9. Archaeplastida (Glaucophyta, Chloroplastida)

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Místnost 78, 2. mezipatro, Benátská 2

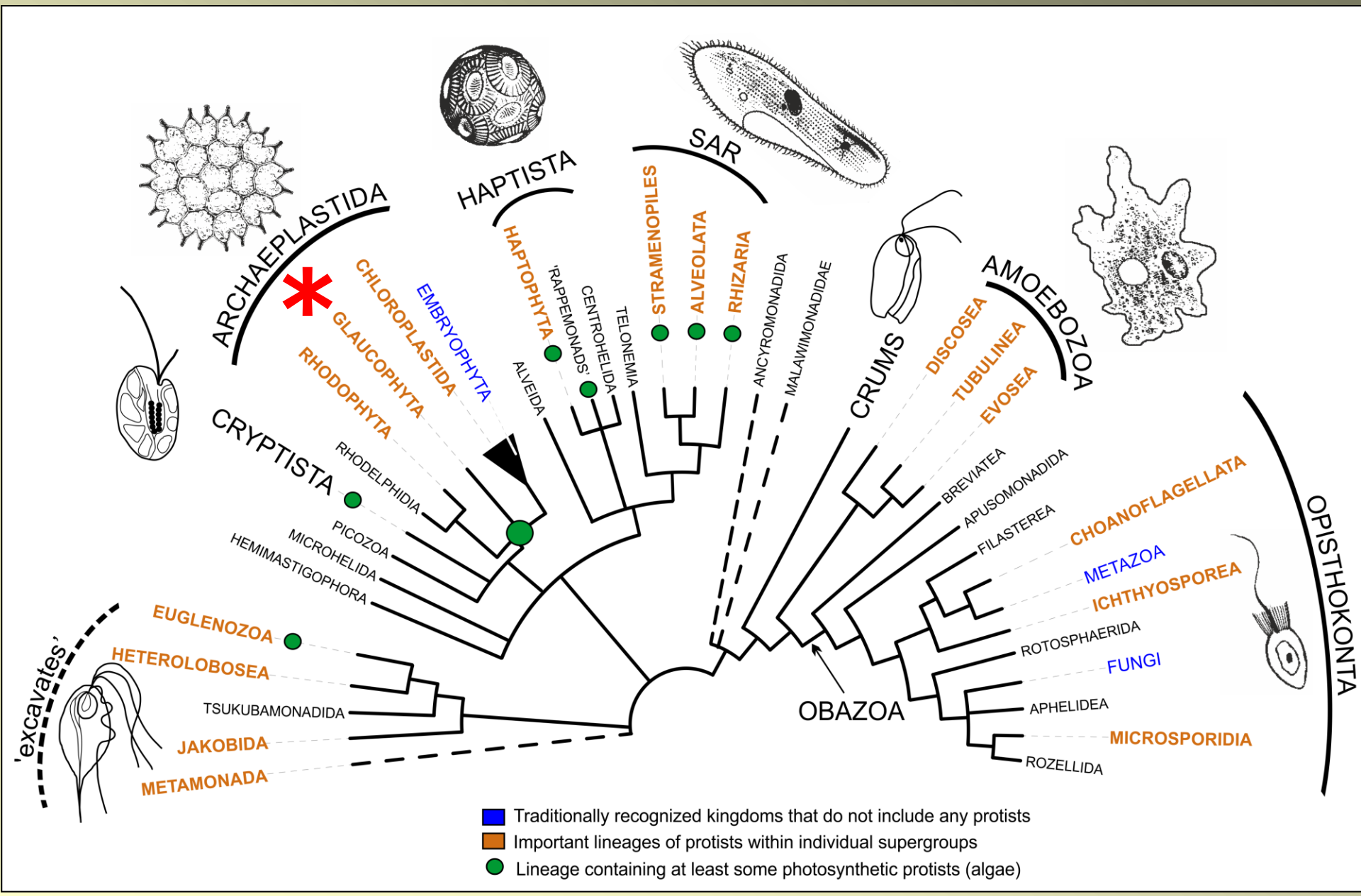
Botanika bezcévných rostlin a protistologie

(MB120P76U)

Přednášky

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

Archaeplastida: Glaucophyta

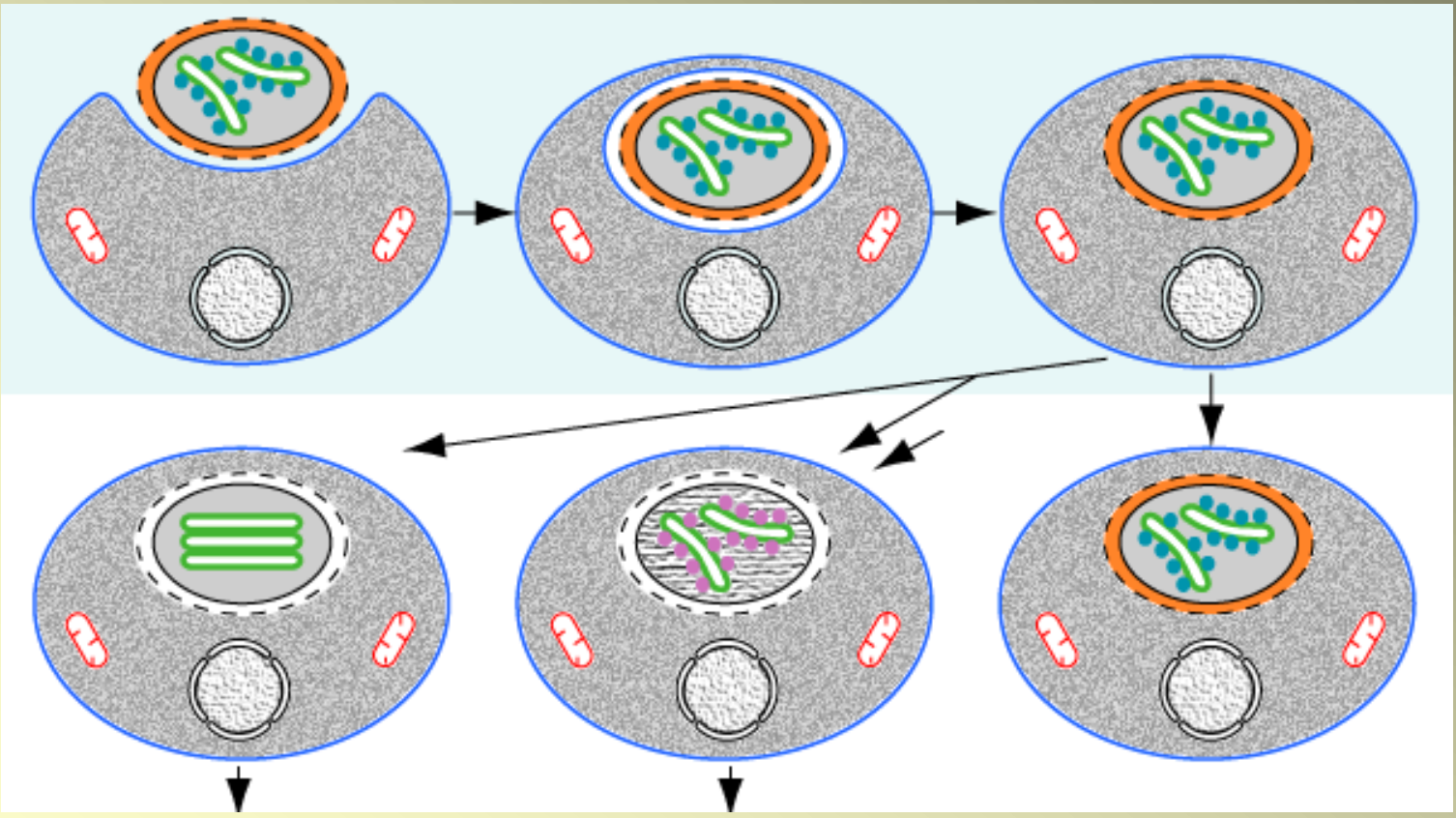


Primární endosymbióza

fagocytóza sinice

sinice v potravní vakuole

2 vrstevná obálka chloroplastu



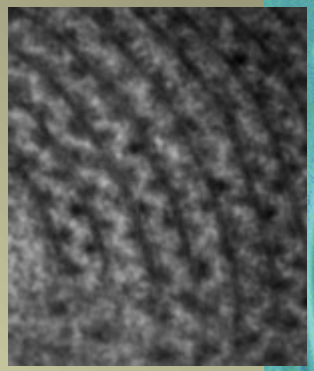
Chloroplastida – thylakoidy tvoří lamely (grana u streptofytní linie)

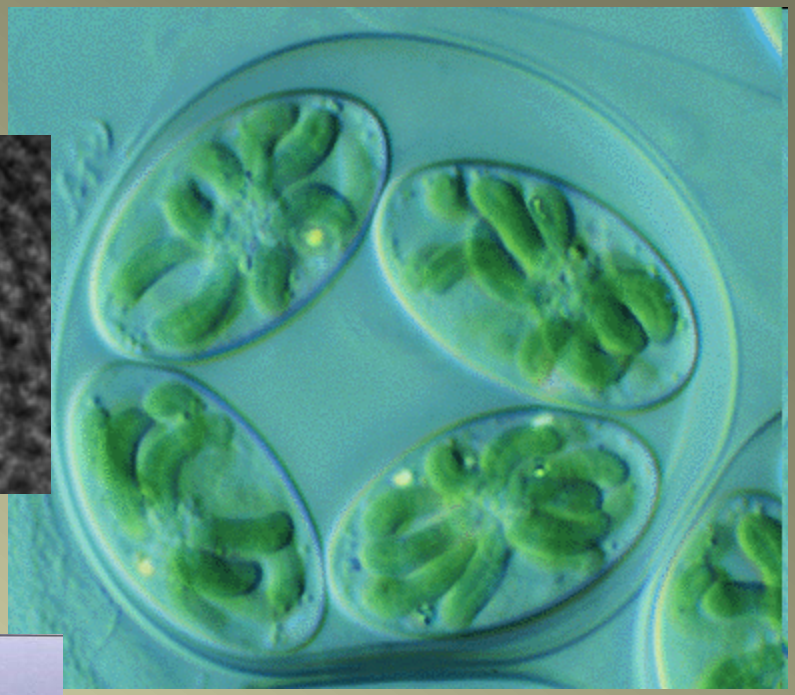
Rhodophyta fykobilisómy

Glaucophyta fykobilisómy zachován peptidoglykan

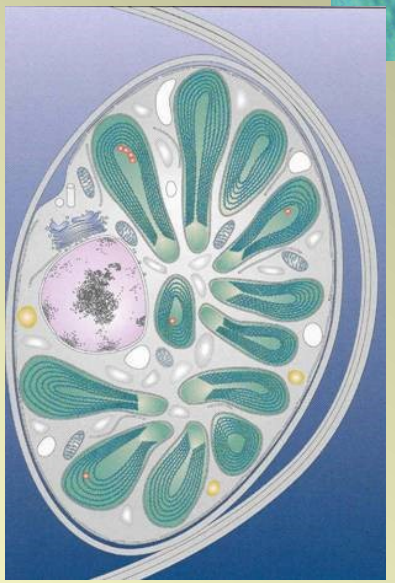
Kde v systému se nacházíme?

Eukaryota
Archaeplastida
Glaucophyta





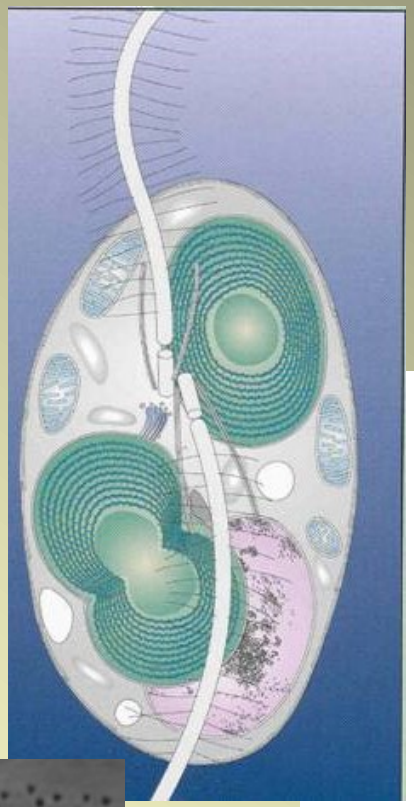
Glaucocystis nostochinearum

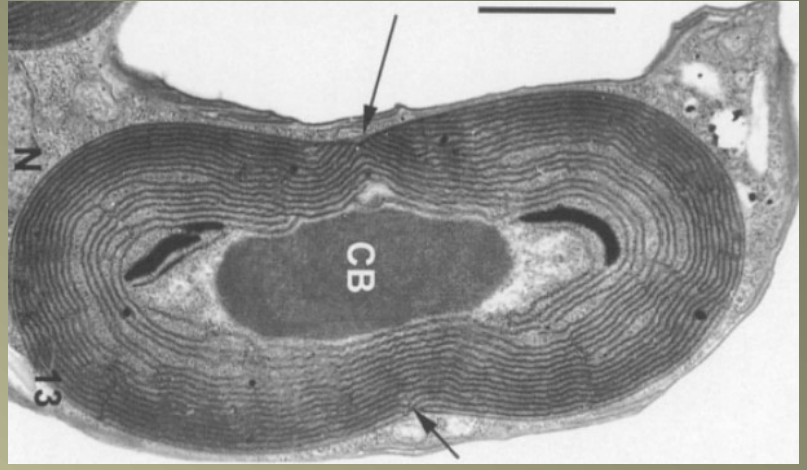


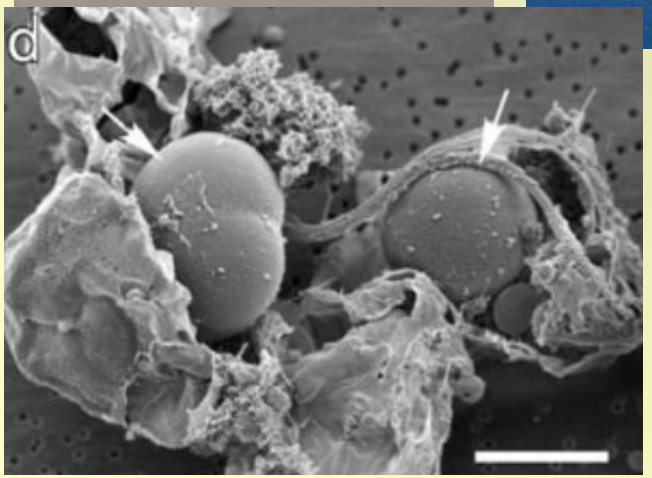
plastidy = cyanely
fykobilizómy, ch *a*, peptidoglykanový obal

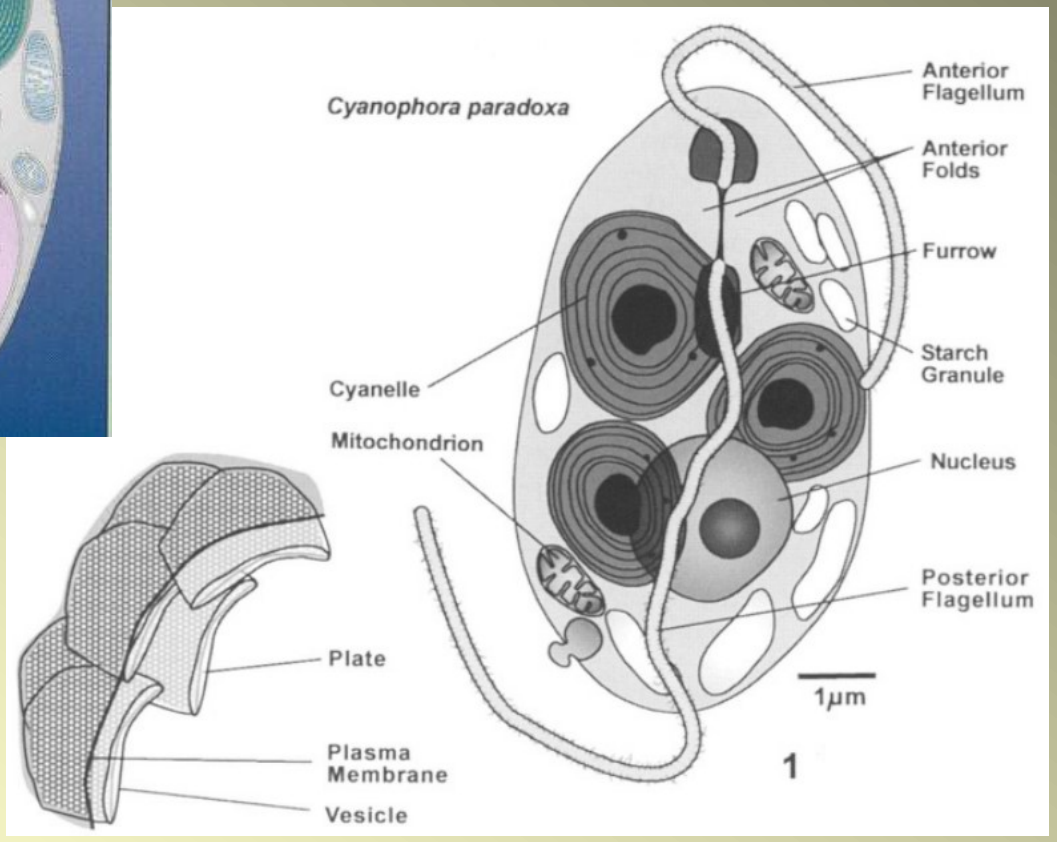
Glaucophyta - nejmenší a nejpůvodnější rostlinná větev

Cyanophora paradoxa



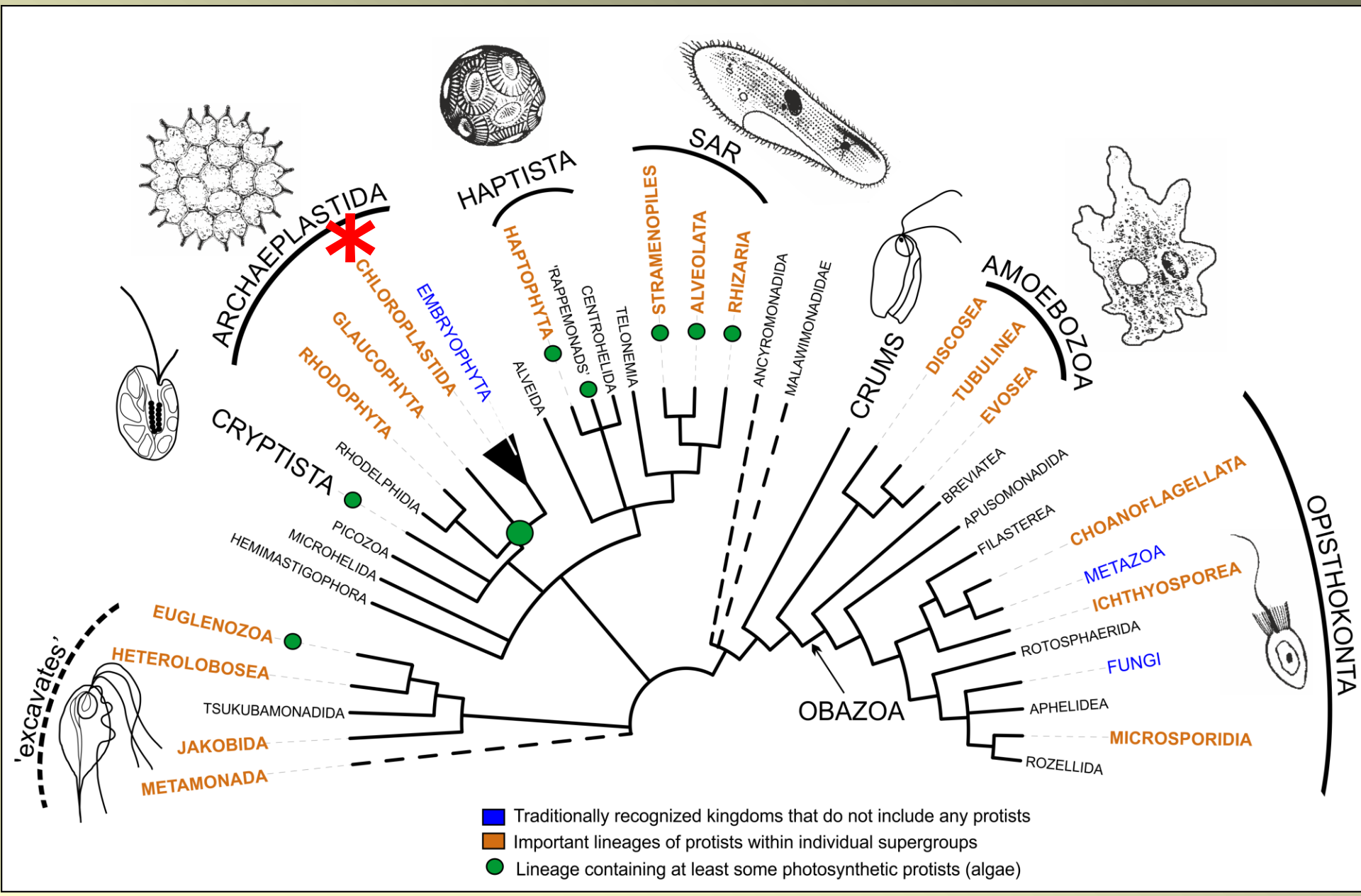






žije v planktonu kyselých sladkých vod

Archaeplastida: Chloroplastida



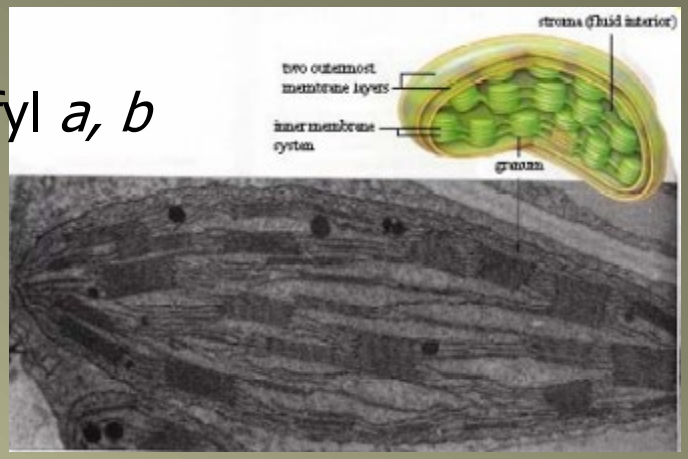
Kde v systému se nacházíme?

