

Nové rody cyanobakterií (po roce 2001)

Premises

- 1) Taxonomic classification is a method for registration of world organismal diversity in dependence of evolutionary (genetic) and ecological relations, and phenotypic variation.**
- 2) All new knowledge is necessary to use for the correction of the system; thus, the classification must be continually changed, corrected and re-evaluated.**
- 3) The present system of cyanobacteria (2008) must be modified according to combined markers, in which the molecular data (as a genetic basis) should be corelated with ultrastructural, phenotypic and ecological data.**

- Přibližně od roku 2000 dochází k reorganizaci klasifikace cyanobakterií.
- Pro revizi systému má největší význam aplikace molekulárních (genetických) metod.
- Ukázalo se, že toto zavedení molekulárních kritérií vede k přesnější definici genetických jednotek (clusterů); v praxi to znamená zmnožení jednotlivých taxonů, zejména na úrovni rodů.
- Základním požadavkem pro revizi nových rodů je tzv. kombinovaný (polyfazický) přístup, tj. s použitím genetických kritérií jako základu (% similarity na základě 16S rRNA sekvenace, případně sekvenace dalších genů) a obligatorní aplikací morfologických, ekologických a biochemických dat.
- Pro definici nových rodů z bakteriologického hlediska by mělo být uplatňováno jako jedno ze základních kritérií % similarity jednotlivých clusterů vyplývajících ze sekvenace.
- U nově stanovených rodů molekulárními metodami je rovněž požadavek autapomorfního cytomorfolického znaku (případně autapomorfní kombinace znaků).
- U popisu nových rodů by měla být dodržována pravidla jak botanických tak bakteriologických nomenklatorických předpisů.

Koncem 20. století byla provedena rozsáhlá revize na základě morfologických znaků a oproti tradičnímu Geitlerovskému systému popsána a revidována celá řada druhů.

Kokální druhy: *Asterocapsa* Chu 1952, *Bacularia* Borzi 1905, *Chamaecalyx* Komárek et Anagnostidis 1986, *Coelomoron* Buell 1938, *Cyanokybus* Schiller 1956, *Gloeocapsopsis* Geitler ex Komárek 1993, *Mantellum* Dangeard 1941, *Pannus* Hickel 1991, *Rhabdogloea* Schroeder 1917, *Stanieria* Komárek et Anagnostidis 1986, *Xenotholos* Gold-Morgan et al. 1994.

Oscillatoriální druhy: *Arthrospira* Stizenberger et Gomont 1892, *Blennothrix* Kützing ex Anagnostidis et Komárek 1988, *Geitlerinema* Anagnostidis 1989, *Komvophoron* Anagnostidis et Komárek 1988, *Leptolyngbya* Anagnostidis et Komárek 1988, *Planktothrix* Anagnostidis et Komárek 1988, *Symplocastrum* (Gomont) Kirchner ex Engler et Prantl 1898, *Tychonema* Anagnostidis et Komárek 1988.

Tyto rody, pokud byly ověřovány molekulárními metodami byly vesměs potvrzeny.

V moderní taxonomické praxi se uplatňují v principu tři metodické přístupy:

- a) Popis na základě morfologických znaků, tj. tradiční přístup. Takto stanovené jednotky by se měly ovšem morfologicky zřetelně lišit od rodů potvrzených molekulární analýzou.
- b) Stanovení rodů čistě na molekulárním základě. (Většina těchto rodů není validně popsána – nejsou splněna kritéria nomenklatorických kódů.)
- c) Použití různé formy kombinovaného přístupu s molekulárním základem.

a) Rody popsané na morfologickém základě (9)

- *Phormidiochaete* Komárek in Anagnostidis 2001
- *Trichocoleus* Anagnostidis 2001
- *Cyanocomperia* Hindák 2002
- *Planctocyanocapsa* Hindák 2002
- *Sphaerocavum* Azevedo & Sant'Anna 2003
- *Cyanocatenula* Joosten 2006
- *Macrospermum* Komárek 2008
- *Ophiothrix* Sant'Anna et al. (in press)
- *Streptostemon* Sant'Anna et al. (in press)

b) Rody popsané pouze na základě molekulárních analýz (4)

- (*Erythrophaera* Waterbury et al. 1988) = *Crocospaera* Zehr et al. 2001; sec. Copeland et al. 2004, 2005
- *Halospirulina* Nübel et al. 2001
- *Thermosynechococcus* Katoh et al. 2001
- *Acaryochloris* Miyashita et al. 2003

c) Rody popsané s kombinovaným přístupem (17)

- *Halomicronema* Abed et al. 2002
- *Planktothricoides* Suda & Watanabe 2002
- *Spirirestis* Flechtner & Johansen 2002
- *Chroogloeocystis* I. Brown et al. 2005
- *Cuspidothrix* Rajaniemi et al. 2005
- *Rexia* Casamatta et al. 2006
- *Brasilonema* Fiore et al. 2007
- *Mojavia* Řeháková & Johansen 2007
- *Halothece* (Garcia-Pichel et al. 1998) Margheri et al. 2008

v tisku:

- *Coleofasciculus* Johansen et al. 2009
- *Dolichospermum* Wacklin et al. 2009
- *Geminocystis* Korelusová et al. 2009
- *Phormidesmis* Turicchia et al. 2009
- *Plectolyngbya* Taton et al. 2009
- *Sphaerospermum* Zapomělová et al. 2009

v rukopisu:

- *Pteridoanabaena* (Hrouzek et al.)
- *Chakia* (Komárková & Komárek)

Phormidiochaete

Komárek in Anagnostidis 2001

- heteropolární trichomy
- absence heterocytů
- keříčkovité kolonie (nepravé větvení)
- izodiametrické buňky

Homoeothrix (traditional concept)

Type species:

H. juliana

- filamentous cyanobacteria
- heterocytes -
- heteropolar filaments (narrowed ends)
- sheaths present
- reproduction by hormogonia

width of filaments =
(3)5-15(20) μm

H. juliana T

H. santolii

H. endophytica

H. rubra



width of filaments =
5-18 μm

P. balearica T

P. nordstedtii

P. fusca



width of filaments =
1-3(5-7) μm

T. bornetii T

T. mucicola

H. varians
H. rivularis
H. janthina
H. stagnalis
H. subtilis
H. batrachospermorum
H. gloeophila
H. articulata
H. simplex
H. violacea
H. gracilis
H. margalefii
H. crustacea
H. poljanskii



Homoeothrix (sensu stricto)

(Thuret ex B. & Fl.) Kirchner 1898

Phormidiochaete

Komárek in Anagnostidis 2001

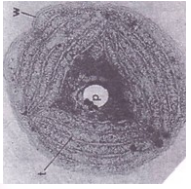
Tapinothrix

Sauvageau 1892

*Phormidiochaete
balearica*



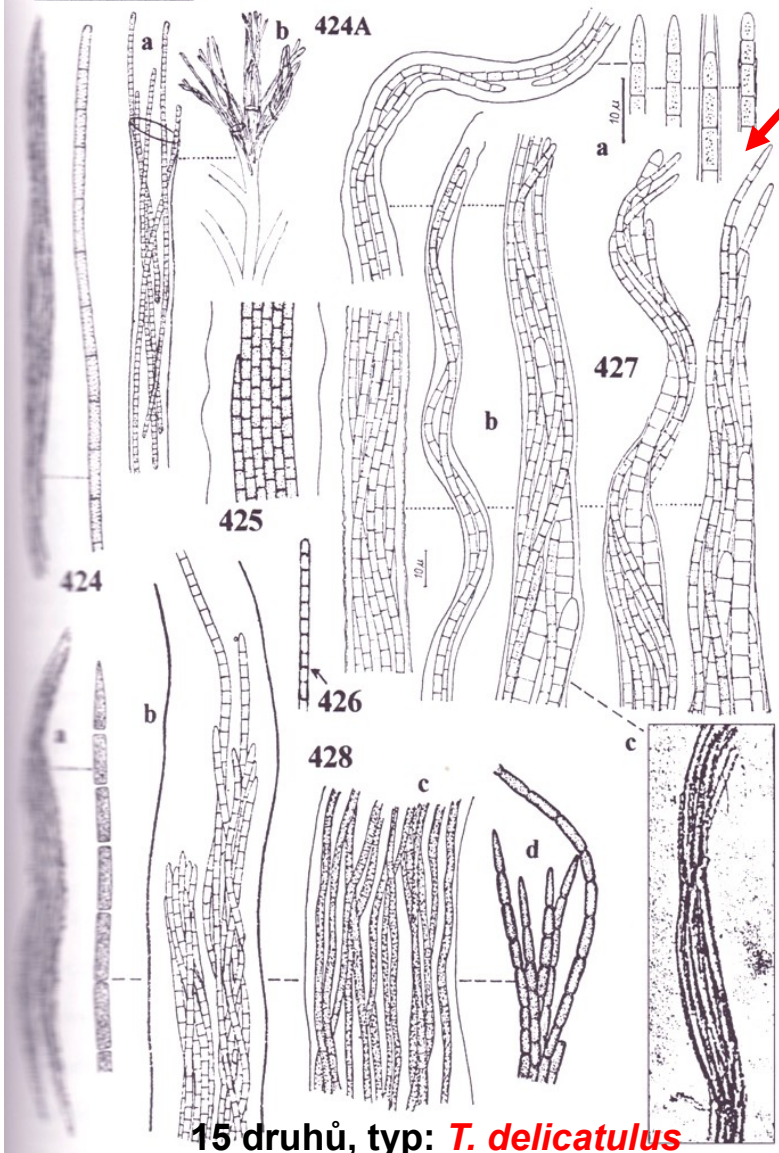
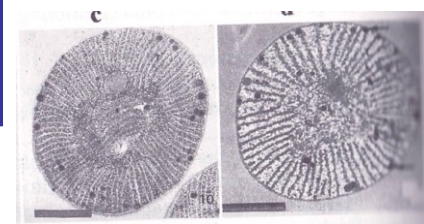
*Phormidiochaete
nordstedtii*



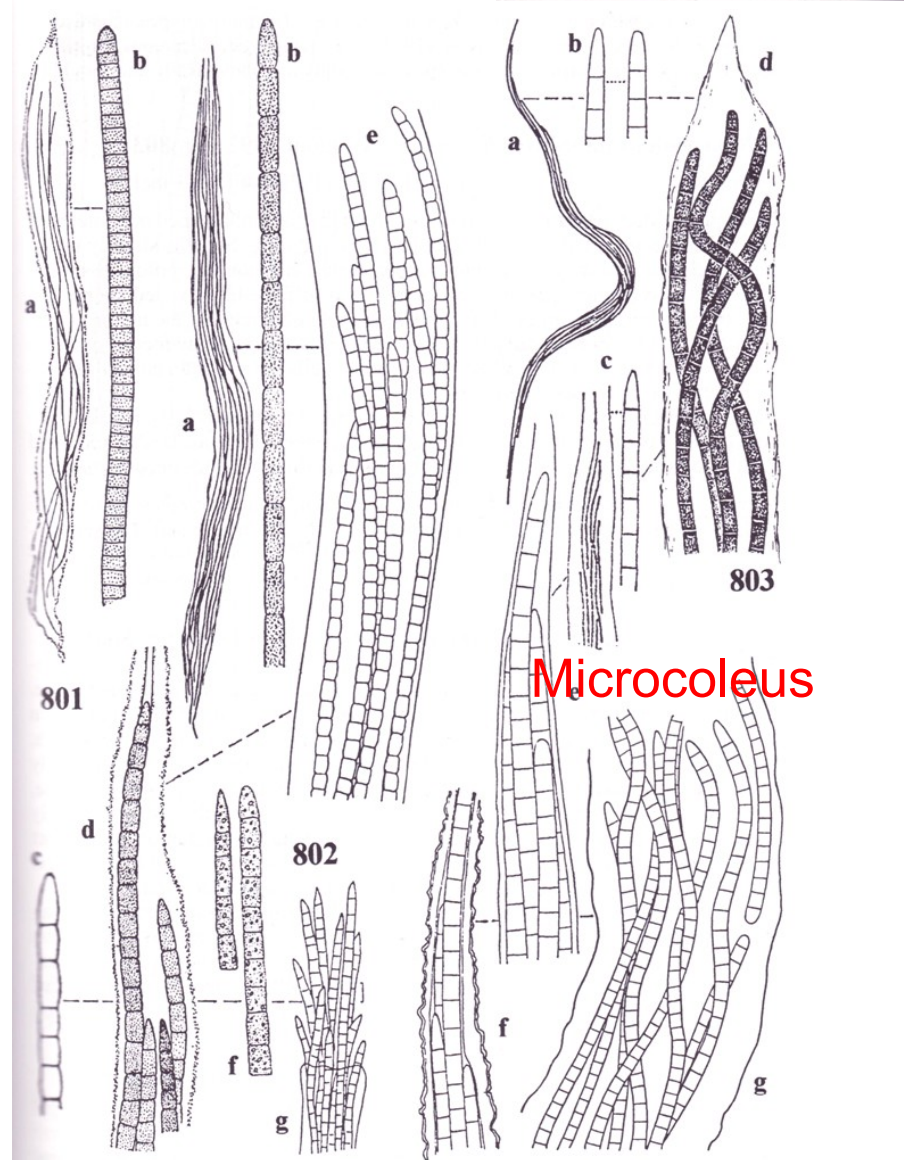
Trichocoleus

Anagnostidis 2001

- fylogenetická pozice
- rozměry a struktura buněk



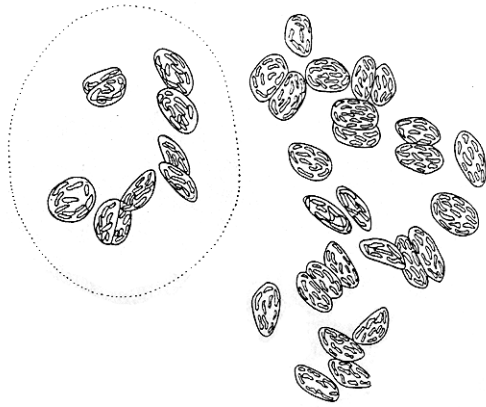
15 druhů, typ: *T. delicatulus*



Microcoleus

Cyanocomperia

Hindák 2002

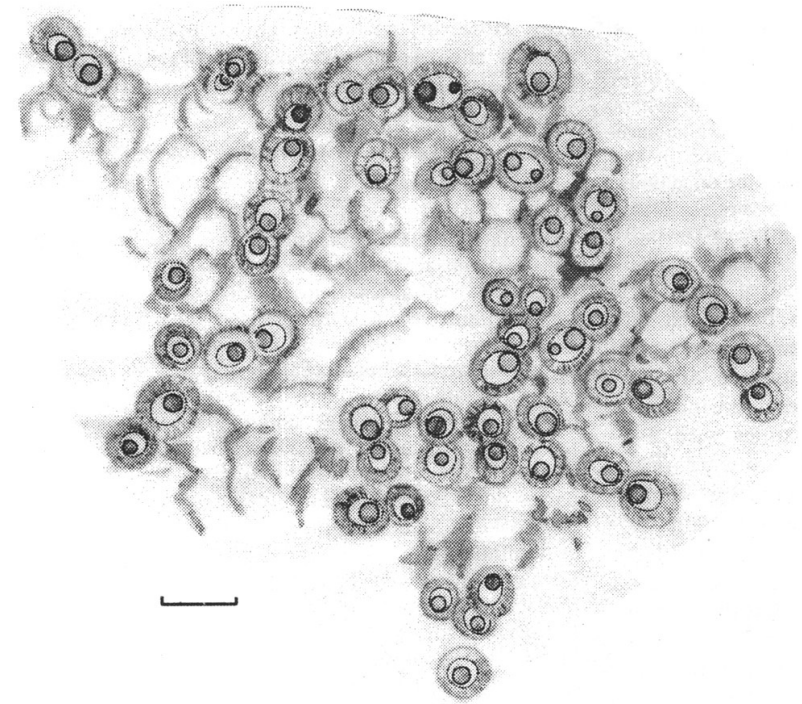


*Cyanocomperia
africana*

- tvar a dělení buněk
- aerotopy v buňkách

Planctocyanocapsa

Hindák 2002



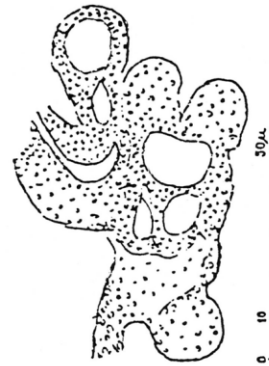
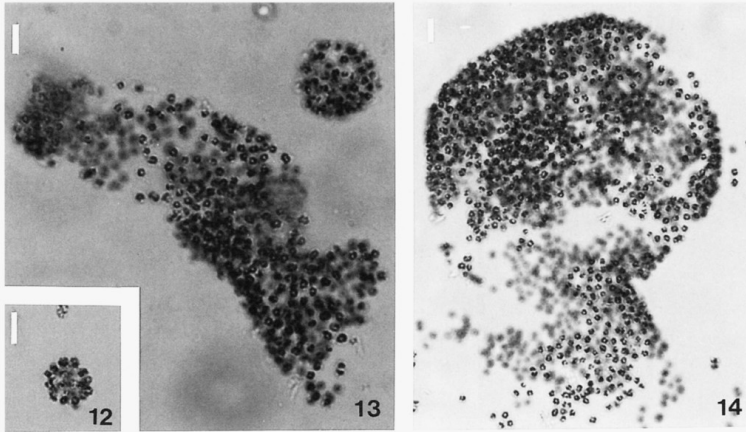
Planctocyanocapsa stagnalis

- životní forma
- zabarvené slizové obaly kolem buněk
- dělení buněk v jedné rovině

