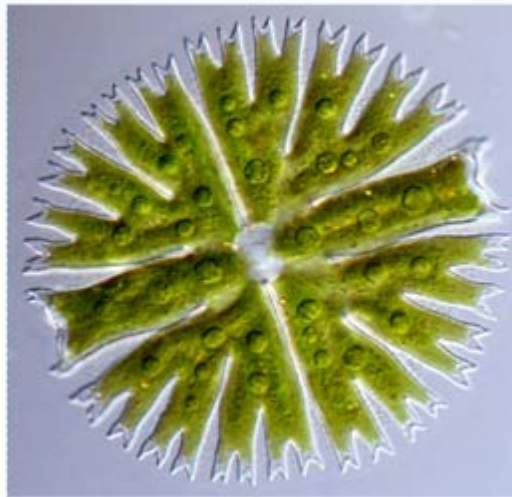


Skrytá diverzita volně žijících protistních organismů



Pavel Škaloud
katedra botaniky PŘF UK

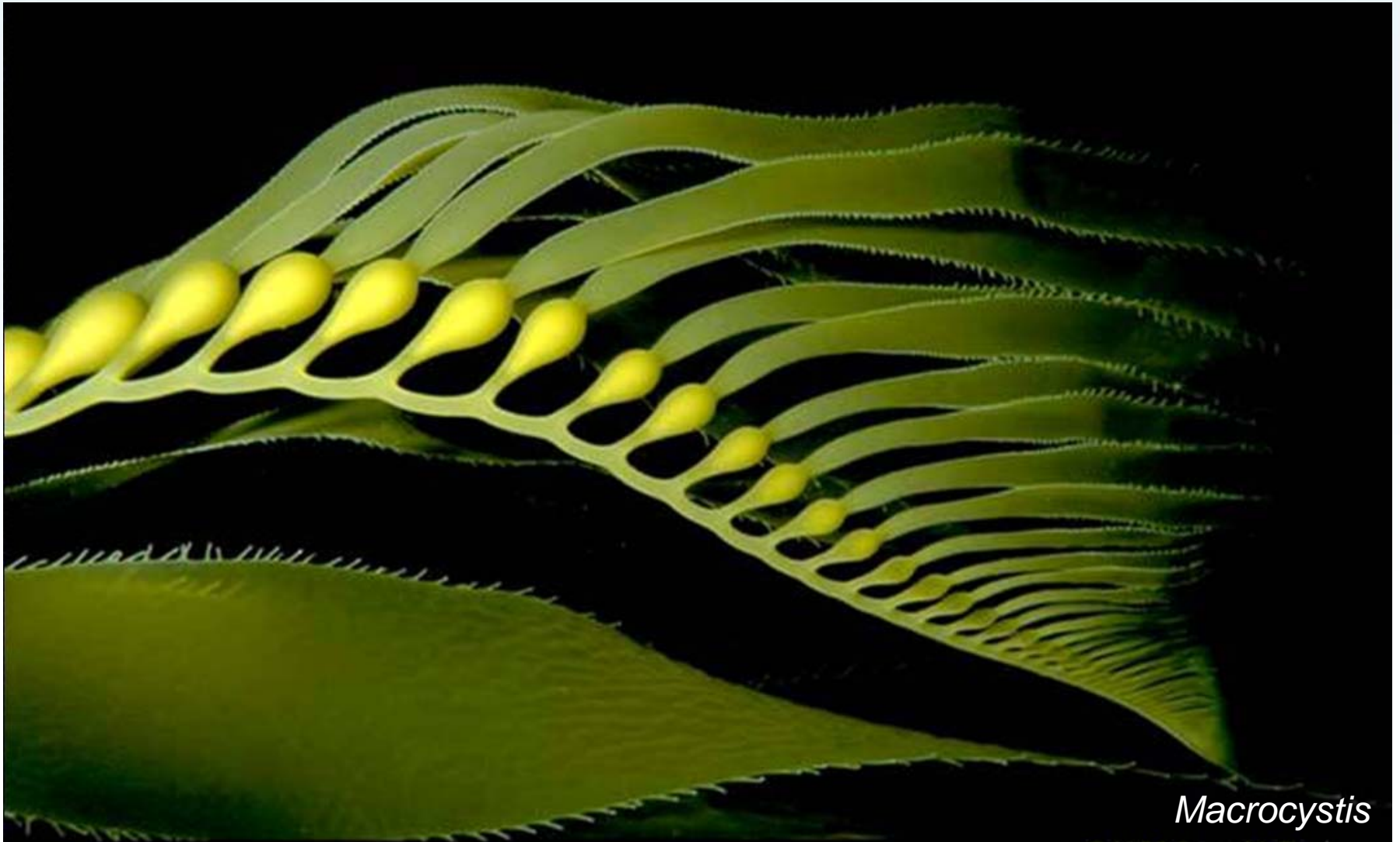
Co jsou to protista?

- Eukaryotické organismy s jednoduchou organizací stélky (jednobuněčné, koloniální či vláknité). Nemají rozlišená pletiva.



Co jsou to protista?

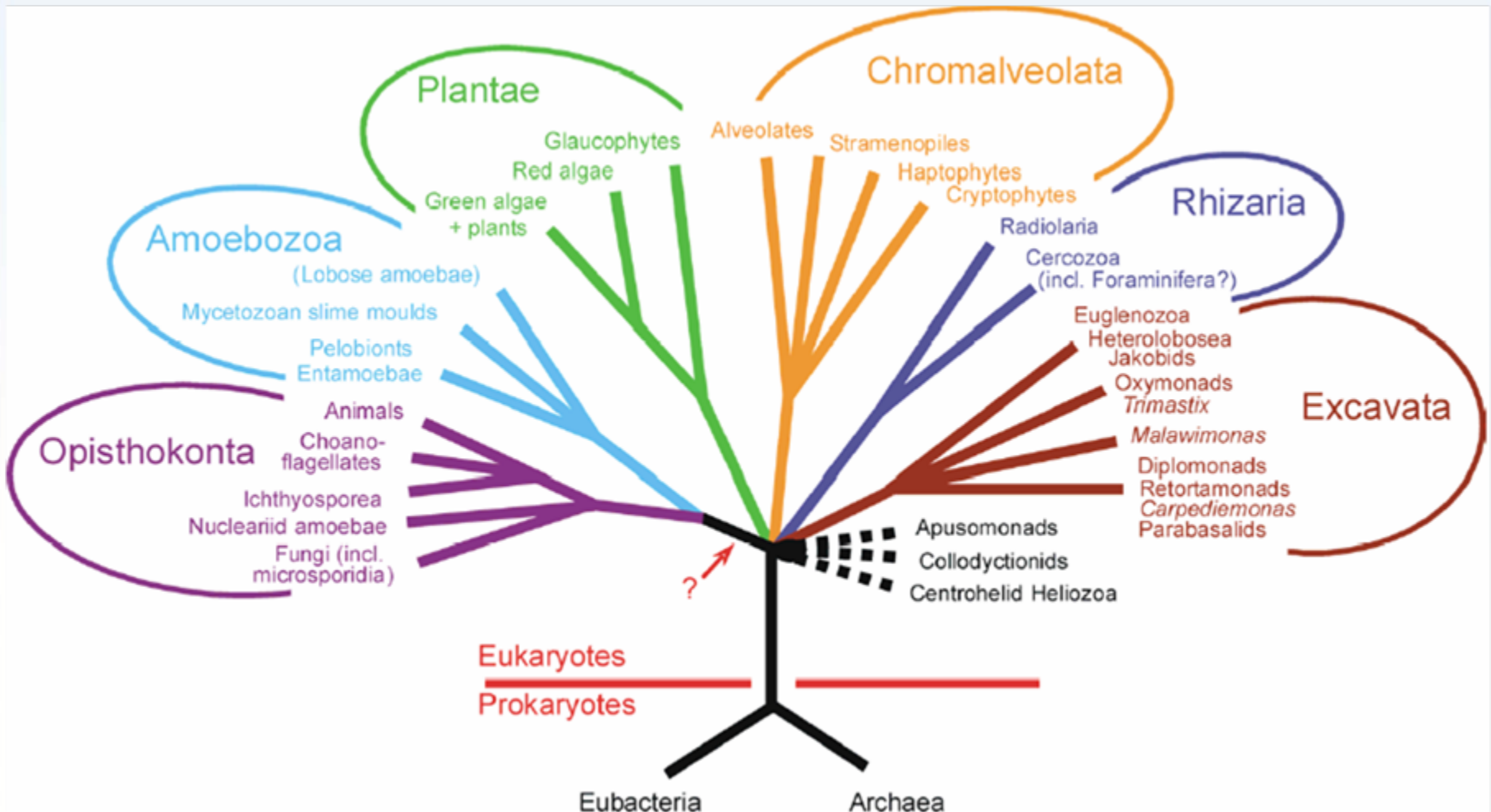
- I chaluhy jsou protista.



Macrocystis

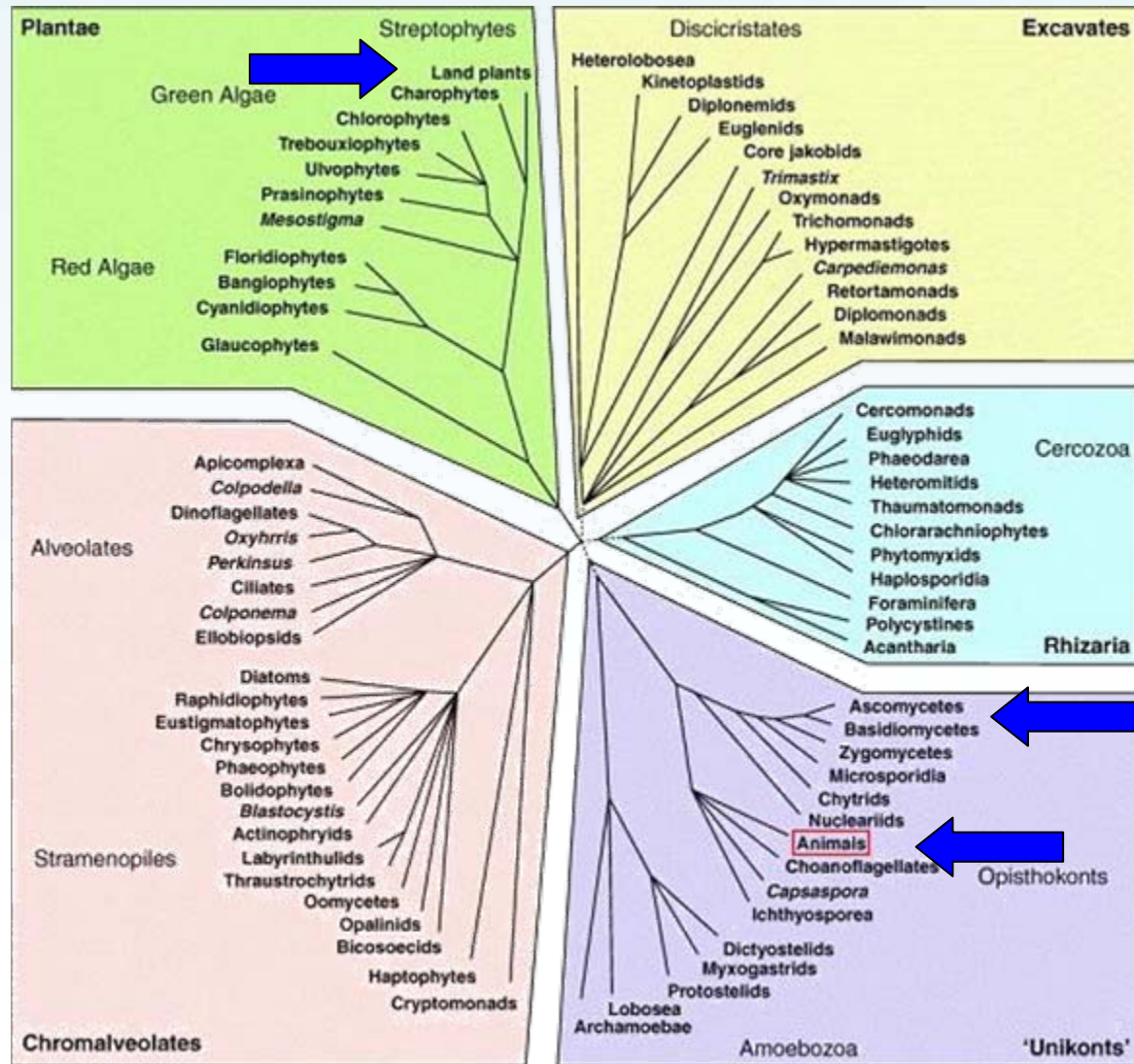
Co jsou to protista?

- Historicky byly tyto organismy řazeny do říše Protista, nyní je již tento pohled překonán



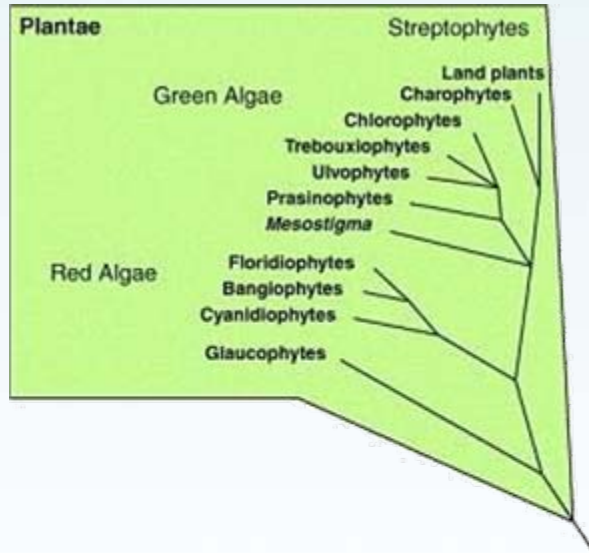
Co jsou to protista?

- Drtivou většinu eukaryotní diverzity na naší planetě tvoří právě protistní organismy.

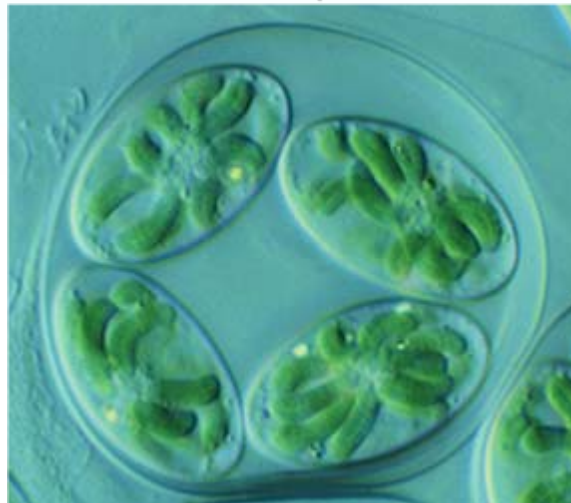


Co jsou to protista?

- Plantae



Rhodophyta



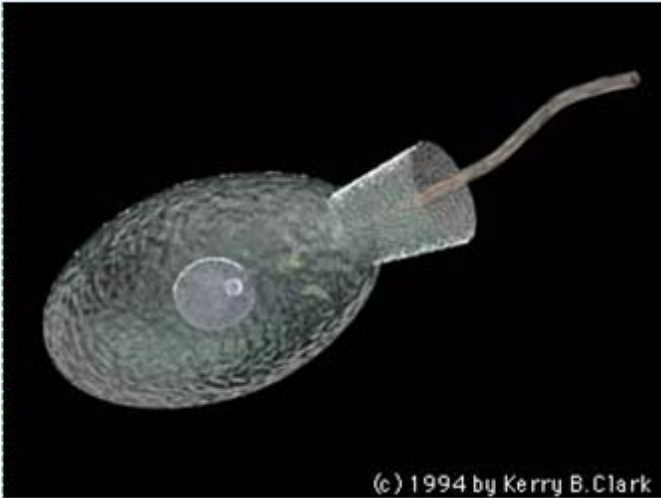
Glaucophyta



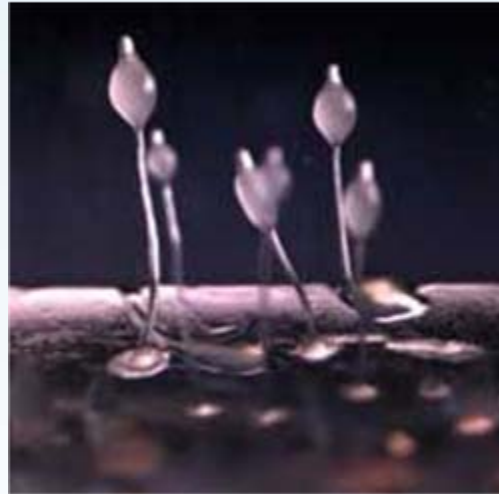
Chlorophyta

Co jsou to protista?