Eukaryota

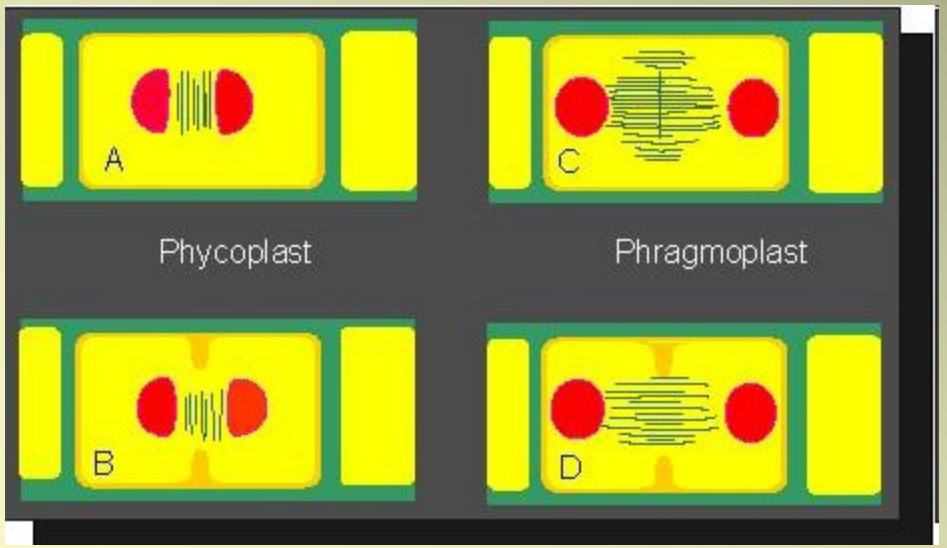
Archaeplastida (rostliny, Plantae)

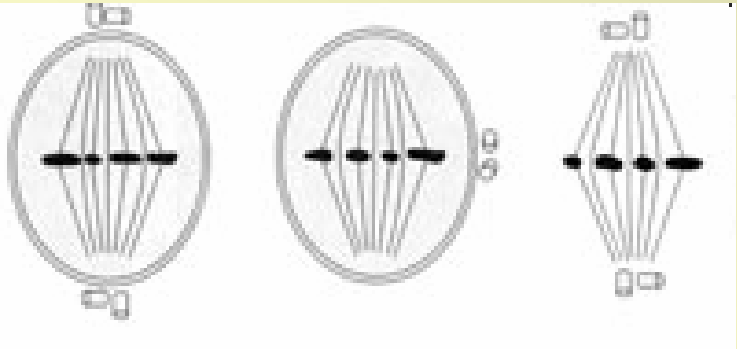
Chloroplastida=Viridiplantae - zelené rostliny

Chlorofyl *a, b*



dvě vývojové linie - *Chlorophyta* a *Streptophyta*

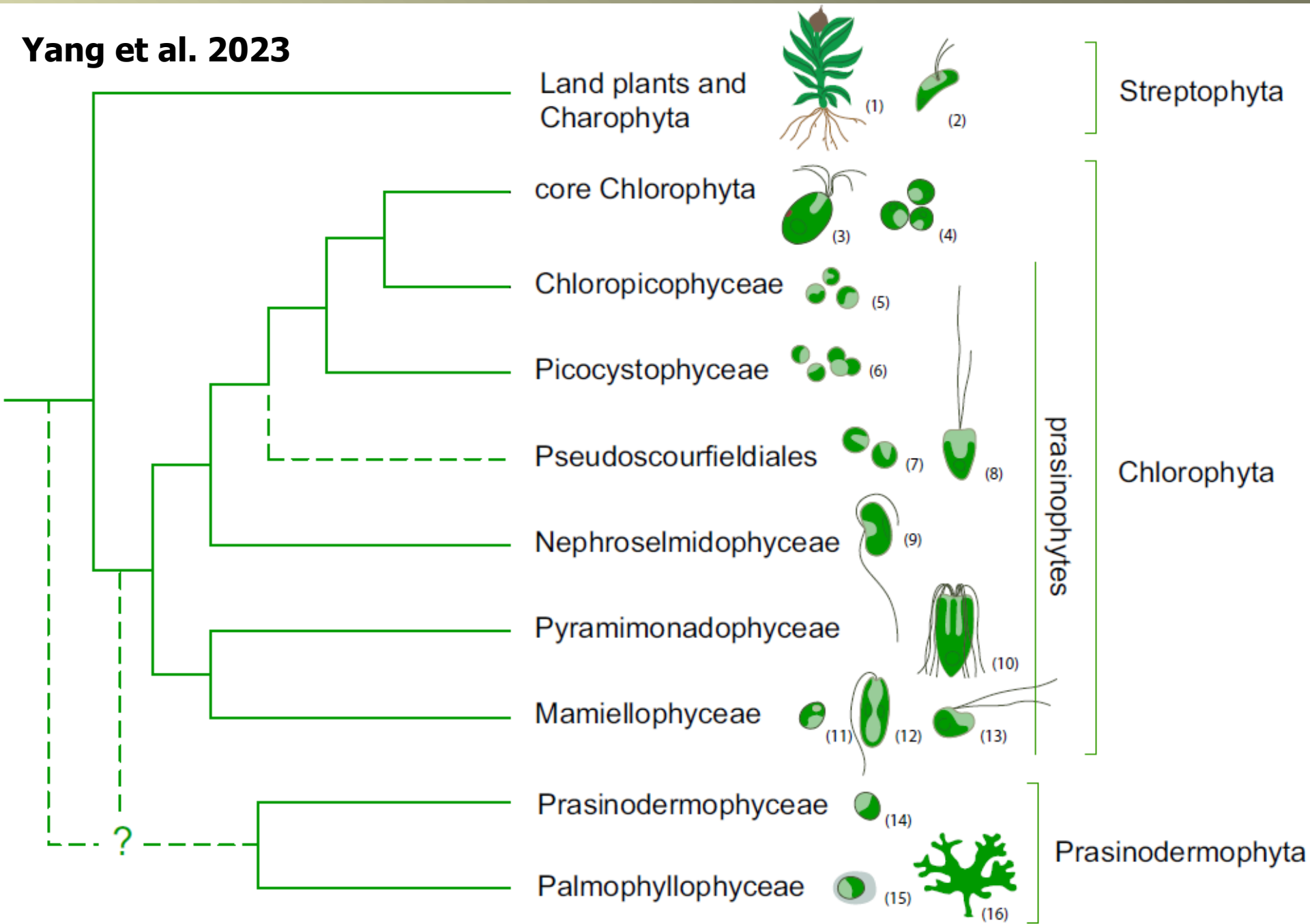


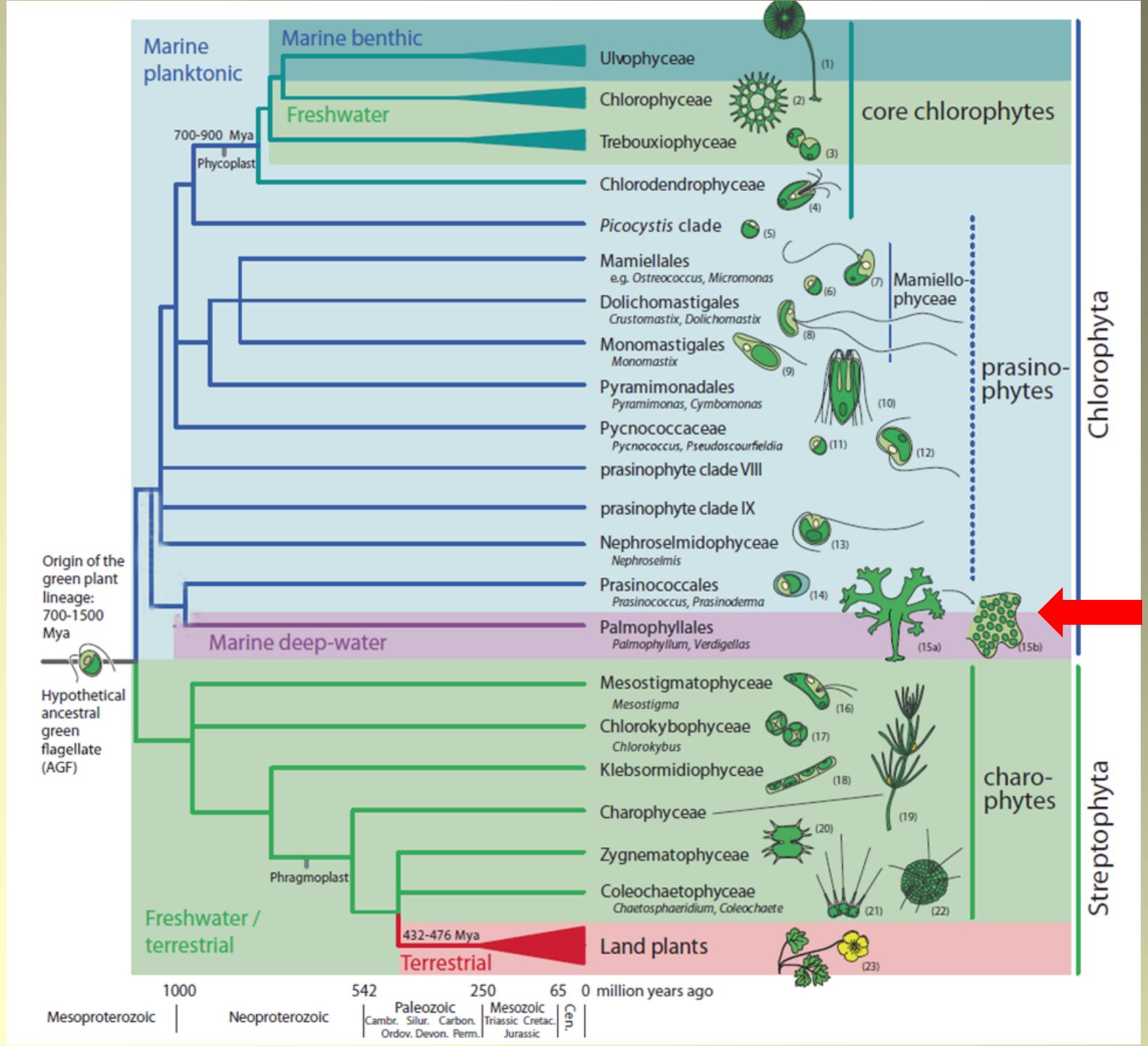


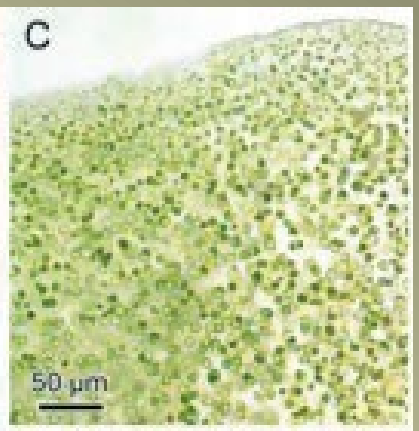
mechorosty a cévnaté rostliny se ze streptofytní linie začaly vyvíjet asi před 700 milióny lety

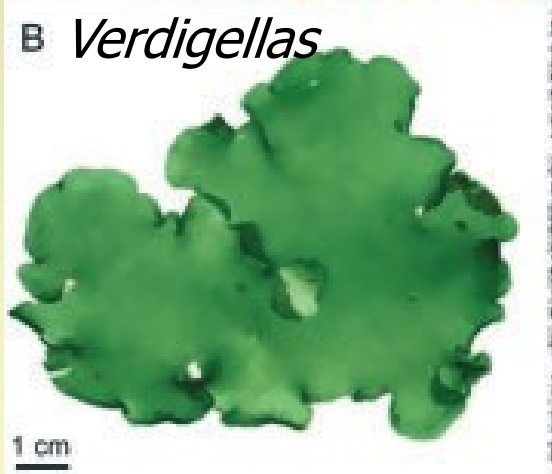
Viridiplantae = Chloroplastida

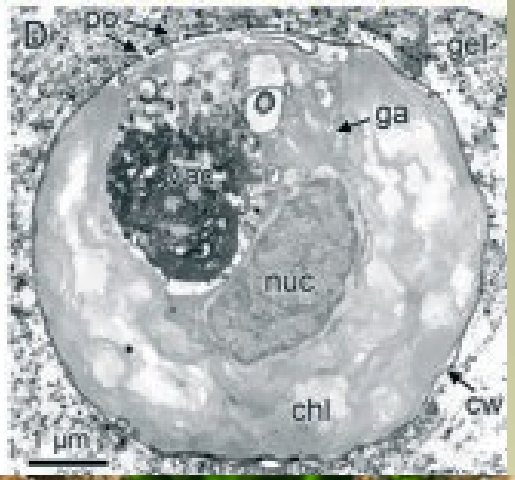
Yang et al. 2023




Marine planktonic
Marine benthic
Freshwater
700-900 Mya
Phycoplast
Ulvophyceae
Chlorophyceae
Trebouxiophyceae
Chlorodendrophyceae
Picocystis clade
Mamiellales
e.g. Ostreococcus, Micromonas
Dolichomastigales
Crustomastix, Dolichomastix
Monomastigales
Monomastix
Pyramimonadales
Pyramimonas, Cymbomonas
Pycnococcaceae
Pycnococcus, Pseudoscourfieldia
prasinophyte clade VIII
prasinophyte clade IX
Nephroselmidophyceae
Nephroselmis
Prasinococcales
Prasinococcus, Prasinoderma
Palmophyllales
Palmophyllum, Verdigellas
Marine deep-water
core chlorophytes
Mamiello-phyceae
prasino-phytes
Chlorophyta
Origin of the green plant lineage: 700-1500 Mya
Hypothetical ancestral green flagellate (AGF)
Mesostigmatophyceae
Mesostigma
Chlorokybophyceae
Chlorokybus
Klebsormidiophyceae
Charophyceae
Zygnematophyceae
Coleochaetophyceae
Chaetosphaeridium, Coleochaete
Phragmoplast
Freshwater / terrestrial
432-476 Mya
Terrestrial
Land plants
charo-phytes
Streptophyta
(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)
(9)
(10)
(11)
(12)
(13)
(14)
(15a)
(15b)
(16)
(17)
(18)
(19)
(20)
(21)
(22)
(23)
1000
542
250
65
0 million years ago
Mesoproterozoic
Neoproterozoic
Paleozoic
Cambr. Silur. Carbon.
Ordov. Devon. Perm.
Mesozoic
Triassic Cretac.
Jurassic
Cen.

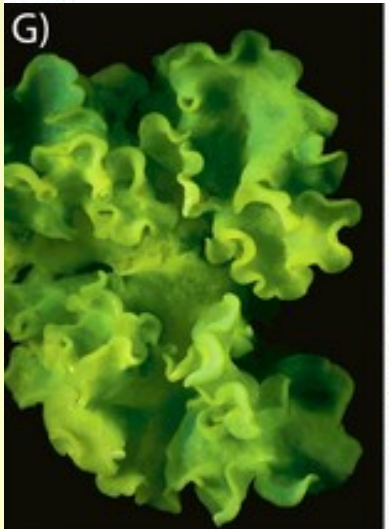




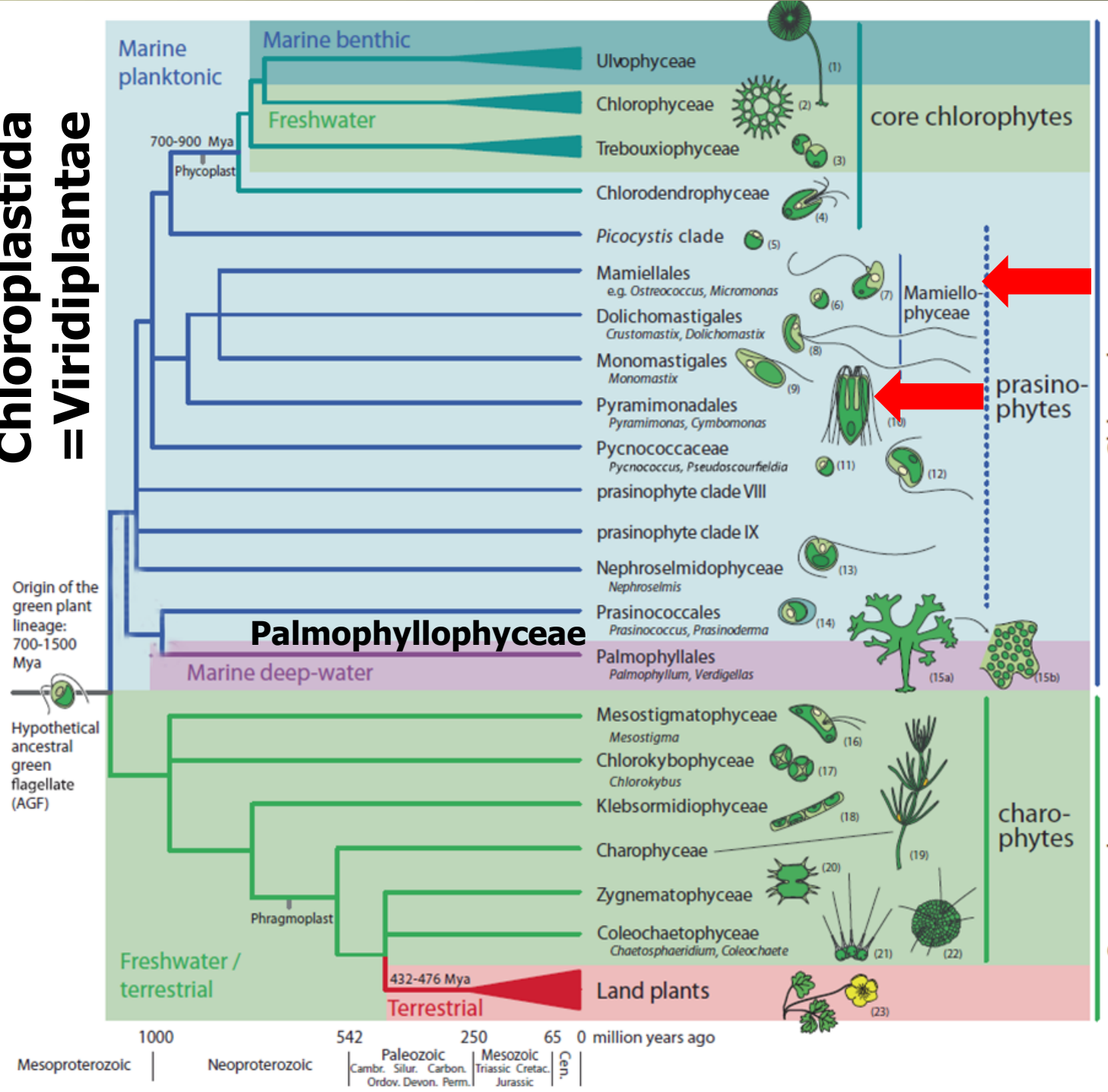


Phalmophyllophyceae
hlubokomořská skupina řas

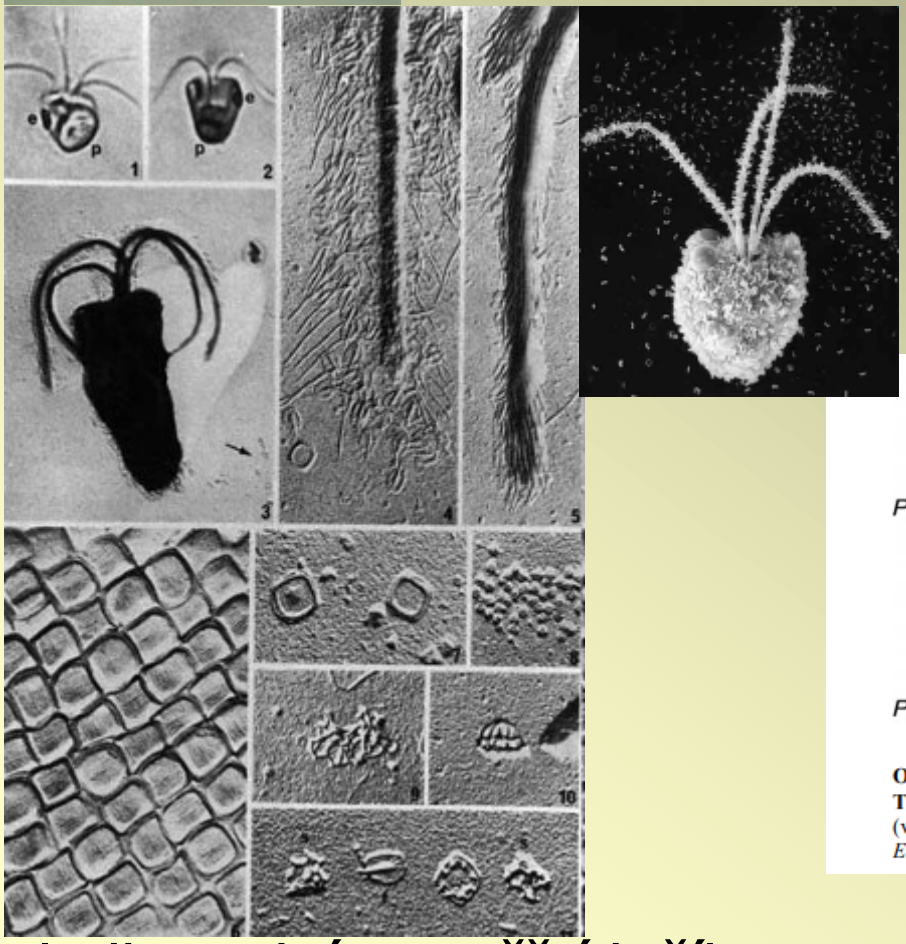
Palmoclathrus



Chloroplastida =Viridiplantae



Pyramimonas

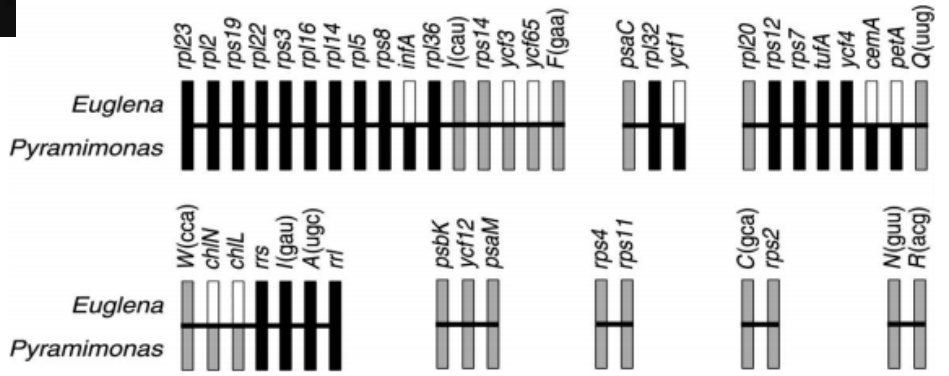


Kde v systému se nacházíme?

