5. Fototrofní SAR

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Místnost 78, 2. mezipatro, Benátská 2

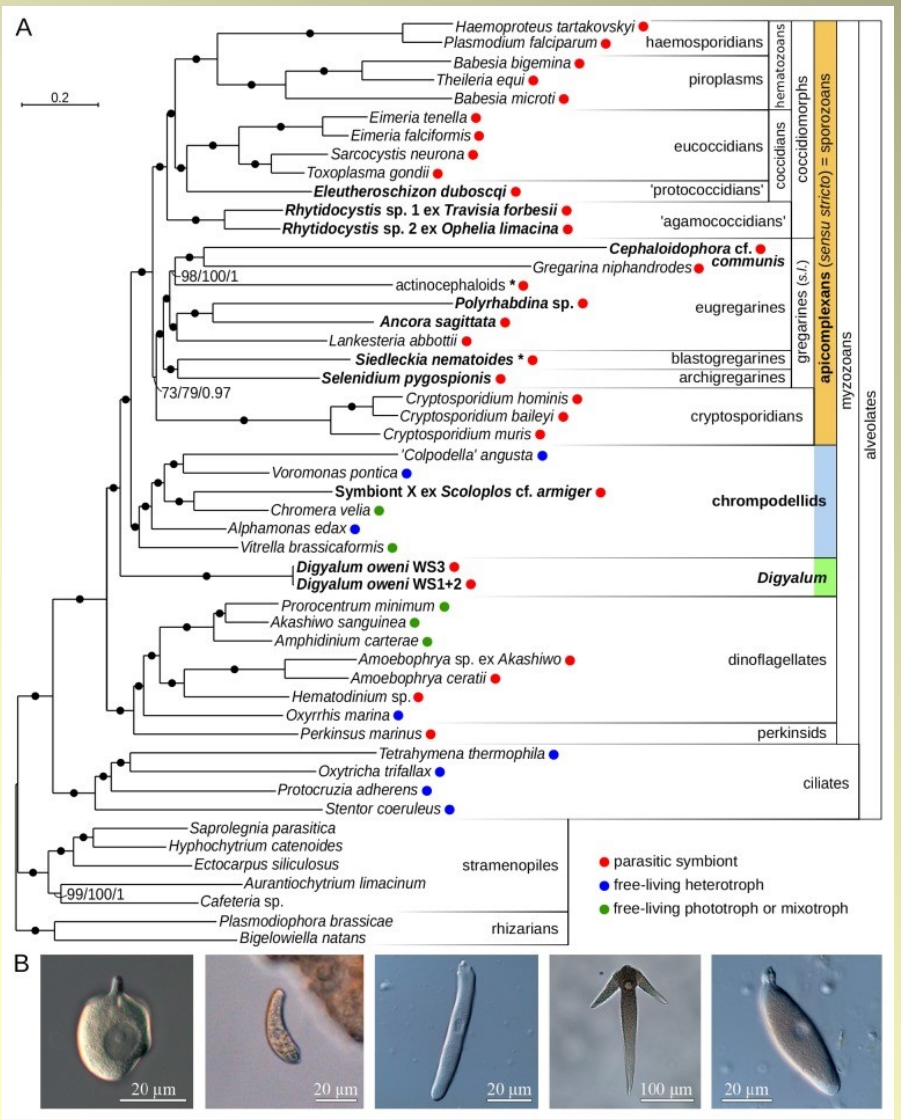
Botanika bezcévných rostlin a protistologie

(MB120P76U)

Přednášky

1) Eukaryotická buňka a její vznik … Tomáš Pánek
2) Systém eukaryot, Excavata … TP
3) Úvod do SAR a heterot. SAR, pohyb, evoluce mnohobuněčnosti … TP
4) Mechorosty … David Svoboda
5) Opisthokonta, Amoebozoa … TP
6) **Fototrofní SAR … Yvonne Němcová**
7) Fototrofní SAR, Haptista, Cryptista … YN
8) Sinice + Archaeplastida (Glaucophyta, Rhodophyta) …YN
9) Archaeplastida (Chloroplastida) … YN
10) Archaeplastida (Chloroplastida)/Mechorosty – pokračování … YN/DS
11) Státní svátek, odpadá výuka
12) Státní svátek, odpadá výuka
13) Lišejníky … DS

ALVEOLATA

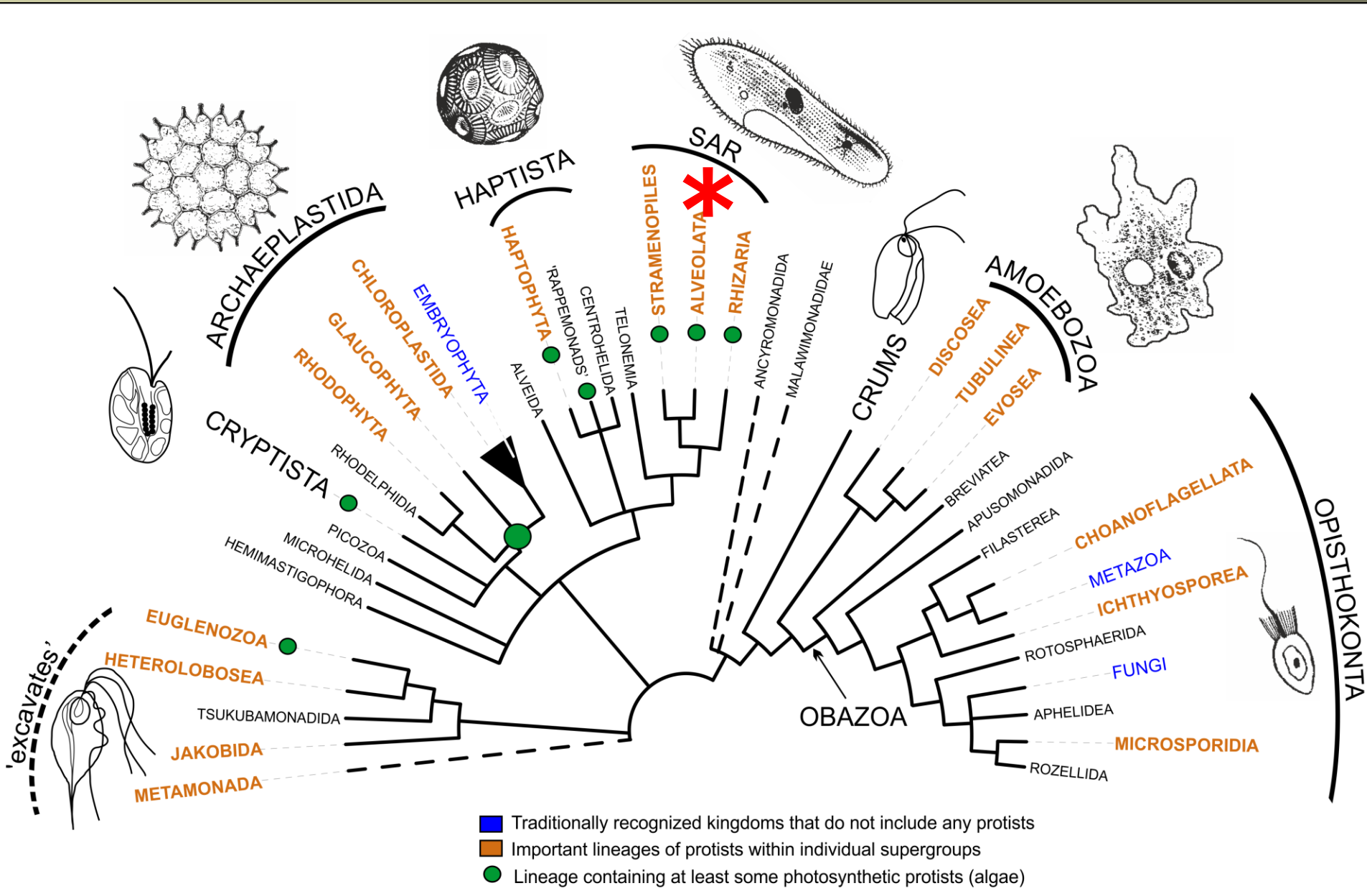


Alveolata – hlavní linie

- **Ciliophora (nálevníci)** – heterotrofní, minule

- **Myzozoa** - volně žijící i fotosyntetičtí
  - Dinoflagellata (obrněnky dnes)
  - Chromerida (dnes)
  - Apicomplexa (minule)

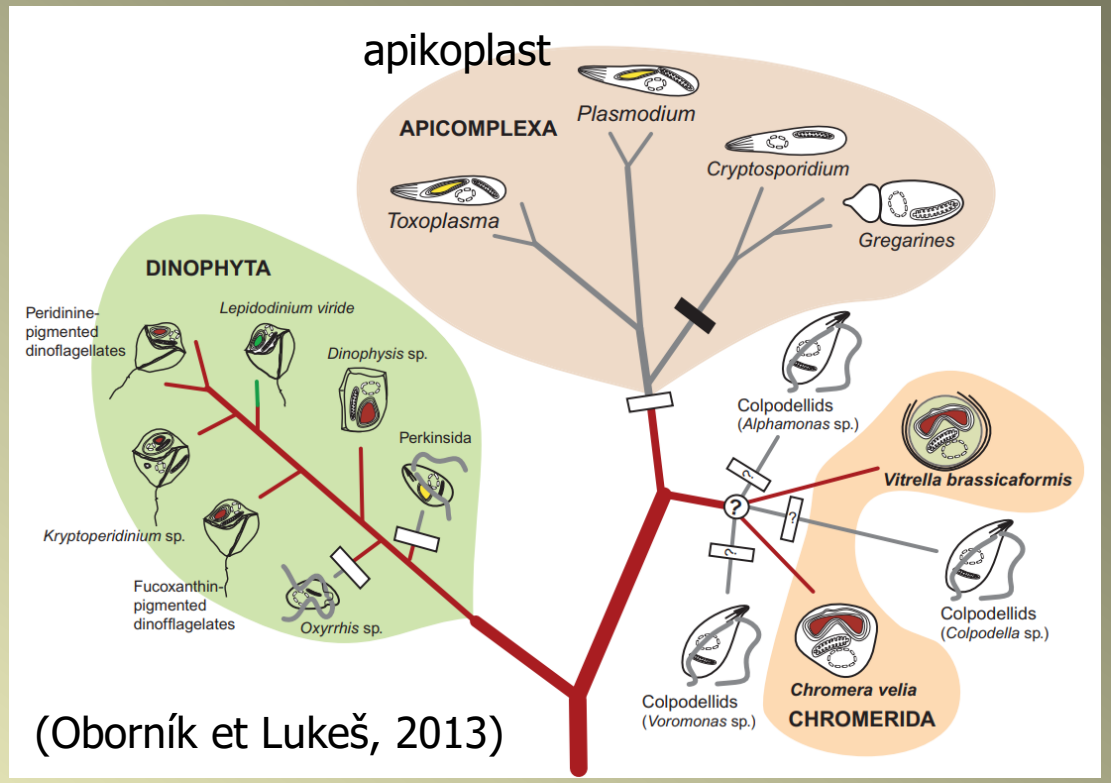
Janouškovec et al. 2019


ARCHAEPLASTIDA
HAPTISTA
SAR
AMOEBOZOA
CRUMS
OBAZOA
OPISTHOKONTA
'excavates'
CRYPTISTA
CHLOROPLASTIDA
GLAUCOPHYTA
RHODOPHYTA
EMBRYOPHYTA
HAPTOPHYTA
'RAPPEMONADS'
ALVEIDA
CENTROHELIDA
TELONEMIA
STRAMENOPILES
ALVEOLATA
RHIZARIA
ANCYROMONADIDA
MALAWIMONADIDAE
DISCOSEA
TUBULINEA
EVOSEA
BREVIATEA
APUSOMONADIDA
FILASTEREA
CHOANOFLAGELLATA
METAZOA
ICHTHYOSPOREA
ROTOSPHAERIDA
FUNGI
APHELIDEA
MICROSPORIDIA
ROZELLIDA
RHODELPHIDIA
PICOZOA
MICROHELIDA
HEMIMASTIGOPHORA
EUGLENOZOA
HETEROLOBOSEA
TSUKUBAMONADIDA
JAKOBIDA
METAMONADA
Traditionally recognized kingdoms that do not include any protists
Important lineages of protists within individual supergroups
Lineage containing at least some photosynthetic protists (algae)

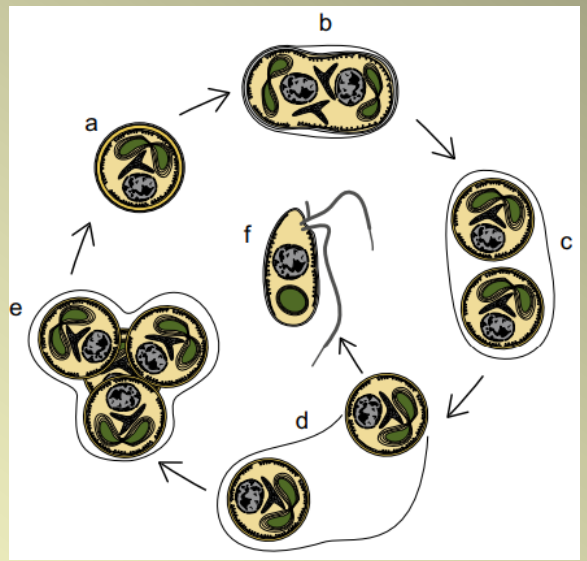
Kde v systému se nacházíme?

Eukaryota
- SAR, Alveolata, Chromerida

Chromera velia



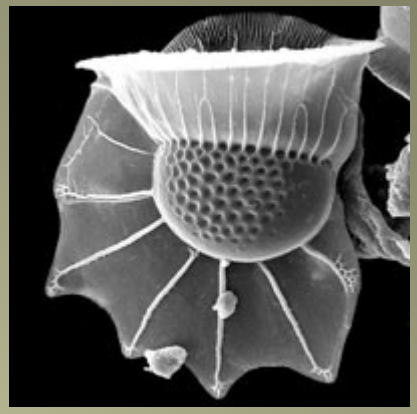
izolována při hledání symbiontů korálu *Plesiastrea versipora* v sydneyském přístavu. Je velmi blízce příbuzná heterotrofním výtrusovcům (kmen Apikomplexa), *ch* a



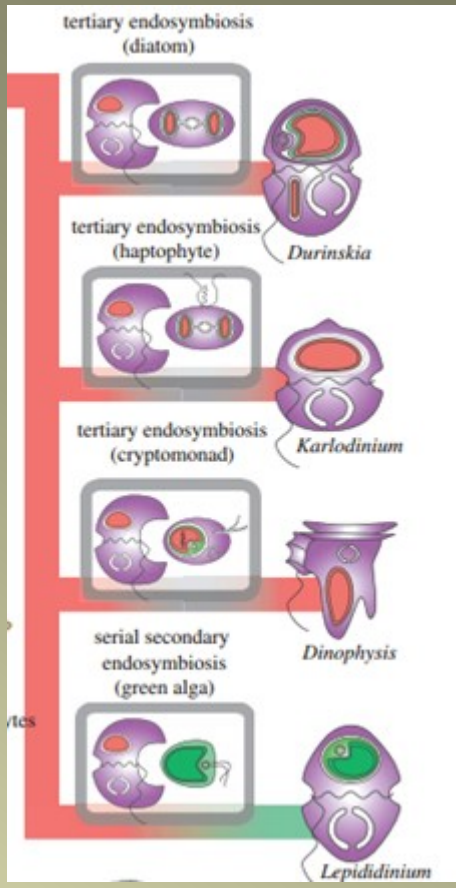
Kde v systému se nacházíme?

Eukaryota

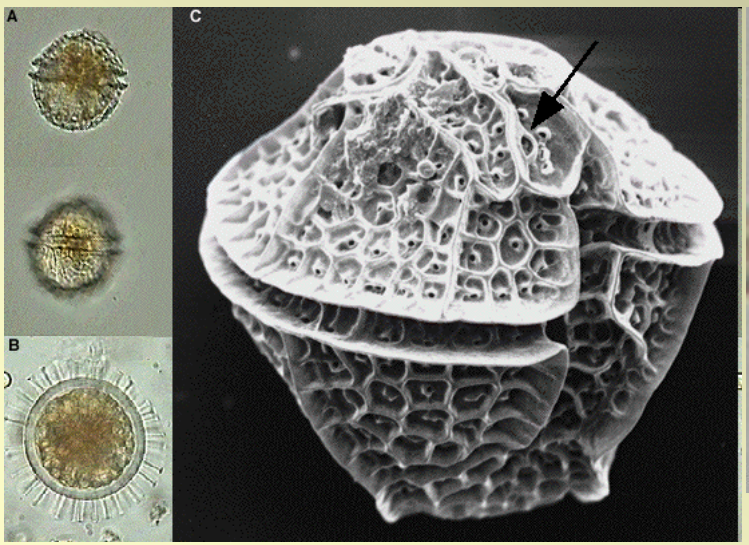
- *SAR, Alveolata*
  - *Dinophyta* (Dinoflagellata) obrněnky



Ornithocercus



heterogenní a velice významná skupina vodních organismů většinou jednobuněční bičíkovci



polovina druhů heterotrofních bez chloroplastů, běžná je fagotrofie
chloroplasty produktem seriálních endosymbióz
histrichosféry - 600 mil. let - prekambrium

peridinin dino-chloroplast with pyrenoid

golgi body

amphiesmal vesicles

trichocyst

part of the cell vacuome

pusules

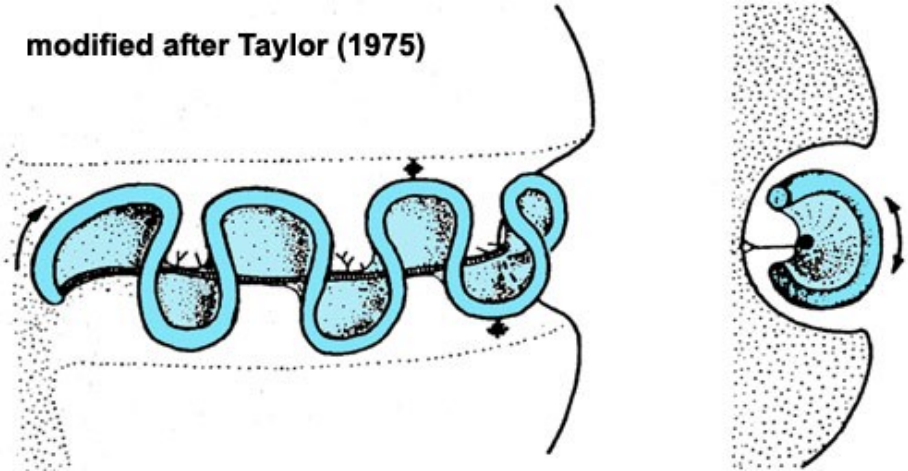
mitochondrion

transverse flagellum

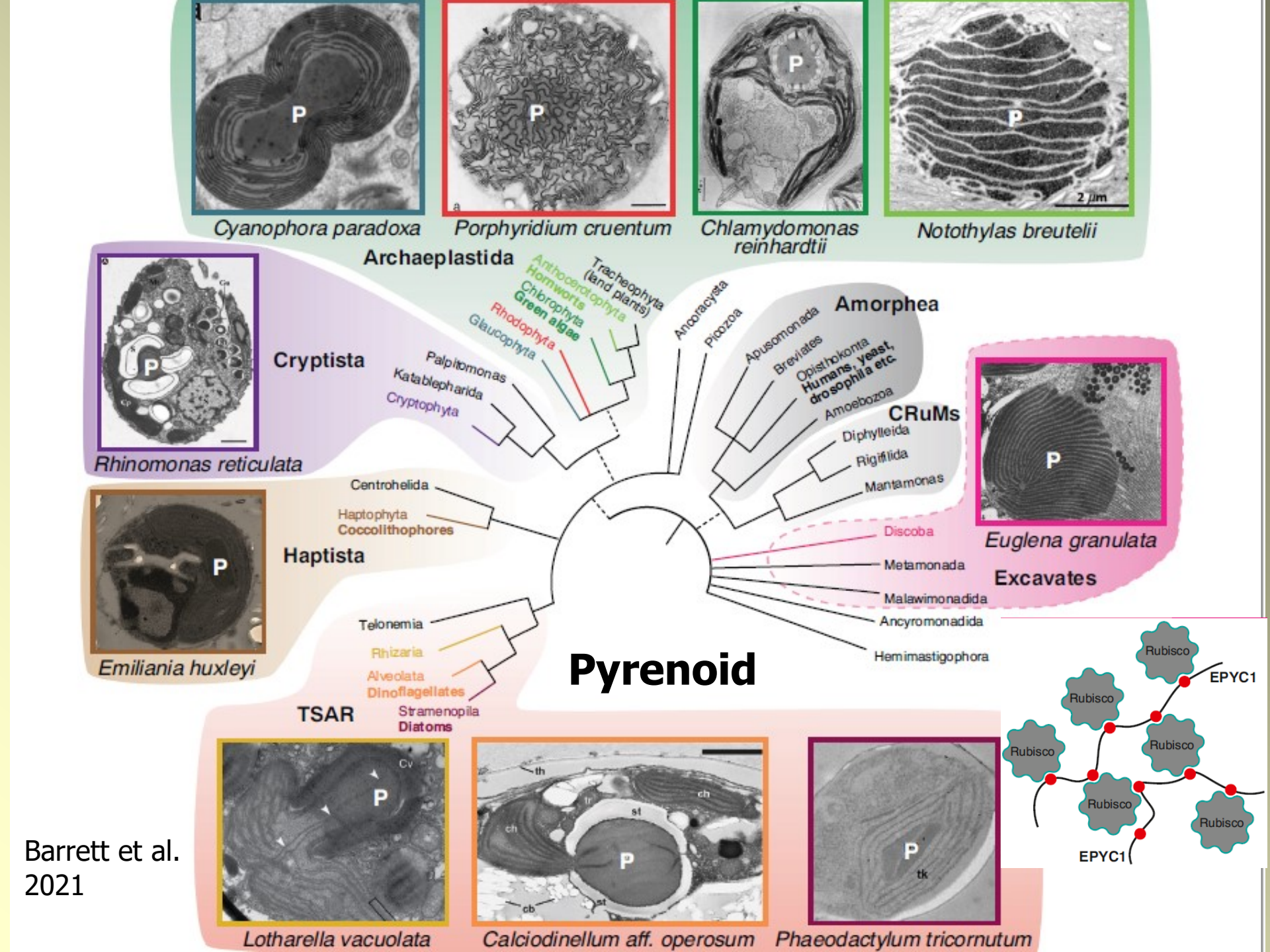
dinokaryon with chromosomes

longitudinal flagellum

modified after Taylor (1975)