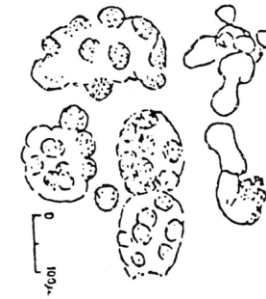
Sphaerocavum

Azevedo et Sant'Anna 2003

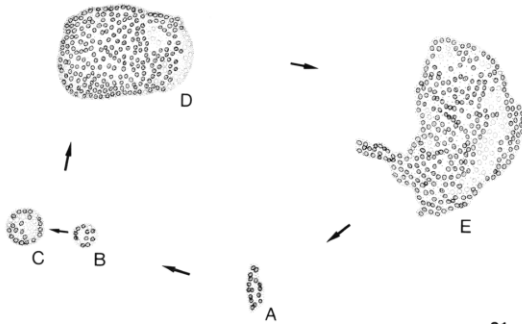
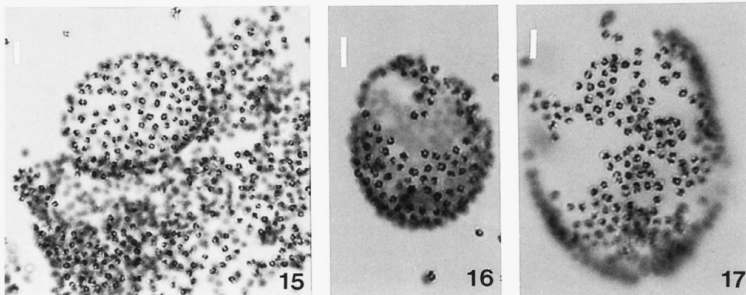
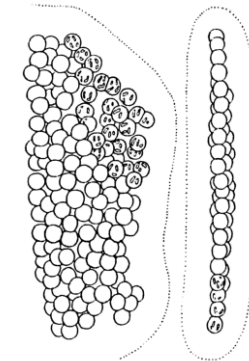
- buňky s plynovými měchýřky
- ploché, zprohýbané kolonie
- dělení buněk ve dvou rovinách



*Sphaerocavum
leloupii*

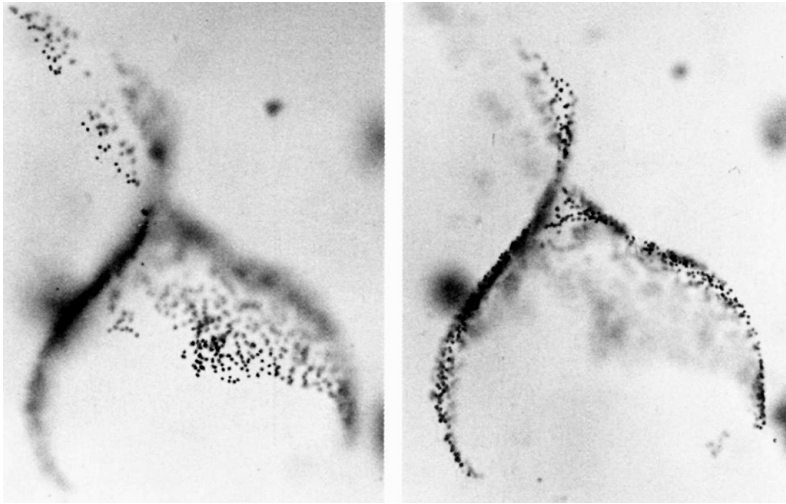


*Sphaerocavum
microcystiforme*



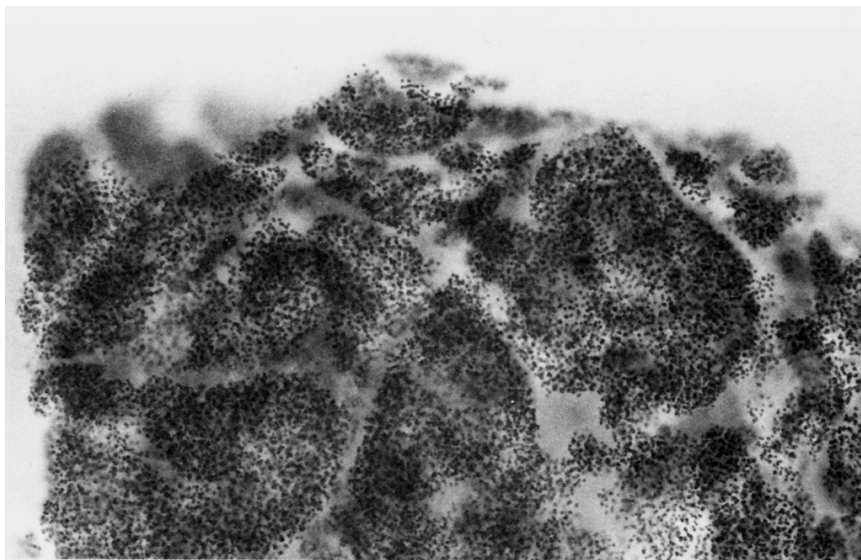
Sphaerocavum brasiliense

Microcystis dimorpha Joosten 2006



Rozdíl od *Pannus*: přítomnost aerotopů v buňkách

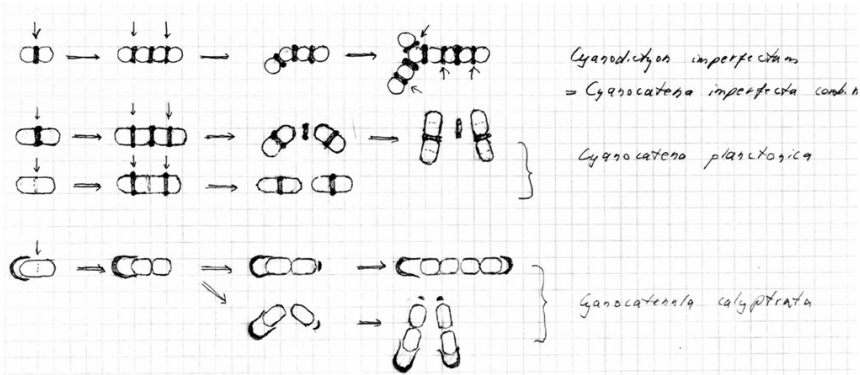
Rozdíl od *Microcystis*: dělení buněk ve dvou rovinách (ploché kolonie)



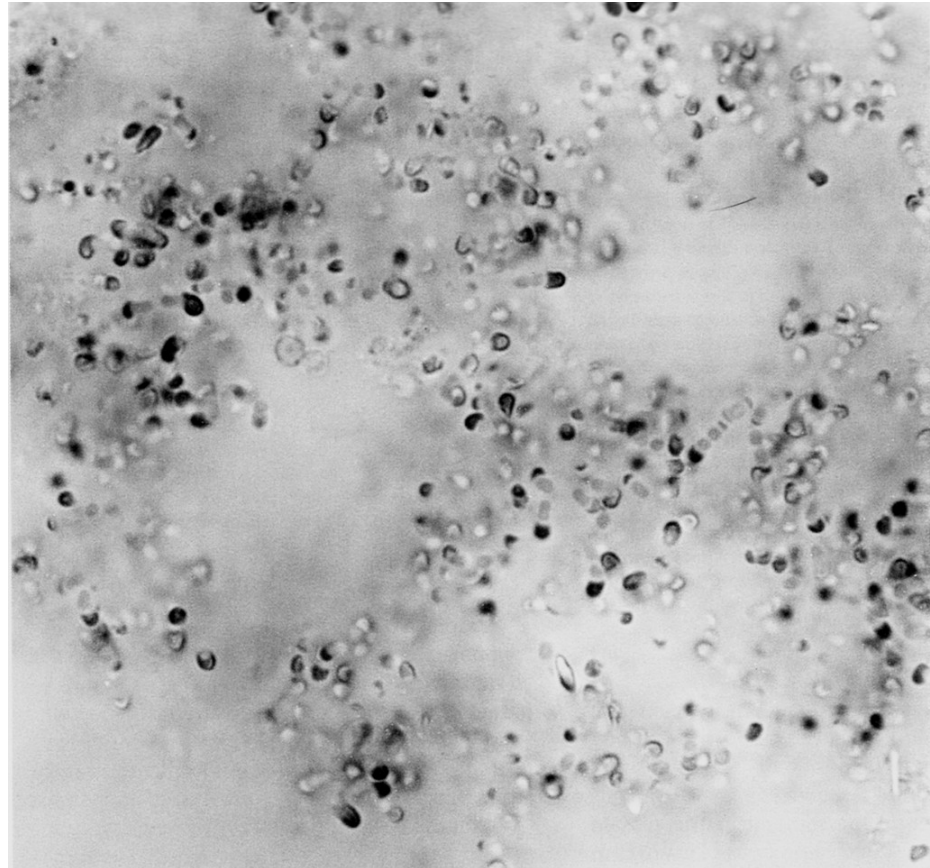
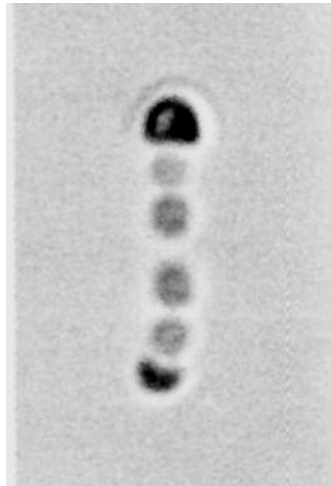
Cyanocatenula

Joosten 2006

- krátké pseudofilamenty
- terminální železitá konkrce ve formě čepiček
- dělení buněk v jedné rovině



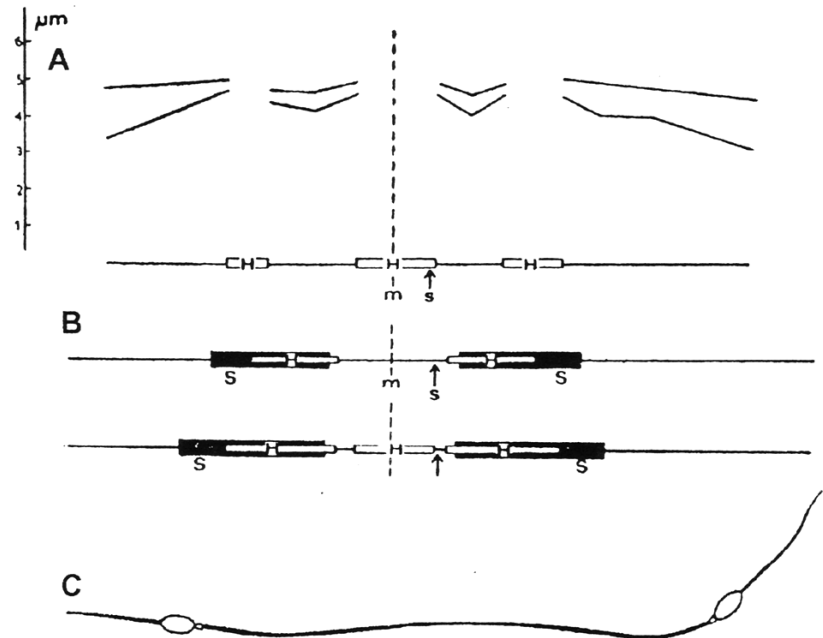
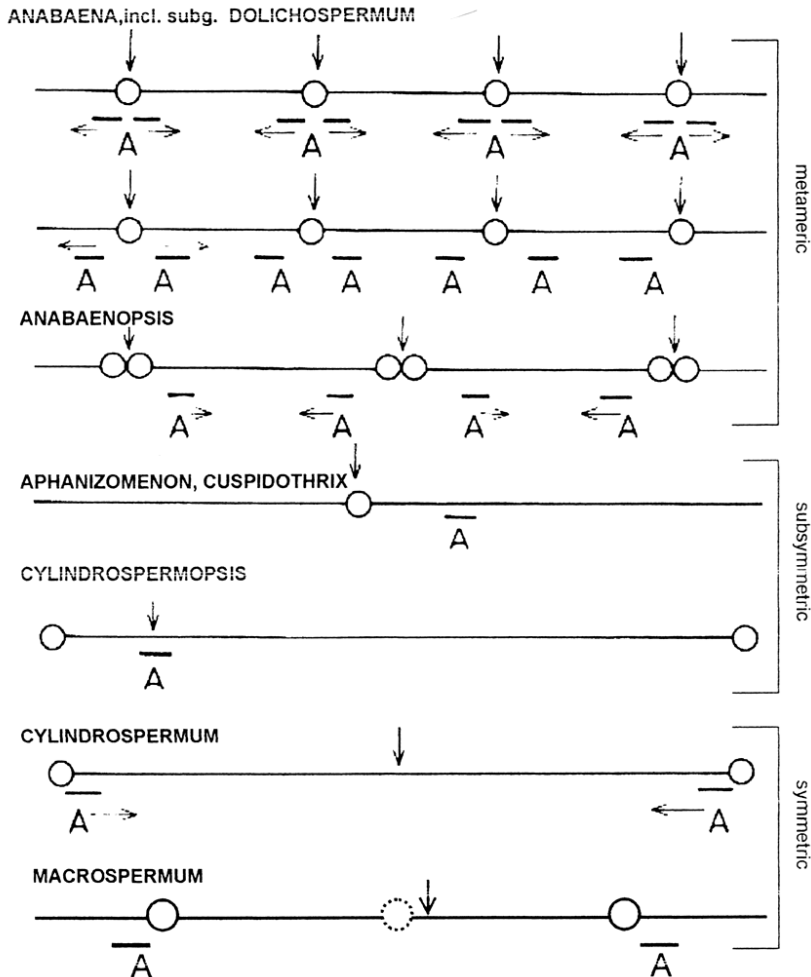
*Cyanocatenula
calyptrata*



Macrospermum

Komárek 2008

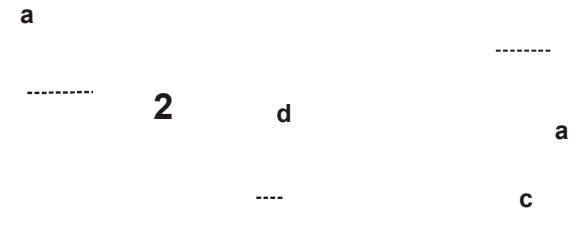
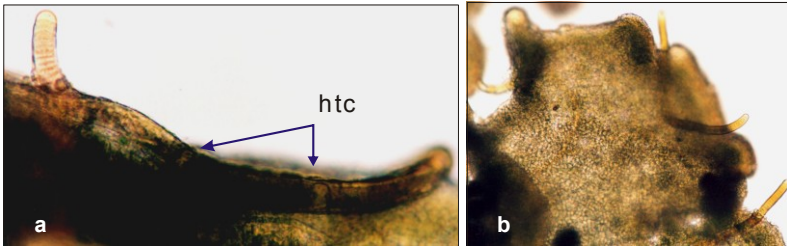
- struktura symetrických vláken
- pozice a počet heterocytů
- pozice a tvar akinet



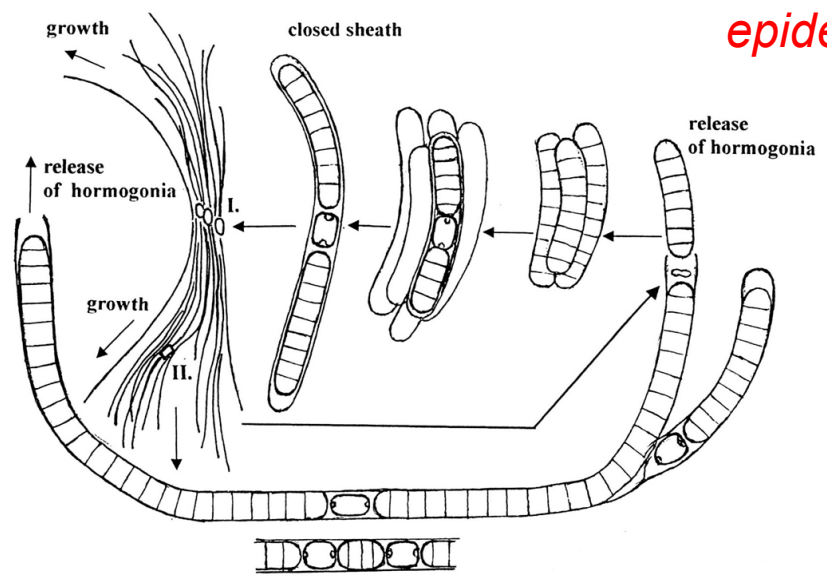
Ophiothrix

Sant'Anna et al. (in press)

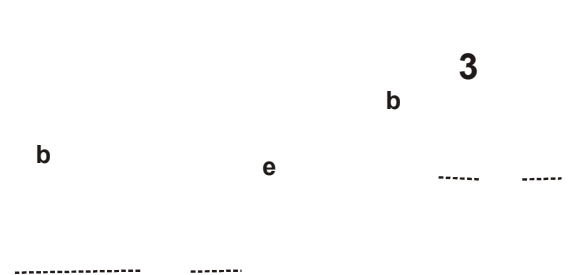
- heteropolární trichomy s heterocyty
- solitární plazivá vlákna
- krátké buňky
- koleodesmioidní nepravé větvení
- výskyt: aericky, epifytně tropické pralesy