Prasinofyta – parafyletická skupina

Pyramimonas parkeae - Nejbližší známý příbuzný chloroplastu euglen

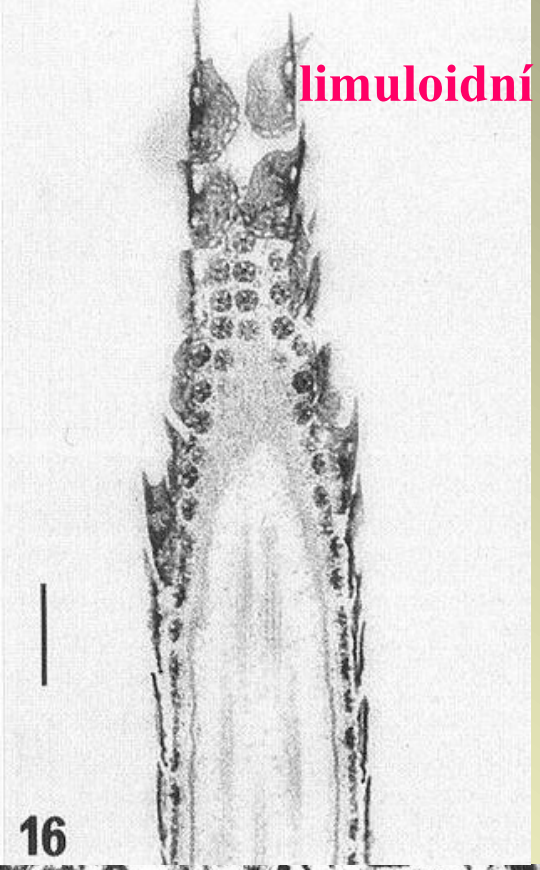
Plastidové genomy sdílí unikátní pořadí určitých genů

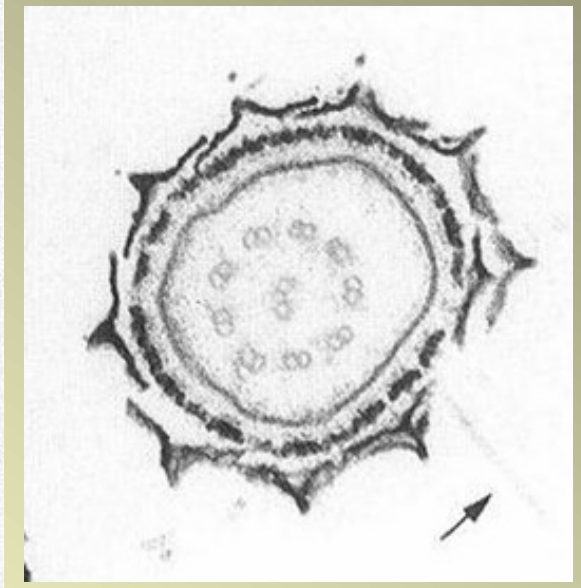


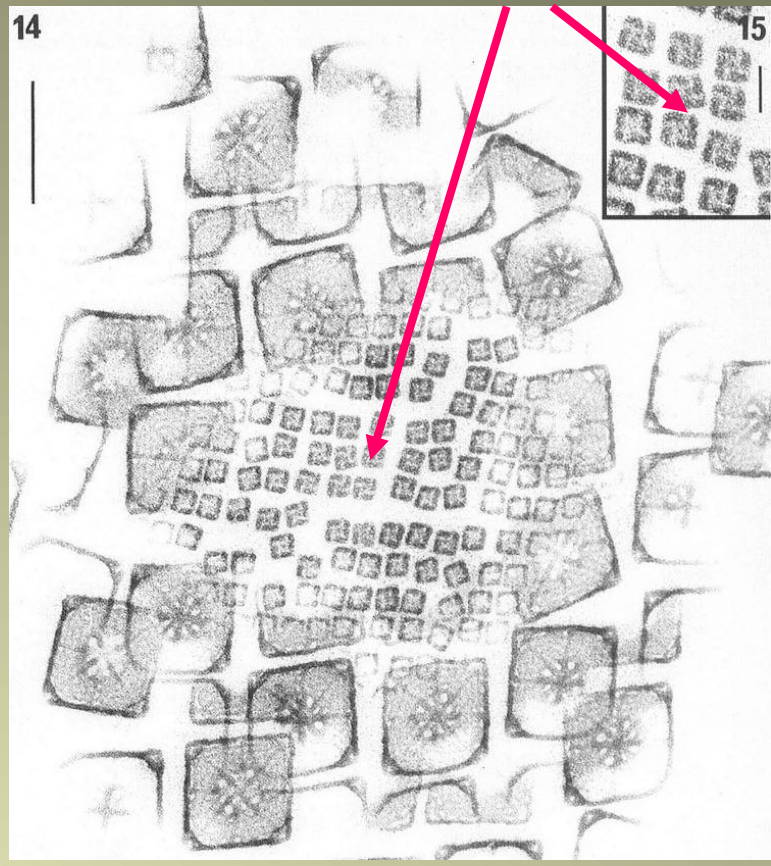
Obr. 1. Genové klastry unikátně sdílené cpDNA organismů *Euglena* a *Pyramimonas* podle Turmelové et al. (2009). Černě vybarvená políčka naznačují ancestrální uspořádání těchto klastrů (vyskytující se i u jiných zelených řas), šedá políčka odkazují na derivované oblasti (specifické pro *Euglena* a *Pyramimonas*) a prázdná políčka označují chybějící geny.

sladkovodní a mořští bičíkovci - popsáno několik nových tříd

Organické šupiny



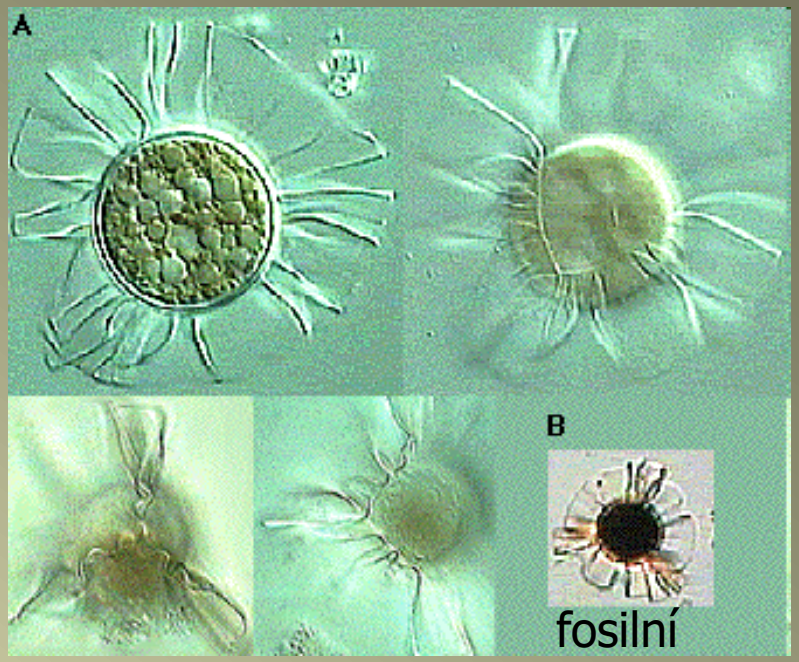


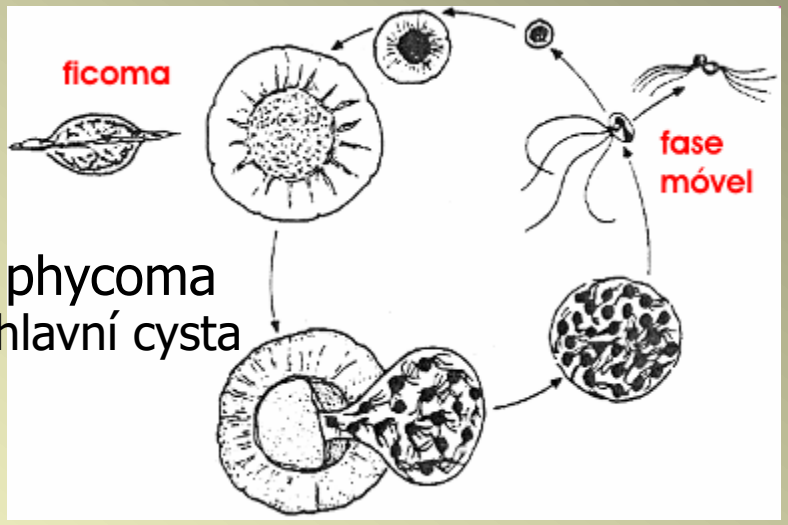


Cymbomonas tetramitiformis

krabicovitá

Pterosperma





fosilní záznamy z pozdního
Prekambria (600 mil.let)

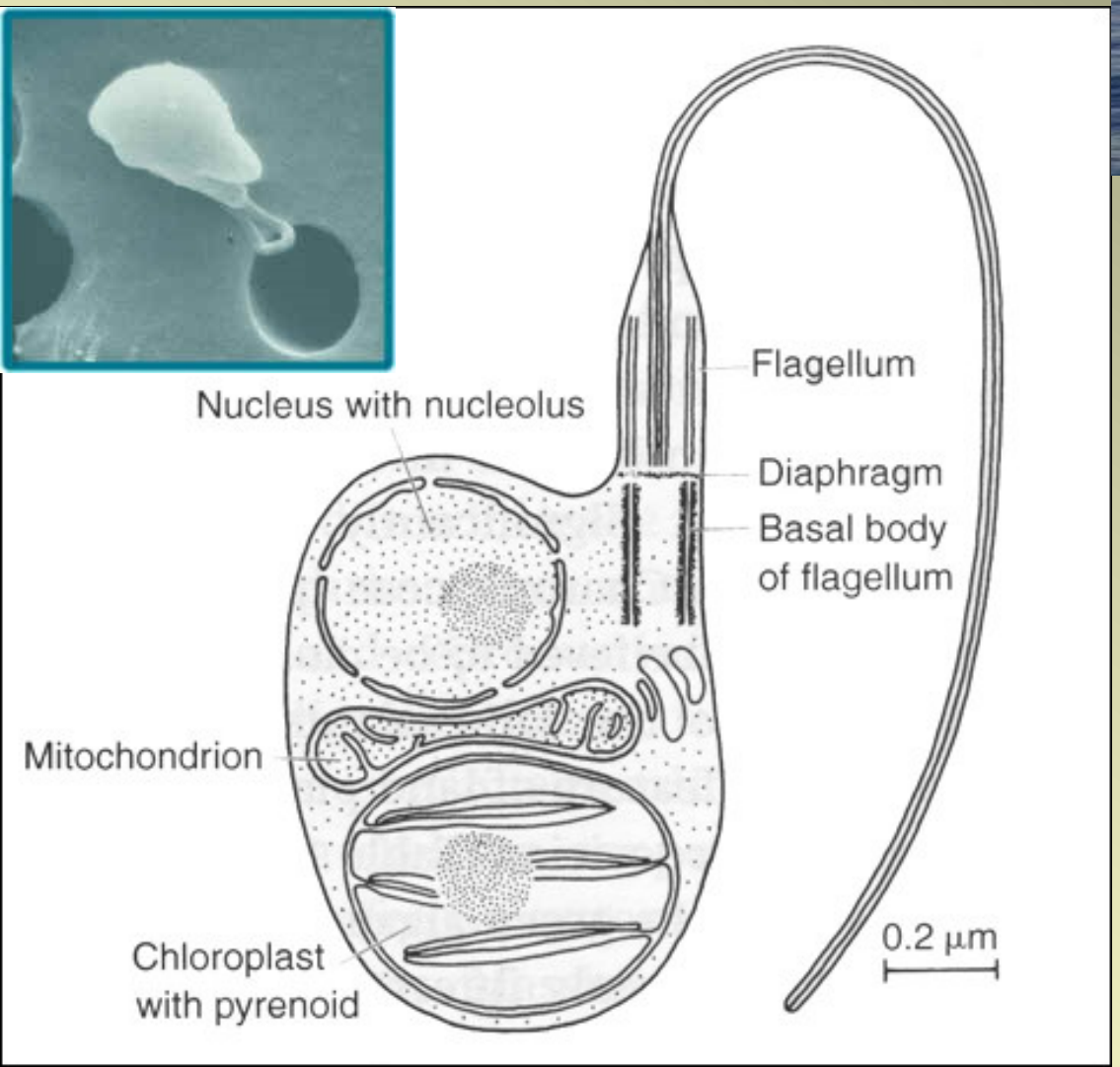
mořský fytoplankton - chladná moře

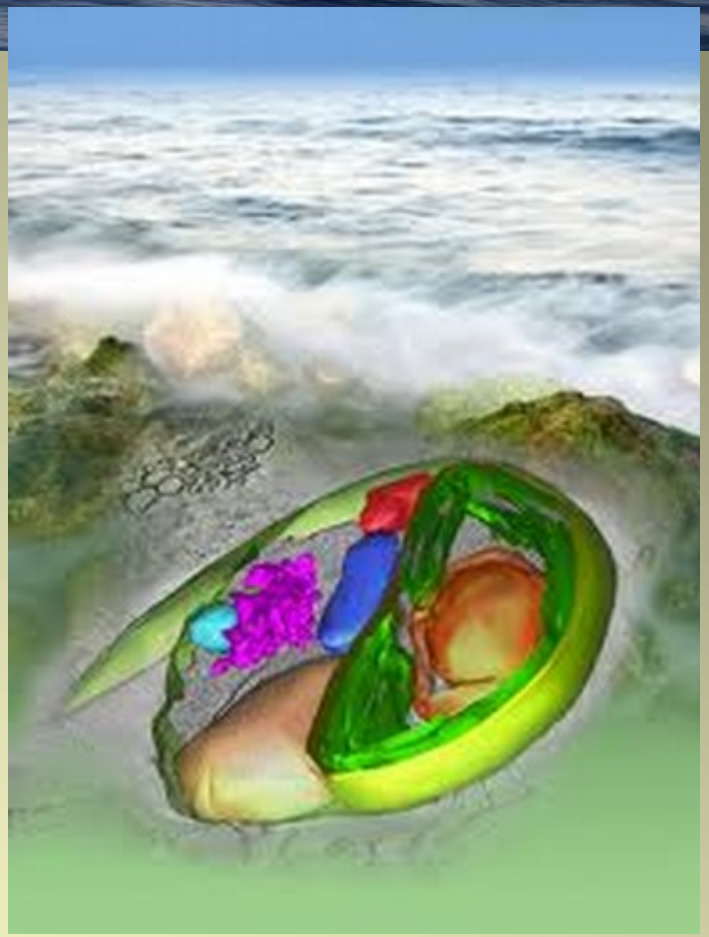
Kde v systému se nacházíme?

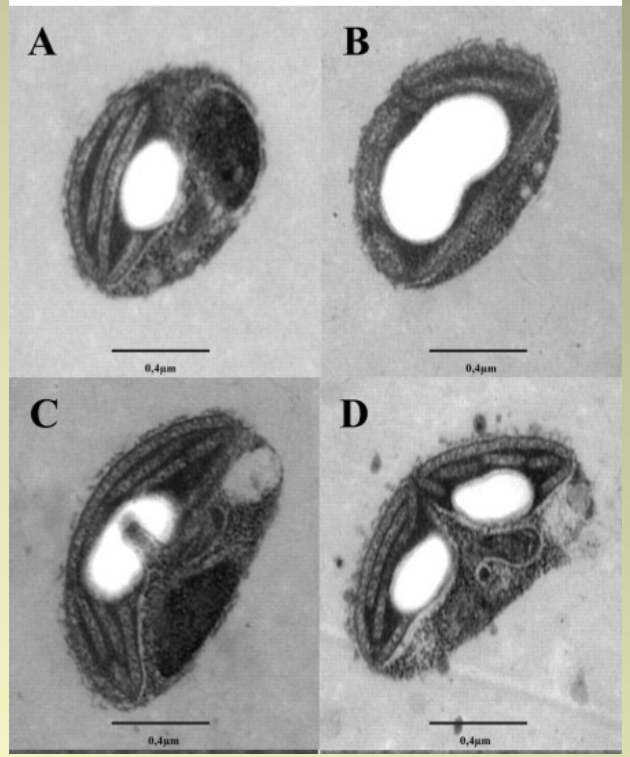
Prasinofyta – parafyletická skupina

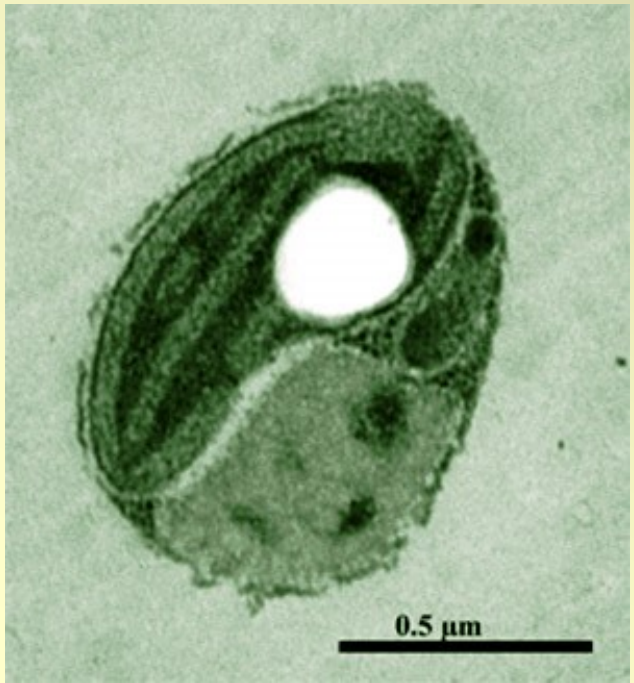
Mamiellophyceae

Micromonas – pikoplankton oceánů, chladnější voda







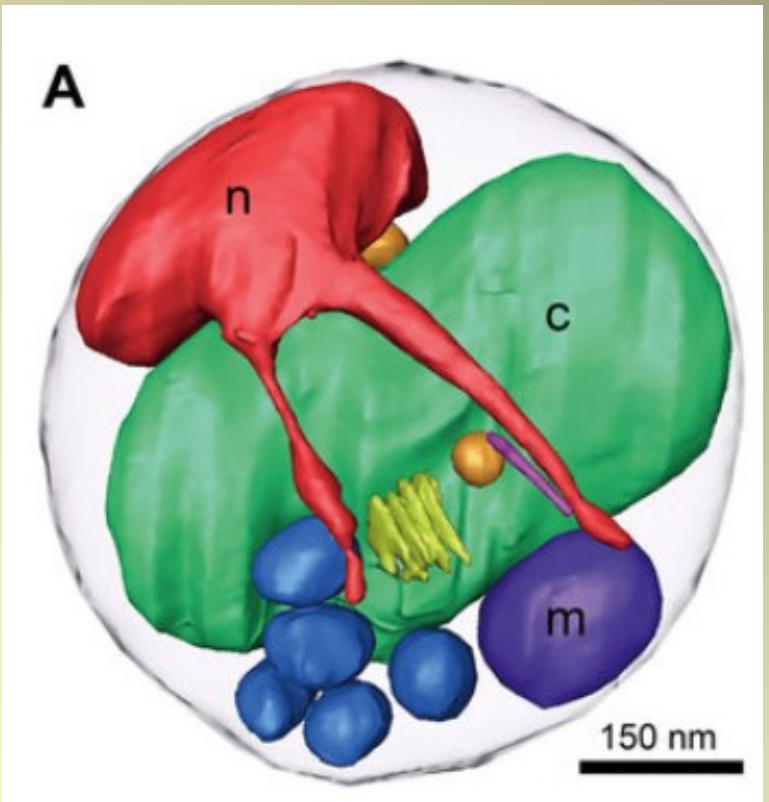


Ostreococcus

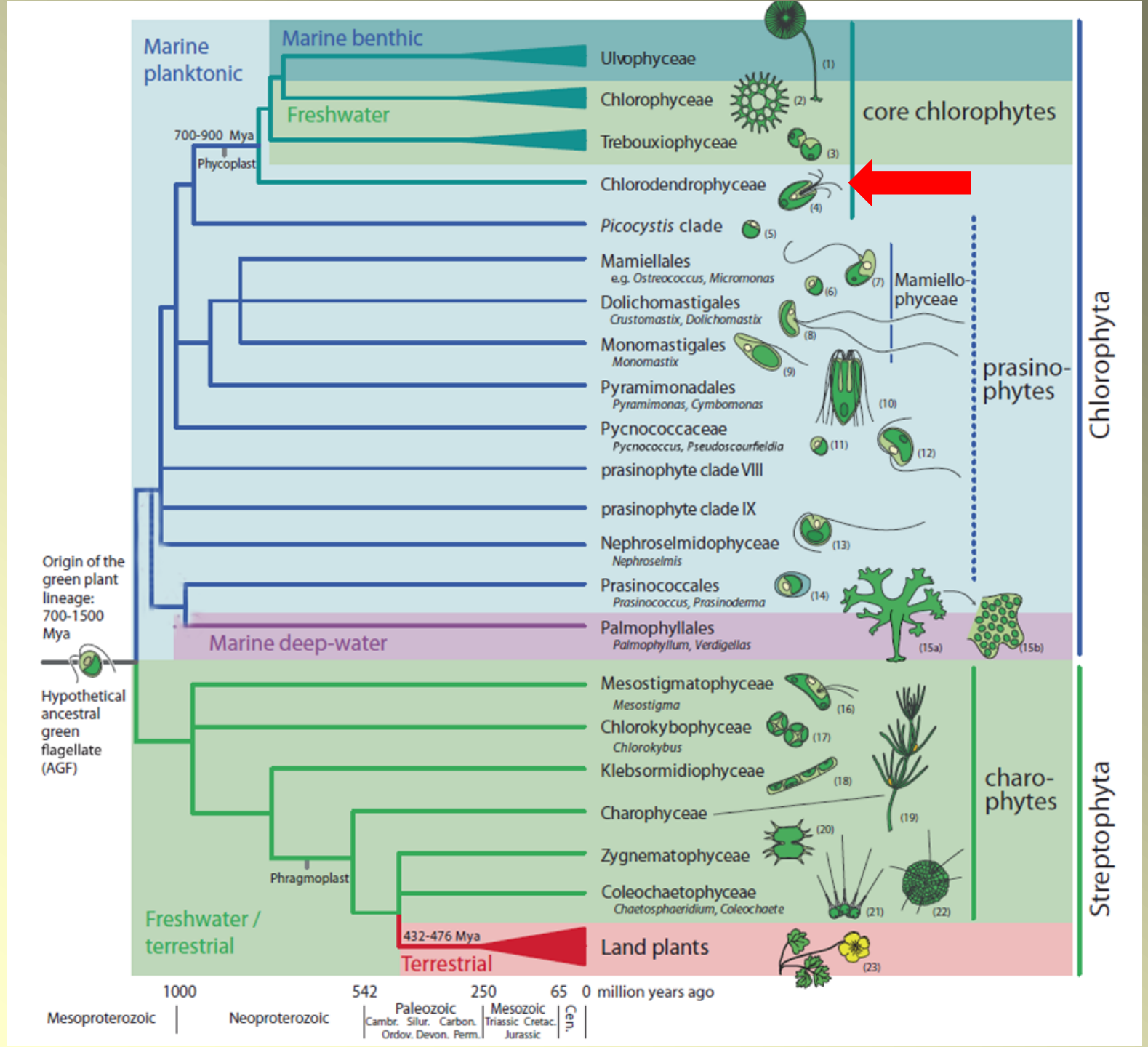
ubikvitní rozšíření, horní-osvětlené vrstvy oceánů

Vegetační zákaly v moři; nejmenší euk. genom

rozmnožují se pohlavně???



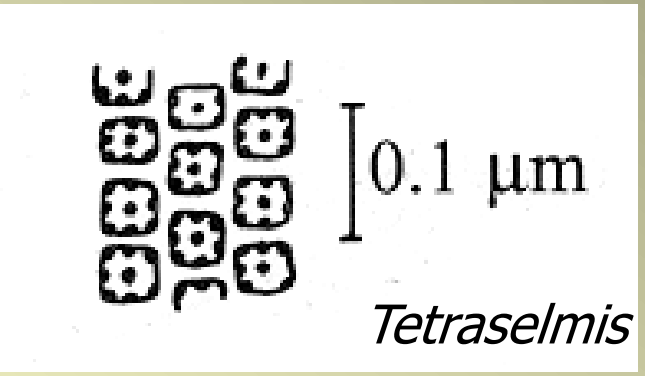
O. tauri: 12.6 millionů bp, ve 20 chromos. Bakterie: 130 tis. až 13 milionů bp. Člověk: 3.2 miliardy párů bází


Marine planktonic
Marine benthic
Freshwater
700-900 Mya
Phycoplast
Ulvophyceae
Chlorophyceae
Trebouxiophyceae
Chlorodendrophyceae
Picocystis clade
Mamiellales
e.g. Ostreococcus, Micromonas
Dolichomastigales
Crustomastix, Dolichomastix
Monomastigales
Monomastix
Pyramimonadales
Pyramimonas, Cymbomonas
Pycnococcaceae
Pycnococcus, Pseudoscourfieldia
prasinophyte clade VIII
prasinophyte clade IX
Nephroselmidophyceae
Nephroselmis
Prasinococcales
Prasinococcus, Prasinoderma
Palmophyllales
Palmophyllum, Verdigellas
Marine deep-water
core chlorophytes
Mamiello-phyceae
prasino-phytes
Chlorophyta
Origin of the green plant lineage: 700-1500 Mya
Hypothetical ancestral green flagellate (AGF)
Mesostigmatophyceae
Mesostigma
Chlorokybophyceae
Chlorokybus
Klebsormidiophyceae
Charophyceae
Zygnematophyceae
Coleochaetophyceae
Chaetosphaeridium, Coleochaete
Phragmoplast
Freshwater / terrestrial
432-476 Mya
Terrestrial
Land plants
charo-phytes
Streptophyta
(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)
(9)
(10)
(11)
(12)
(13)
(14)
(15a)
(15b)
(16)
(17)
(18)
(19)
(20)
(21)
(22)
(23)
1000
542
250
65
0 million years ago
Mesoproterozoic
Neoproterozoic
Paleozoic
Cambr. Silur. Carbon.
Ordov. Devon. Perm.
Mesozoic
Triassic Cretac.
Jurassic
Cen.

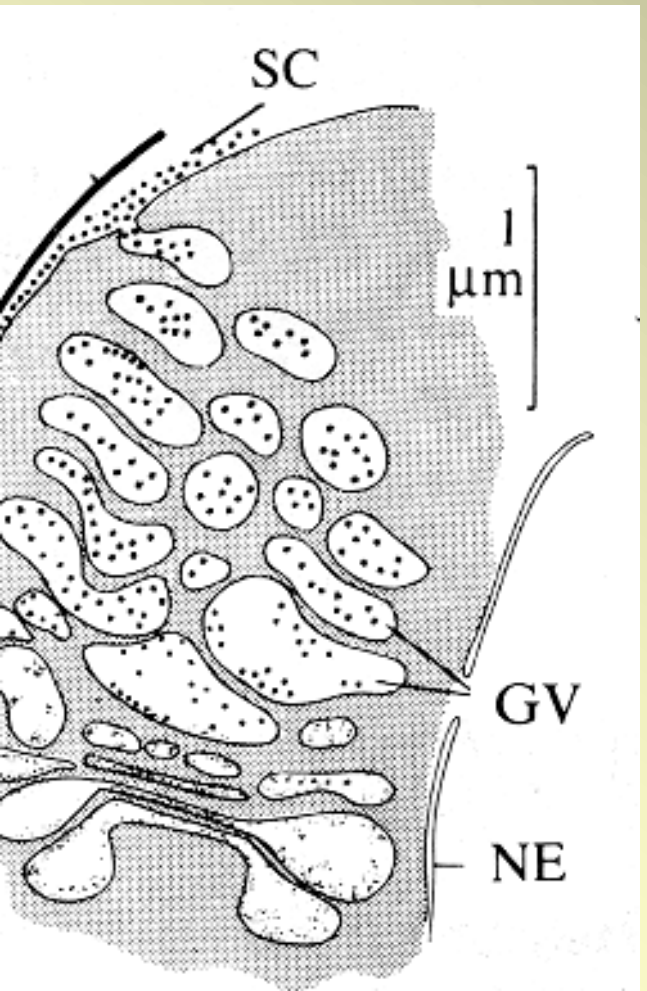
Kde v systému se nacházíme?