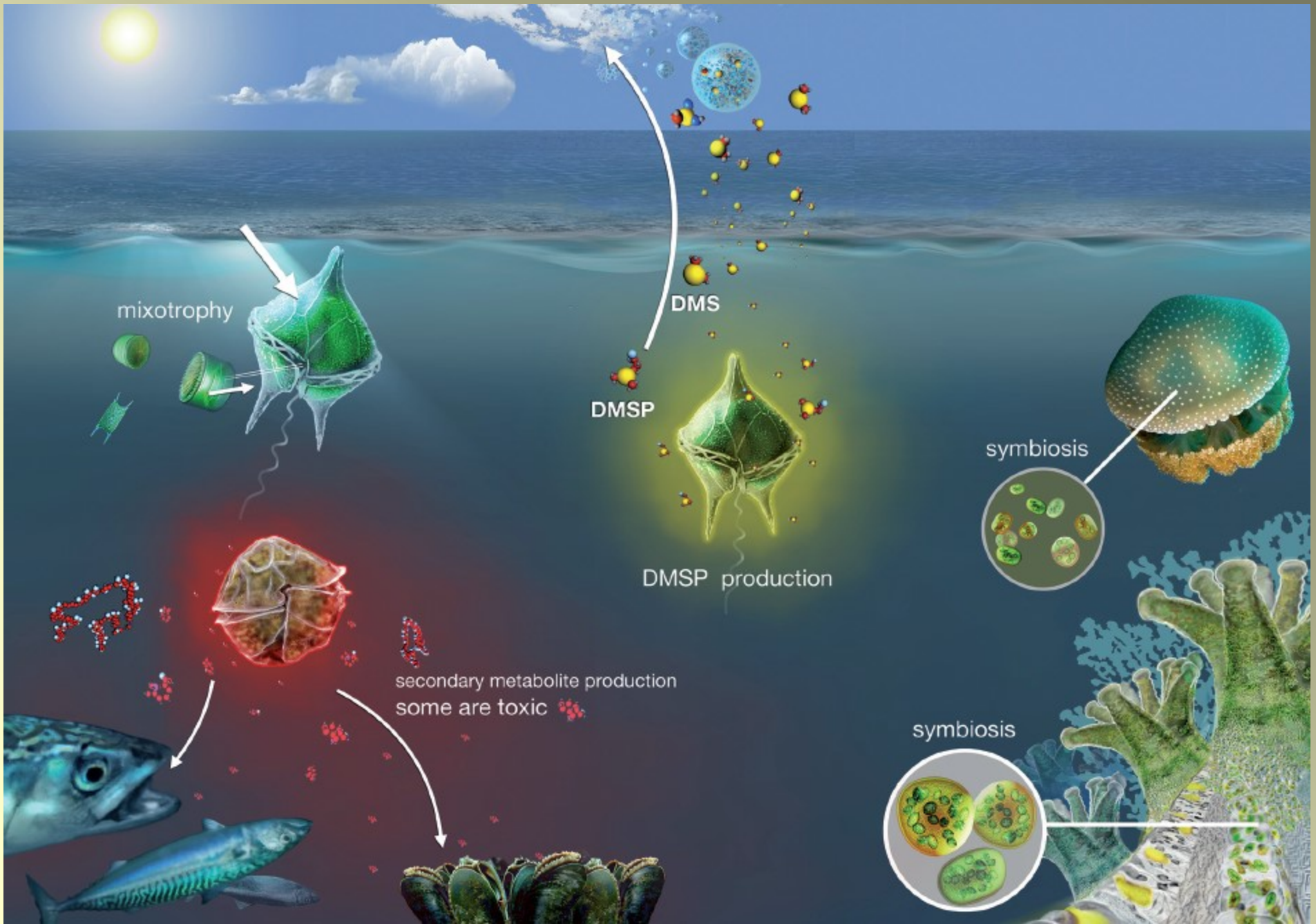


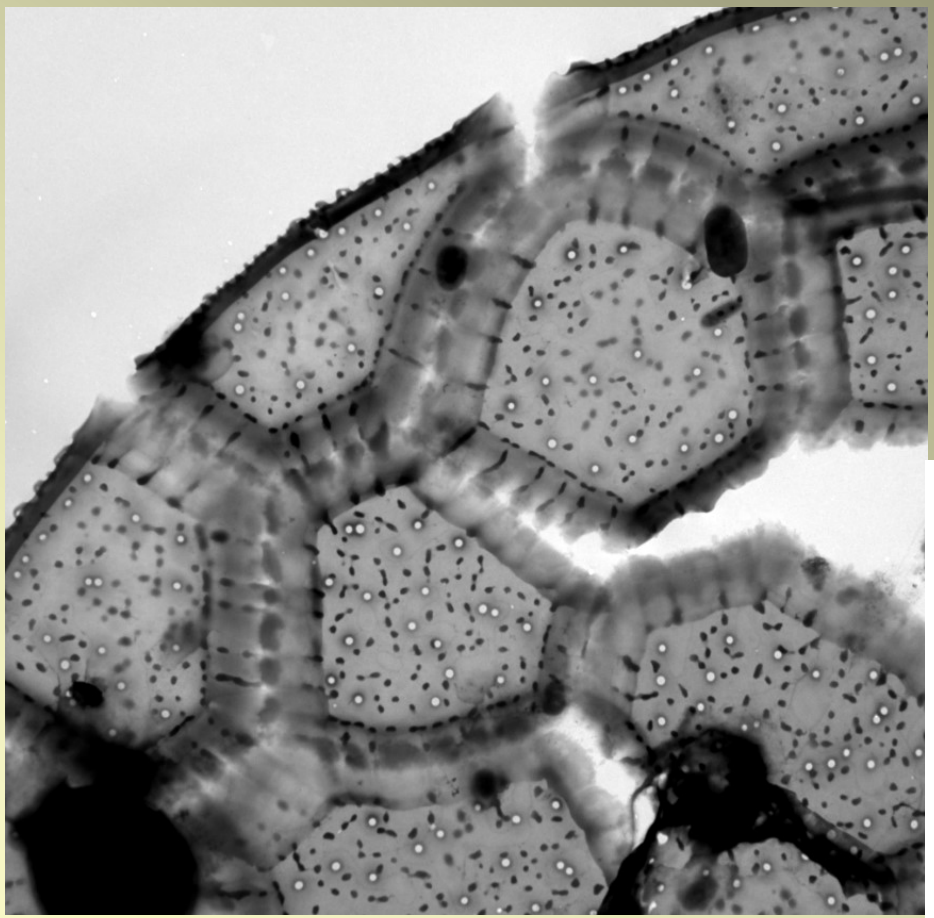
typical motile thecate cell



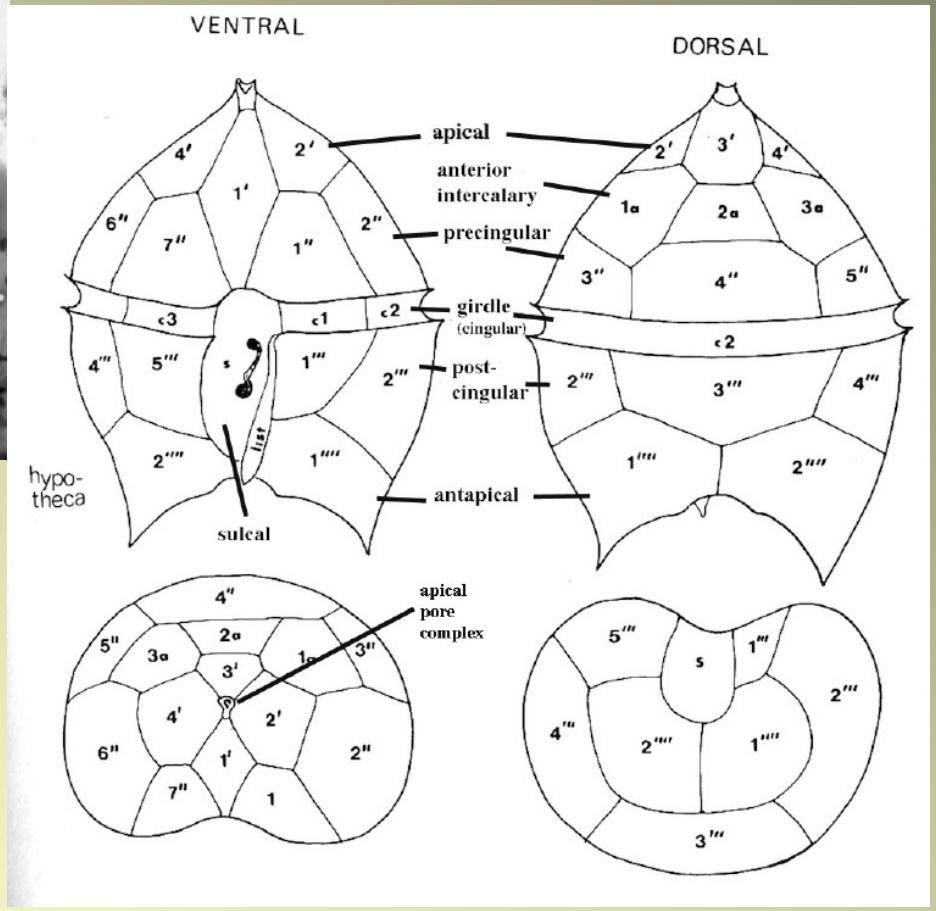
Barrett et al. 2021

Ekologické role obrněnek





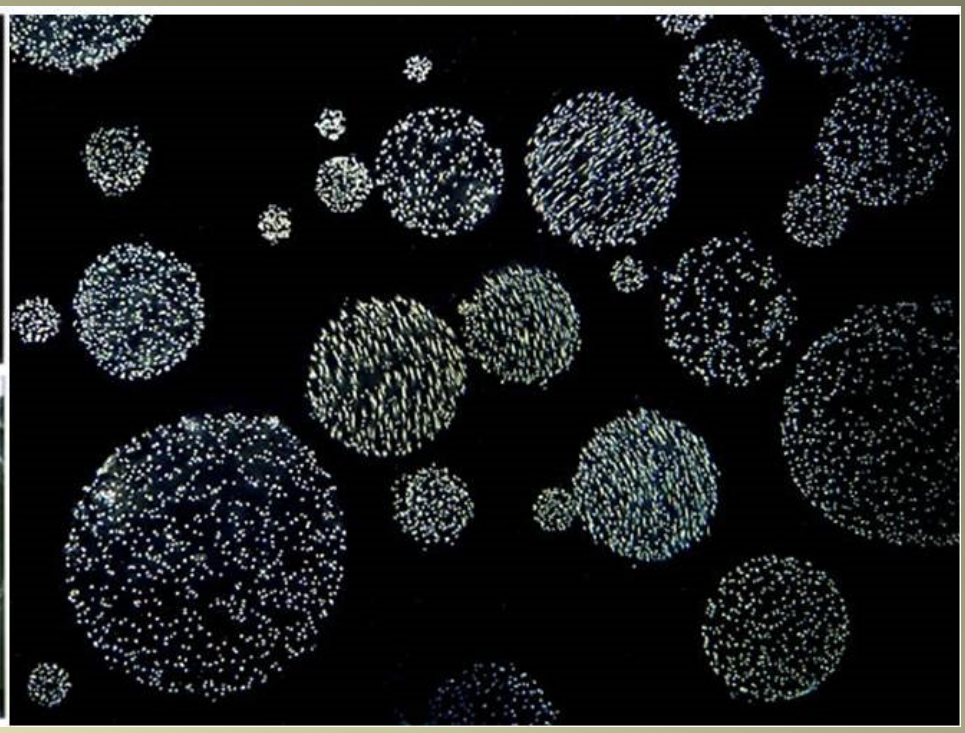
théka složená z destiček



poloha a počty destiček důležitým znakem pro určování

Kleptoplastidy, „ukradené“ plastidy, pocházejí z haptofyta *Phaeocystis antarctica*

obrněnka *Karenia*

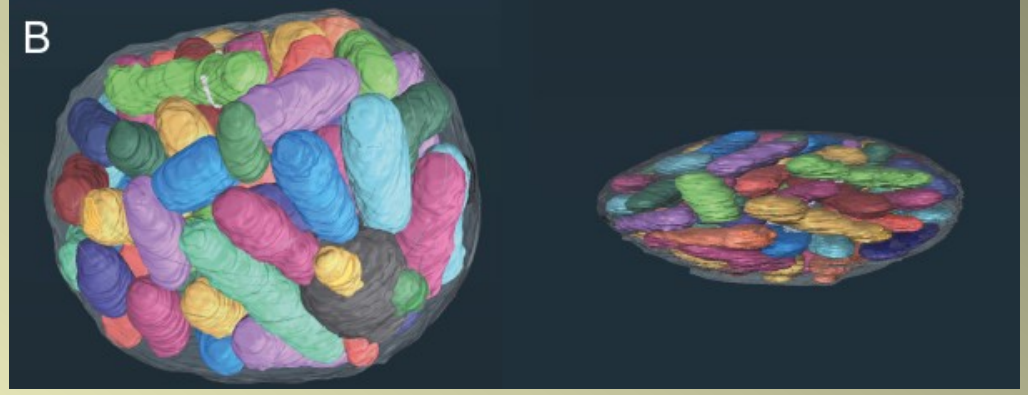


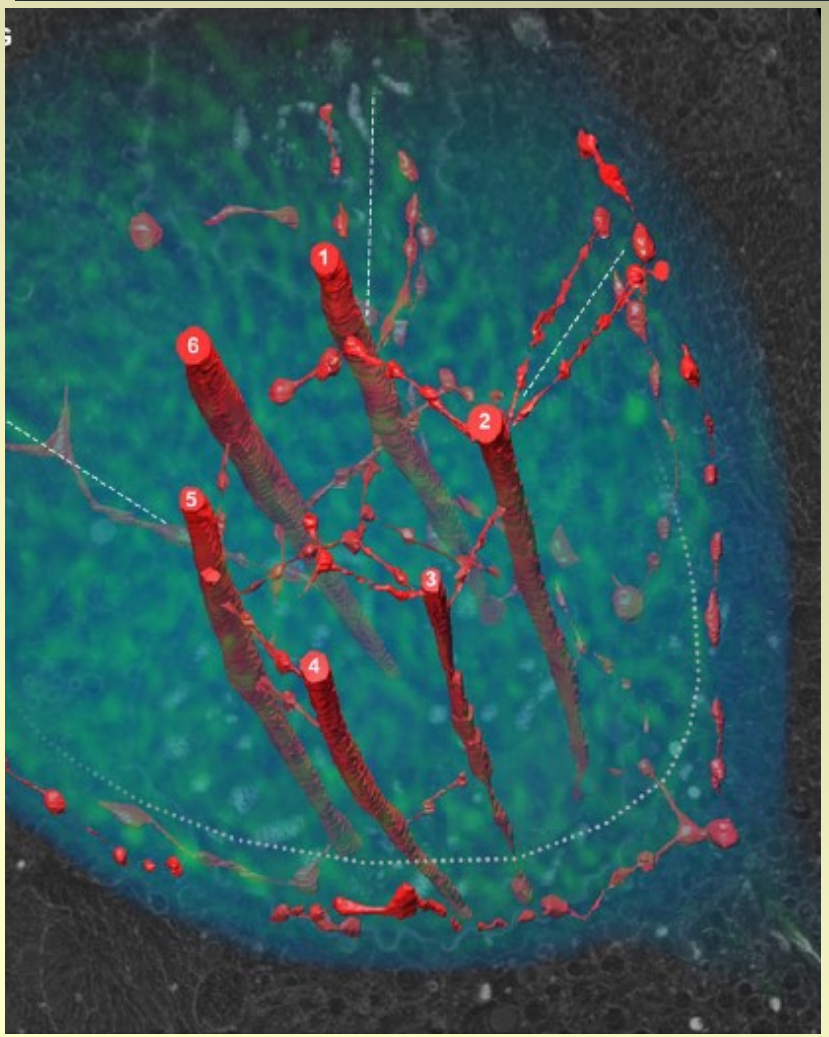
Ross Sea, Antarctica

tvoří vodní květy v Rossově moři

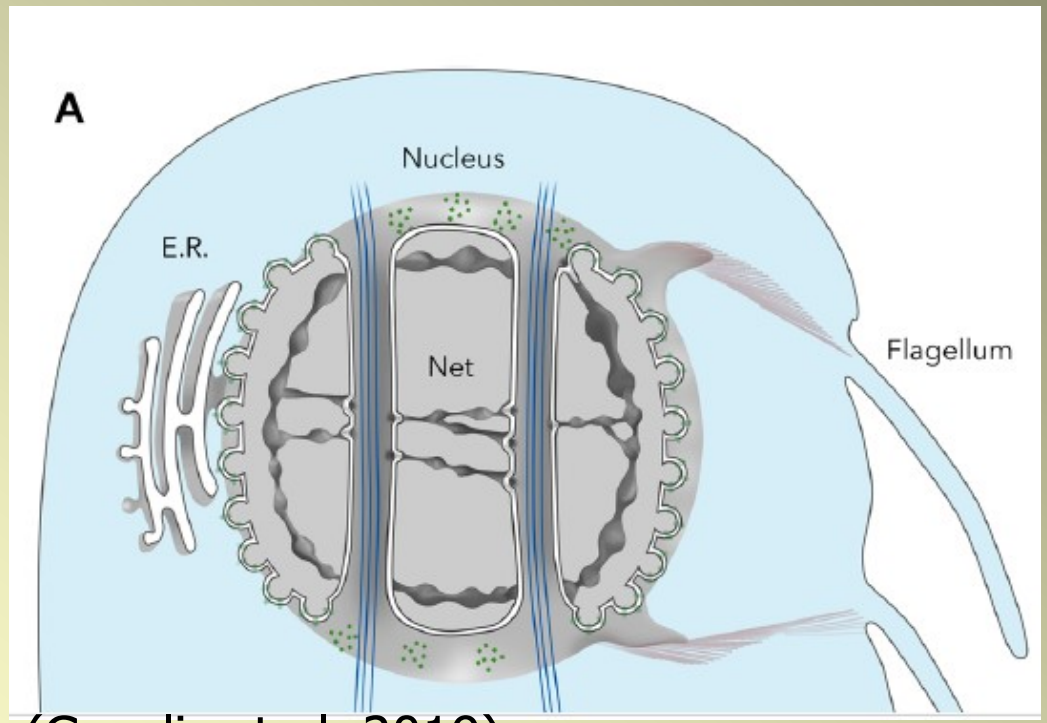
Příjem plastidů rychlý (cca 2 dny), vydrží několik měsíců. Dormantní stádia (cysty) obsahují vysoký počet životaschopných plastidů z haptofyta.

(Gast et al. 2007)



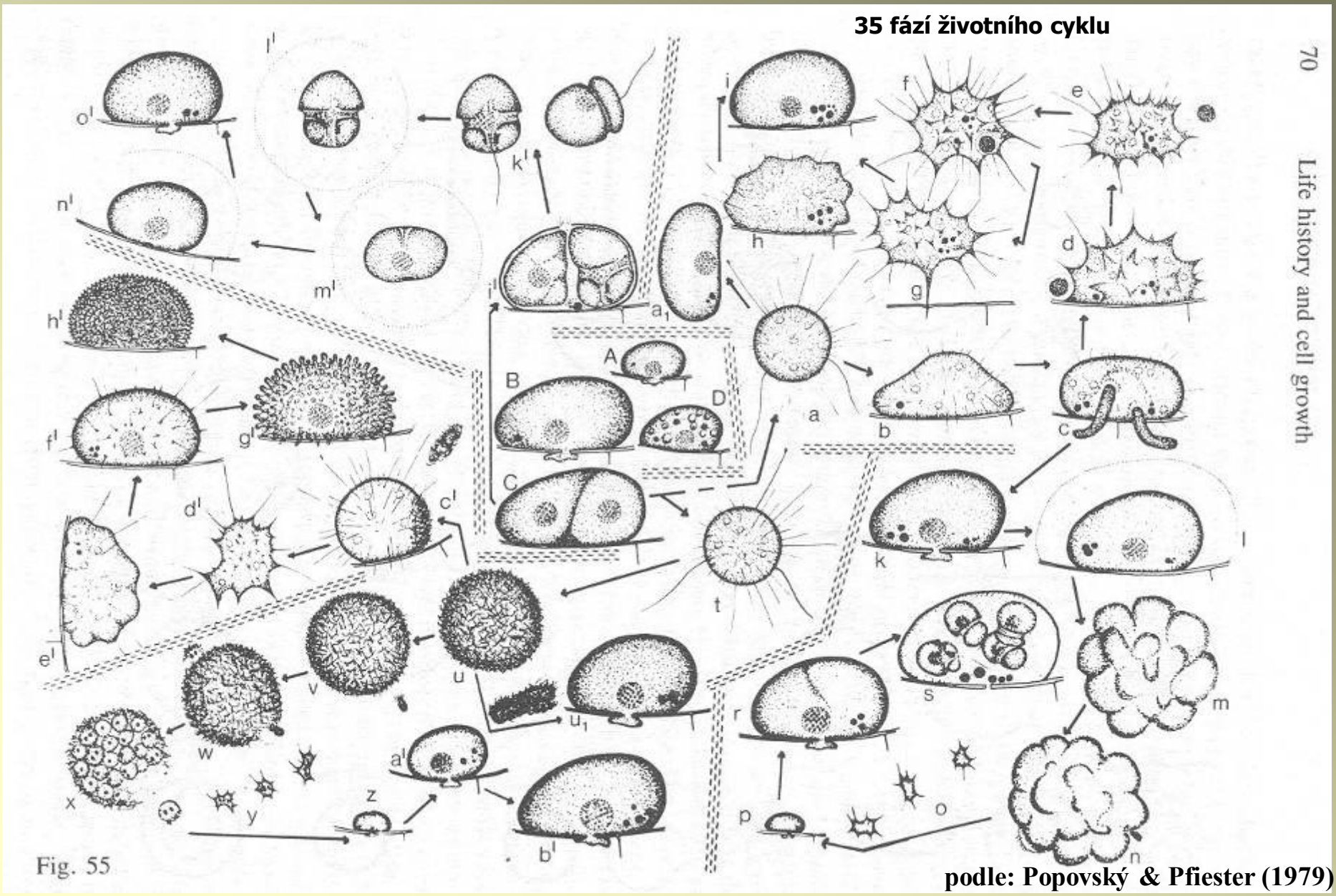


dinokaryon - jádro bez histonů s permanentě kondenzovanou DNA

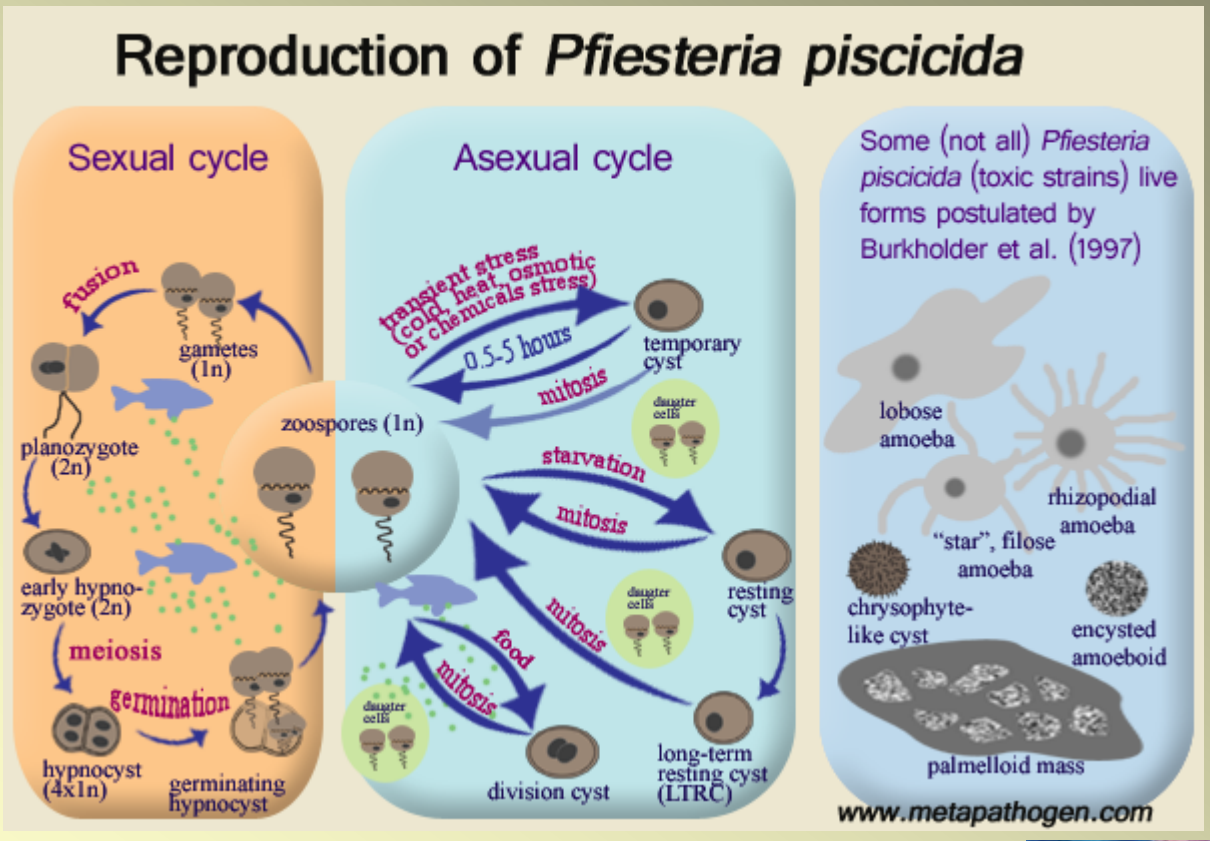


(Gavelis et al. 2019)

Cystodinedria inermis - polymorfní životní cyklus (nebo omyl?)



Pfiesteria piscicida

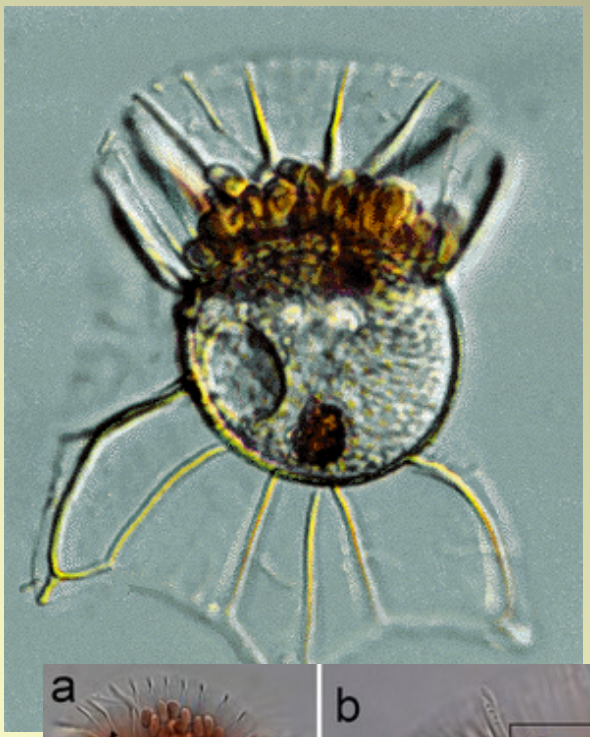


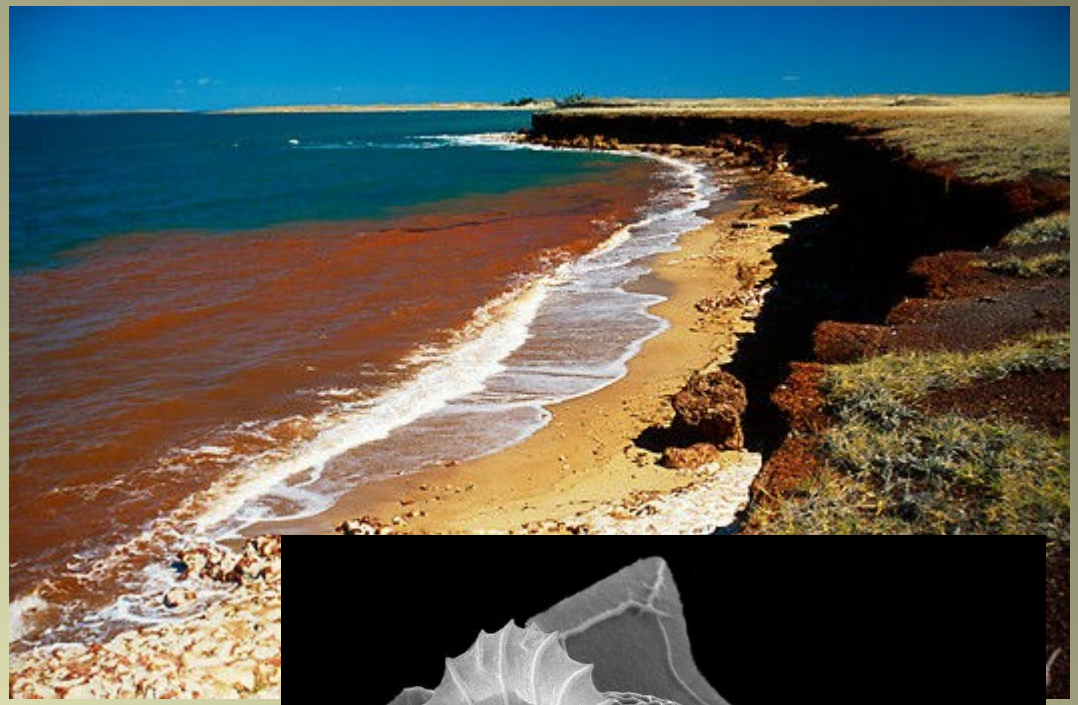
Chesapeake Bay, Maryland, léto 1997, toxické populace

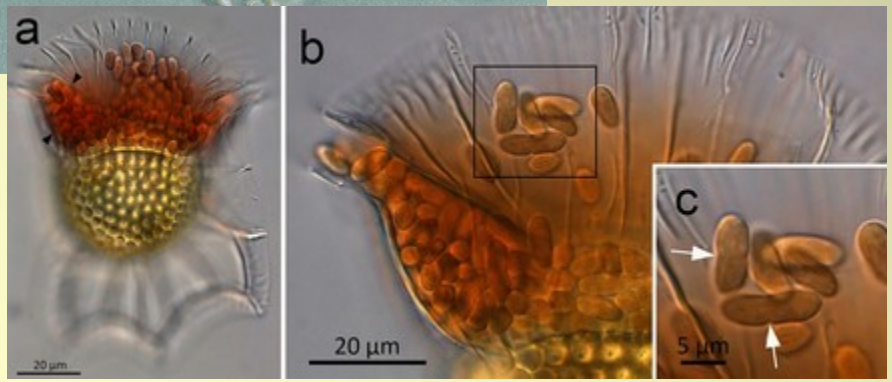
nebezpečný parazit ryb, vyjímečně i lidí

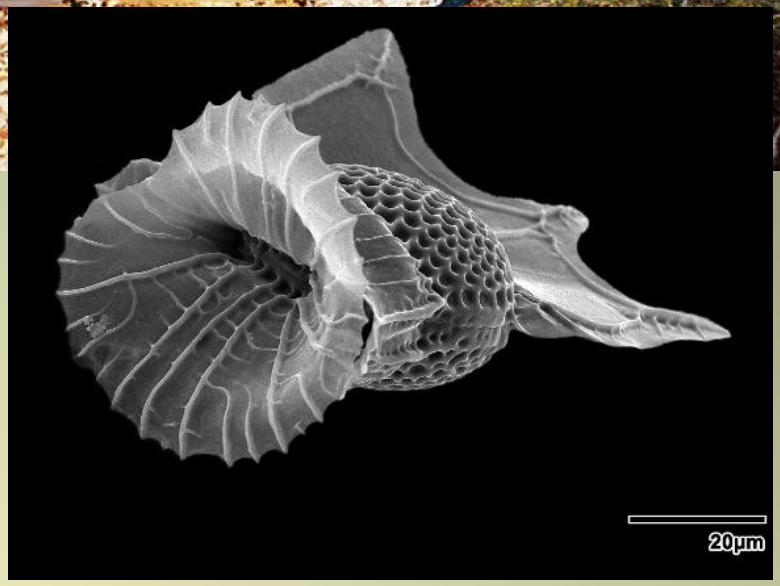
Dinophysis - red tides, toxiny v mořské vodě, Baltské moře

Ornithocercus





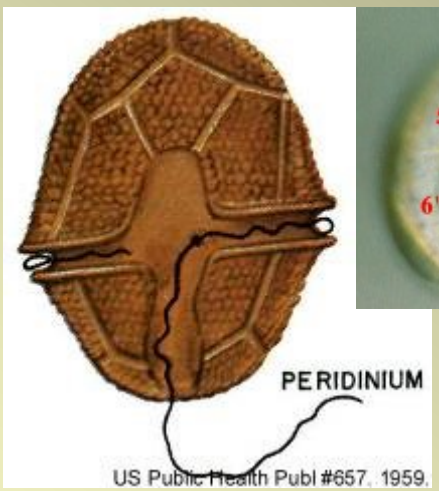


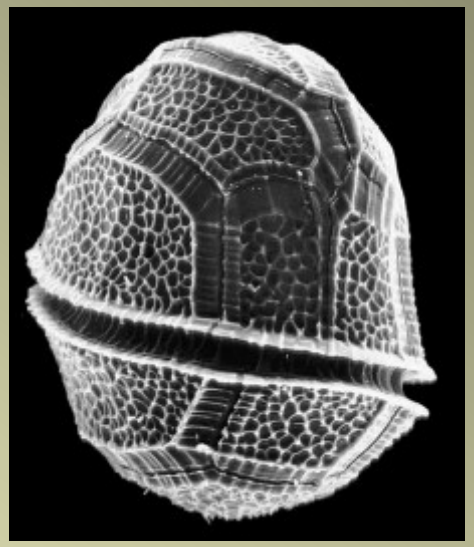


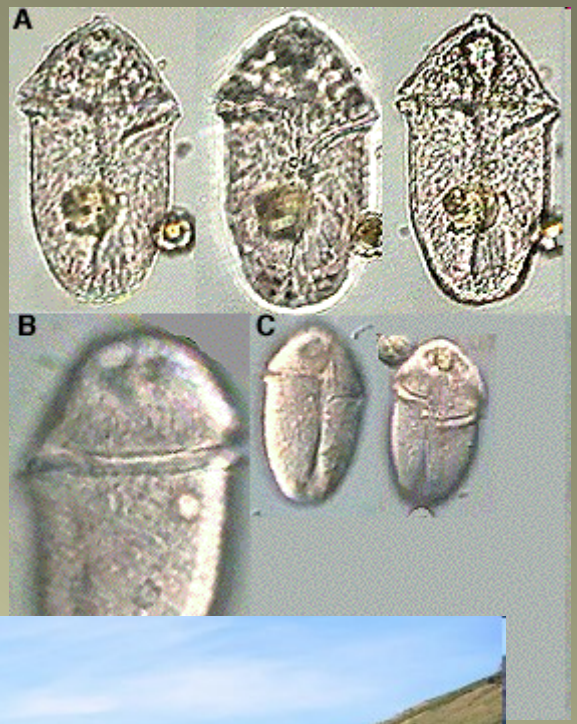
symbiotické, heterocytární sinice namísto chloroplastů
tropický mořský plankton, proxi pro změnu klimatu