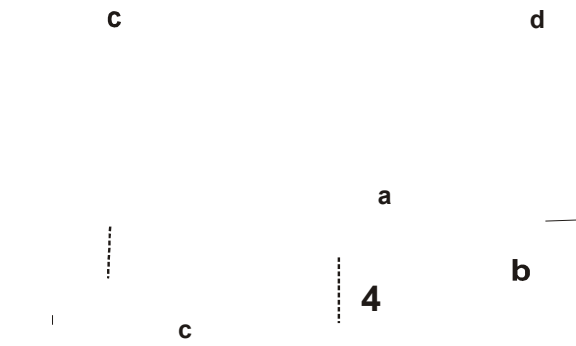
Ophiothrix epidendron



Ophiothrix epibryos



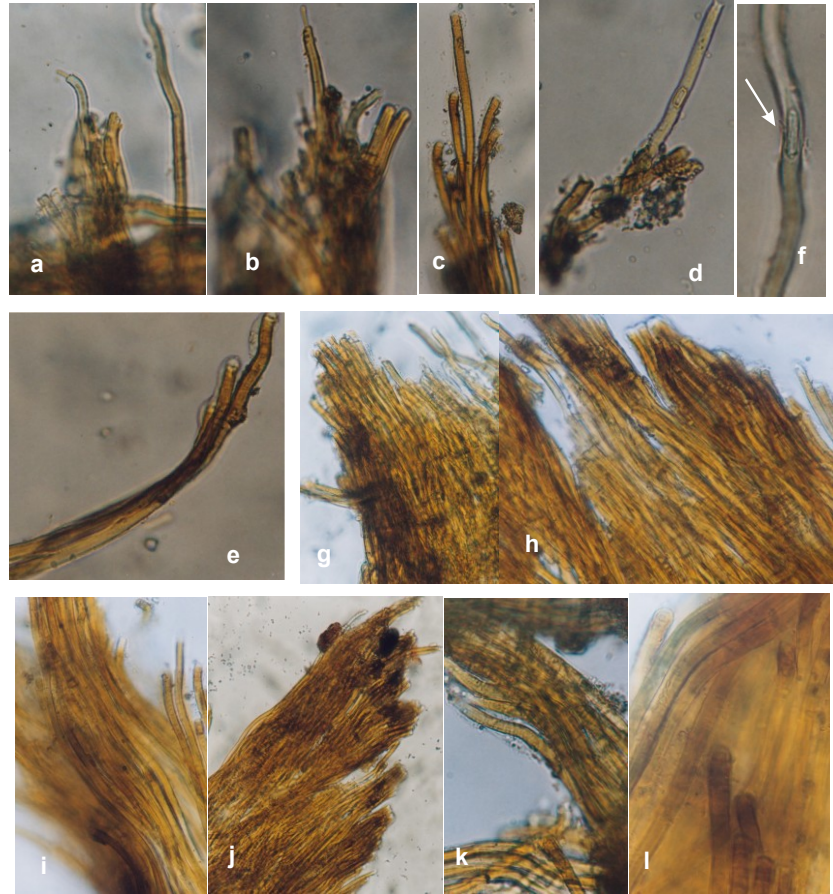
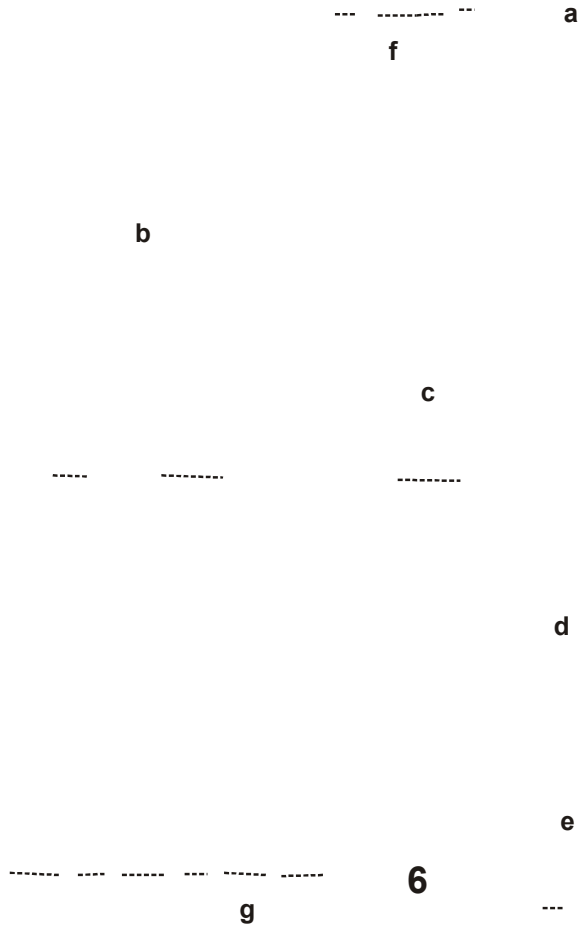
Ophiothrix hansgirgii



Streptostemon

Sant'Anna et al. (in press)

- heteropolární trichomy s bazálními heterocyty
- husté fascikulární kolonie
- absence nepravého větvení
- aerický výskyt v tropických pralesích



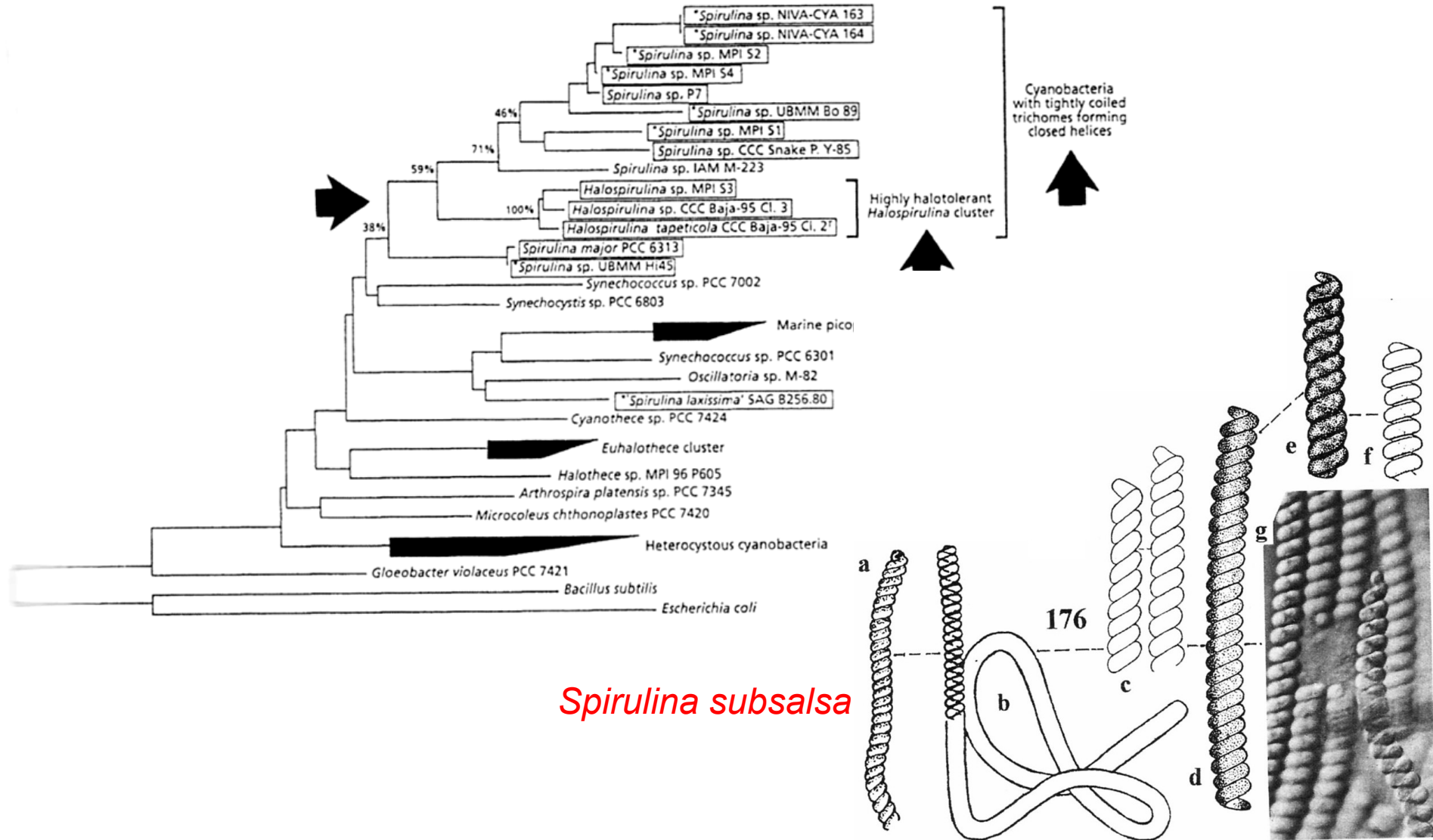
Streptostemon capitatum

(+ *S. lutescens*)

Halospirulina

Nübel et al. 2001

- jeden subcluster z rodu *Spirulina*
- morfologicky identický se *S. subsalsa*



Spirulina subsalsa

Thermosynechococcus

Katoh et al. 2001

- termofilie
- zvláštní fylogenetický cluster

Plant Cell Physiol. 42(6): 599-607 (2001)
ISPP © 2001

Functional Analysis of *psbV* and a Novel c-type Cytochrome Gene *psbV2* of the Thermophilic Cyanobacterium *Thermosynechococcus elongatus* Strain BP-1

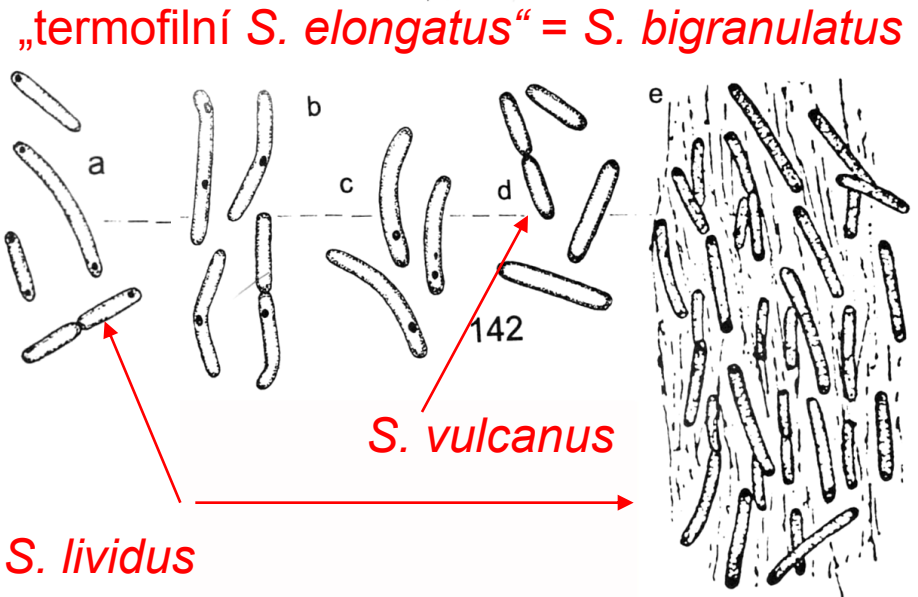
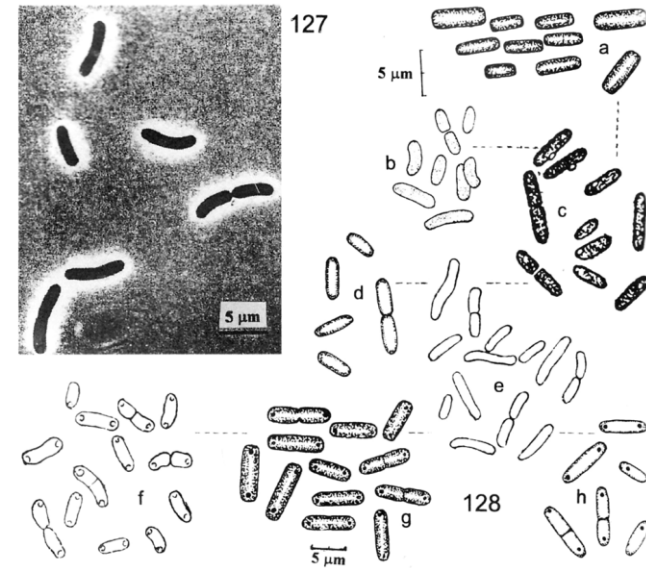
Hiroshi Katoh¹, Suwako Itoh¹, Jian-Ren Shen² and Masahiko Ikeuchi^{1,3}

¹ Department of Life Sciences (Biology), University of Tokyo, Komaba 3-8-1, Meguro, Tokyo, 153-8902 Japan

² RIKEN Harima Institute, Mikazuki-cho, Sayo-gun, Hyogo, 679-5148 Japan

Cytochrome *c-550* is an extrinsic protein associated with photosystem II (PSII) in cyanobacteria and lower eukaryotic algae and plays an important role in the water-splitting reaction. The gene (*psbV*) for cytochrome *c-550* was cloned from the thermophilic cyanobacteria *Thermosynechococcus* (formerly *Synechococcus*) *elongatus* and *T.* (formerly *Synechococcus*) *vulcanus*. In both genomes, located downstream of *psbV* were a novel gene (designated *psbV2*) for a c-type cytochrome and *petJ* for cytochrome *c-553*. The deduced product of *psbV2* showed composite similarities to *psbV* and *petJ*. Phenotype of *psbV*-disruptant in *Thermosynechococcus* was practically the same as that reported in *Synechocystis* sp. PCC 6803. Either *psbV* or *psbV2* gene of *T. elongatus* was expressed in the *psbV*-disruptant of *Synechocystis* sp. PCC 6803, which resulted in recovery of the photoautotrophic growth. However, the enhanced requirement of Ca^{2+} or Cl^{-} ions in the *psbV*-disruptant of *Synechocystis* was suppressed by expression of *psbV* but not by expression of *psbV2*. Thus, it is concluded that *psbV2* can partly replace the role of *psbV* in PSII. The close tandem arrangement of *psbV/psbV2/petJ* implies that *psbV2* was created by gene duplication and intergenic recombination during evolution.

+ přibližně 12 molekulárních a biochemických prací



Acaryochloris

Miyashita et al. 2003

J. Phycol. 39, 1247–1253 (2003)

ACARYOCHLORIS MARINA GEN. ET SP. NOV. (CYANOBACTERIA), AN OXYGENIC PHOTOSYNTHETIC PROKARYOTE CONTAINING CHL *D* AS A MAJOR PIGMENT¹

Hideaki Miyashita,² Hisato Ikemoto, Norihide Kurano, Shigetoh Miyachi

Marine Biotechnology Institute, Kamaishi, Iwate 026-0001, Japan

and

Mitsuo Chihara

3-19-17, Fuseshimachi, Kashiwa, Chiba 277-0823, Japan

RESULTS

Acaryochloris Miyashita et Chihara, gen. nov.

Acaryochloris (A.cary.o.chlo'ris. Gr. pref. *a*, without; Gr. comp. *caryo*-, nucleus-; Gr. adj. *chloros*, green; M.L. fem. n. *Acaryochloris*, without nucleus green)

Cells are spheroidal or ellipsoidal. They are sheathed and nonmotile. The cells contain chl *d* as a major pigment. Phycobilisomes are absent. Thylakoids are appressed peripherally. Gas vacuole is absent. Reproduction is performed asexually by binary division.

The type species is *Acaryochloris marina* Miyashita et Chihara.

Acaryochloris marina Miyashita et Chihara, sp. nov.

Acaryochloris marina (ma.ri'na. L. adj. *marinus*, growing in the sea)

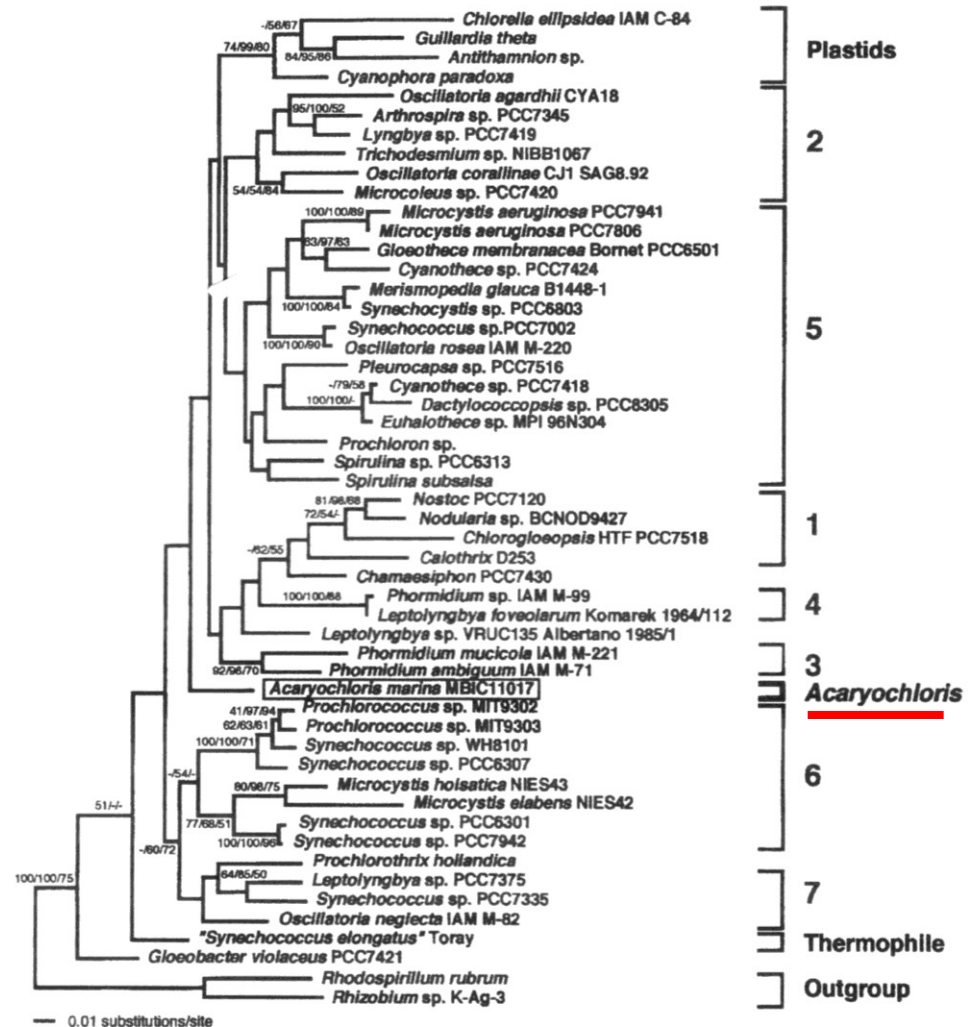
Cells are 1–1.5 µm in diameter and 1.5–3.0 µm in length.