- Unikonts



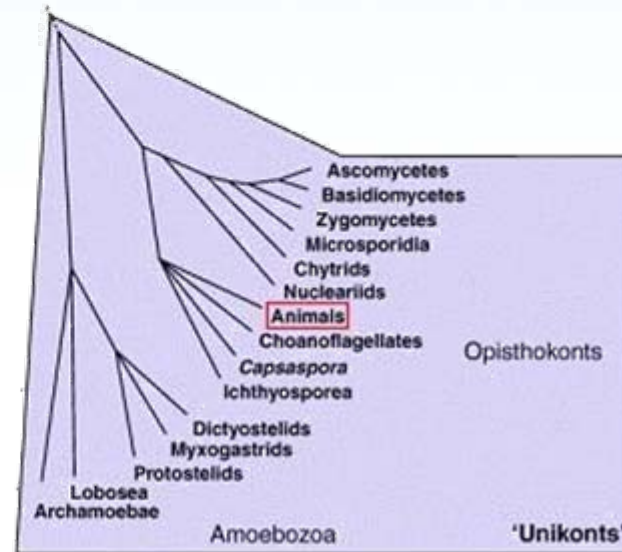
choanoflagellata



Dictyostelides

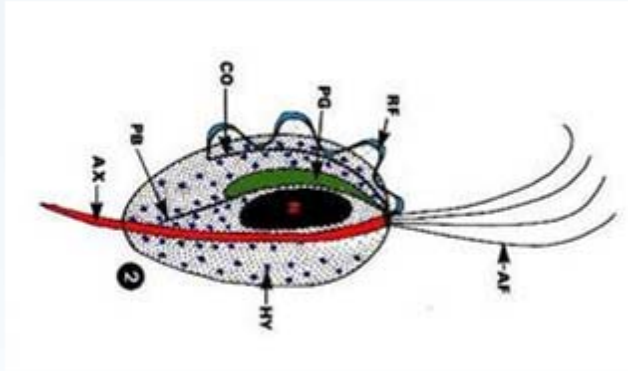


Lobosea

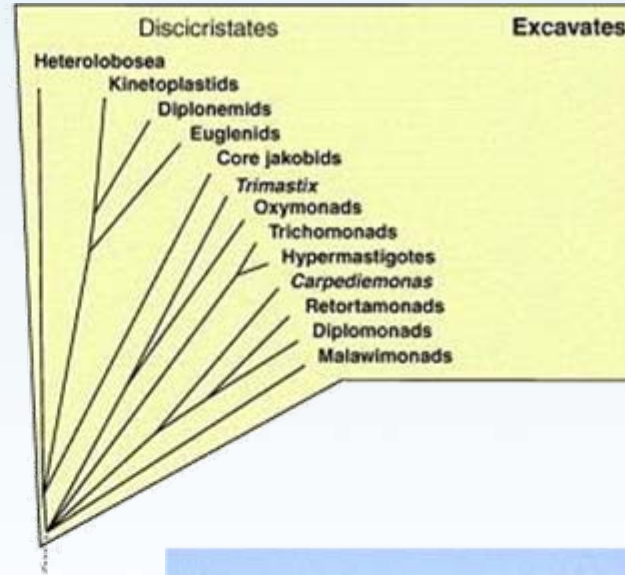


Co jsou to protista?

- Excavata



Trichomonadida



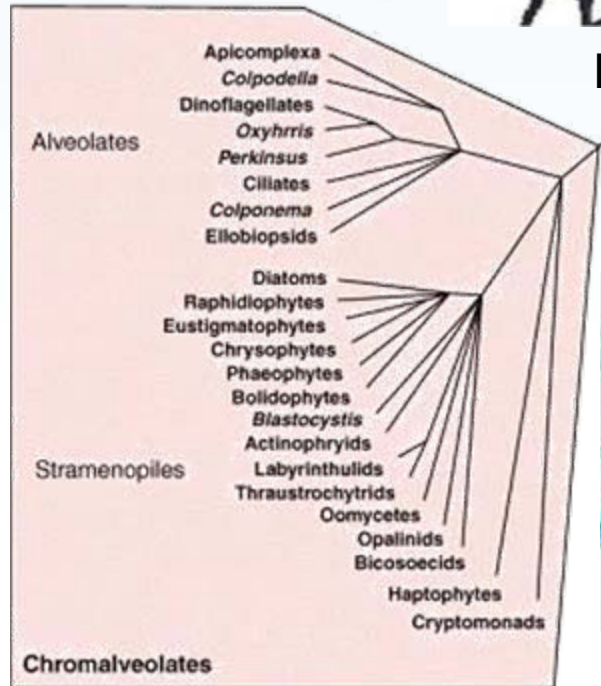
Kinetoplastida



Euglenophyta

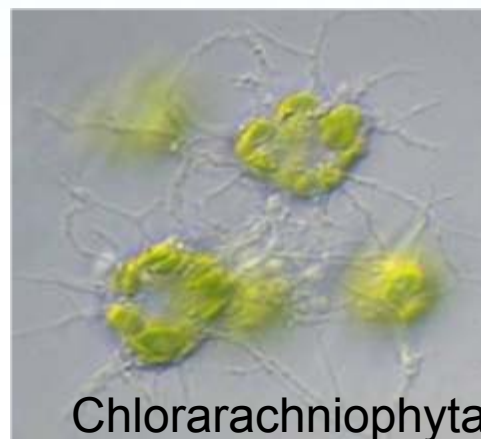
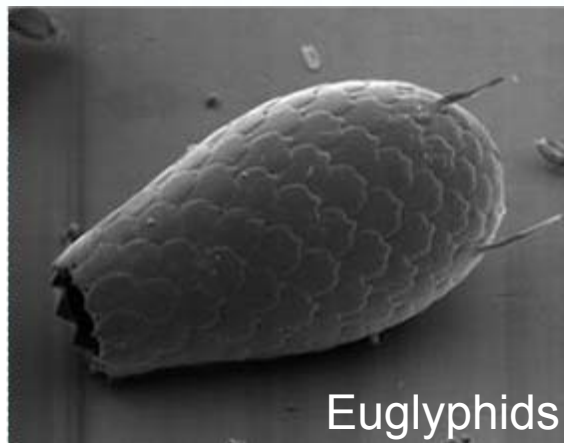
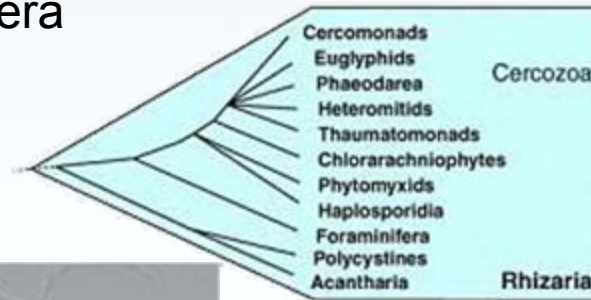
Co jsou to protista?

- Chromalveolata



Co jsou to protista?

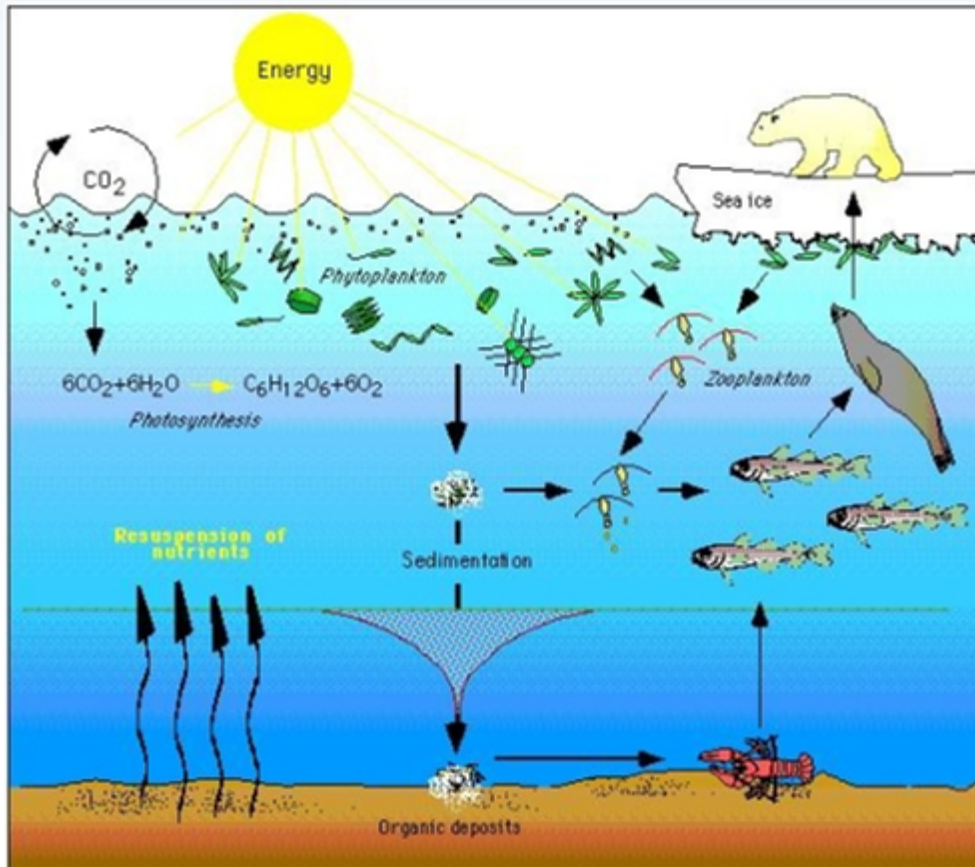
- Rhizaria



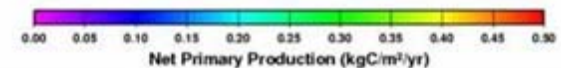
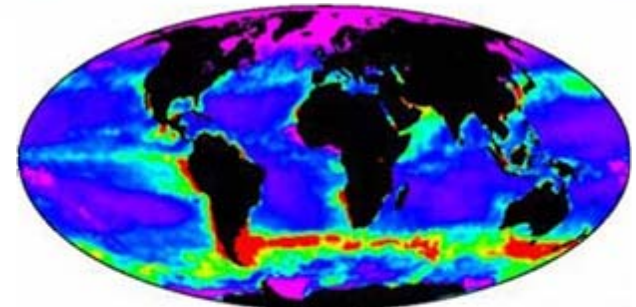
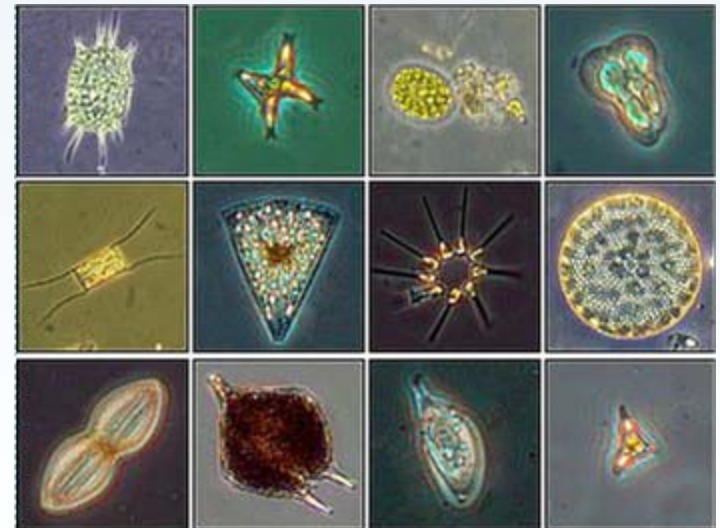
Velikost a početnost protist

- Mořský fytoplankton – 10^{25} buněk:

10 000 000 000 000 000 000 000 000 000 000 buněk



Drawn by Christopher Krembs

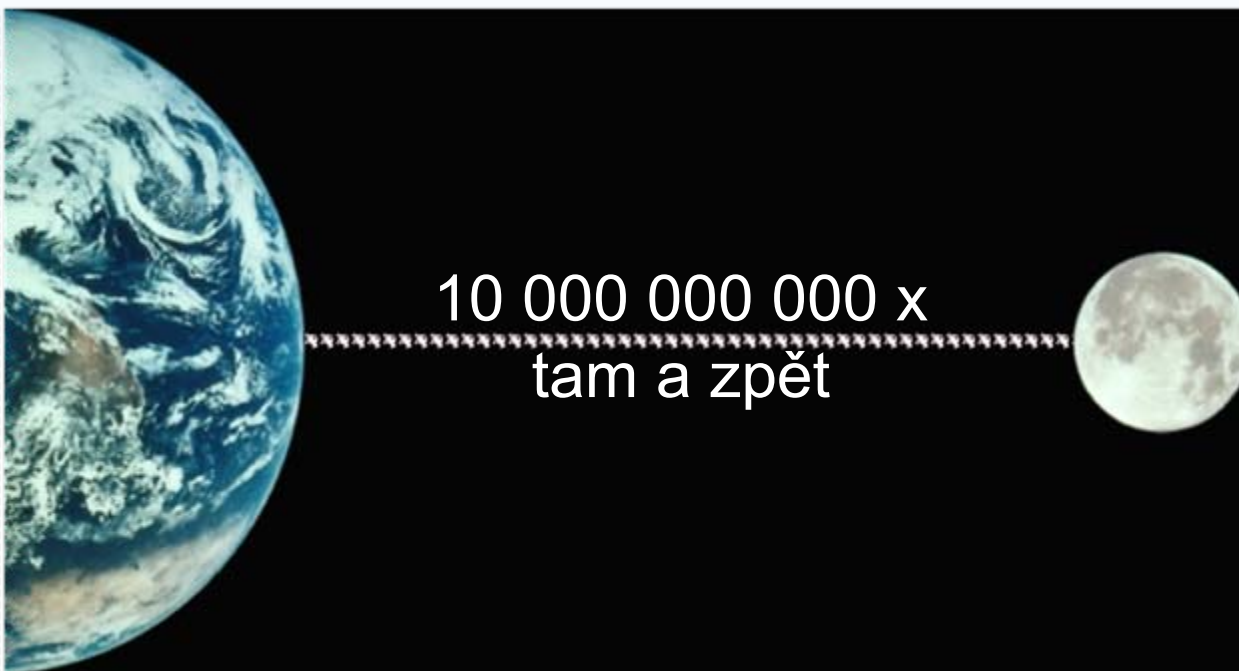


Velikost a početnost protist

- Mořský fytoplankton – 10^{25} buněk
- Průměrná velikost jedné buňky fytoplanktonu – $2\ \mu\text{m}$

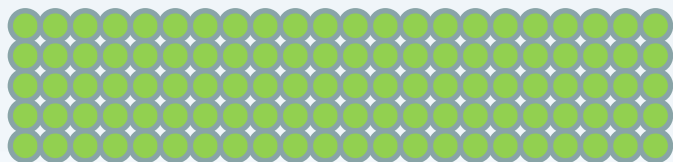


Řada buněk – 20 000 000 000 000 000 km

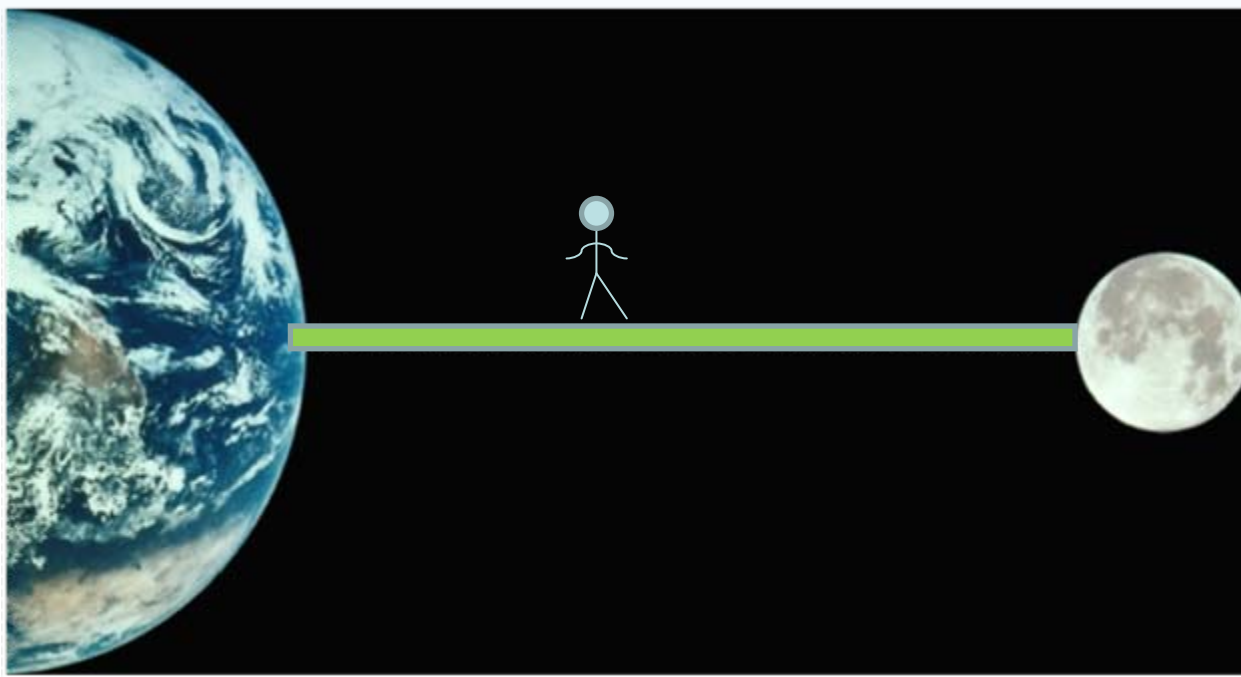


Velikost a početnost protist

- Mořský fytoplankton – 10^{25} buněk
- Průměrná velikost jedné buňky fytoplanktonu – $2\ \mu\text{m}$