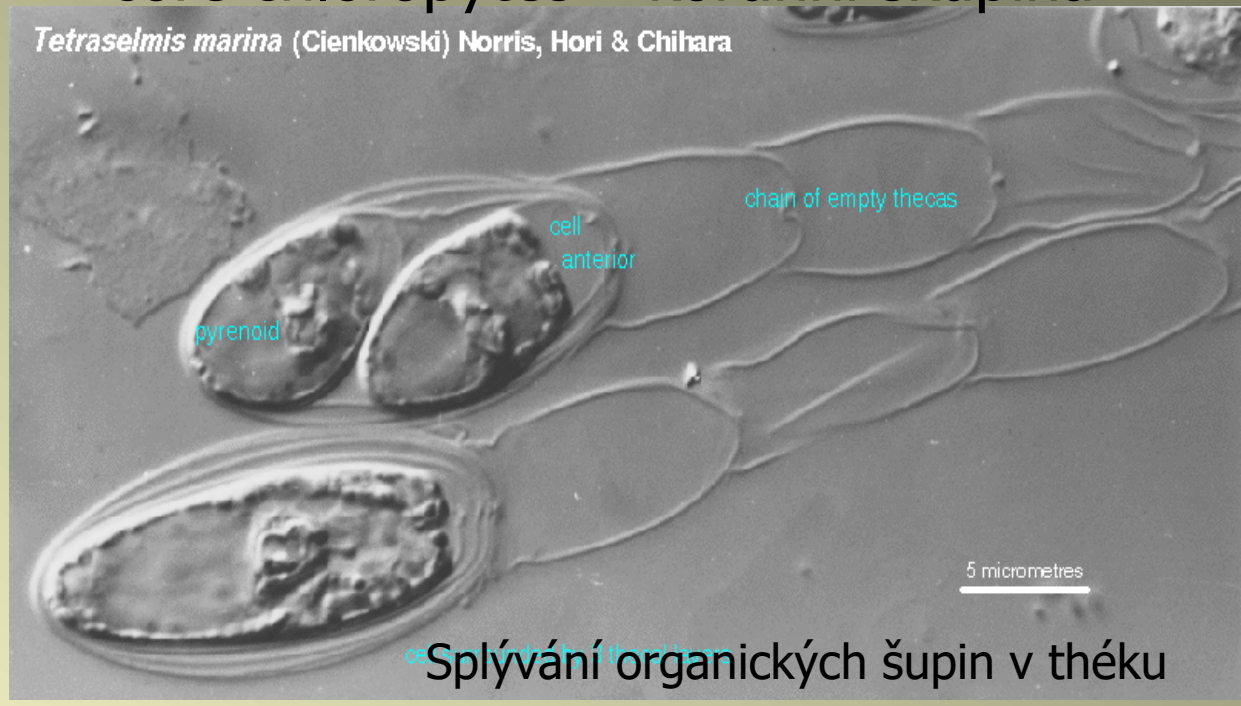
Třída: *Chlorodendrophyceae*

core chloropytes – korunní skupina



Tetraselmis





Splývání organických šupin v théku

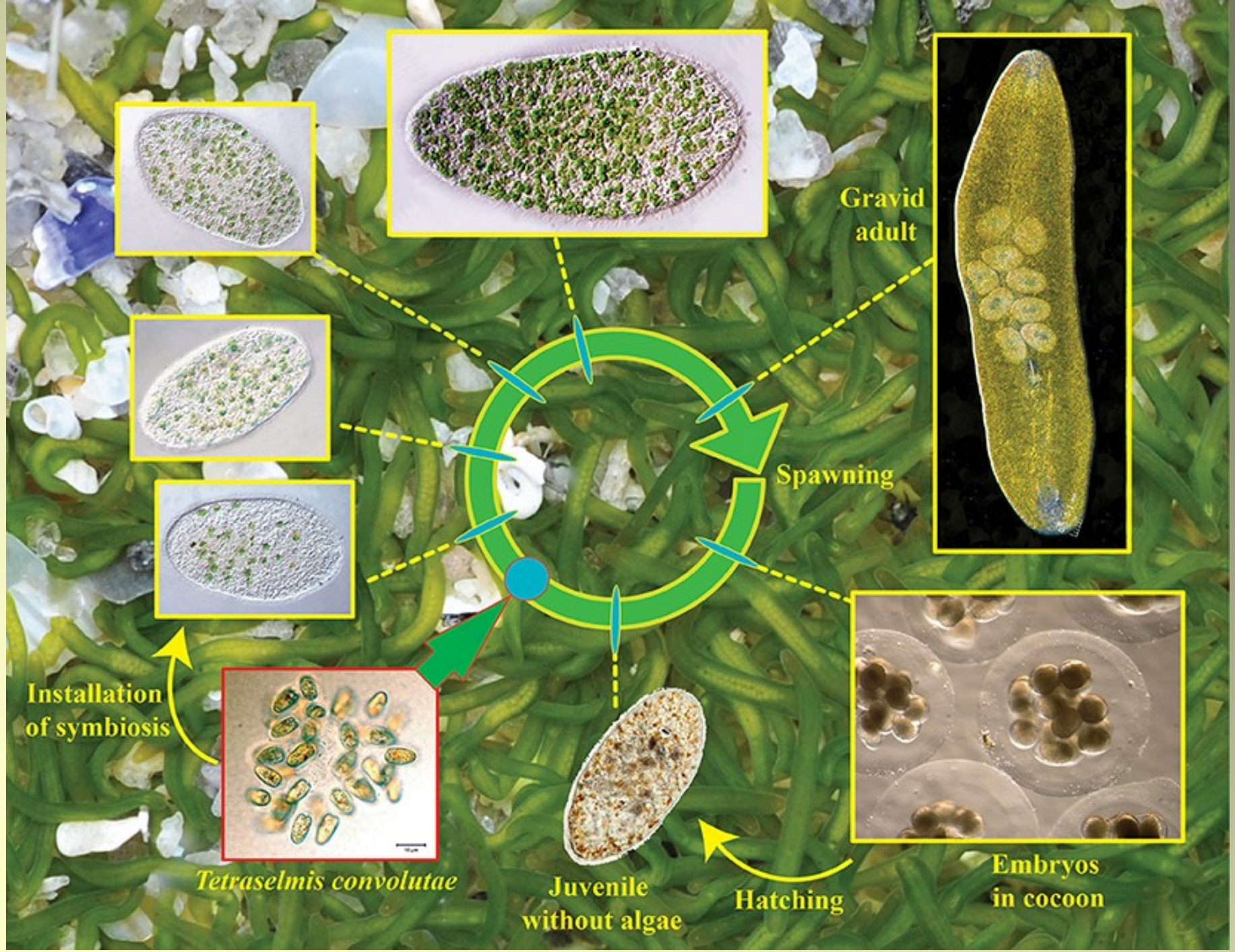
4 bičíky

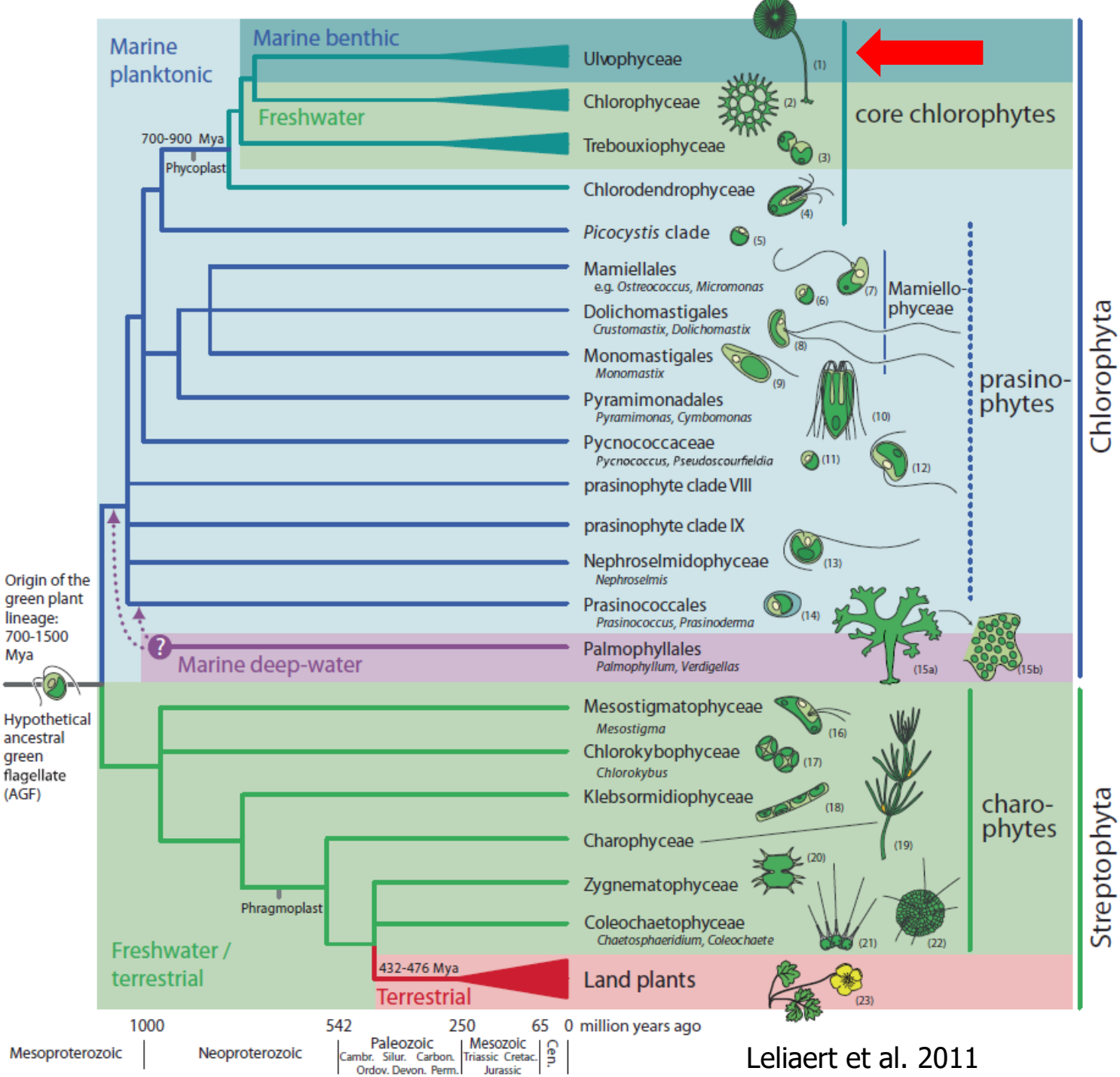
Ekologie - endosymbionti různých heterotrofních organismů

Radiolaria

(*Convoluta) Symsagittifera roscoffensis* – nemá trávicí systém, symbióza s *Tetraselmis*

Noctiluca


Gravid
adult
Spawning
Installation
of symbiosis
Tetraselmis convolutae
Juvenile
without algae
Hatching
Embryos
in cocoon

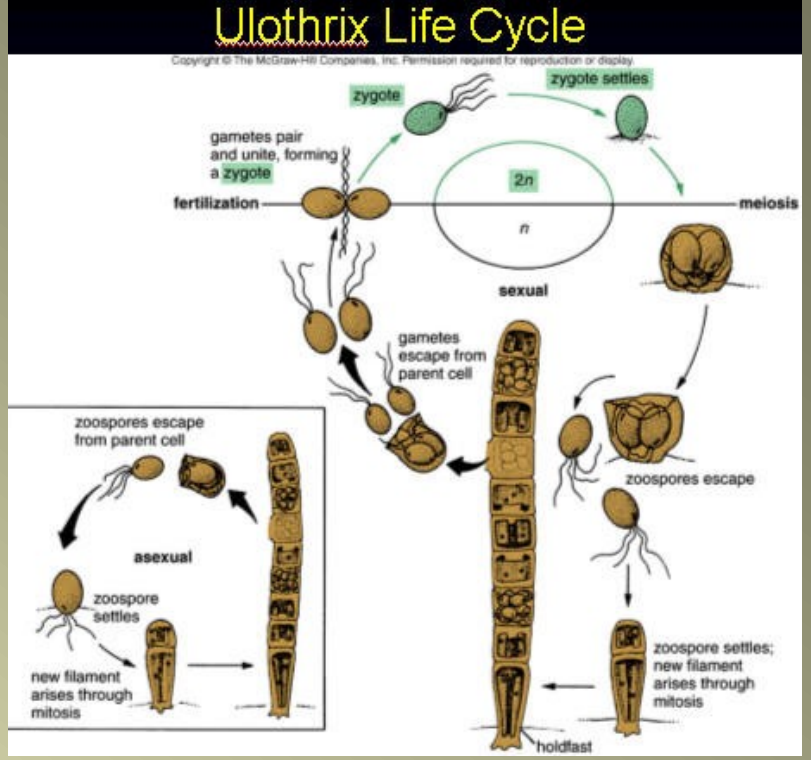


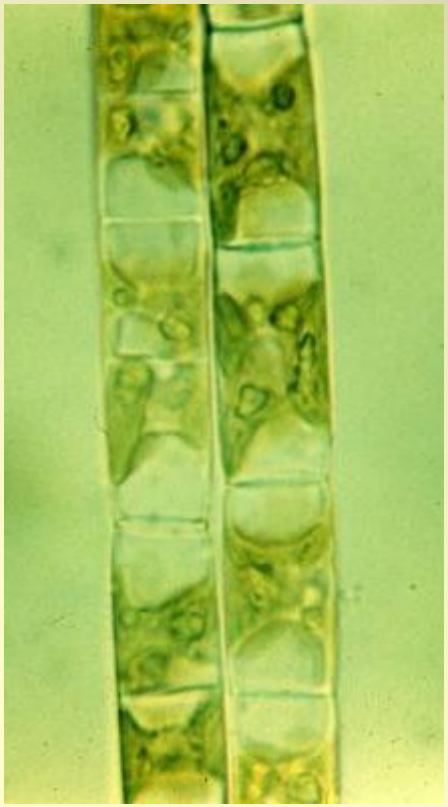
Leliaert et al. 2011

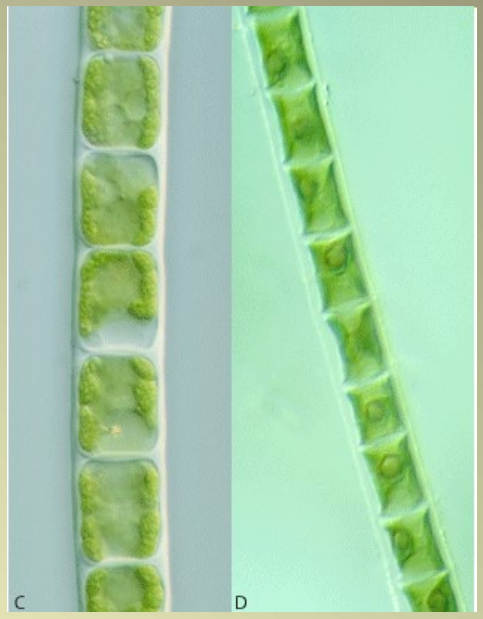
Kde v systému se nacházíme?

Třída: *Ulvophyceae*

Ulothrix (kadeřnatka)- hojná nárostová řasa mořského i sladkovodního bentosu



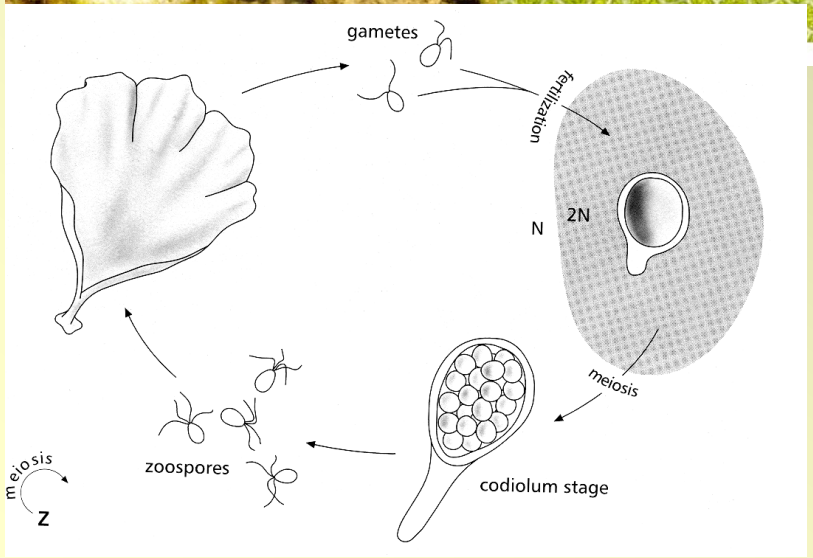


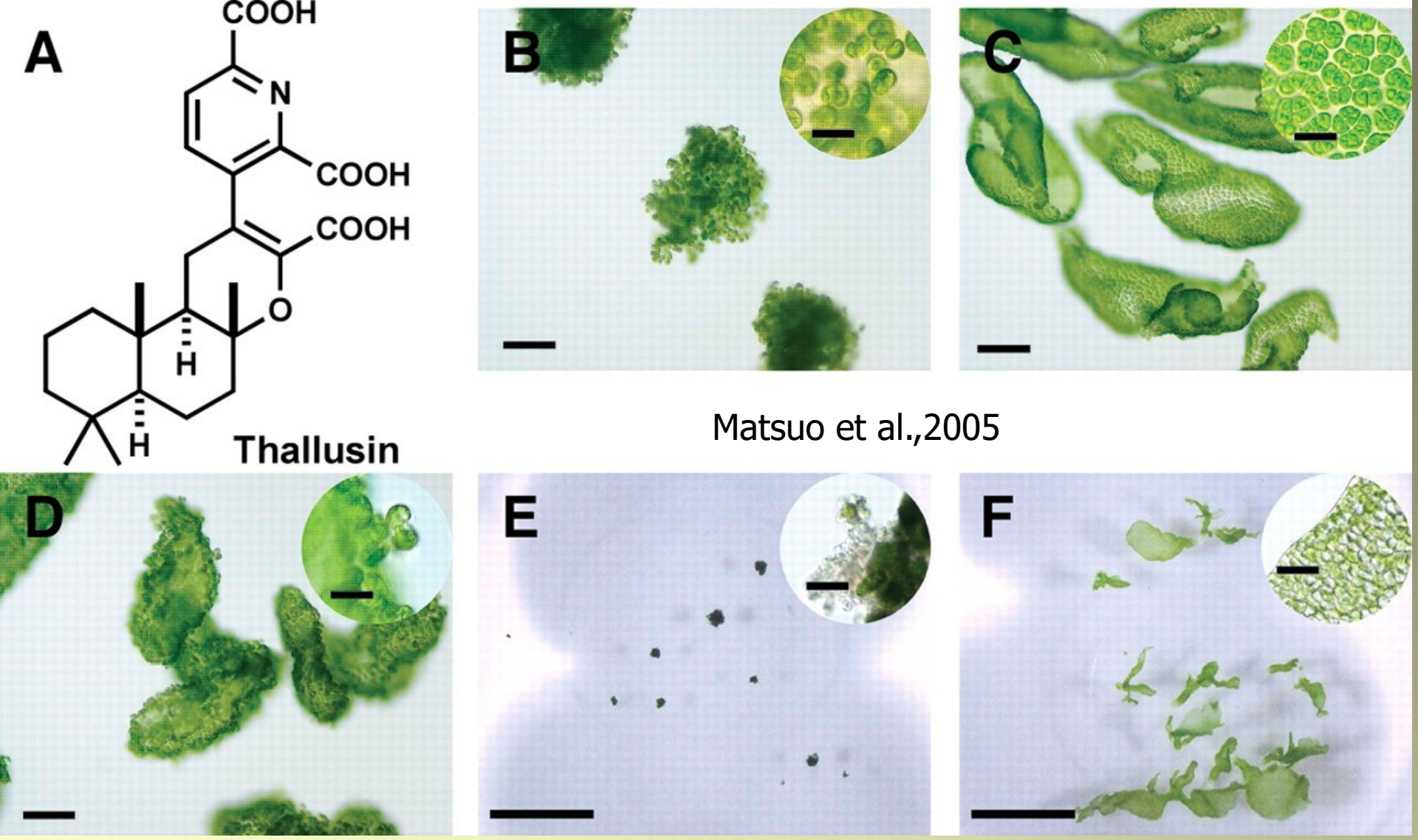


Monostroma tolerantní k různým koncentracím solí, jí se

Aonori

nelze pěstovat axenicky

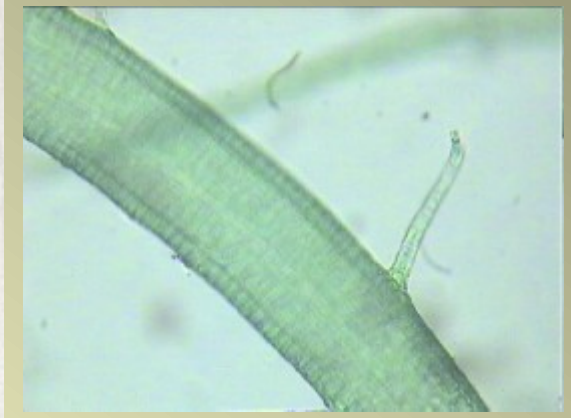


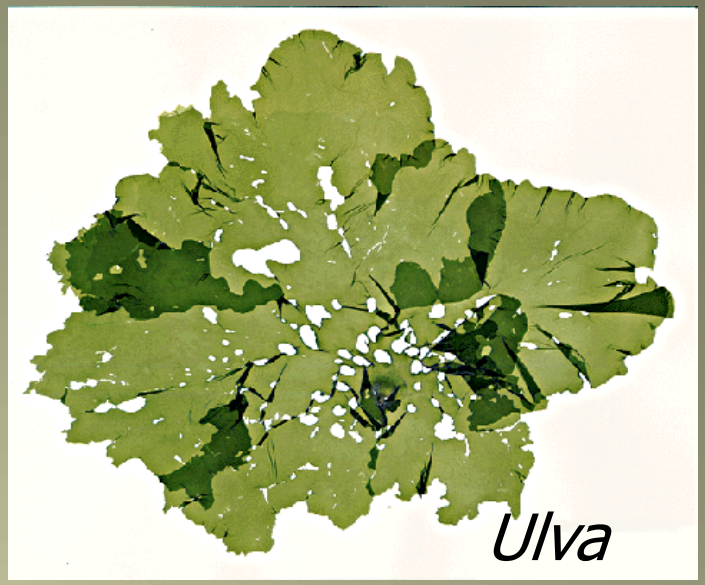


Matsuo et al.,2005

kultivace *Monostroma* bez přítomnosti bakterií – axenicky, desintegrace stélky

Ulva - ubikvitní druhy mořského litorálu
= *Enteromorpha* – ekomorfa – salinní lokality





primárně tůňky v dostřikové zóně

Ulva clathrata akvakultury, Mexiko

sekvestrace živin P a N z akvárií

(Qingdao on 18.7.2011)
South China

Going Green: Beach Carpet

Kde v systému se nacházíme?