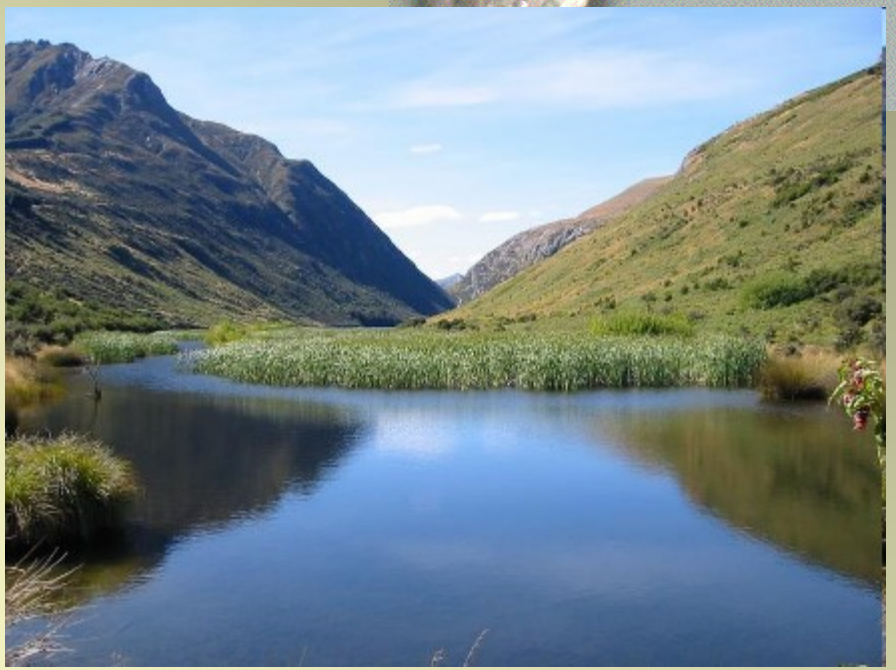
Peridinium

Gymnodinium









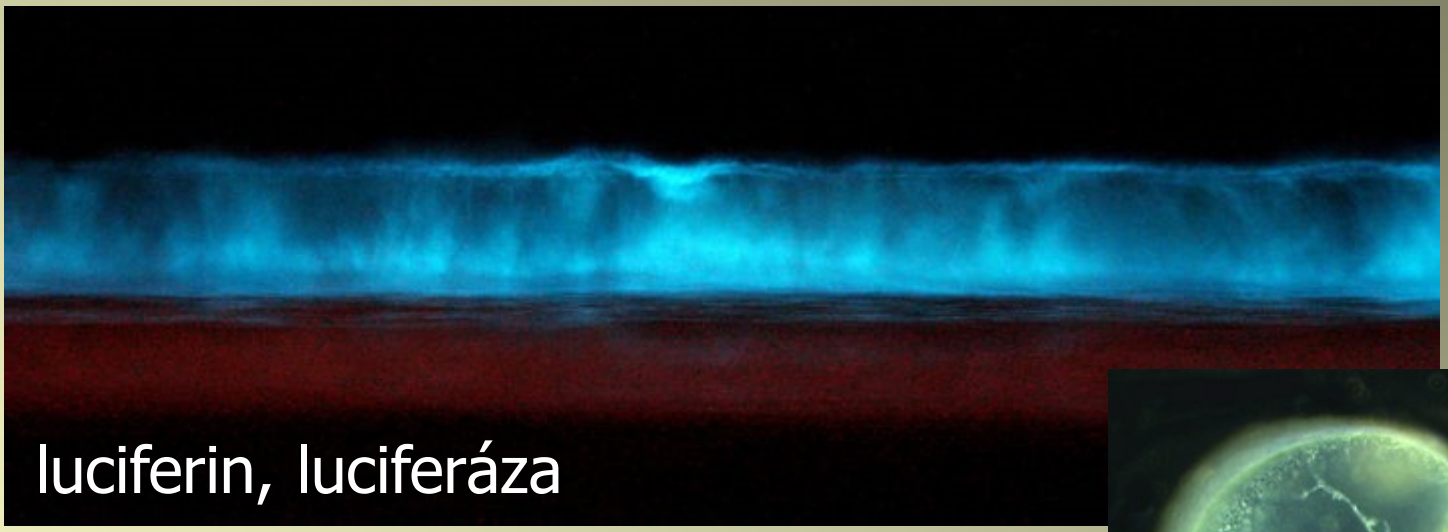
sladkovodní obrněnky

Ceratium - naše nejhojnější obrněnky

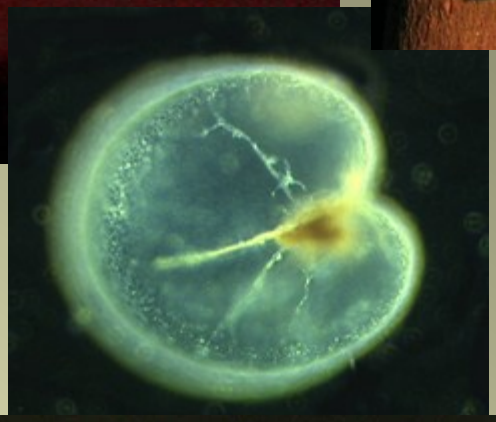
C. hirundinella

C. cornutum

Noctiluca scintilans

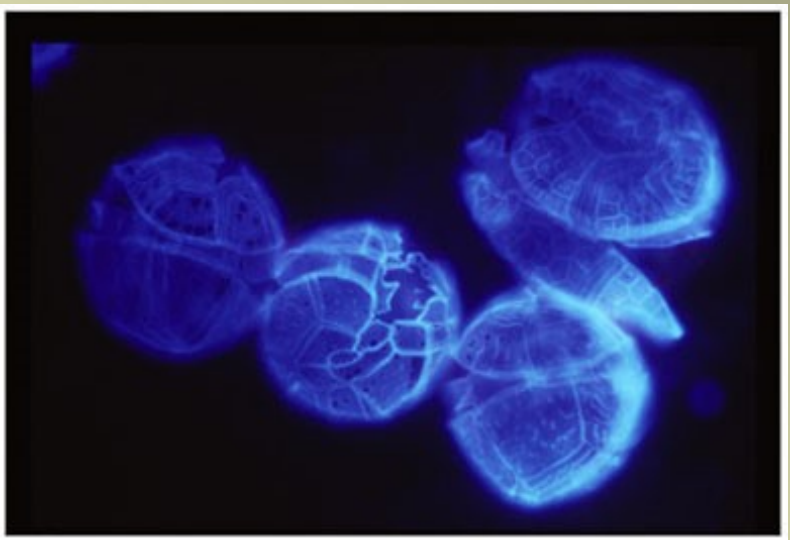


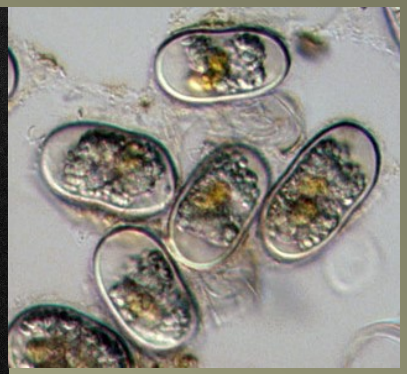
luciferin, luciferáza



bioluminiscence
scintilony - specializované organely

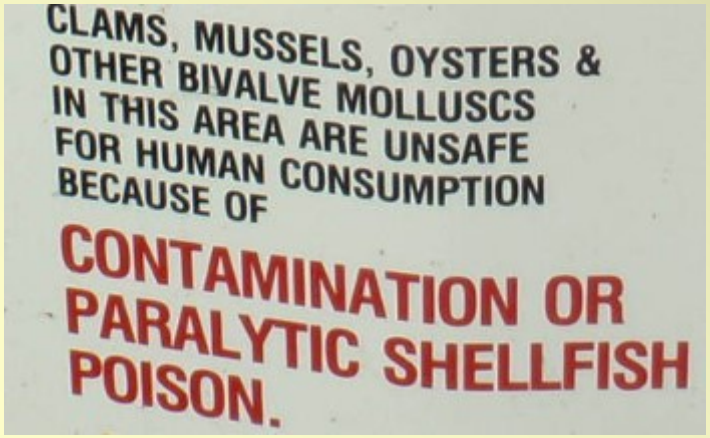
Alexandrium - cysty pomáhají přežít nepříznivé období (zimu); šíření na nová území, neurotoxin (saxitoxin)





hromadění toxinů během potravního řetězce, otrava příznaky do 30 min.

Vancouver (Canada) květen 2012



Plague #1 - Water turns to blood and fish die

Exodus 7:17-18

Thus says the LORD, "By this you shall know that I am the LORD: behold, with the staff that is in my hand I will strike the water that is in the Nile, and it shall **turn into blood**. The **fish** in the Nile **shall die**, and the Nile will stink, and the Egyptians will grow weary of drinking water from the Nile."

Libanon - Beirut River

Austrálie Sydney - Bondi Beach

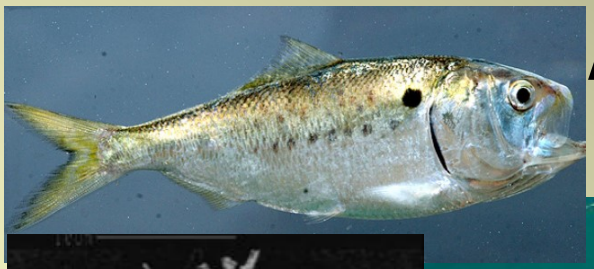
China's Yangtze River

řeka Nil

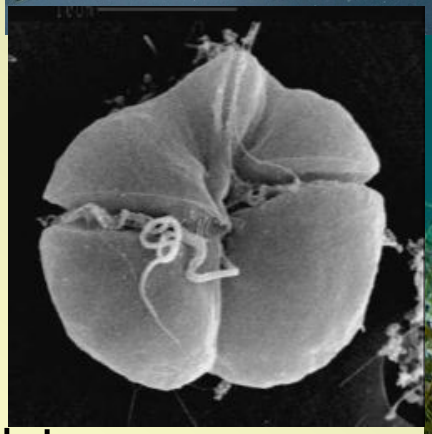
Karenia brevis – Florida, Mexický záliv, brevetoxiny – úmrtí ryb, ale i velkých savců (Florida 2002: 34 kapustňáků; 2004: 107 delfínů)

Proč Florida???

Brevoortia spp.

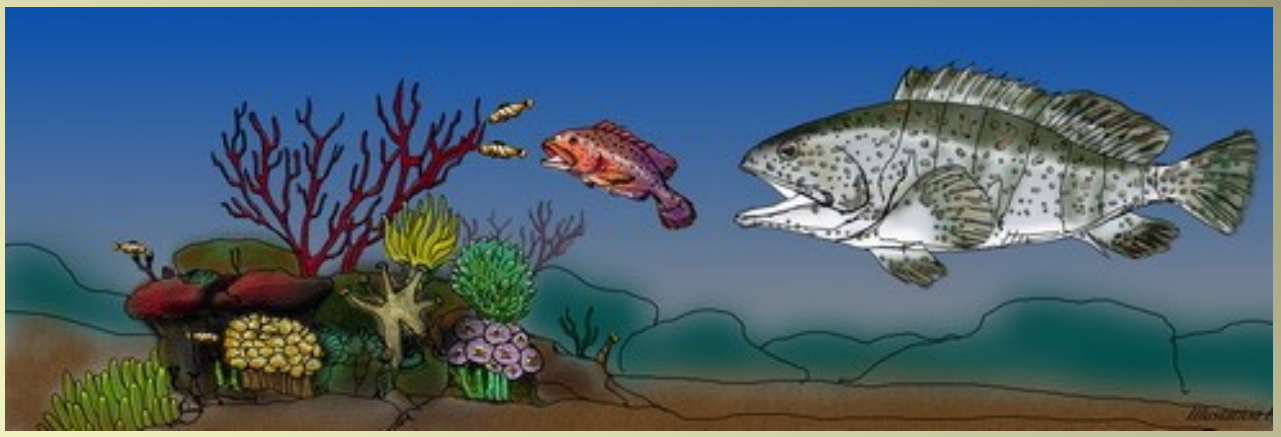


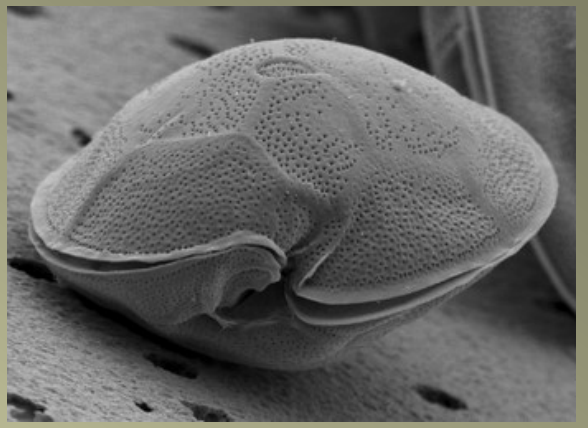
Thalassia testudinum

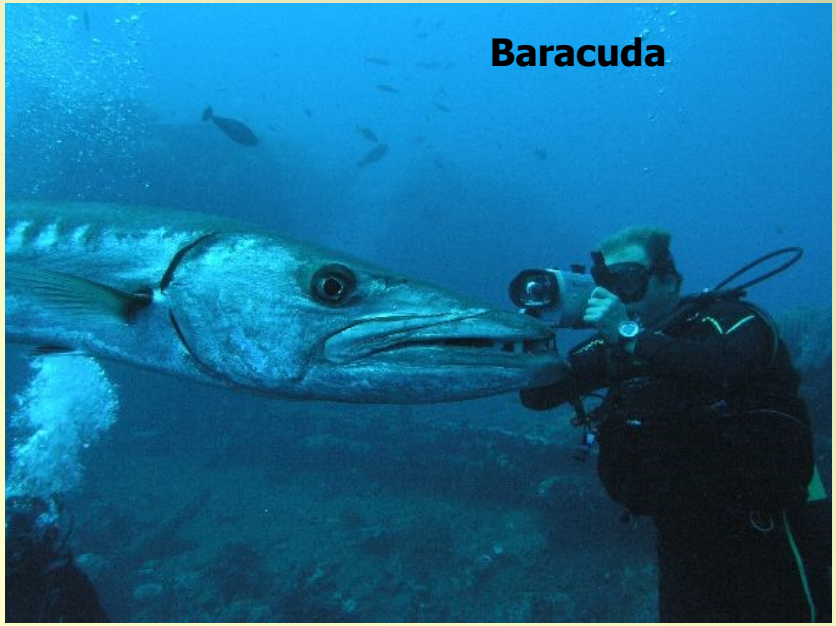


Leanne et al. (2005), Nature

Gambierdiscus toxicus – tropická a subtropická moře, epifyticky na korálech a makrořasách, bioakumulace v potravním řetězci, ciguatoxin obsažen ve velkých dravých rybách

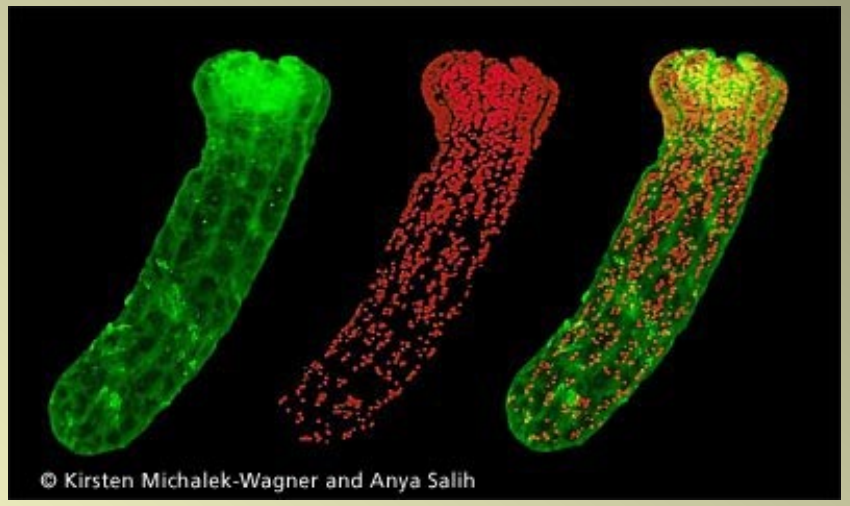






Kuba r. 1800

Ekosystém korálových útesů

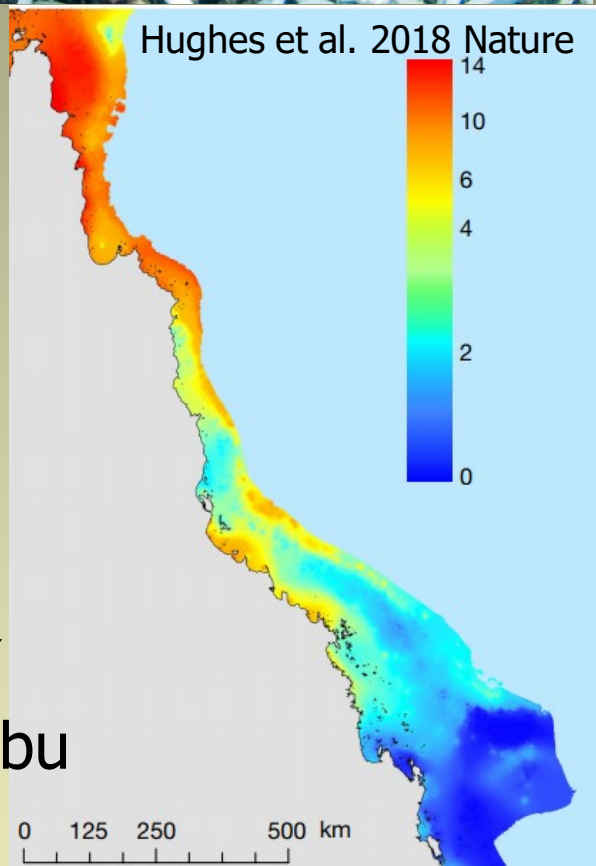


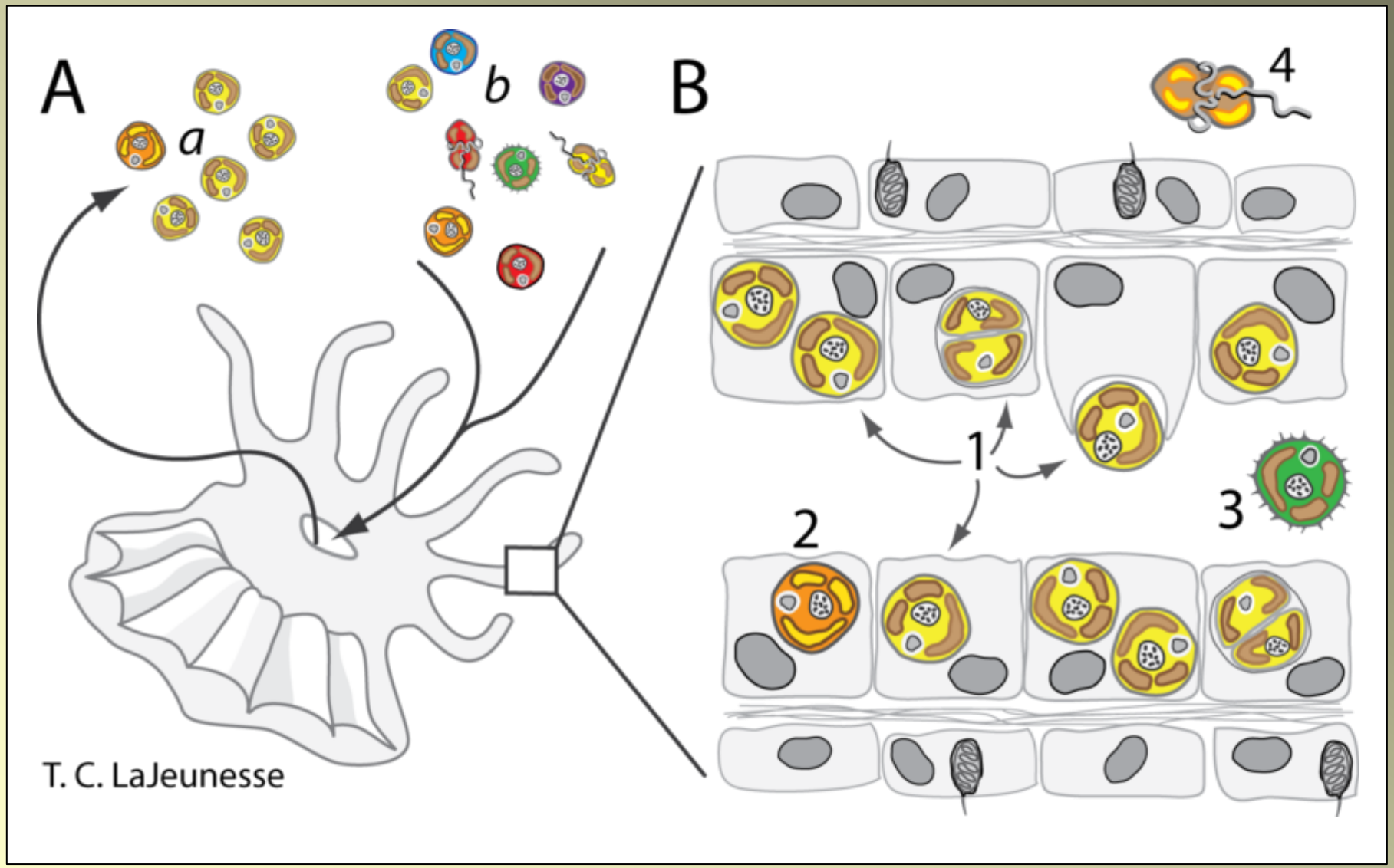
Měkký korál (*Lobophytum compactum*) zeleně – tkáň polypa, červeně *Symbiodinium*

Symbiodinium - obrněnka

2016 Coral bleaching event

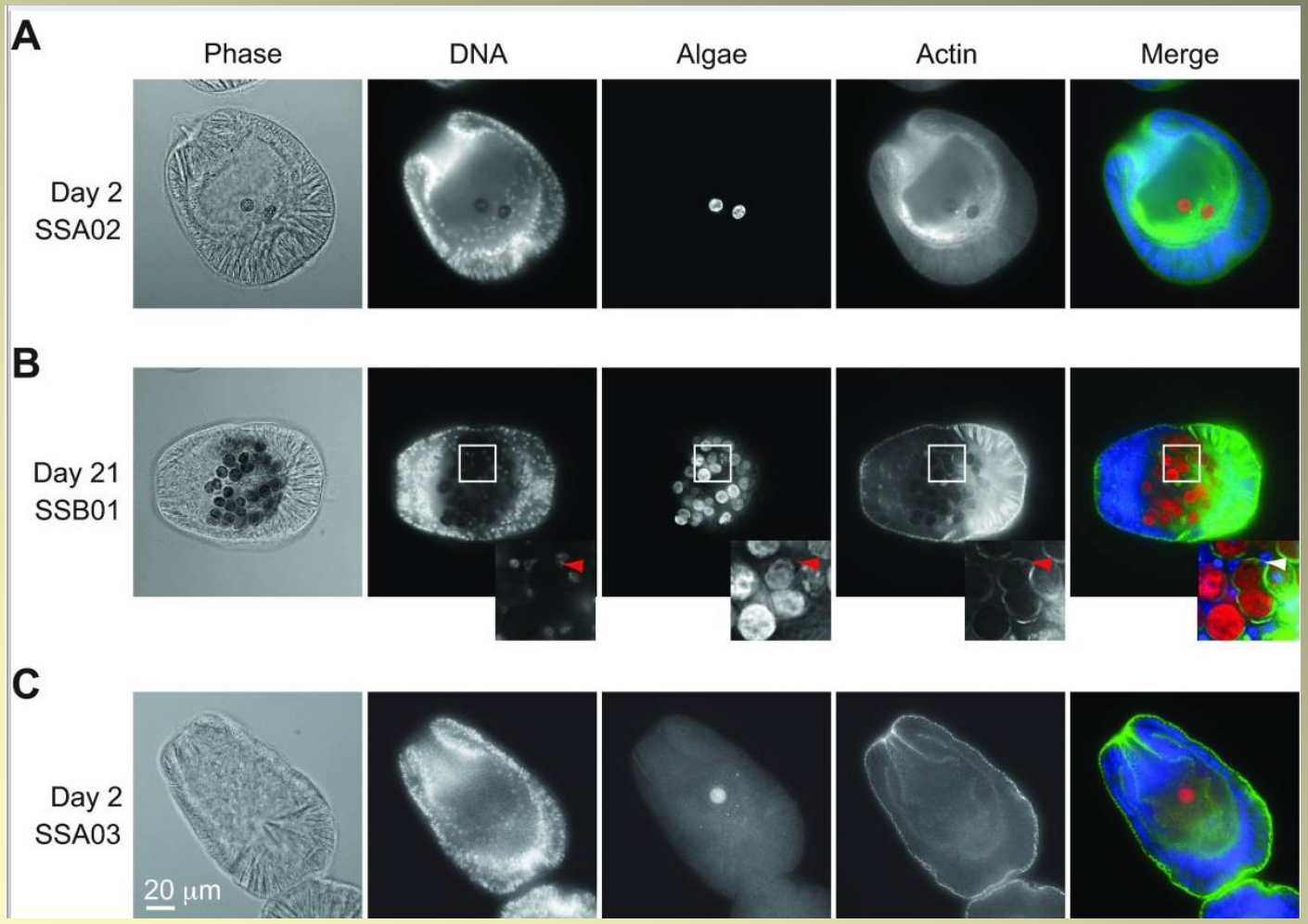
- dříve cyklony, hvězdice, El Niño
- 2016 El Niño v kombinaci s globálním oteplováním
- vyšší t – vypudí Symbiodinium
- stupnice popisující míru oteplení a dobu vystavení





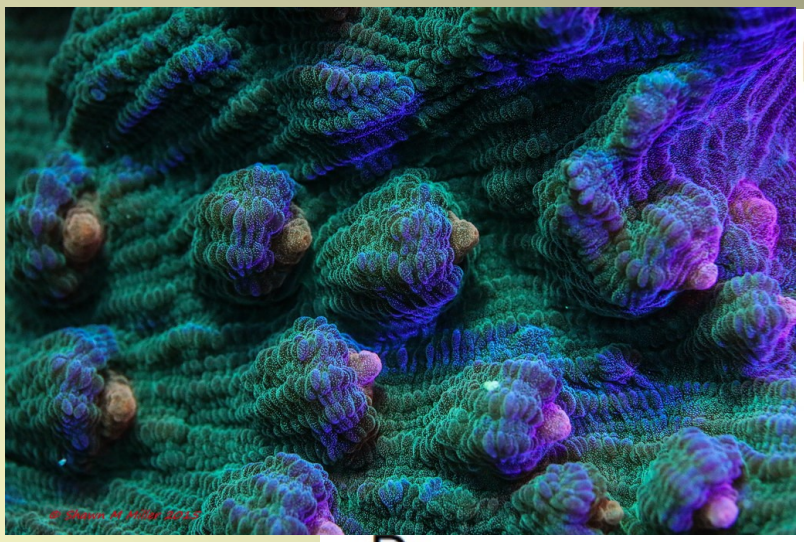
Žahavci uvolňují miliony buněk do prostředí (a) velké objemy vody protékají gastrovaskulárním systémem – přináší malé částečky potravy spolu s dalšími b.*Symbiodinium* spp. (b)

Hambleton et al. 2014

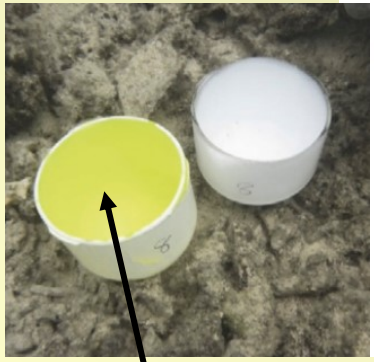


larva *Aiptasia pallida* s kompatibilním kmenem *Symbiodinium* (A,B) a nekompatibilním (C). (A,B) kumulace buněk uvnitř gastrodermálních buněk hostitele. (C) nekompatibilní *Symbiodinium* uvnitř trávící dutiny ne v gastrodernálních buňkách – bude stráveno

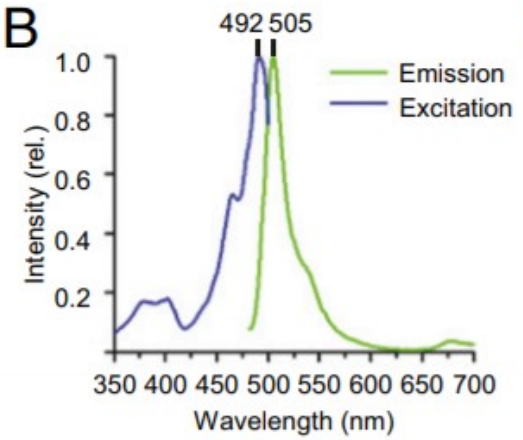
Jak přilákat *Symbiodinium*?