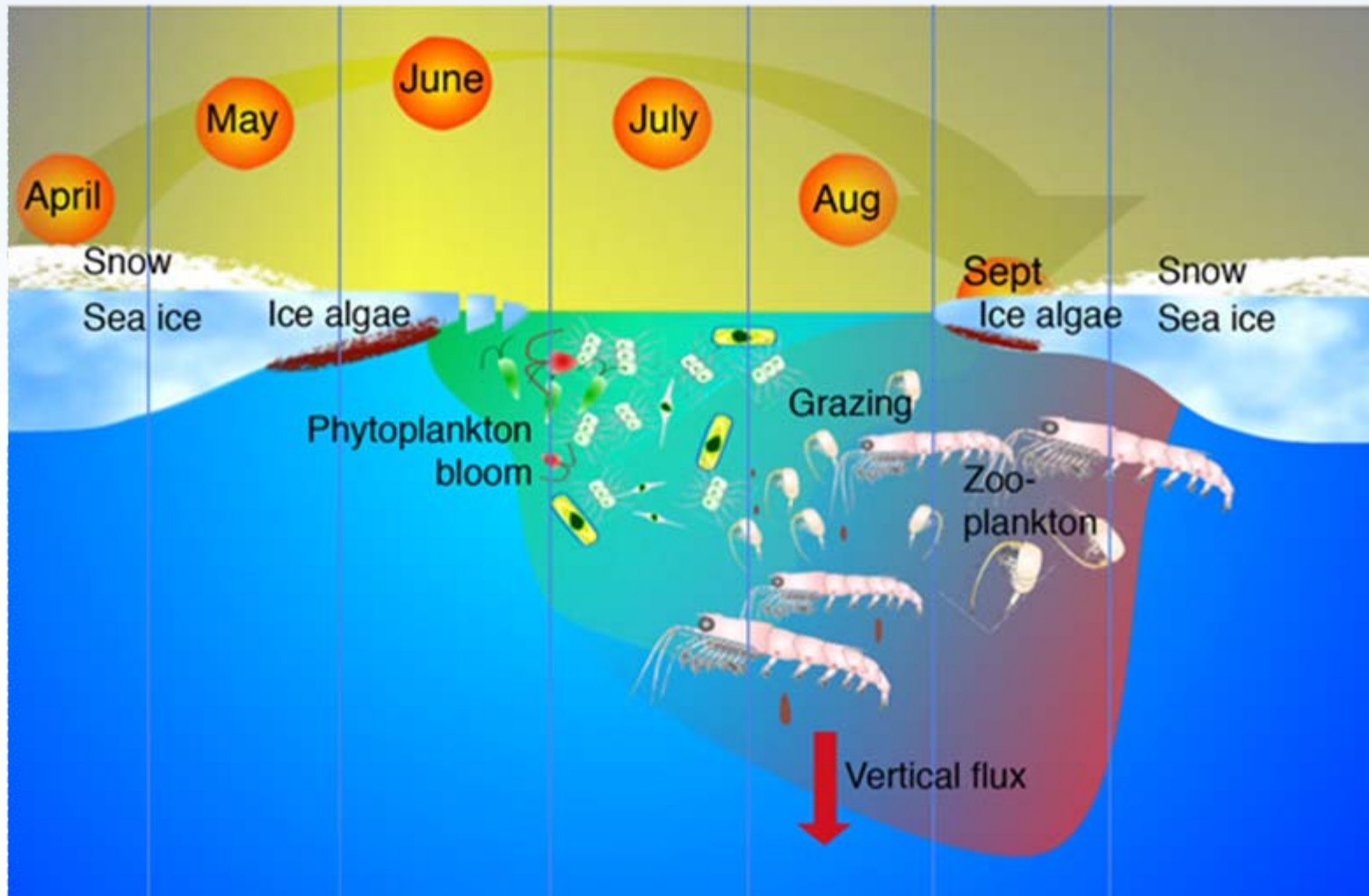
Deska o šířce 30 cm a tloušťce 8 cm (150 000 x 40 000 buněk)



Velikost a početnost protist

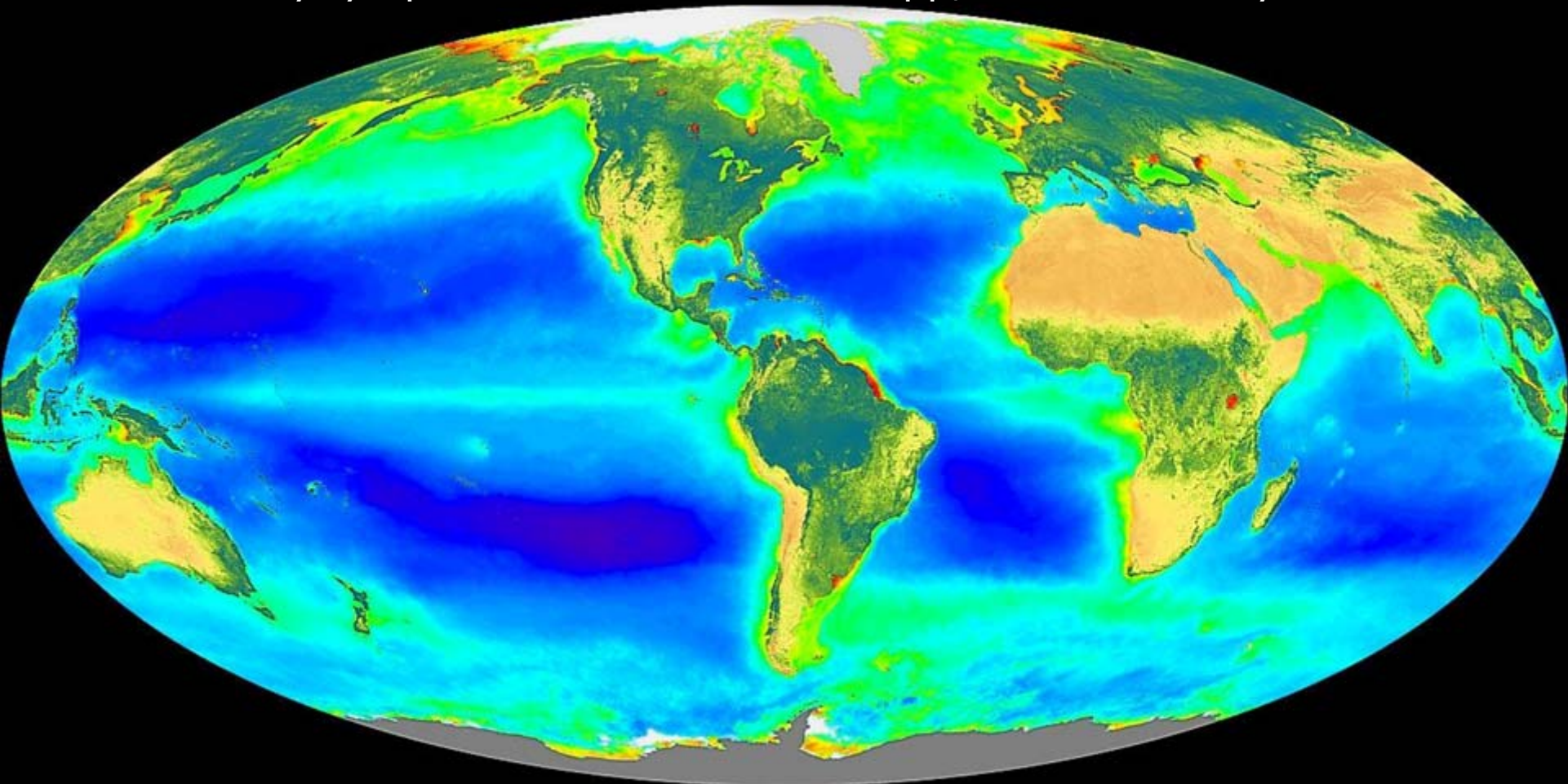
Ohromná dynamika:

- Mořský fytoplankton – 10^{25} buněk
- Každá buňka se dělí v průměru 1x za den, stejný počet buněk denně sežrán zooplanktonem



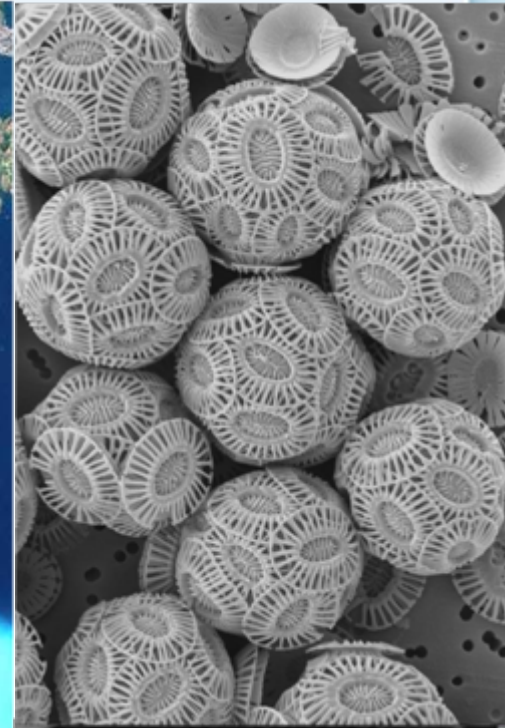
Globální význam protist

- Primární produkce, řasy se podílí na celé polovině produkce O_2
 - Mořský fytoplankton - 40 % celkové pp, z toho rozsivky 20-25 %



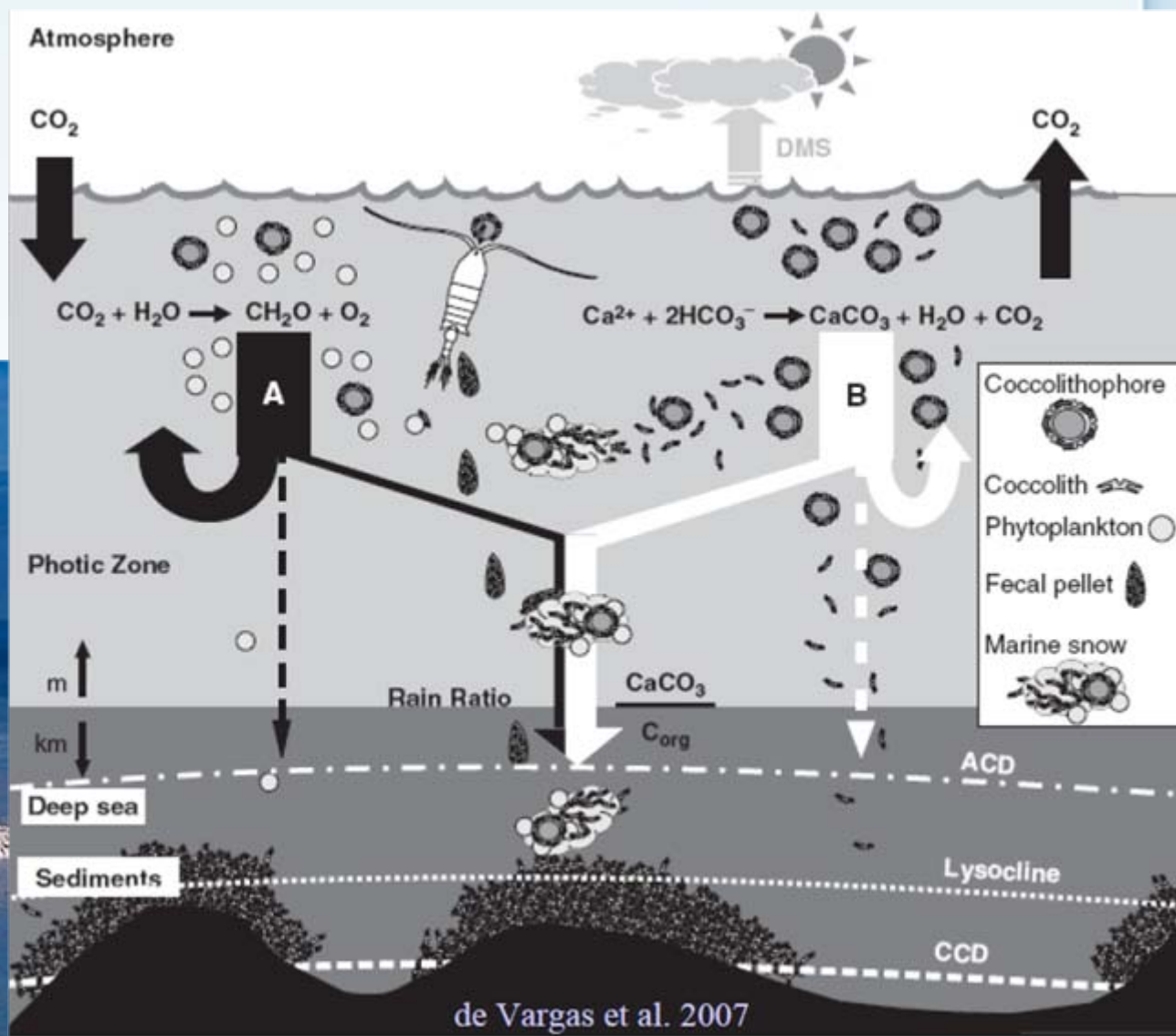
Globální význam protist

- *Emiliana huxleyi* – nejhojnější eukaryot na planetě, white tides



Globální význam protist

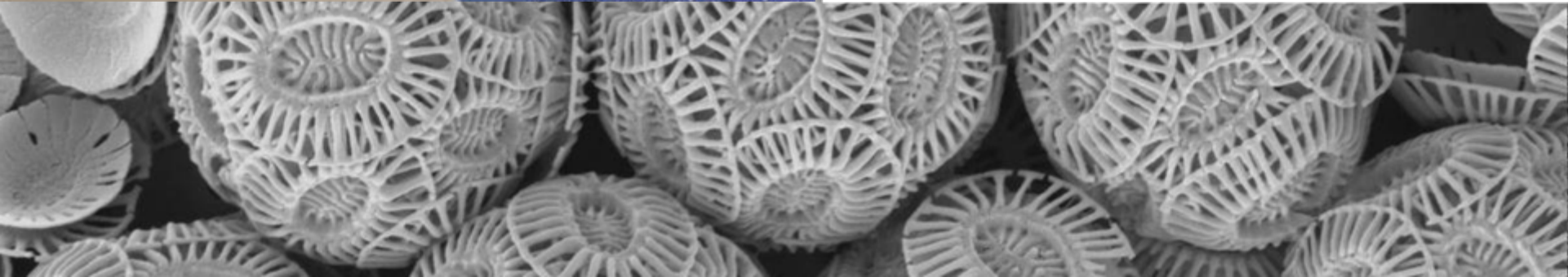
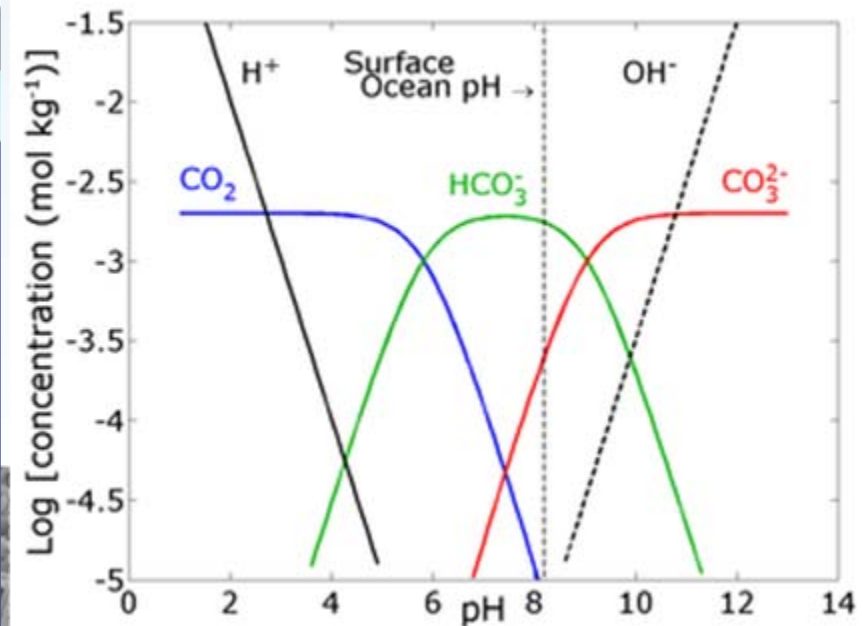
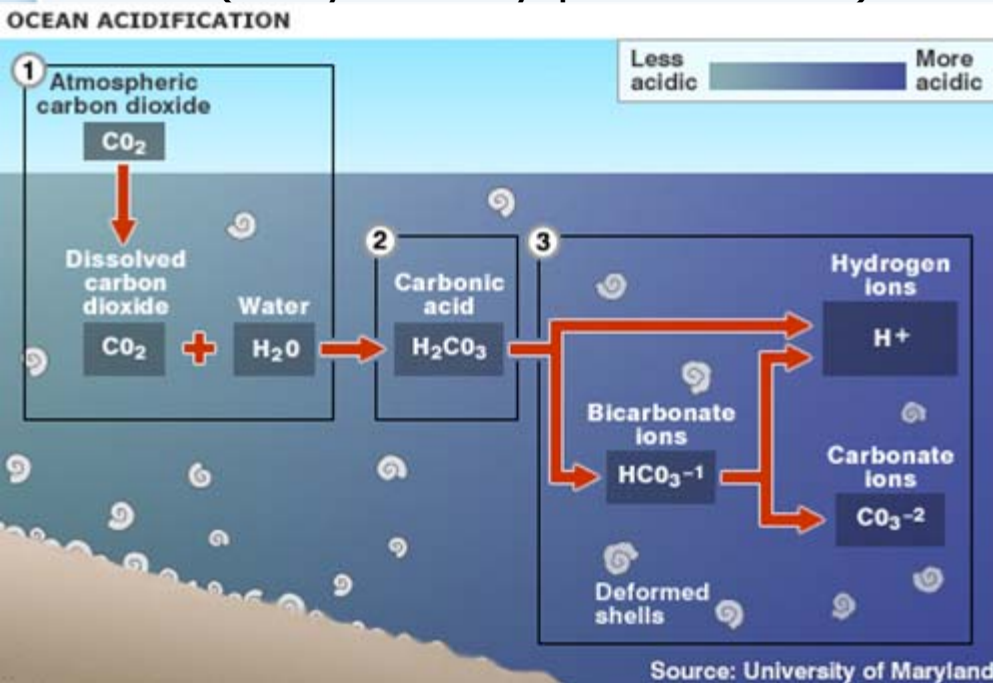
- *Emiliana huxleyi* – kokolity
- Výrazné ovlivnění globálního klimatu na Zemi
- Vápence (Dover cliffs)