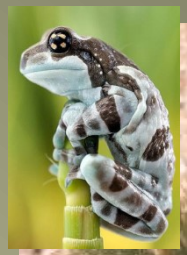
Cladophorales

Aegagrophila (řasokoule zelená)

A. linnaei
„Marimo"

Akan Lake Hokkaido

Cladophora (žabí vlas)



základní indikátor beta-mesosaprobní zóny

Cladophora glomerata -

jedna z nejhojnějších řas ve středoevropské krajině

Anadyomene

Středozemní moře

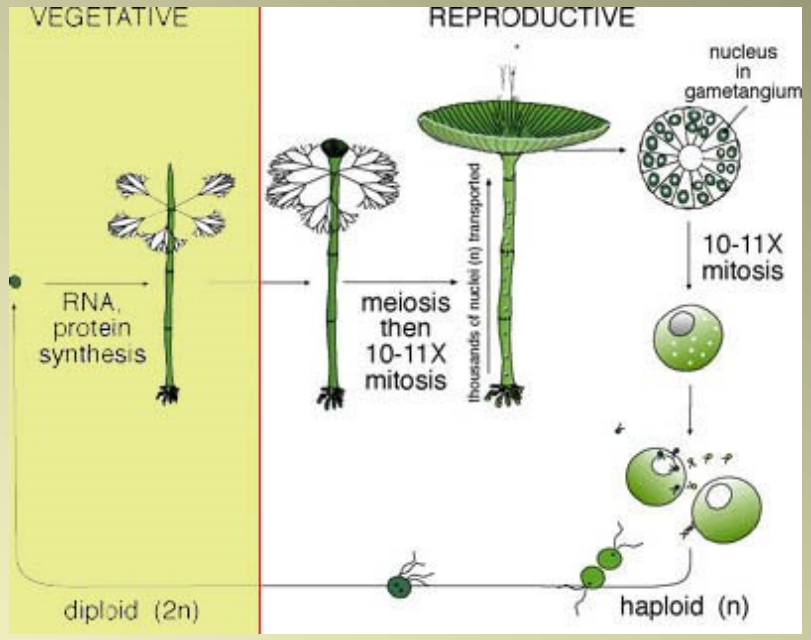
Anadyomene stellata

=rising from the sea

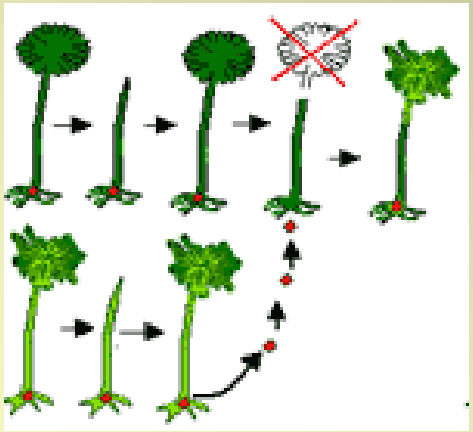
habitaty s velkým predačním tlakem, produkuje toxickou látku odpuzující ryby a bakterie

Anadyomene (Aphrodite) na fresce z Pompejí (1st century AD)

Dasycladales



Acetabularia a její obrovská jádra



coenocytická stélka – celé jediná buňka

nejstarší nálezy z kambria (550 miliónů let), rozvoj ve druhohorách

Trentepohliales

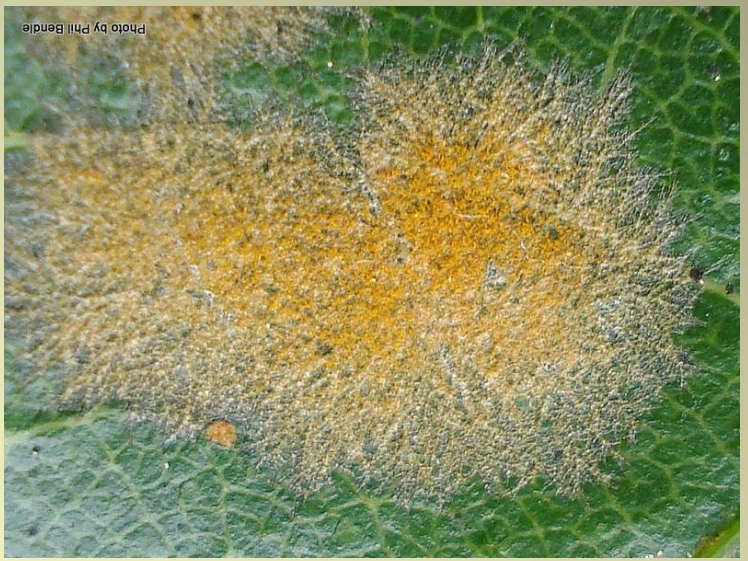
terestričtí specialisté; řasy jako paraziti

Cephaleuros

Nový Zéland - Melicytus spp.

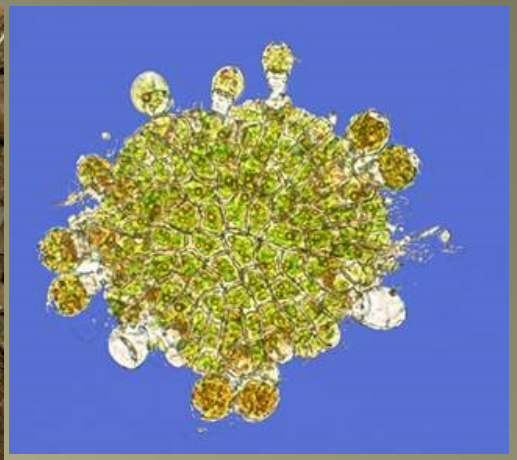
Hawaii – guava (*Psidium guajava)*

kvajáva

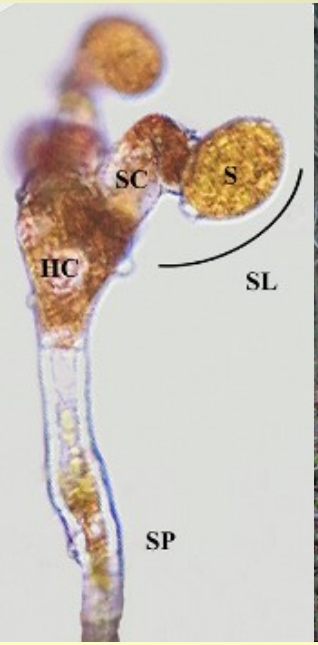


čajovník, kávovník, olejová palma, avokádo, mango, kokosová palma, kvajáva, kešu

Trentepohliales

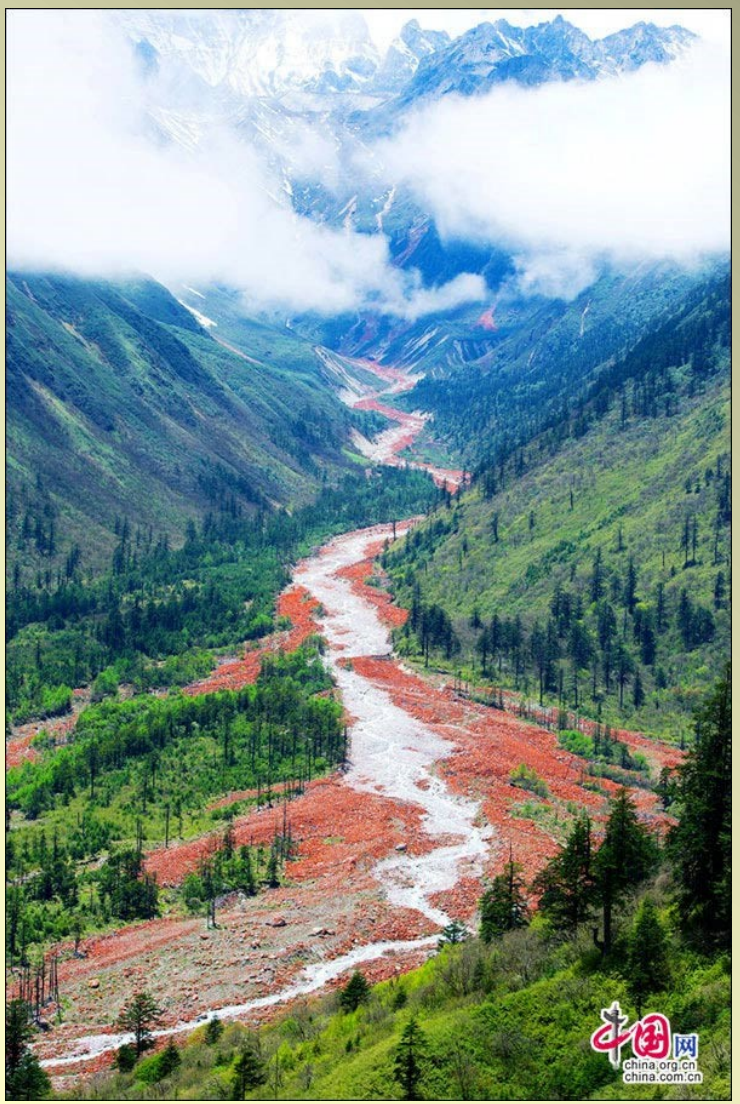


Trentepohlia, Phycopeltis



sekundární karotenoidy – obrana proti UV a nadměrnému ozáření

terestričtí specialisté; řasy jako paraziti



T. umbrina

Trentepohlia jolithus – severní svahy Mount Gongga (Čína), údolí řeky Yaijiageng "Red-Stone-Valley."

Švédsko- Arvidsjaur 2015

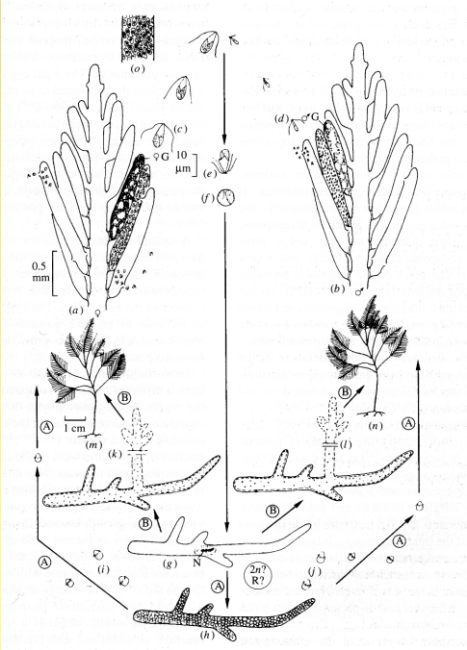
Kde v systému se nacházíme?

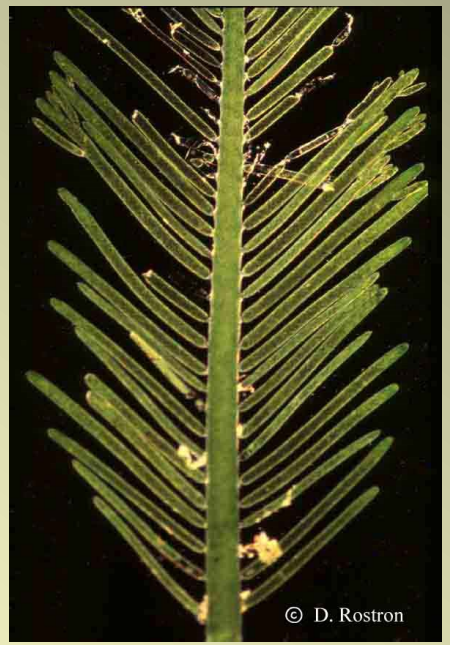
Bryopsidales

sifonální (coenocytická) stélka

uniaxiální

multiaxiální



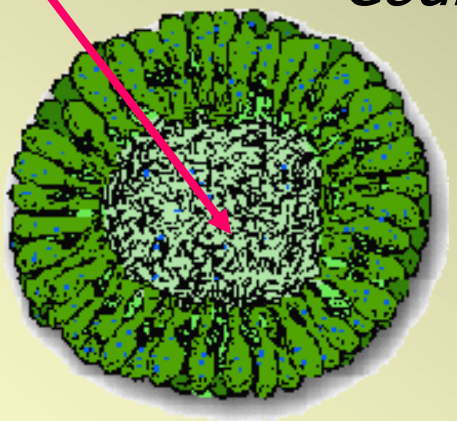


Bryopsis

medula

Codium

utrikulus

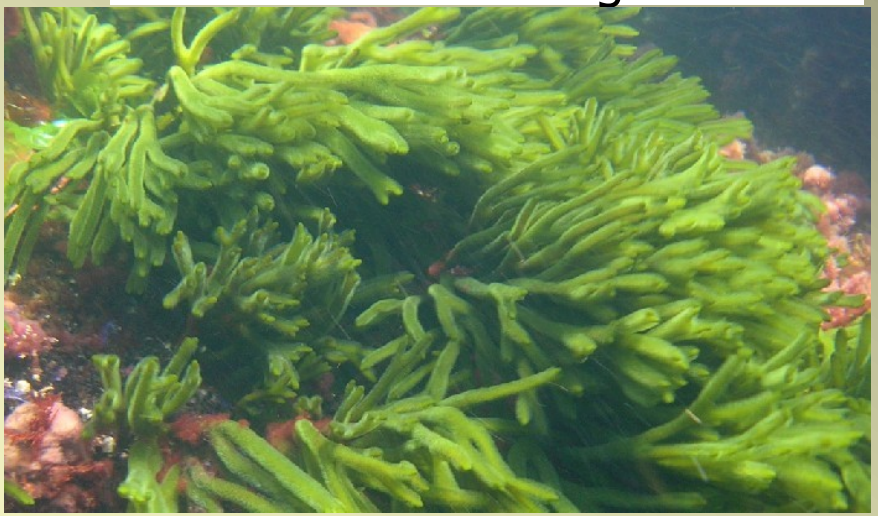


Codium

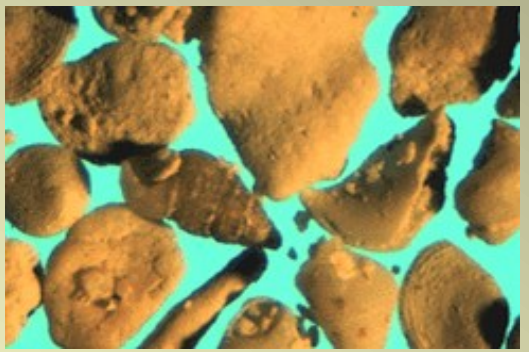
Codium bursa

C. fragile

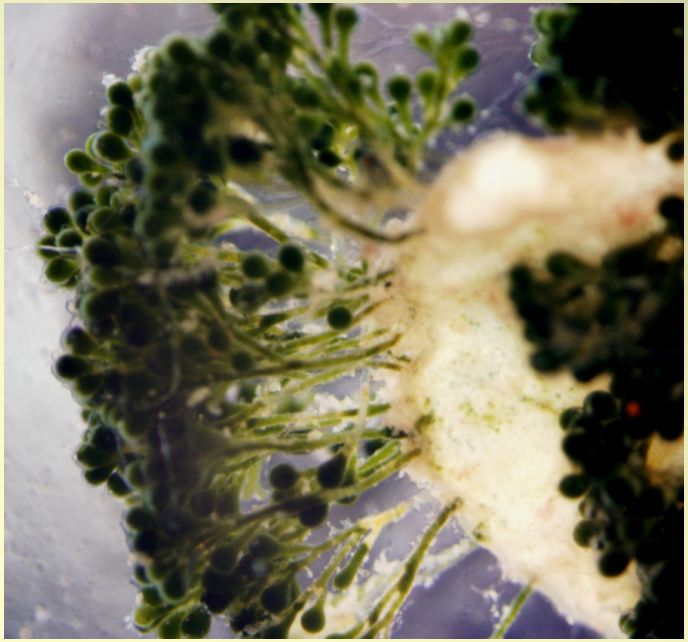
Dead Man's Fingers

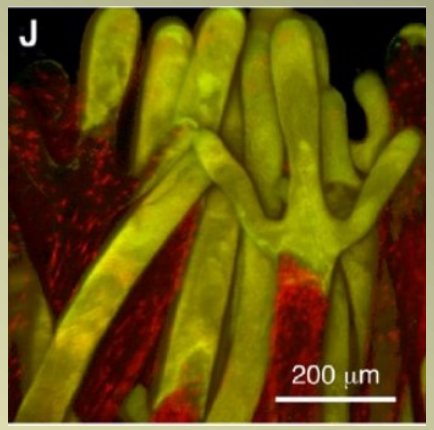


Bryopsidales



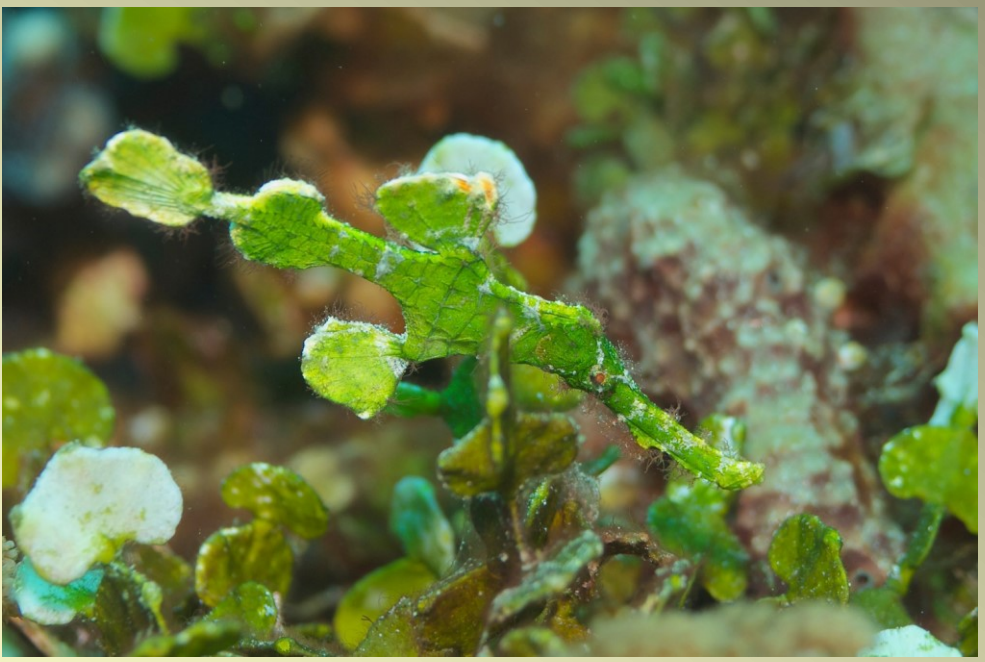
Halimeda - význačný druh subtropických a tropických litorálních mořských ekosystémů; biogenní vznik písku





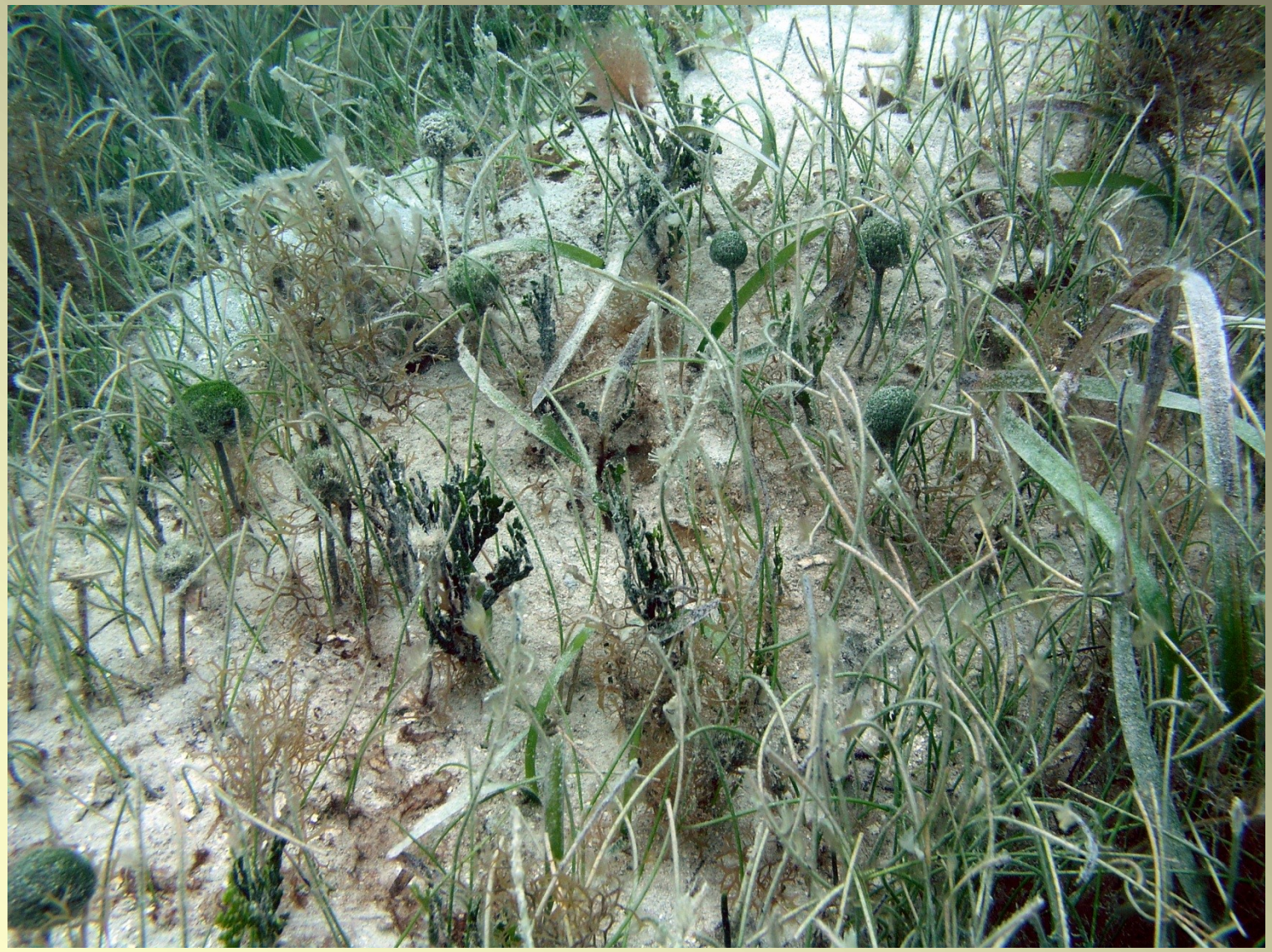
coenocytické, makroskopické stélky

Halimeda - mimikry



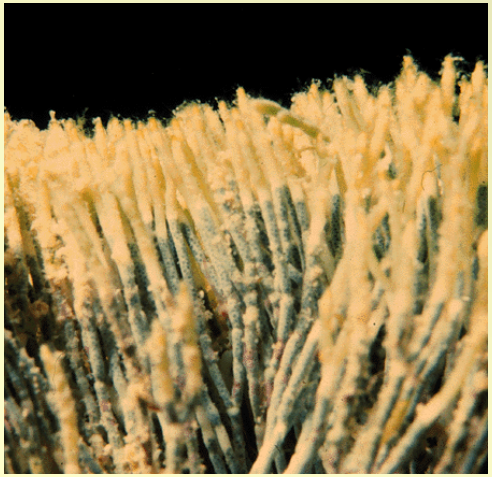
Solenostomus halimeda - ryba, dokáže měnit barvu a napodobit i prázdné=bílé segmenty

krab *Huenia heraldica* připevňuje části stélky k rostru

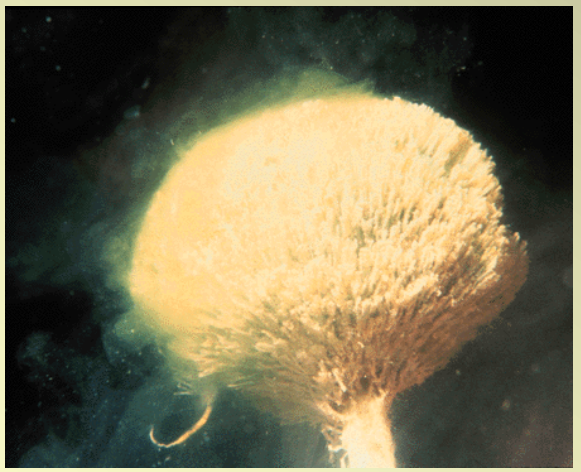


shallow seagrass meadows (*Penicillus, Halimeda*)

Simultánní uvolňování ♂ a ♀ gamet
příklad: *Penicillus*; podobně jako u korálů



♀ gametangia



♂ rostlina vypouští gamety

Caulerpa lentilifera – zelená řasa

pěstována na Filipínách + Japonsko – písčito-bahnitá dna mělkých chráněných zátok, antibakteriální a antifungální účinky (fukoidany) proti vysokému tlaku a revmatismu

Lato

Umi-budō served Okinawan style

Lato, the strange sea salad Coron, Philippines

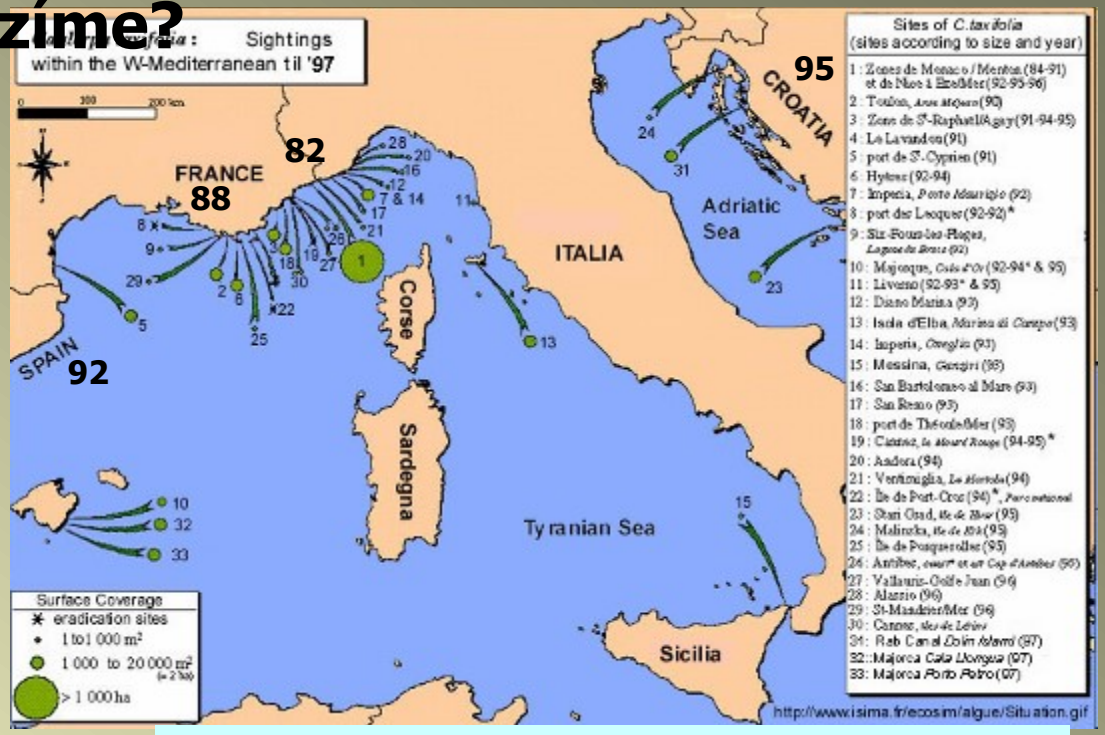
Coron, Filipíny - kmen Tagbanua se živí sběrem a prodejem *C. lentilifera*

Kde v systému se nacházíme?

