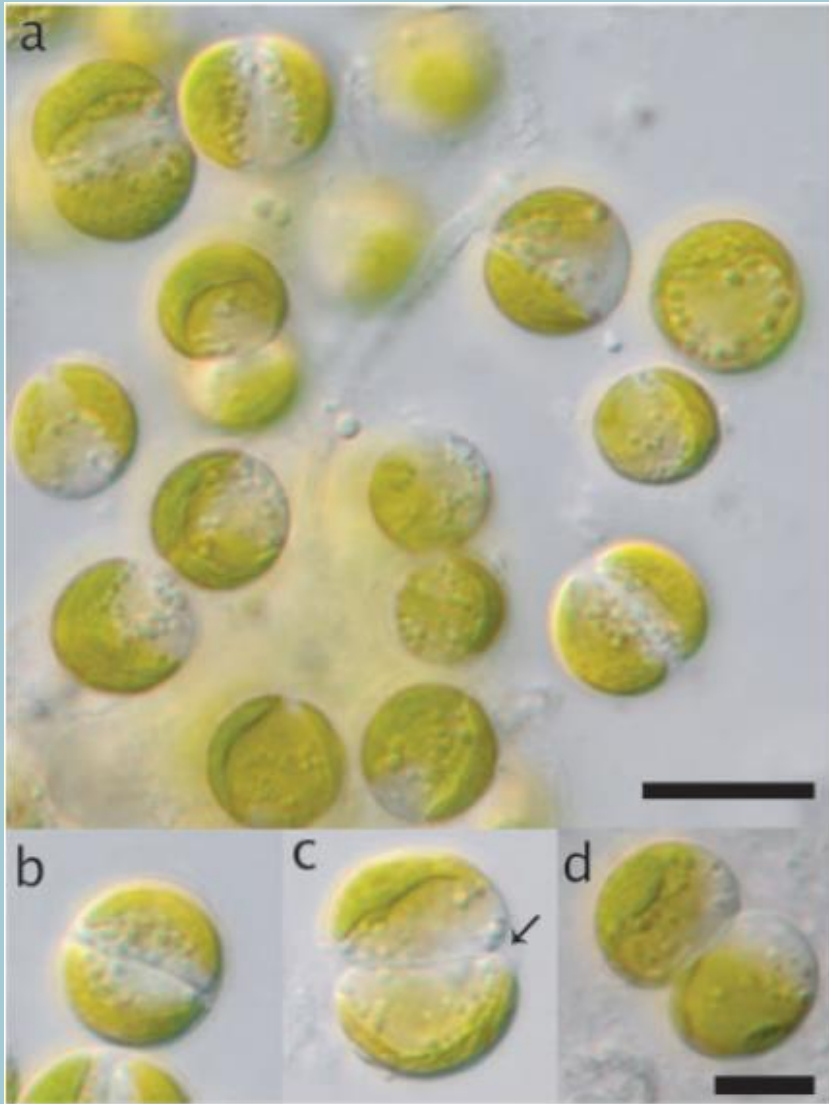
**Elliptochloris bilobata**

**Pseudochlorella subsphaerica**



# Trebouxiophyceae, *Elliptochloris*

- symbionti lišejníků (*Baeomyces*, *Catolechia*), sasanek (*Anthopleura*)

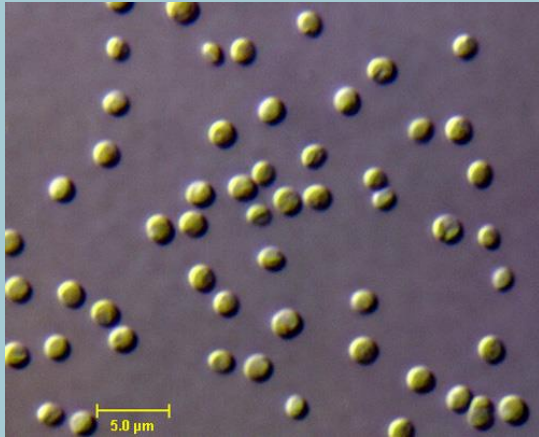




# Trebouxiophyceae, pikoplanktonní řasy

- zelené kuličky s průměrnou velikostí do 3  $\mu\text{m}$

*Nannochloris*

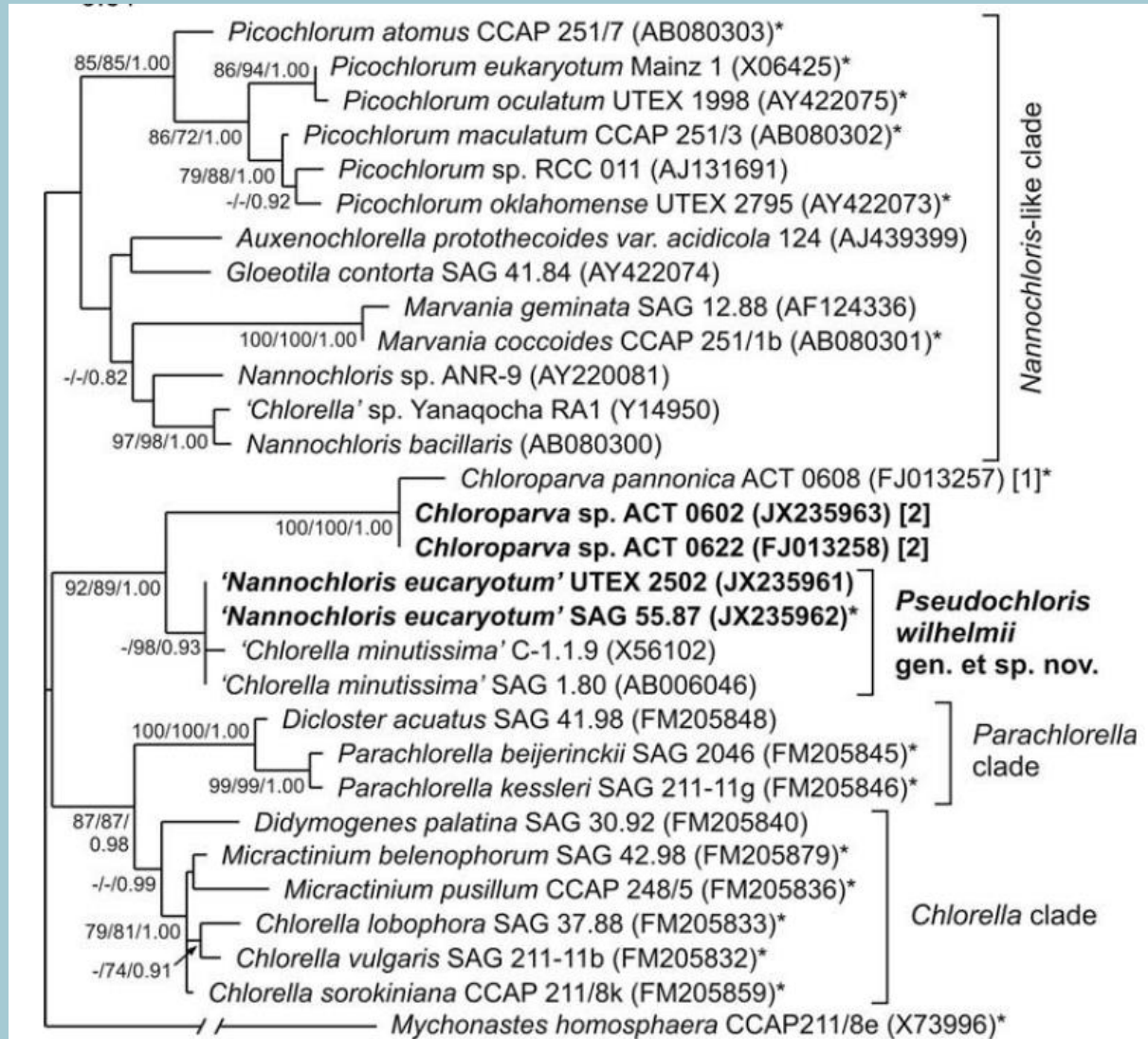
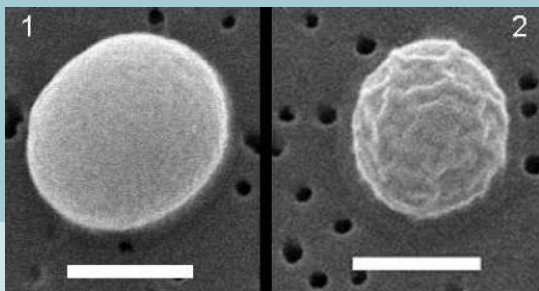