Globální význam protist

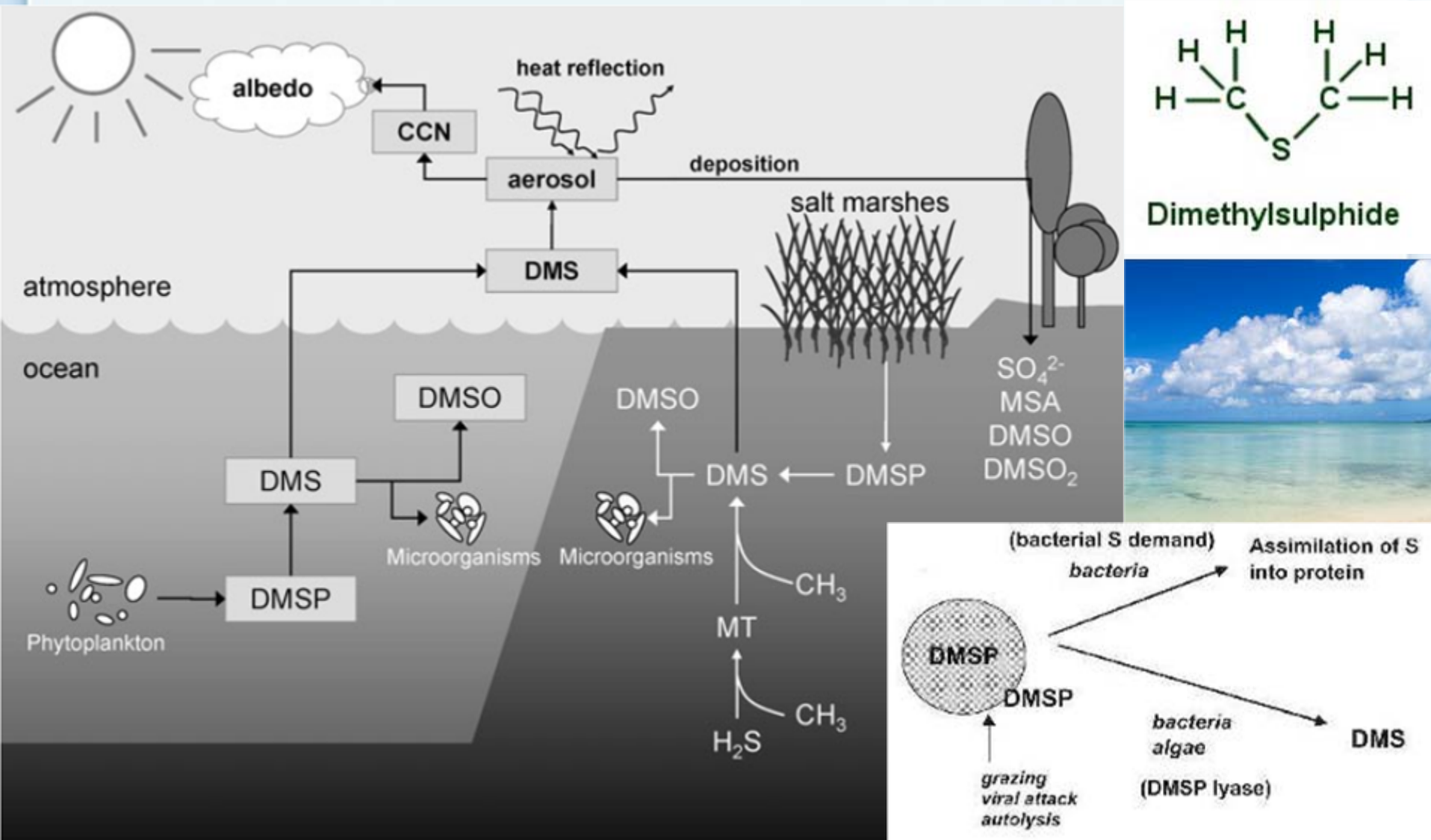
- *Emiliana huxleyi*

- acidifikace moří: oxid uhličitý snižuje pH mořské vody, čímž se mění rovnovážný stav jeho tří rozpustných forem ve prospěch CO_2 (nevyužitelný pro emiliani)



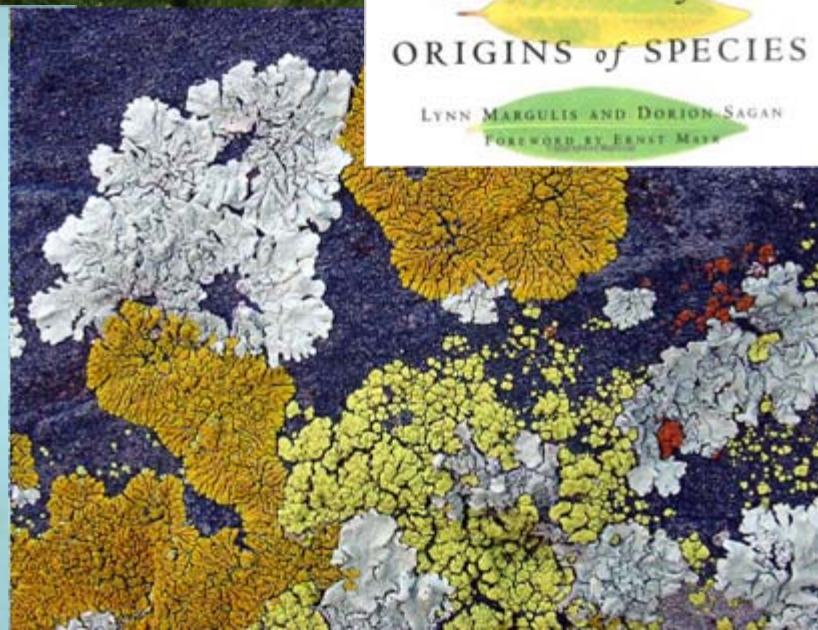
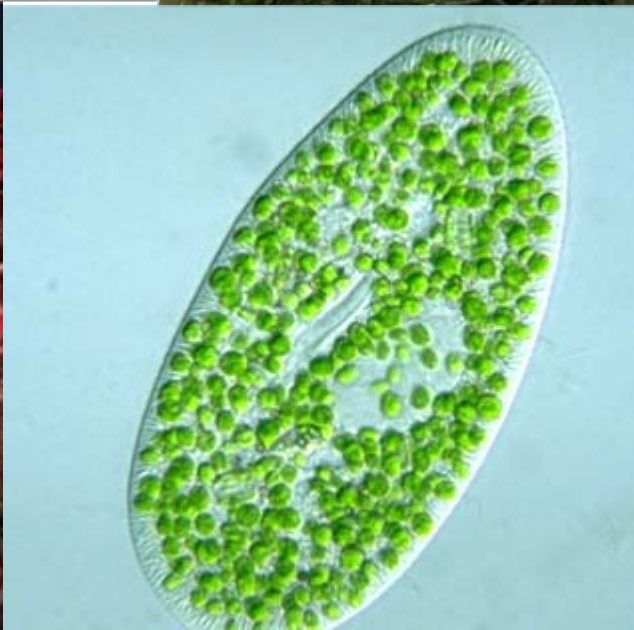
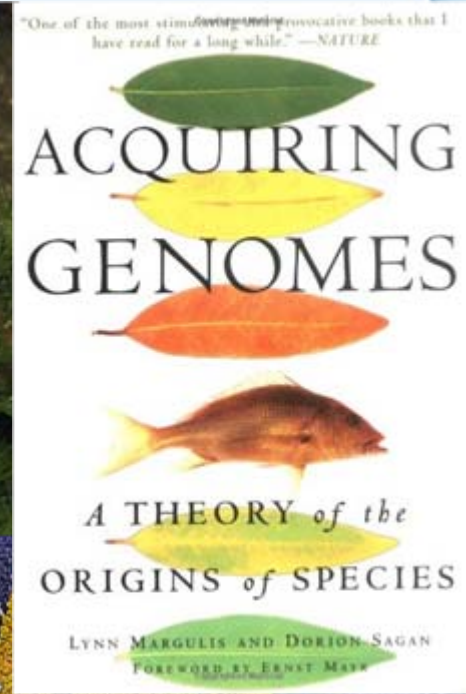
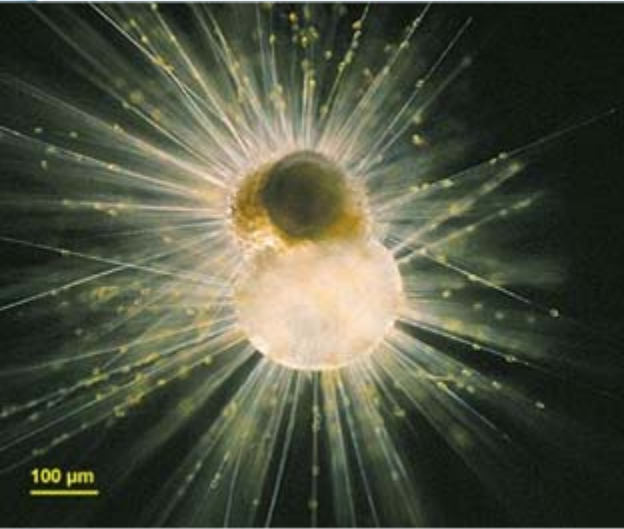
Globální význam protist

- *Emiliana huxleyi*
 - dimethylsulfid: kondenzační jádra v mracích, ochlazování planety



Globální význam protist

- Symbiotické interakce
 - změny životního stylu, zvýšení fitness, speciální události



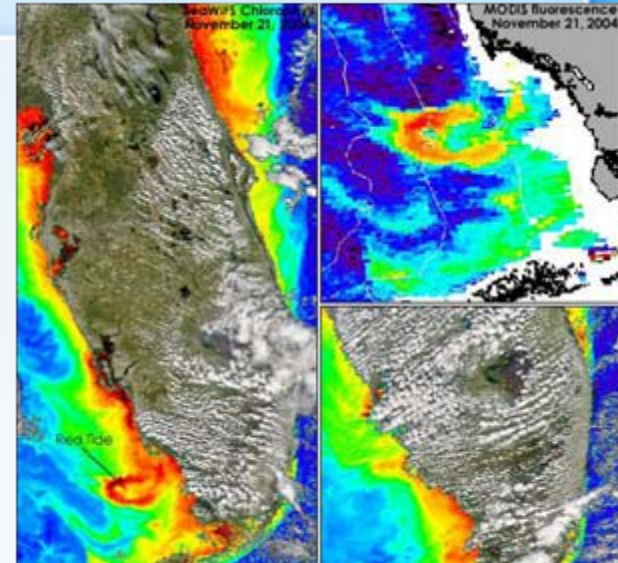
Globální význam protist

- Protista jako geologická síla
 - Křída – z mořských mikroorganismů (foraminifera, kokolity),
 - Silicity – nahromadění schránek protist (rozsivky, mřížovci): křemenec, diatomit, buližník,



Význam protist

- Produce toxinů (obrněnky - red tides)
- CFP (ciguatera fish poisoning)
 - Nejrozšířenější onemocnění způsobené mořskými toxiny (50000 onemocnění ročně)
 - Kumulace v mořských tropických rybách
 - Gastrointestinální potíže: průjem, zvracení
 - Neurologické projevy: teplotní změny
 - Kardiologické potíže: arytmie, zástava srdce
 - Mortalita: 0,1 - 12 %



A hidden danger lurks among the reefs.

Beware of Ciguatera (pronounced sig-wa tērra)



Hogfish (*Lachnolaimus maximus*)

Tiny algae can produce toxins that concentrate in the organs and flesh of large carnivorous reef fish (such as barracuda, hogfish, red snapper and groupers). Ciguatera fish doesn't look or taste bad.

Symptoms of ciguatera appear within

6-24 hours, and include vomiting, diarrhea, abdominal pain and cramping, as well as unusual sensations (such as itching skin, aching teeth and painful urination).

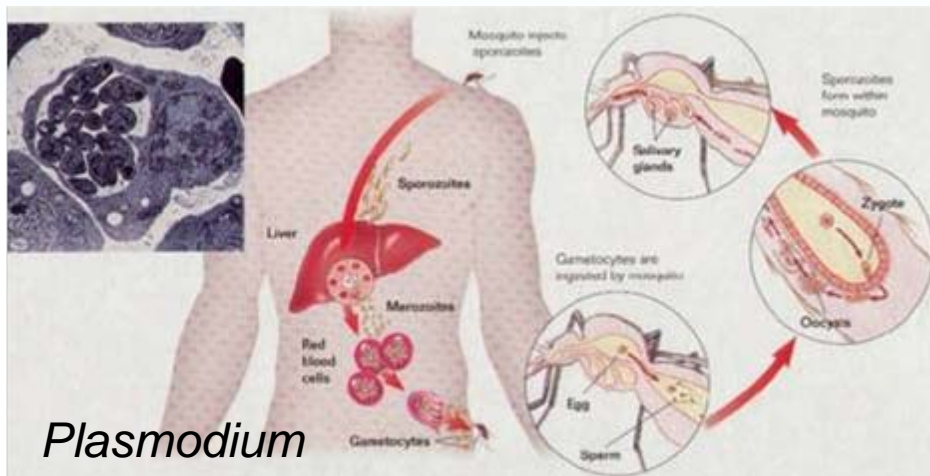
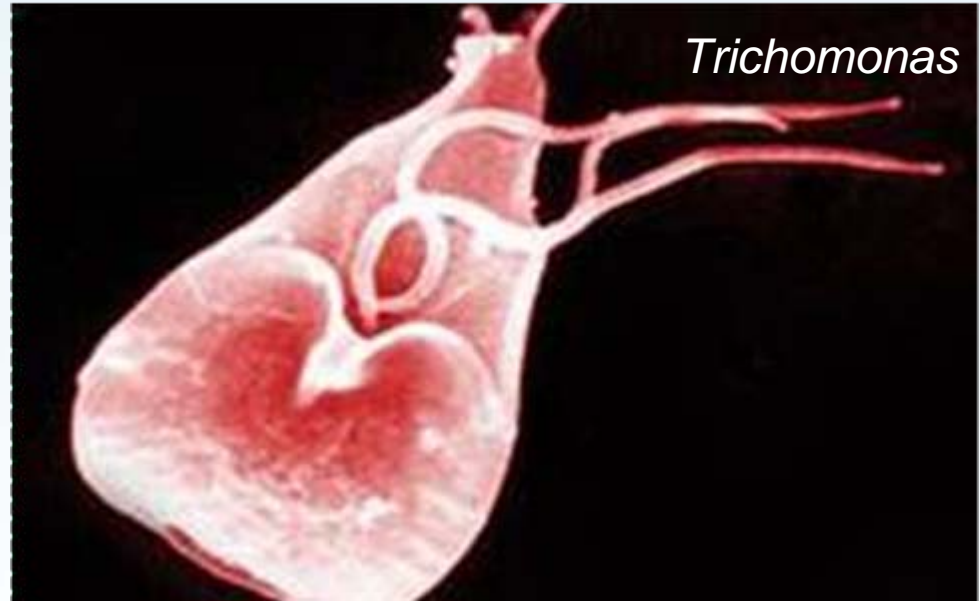
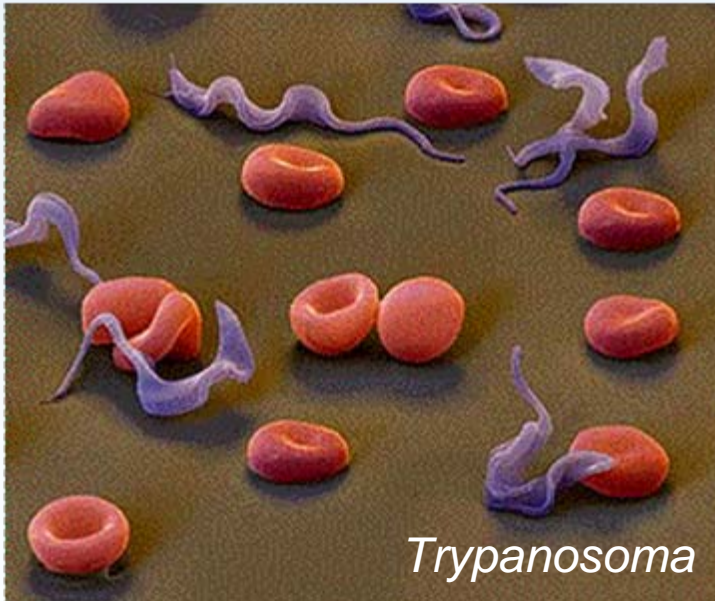
The classic symptom of ciguatera is the sensation that cold things feel hot to the touch. For some people, these symptoms come and go for months or even years, and can be triggered by eating seafood, caffeine or alcohol.