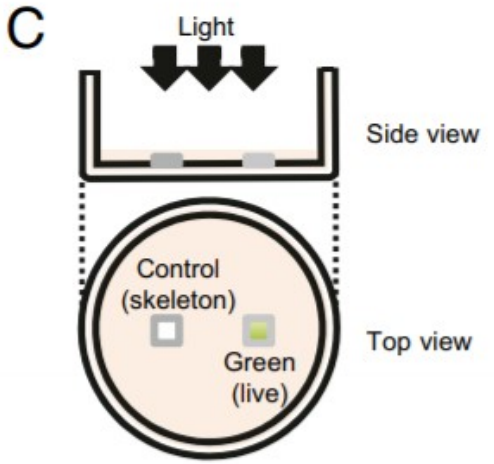


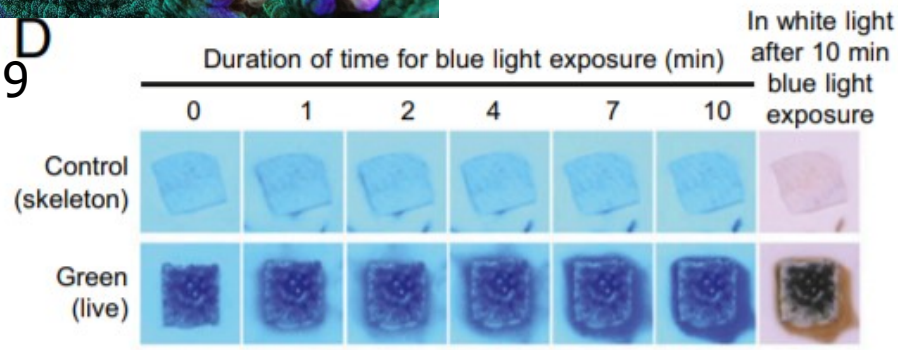
Aihara et al. 2019

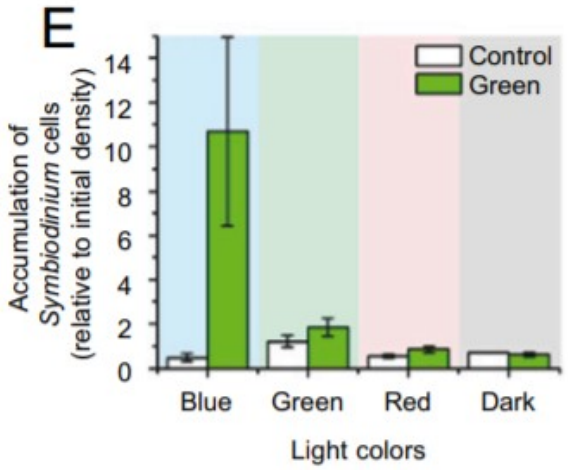


past se zeleným fluorescenčním barvivem

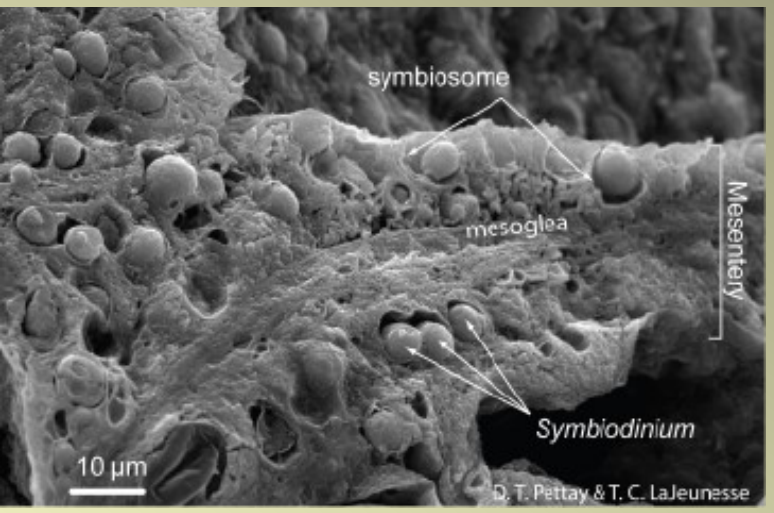


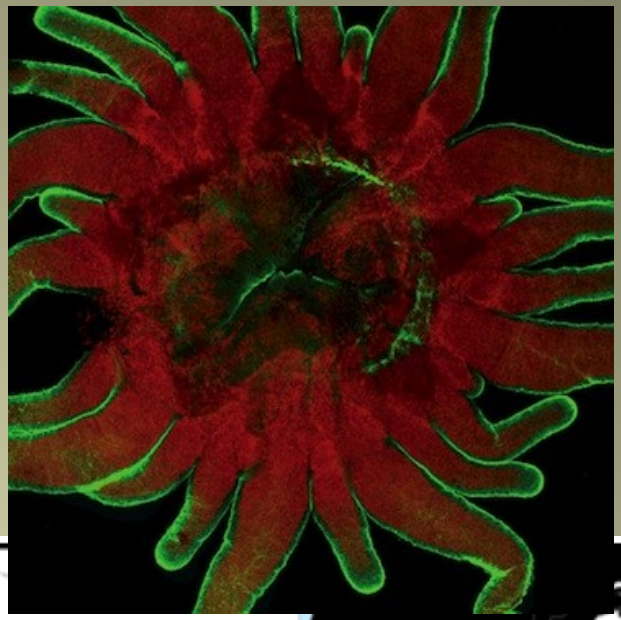




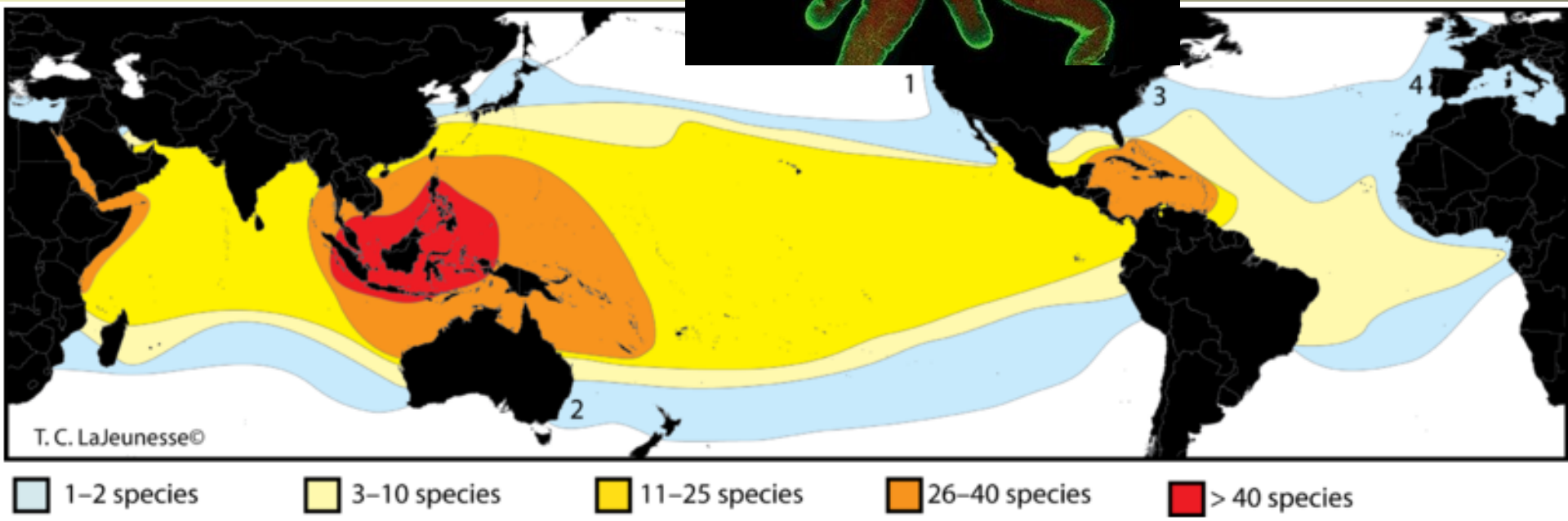


Echinophyllia aspera – korál; GFP – excitace modrým světlem – vyzařování zelené fluoresc. *Symbiodinium* aktivně přitahováno - fototaxe





mořská sasanka
Aiptasia pallida
Symbiodinium - červeně



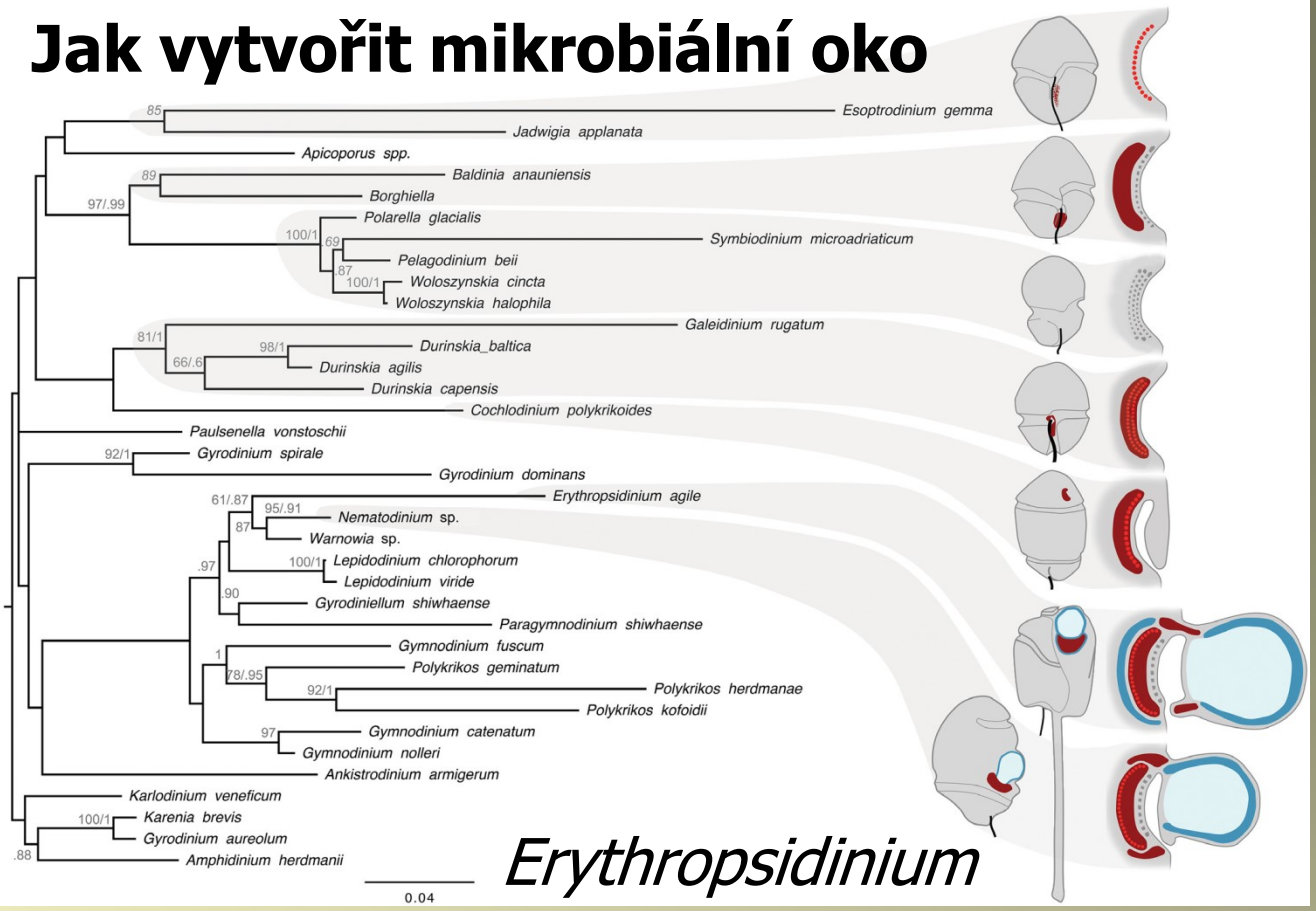
Distribuce a odhady diverzity druhů rodu *Symbiodinium* asociovaných s žahavci

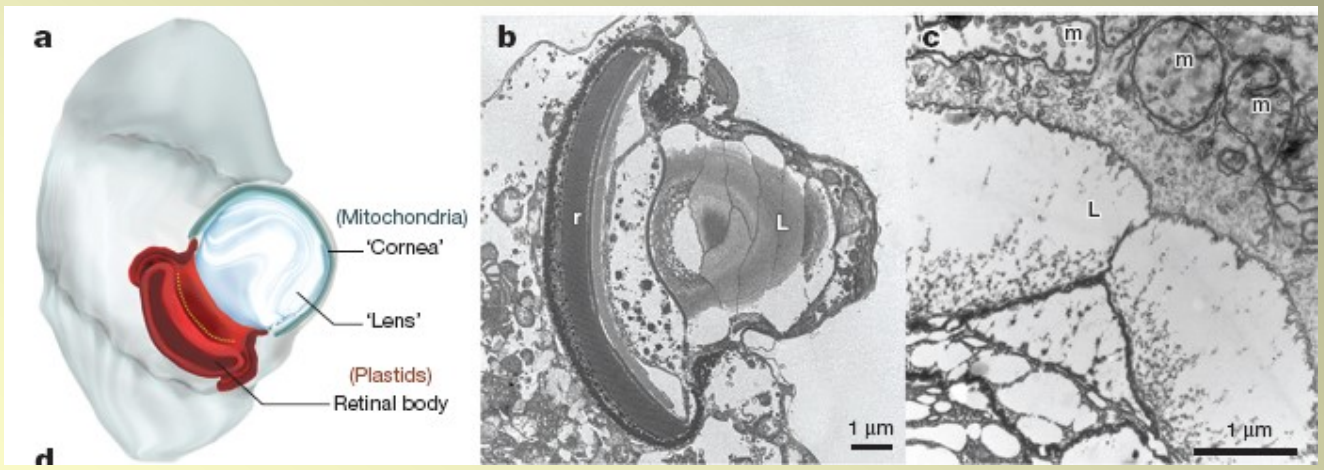
Warnowiid dinoagellate

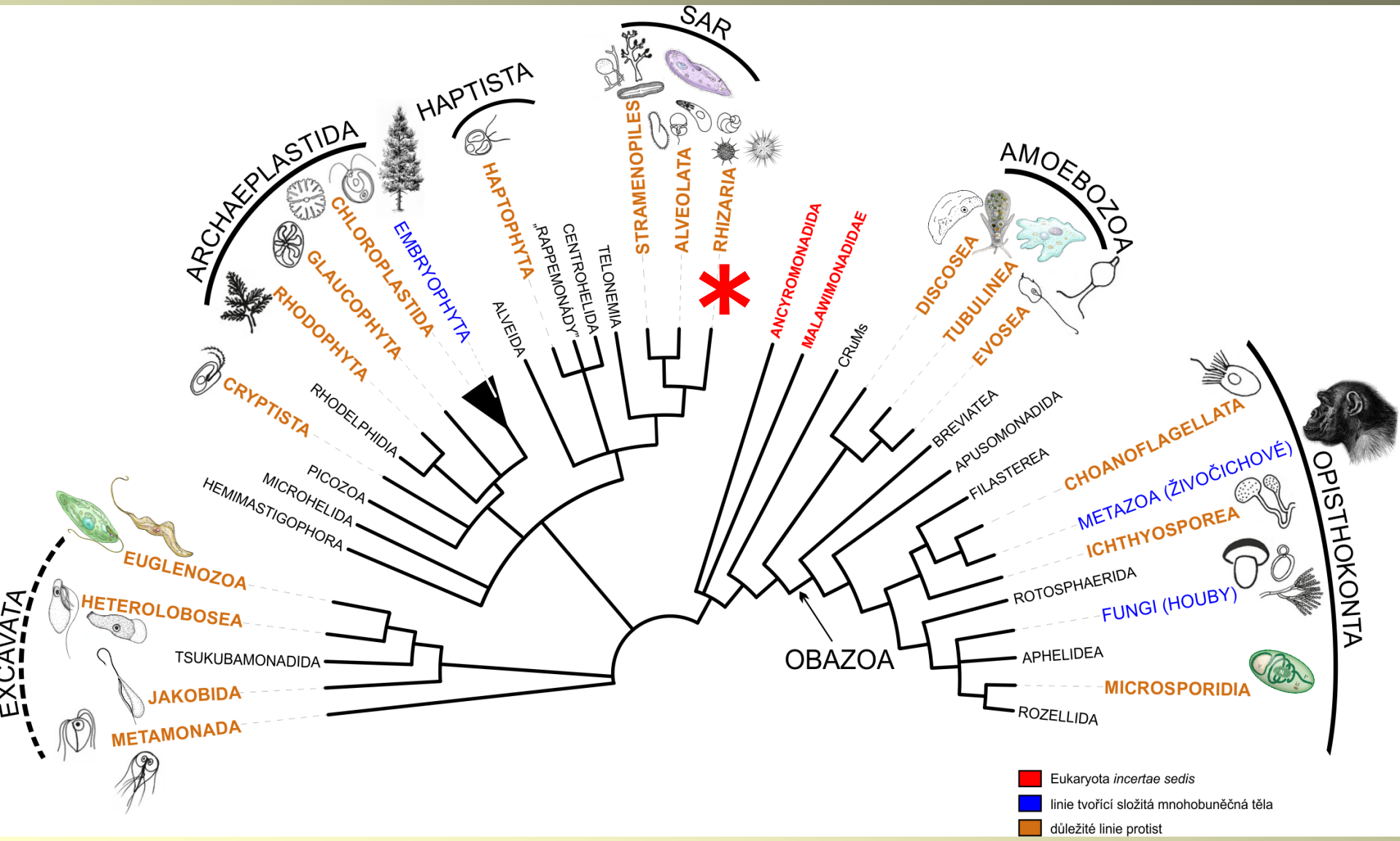
Nematodinium
základní části ocelloidu – souhra buněčných organel

Gavelis et. al. 2015

Jak vytvořit mikrobiální oko





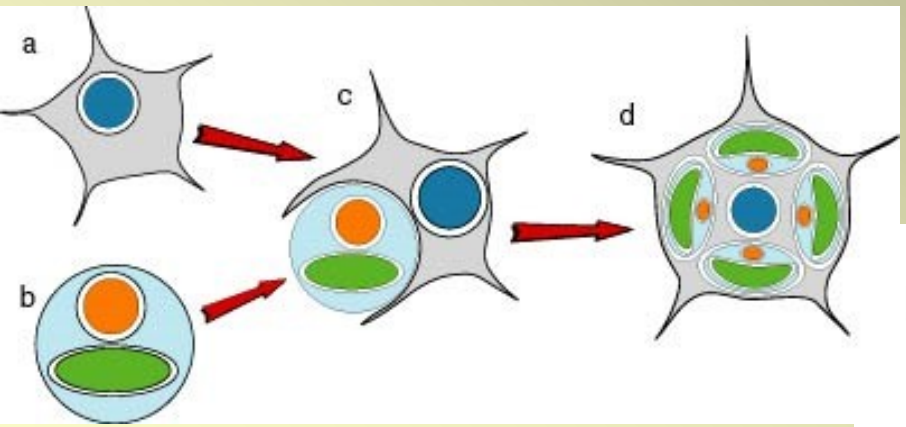

SAR
HAPTISTA
ARCHAEPLASTIDA
AMOEBOZOA
OPISTHOKONTA
EXCAVATA
OBAZOA
STRAMENOPILES
ALVEOLATA
RHIZARIA
HAPTOPHYTA
"RAPPEMONÁDY"
CENTROHELIDA
TELONEMIA
ALVEIDA
EMBRYOPHYTA
CHLOROPLASTIDA
GLAUCOPHYTA
RHODOPHYTA
CRYPTISTA
RHODELPHIDIA
PICOZOA
MICROHELIDA
HEMIMASTIGOPHORA
EUGLENOZOA
HETEROLOBOSEA
TSUKUBAMONADIDA
JAKOBIDA
METAMONADA
ANCYROMONADIDA
MALAWIIMONADIDAE
CRuMs
DISCOSEA
TUBULINEA
EVOSEA
BREVIATEA
APUSOMONADIDA
FILASTEREA
CHOANOFLAGELLATA
METAZOA (ŽIVOČICHOVÉ)
ICHTHYOSPOREA
ROTOSPHAERIDA
FUNGI (HOUBY)
APHELIDEA
MICROSPORIDIA
ROZELLIDA
Eukaryota *incertae sedis*
linie tvořící složitá mnohobuněčná těla
důležité linie protist

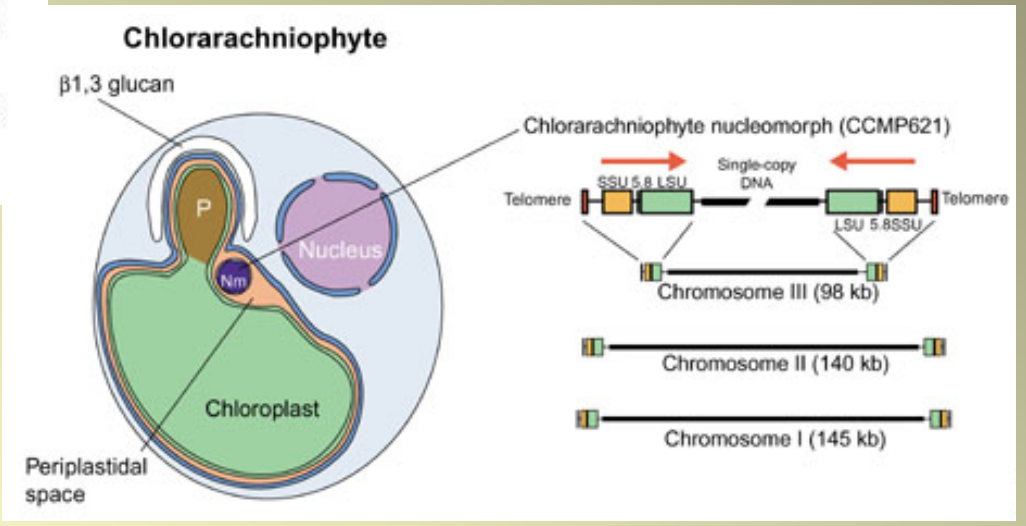
Kde v systému se nacházíme?

Eukaryota

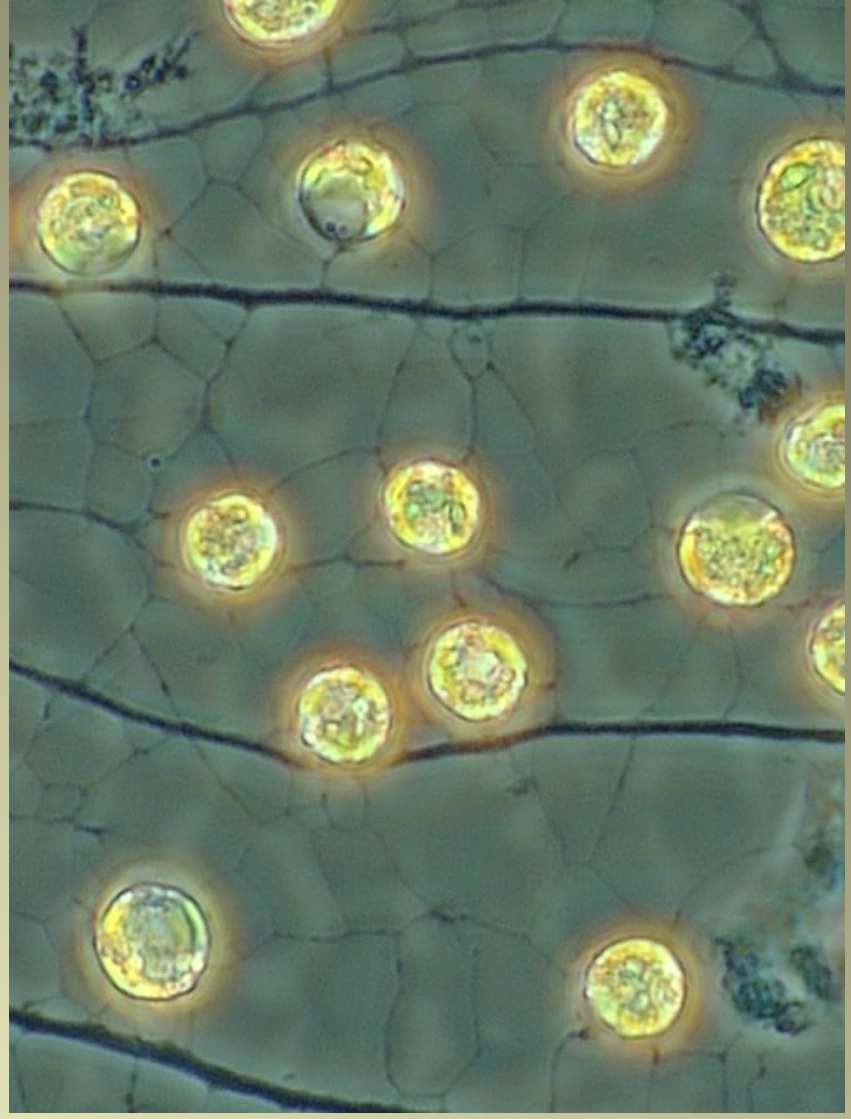
- *SAR, Rhizaria, Cercozoa*
  - *Chlorarachniophyta* (*Chlorarachnea*)

malá, ale z teoretického a evolučního hlediska důležitá skupina mají nukleomorf - svědectví endosymbiózy





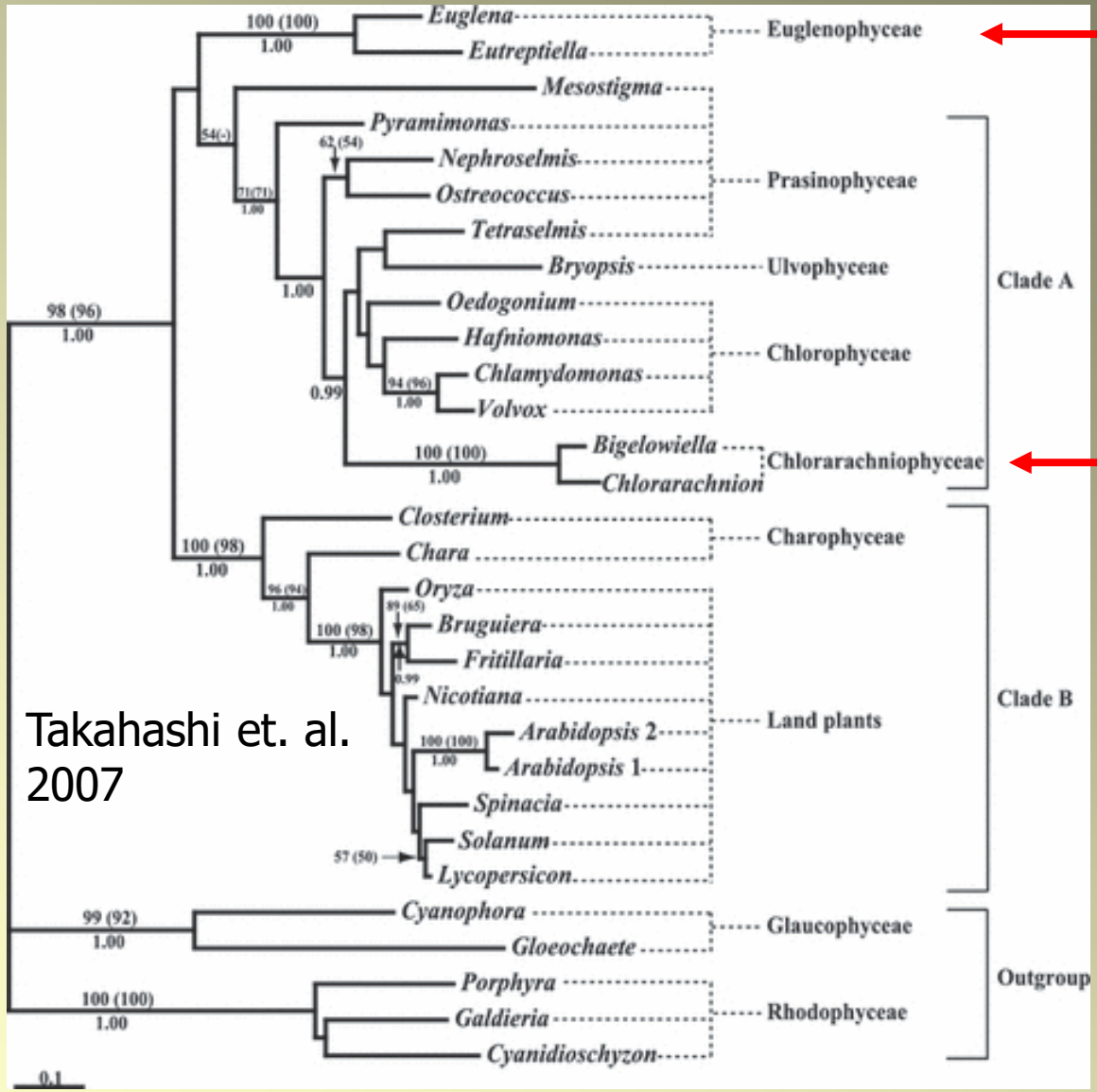
zatím cca 15 druhů, žijí většinou v bentosu (sub-)tropických moří