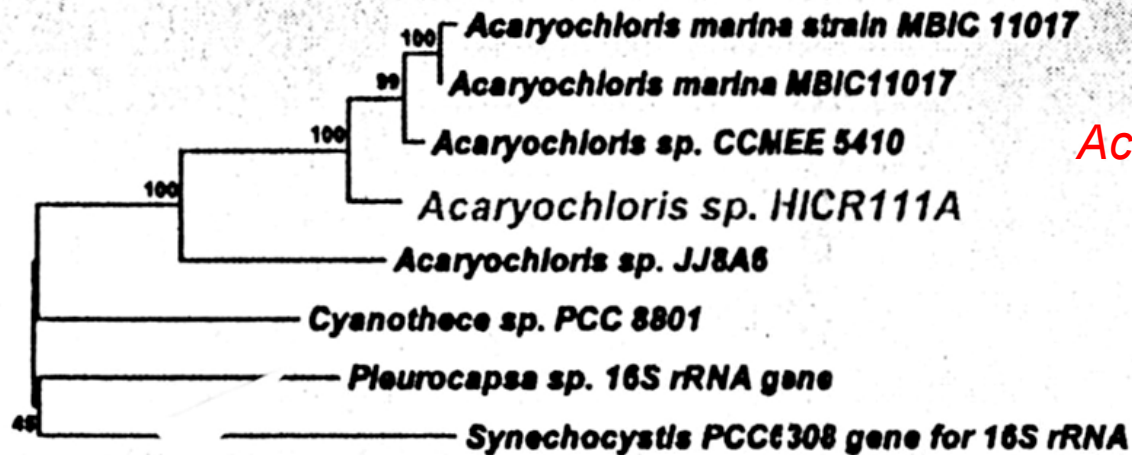
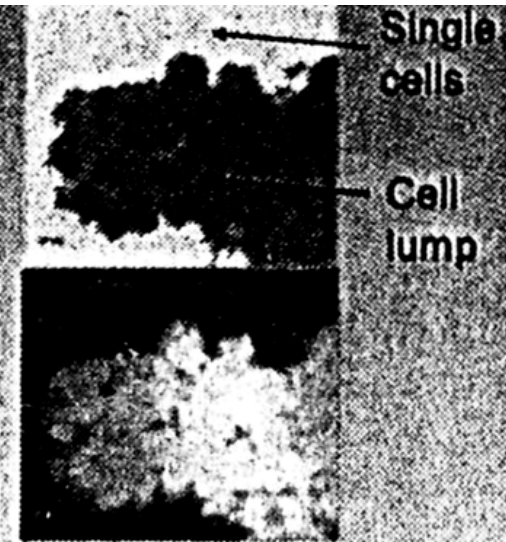
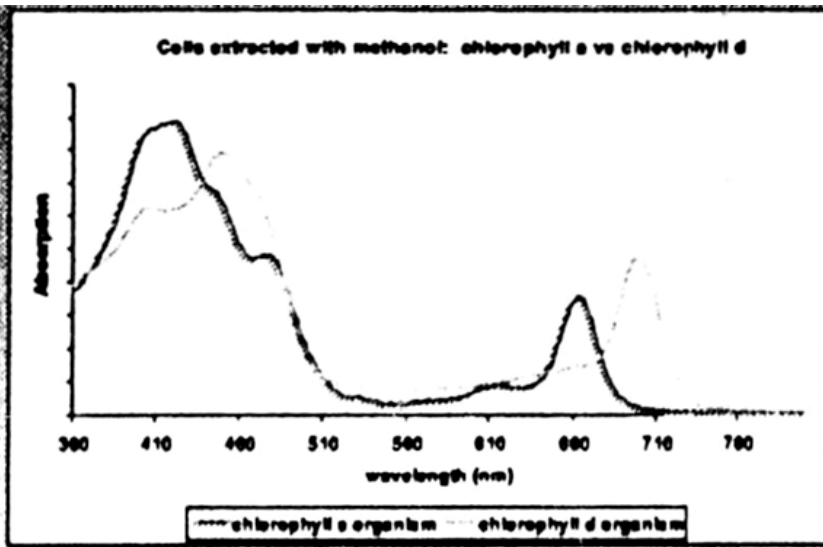
Type strain: Isolated from algal suspension squeezed out from *Lissoclinum patella* Gottschaldt collected at “Milky Way” in the coast of the Republic of Palau on 10 August 1993. *Acaryochloris marina* MBIC11017.

Habitat: Mainly as a symbiont in colonial ascidians.

Distribution: The shallow waters of the Republic of Palau, probably widely distributed in the tropical and subtropical marine coastal environment.

- kokální koloniální typ
- přítomnost chlorofylu *d*
- fylogenetická pozice





Acaryochloris marina

0.01

Phylogenetic tree for new *Acaryochloris* isolates based on full 16S rRNA sequences

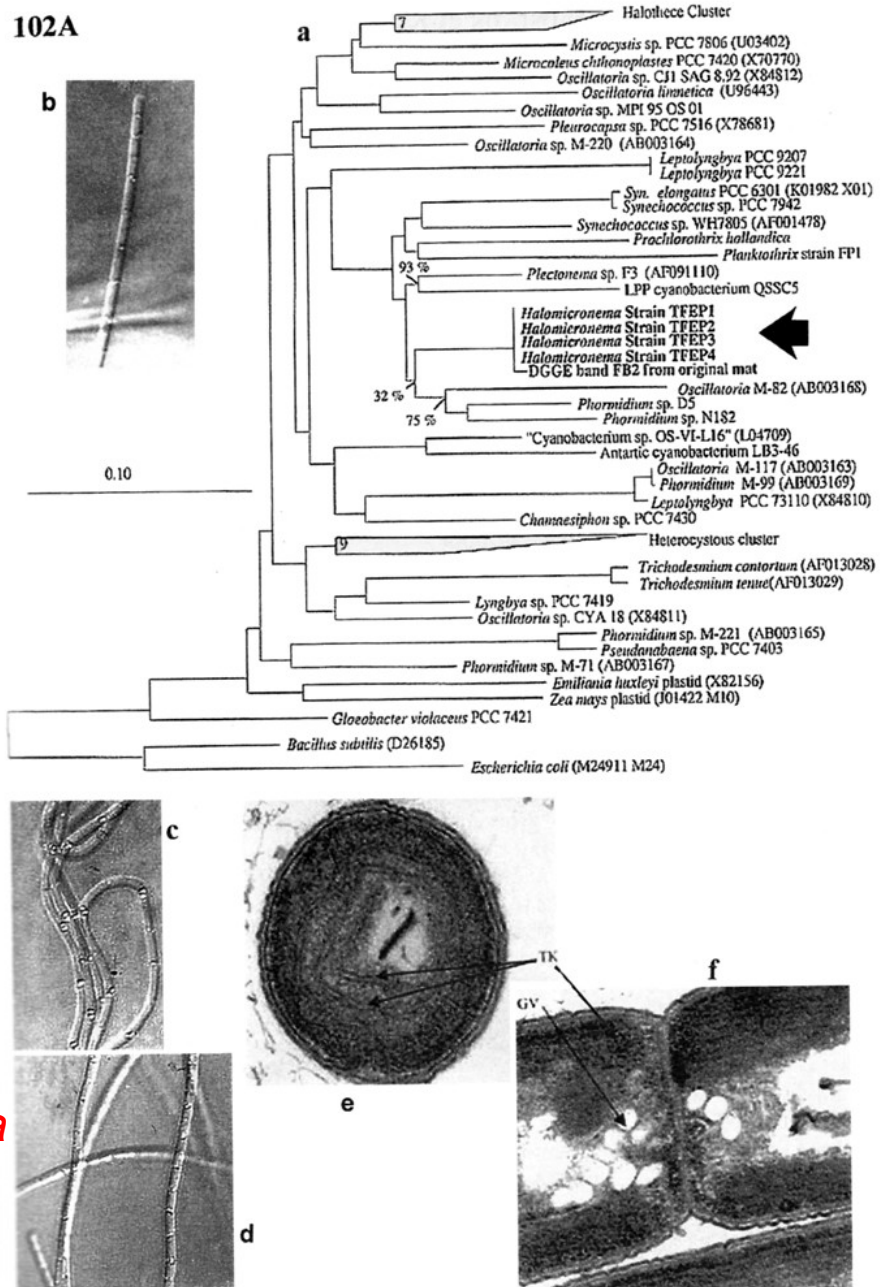
Mohr 2008

Halomicronema

Abed et al. 2002

- pseudanabaenoidní, tenká vlákna, morfologicky podobná rodu *Limnothrix*
- halofilie
- morfologie buněk
- přítomnost polárních plynových měchýřků
- parietální uložení thylakoidů
- fylogenetická pozice

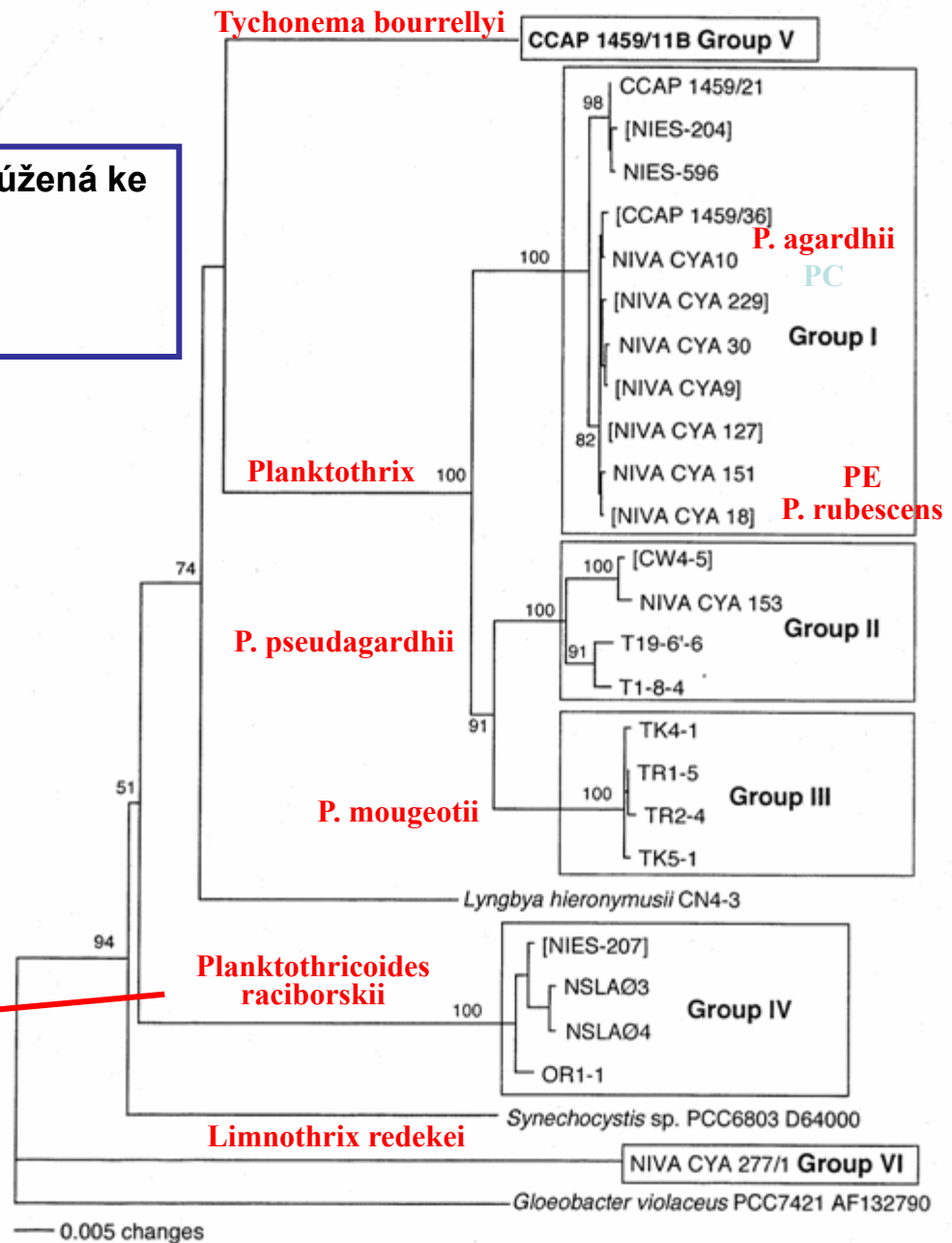
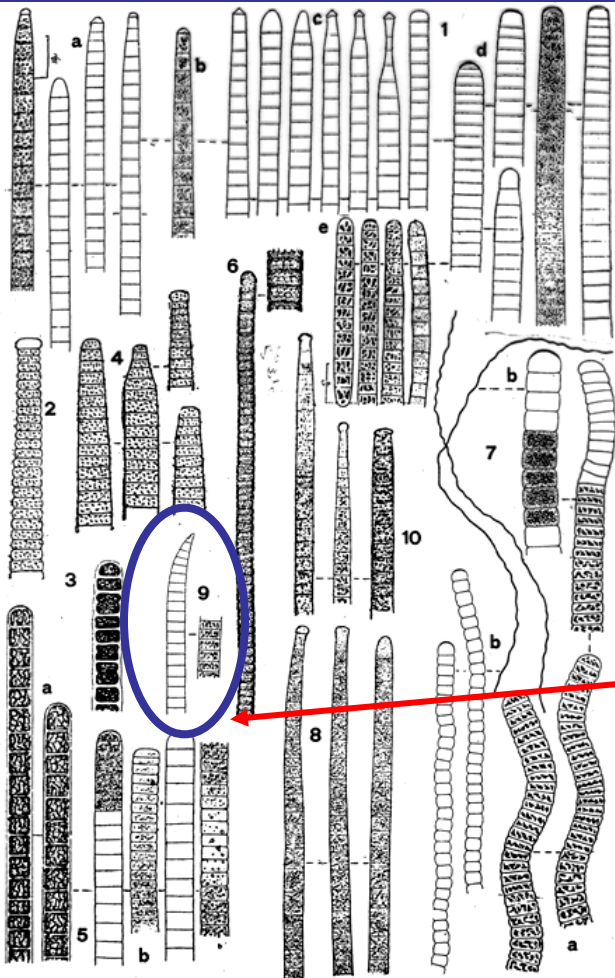
*Halomicronema
excentricum*



Planktothricoides

Suda & Watanabe 2002

- solitární planktonní vlákna bez pochev zúžená ke konci
- přítomnost plynových měchýřků
- fylogenetická pozice

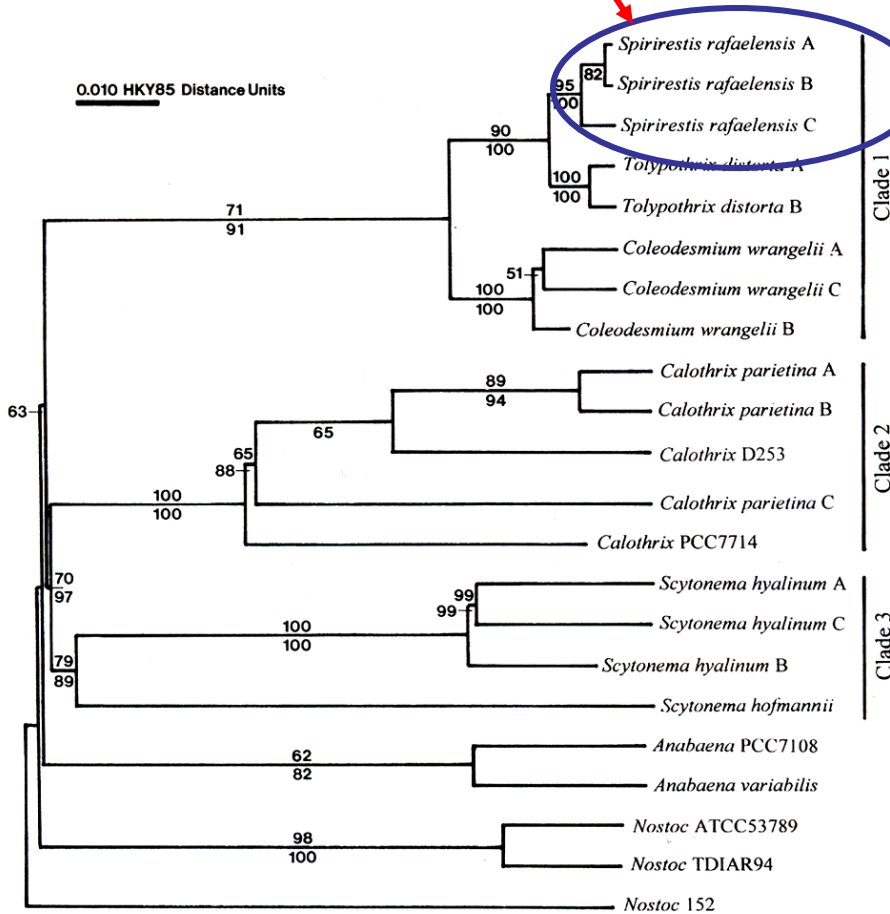


After SUDA et al. 2001

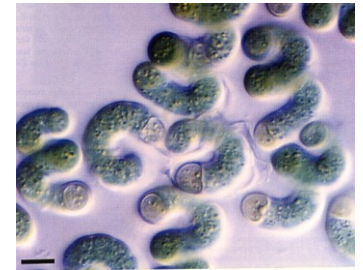
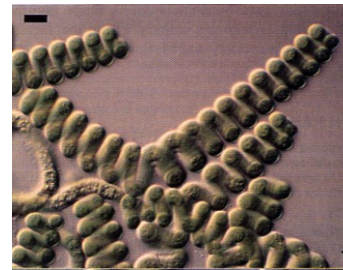
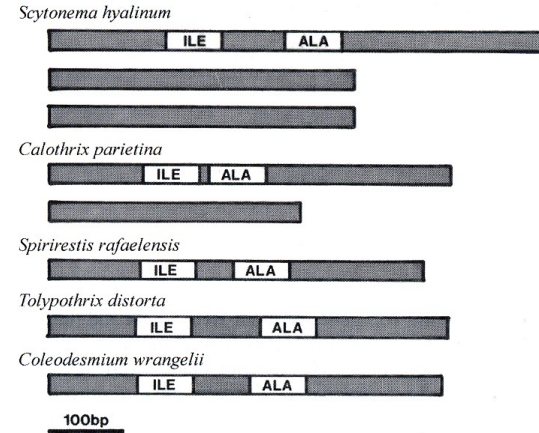
Spirirestis