*Picochlorum*



*Pseudochloris*

*Chloroparva*

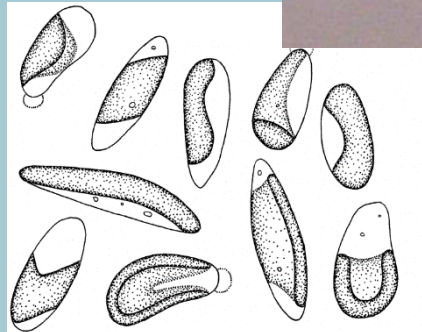
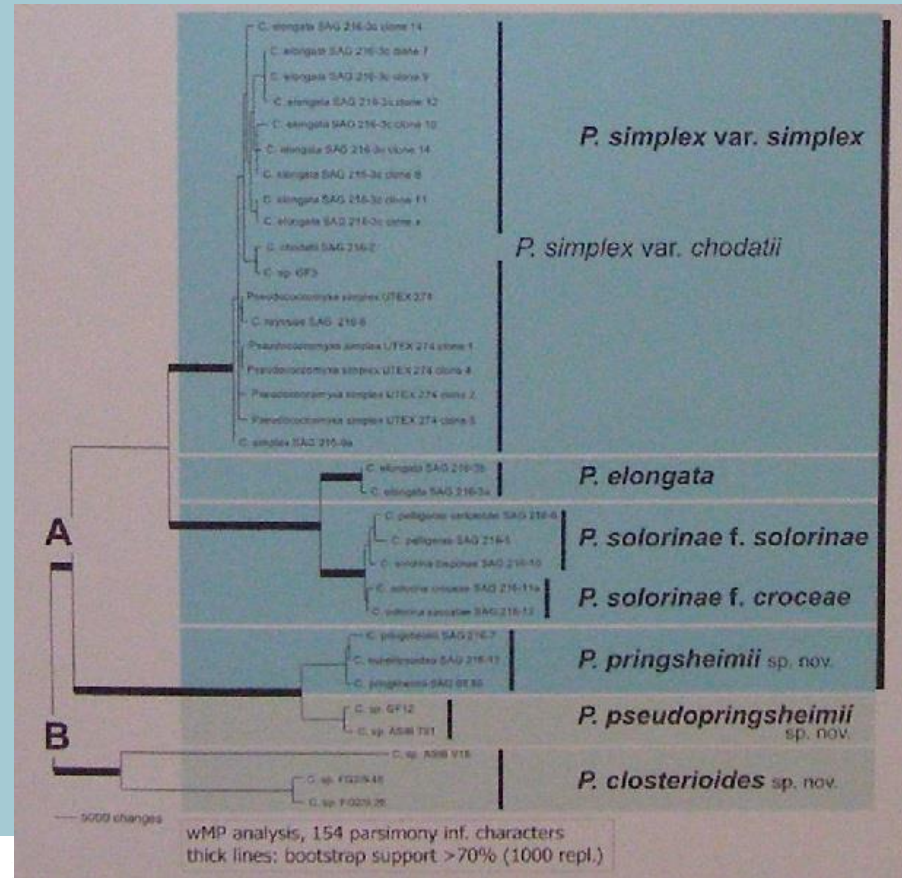


# Trebouxiophyceae, Botryococcus-clade

## *Botryococcus*

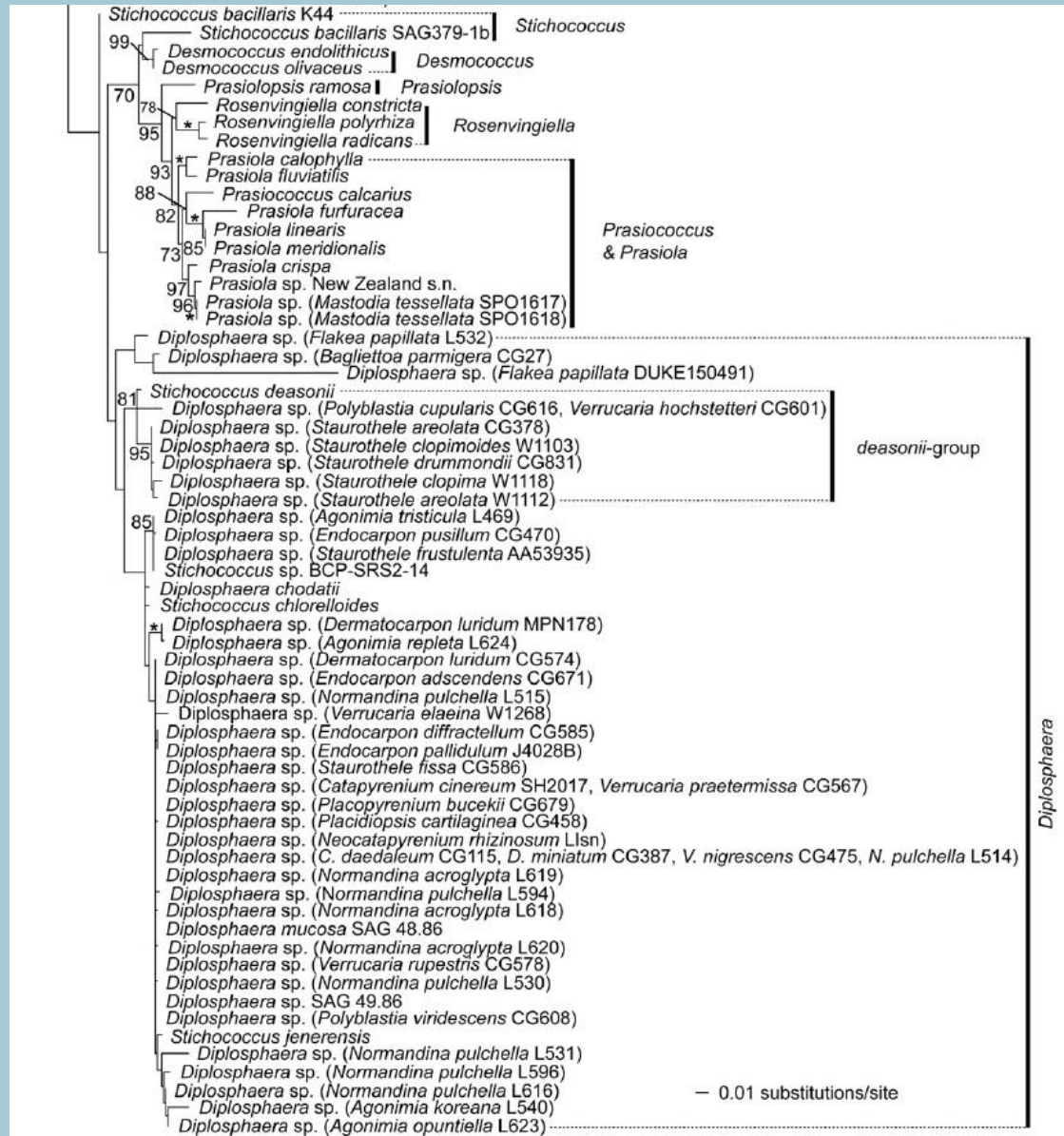
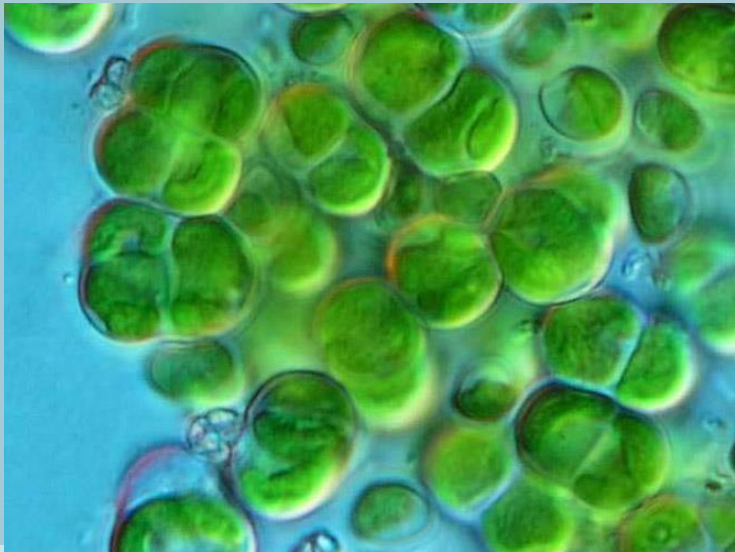


## *Pseudococcomyxa/Coccomyxa*



# Trebouxiophyceae, Prasiolales

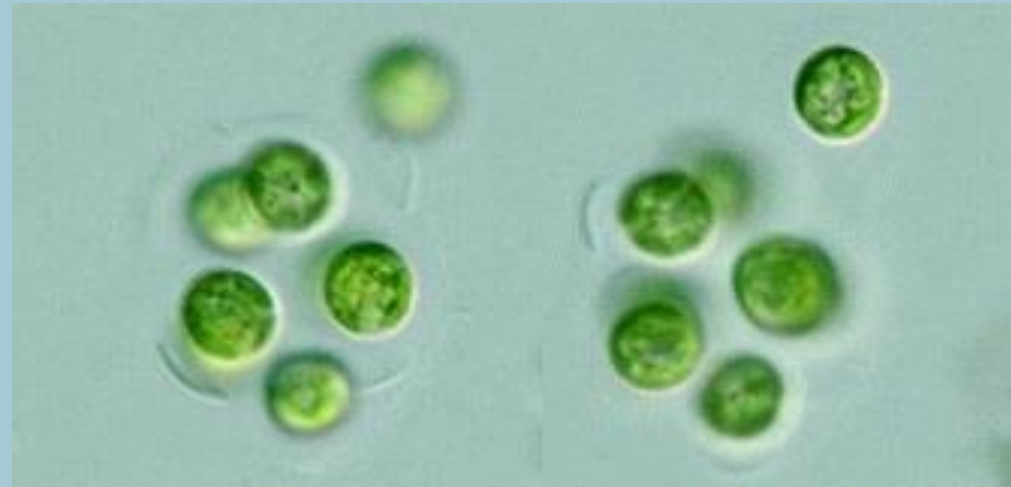
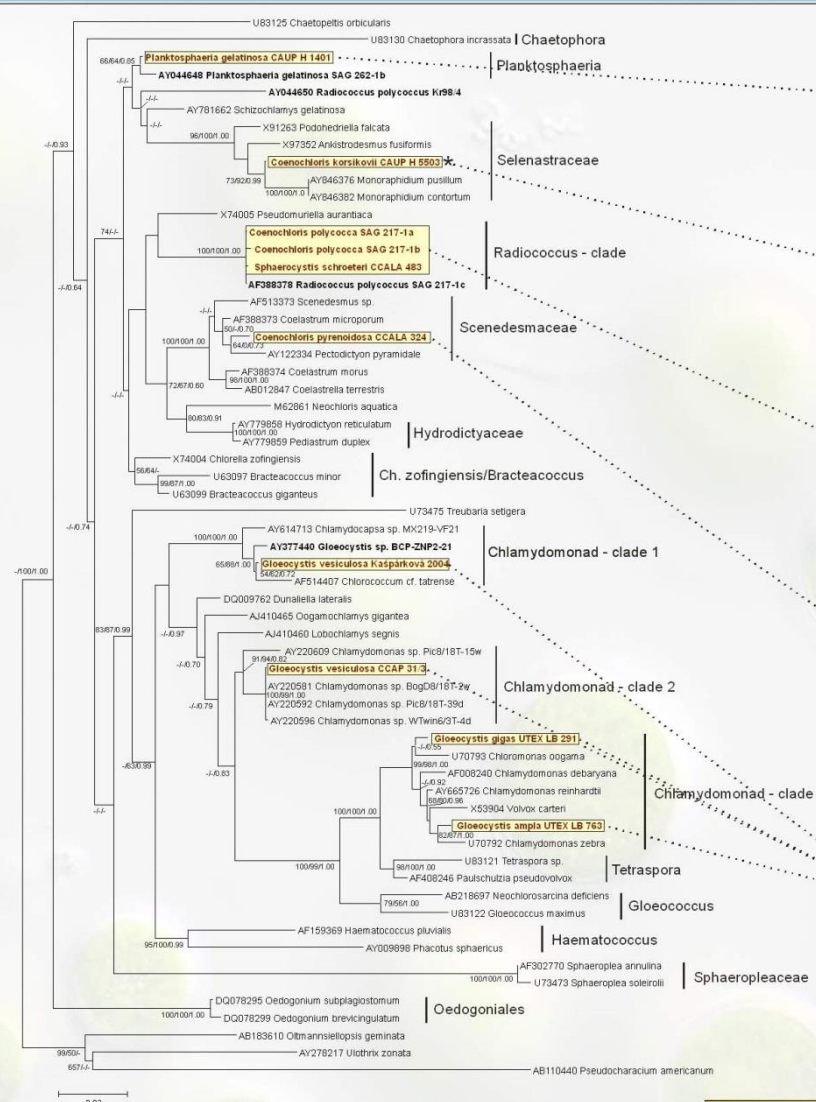
- Stichococcus* / *Diplosphaera*