Třída: *Ulvophyceae*

- Bryopsidales

Caulerpa taxifolia



SCUBA DIVERS

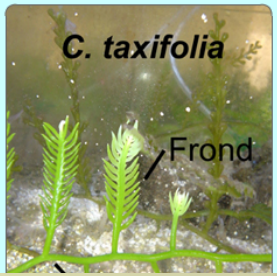
The help of SCUBA divers is critical to finding new infestations of *Caulerpa* in the wild. You can help by learning what *Caulerpa* looks like and keeping an eye out for it on your dives.

There are many species of *Caulerpa* that are used in the aquarium trade that could be released into the wild. Though many of them are tropical species, *Caulerpa taxifolia* and *Caulerpa racemosa* have both taken over large areas of seafloor in temperate waters due to their cold tolerance. Because *Caulerpa* is only native in the United States in Hawaii and some parts of Florida, divers should be on the lookout for all species of *Caulerpa*, which have many consistent features between them. All are bright green, have a runner by which it spreads, and upright fronds (Identification).

Caulerpa can grow on mud, sand or rock, and in shallow or deep water. It grows low to the bottom, typically six to 12 inches high. It can grow in calm or rough waters. Fragments of *Caulerpa* do not float and it is therefore not likely to be found on docks, boat hulls or in ballast water.

If you think you have found *Caulerpa* in the wild:

- Note as much information as possible (location, depth, bottom type, size of the patch).
- Record the location with a GPS if possible.
- Take a photo if possible.
- Collect a small piece and press it flat in newspaper (be careful - even a 1-mm piece broken off can start a new infestation).



Report the sighting and it will be investigated.

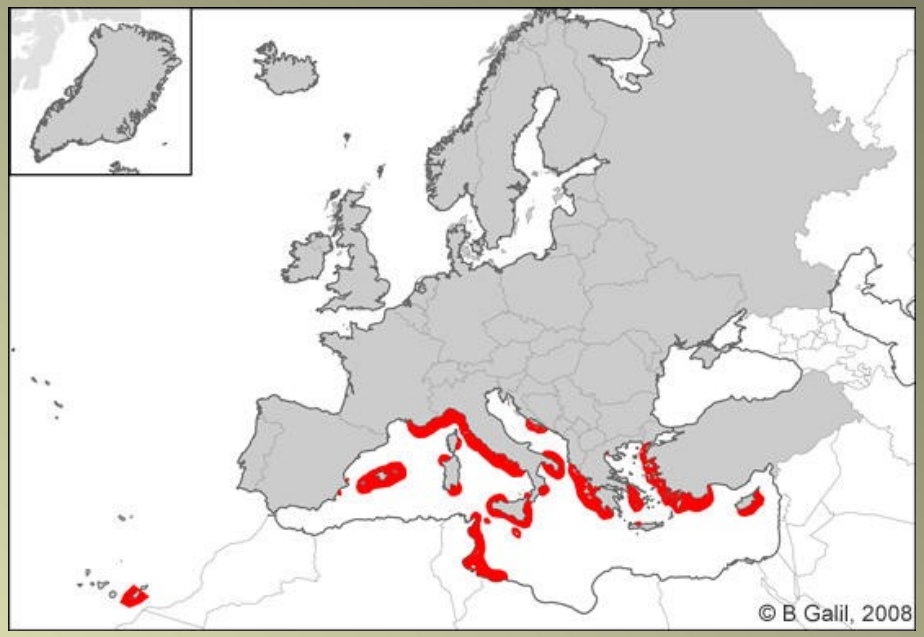
Click here to report a sighting of *Caulerpa* in the wild or in a pet store.

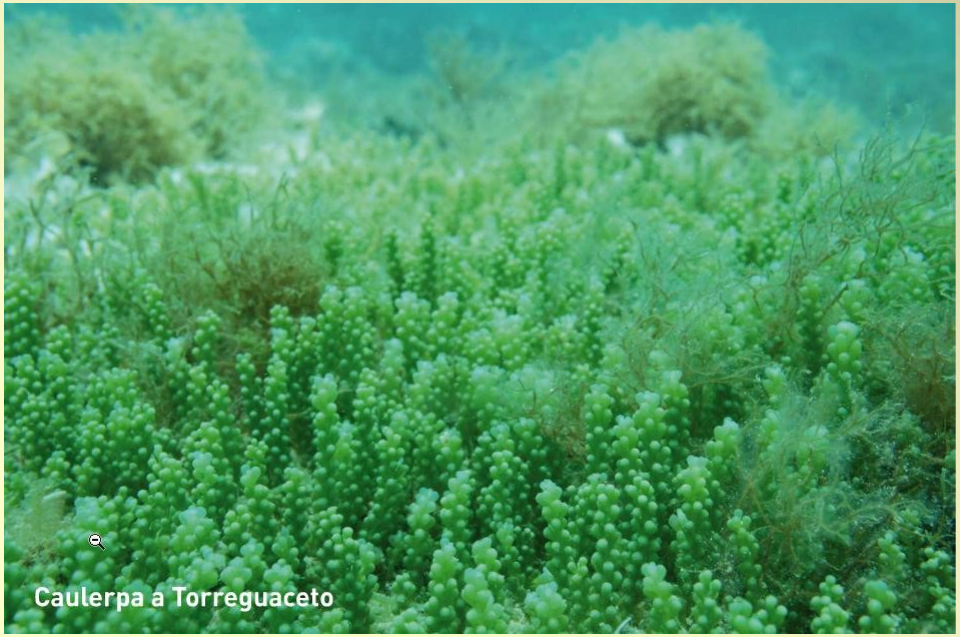
Click here to learn how to identify *Caulerpa*.

Thank you for your help. New infestations will most likely be detected by the SCUBA diving community. A map of surveys done for *Caulerpa* in California is available here.

Invaze *Caulerpa cylindracea*

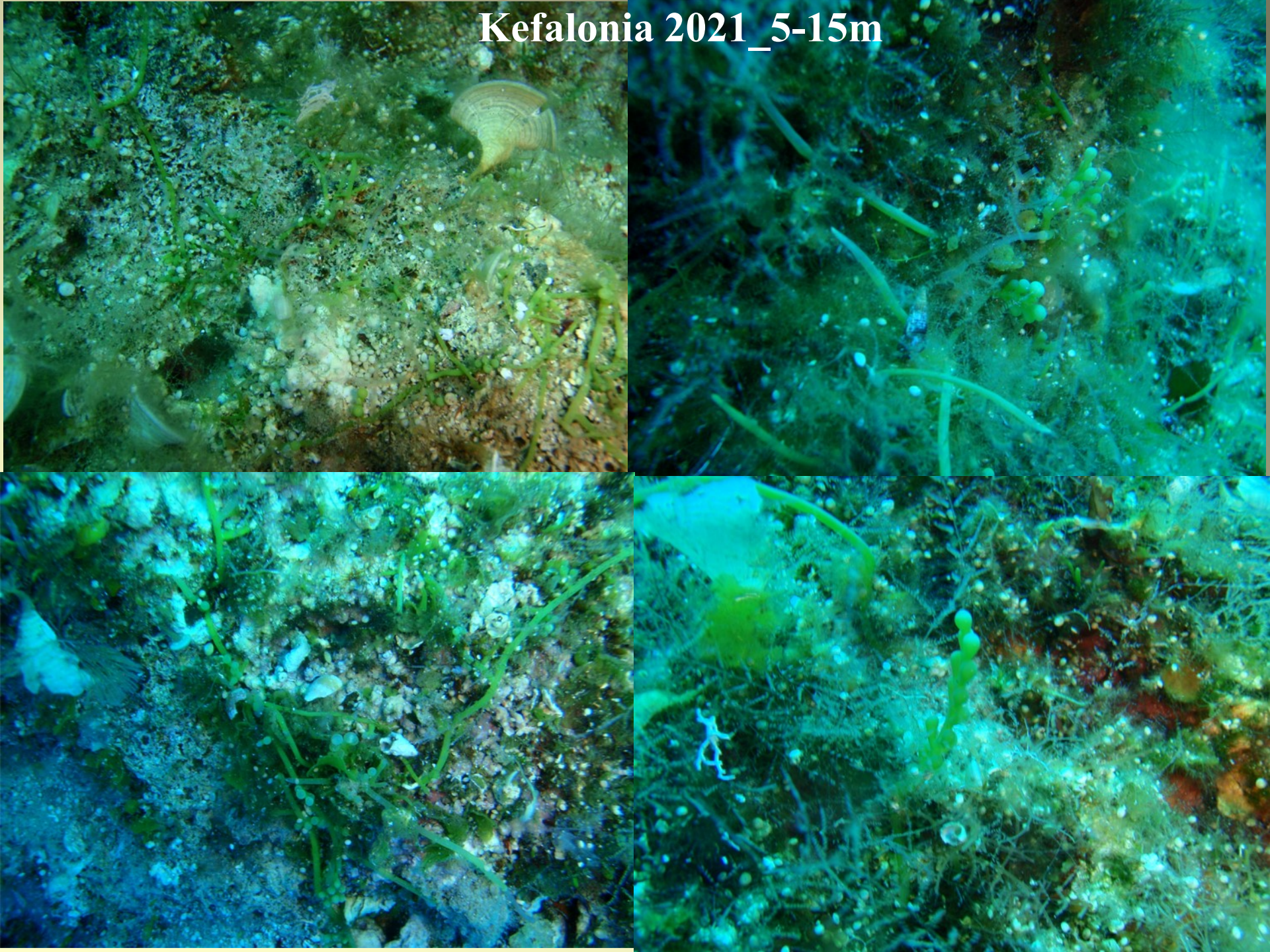
killer alga II

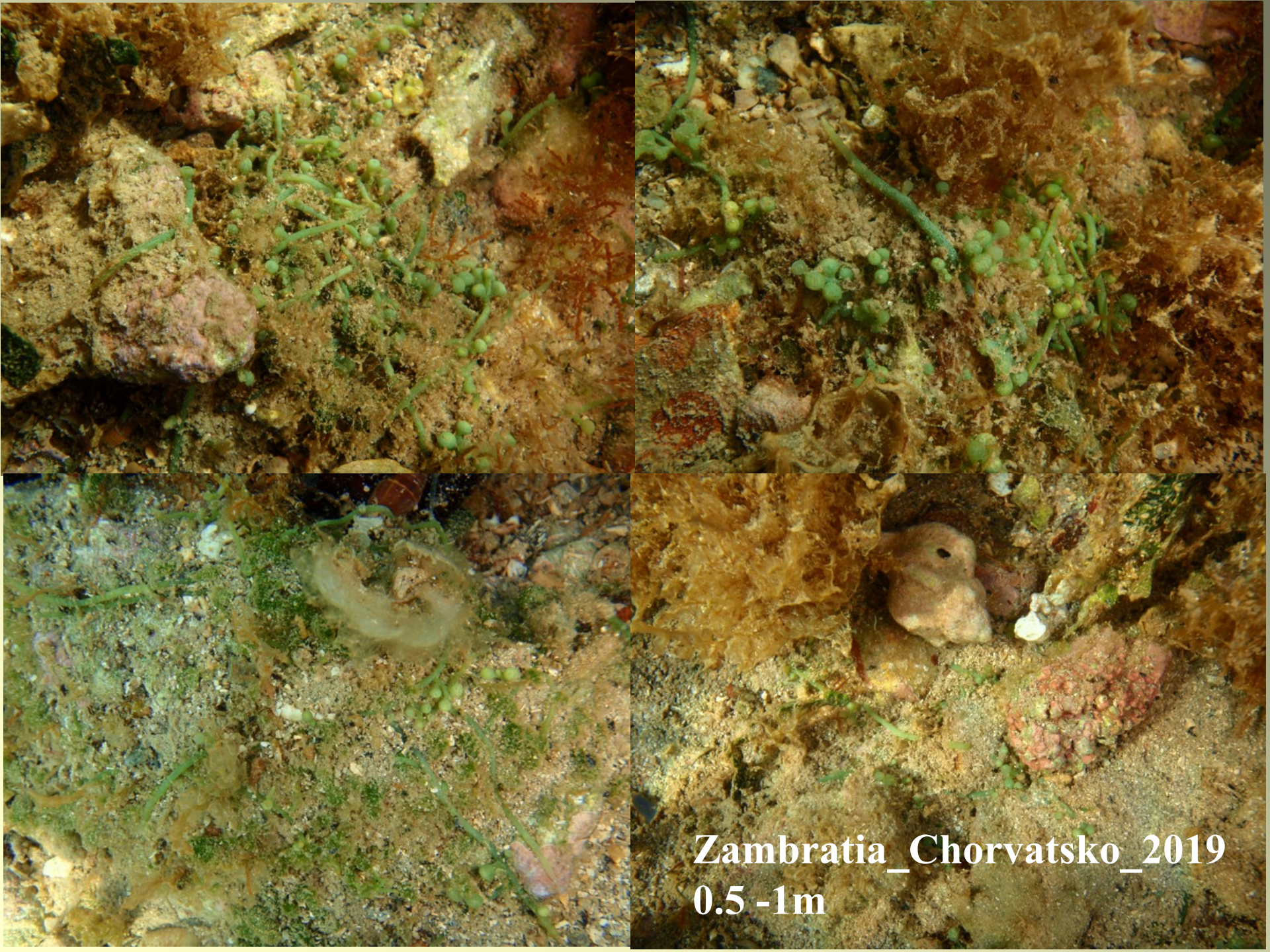


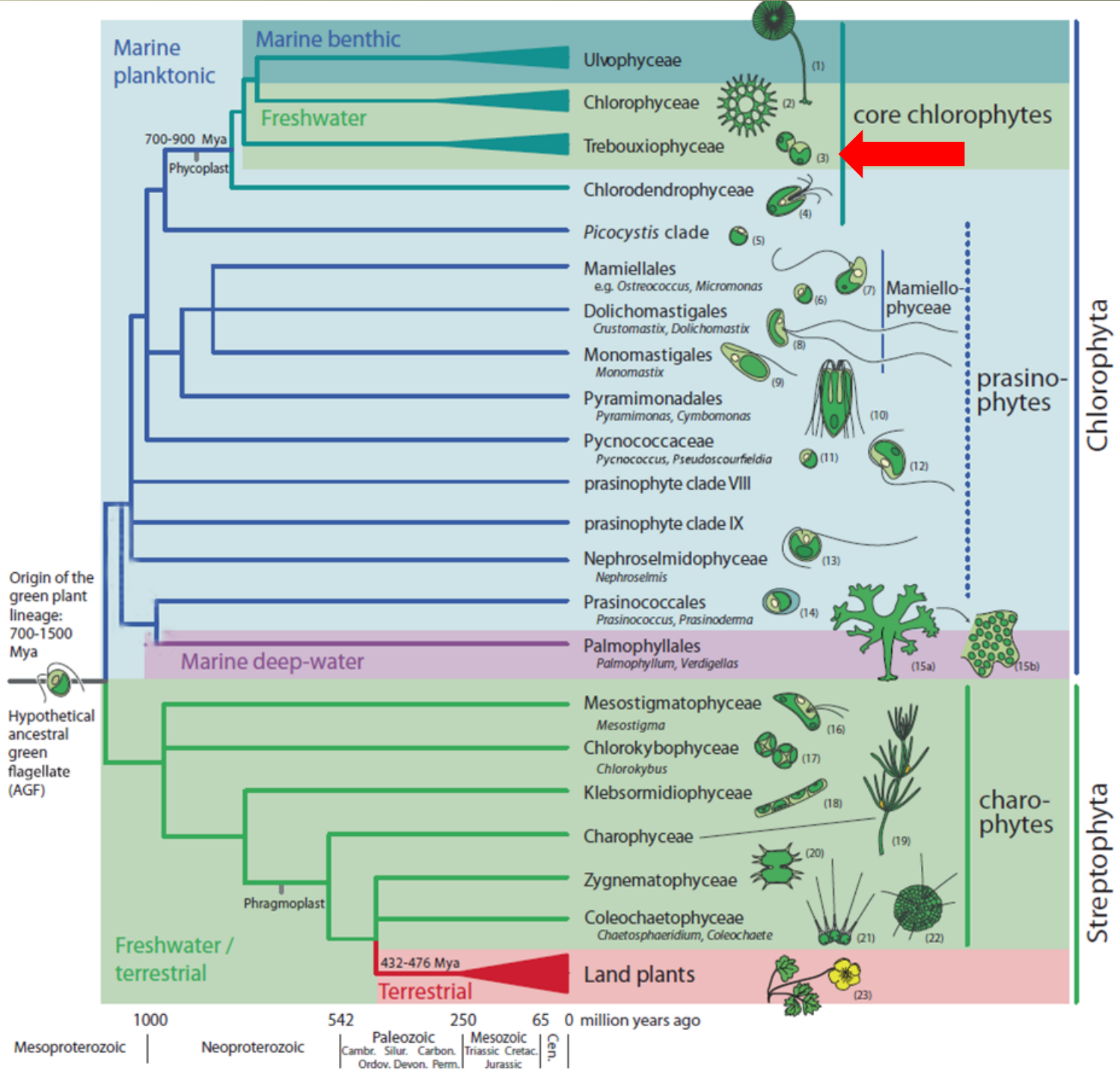


invazní varieta - 11 států, všechny velké ostrovy, daleko rychlejší invaze než u *C. taxifolia*

Kefalonia 2021_5-15m

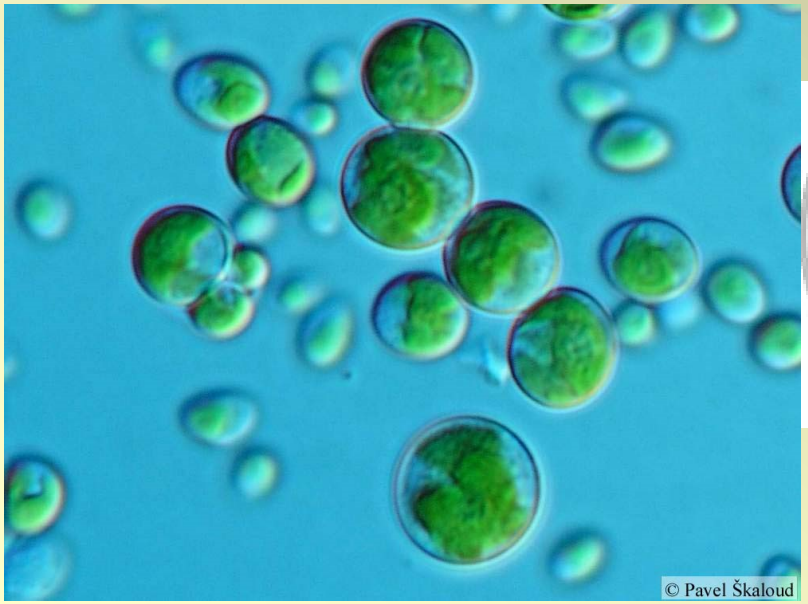



Zambratia_Chorvatsko_2019
0.5 -1m


Marine planktonic
Marine benthic
Freshwater
700-900 Mya
Phycoplast
Ulvophyceae
Chlorophyceae
Trebouxiophyceae
Chlorodendrophyceae
Picocystis clade
Mamiellales
e.g. Ostreococcus, Micromonas
Dolichomastigales
Crustomastix, Dolichomastix
Monomastigales
Monomastix
Pyramimonadales
Pyramimonas, Cymbomonas
Pycnococcaceae
Pycnococcus, Pseudoscourfieldia
prasinophyte clade VIII
prasinophyte clade IX
Nephroselmidophyceae
Nephroselmis
Prasinococcales
Prasinococcus, Prasinoderma
Palmophyllales
Palmophyllum, Verdigellas
Marine deep-water
core chlorophytes
Mamiello-phyceae
prasino-phytes
Chlorophyta
Origin of the green plant lineage: 700-1500 Mya
Hypothetical ancestral green flagellate (AGF)
Mesostigmatophyceae
Mesostigma
Chlorokybophyceae
Chlorokybus
Klebsormidiophyceae
Charophyceae
Zygnematophyceae
Coleochaetophyceae
Chaetosphaeridium, Coleochaete
Phragmoplast
Freshwater / terrestrial
432-476 Mya
Terrestrial
Land plants
charo-phytes
Streptophyta
(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)
(9)
(10)
(11)
(12)
(13)
(14)
(15a)
(15b)
(16)
(17)
(18)
(19)
(20)
(21)
(22)
(23)
1000
542
250
65
0 million years ago
Mesoproterozoic
Neoproterozoic
Paleozoic
Cambr. Silur. Carbon.
Ordov. Devon. Perm.
Mesozoic
Triassic Cretac.
Jurassic
Cen.