Flechtner & Johansen 2002

- morfologie heteropolárních trichomů
- nepravé větvení
- fylogenetická pozice



Organization of the ITS region



16S sequence similarity to related
Tolypothrix = 90.4 - 91.4%

Spirirestis
rafaelensis



Chroogloeocystis

I. Brown et al. 2005



FEMS Microbiology Ecology 52 (2005) 307–314

FEMS
MICROBIOLOGY
Ecology

www.fems-microbiology.org

- polarizované kolonie
- ultrastruktura podobná *Chroococcus*
- fylogenetická pozice

A novel cyanobacterium exhibiting an elevated tolerance for iron

Igor I. Brown^{a,b,*}, Daniel Mumme^c, Keith E. Cooksey^a

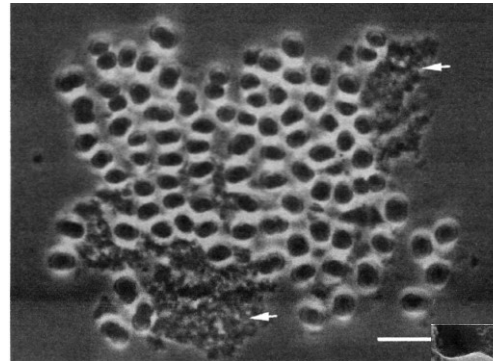
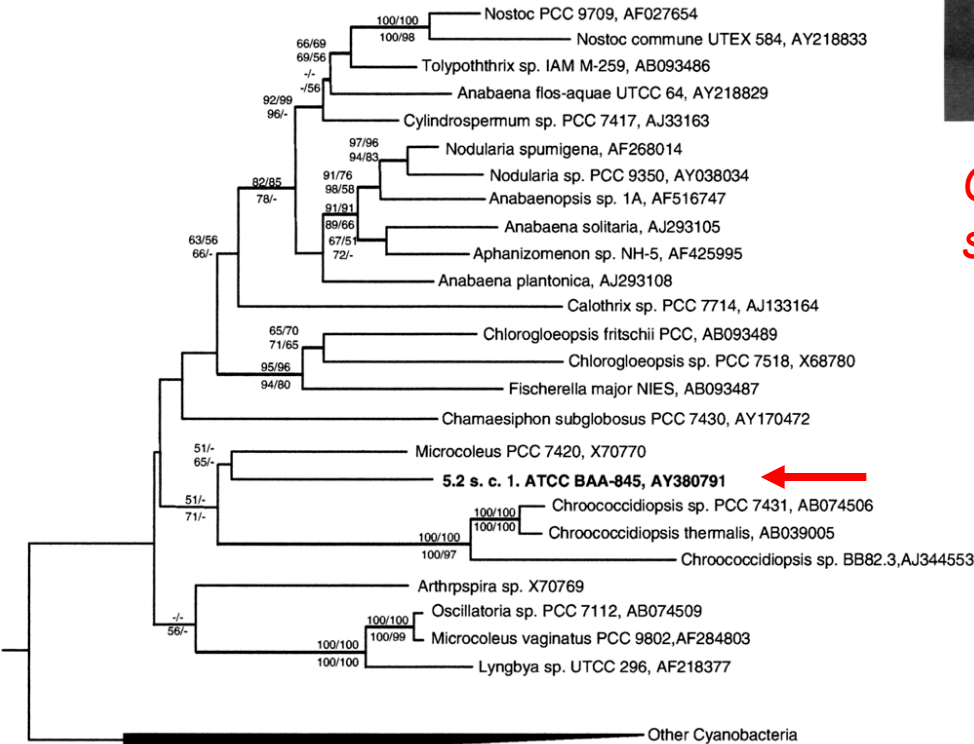
^a The Department of Microbiology, Montana State University, 109 Lewis Hall, Bozeman, MT 59717, USA

^b Thermal Biology Institute, Montana State University – Bozeman, MT, USA

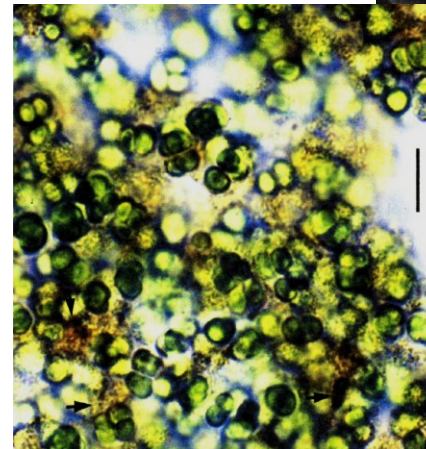
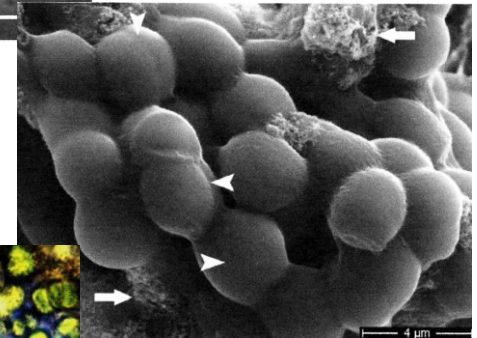
^c Microbial Ecology Program, Division of Biological Sciences, University of Montana, 32 Campus Drive # 4824, Missoula, MT 59812, USA

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*Chroogloeocystis
siderophila*



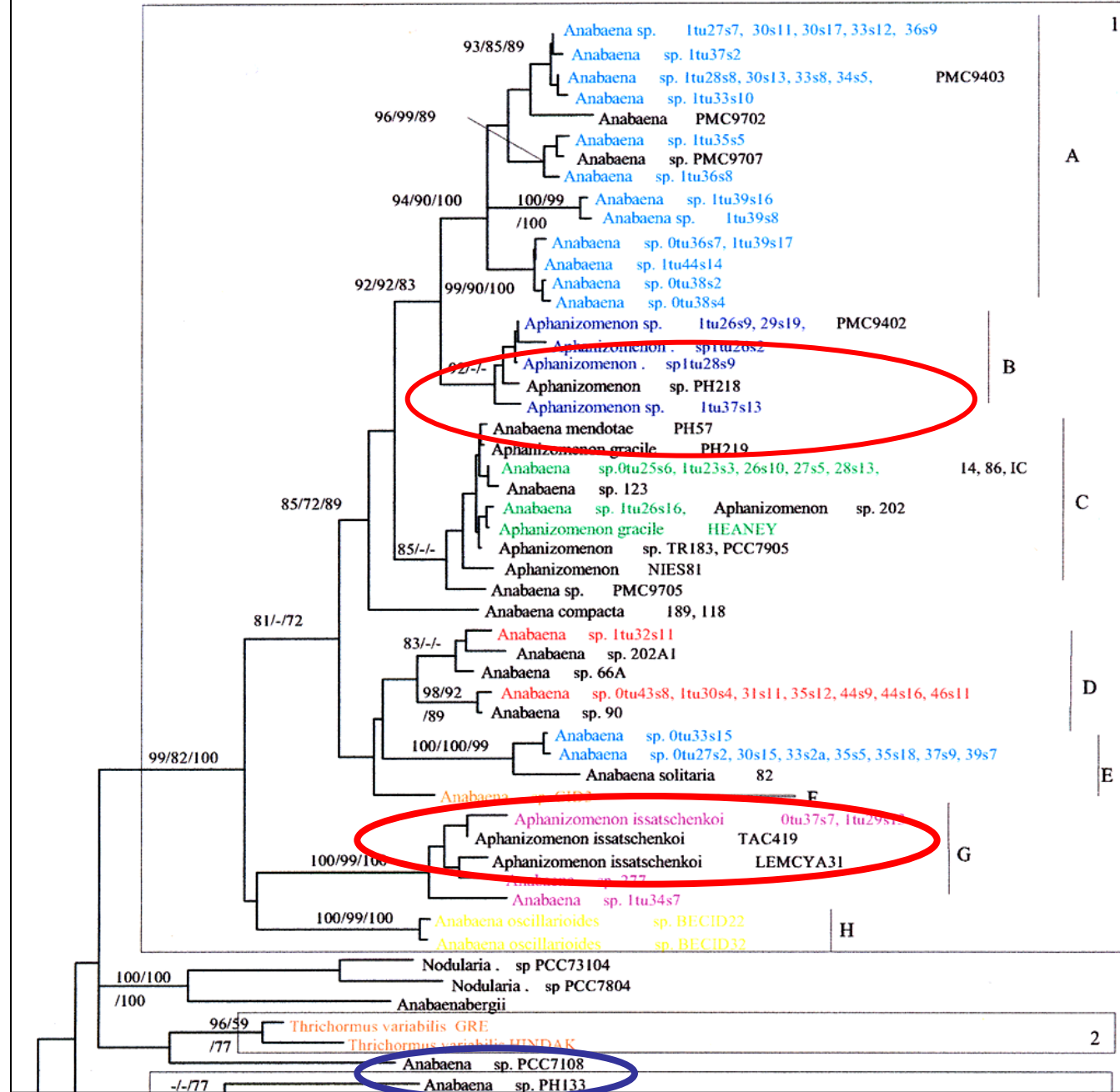
Molekulární analýza planktonních typů z rodu *Anabaena* a *Aphanizomenon*

Gugger et al. 2002

Itemann et al. 2002

Rajaniemi et al. 2005a,b

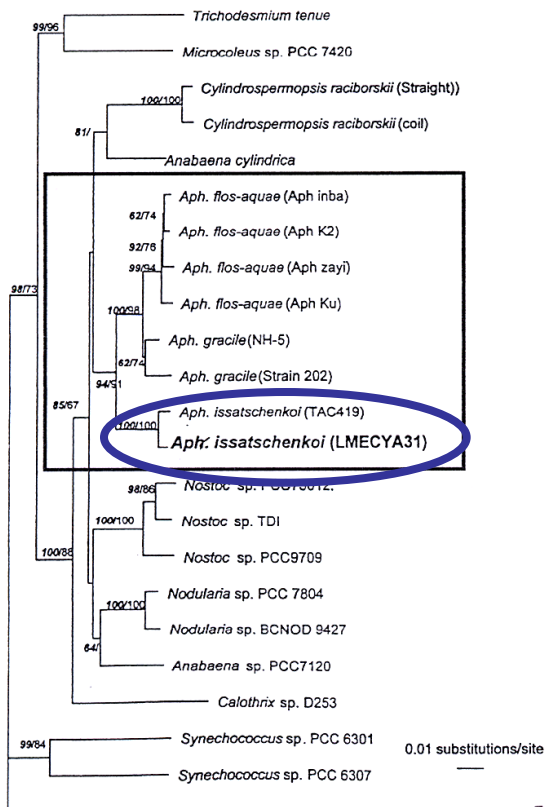
Willame et al. 2006



Cuspidothrix

Rajaniemi et al. 2005

- solitární planktonní vlákna
- prodloužené a špičaté terminální buňky
- fakultativní přítomnost aerotopů
- fylogenetická pozice