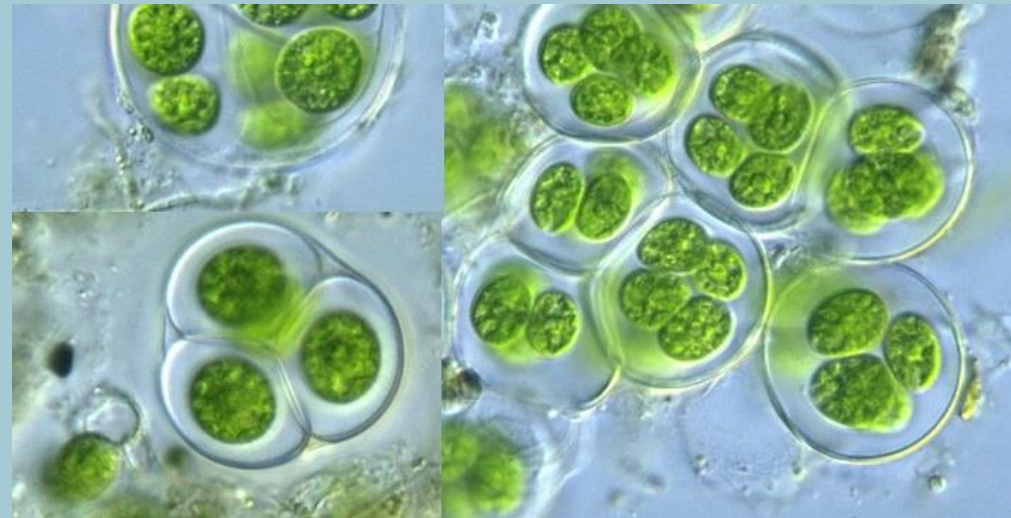
# Radiococcaceae (Chlorophyceae + Trebouxiophyceae)

polyfyletická skupina čekající na revizi

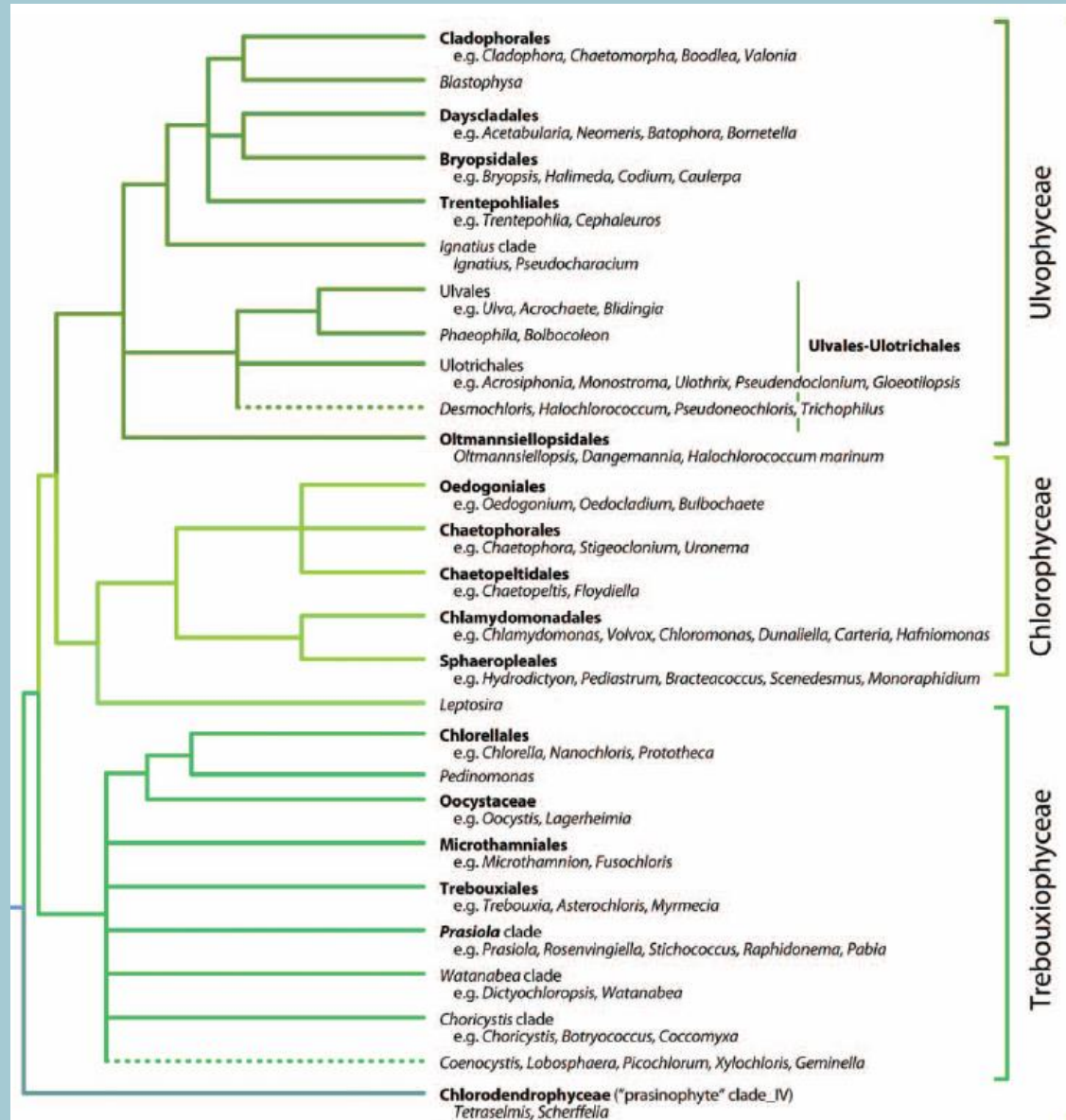
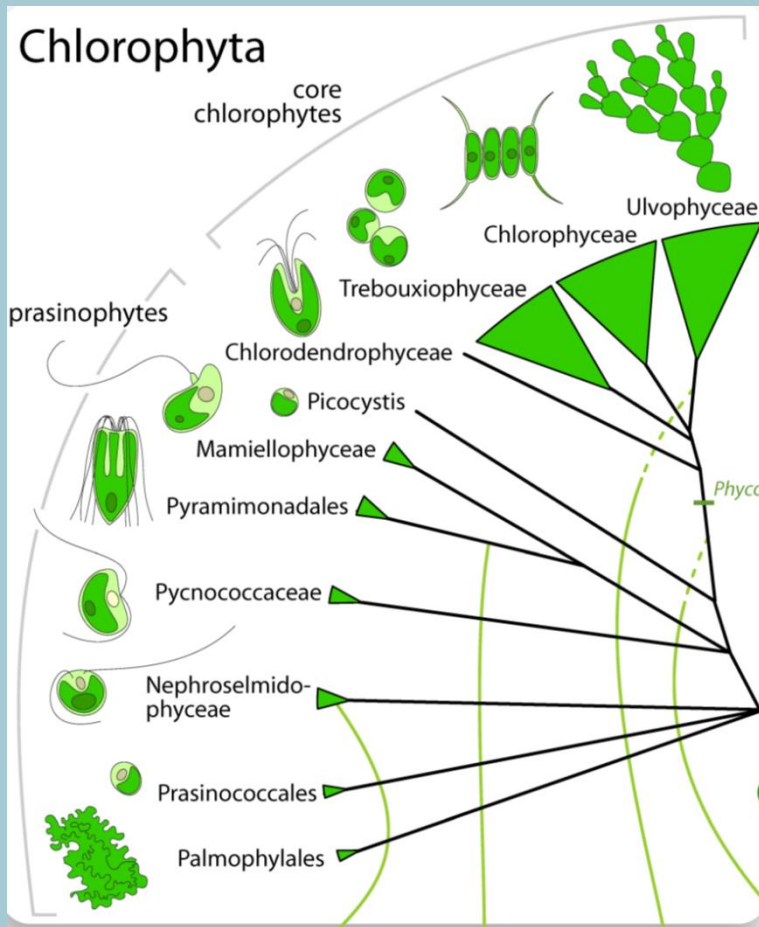
*Coenochloris*