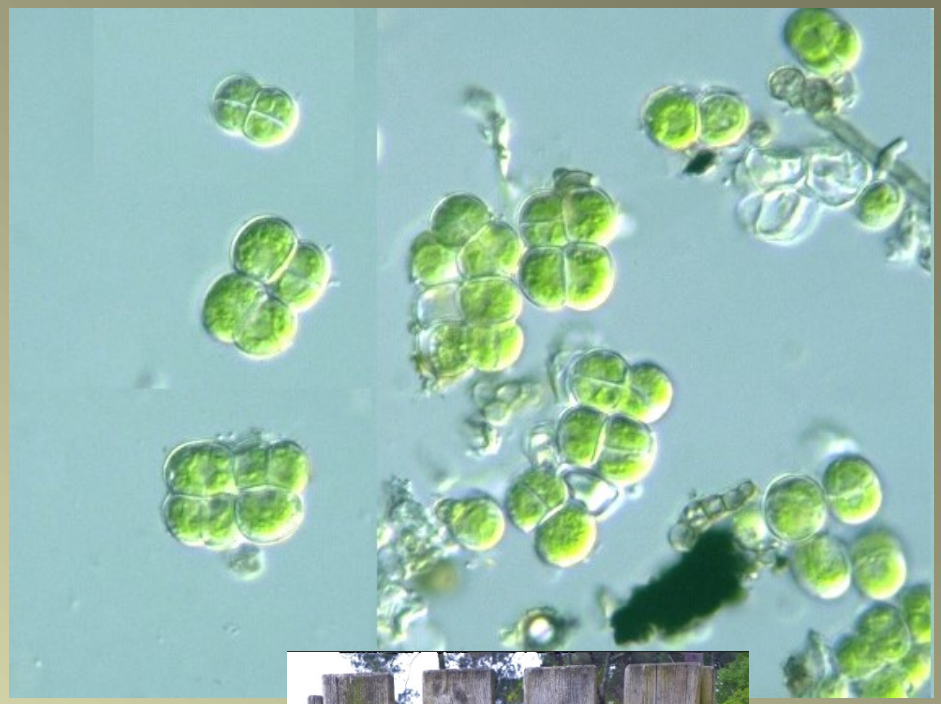
Třída: *Trebouxiophyceae*

Trebouxia - nejhojnější fykobiont



typická metacentrická mitóza; řada terestrických zástupců

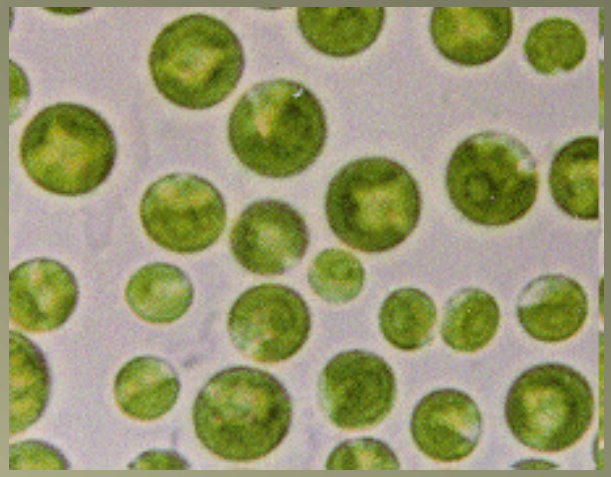
Apatococcus - zrněnka

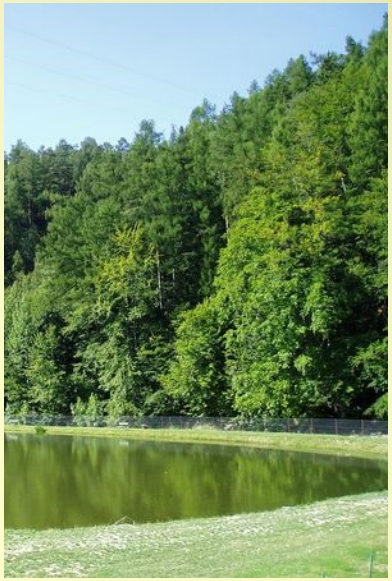


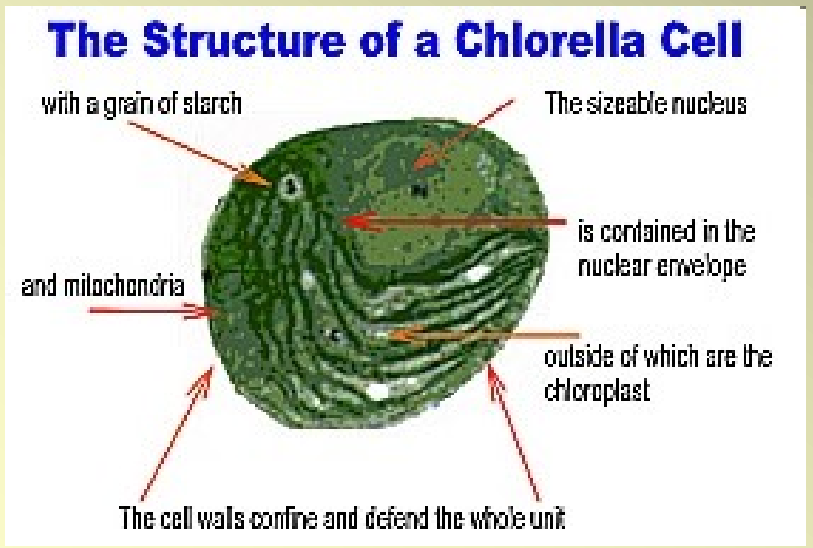
nejhojnější řasa na světě?

sarcinoidní, koloniální stélka

Chlorella



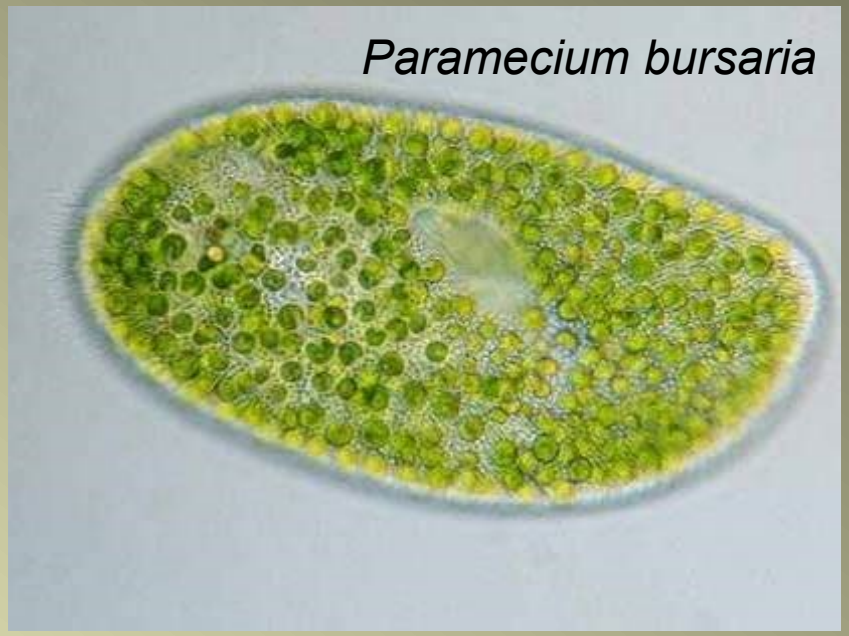


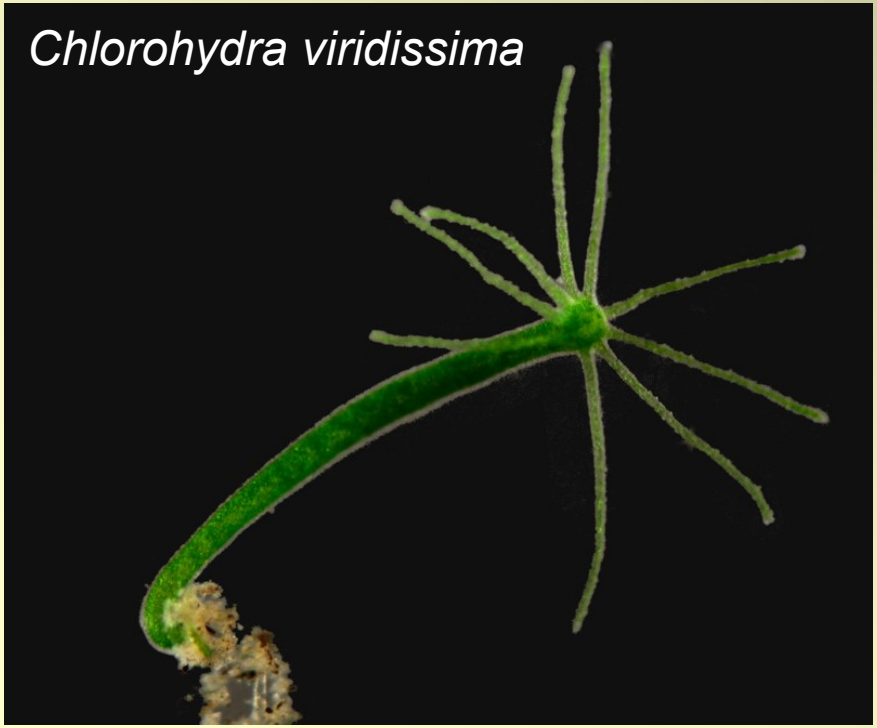


Borka stromů, plankton, půda - antibakteriální látky

Chlorella jako endosymbiont

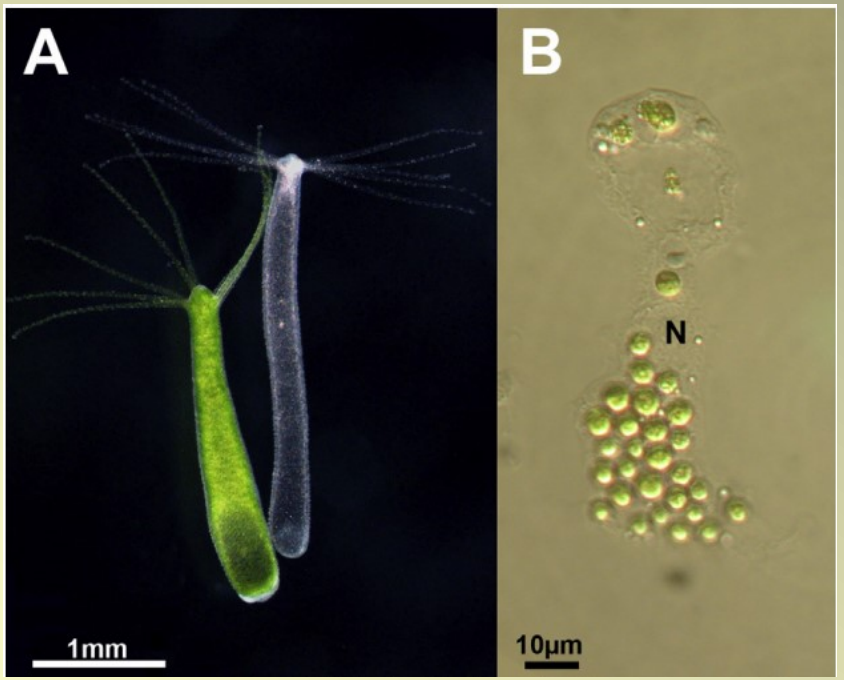
- polypy *(Chlorohydra* - nezmar zelený)
- sladkovodní houby
- nálevníci *(Paramecium* - trepka*)*

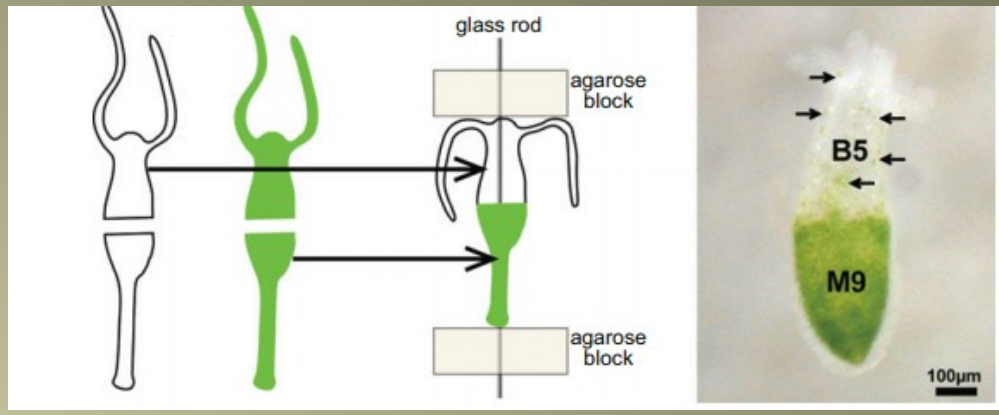


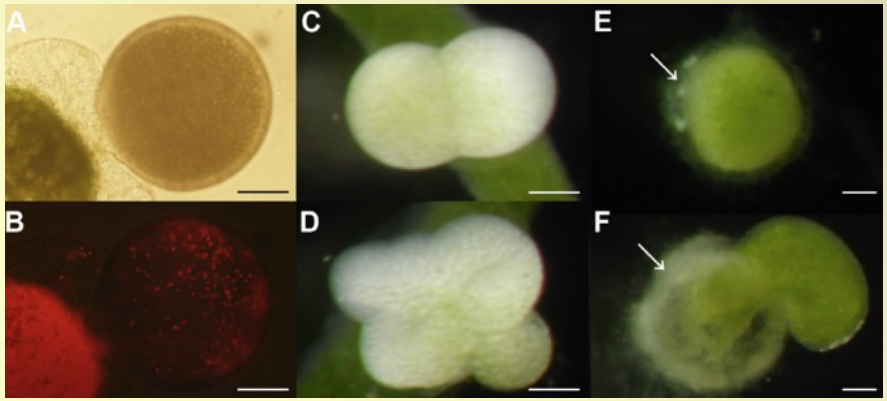


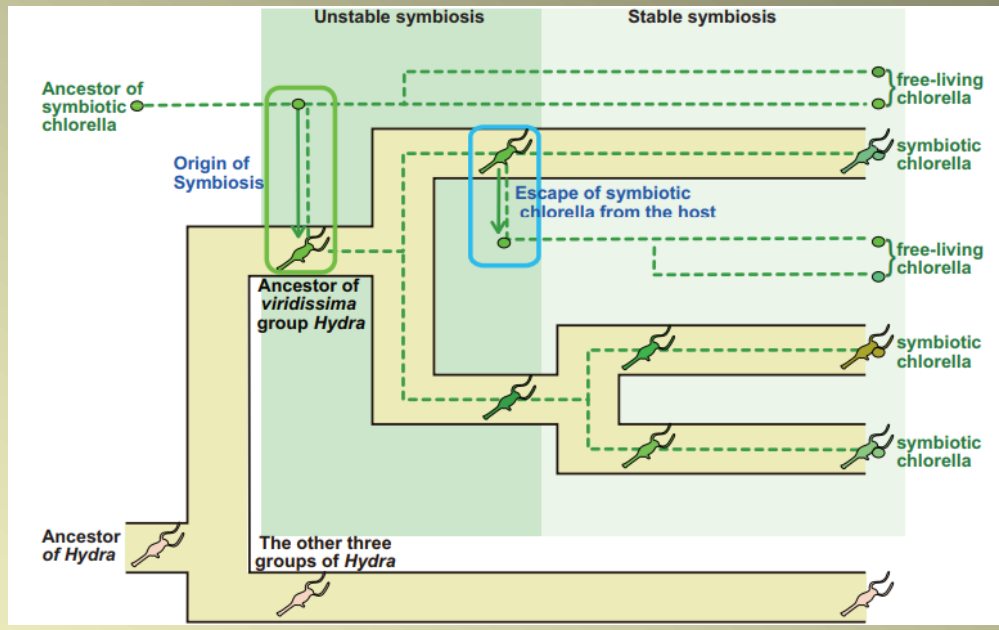
Symbióza mezi nezmarem a chlorelou

endodermální epitel s chlorelami







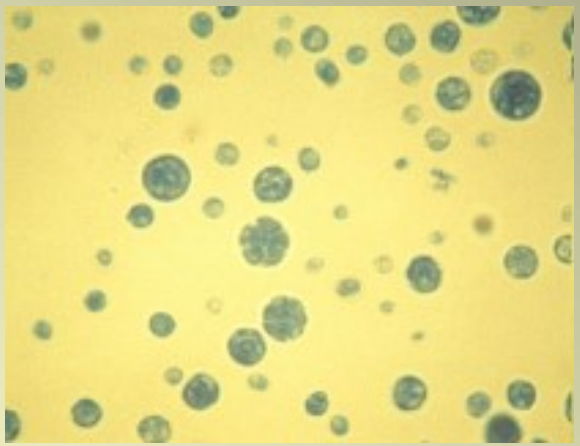


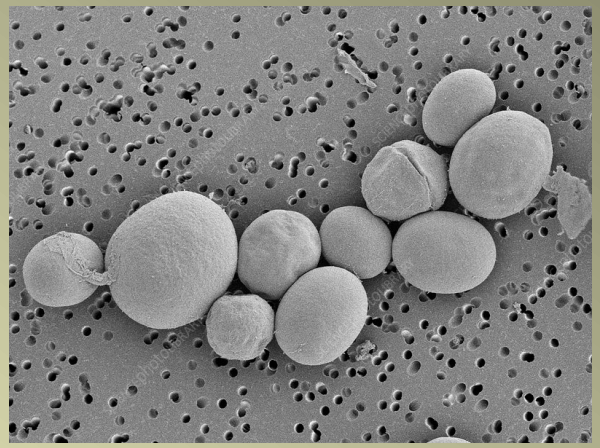
pravděpodobně se endosymbióza udála jen jednou

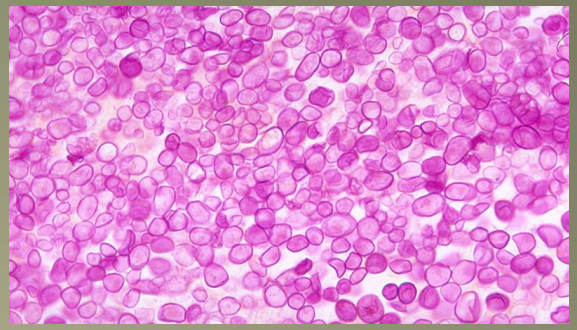
předání chlorely při pohlavním rozmnožování - vajíčko

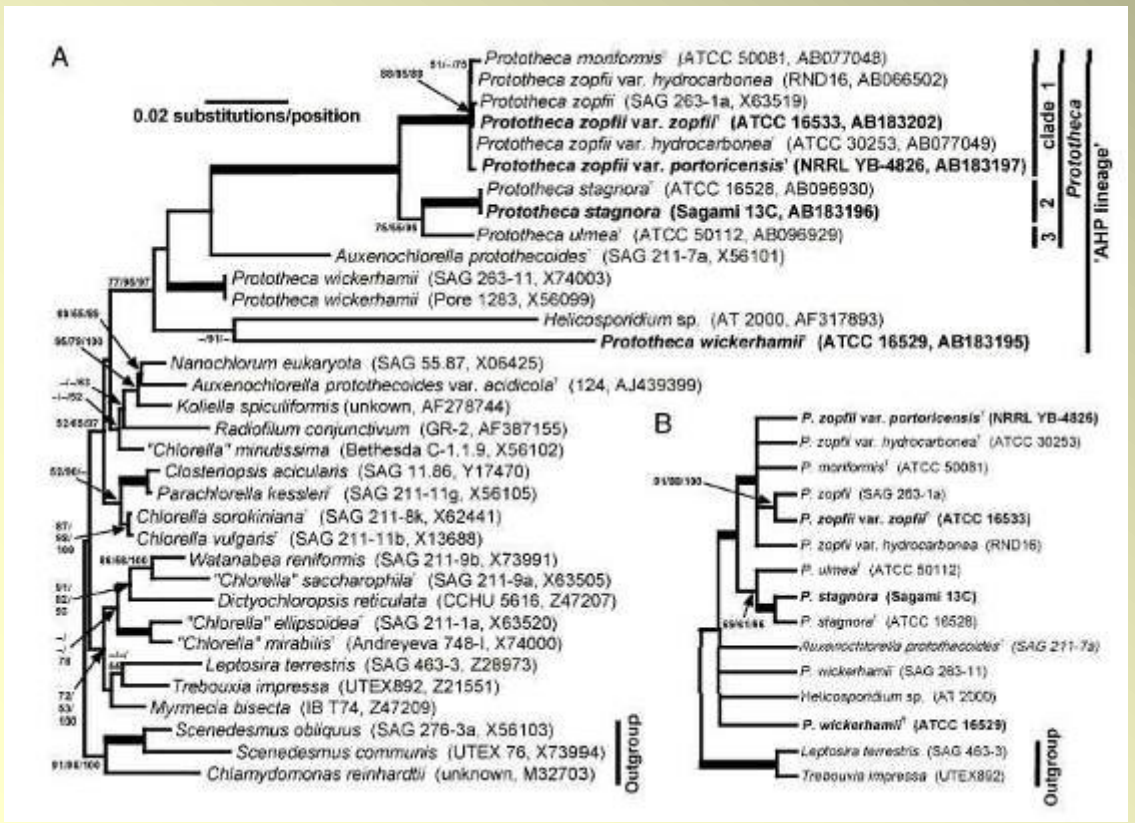
Kawaida et. al. 2013

Prototheca – patogenní rostlina









půda, paraziti živočichů

živí se osmotrofně - sacharidy

Kultivace *Chlorella*

USA, Japonsko, Taiwan, Holandsko, Německo, Israel, Česká republika, Bulharsko.

kruhovité kultivační nádrže (Taiwan)

uzavřený fotobio-reaktor - Německo

kultivační jednotky MBÚ Třeboň - Algatech

Kultivační jednotky v Třeboni

Biopaliva z řas

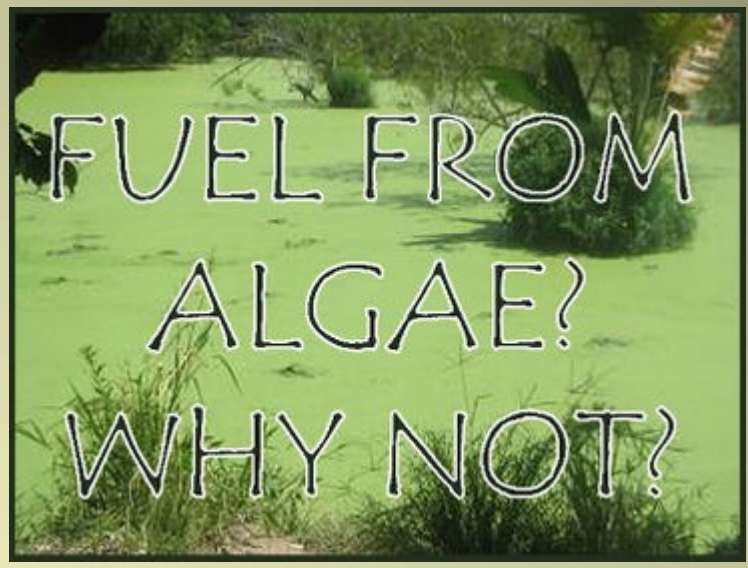
- alternativa fosilním palivům
- řasy nezabírají zemědělskou půdu
- některé řasy lze pěstovat na mořské nebo odpadní vodě
- řasy mají vysokou růstovou rychlost

biodiesel

metan

etanol, butanol

H_2

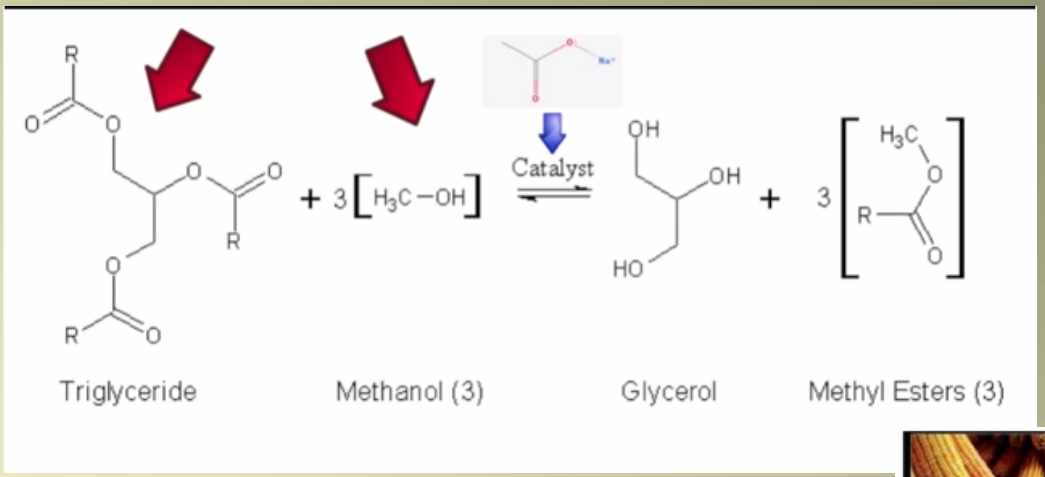


2012 Obama's Energy Plan -- Algae

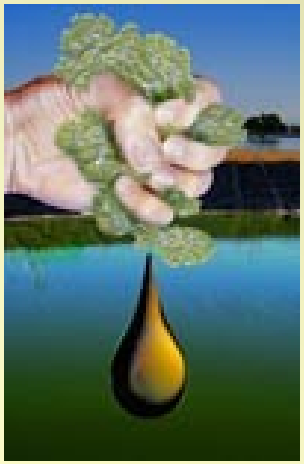
(CNSNews.com) - "The American people aren't stupid," President Obama said on Thursday -- as he insisted that drilling for more oil on U.S. territory is "not a strategy to solve our energy challenge."