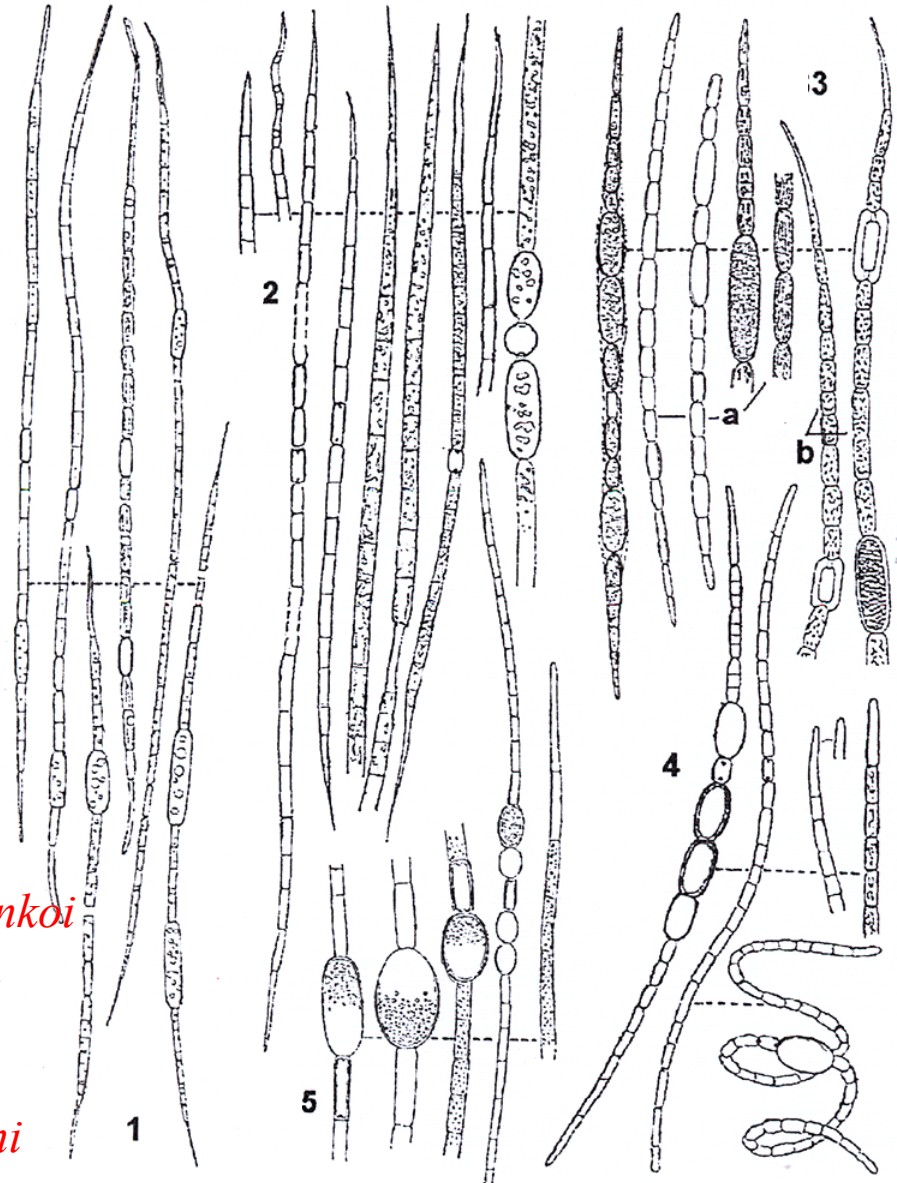
1. *C. issatschenkoii*

2. *C. tropicalis*

3. *C. elenkinii*

4. *C. capricorni*

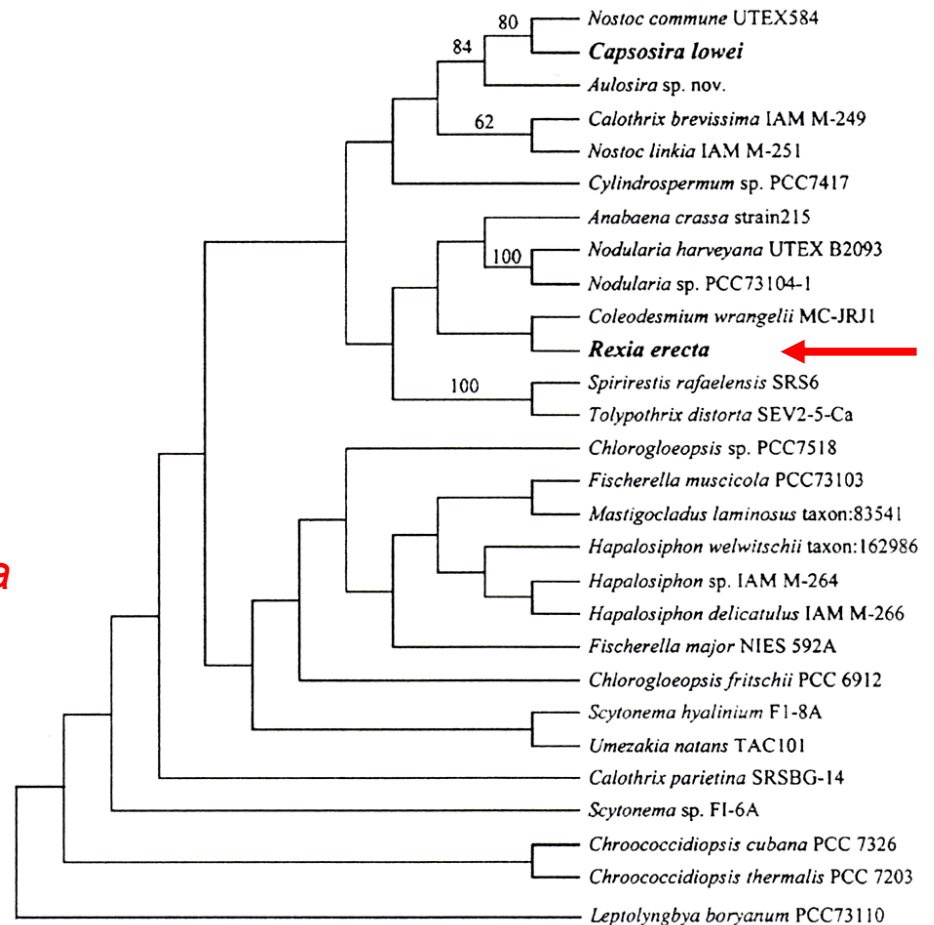
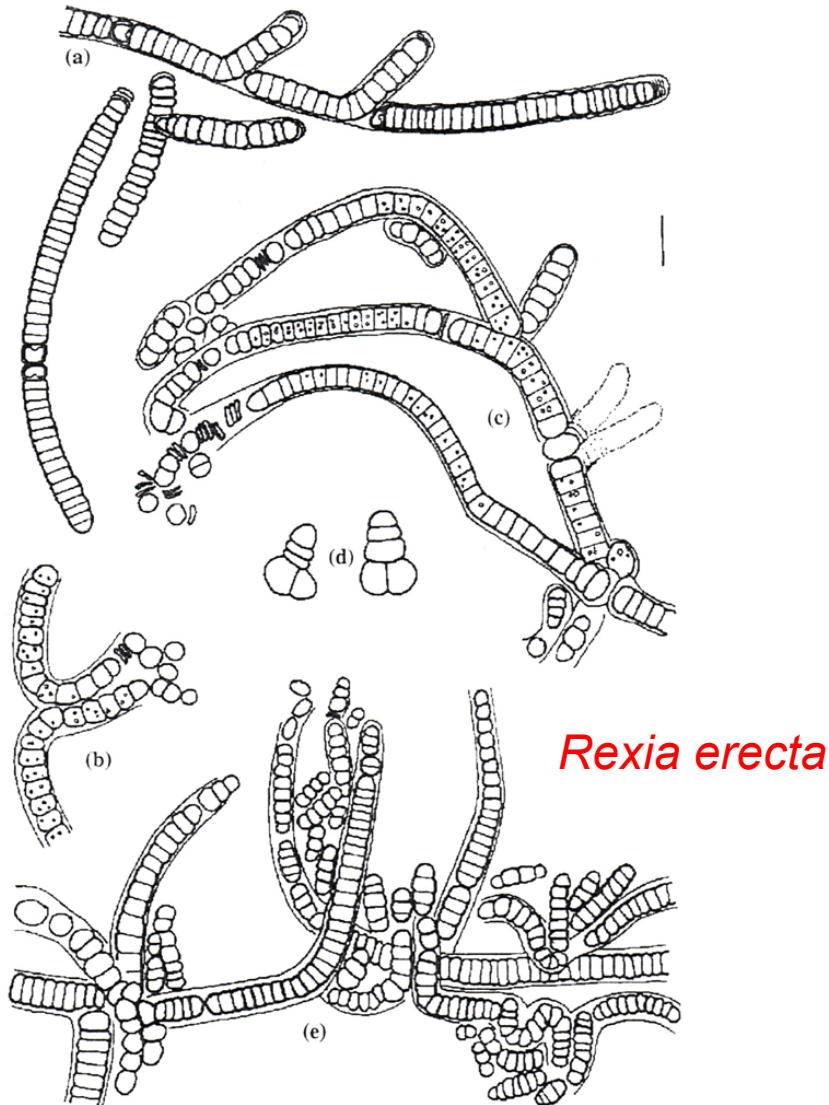
5. *C. ussatchevii*



Rexia

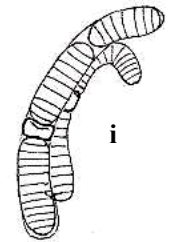
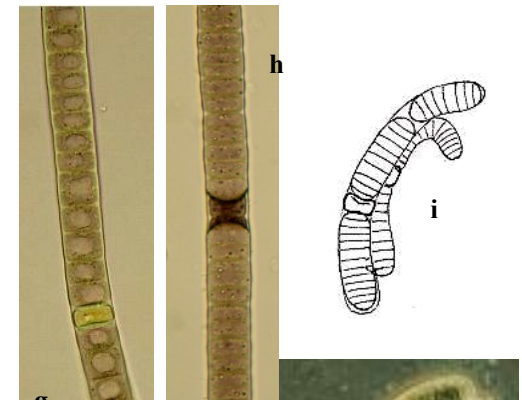
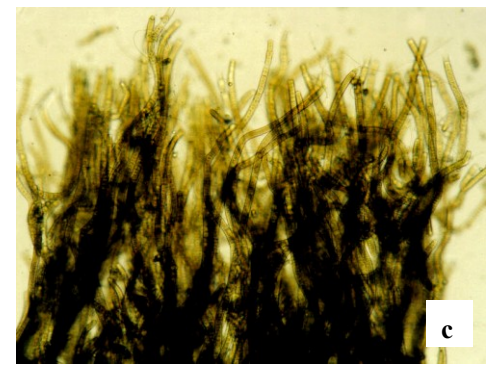
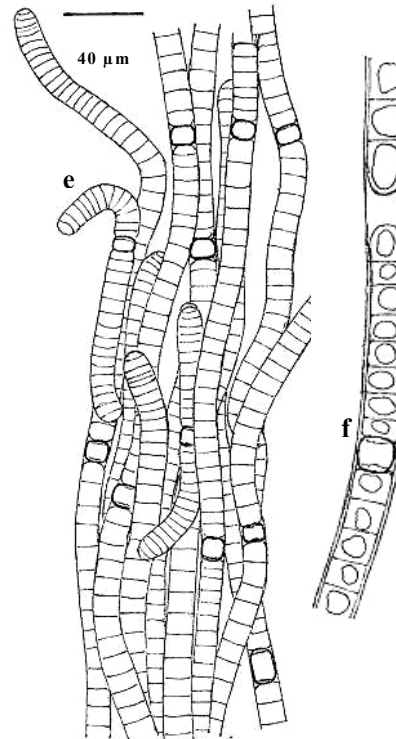
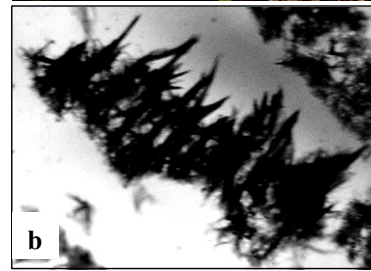
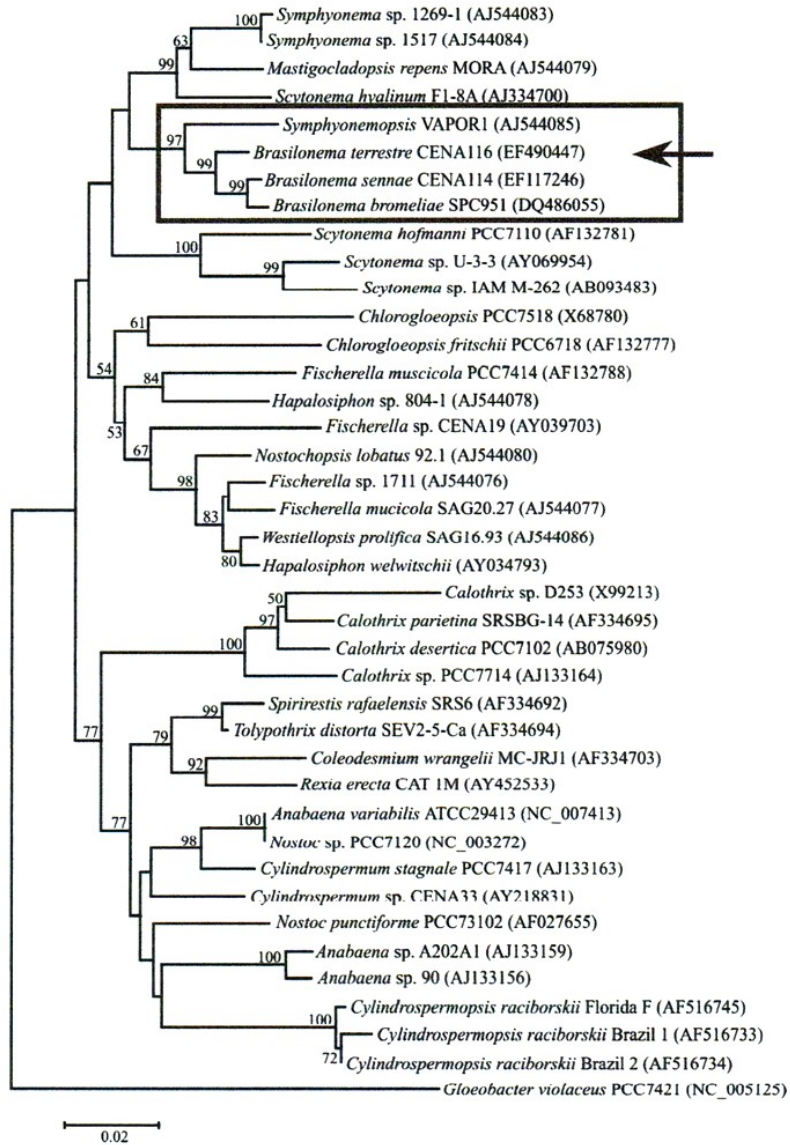
Casamatta et al. 2006

- heteropolární vlákna s bazálními heterocyty
- bohaté nepravé větvení
- schopnost podélného dělení iniciálních buněk
- fylogenetická pozice



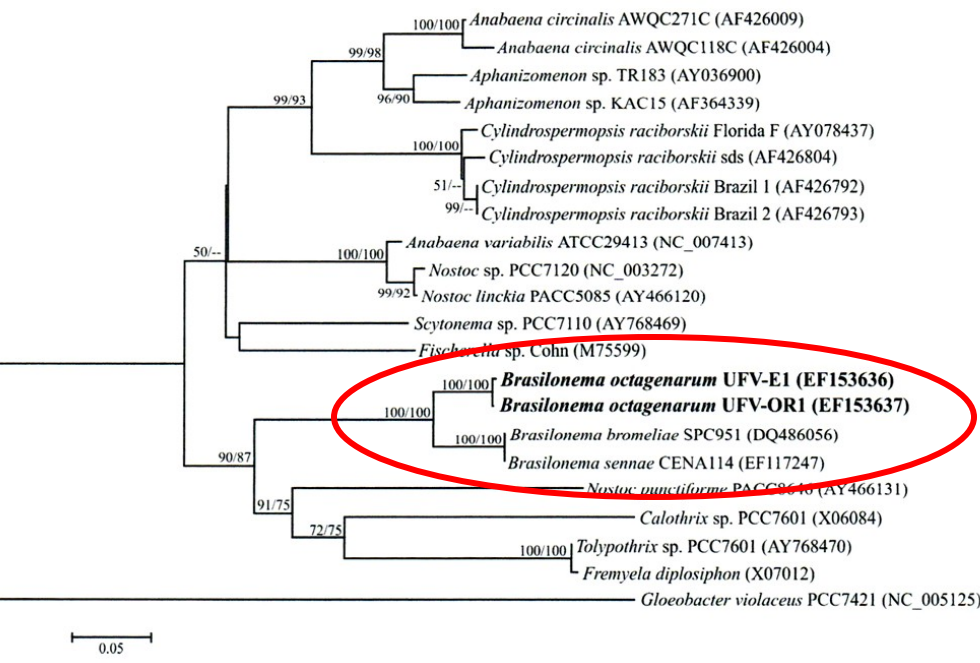
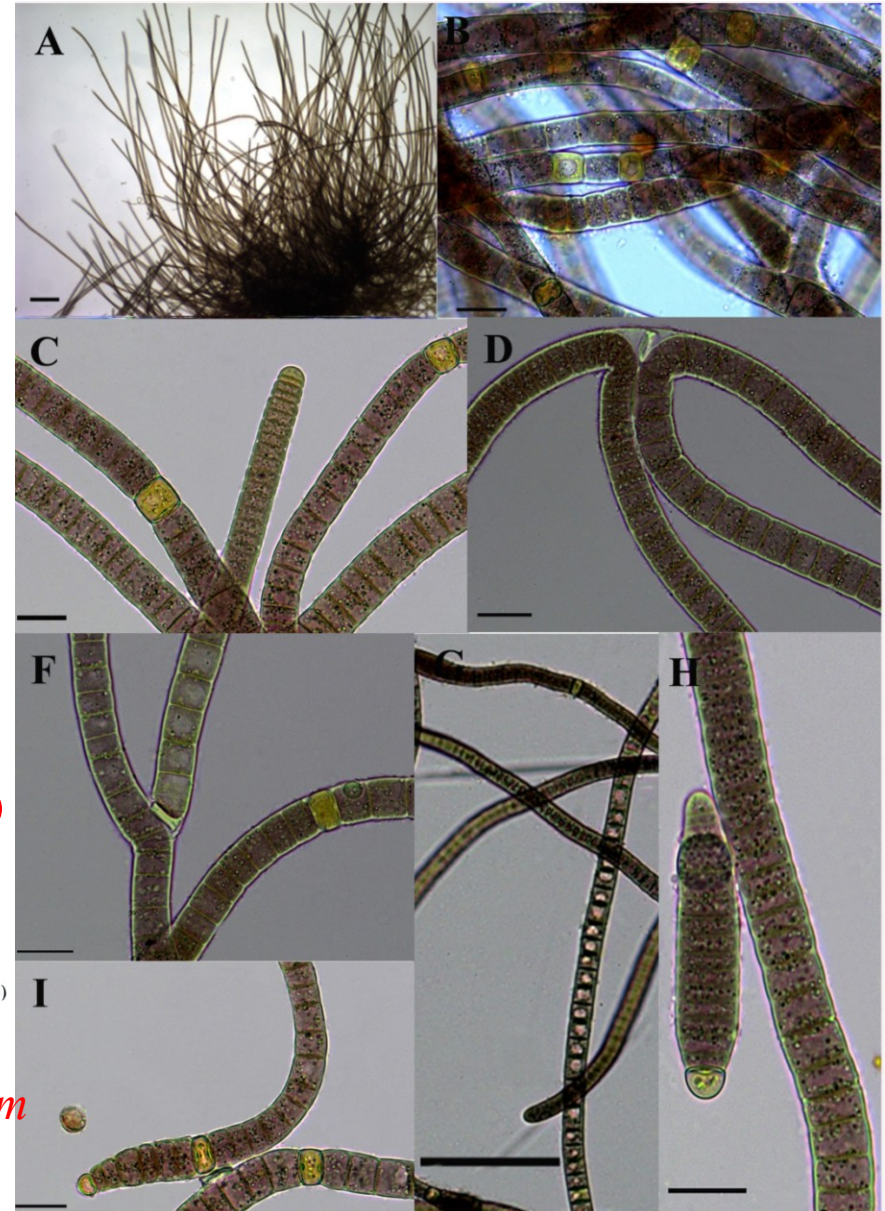
Brasilonema

Fiore et al. 2007



f-j 10 μm

- izopolární vlákna
- svazečkovité kolonie
- poměrně řídké scytonematoidní a tolypotrichoidní nepravé větvení
- fylogenetická pozice



Brasilonema octagenarum

Phenotypic review of the genus *Brasilonema* (taxonomically defined morphospecies).

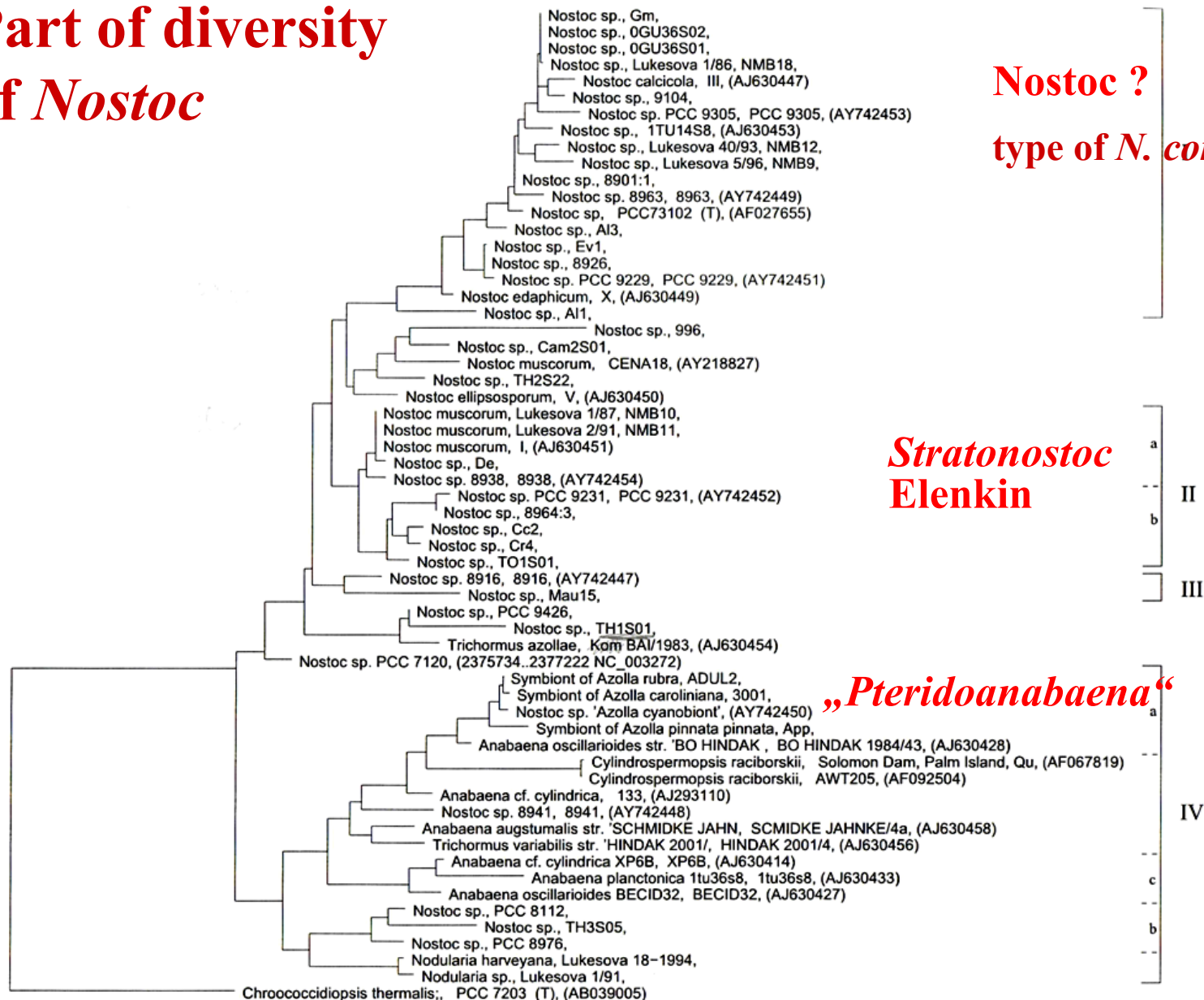
	<i>bromeliae</i> *	<i>sennae</i> *	<i>epidendron</i> *	<i>terrestre</i>	<i>roberti-lamyi</i>	<i>ornatum</i>
width of filaments [µm]	10-14.8-21	10-11.5-20	7-10.9-12(14)	12-17	12-18	20-23
width of trichomes [µm]	8-13.2-18	6-7.7-12.5	5.5-8.2-10(11)	9-15		17-18
morphology of sheaths	thin, firm	thin, firm, later lamellated	thin, firm	thin, firm, slightly ornamented	thick, finely lamellated	thick, lamellated, ornamented
colour of sheaths	colourless, rarely to yellowish-brown	rarely colourless partly yellow-brown	colourless	colourless to yellow-brown	colourless	colourless
colour of cells	greyish blue or brownish, olive-green, or violet	blue-green or olive-green	bright blue-green	greyish-green or blue-green		dark blue-green
form of thallus	free fascicles	regular erect fascicles	irregular erect fascicles	mats to irregular erect fascicles	mats to erect fascicles	creeping fascicles
colour of thallus	blackish-green to blackish violet	dirty green, brownish, or blackish-green	dark green to black (dried)	dirty green		greyish-green
heterocytes [µm]	± cylindrical 4-19 x 15-16.8	cylindrical 6.8-15.4 x 10.2-11.2	barrel-shaped to cylindrical (7)8-10(11.5) x 7-9	short barrel-shaped to cylindrical 6-17 x 13-14	discoïd to cylindrical	discoïd 3-6 x 17-18
ecology	subaerophytic, epiphytic on living and dead leaves of Bromelias (inside of leaf rosettes)	subaerophytic, edge of springs on wet wooden, stony and iron substrates	subaerophytic, corticolous, on old wooden substrates in rainy forests	subaerophytic, on periodically wetted stony substrates	“aerophytic”	subaerophytic, on bark of old trees among mosses and lichens
distribution	Brazil (SP), São Paulo (Botan. Garden), Paranapiacaba	Brazil (SP), Paranapiacaba	Brazil (SP), Paranapiacaba, Jureia	Brazil (SP), village San Pedro, Ilha de Cardoso	Guadeloupe	Brazil (SP), Campos de Jordão (Horto forestal)