Grog grouper (*Myxostipia micropipis*)

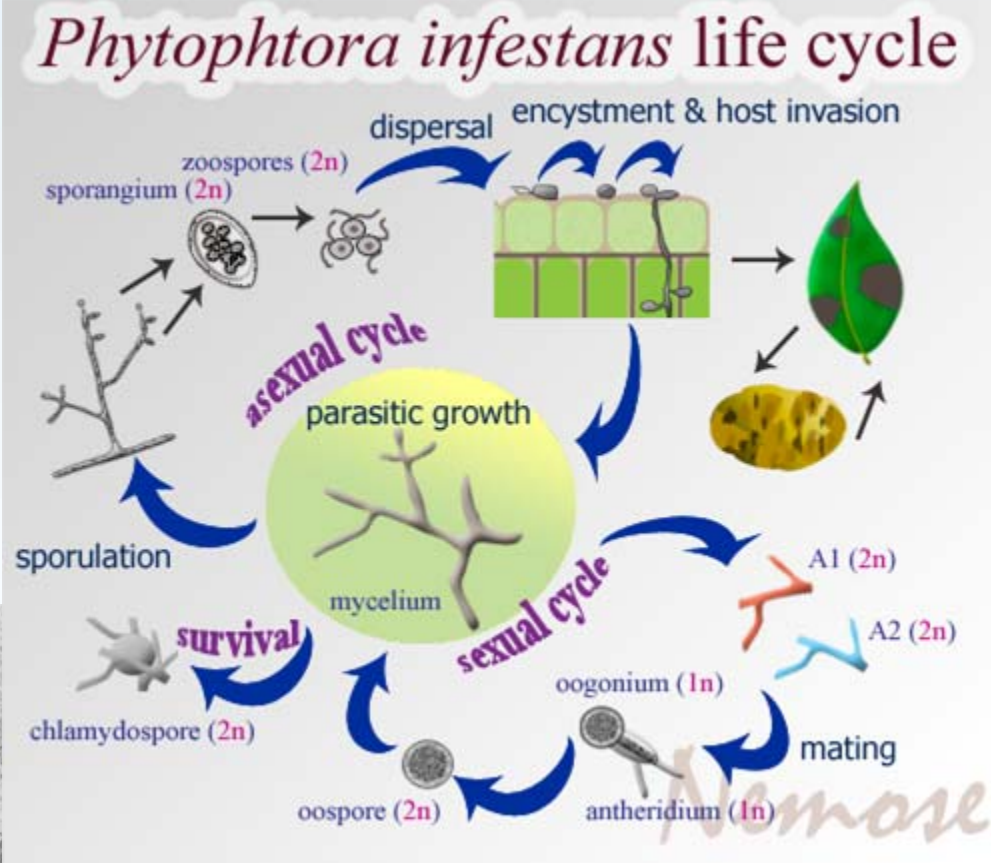
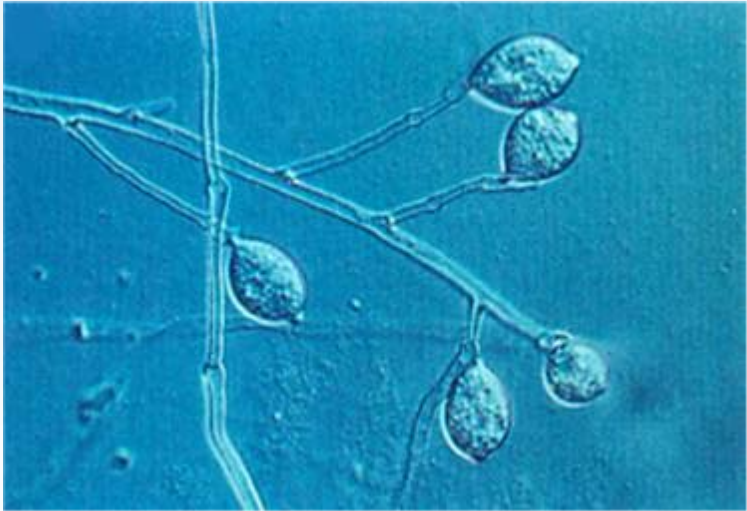
Význam protist

- významní parazité člověka

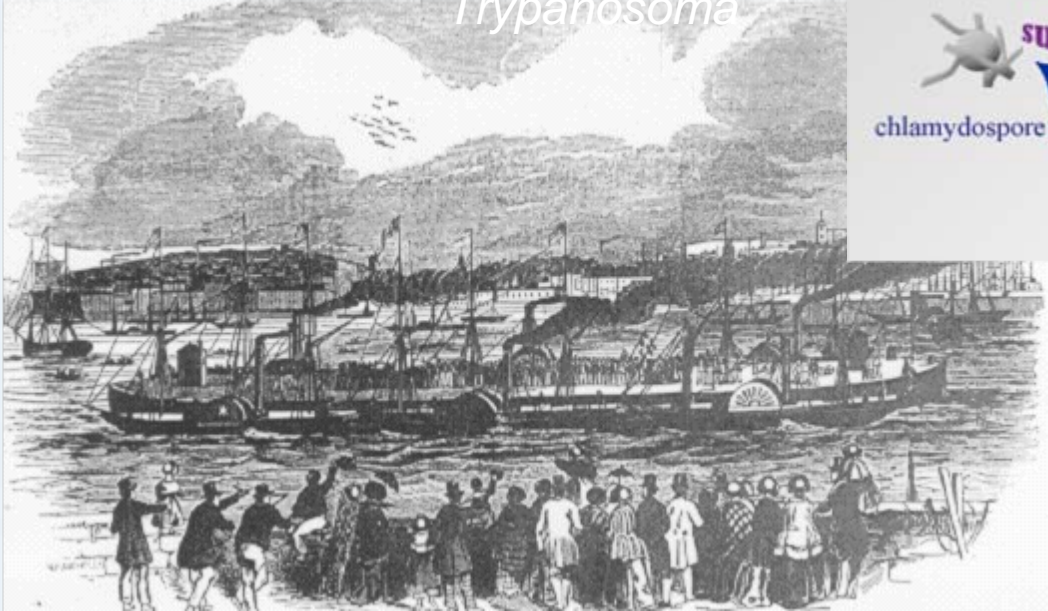


Význam protist

- Parazité zemědělských plodin



Trypanosome



Plíseň bramborová

Význam protist

- Potraviny



Význam protist

- hnědé řasy – algináty (potravinářství, kosmetika, stavební materiály,)



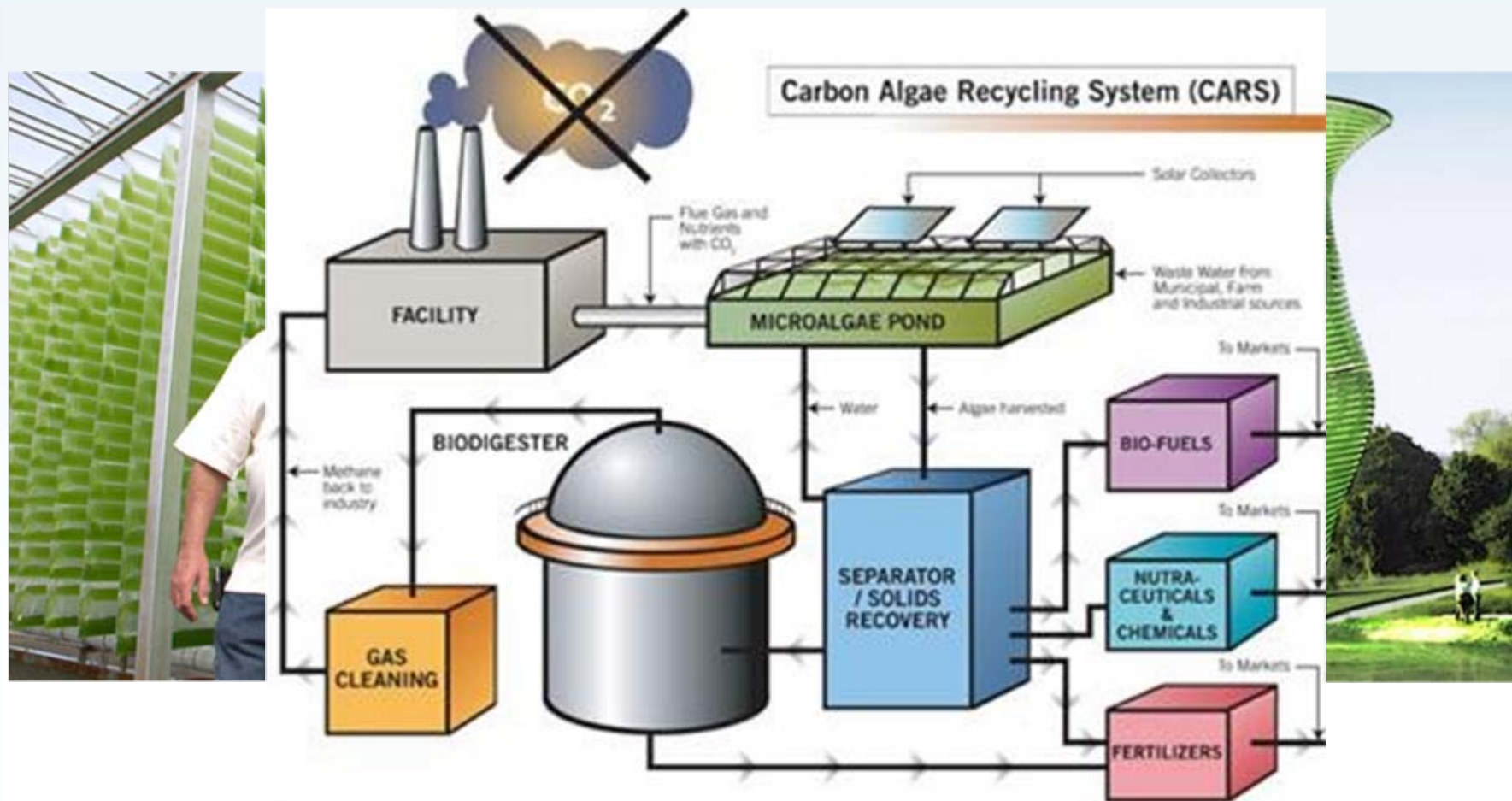
Význam protist

- Bionafta – zapomeňme na kukuřici, budeme jezdit na řasy!



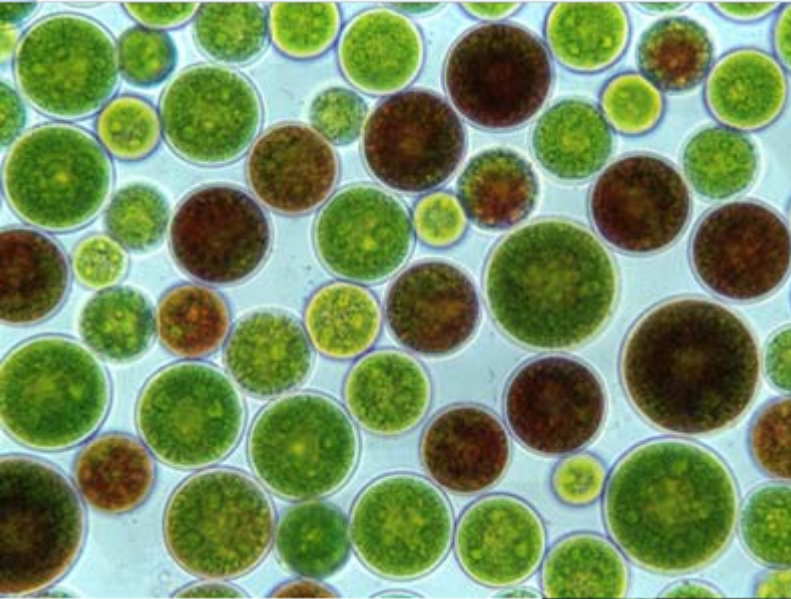
Význam protist

- Bionafta – zapomeňme na kukuřici, budeme jezdit na řasy!



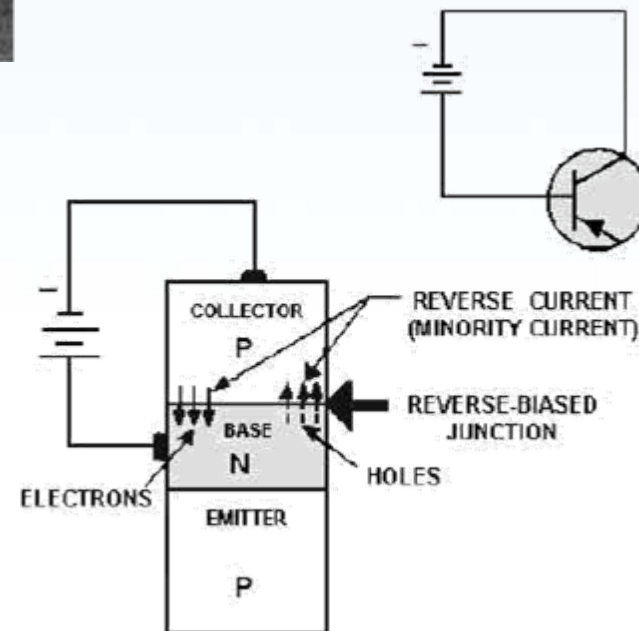
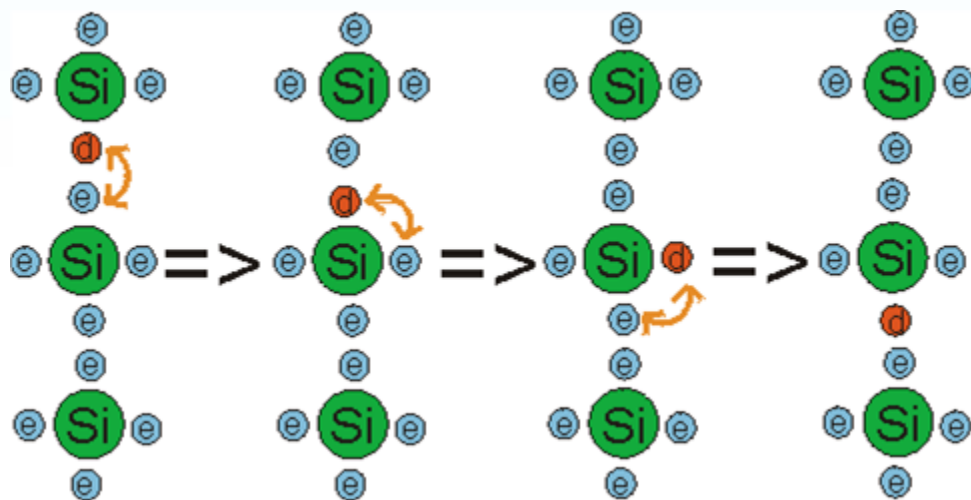
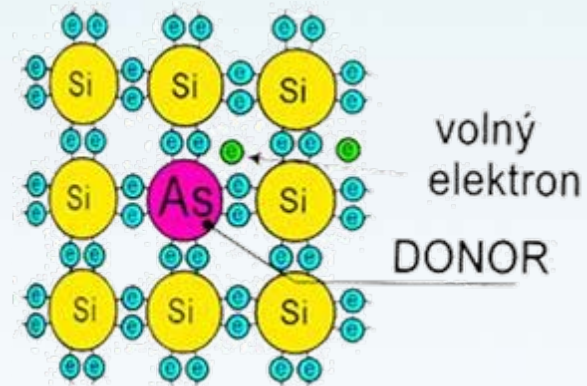
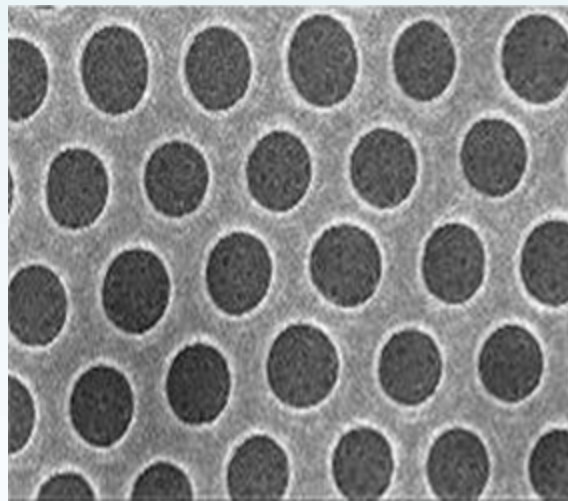
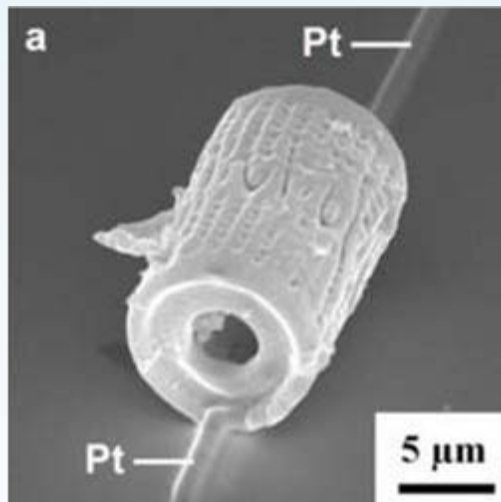
Význam protist

- Velkoplošné kultivace zelených řas (chlorofyl, astaxanthin)



Význam protist

- nanotechnologie – rozsvivky jako senzory a miniaturní transformátory



Význam protist

- kriminalistika – forensí limnologie

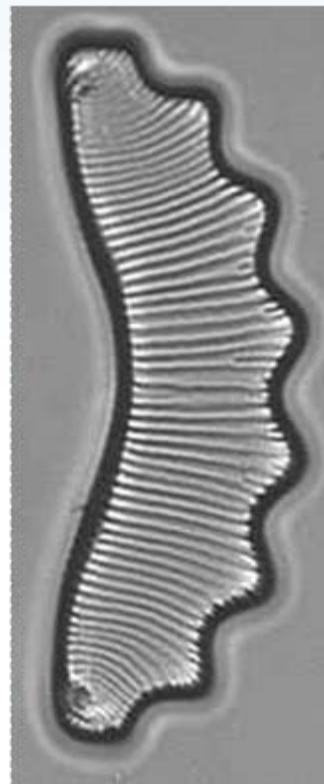


CASE REPORT

Peter A. Siver,¹ Ph.D.; Wayne D. Lord,² Ph.D.; and Donald J. McCarthy³

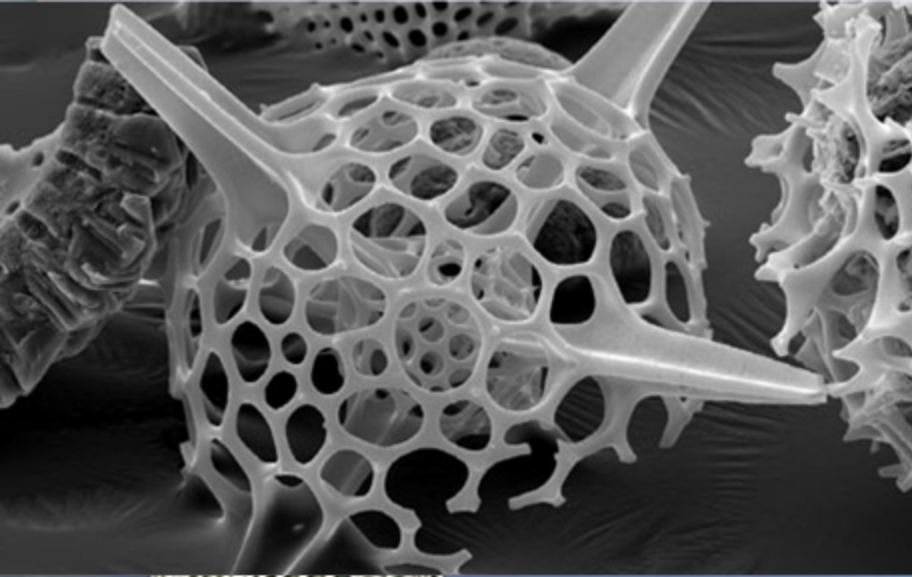
Forensic Limnology: The Use of Freshwater Algal Community Ecology to Link Suspects to an Aquatic Crime Scene in Southern New England