Chlorarachnion reptans fázový kontrast

popsán Geitlerem 1930 jako xantofyt (různobrvka), znovu objeven Norrisem 1966

1984 popsána Chlorarachniophyta

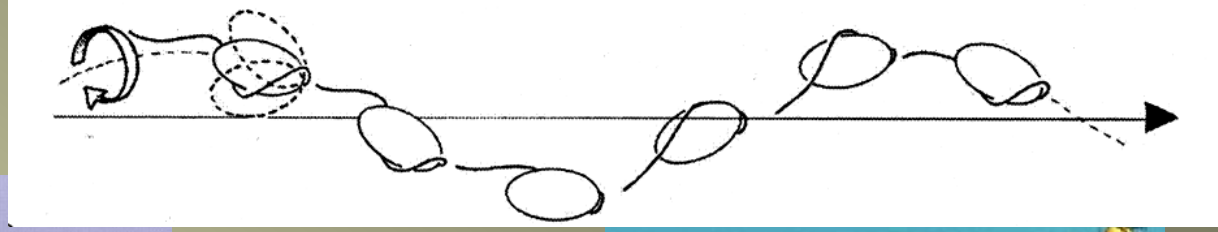


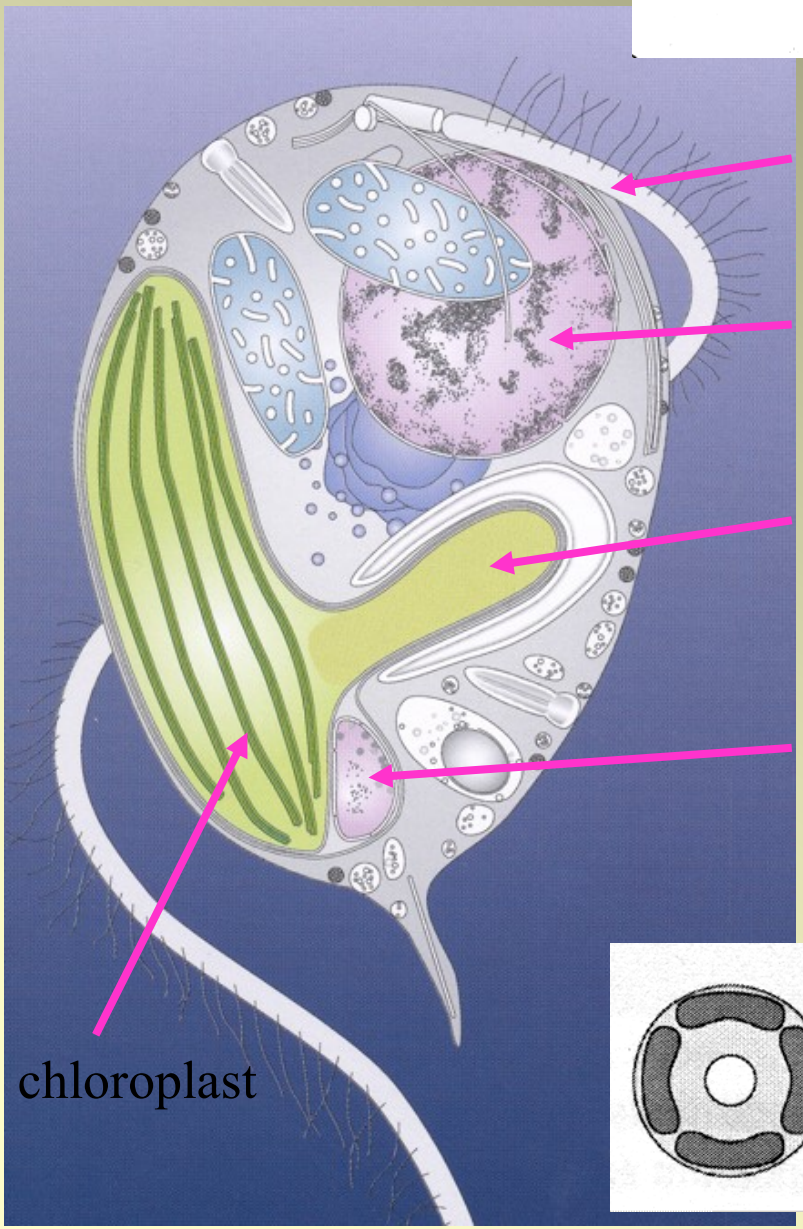
Takahashi et. al. 2007

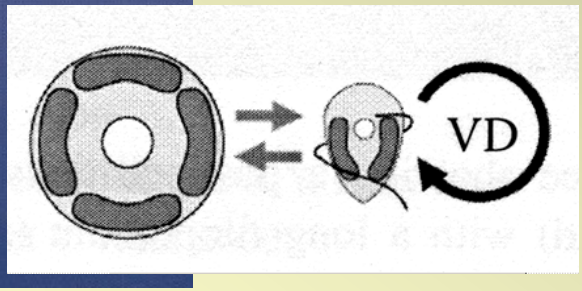
Phylogeny of *psbO* genes from 21 operational taxonomic units of green plant plastids, four secondary phototrophs (Euglenophyta and Chlorarachniophyta),

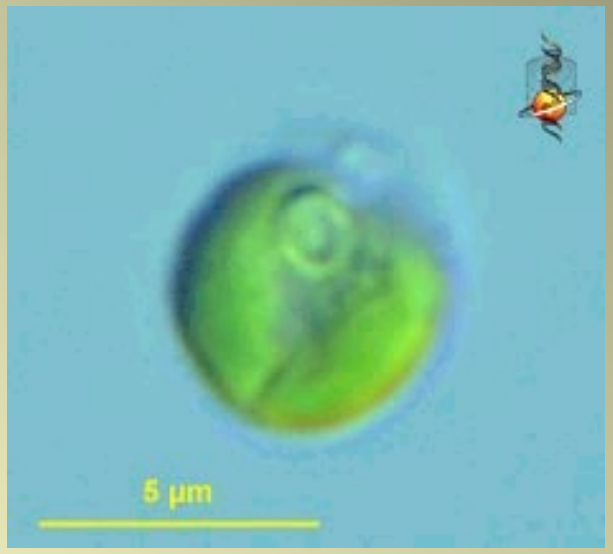
Plastidy chlorarachniofyt a krásnooček (euglen) mají různý evoluční původ, přestože pocházejí ze zelené řasy (plastidy vznikly nezávisle). Plastid euglen je starší.

Bigelowiella natans



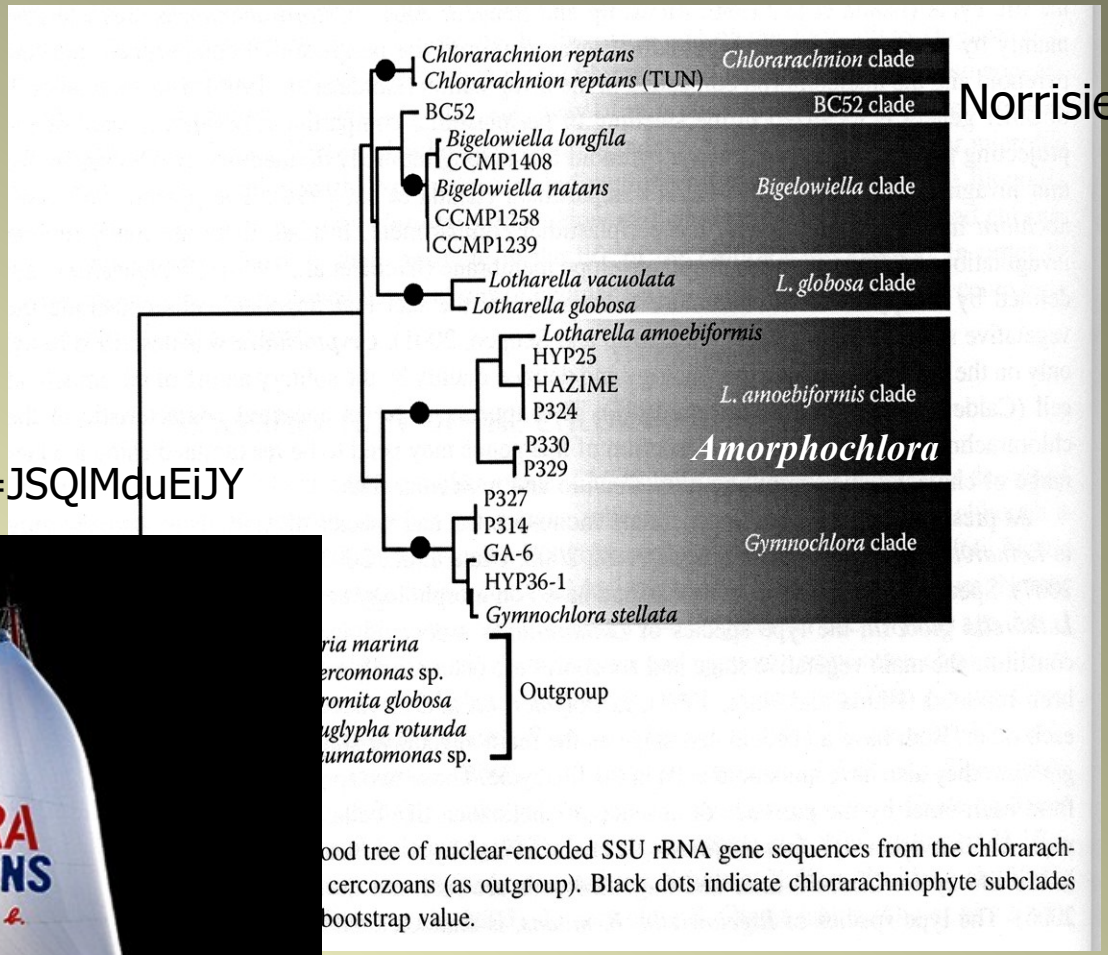






Ekologie

Fylogeneze chlorarachniofyt na základě genu pro SSUrRNA:



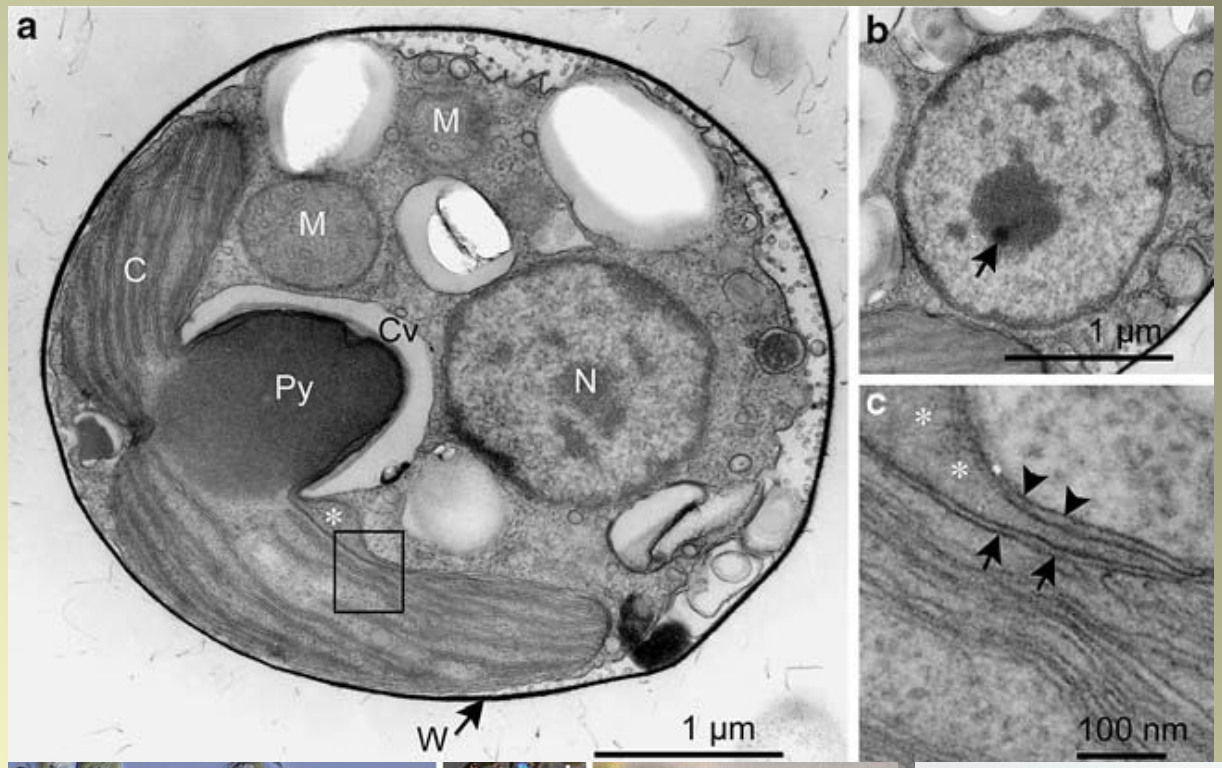
Norrisiella

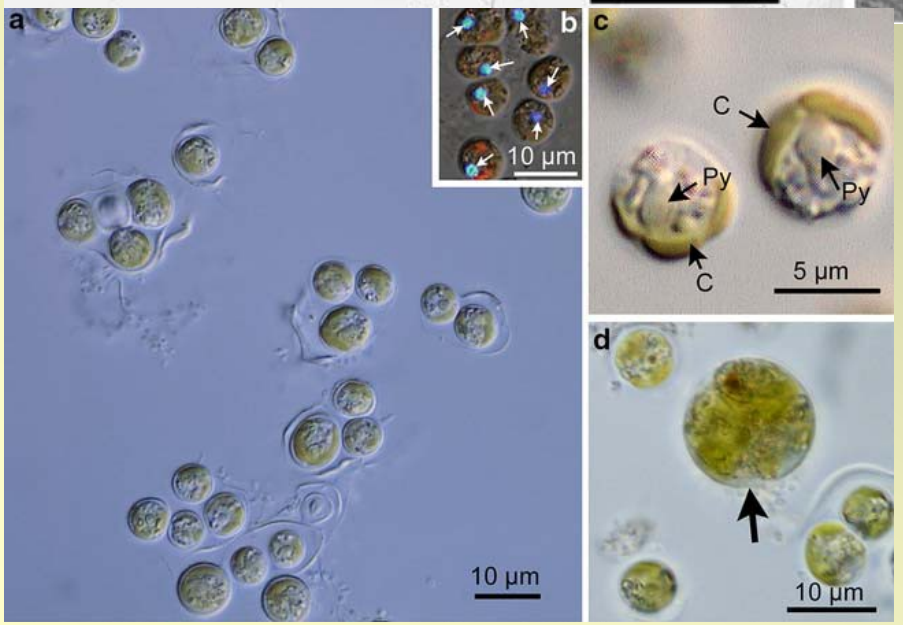
https://www.youtube.com/watch?v=JSQlMduEiJY

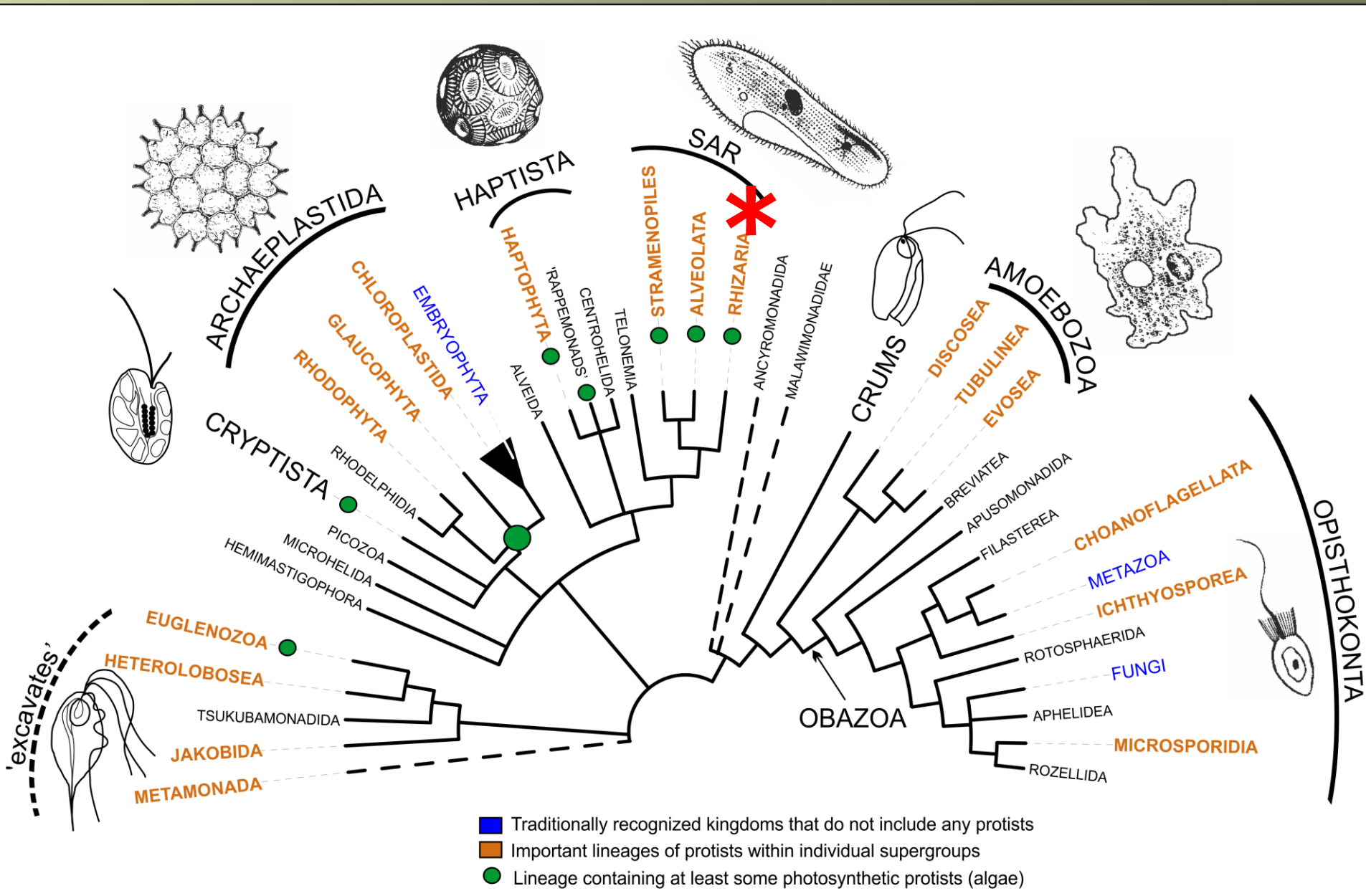
environmentální sekvenování

Norrisiella

z pobřeží
Baja California, Mexico






ARCHAEPLASTIDA
HAPTISTA
SAR
AMOEBOZOA
CRYPTISTA
CRUMS
OBAZOA
OPISTHOKONTA
'excavates'
CHLOROPLASTIDA
GLAUCOPHYTA
RHODOPHYTA
EMBRYOPHYTA
HAPTOPHYTA
'RAPPEMONADS'
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ALVEOLATA
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MALAWIMONADIDAE
DISCOSEA
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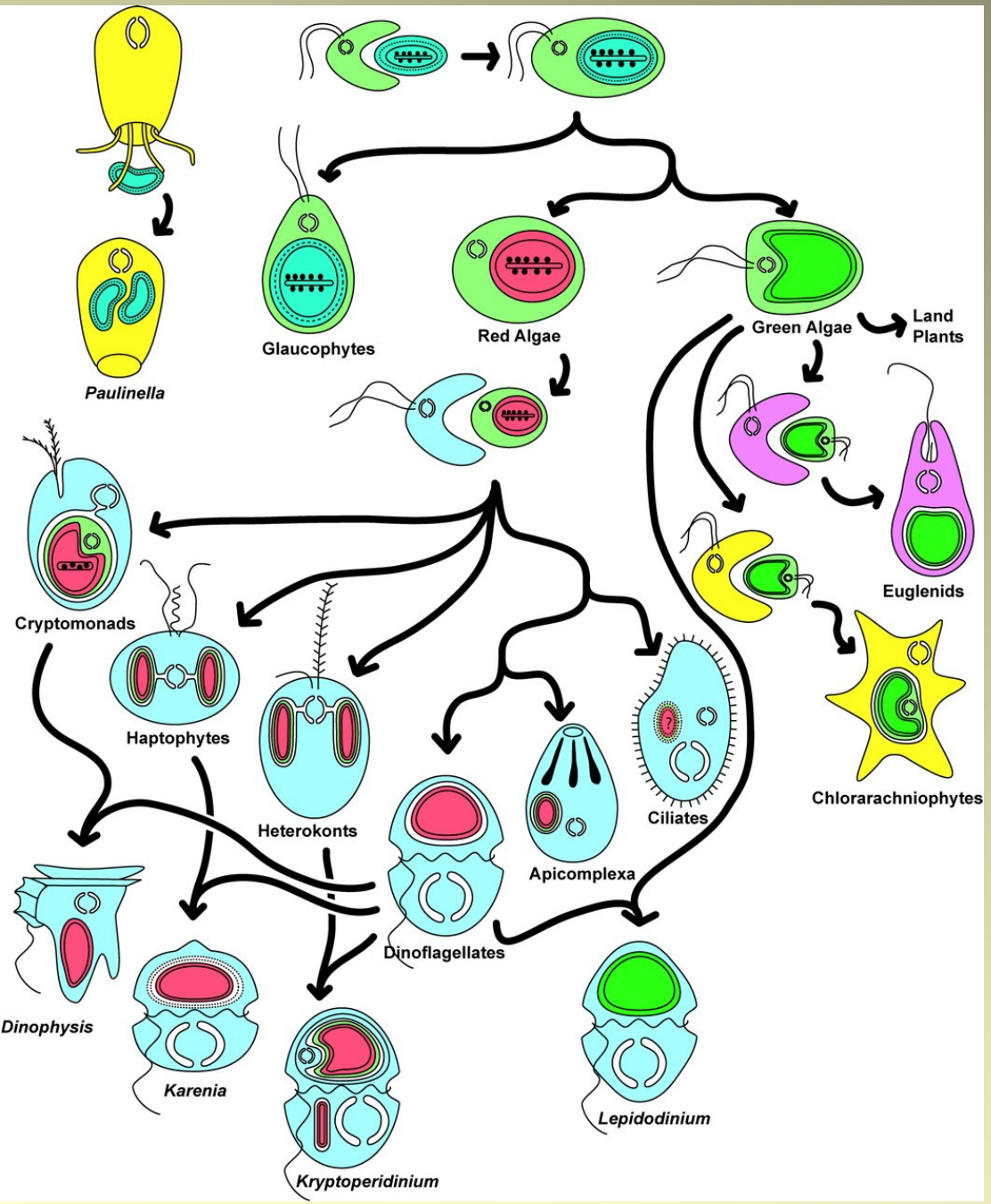
METAZOA
ICHTHYOSPOREA
ROTOSPHAERIDA
FUNGI
APHELIDEA
MICROSPORIDIA
ROZELLIDA
RHODELPHIDIA
PICOZOA
MICROHELIDA
HEMIMASTIGOPHORA
EUGLENOZOA
HETEROLOBOSEA
TSUKUBAMONADIDA
JAKOBIDA
METAMONADA
Traditionally recognized kingdoms that do not include any protists
Important lineages of protists within individual supergroups
Lineage containing at least some photosynthetic protists (algae)

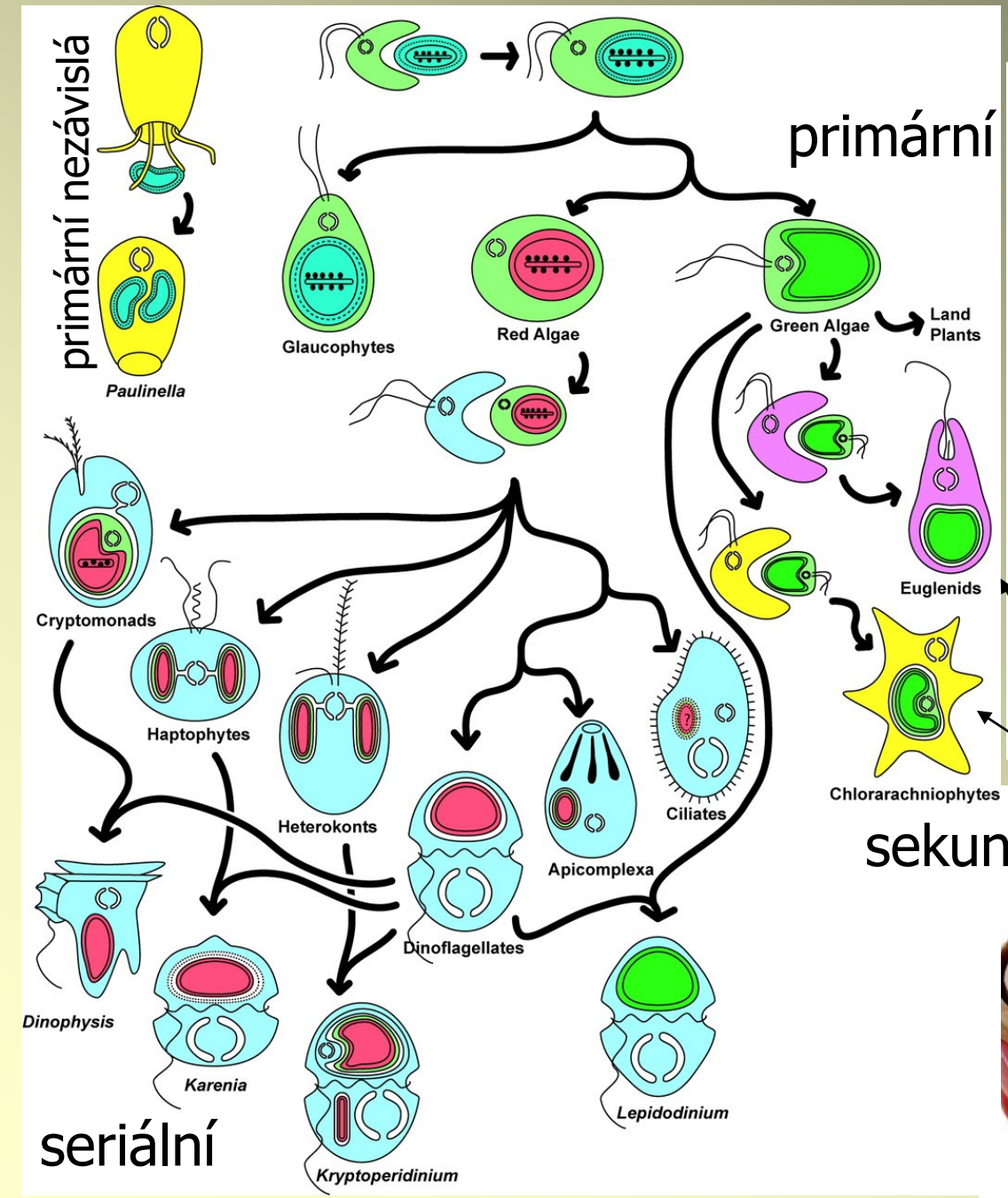


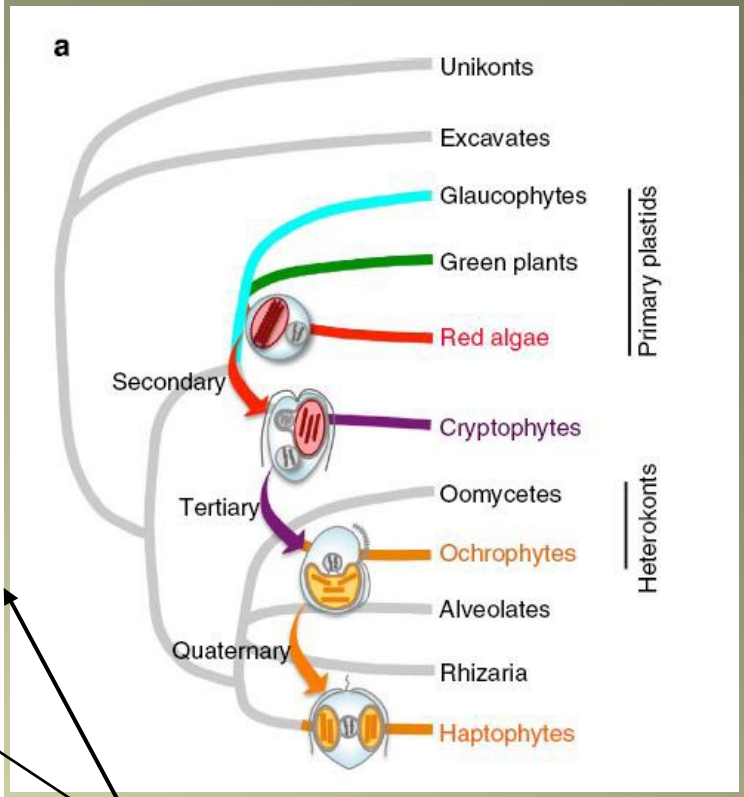
Rhizaria
Cercozoa
Euglyphida

Paulinella chromatophora – získala plastid nezávislou primární endosymbiózou (sinice) před 60-200 mil. let

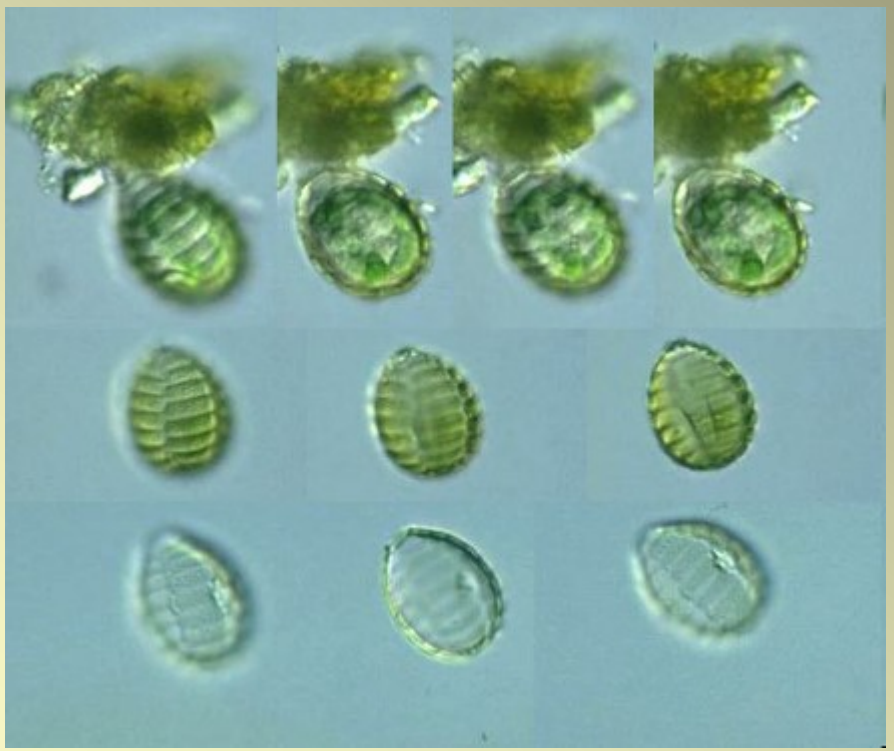
kromě *P. chromatophora* jsou zatím popsány jestě další dva fotosyntetizující druhy *P. micropora* (sladkovodní) a *P. longichromatophora* (mořská)