*Gloeocystis*

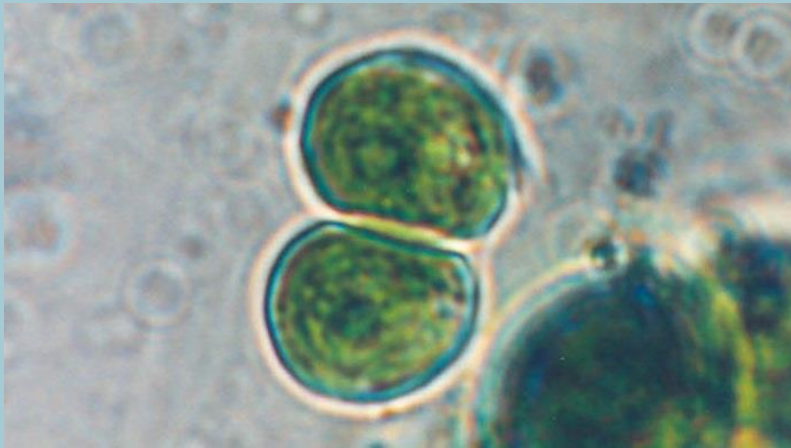


# Ulvophyceae



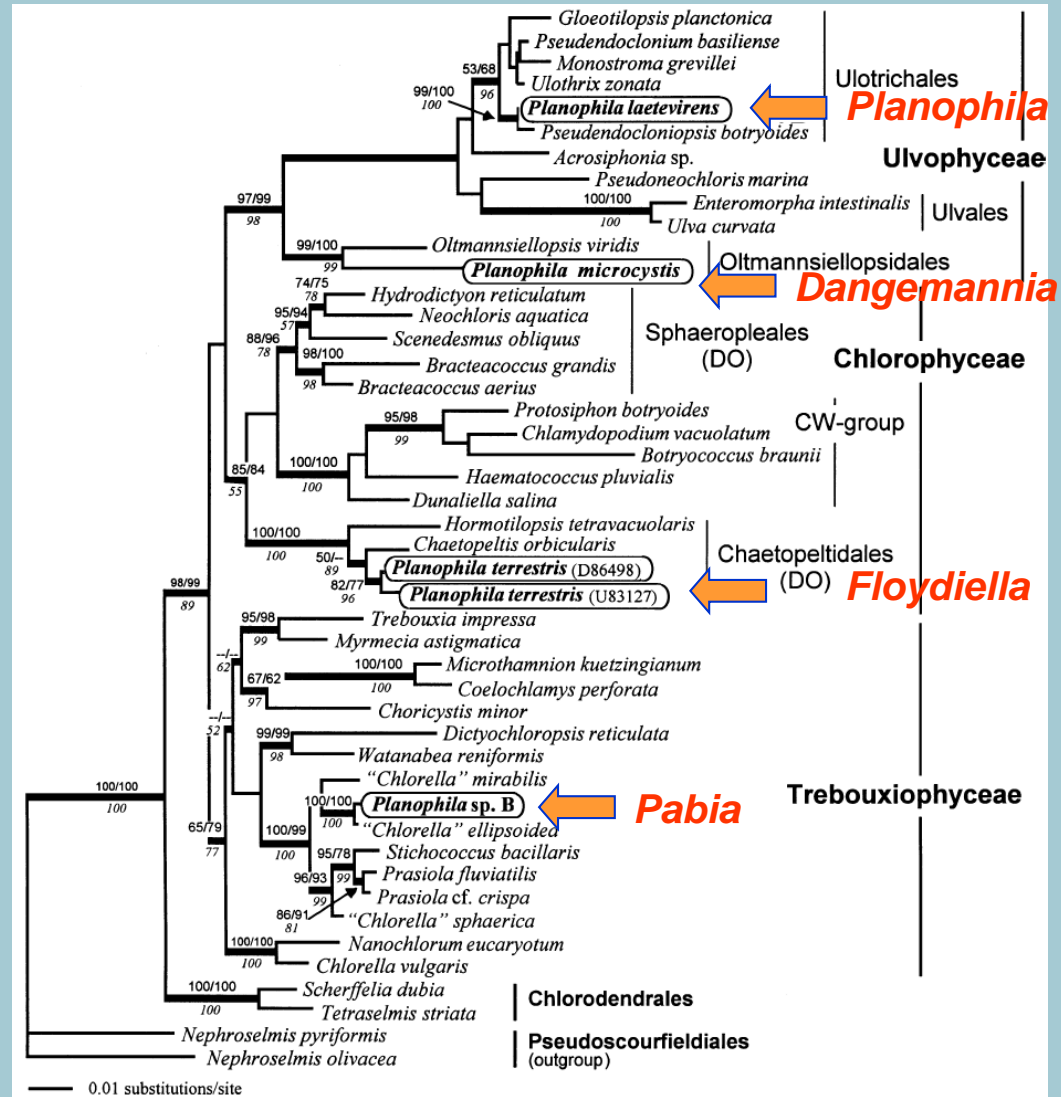
# Ulvophyceae, *Planophila*

- sladkovodní i půdní řasa, sarcinoidní stélka, čtyřbičíkaté zoospory
- polyfyletická skupina



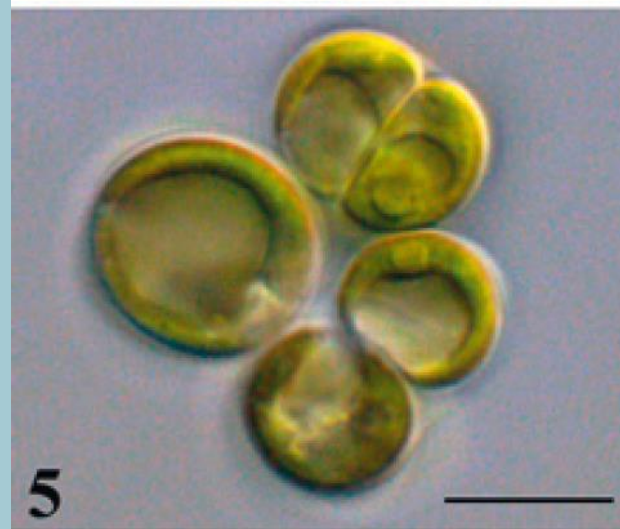
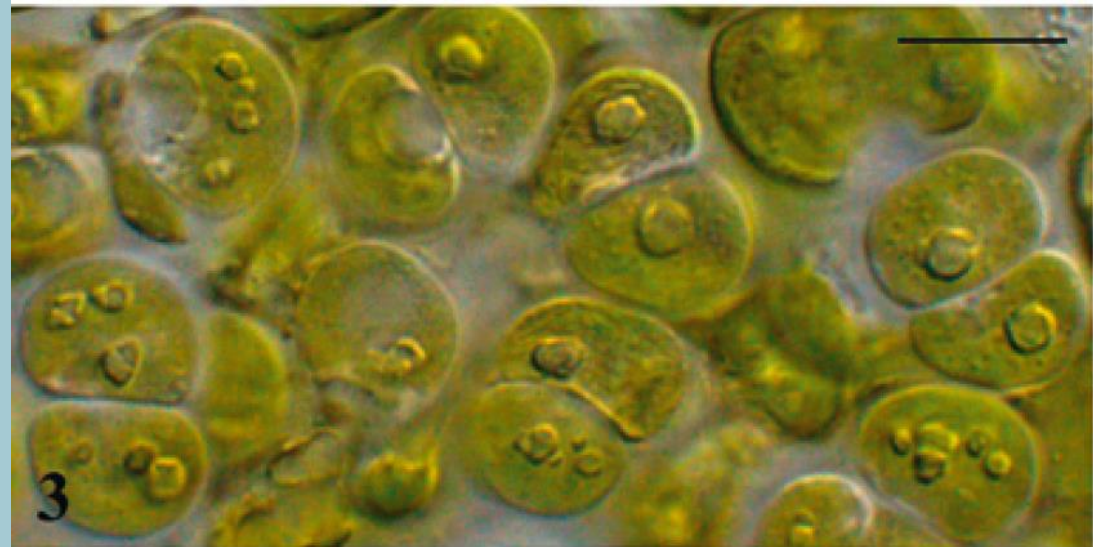
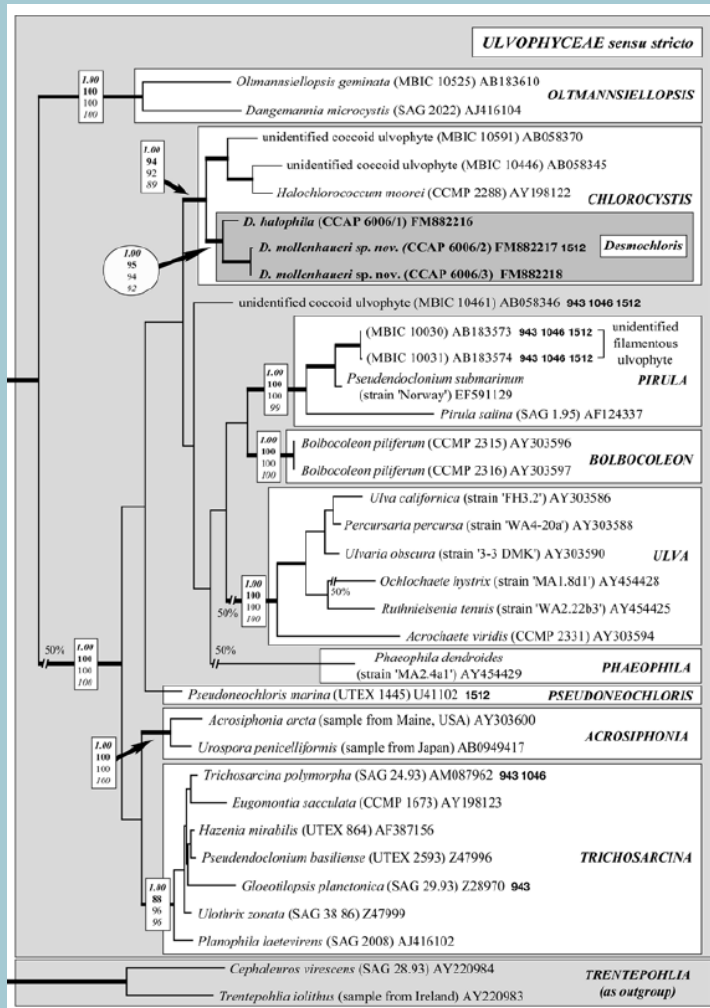
*Planophila*