* = supported by molecular sequencing

Sant'Anna et al. 2007

Part of diversity of *Nostoc*

**Nostoc ?
type of *N. commune***



***Stratonostoc*
Elenkin**

„*Pteridoanabaena*“

Mojavia

Řeháková & Johansen 2007

- speciální životní cykly
- morfologie vláken
- fylogenetická pozice

NOSTOC

T: *N. commune*

26 revidovaných
druhů



N. pruniforme
N. caeruelum
N. linckia
N. zetterstedtii
N. verrucosum
N. parmelioides
N. desertorum

STRATONOSTOC

T: *S. muscorum*

18 druhů ; platně popsány
rod, druhový koncept
nerevidován

diffuse macroscopic mats



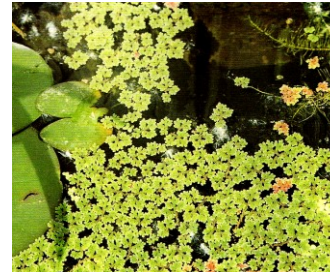
N. (S.) paludosum
N. (S.) ellipsosporum
N. (S.) calcicola
N. (S.) humifusum
N. (S.) edaphicum
N. (S.) viride

PTERIDOANABAENA

T: *P. azollae*

1 druh; dosud v rukopisu

symbiotic

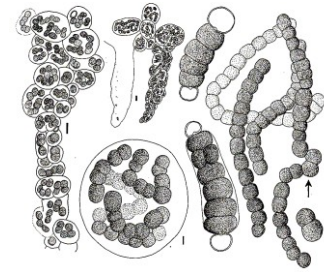


MOJAVIA

T: *M. pulchra*

1 druh

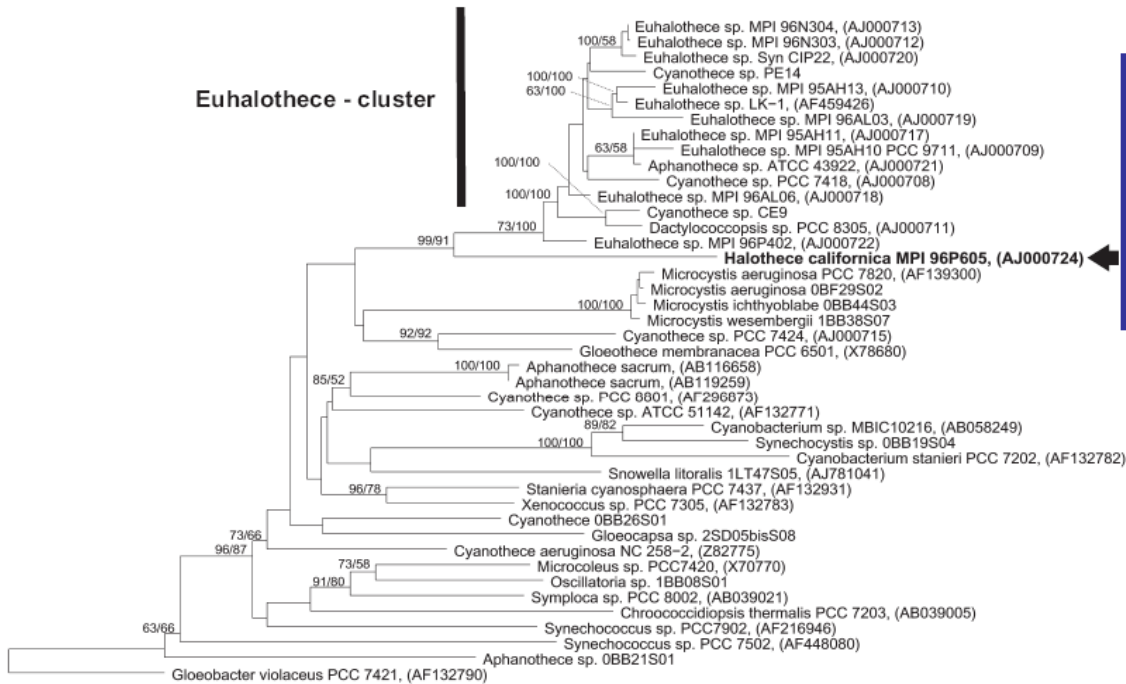
terrestrial,
microscopic colonies



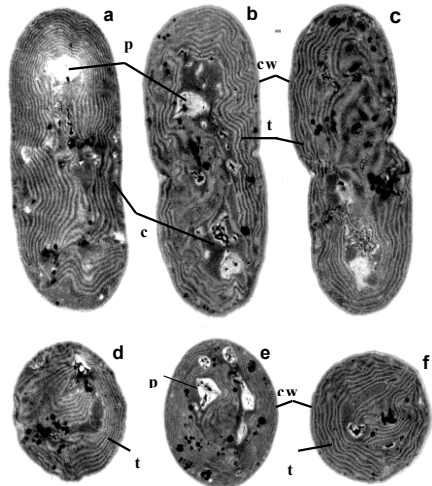
Halothece

(Garcia-Pichel et al. 1998) Margheri et al. 2008

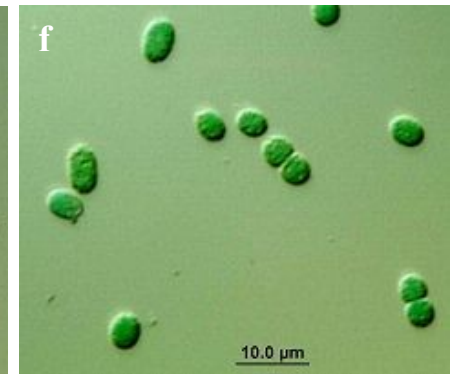
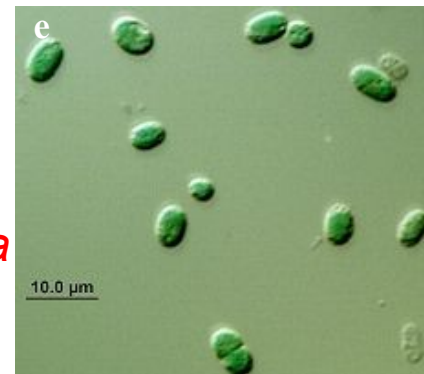
Euhalothece - cluster



- solitérní buňky
- fakultativní pseudofilamenty
- specifická ultrastruktura
- fylogenetická pozice

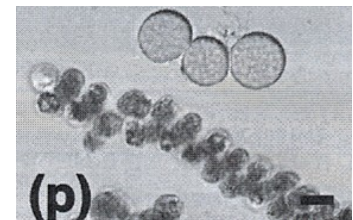
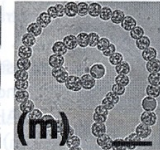
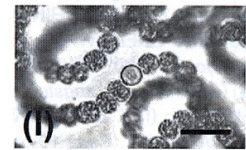
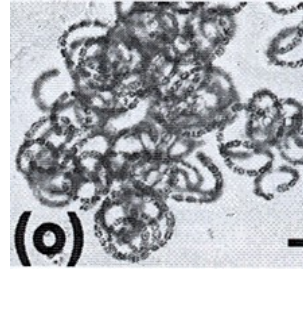
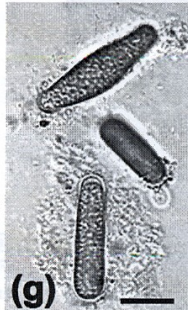
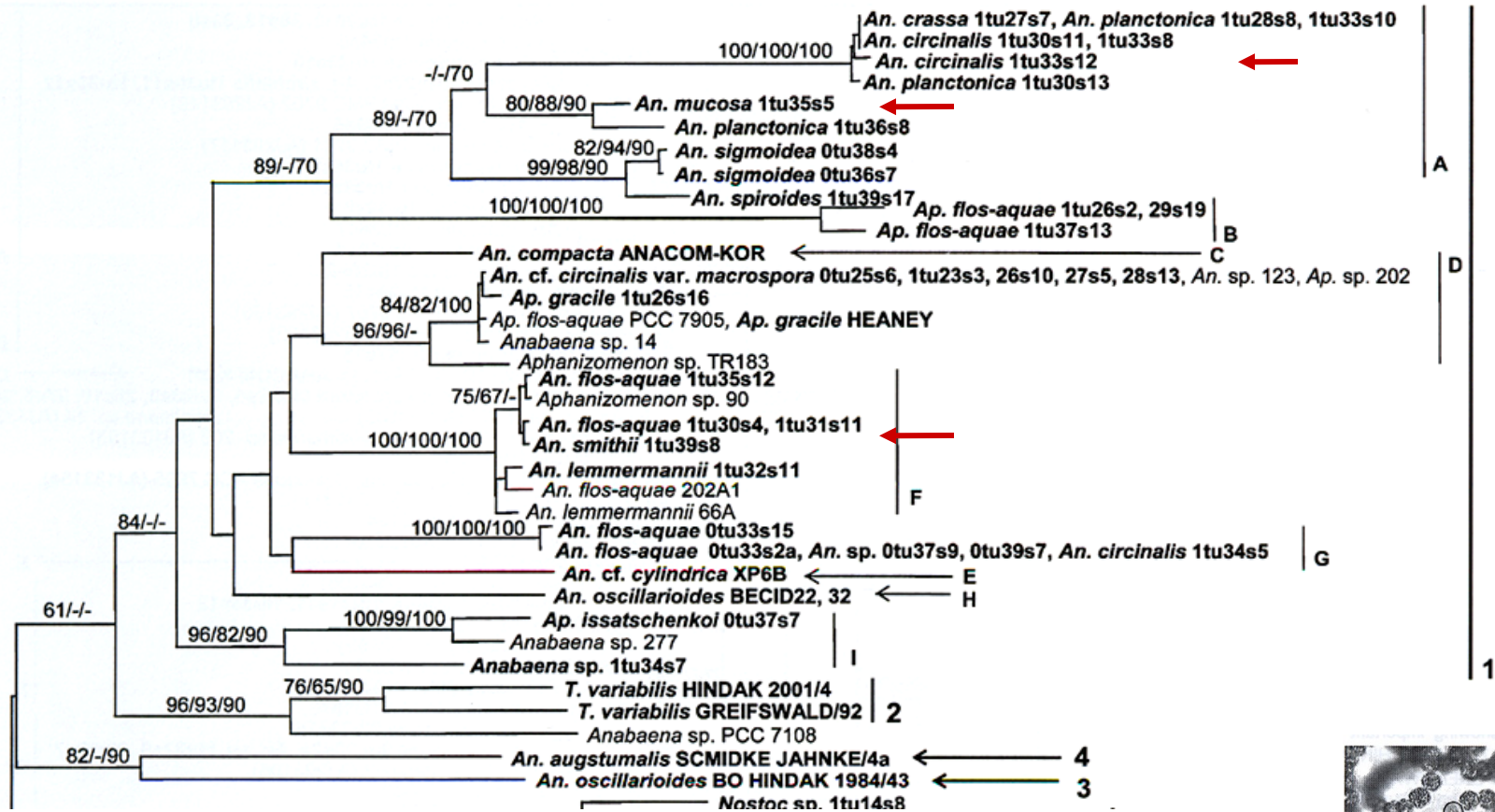


Halothece californica



Anabaena - planktic species (*Dolichospermum*)

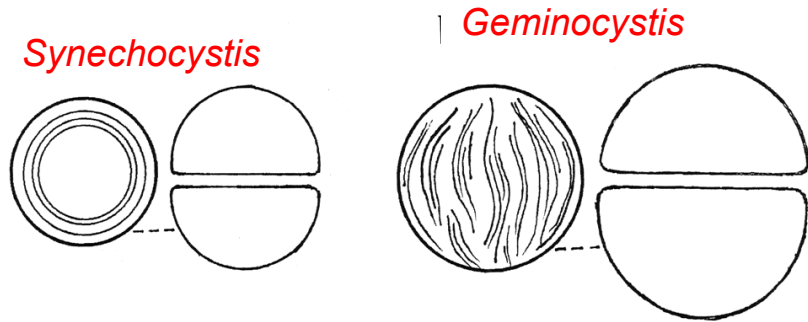
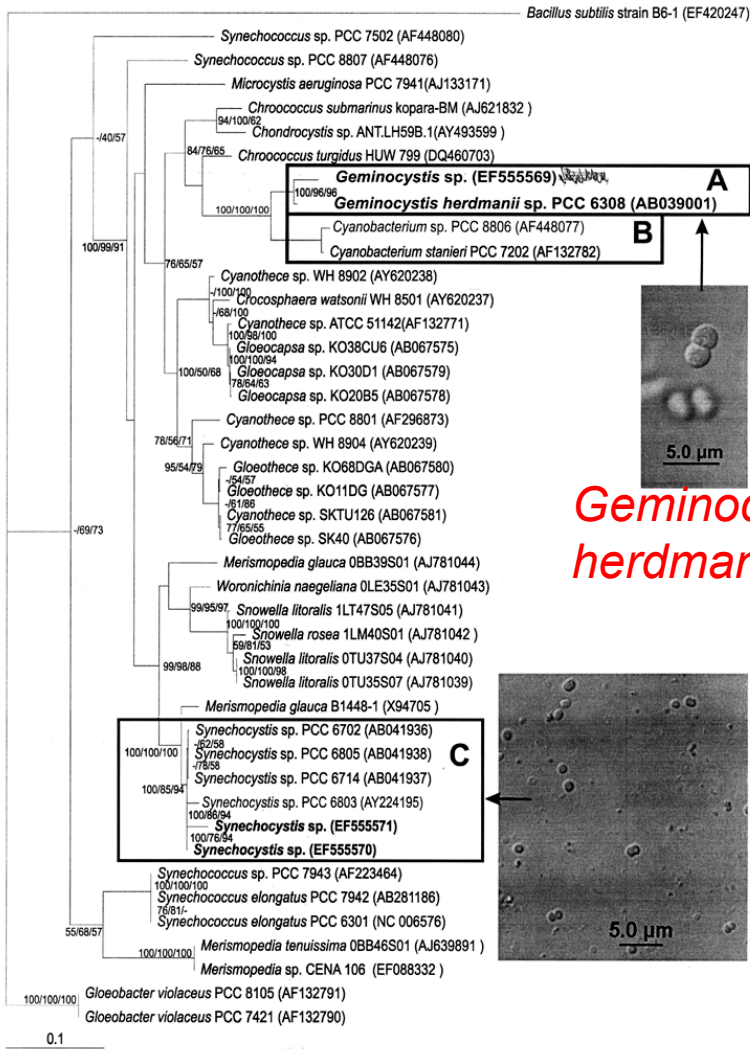
- planktonní, solitární vlákna
- obligatorní tvorba plynových měchýřků
- akinety se tvoří oddáleně paraheterocyticky