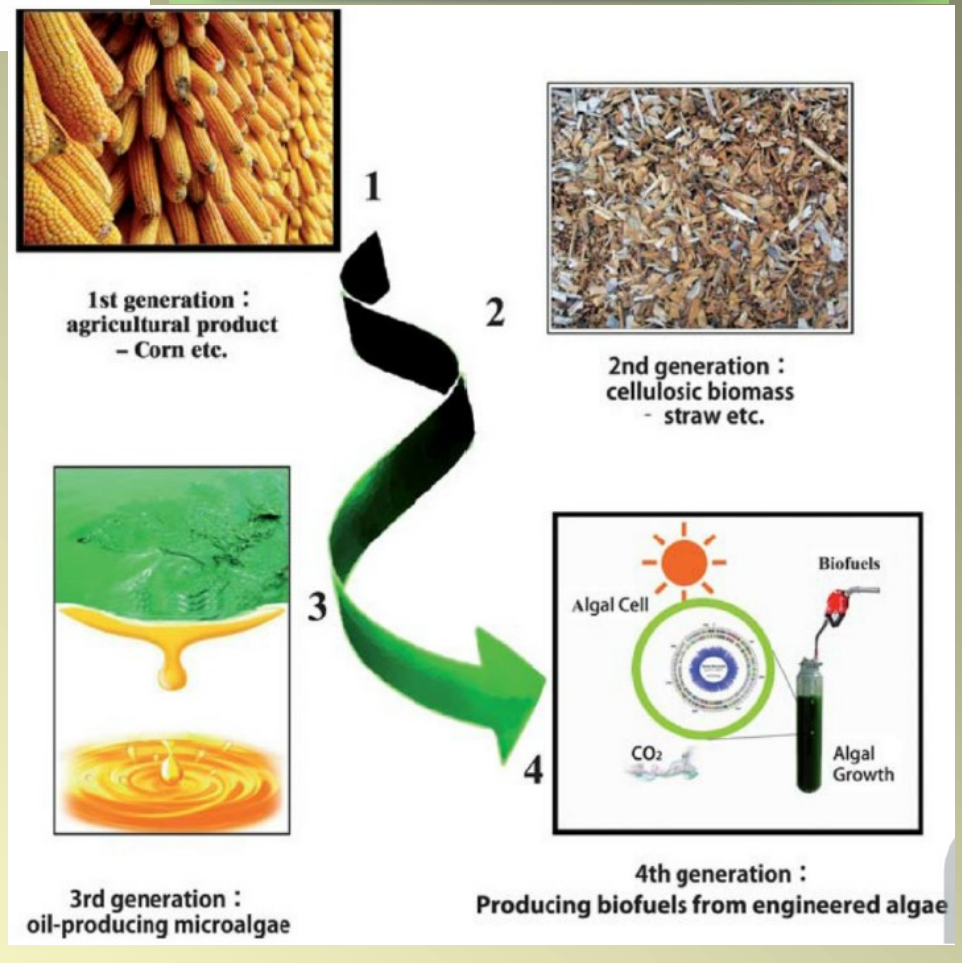
The president's solution? Algae, for one.

Biopaliva z řas



transesterifikace

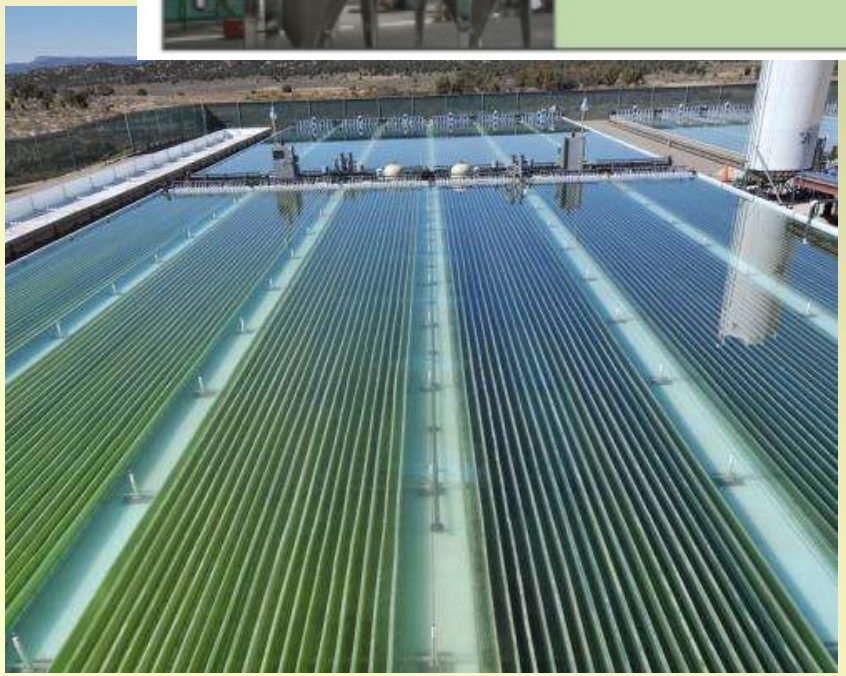




Make a biofuel at home
https://www.youtube.com/watch?v=TC9h78b2RM4

Typy produkce řas (sinic)

ALGAE PRODUCTION TYPE	ADVANTAGES	CHALLENGES
RACEWAY 	Low capital costs Evaporative cooling (outside) maintains temperature	Difficult to regulate chemistry High likelihood of contamination Difficult to scale up
PHOTOBIOREACTOR 	Higher surface to volume ratio	Difficult to scale up High likelihood of contamination Very high capital cost Requires temperature maintenance Requires periodic cleaning
FERMENTATION 	Achieves high biomass concentrations Easier to maintain optimal conditions for production	Competes for feedstock with other biofuel technologies and possibly food supply (sugarcane) Scaling up to achieve efficiency of scale



Utah State University

South Australian Research and Development Institute

Biopalivo z řas (první 2007)

Solazyme=TerraVia

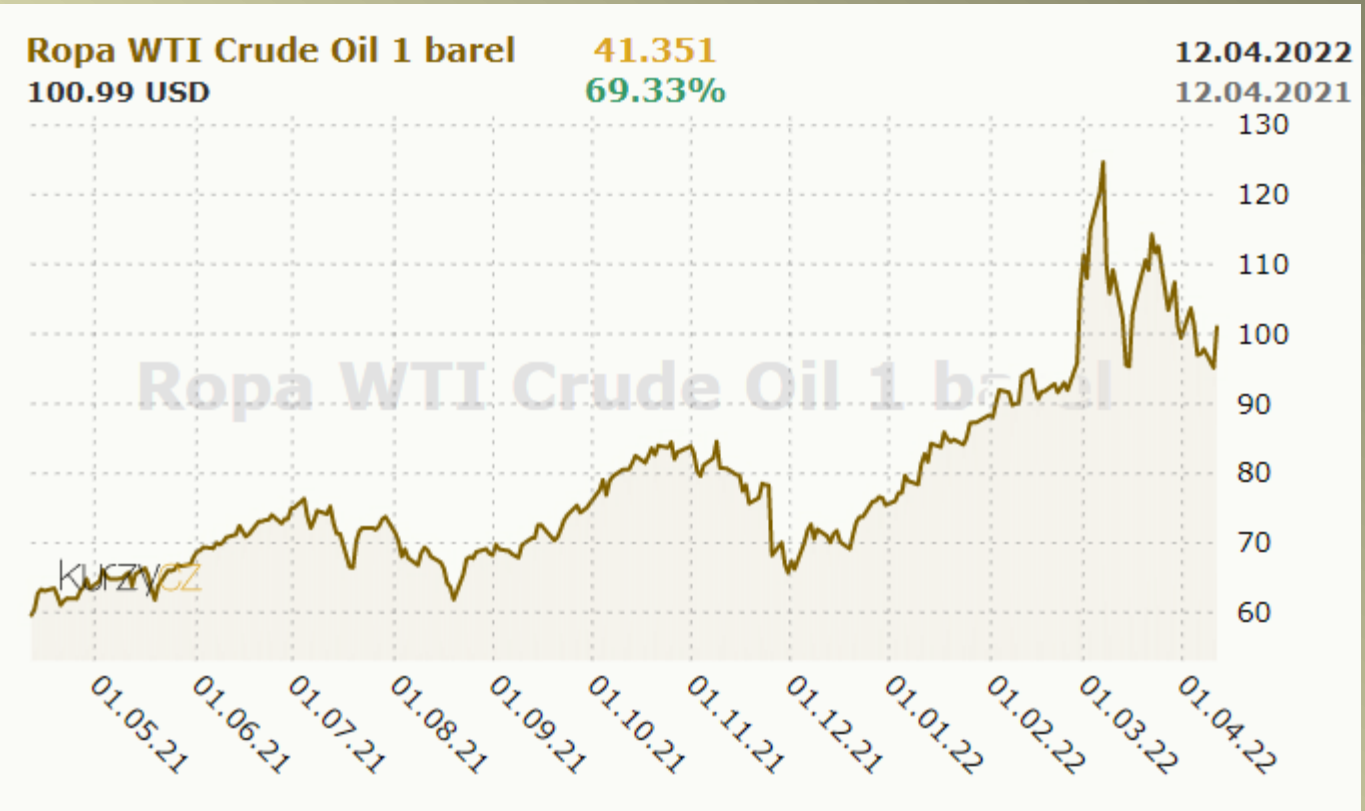
2011 ve spolupráci s U.S Navy, 100% palivo z řas bylo použito pro plavbu 300 m dlouhé nákladní lodě ze Sev. Evropy do Indonésie (plavba trvala měsíc), 300 t paliva spotřebováno

Jet fuel, Solajet(R) HRJ-5, v helikoptéře MH-60S Seahawk testovací let - 50/50 smícháno palivo s benzínem

"taking the world's smallest organisms to solve some of the world's biggest challenges."

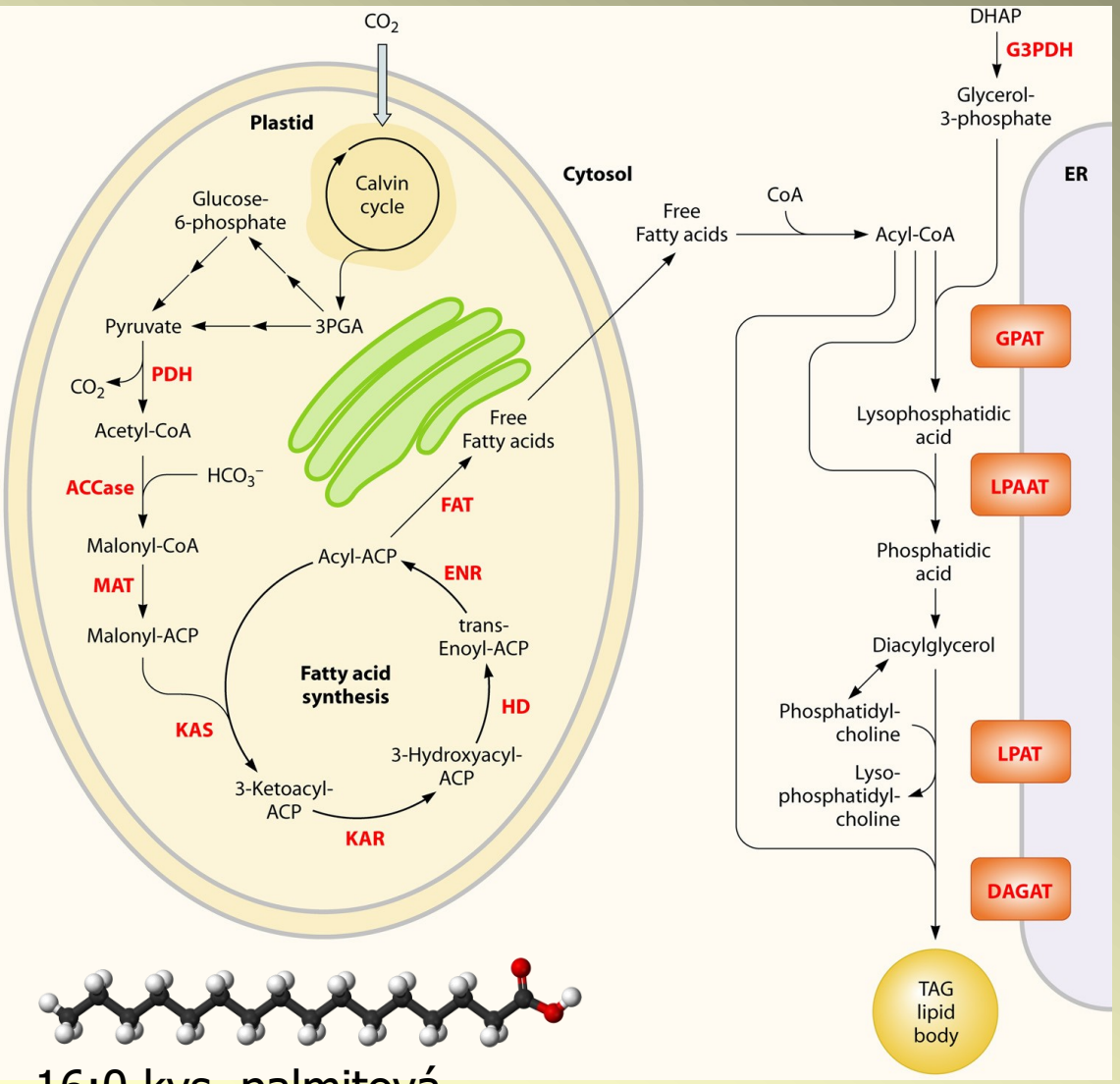
2014: $120 in 2011, fell to $70 in 2014 and reached $30 at the end of 2015

Vývoj ceny ropy



snaha odříznout se od ruských fosilních paliv

Syntéza lipidů v řasové buňce

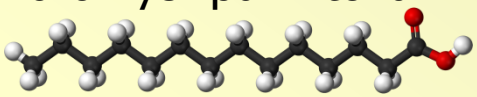


Enzymy účastnící se produkce tuků lze ovlivňovat tak, aby byly produkovány požadované typy tuků – ty pak mohou být transestrifikovány (biofuel) nebo krakovány na letecký benzín (biojet fuel)

FAT = acyl-ACP thioesterase uvolnění MK z cyklu

Různé typy FAT z různých organismů – specifické pro MK určité délky – využity pro změnu délky řetězce

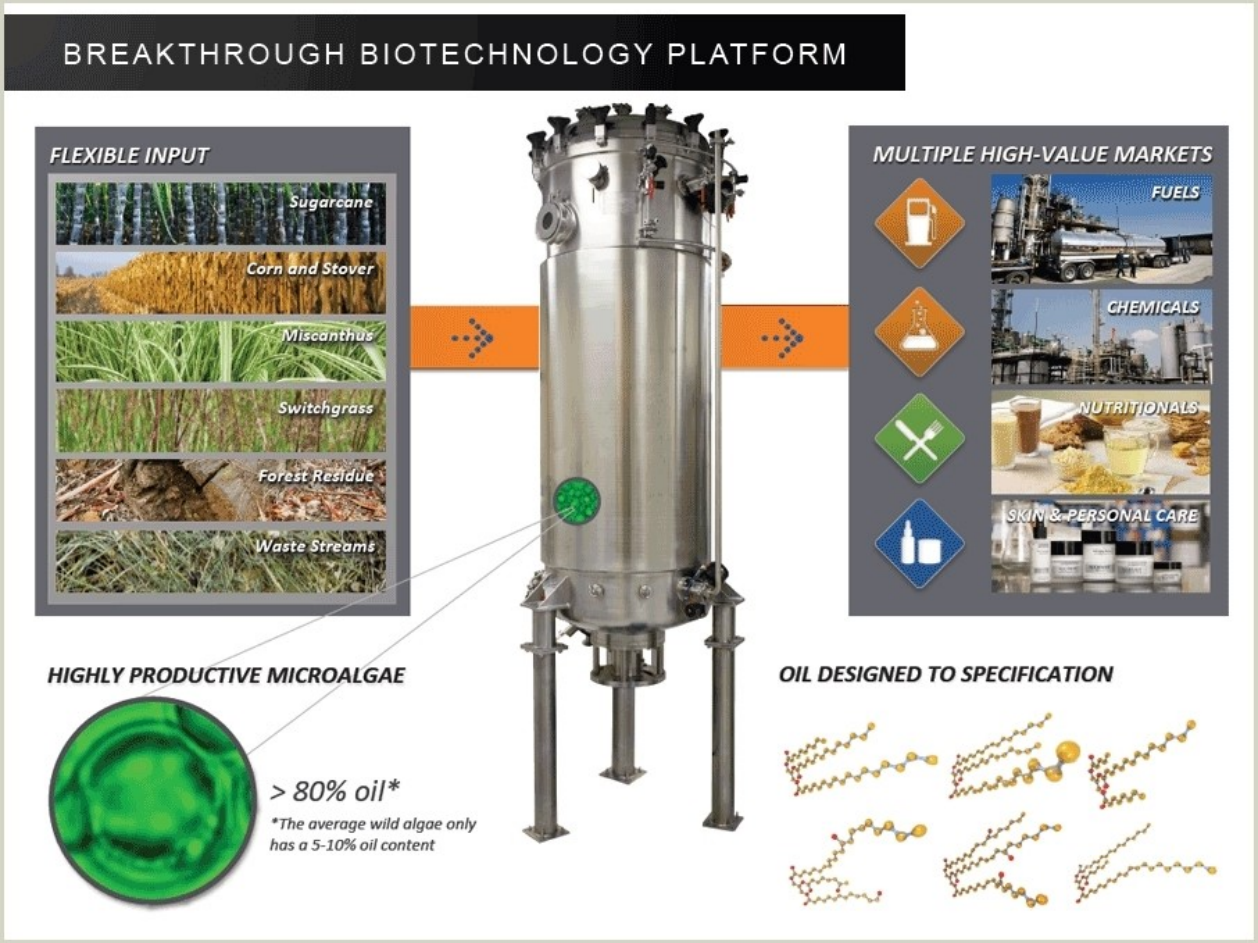
16:0 kys. palmitová

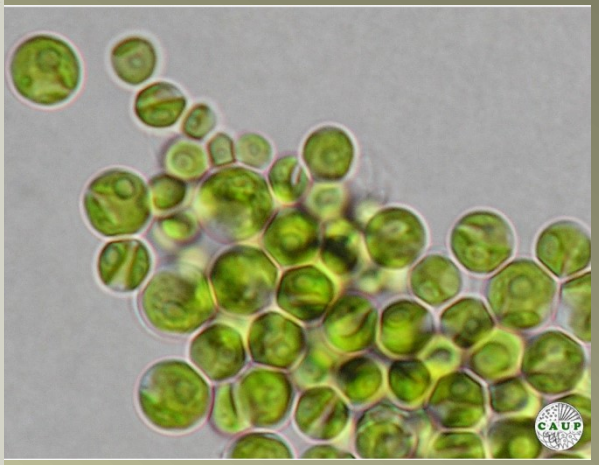


14:0 kys. myristová

Řasové mastné kyseliny 14-20 C nejčastěji 16:1, 16:0 a 18:1. Naopak ideální MK pro produkci biopaliva 12:0 a 14:0.

1) over-exprimace určitých genů, účastnících se produkce lipidů
2) blokování metabolických drah vedoucí k akumulaci energeticky bohatých zásobních látek (škrob)
3) omezení katabolismu lipidů – utlumení genů, účastnících se β oxidace MK



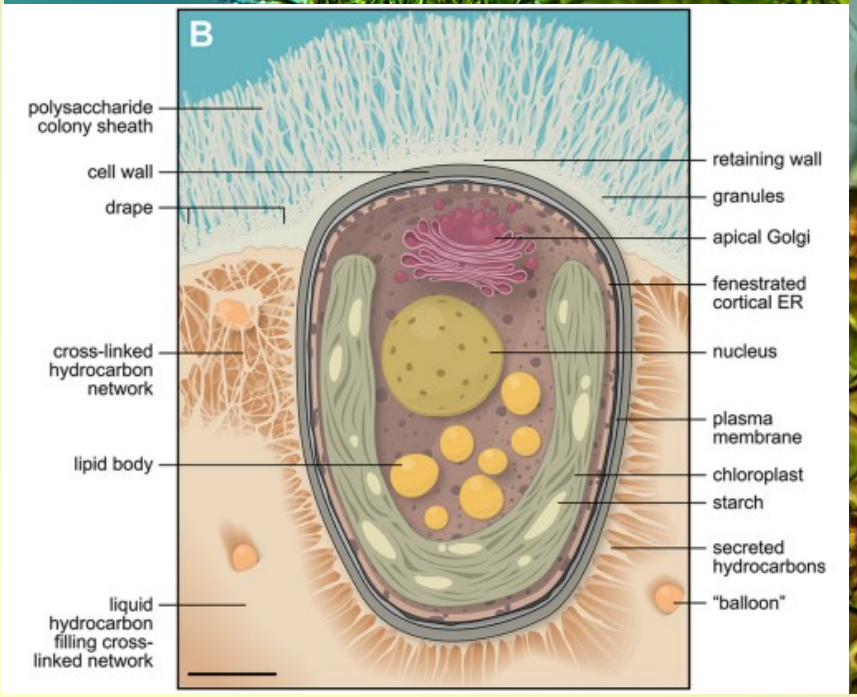


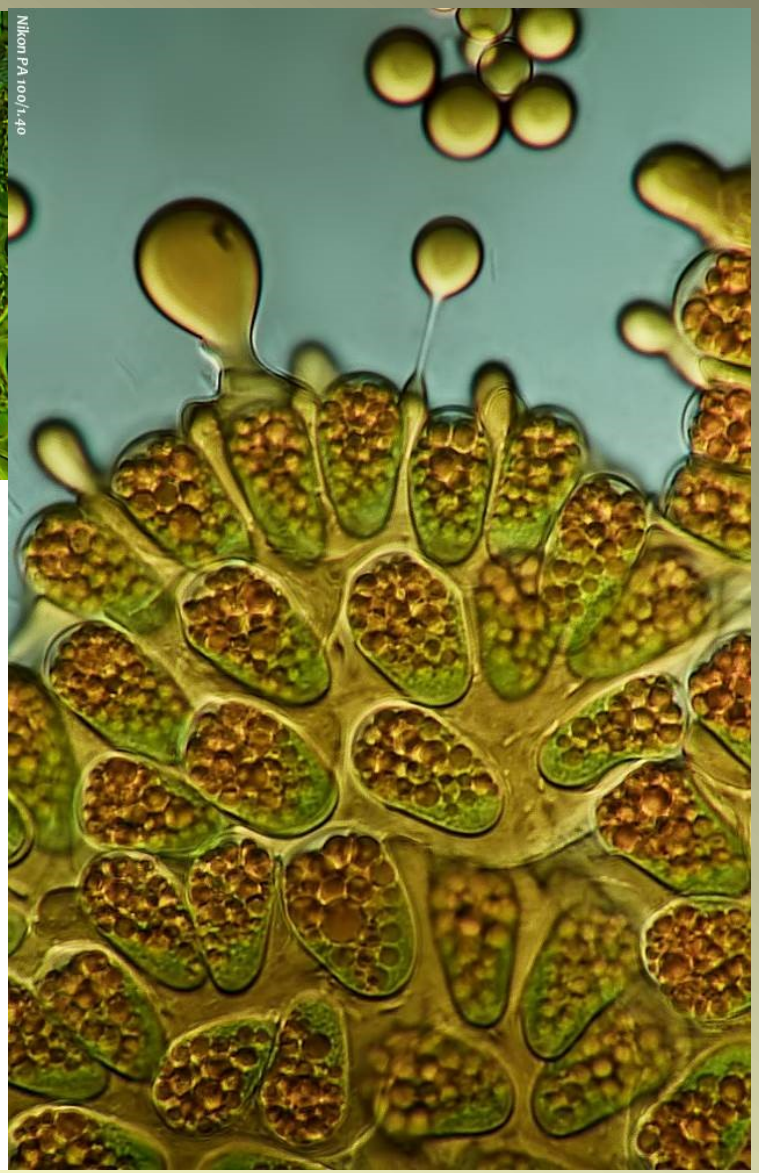
Geneticky modifikovaná *Chlorella* pěstována v bioreaktoru heterotrofně na médiu obsahujícím jednoduché cukry

Botryococcus

biopaliva - pyrolýza

Botryococcus braunii – koloniální zelená řasa





Botryococcus

Vodní květ, jezero Kinneret, Izrael
leden 2000

velikost kolonií 30µm – 2mm. Typická organizace kolonií
(skenovací elektronový mikroskop)

fosilní usazeniny extrémně bohaté na uhlovodíky

Bio-Fuel Growing Eco Pods
Rejuvenate Stalled Boston Project