Authorized Reprint 1994 from Journal of Forensic Sciences MAY 1994
Copyright American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103



Význam protist

- Aplikace biologických konstručních mechanismů



Dubai harbour

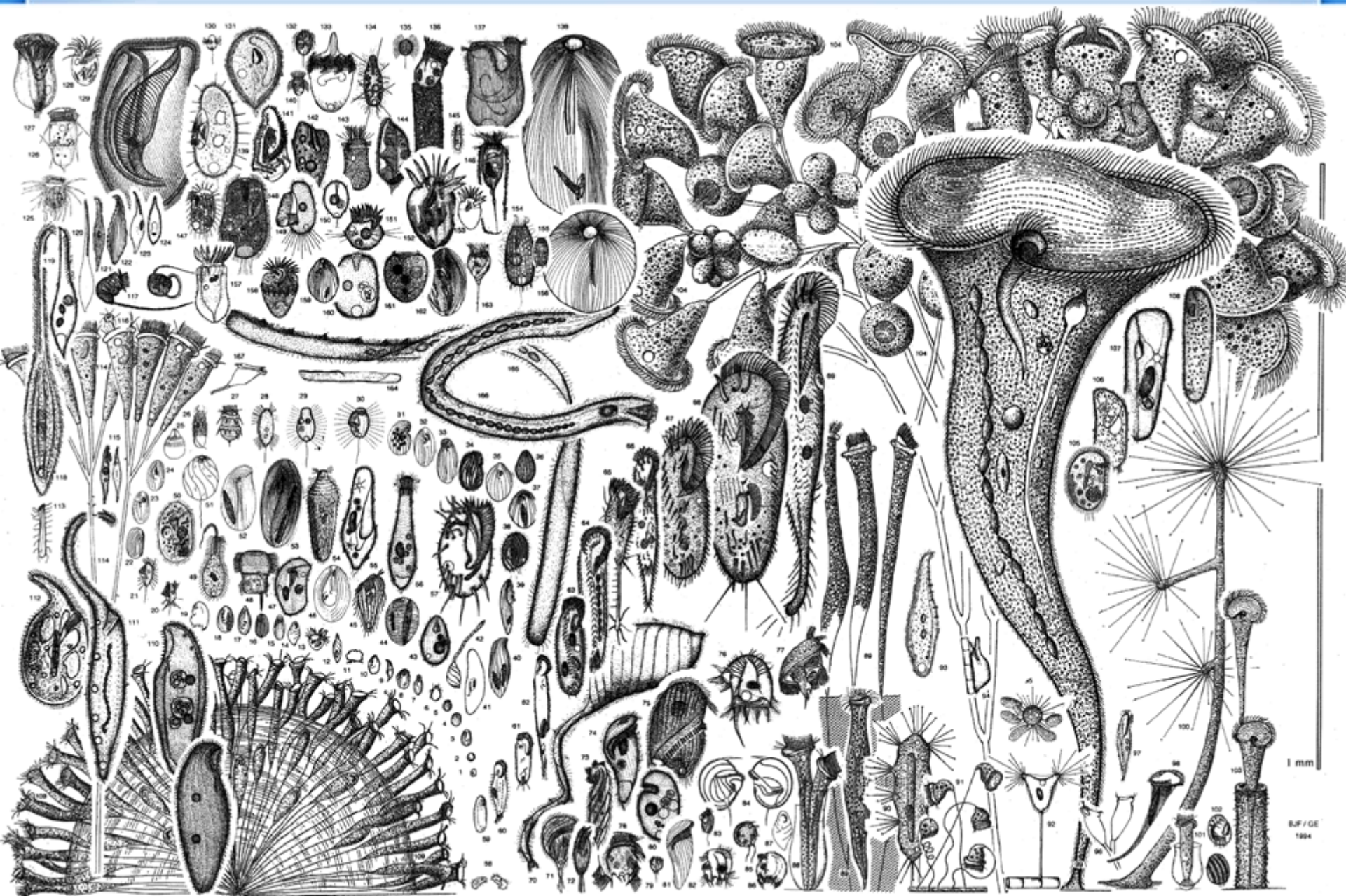


Význam protist

- Nutnost a zároveň problém: stanovení hranic mezi druhy a jejich přesná determinace.



Druhové bohatství protist



Druhové bohatství protist

- Kolik druhů protist skutečně žije na Zemi?
- V současnosti popsáno cca 213 000 druhů

20 000 (Finlay)

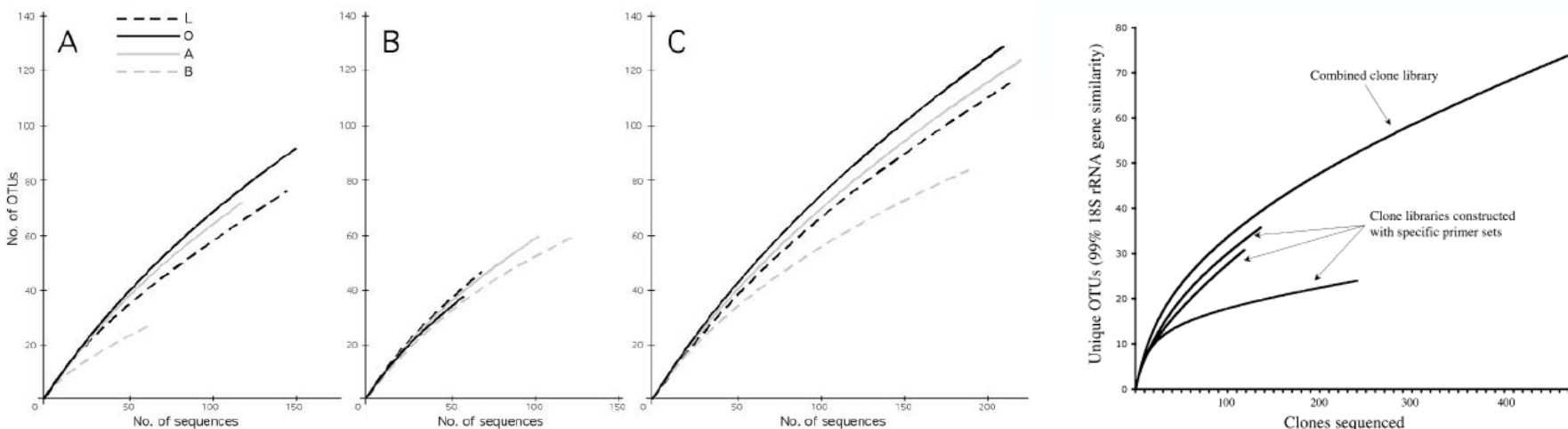
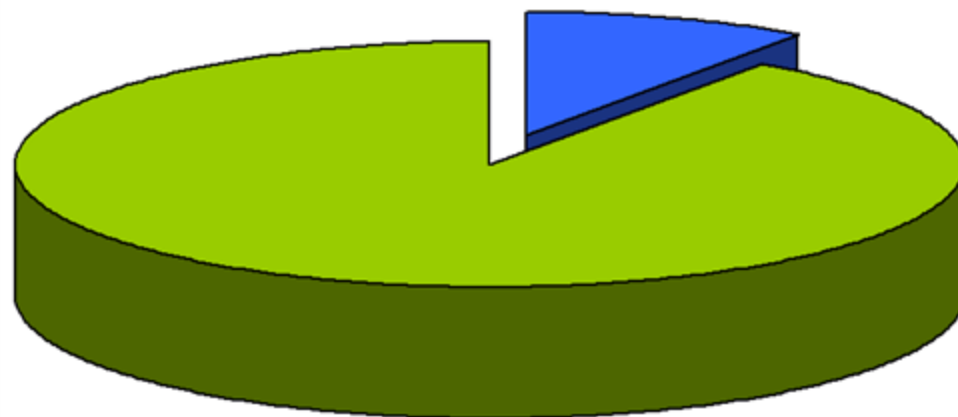
600 000 (Encyclopaedia Britannica)

1 300 000 (Foissner)

2 000 000 (Adl)

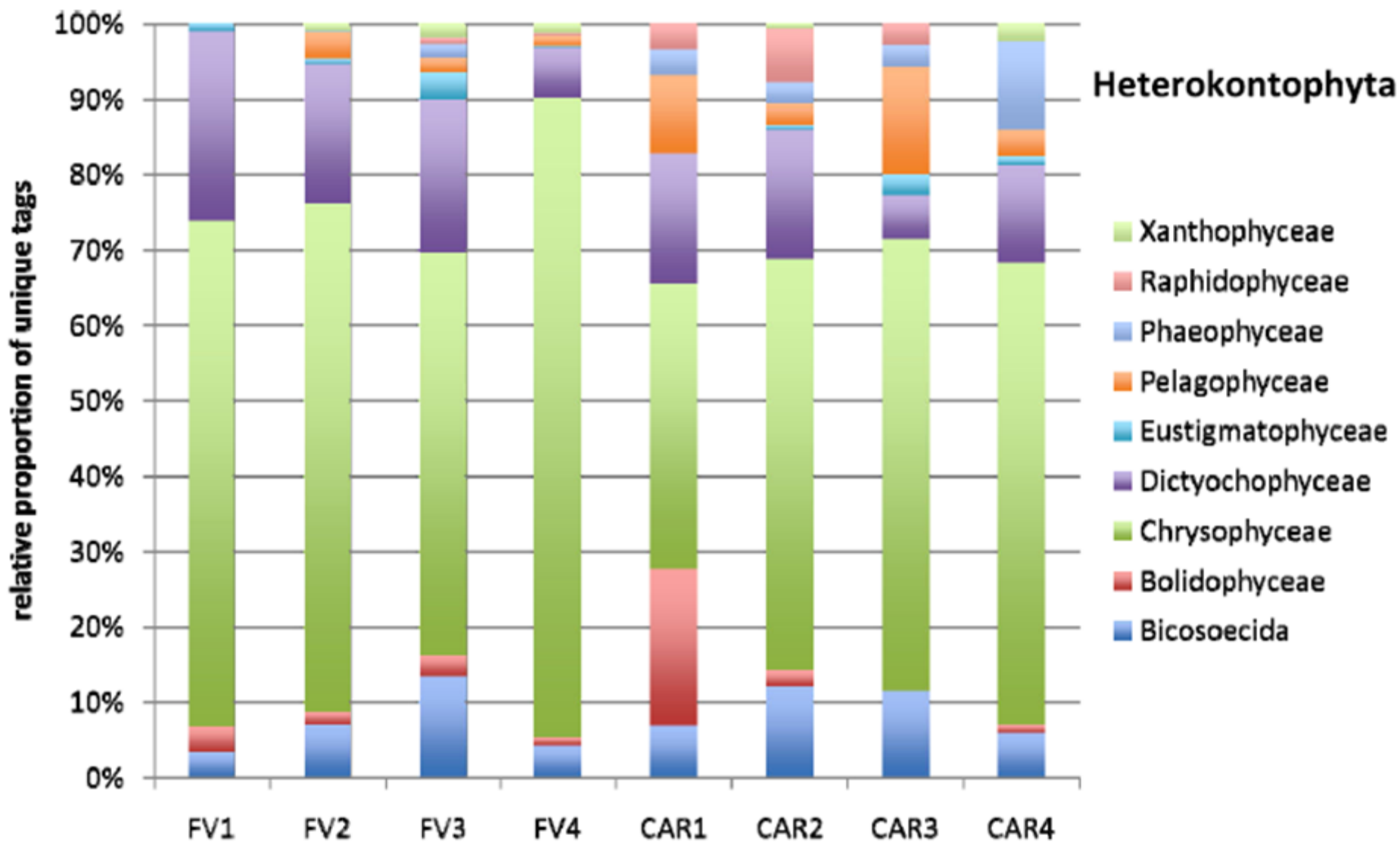
- Accumulation curves:

Podíl dosud nepopsaných druhů – 84-90 % !!!



Druhové bohatství protist

- 454 sekvenování – jaká je reálná diverzita protist (mořský bentos)?



Skrytá diverzita protist

Paramecium aurelia – *P. pimaurelia*, *biaurelia*, *triaurelia*.....*P. quadecaurelia*

TRANSACTIONS of the American Microscopical Society

VOL. 94

APRIL 1975

NO. 2

THE *PARAMECIUM AURELIA* COMPLEX OF FOURTEEN SIBLING SPECIES¹

T. M. SONNEBORN

TABLE I

Mating reactions and breeding relations among species of the *P. aurelia* complex
(the six species lacking from the table undergo no interspecific reactions)

Species	Mating types	<i>P. primaurelia</i>		<i>P. triaurelia</i>		<i>P. tetraurelia</i>		<i>P. pentaurelia</i>		<i>P. septaurelia</i>		<i>P. octaurelia</i>		<i>P. decaurelia</i>		<i>P. dodecaurelia</i>		
		O	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E	
<i>P. primaurelia</i>	O		+++															
	E	C3		+				++	++			±	±					
<i>P. triaurelia</i>	O		C1		+++					±		++						
	E			C3														
<i>P. tetraurelia</i>	O					+++						+++		+				
	E				C3													
<i>P. pentaurelia</i>	O		C2				+++					±						
	E			C2				C3										
<i>P. septaurelia</i>	O			C1					C3									
	E									C3								
<i>P. octaurelia</i>	O				C1	C1	C3				+++			+				
	E											C3			+			
<i>P. decaurelia</i>	O												C3	+++				?
	E																	
<i>P. dodecaurelia</i>	O																	+++
	E																	

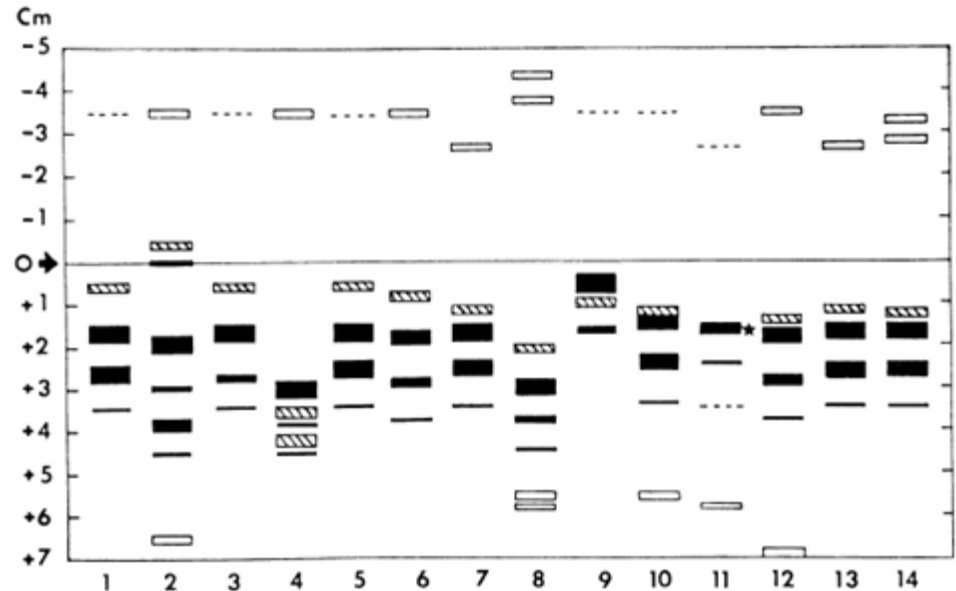
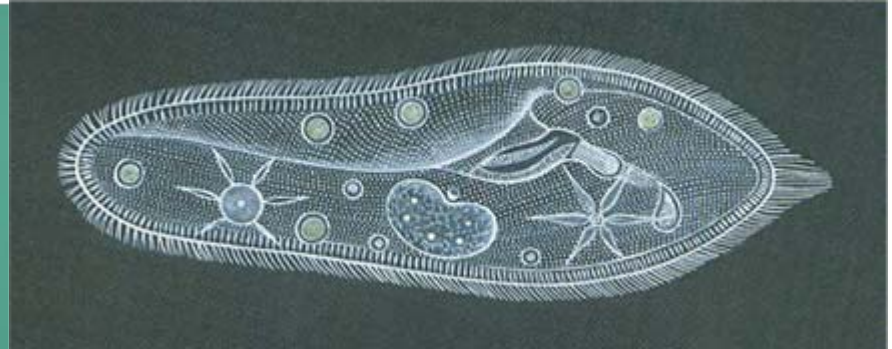
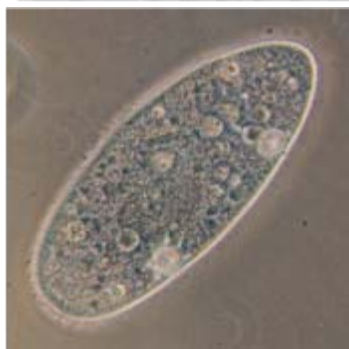


FIG. 2. Isozyme patterns for esterases A, B, and C using axenic stocks on Electrostararch (after Allen et al., 1973). The numbers 1 to 14 refer to the species of the *P. aurelia* complex: 1 = *P. primaurelia*; 2 = *P. biaurelia*; etc. Bands for esterase A are represented by dark bars, esterase B by bars filled with diagonal lines, and esterase C by hollow bars; weak esterases (i.e., of very low activity) are represented by dashed lines: *: this dark bar marks also the position of esterase B of *P. undecaurelia*. The position of the bands is that attained after 4–5 hr at 23 C with 8–10 v/cm (- = cathodal, + = anodal). See Allen et al. (1971, 1973) for methods of culturing and harvesting stocks, of preparation of extracts and gels, and of carrying out the electrophoresis.