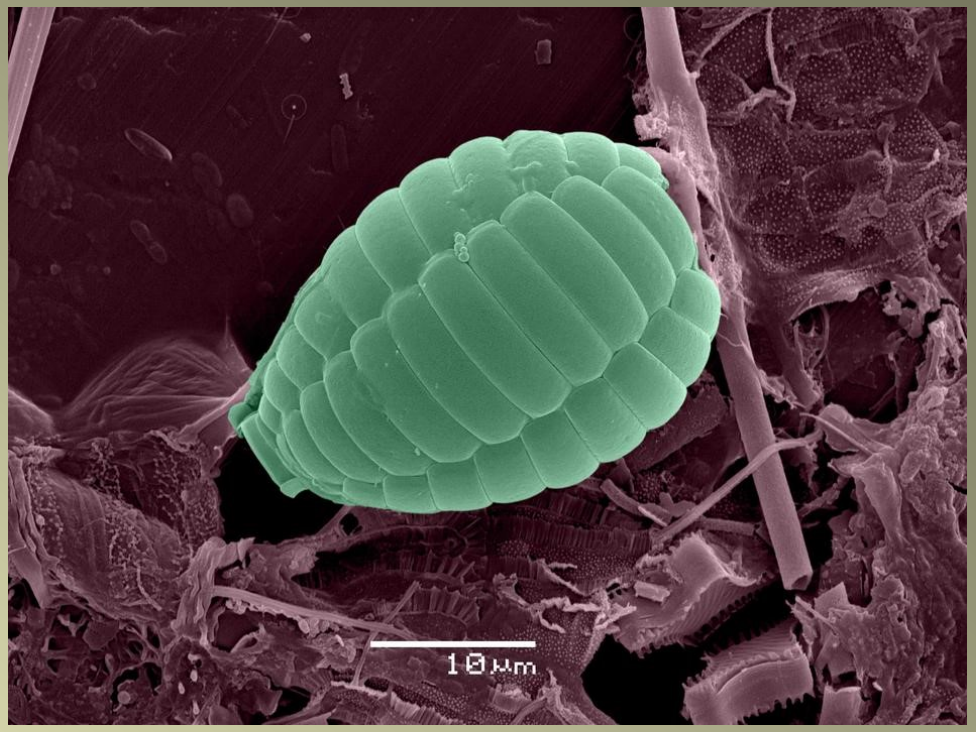
Seriální endosymbiózy





Paulinella chromatophora





rašeliništní testátní améba
křemitá schránka
stabilní endosymbióza sinice

jediná známá
"rostlinná" nerostlina

jaderné genomy z kultury druhu *Paulinella chromatophora*

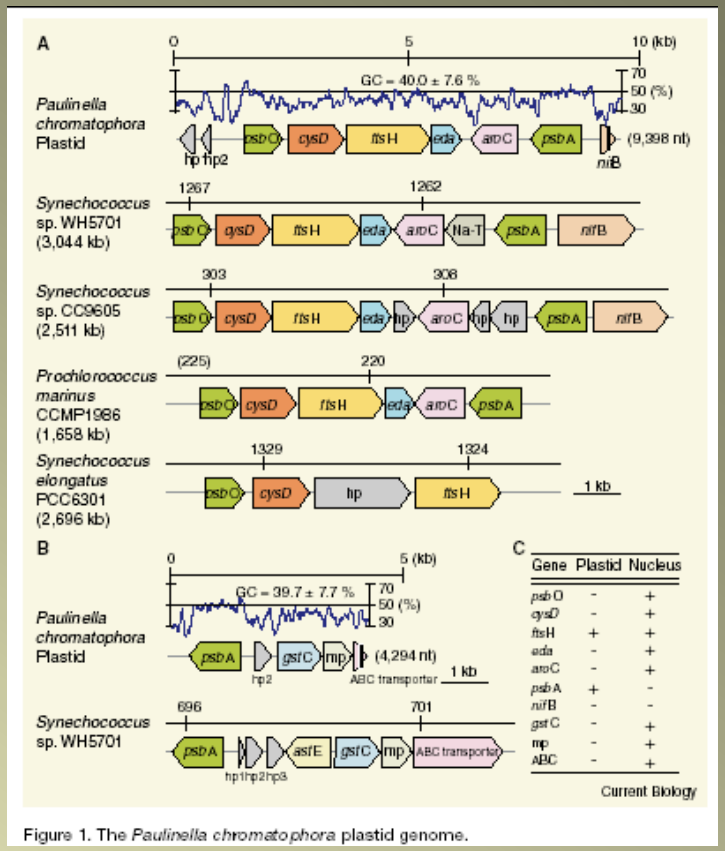
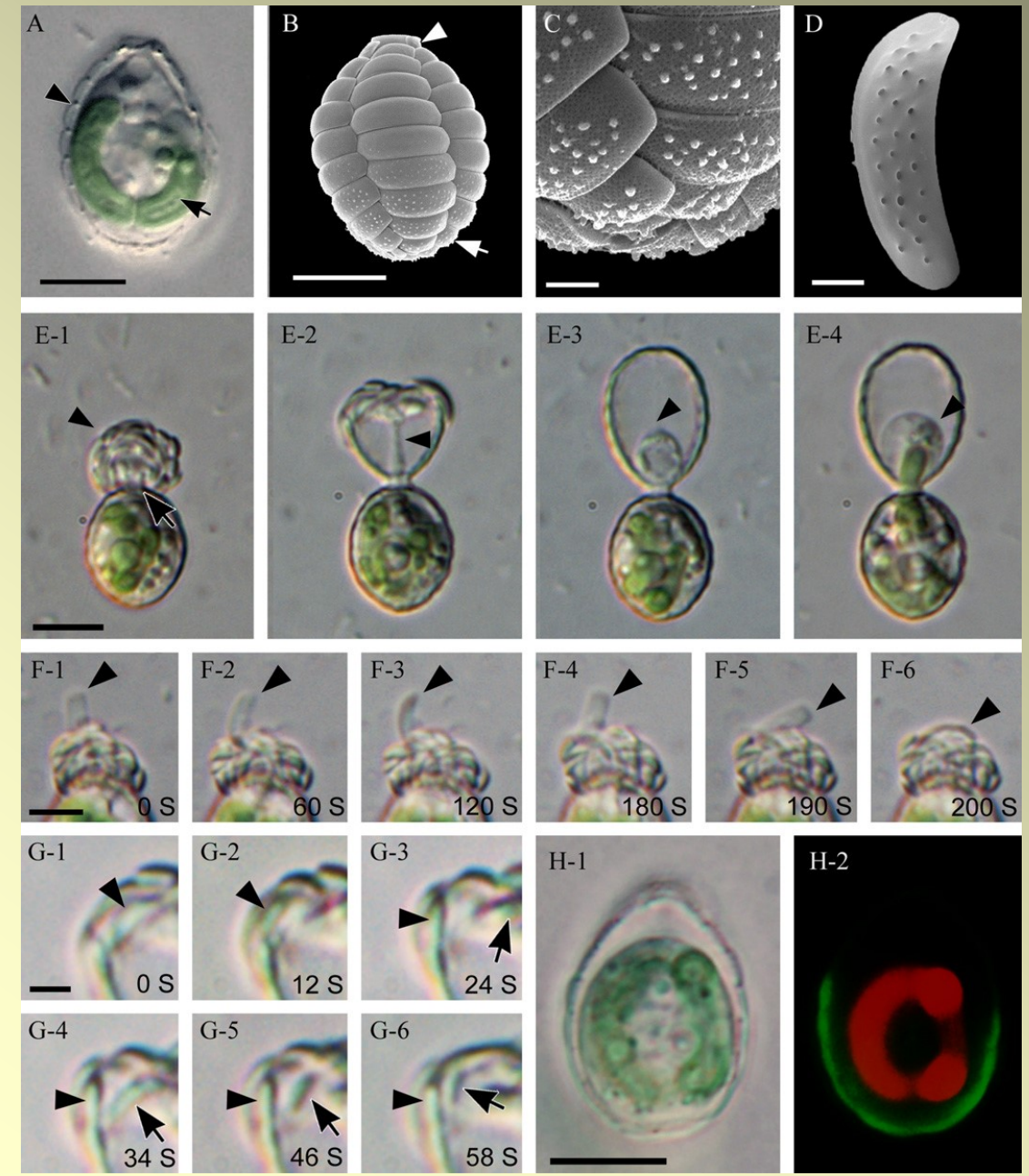


Figure 1. The *Paulinella chromatophora* plastid genome.

redukce genomu plastidu - jen 26% genů *Synechococcus* plastid zcela závislý na hostiteli

Yoon et al., 2006, Curr. Biol. 16

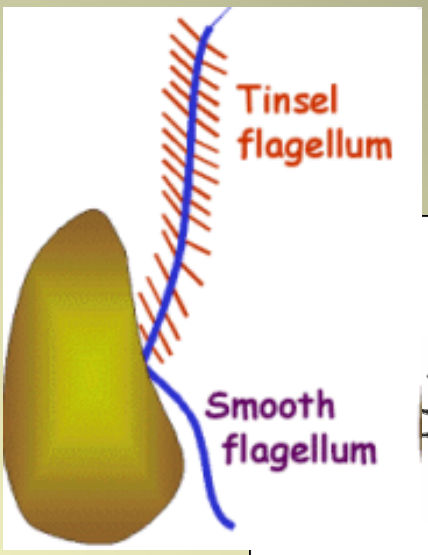
Tvorba křemičité chránky fotosyntetizující améby *Paulinella chromatophora*

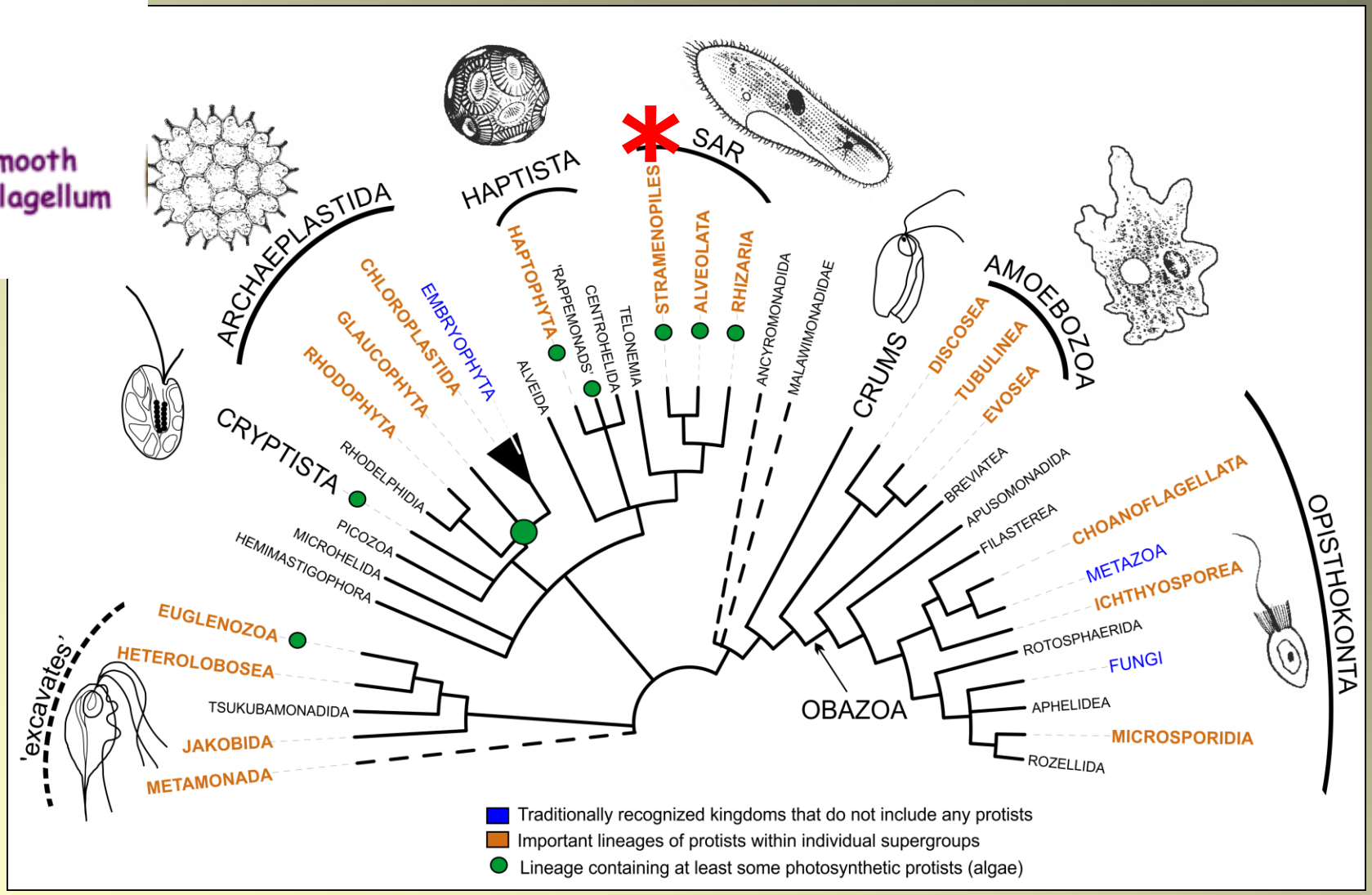


Uspořádání destiček pomocí výběžku - pseudopodia.
Celý proces trvá 5 hod.

Nomura et al. 2013

Stramenopiles (Heterokontophyta)





2 různé bičíky, ch *a* a *c*, *fucoxanthin,* chrysolaminaran ve vakuolách, u někt. skupin mnohobuněčnost

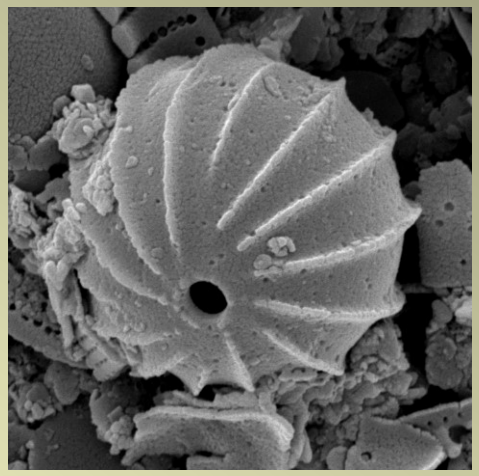
Kde v systému se nacházíme?

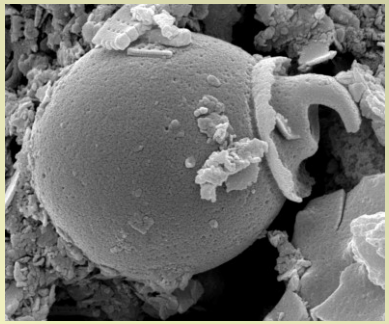
Eukaryota

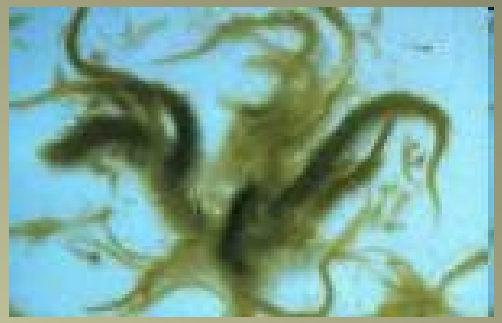
SAR Stramenopiles

Chrysophyceae (zlativky)

Dinobryon







endogenní křemité stomatocysty, někteří křemičité šupiny

hlavně sladkovodní bičíkaté a kapsální organismy, cca 700 druhů

Dinobryon - bičíkovci v kelímkovitých schránkách

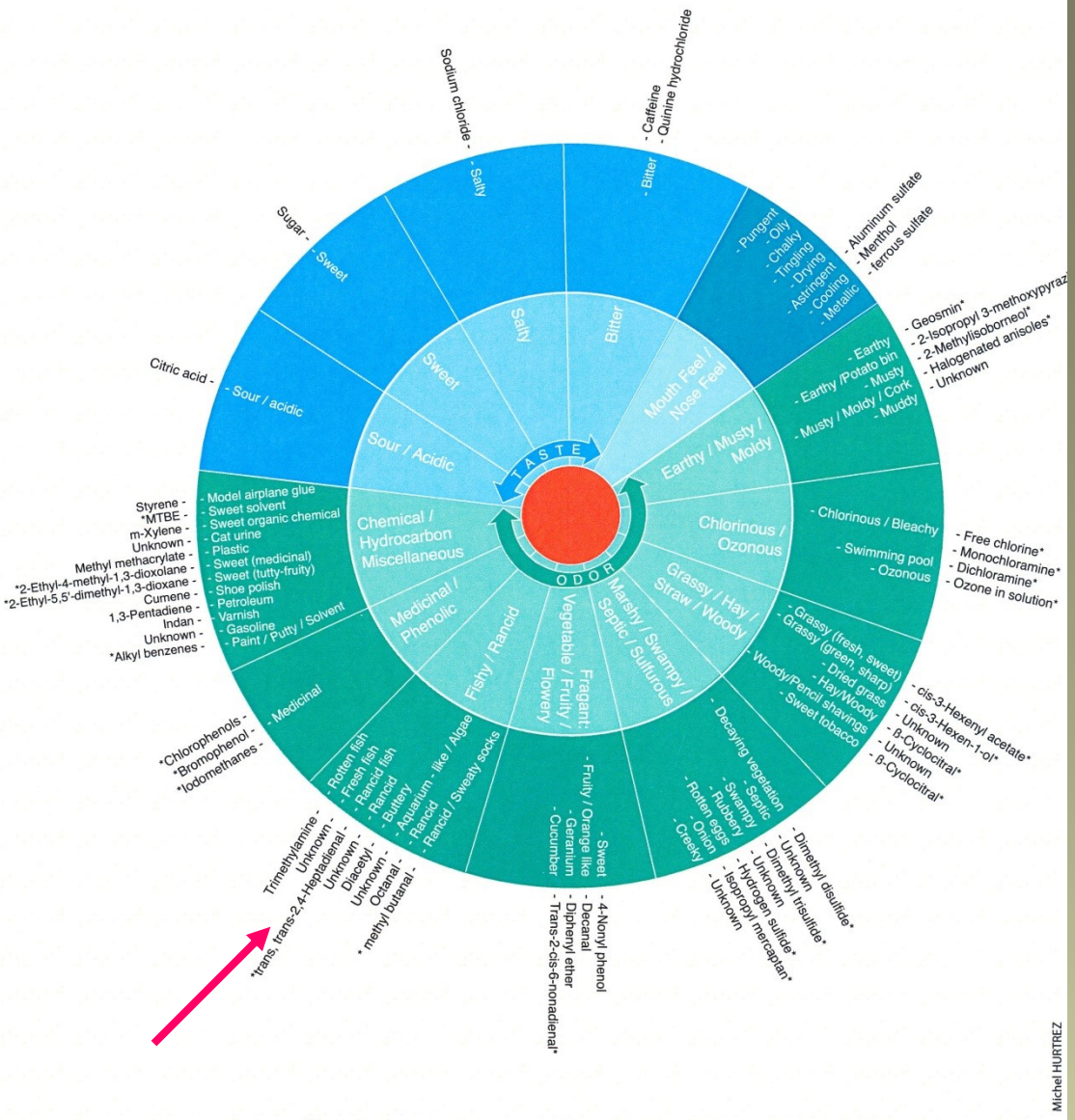
mixotrofní výživa 2 bakterie/min

Vegetační zákaly

Uroglena, Dinobryon, Synura
aldehydy a ketony (n-haptanal) – ovlivňují chuť, způsobují zápach pitné vody – smrdí rybinou

rybina, olej z tresčích jater, pižmo, okurka

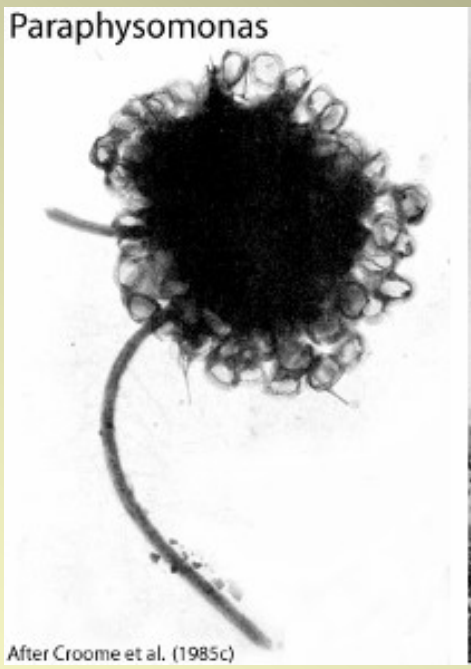
zápach ve fázi odumírání populace

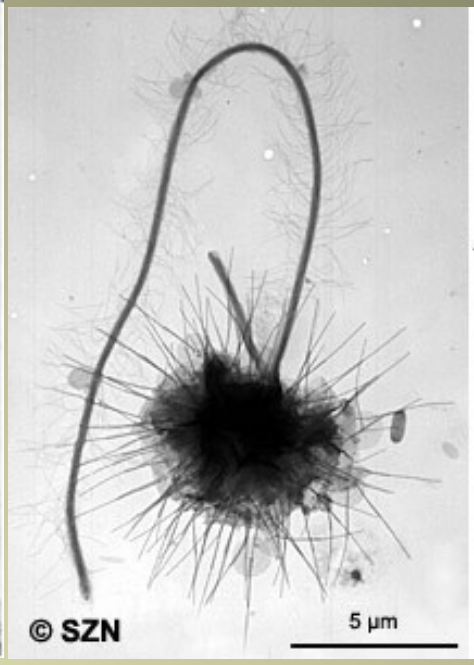


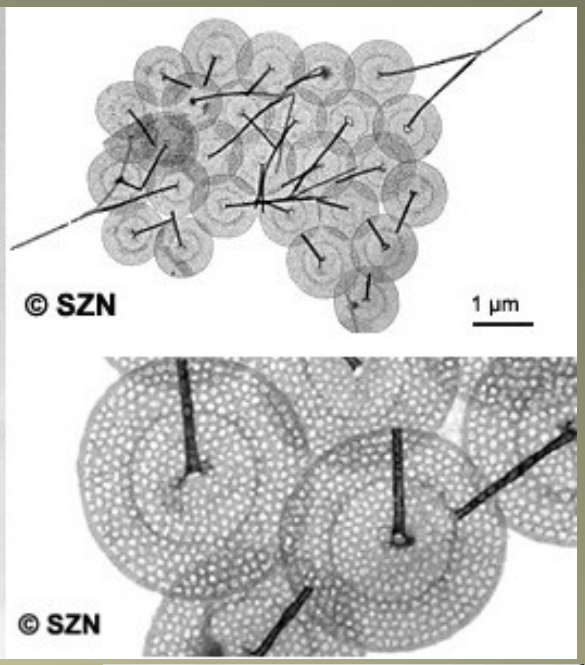
Gary A. Burlingame

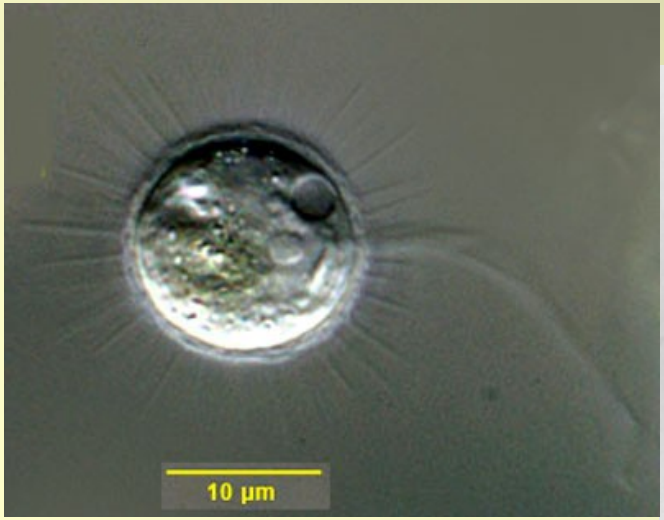
Philadelphia Water Department

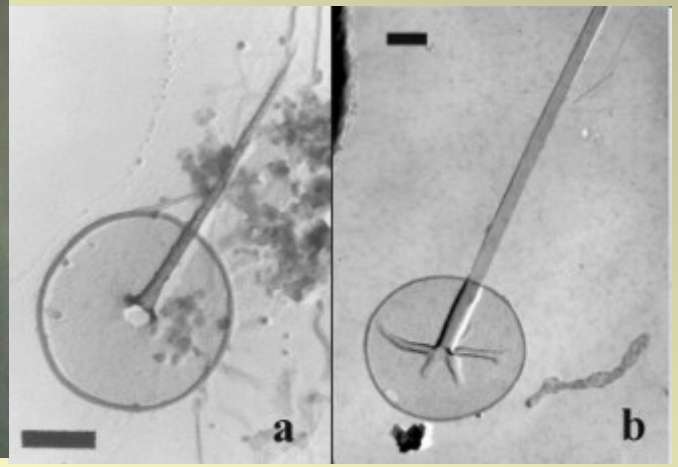
Paraphysomonas - mikroorganismus s ubikvitním rozšířením?





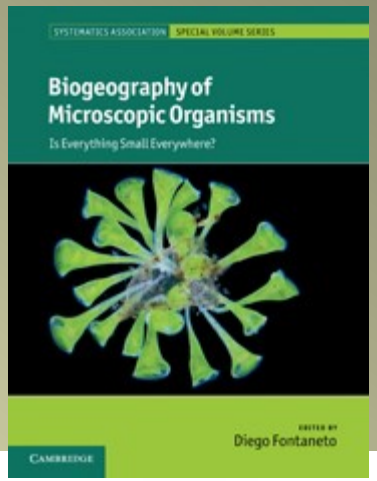






křemičité šupiny, známo více než 120 druhů

Everything is everywhere, environment selects



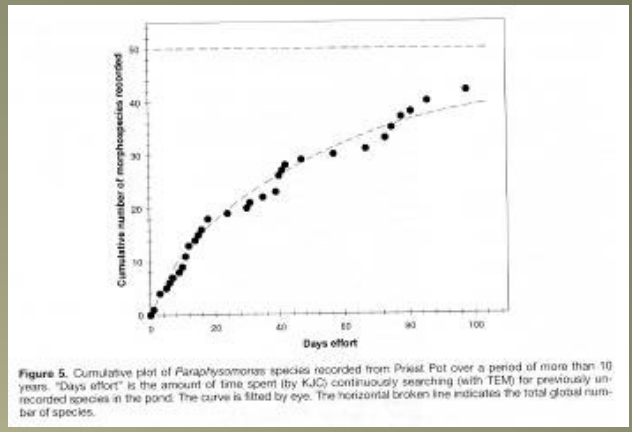


Figure 5. Cumulative plot of *Paraphysomonas* species recorded from Priest Pot over a period of more than 10 years. "Days effort" is the amount of time spent (by KJC) continuously searching (with TEM) for previously unrecorded species in the pond. The curve is fitted by eye. The horizontal broken line indicates the total global number of species.

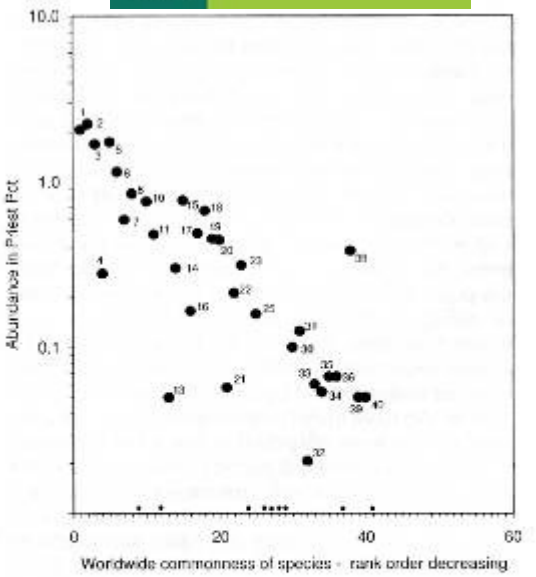
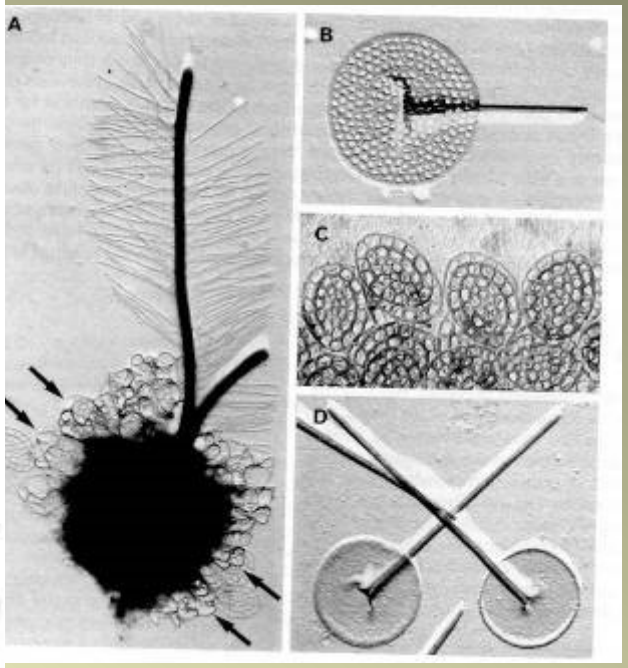
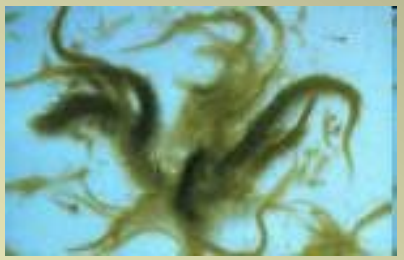


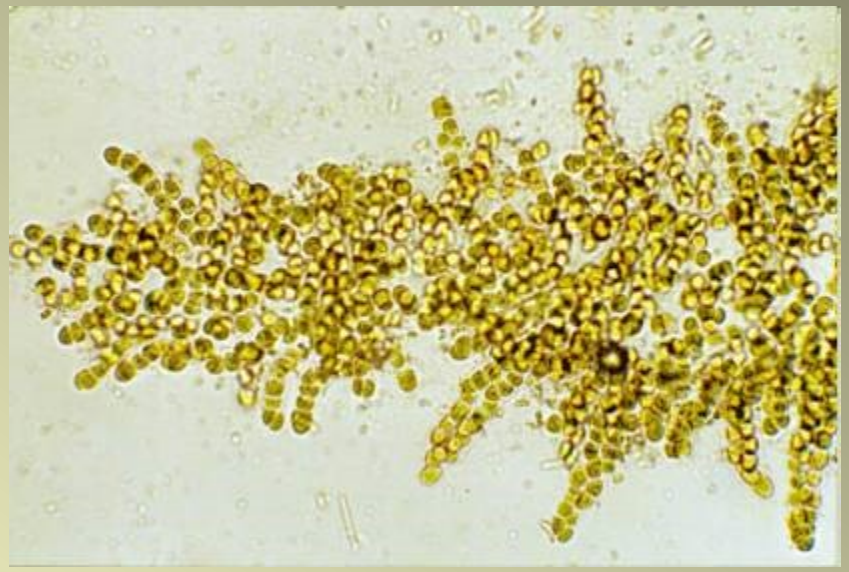
Figure 3. The abundance of each *Paraphysomonas* species in 25.2 µl of Priest Pot sediment, plotted against its worldwide commonness (ranked, decreasing from left to right). Spearman's rank correlation coefficient *R* (0.69) indicates that the degree of agreement between the two datasets is highly significant ($t = 8.1$ with 39 df). Numbers assigned to species are as in Table 1. Small symbols indicate those species that were recorded in surveys conducted worldwide, but not in the current study of Priest Pot.