- *Planophila* – půdní, aerofytická
- *Dangemannia* – sladkovodní i mořská
- *Pabia* – půdní, arktická
- *Floydiella* - sladkovodní



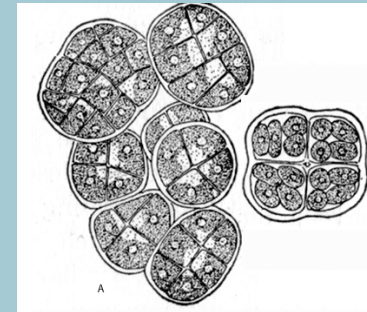
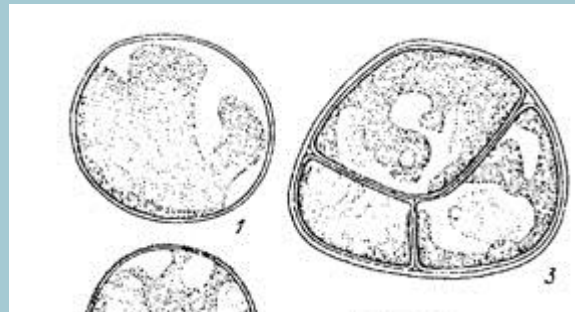
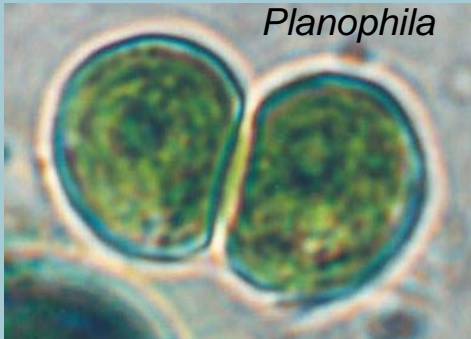
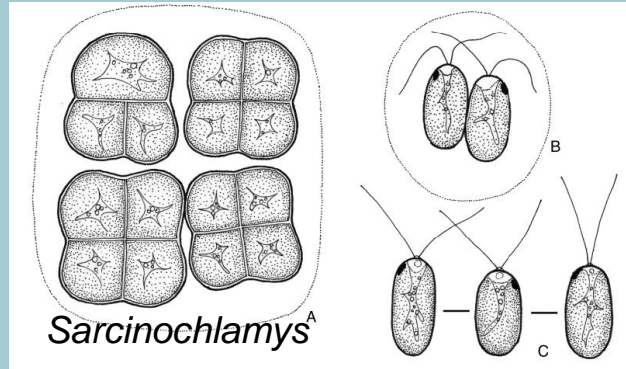
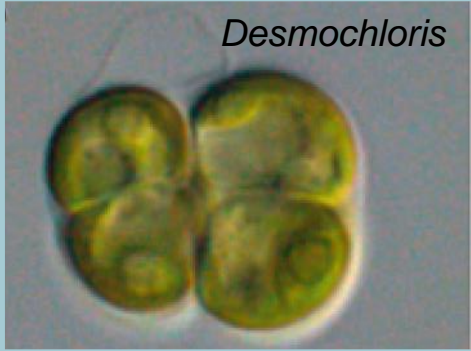
# Ulvophyceae, *Desmochloris*

- půdní řasa, sarcinoidní stélka, 2bičíkaté zoospory!



# sarcinoidní rody

- 12 kryptických rodů

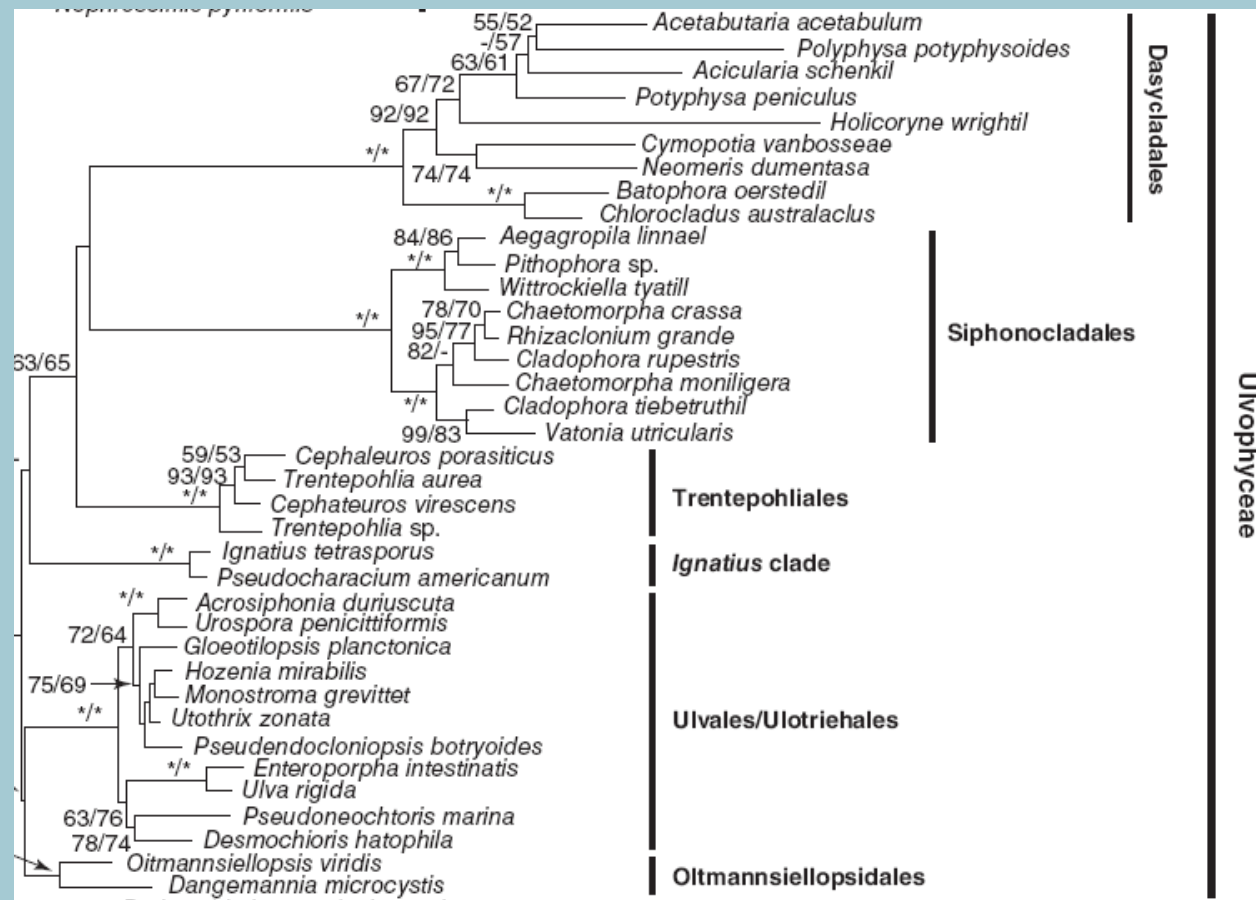
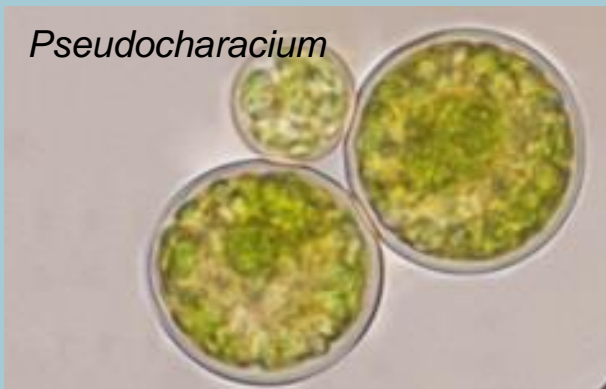
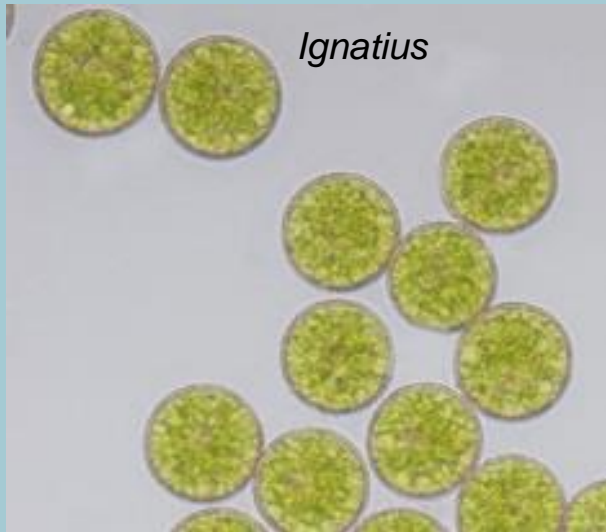