Skrytá diverzita protist

Paramecium aurelia

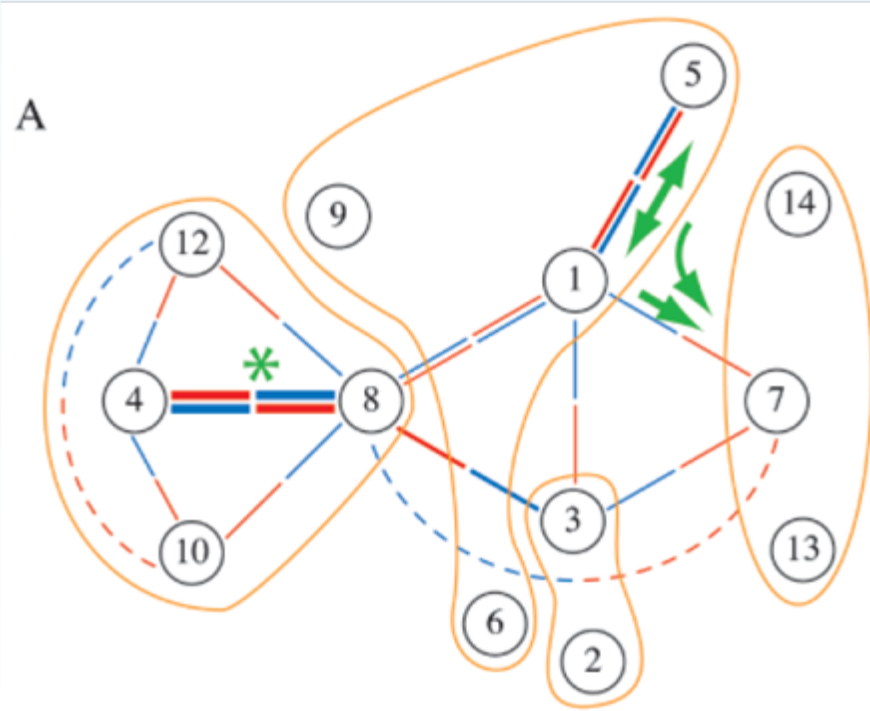
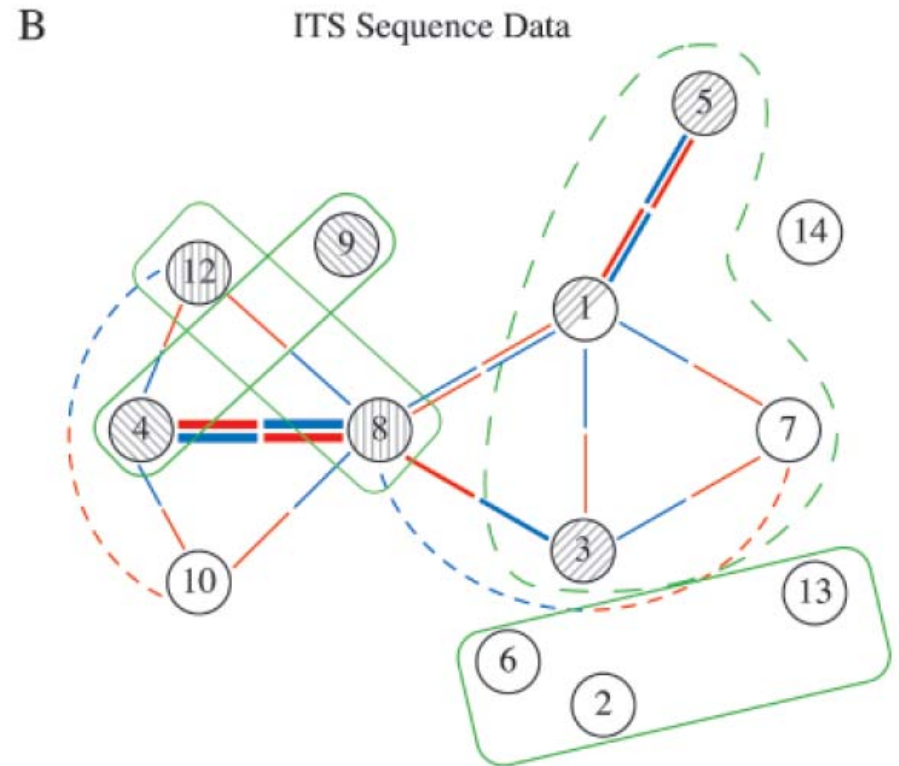


Fig. 5. Relationships among species in the *Paramecium aurelia* species complex. Numbered circles indicate classical syngens. **A.** Diagrammatic representation of the putative relationships of *Paramecium* syngens studied here, based on non-DNA-sequence studies. The distance between any two syngens in the diagram is arbitrary, while the relative intensity of the intersyngen pairing reaction (Sonneborn 1957, 1974) is expressed by the thickness of the lines uniting them. Red (odd mating type) and blue (even mating type) bars show the types of syngen pairings observed. Where dashed, they represent old results, perhaps suspect (Sonneborn 1974). The green asterisk emphasizes the most blatant example where an intense pairing reaction may not be paralleled by extensive genetic exchange. In the syngen 4 × 8 crosses, there are essentially no viable hybrids (Sonneborn 1974). Green arrows mark the direction of successful mitochondrial transplantations (Beale and Knowles 1976). Orange loops en-

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Paramecium aurelia Revisited

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close groups of syngens showing greatest similarity in isozyme patterns (Allen et al. 1983). **B.** Contributions of DNA sequence data. Cross-hatching pattern identifies syngens with identical ITS2 sequence. Green loops enclose syngens most obviously closely related by internal transcribed spacer (ITS) analyses, either identical ITS2 or uniquely shared hemi-CBC in ITS2; or less confidently, as shown by dashed green loop, a hemi-CBC in the mid-region of the ITS1 helix.

Skrytá diverzita protist

Sellaphora pupula – 6 „fenodémů“ žijících pospolu v 1 jezírku

Phycologia (2004) Volume 43 (4), 459–482

Published 30 July 2004

The *Sellaphora pupula* species complex (Bacillariophyceae): morphometric analysis, ultrastructure and mating data provide evidence for five new species

DAVID G. MANN^{1*}, SARAH M. McDONALD¹, MICHA M. BAYER¹, STEPHEN J.M. DROOP¹, VICTOR A. CHEPURNOV^{1,2}, ROBERT E. LOKE³, ADRIAN CIOBANU⁴ AND J.M. HANS DU BUIF³

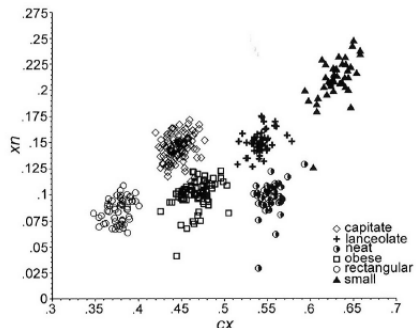


Fig. 16. Contour segment analysis: maximum curvature of all contour points (cx) plotted against the maximum of all segment minimum curvatures (x1), giving six clusters corresponding to the six demes of *S. pupula*.

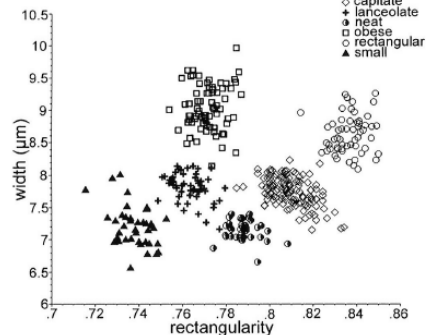
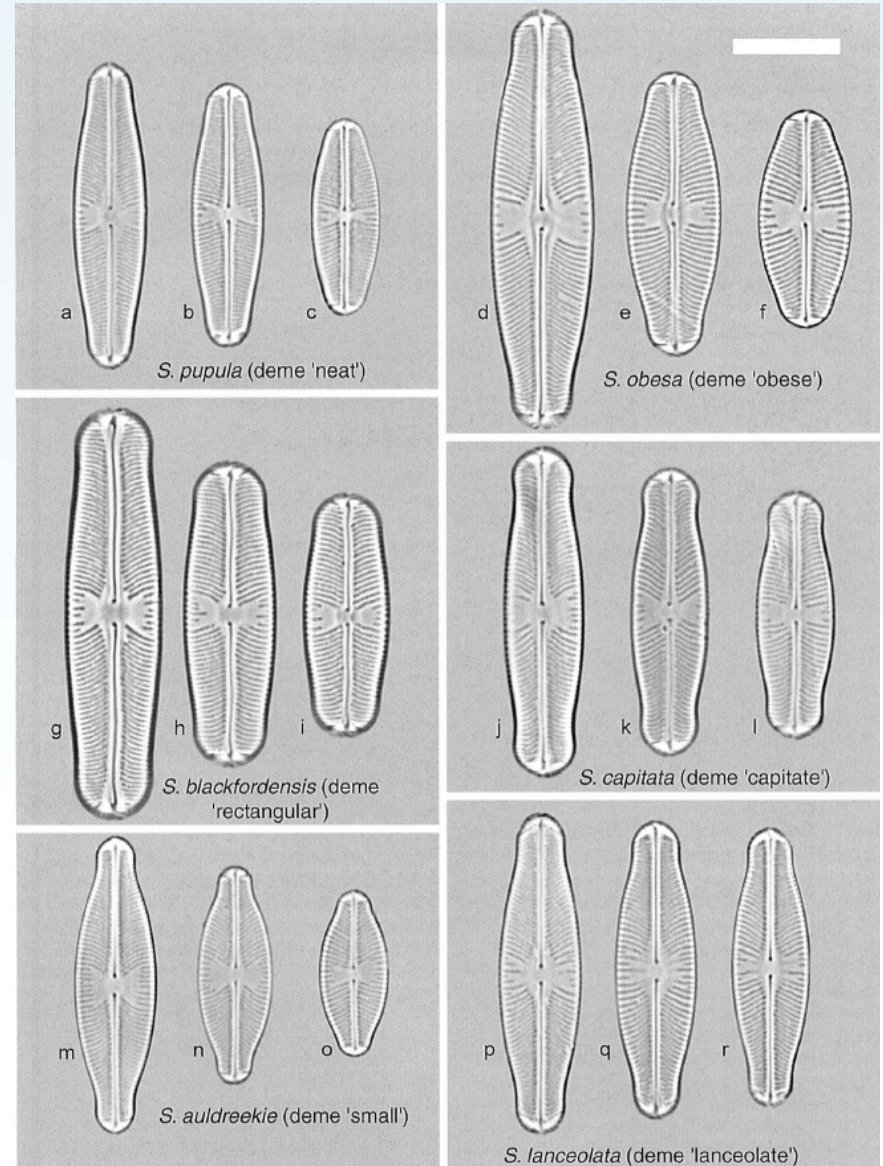
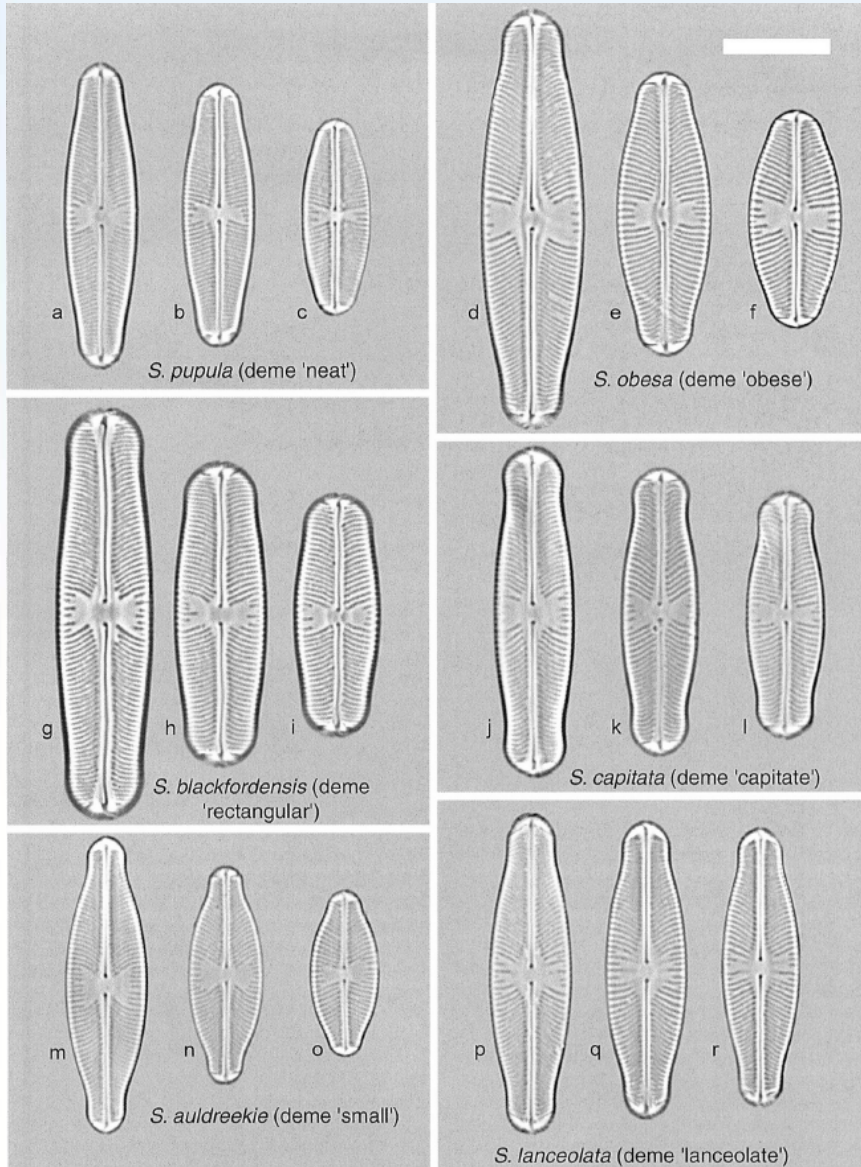


Fig. 14. Rectangularity vs width. This plot shows six fairly distinct clusters corresponding to the six demes within *Sellaphora pupula*.



Skrytá diverzita protist

Čemu odpovídá variabilita rodů a druhů rozsivek?



Classification of *Homo sapiens* within the order Primates

species
sapiens

contained forms:
modern humans

genus
Homo

modern and
archaic humans

family
Hominidae

humans and
great apes

superfamily
Hominoidea

humans and
all apes
(great apes
and gibbons)