Finlay & Clark, 1999

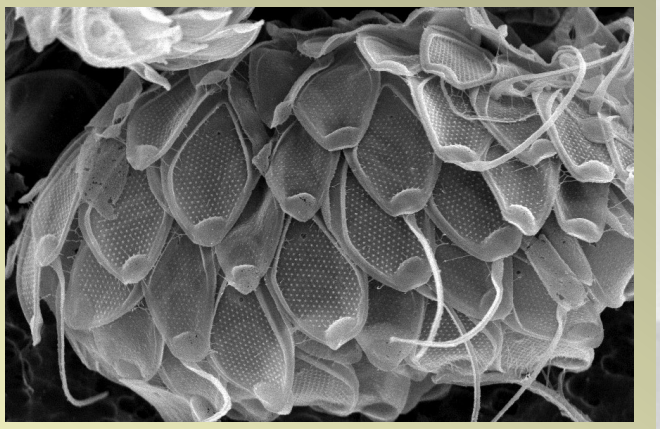
Hydrurus foetidus

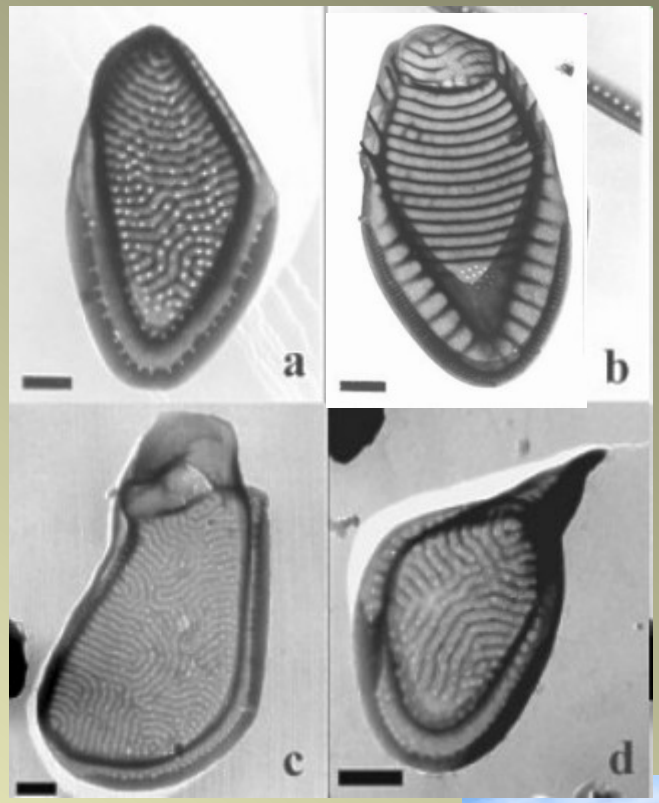


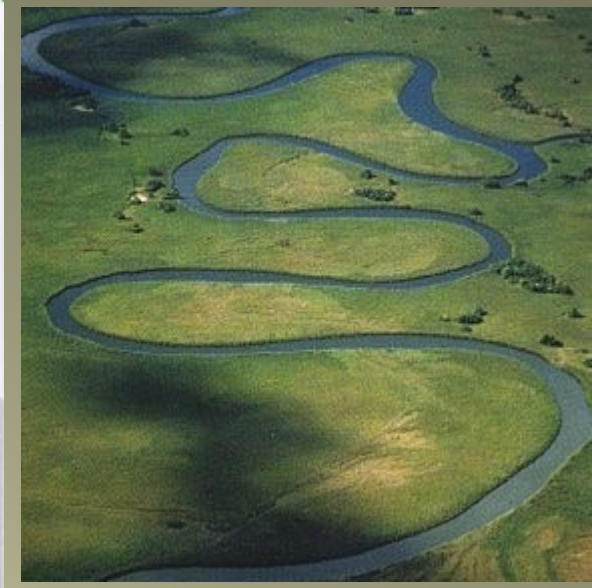


neznečištěné okysličené vody

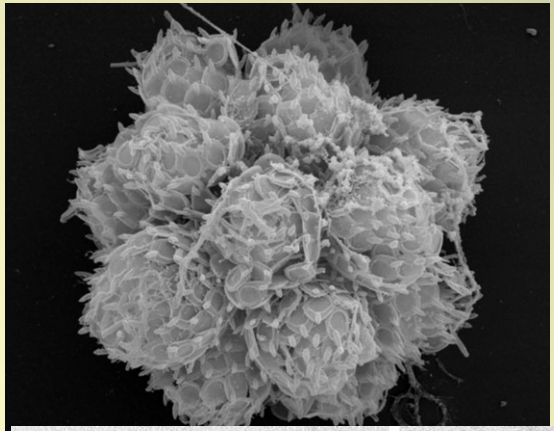
Mallomonas



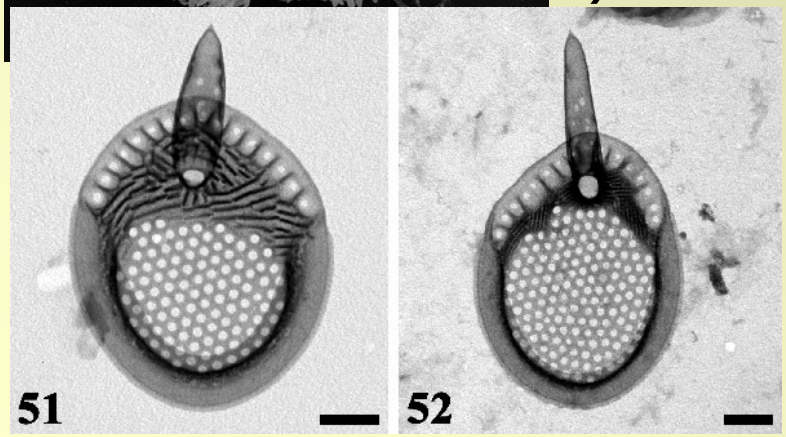




aluviální tůně

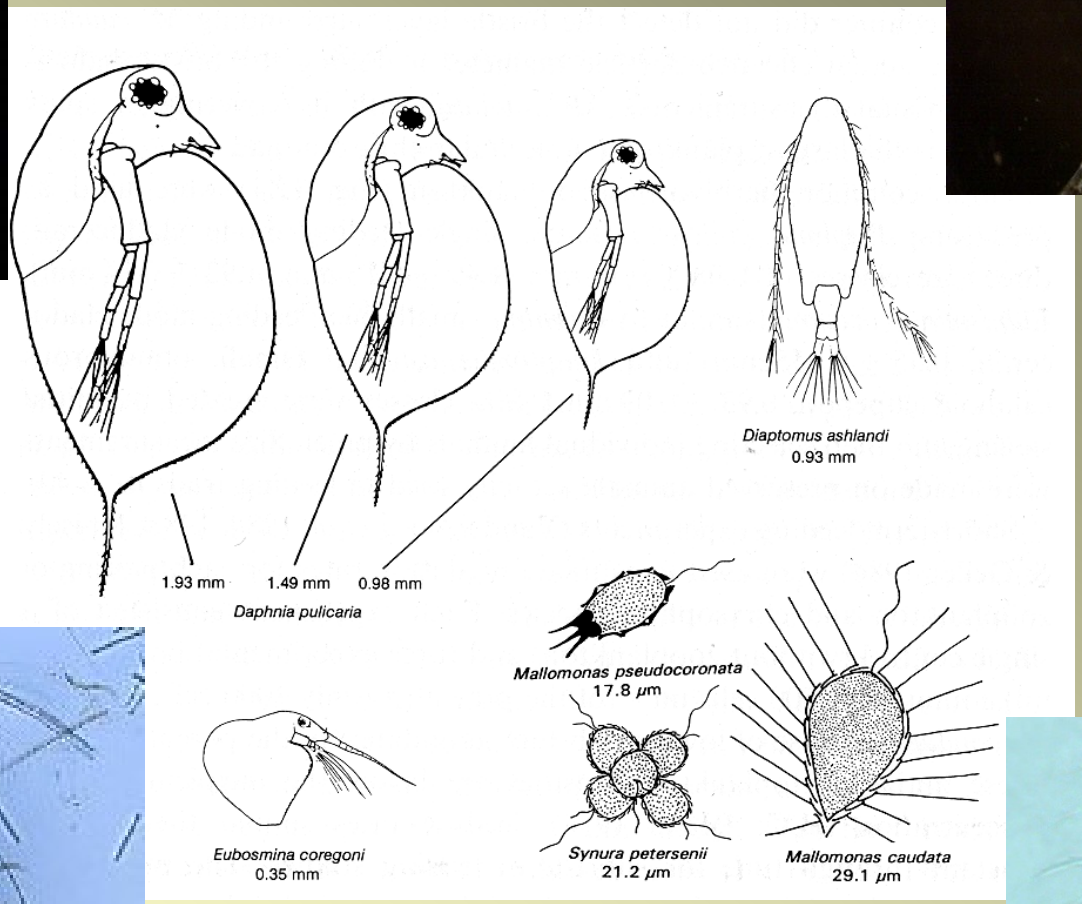


Synura



skandinávská jezera

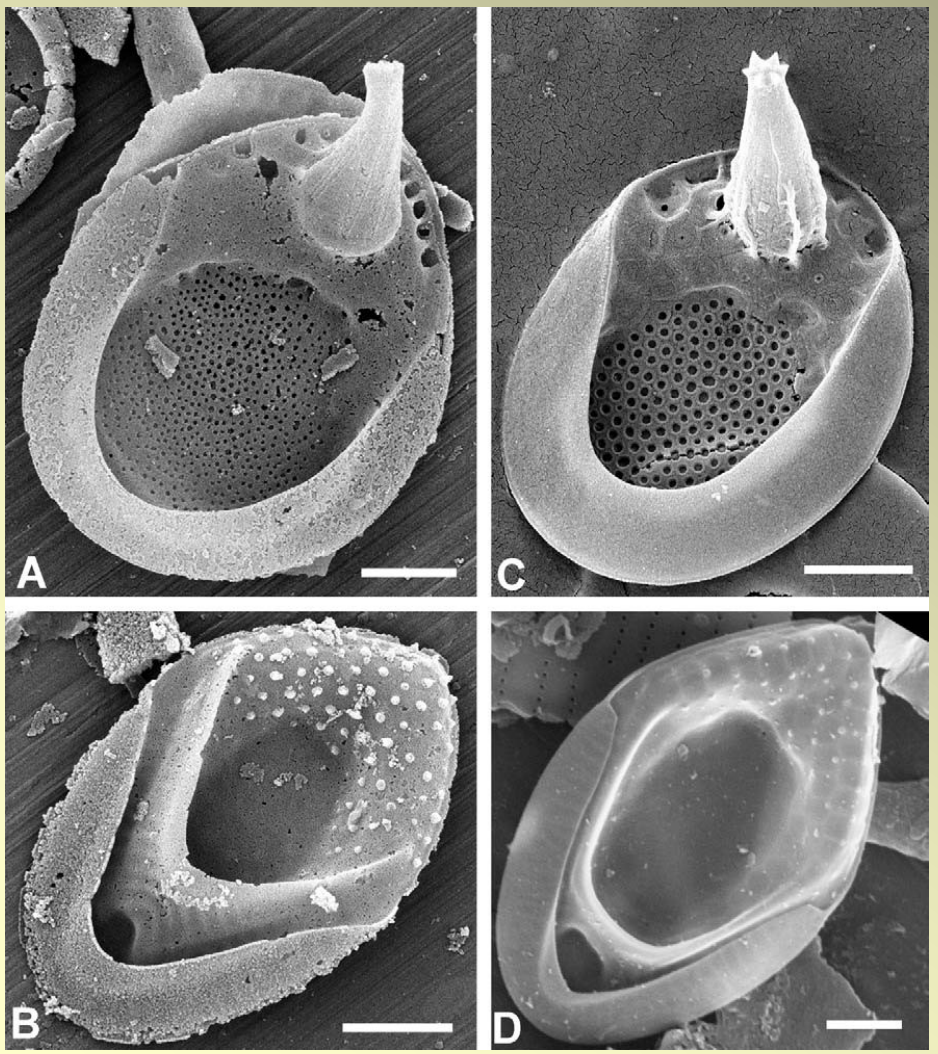
Predace



šupiny místo brnění

Nejstarší křemičité šupiny

47 milionů let - Eocén

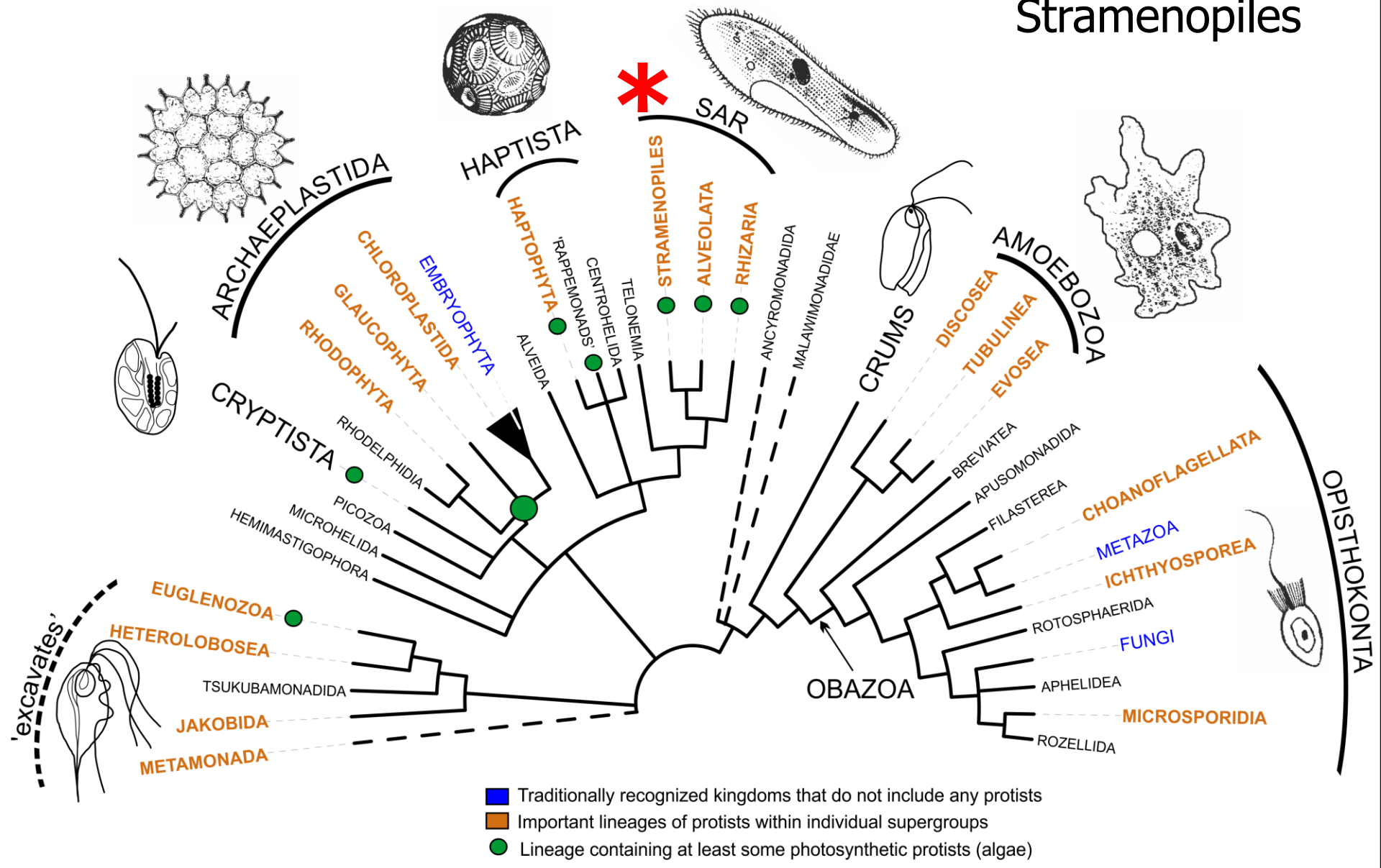


the Giraffe Pipe kimberlitová lokalita, Northwest Territories, Kanada

vrty 95.6 m and 127.6 m

Siver & Wolfe, 2005

Stramenopiles



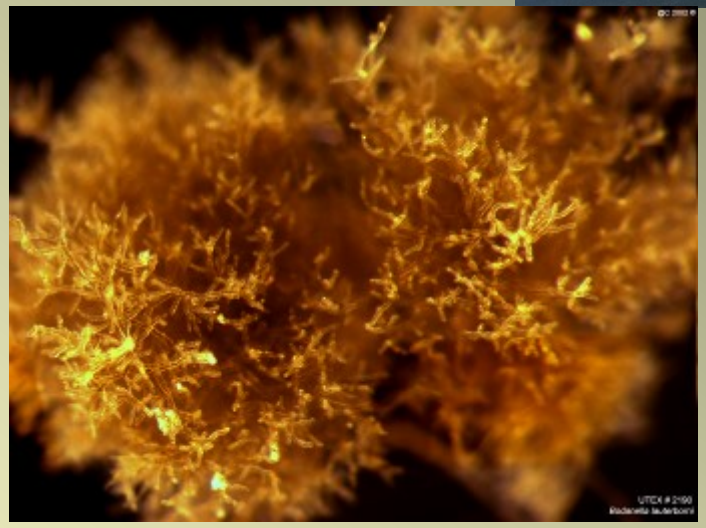
Kde v systému se nacházíme?

Eukaryota

SAR *Stramenopila*

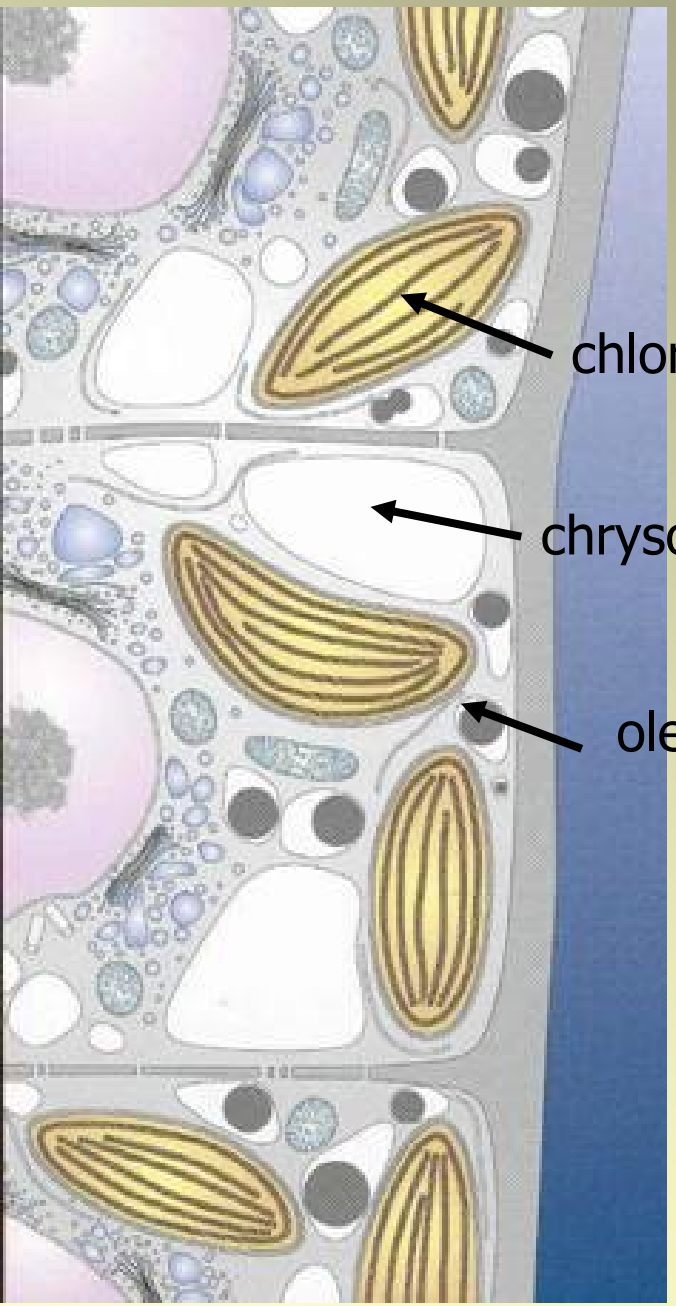
Phaeophyceae - chaluhy

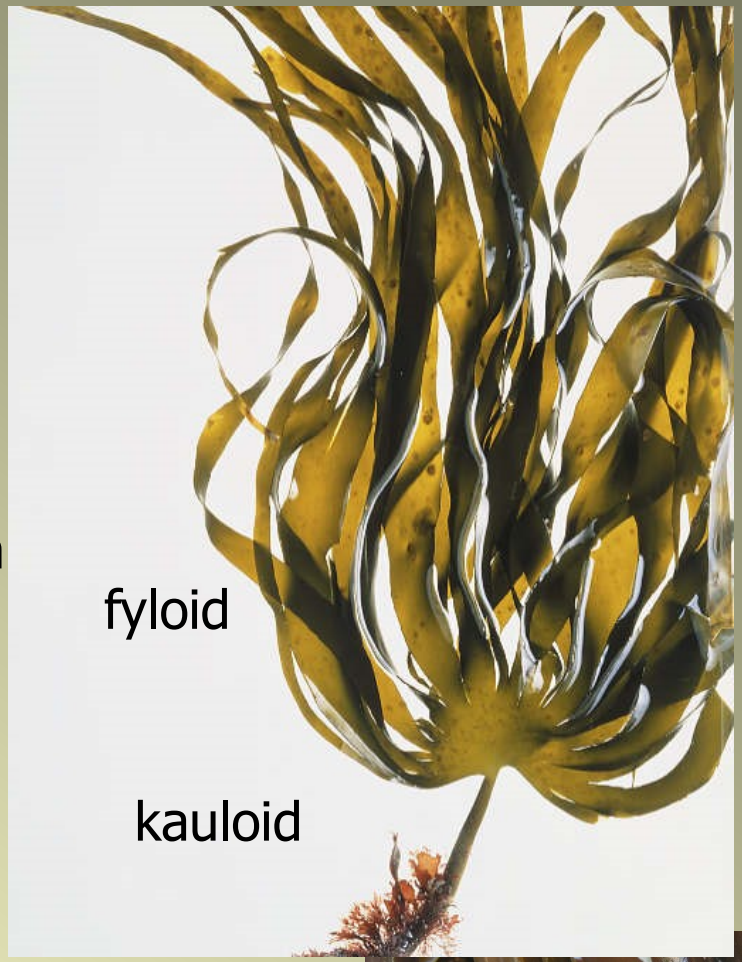
Bodanella - sladkovodní



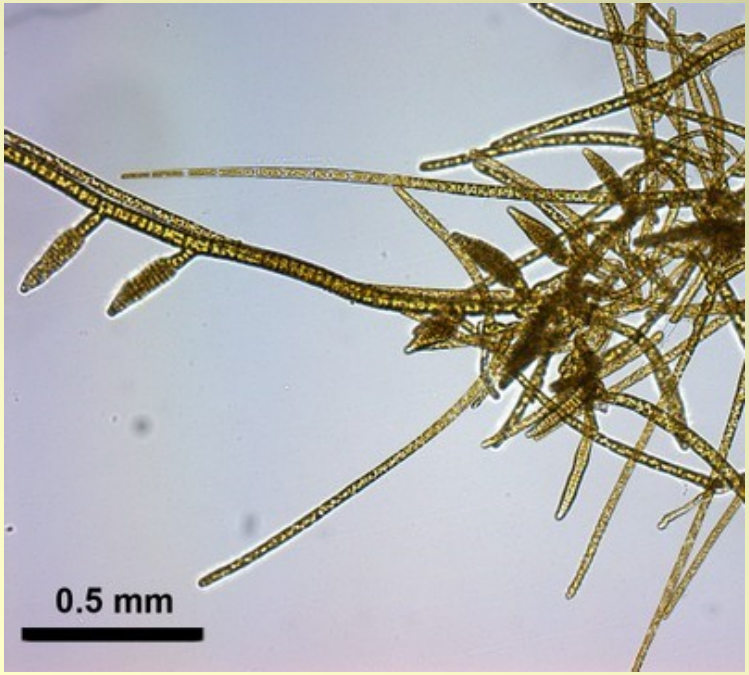
Bodamské jezero

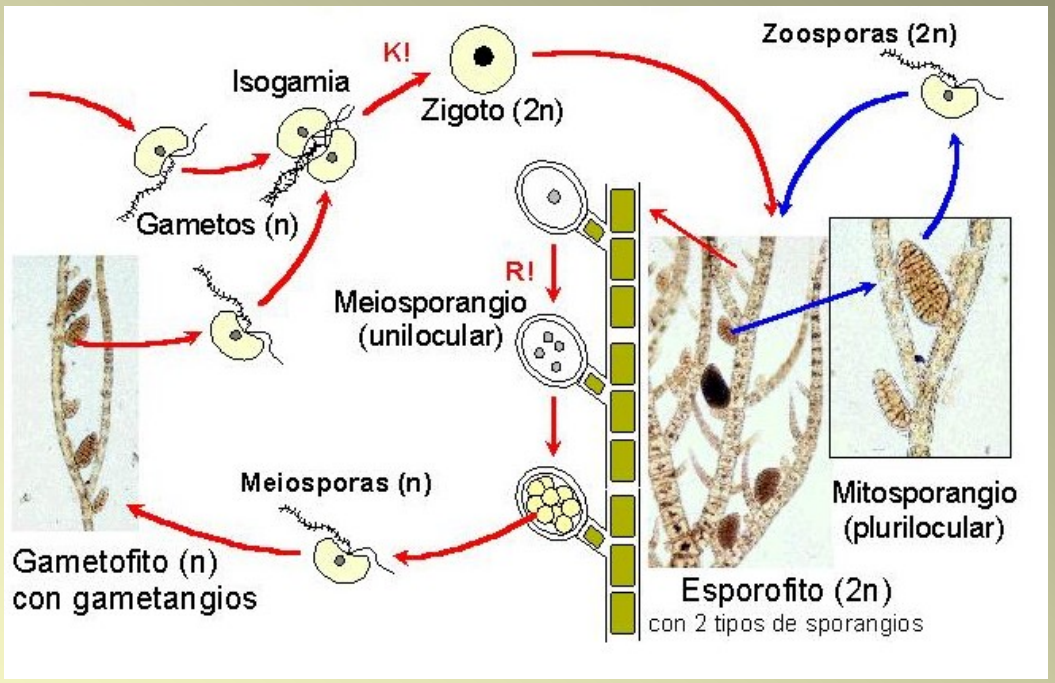
- zatím cca 2000 druhů, známé až z miocénu (- 15 mil. let);
- jen tři rody sladkovodní, většina litorál a sublitorál moří;
- heterotrichální až pletivné stélky; fenolické látky
- fukoxanthin - hnědý karotenoidní pigment;
- obskurní polysacharidy v buněčných stěnách, algináty;
- marikultury, zdroj jódu;