+ *Dangemannia*,  
*Pabia*, *Floydiella*



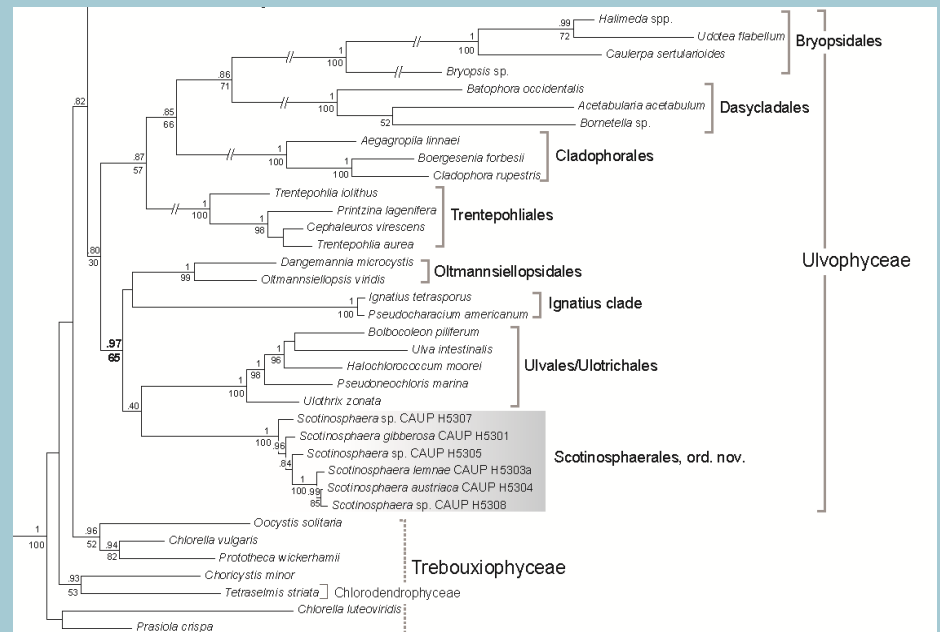
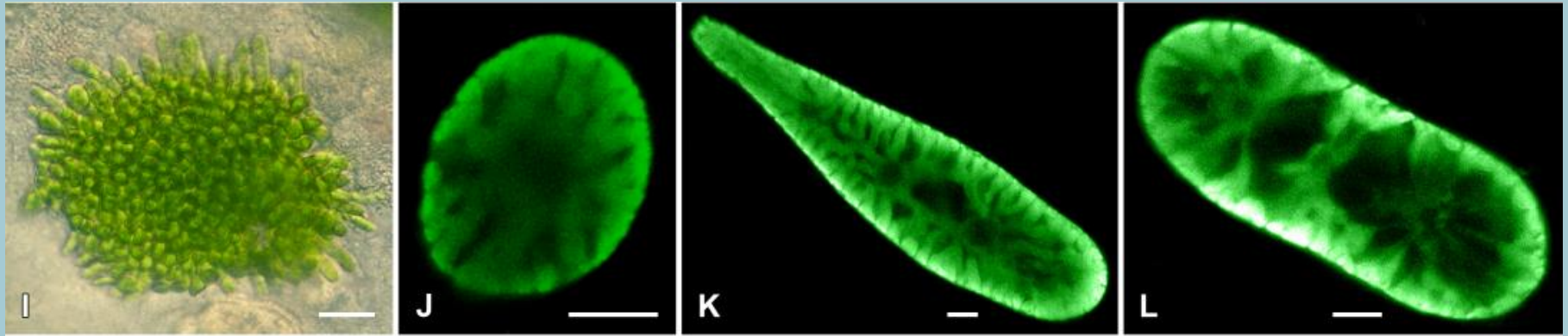
# Ulvophyceae, Ignatius-clade

- kokální řasy, 4bičíkaté zoospory
- *Ignatius* – půdní
- *Pseudocharacium* – sladkovodní, epifyt na vláknitých řasách