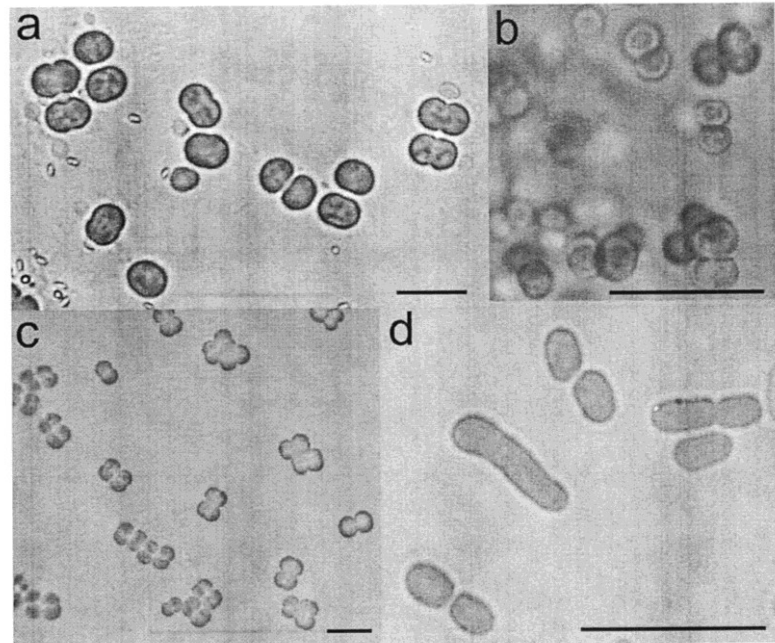
Geminocystis

Korelusová et al. 2009

- solitární kulovité buňky
- pozice thylakoidů
- fylogenetická pozice



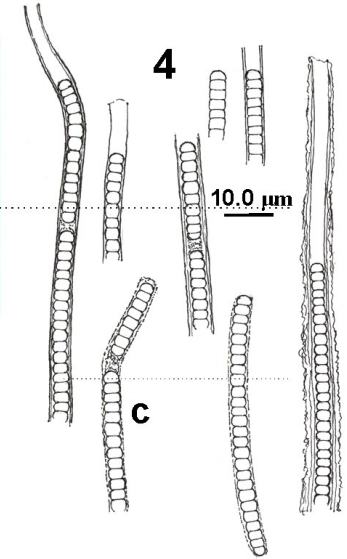
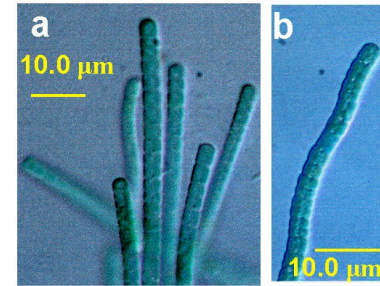
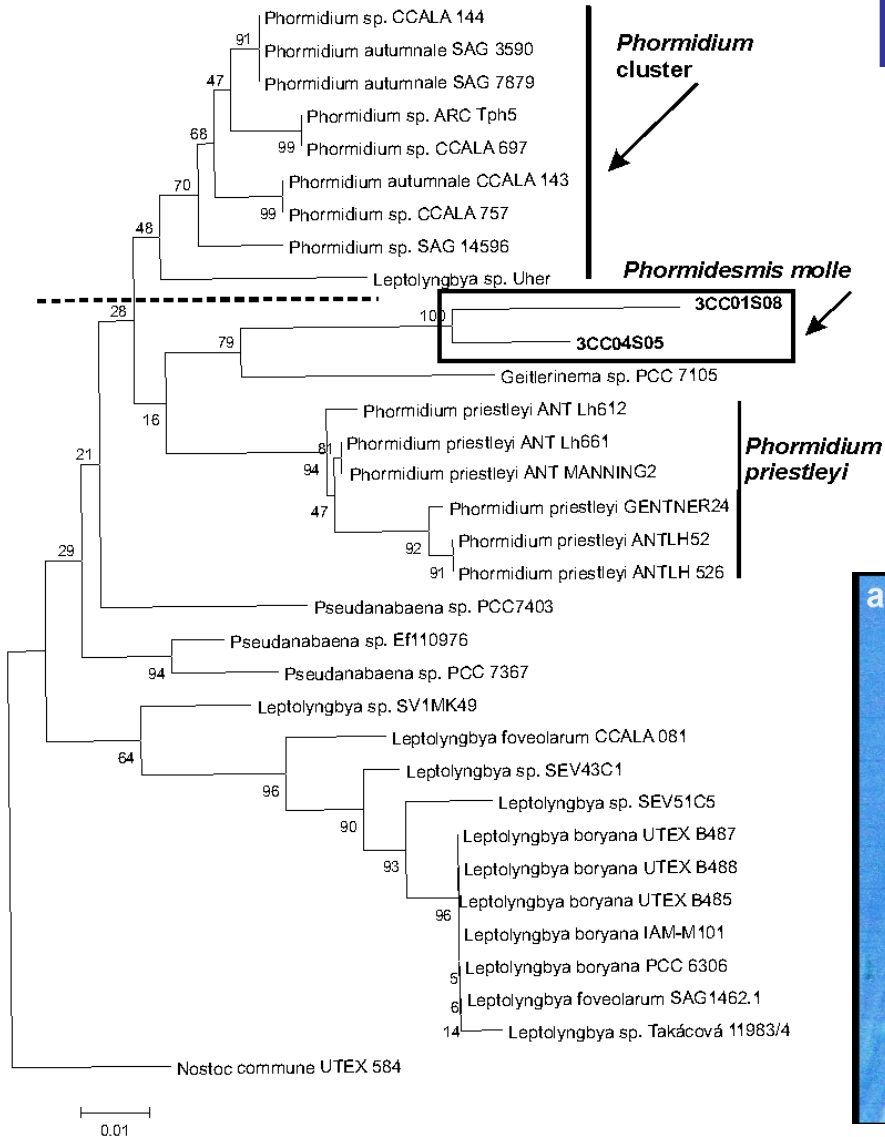
Geminocystis herdmanii



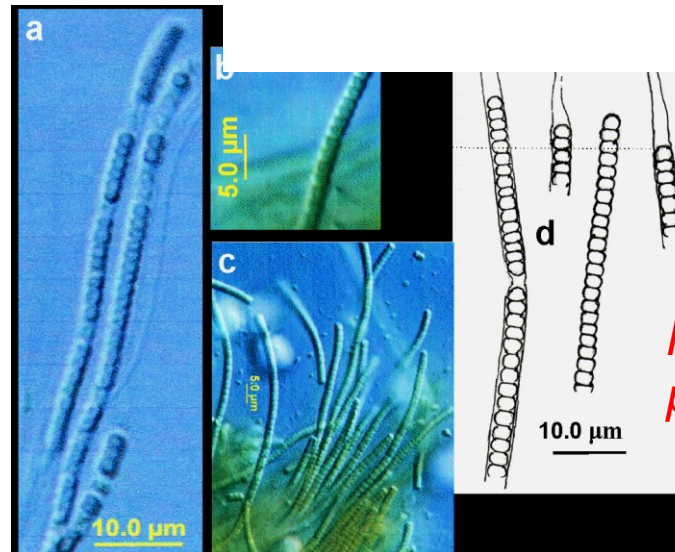
Phormidesmis

Turicchia et al. 2009

- morfologie trichomů a vláken
- absence zvláštních koncových buněk
- ultrastruktura
- fylogenetická pozice



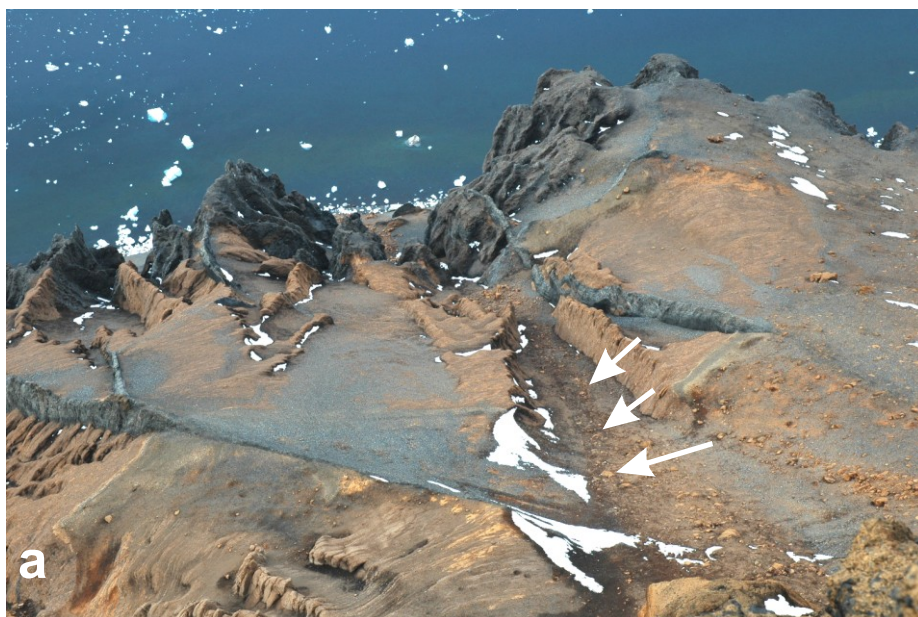
Phormidesmis molle



Phormidesmis priestleyi



A Typická lokalita *P. molle* (mokřady sev. Belize)



B Typická lokalita *P. priestleyi* (reofilní úseky glaciálních potoků v Antarktidě)

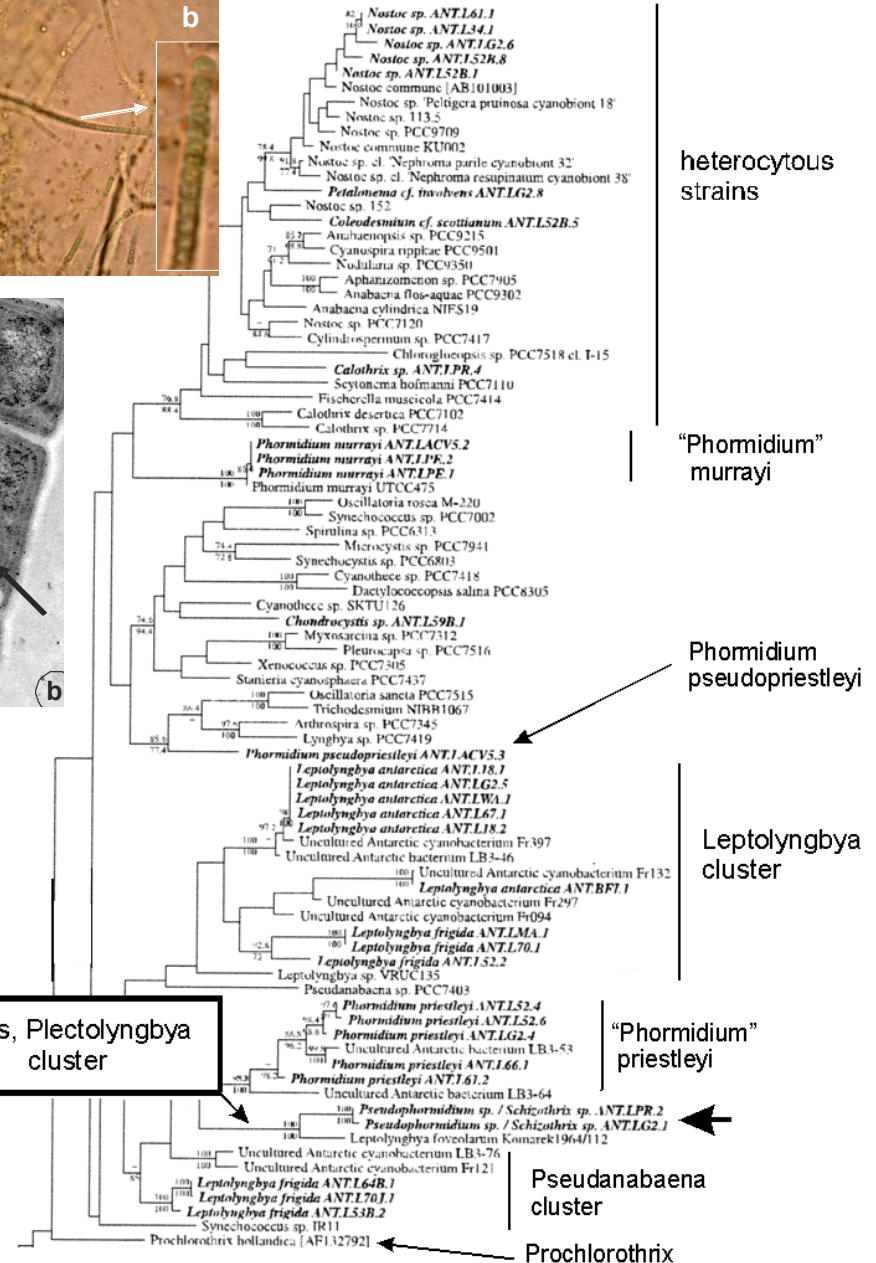
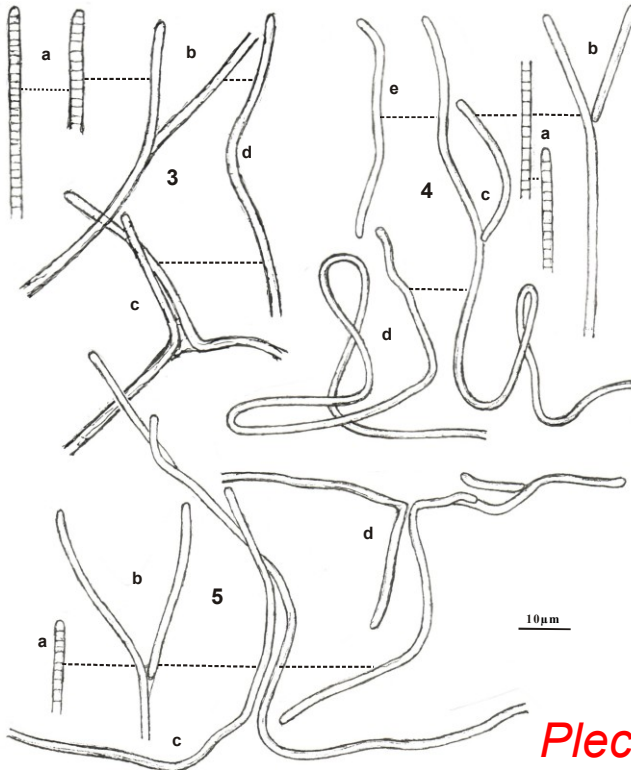


Plectolyngbya

Taton et al. 2009



- morfologie a velikost vláken
- nepravé větvení
- charakteristická ultrastruktura
- fylogenetická pozice



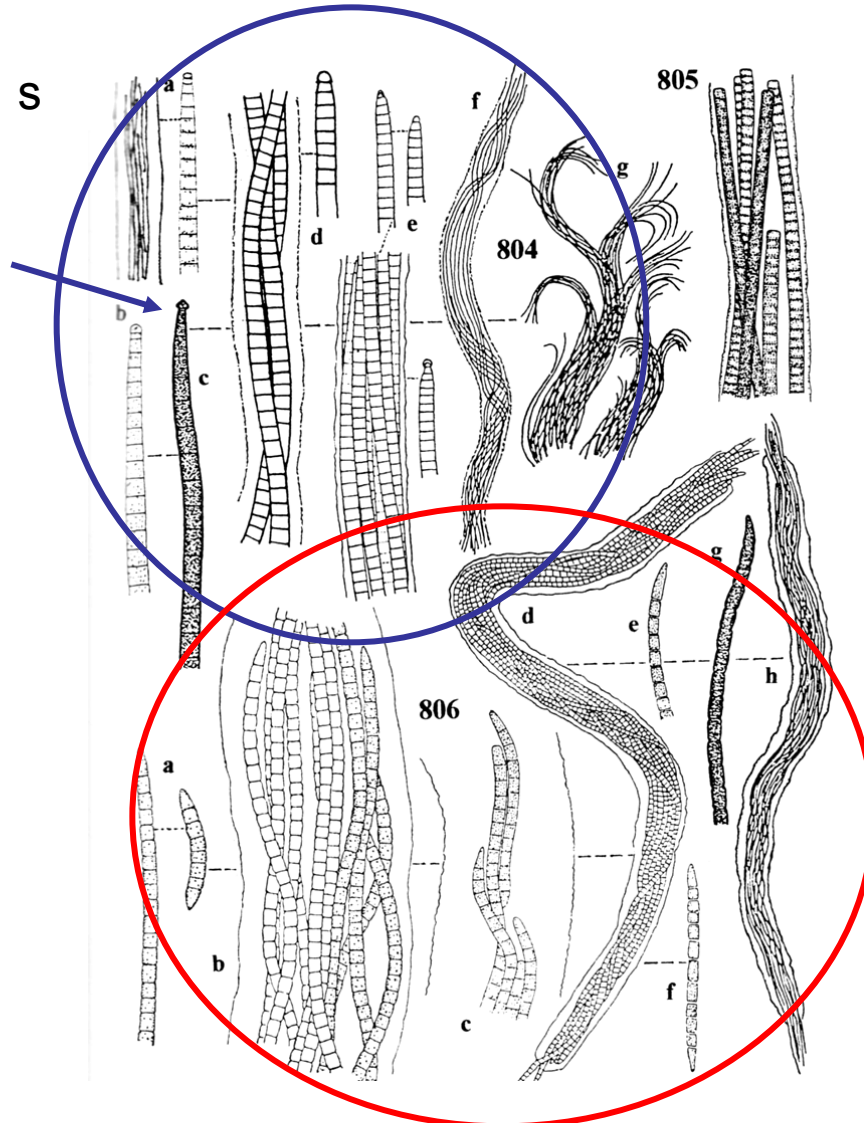
Plectolyngbya hodgsonii

Coleofasciculus

Johansen et al. 2009

- fylogenetická pozice
- konce trichomů nezúžené, koncová buňka konická, bez kalyptry

Typický *Microcoleus* s
typem *M. vaginatus*



Coleofasciculus
chthonoplastes

Sphaerospermum

Zapomělová et al. 2009

- fylogenetická pozice
- pozice sferických akinet vedle heterocytů
- morfologie terminálních buněk