chloroplast
chrysolaminaran
olej


fyloid
kauloid
rhizoid

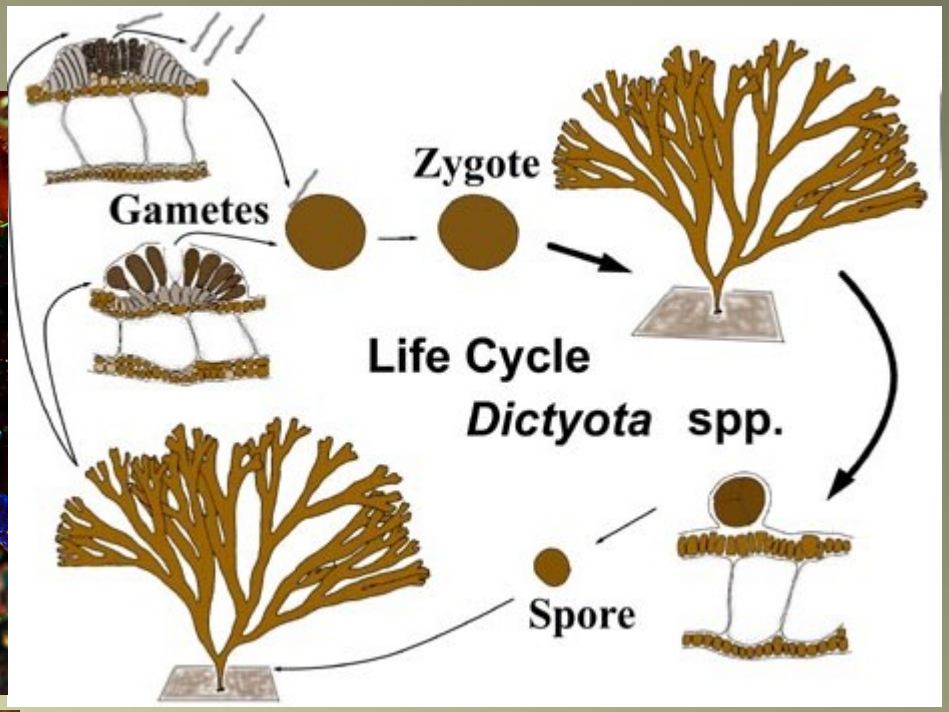
Ectocarpus



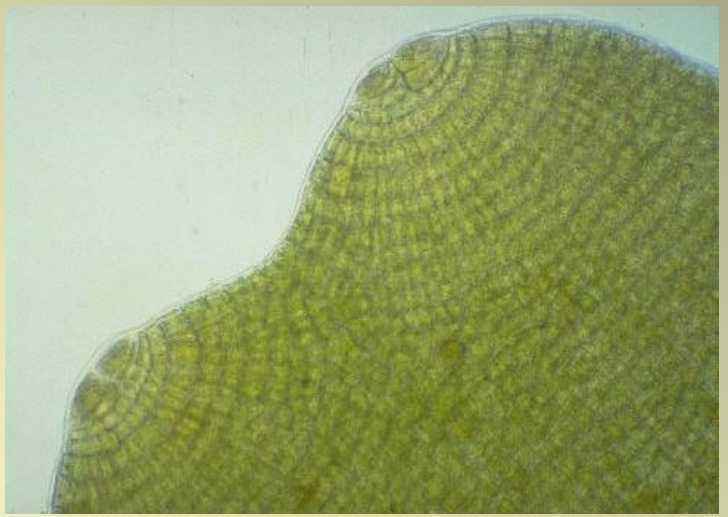


heterotrichální stélka, izomorfní rodozměna, litorál moří

Dictyota

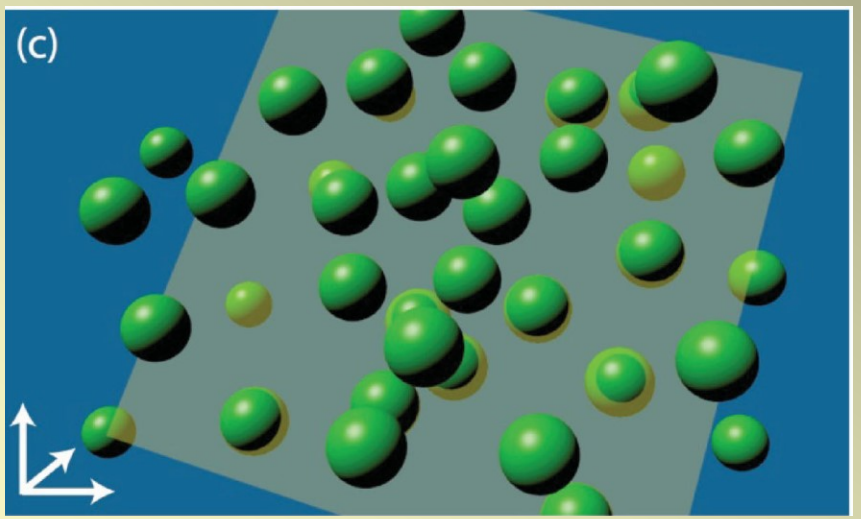


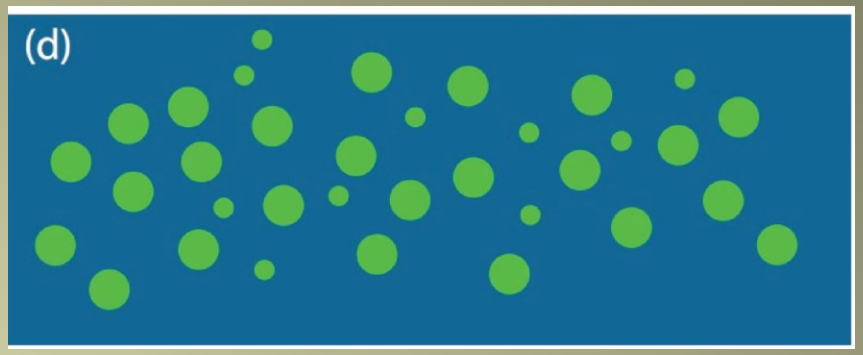
izomorfní rodozměna



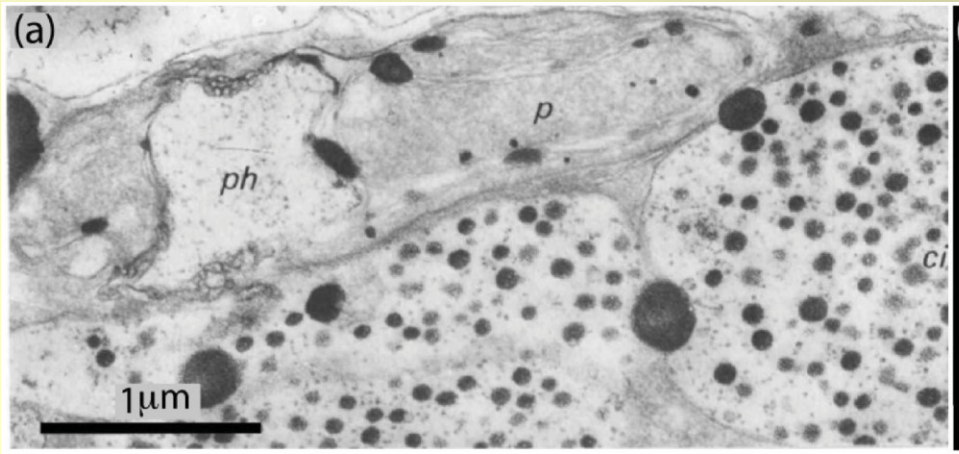
Iridiscence mořských chaluh

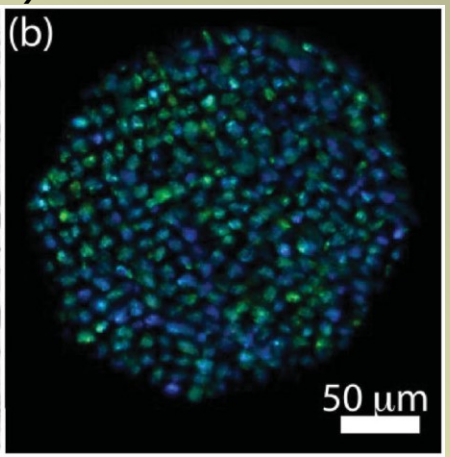
strukturní barvy – interakce světla s nanostrukturami (≈100 nm) – interference vytváří jasné saturované barvy





TEM microfotografie iridiskujících tělísek *Cystoseira tamariscifolia*.





iridescent bodies = fotonické struktury

(Chandler et al. 2016).

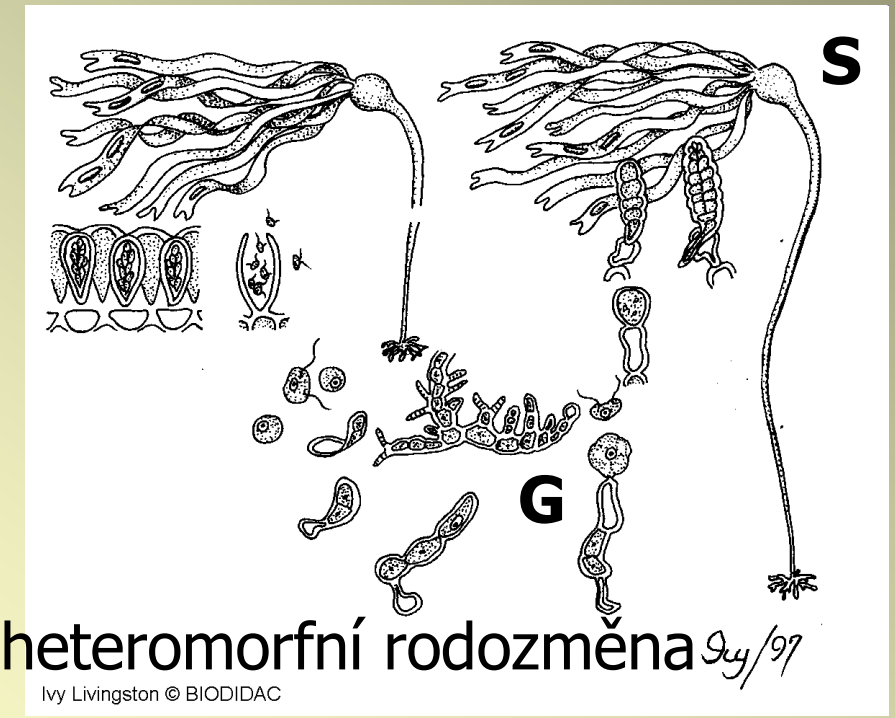
Dicyotales: D. dichotoma and *D. cyanoloma*

Fucales: Cystoseira tamariscifolia

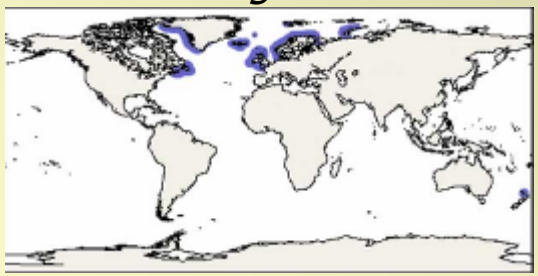
Padina

kosmopolitní litorální rod

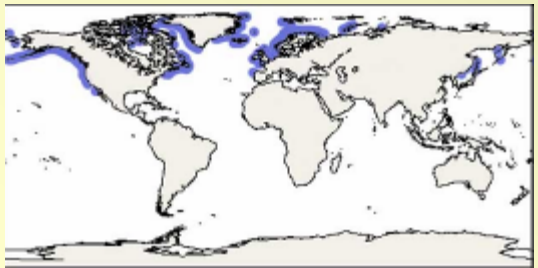
Laminaria



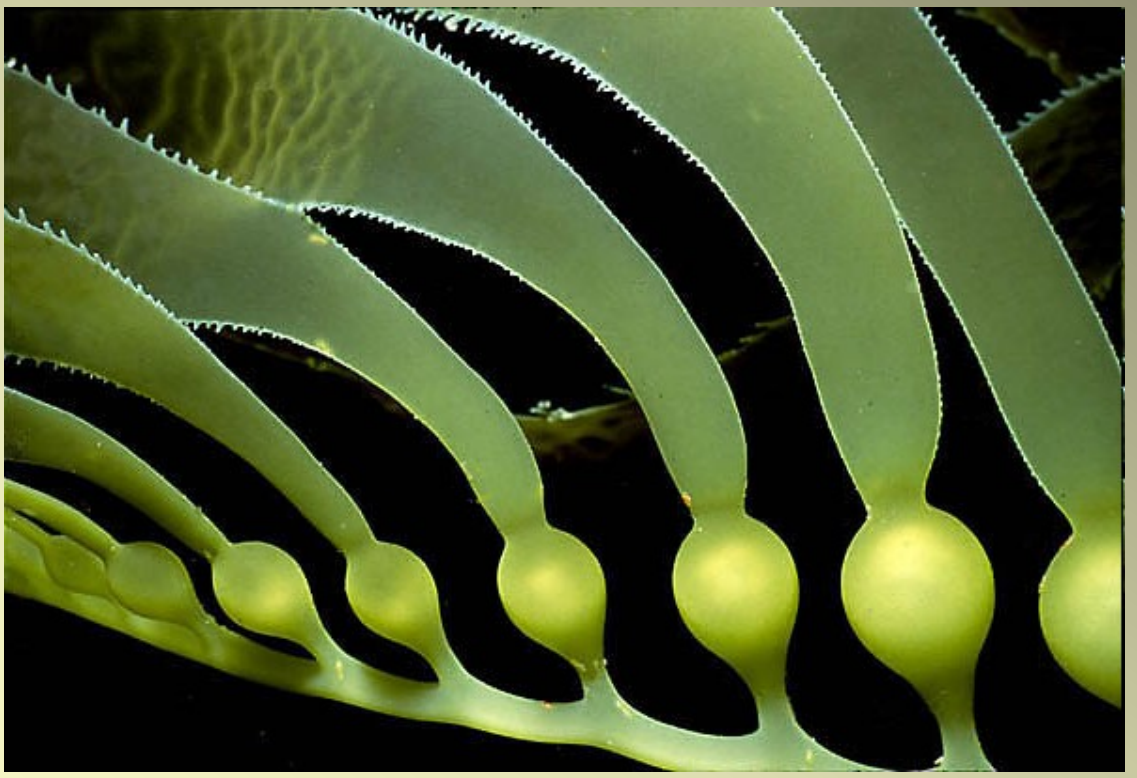
L. digitata

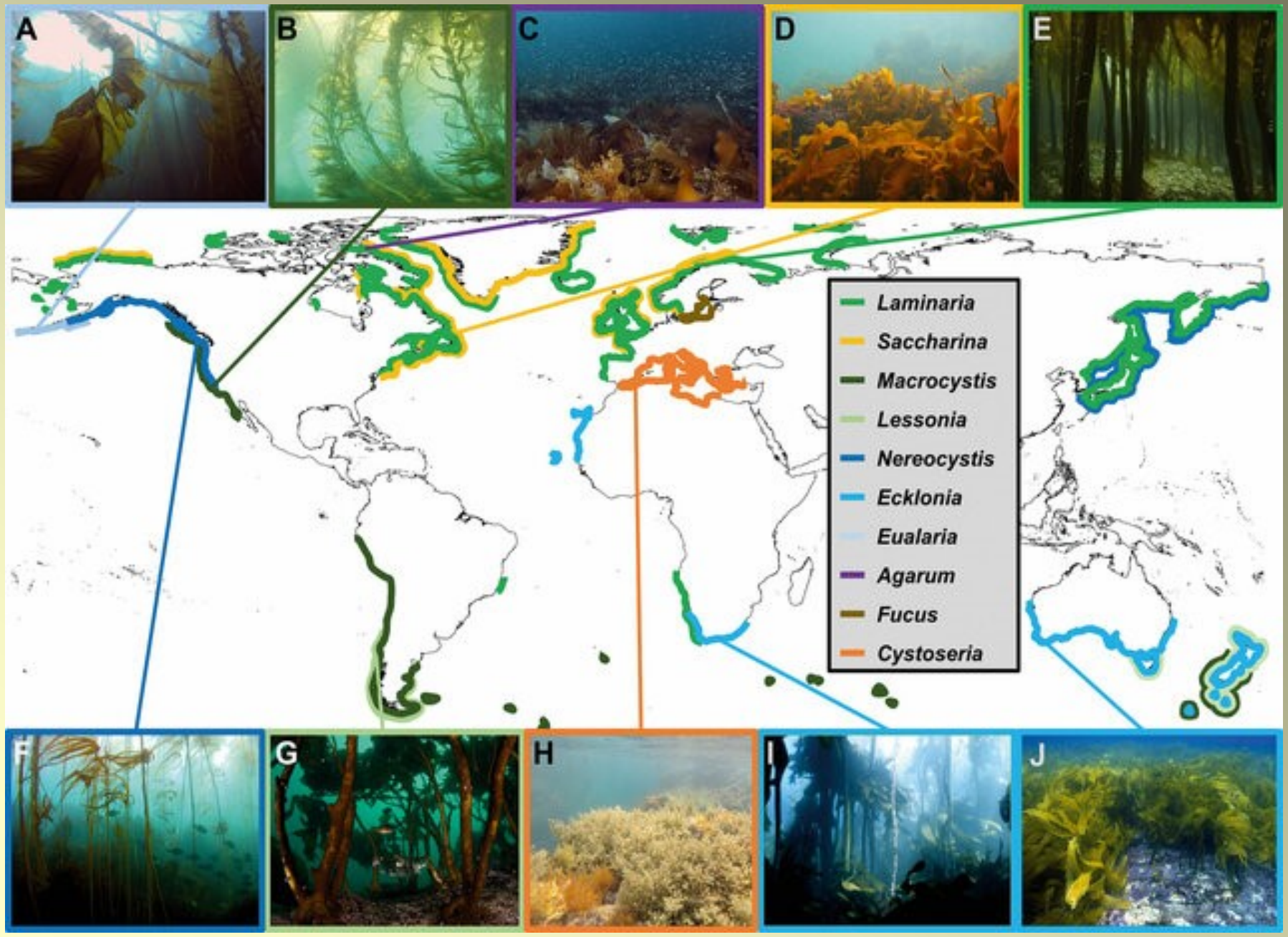


Saccharina latissima



Macrocystis





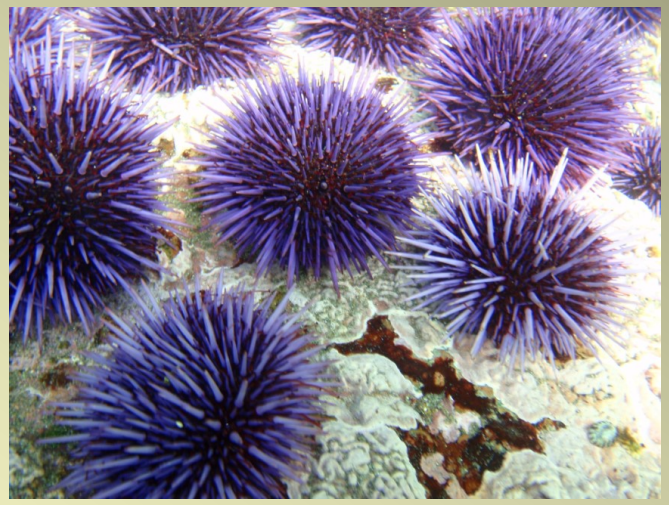
DOI: https://doi.org/10.3354/meps12867

kelp forest = chaluhový les

Macrocystis

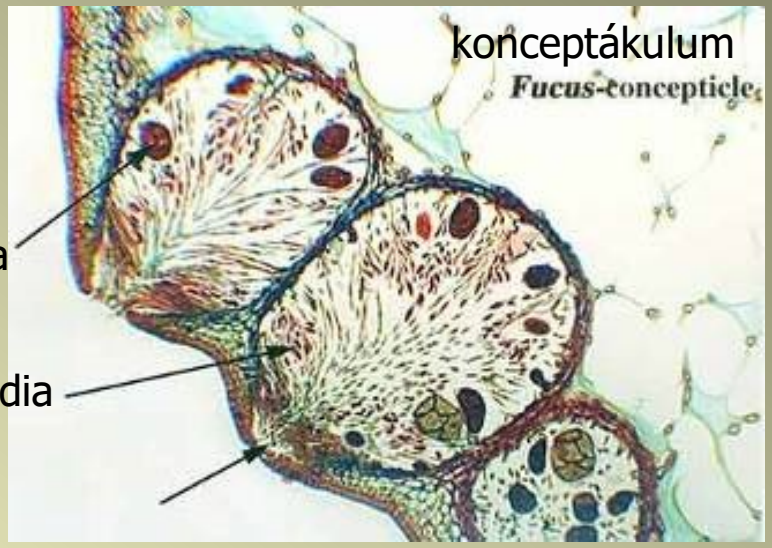
Mexiko, Baja California

Bufadora



Fucus

Chaluha bublinatá

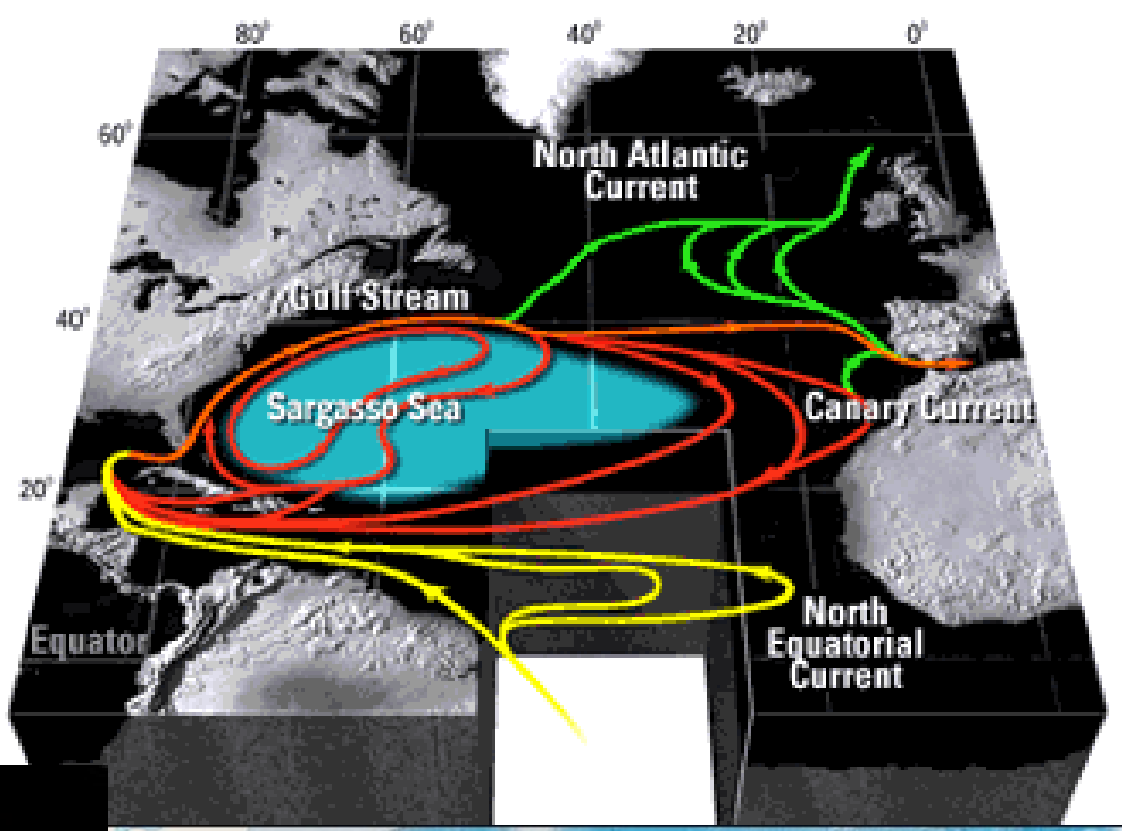


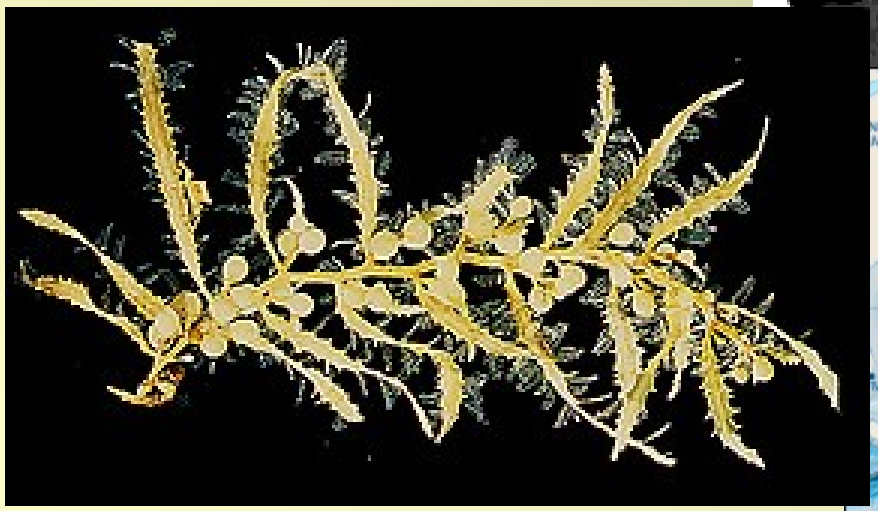
bez rodozměny – G na S

- diplontní životní cyklus; receptákula, konceptákula

Fucus Ascophyllum

Sargassum





- bentické a pelagické druhy

5 mil. km^2

Unikátní ekosystém

rozedranec sargasový *Histrio histrio*

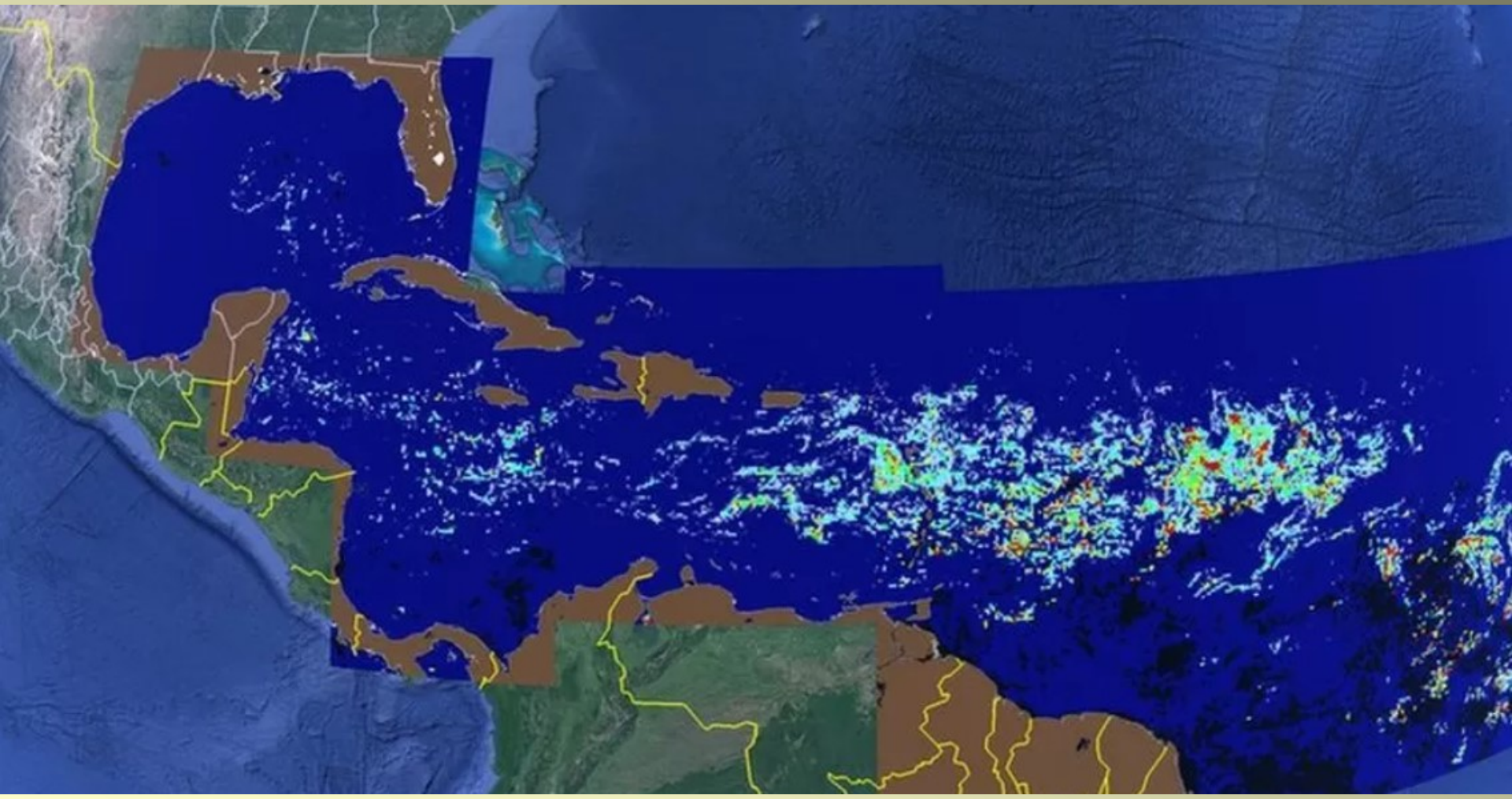
Scyllaea pelagica

Sargassum natans
S. fluitans

Planes minutus
krab sargasový

mimikry připomínají *Sargassum*

5000-mile-wide seaweed blob heads toward Florida



Letošní pás mořských řas váží asi deset milionů tun a je tak obrovský, že jej lze v celém rozsahu pozorovat jen z vesmíru. (16. března 2023)

Autor: Profimedia.cz

Ve Fort Lauderdale na Floridě odhrnuje traktor chaluhy, které byly vyplaveny na břeh. (16. března 2023)

Autor: Profimedia.cz

Algináty – extrahovány z buněčné stěny