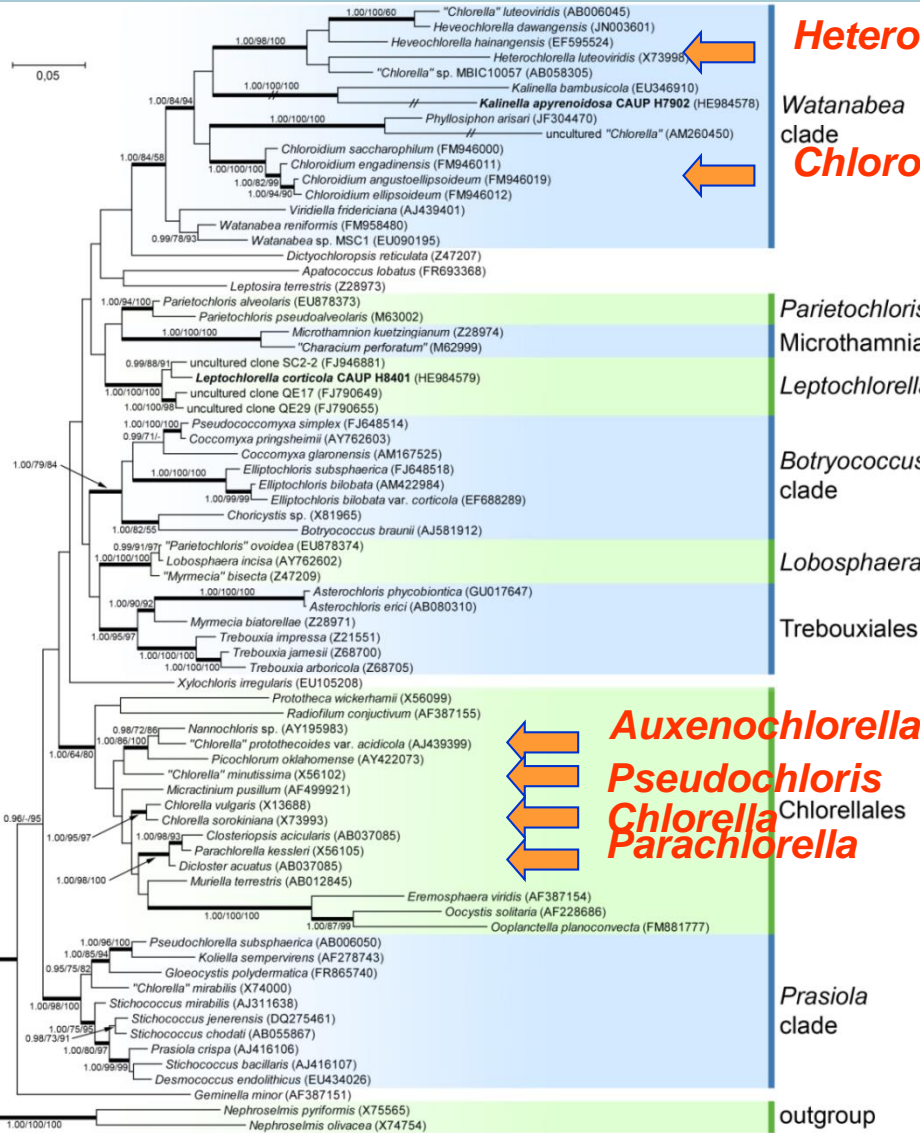
# Ulvophyceae, Scotinosphaerales

- Scotinosphaera* – sladkovodní i půdní, velké buňky s asteroidním chloroplastem



# Závěry

- konvergentní morfologická evoluce u nepříbuzných linií



**Heterochlorella**

Watanabea clade

**Chloroidium**

*Parietochloris*

Microthamniales

*Leptochlorella*

*Botryococcus*

clade

*Lobosphaera*

Trebouxiales

**Auxenochlorella**

**Pseudochloris**

**Chlorella**

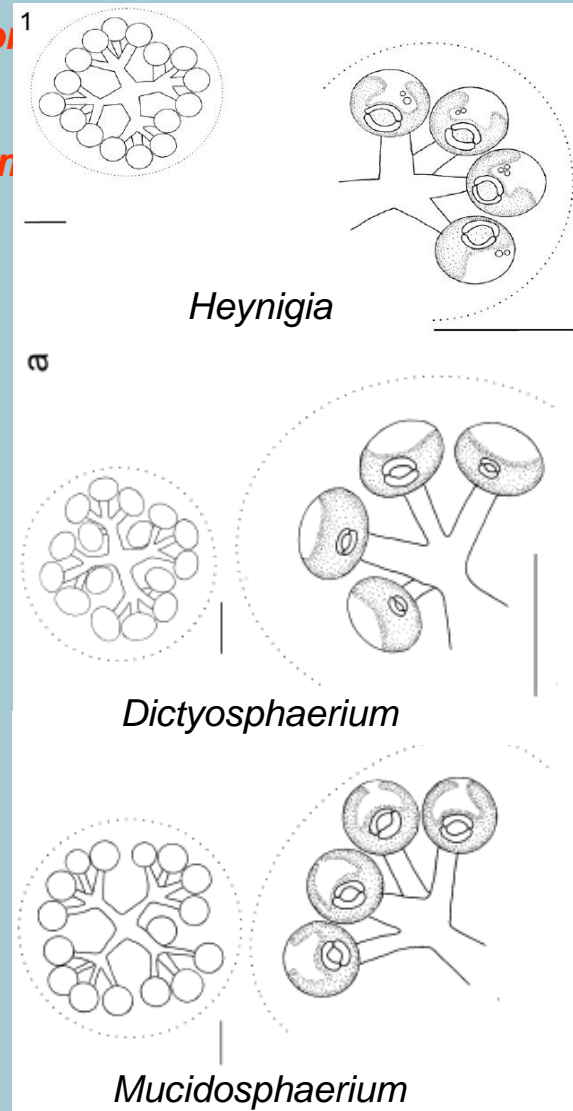
**Parachlorella**

Chlorellales

*Prasiola*

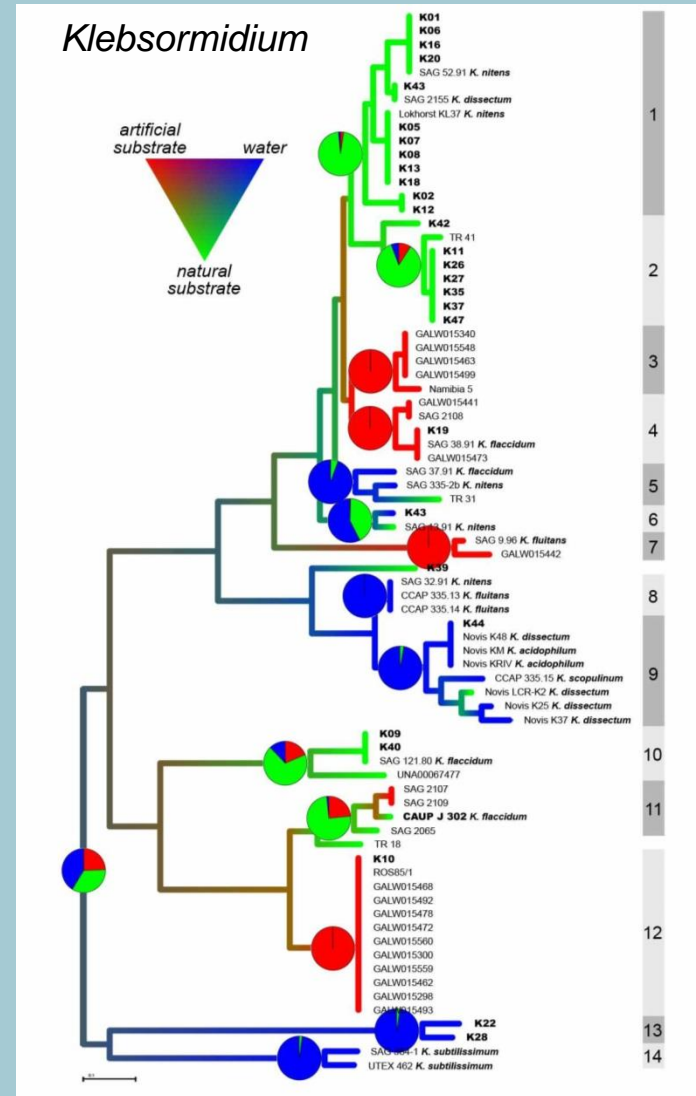
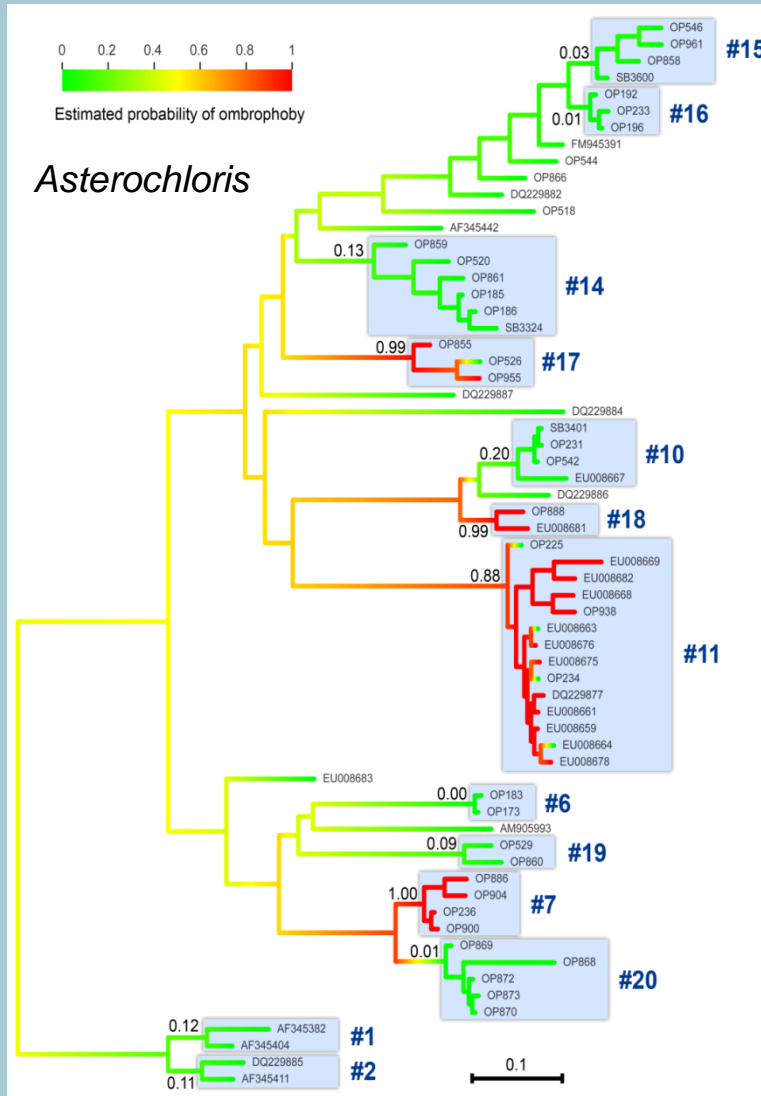
clade

outgroup



# Závěry

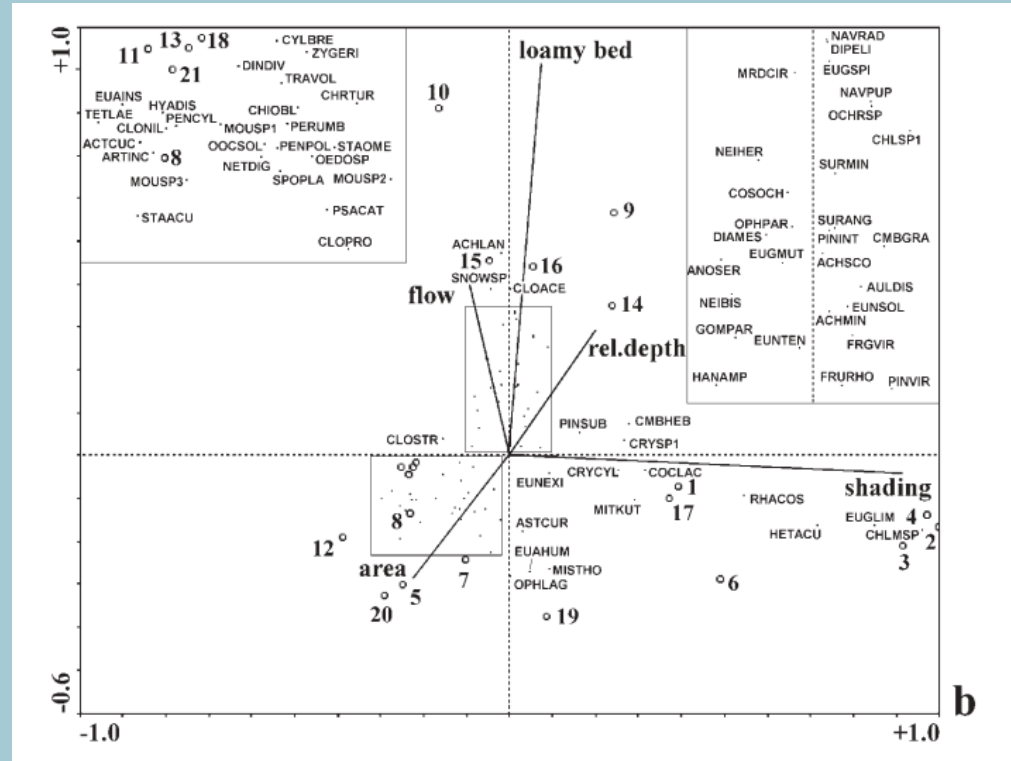
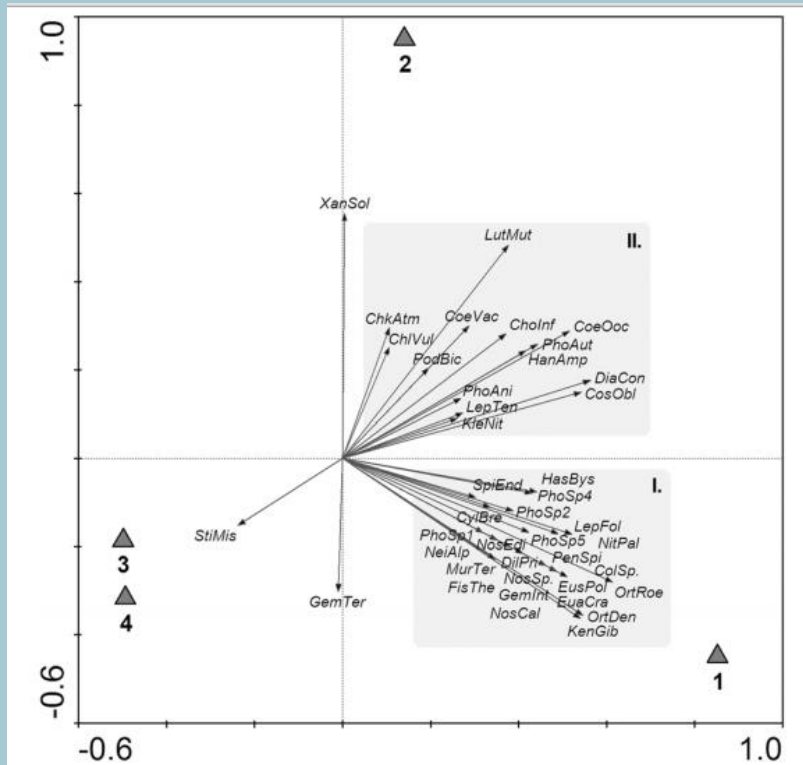
- striktní ekologická diferenciacie kryptických linií



Peksa & Škaloud (2011): *Molecular Ecology* **20**, 3936 – 3948, Škaloud & Rindi (2013), *Journal of Eukaryotic Microbiology* **60**, 350 - 362

# Závěry

- konvergentní morfologická evoluce u nepříbuzných linií
- striktní ekologická diferenciacce kryptických linií
  - fatální pro ekologické studie založené na morphospecies?



# Závěry

- platí ekologické charakteristiky sladkovodního fytoplanktonu?

## REVIEW

### Towards a functional classification of the freshwater phytoplankton

COLIN S. REYNOLDS<sup>1</sup>, VERA HUSZAR<sup>2</sup>, CARLA KRUK<sup>3</sup>, LUIGI NASELLI-FLORES<sup>4</sup> AND SERGIO MELO<sup>5</sup>  
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 CORRESPONDING AUTHOR: COLIN S. REYNOLDS. E-MAIL: csr@ceh.ac.uk

Table I: Trait-separated functional groups of phytoplankton (updated from Reynolds, 1997)

Codon	Habitat	Typical representatives	Tolerances	Sensitivities
<b>A</b>	Clear, often well-mixed, base poor, lakes	<i>Urosolenia</i> , <i>Cyclotella comensis</i>	Nutrient deficiency	pH rise
<b>B</b>	Vertically mixed, mesotrophic small-medium lakes	<i>Aulacoseira subarctica</i> <i>Aulacoseira islandica</i>	Light deficiency	pH rise, Si depletion stratification
<b>C</b>	Mixed, eutrophic small-medium lakes	<i>Asterionella formosa</i> <i>Aulacoseira ambigua</i> <i>Stephanodiscus rotula</i>	Light, C deficiencies	Si exhaustion stratification
<b>D</b>	Shallow, enriched turbid waters, including rivers	<i>Synedra acus</i> <i>Nitzschia spp</i> <i>Stephanodiscus hantzschii</i>	Flushing	nutrient depletion
<b>N</b>	mesotrophic epilimnia	<i>Tabellaria</i> <i>Cosmarium</i> <i>Staurodesmus</i>	Nutrient deficiency	stratification pH rise
<b>P</b>	eutrophic epilimnia	<i>Fragilaria crotonensis</i> <i>Aulacoseira granulata</i> <i>Closterium aciculare</i> <i>Staurastrum pingue</i>	Mild light and C deficiency	stratification Si depletion
<b>T</b>	deep, well-mixed epilimnia	<i>Geminella</i> <i>Mougeotia</i> <i>Tribonema</i>	Light deficiency	Nutrient deficiency
<b>S1</b>	turbid mixed layers	<i>Planktothrix agardhii</i> <i>Limnothrix redekei</i> <i>Pseudanabaena</i>	highly light deficient conditions	flushing
<b>S2</b>	shallow, turbid mixed layers	<i>Spirulina</i> <i>Arthrospira</i> <i>Raphidiopsis</i>	light deficient conditions	flushing
<b>S<sub>N</sub></b>	warm mixed layers	<i>Cylindrospermopsis</i> <i>Anabaena minutissima</i>	light, nitrogen-deficient conditions	flushing

# Závěry

- EU Framework Directive – rámcová směrnice EU pro vodní politiku
  - ochrana vod, kontrola znečištění

RBD	Rivers										Lakes												
	QE1.1 Phytoplankton	QE1.2 Other aquatic flora	QE1.2.3 Macrophytes	QE1.2.4 Phytobenthos	QE1.3 Benthic invertebrates	QE1.4 Fish	QE1.5 Other species	QE2 Hydromorphological QEs	QE3.1 General Parameters	QE3.3 on priority specific pollutants	QE3.4 Other national pollutants	QE1.1 Phytoplankton	QE1.2 Other aquatic flora	QE1.2.3 Macrophytes	QE1.2.4 Phytobenthos	QE1.3 Benthic invertebrates	QE1.4 Fish	QE1.5 Other species	QE2 Hydromorphological QEs	QE3.1 General Parameters	QE3.3 Non priority specific pollutants	QE3.4 Other national pollutants	
CZ_1000																							
CZ_5000																							
CZ_6000																							

**Table 5.1.1:** Quality elements monitored

	QE Monitored
	QE Not monitored
-	Not Relevant

Source: WISE

# Závěry

- harmonizovaný seznam druhů pro hodnocení kvality vod a jejich ochranu
  - cca 300 druhů kokálních zelených řas

213	Chlorophyceae	Crucigenia			2.05	1		
210	Chlorophyceae	Crucigenia fenestrata			2.05	1		
212	Chlorophyceae	Crucigenia quadrata			2.05	1	2.85	4
214	Chlorophyceae	Crucigenia tetrapedia	4.87	1	2.05	1	2.80	1
215	Chlorophyceae	Crucigeniella apiculata			4.73	4		
217	Chlorophyceae	Crucigeniella rectangularis	1.99	1			1.41	2
288	Chlorophyceae	Dictyosphaerium ehrenbergianum	4.01	2				
289	Chlorophyceae	Dictyosphaerium pulchellum	2.27	1	2.25	1		
291	Chlorophyceae	Dictyosphaerium tetrachotomum	0.95	1				
320	Chlorophyceae	Eudorina elegans			4.59	2	2.77	2
366	Chlorophyceae	Golenkinia radiata	4.23	1			3.30	1
420	Chlorophyceae	Lagerheimia ciliata	3.83	1			3.12	1
422	Chlorophyceae	Lagerheimia genevensis	3.15	1				
425	Chlorophyceae	Lagerheimia subsalsa					3.02	1
450	Chlorophyceae	Micractinium pusillum	3.29	1			3.45	2
469	Chlorophyceae	Monoraphidium griffithii			5.34	1	3.05	1
471	Chlorophyceae	Monoraphidium komarkovae	2.33	1	5.09	3	1.77	1
472	Chlorophyceae	Monoraphidium minutum	3.90	2	2.82	2	3.60	2
490	Chlorophyceae	Nephrocytium agardhianum					1.76	2
513	Chlorophyceae	Oocystis borgei			5.01	1		
514	Chlorophyceae	Oocystis lacustris			2.70	1		
515	Chlorophyceae	Oocystis marssonii	2.22	2			3.15	1
527	Chlorophyceae	Pandorina morum			4.55	2		
535	Chlorophyceae	Pediastrum duplex					3.02	2
536	Chlorophyceae	Pediastrum duplex var. gracillimum					3.02	2
539	Chlorophyceae	Pediastrum simplex			4.91	1	2.60	2
541	Chlorophyceae	Pediastrum tetras					3.05	3
565	Chlorophyceae	Phacotus			4.89	1		
563	Chlorophyceae	Phacotus lendneri			4.89	1	2.30	1
564	Chlorophyceae	Phacotus lenticularis			4.89	1		
614	Chlorophyceae	Quadrigula pfizeri	0.78	2	0.93	4		



# Závěry

- pro hodnocení vod je nutné vybrat molekulárně charakterizované, dobře vymezené druhy se známými ekologickými charakteristikami

Old designation	Revised or confirmed designation	Reference
<i>Monoraphidium convolutum</i>	To be included in a new genus not yet designated	Krienitz et al. (2011b)
<i>Monoraphidium dybowskii</i>	To be included in a new genus not yet designated	Krienitz et al. (2011b)
<i>Monoraphidium griffithii</i> *	<i>Monoraphidium griffithii</i> * (Berkeley) Komárková-Legnerová	Krienitz et al. (2001)
<i>Monoraphidium minutum</i>	<i>Nephrochlamys subsolitaria</i> (G.S. West) Korshikov	Krienitz et al. (2011b)
<i>Monoraphidium pusillum</i>	To be included in a new genus not yet designated	Krienitz et al. (2011b)
<i>Neodesmus danubialis</i>	<i>Neodesmus danubialis</i> Hindák	Hegewald & Hanagata (2000)
<i>Nephrochlamys subsolitaria</i>	<i>Nephrochlamys subsolitaria</i> G.S. West	Krienitz et al. (2011b)
<i>Oocystis marssonii</i>	<i>Oocystis marssonii</i> Lemmermann	Hepperle et al. (2000)
<i>Oocystis solitaria</i>	To be included in a new genus not yet designated	Hepperle et al. (2000)
<i>Paradoxia multiset*</i>	<i>Paradoxia multiset*</i> Svirenko	Henley et al. (2004)
<i>Pediastrum biradiatum</i>	<i>Parapediastrum biradiatum</i> (Meyen) E. Hegewald	Buchheim et al. (2005)
<i>Pediastrum boryanum</i>	<i>Pseudopediastrum boryanum</i> (Turpin) E. Hegewald	Buchheim et al. (2005)
<i>Pediastrum duplex*</i>	<i>Pediastrum duplex*</i> Meyen	Buchheim et al. (2005)
<i>Pediastrum kawraiskyi</i>	<i>Pseudopediastrum kawraiskyi</i> (Schmidle) E. Hegewald	Buchheim et al. (2005)
<i>Pediastrum simplex</i>	<i>Monactinus simplex</i> (Meyen) Corda	Buchheim et al. (2005)
<i>Pediastrum tetras</i>	<i>Stauridium tetras</i> (Ehrenberg) E. Hegewald	Buchheim et al. (2005)
<i>Planktosphaeria gelatinosa*</i>	<i>Planktosphaeria gelatinosa*</i> G.M. Smith	Wolf et al. (2003b)
<i>Polyedriopsis spinulosa*</i>	<i>Polyedriopsis spinulosa*</i> (Schmidle) Schmidle	Hegewald et al. (2001)
<i>Pseudococcomyxa simplex</i>	<i>Coccomyxa</i> sp.	Pröschold et al. (2011)
<i>Pseudodictyosphaerium jurisii</i>	<i>Mychonastes jurisii</i> (Hindák) Krienitz et al.	Krienitz et al. (2011a)
<i>Quadricoccus ellipticus</i>	<i>Quadricoccus ellipticus</i> Hortobágyi	Krienitz & Bock (2011)
<i>Quadrigula closterioides*</i>	<i>Quadrigula closterioides*</i> (Bohlin) Printz	Krienitz et al. (2001)
<i>Scenedesmus arcuatus</i>	<i>Comasiella arcuata*</i> (Lemmermann) E. Hegewald et al.	Hegewald et al. (2010)

The background of the slide is a microscopic image showing numerous small, green, spherical cells, likely yeast or bacteria, scattered across a light blue background. The cells are in various stages of focus, with some appearing sharp and others blurred.

**Děkuji za pozornost**