infraorder
Simiiformes

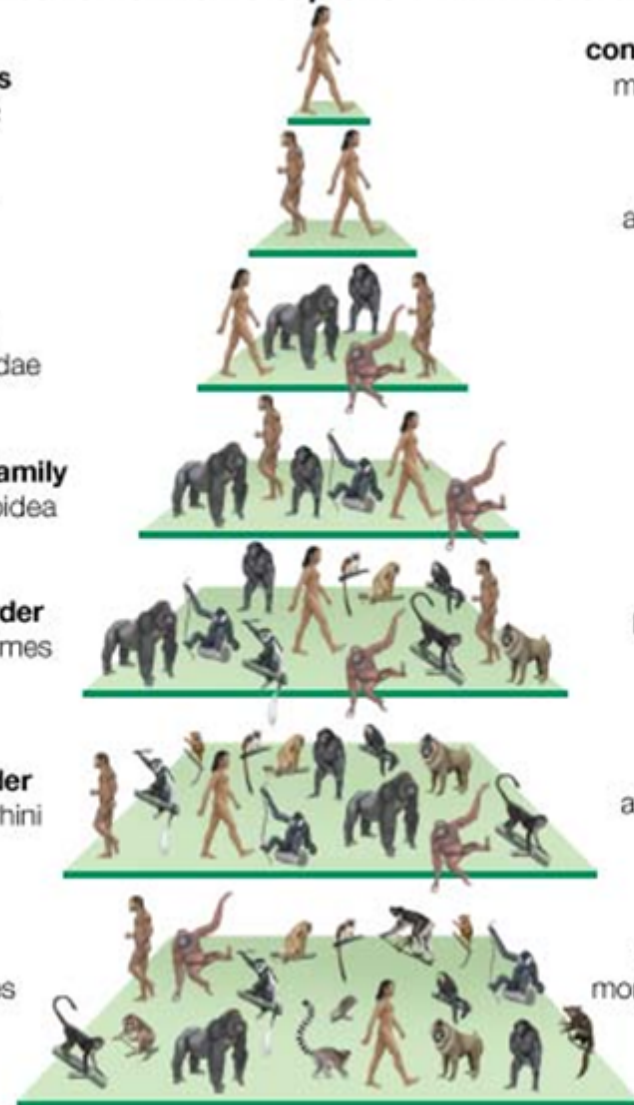
humans, apes,
and monkeys

suborder
Haplorrhini

humans,
apes, monkeys,
and tarsiers

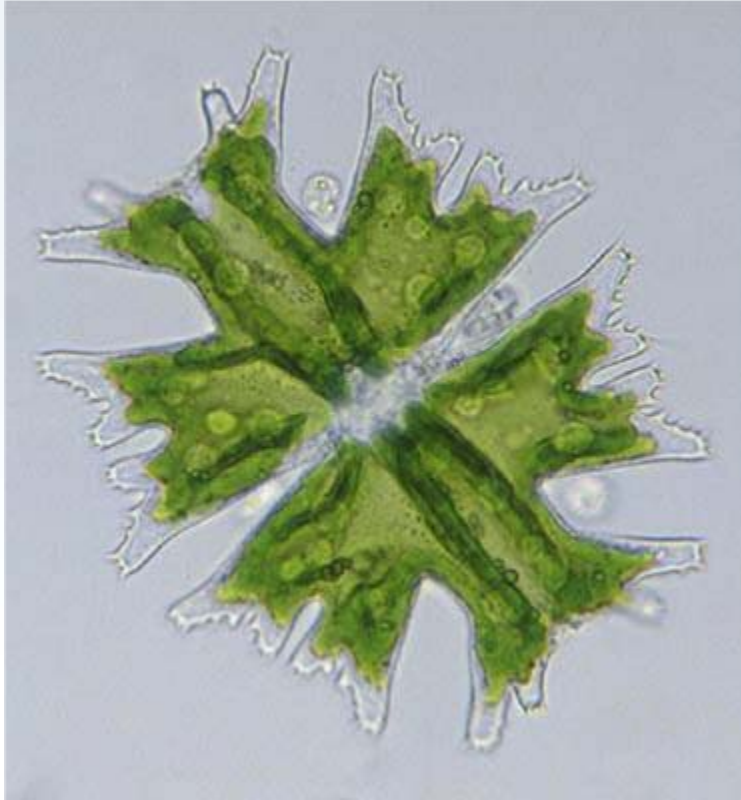
order
Primates

humans, apes,
monkeys, tarsiers,
lemurs, and
lorises

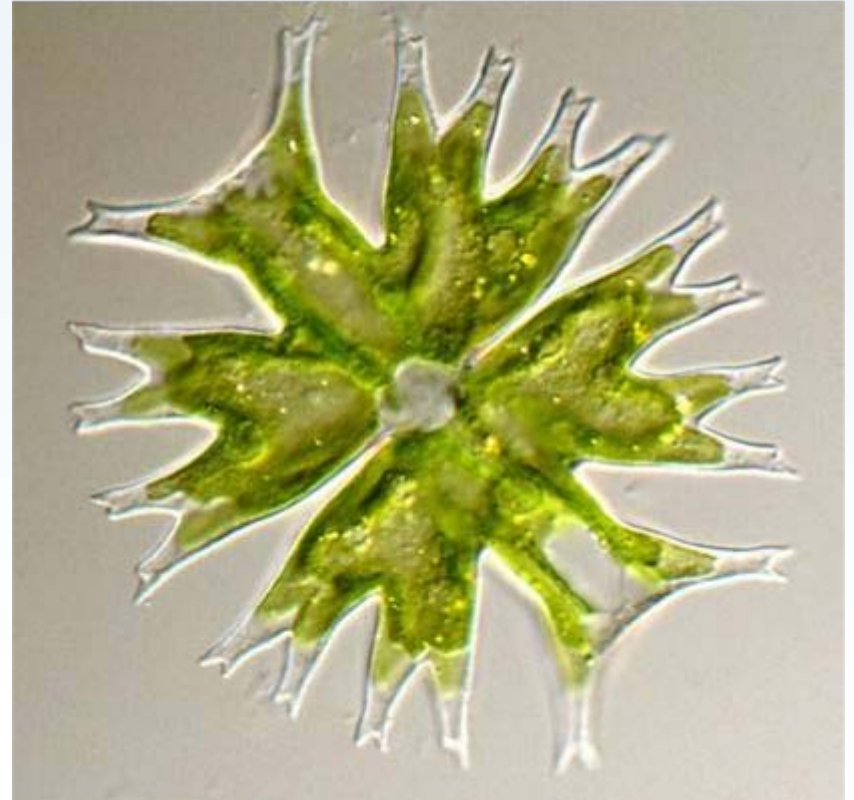


Koncepty druhů

- Základní otázka: jak určit hranice mezi druhy a jak spolehlivě jednotlivé druhy určit?



Micrasterias americana



Micrasterias crux-melitensis

Koncepty druhů

- Tradiční morfologický druhový koncept

„Chorellales“



COELASTRUM



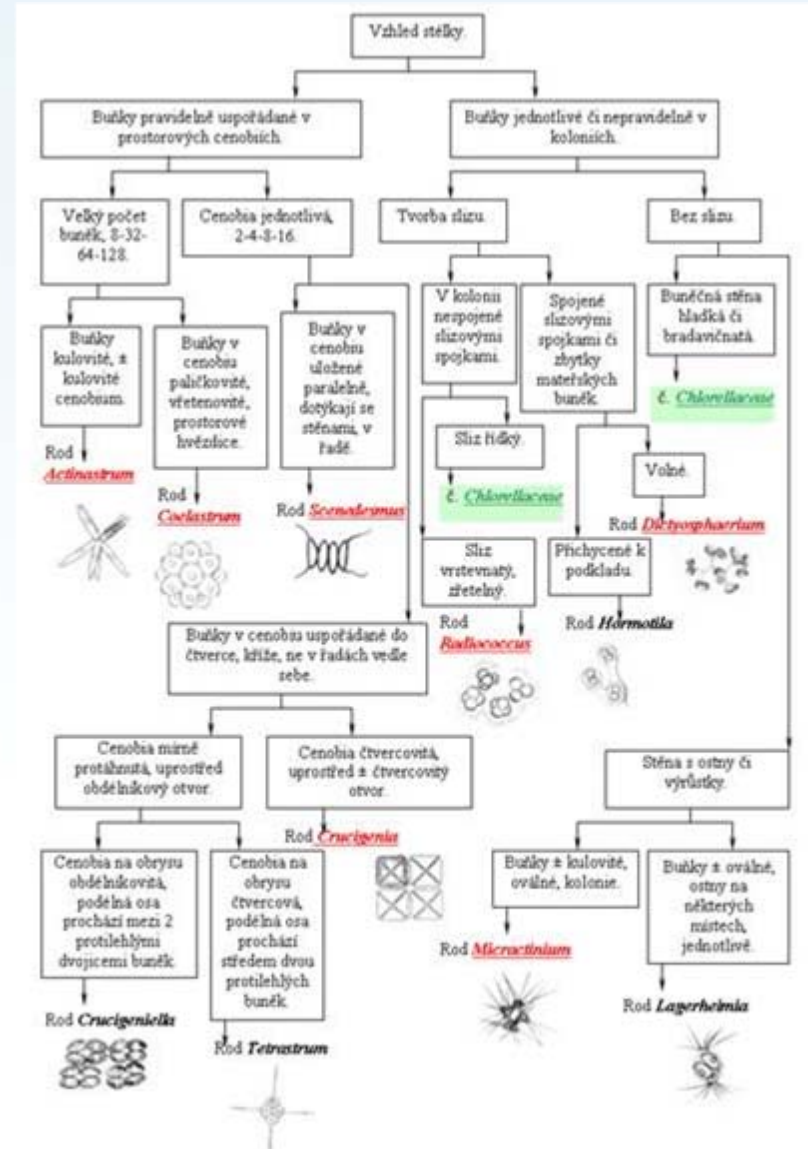
SCENEDESMUS



CHODATELLA



GOLENKINIA

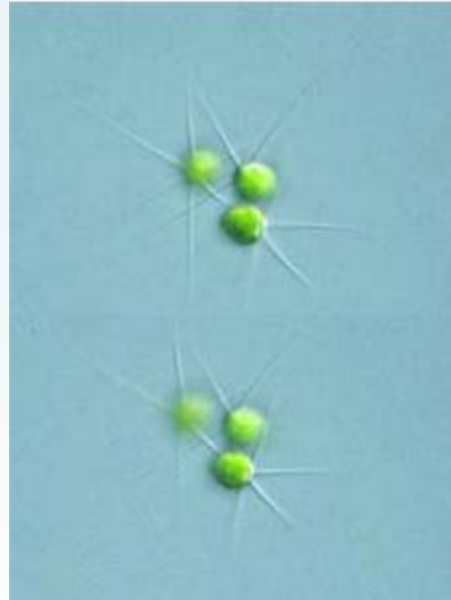
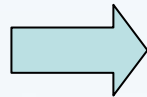


Koncepty druhů

- Tradiční morfologický druhový koncept



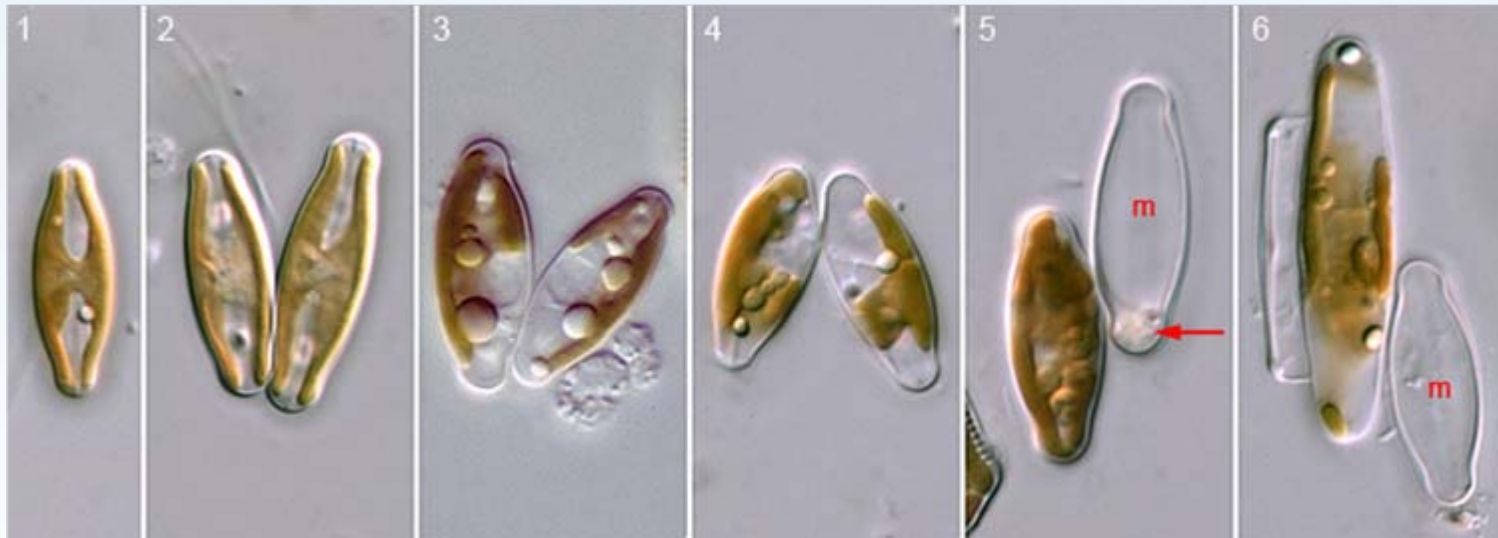
Micractinium



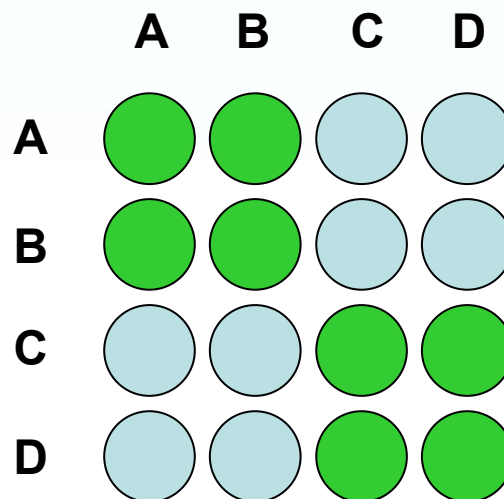
Brachionus

Koncepty druhů

- Biologický druhový koncept



Sellaphora pupula



Křížící pokusy:

**kmeny A-B a C-D
představují separátní
biologické druhy**

Koncepty druhů

- Biologický druhový koncept
- ALE – občasné mezidruhové křížení, problém alopatrických populací

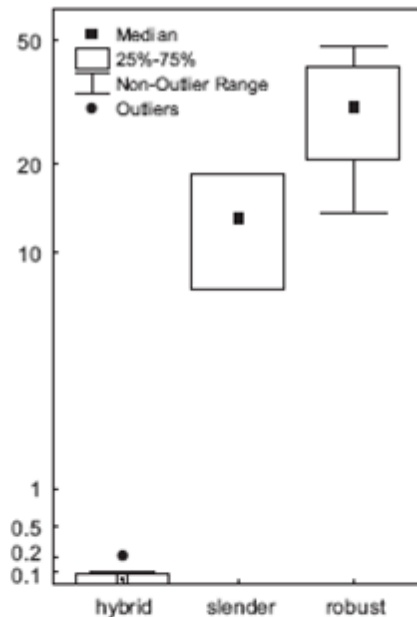
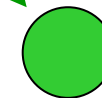
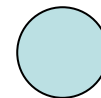
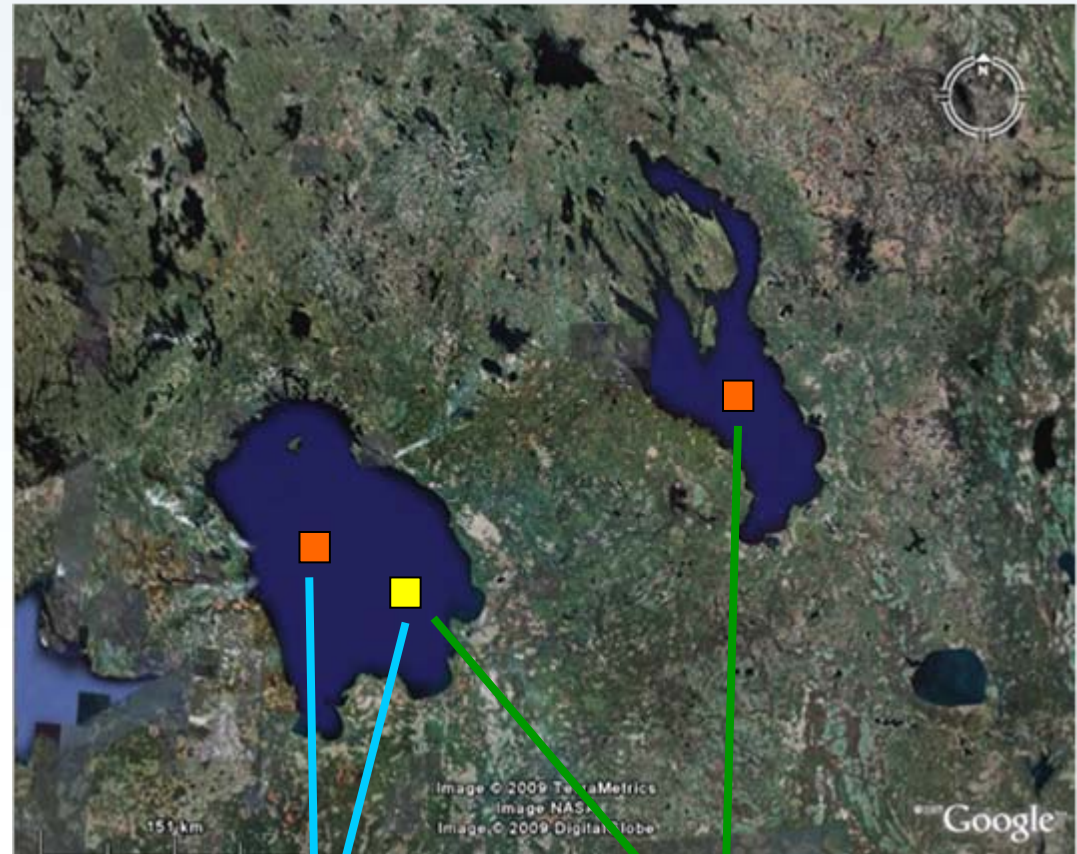
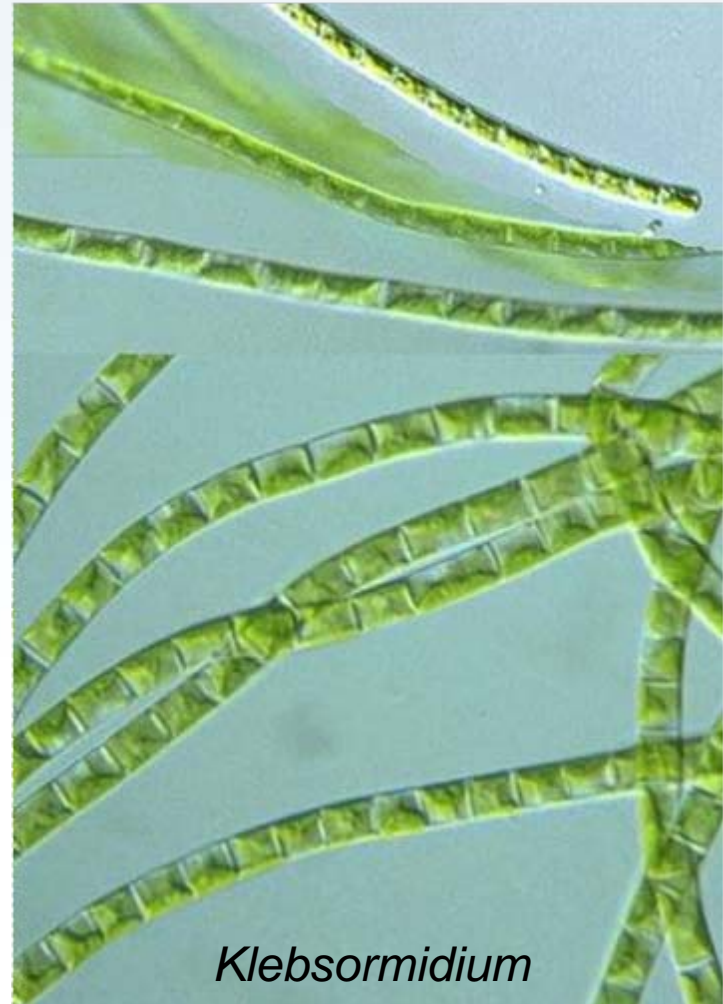


Figure 5. Boxplots of the average percentage of cells involved in sexual reproduction in crosses with *Eunotia bilunaris* strains of the same ('slender' and 'robust') and different groups ('hybrid'). A $\log(x+1)$ scale was used because of the large differences between the different categories. For crosses within the group 'slender' three different combinations of strains (four different strains) were used, within 'robust' five combinations (seven strains) and between slender and robust ten (four 'slender' and six 'robust' strains).



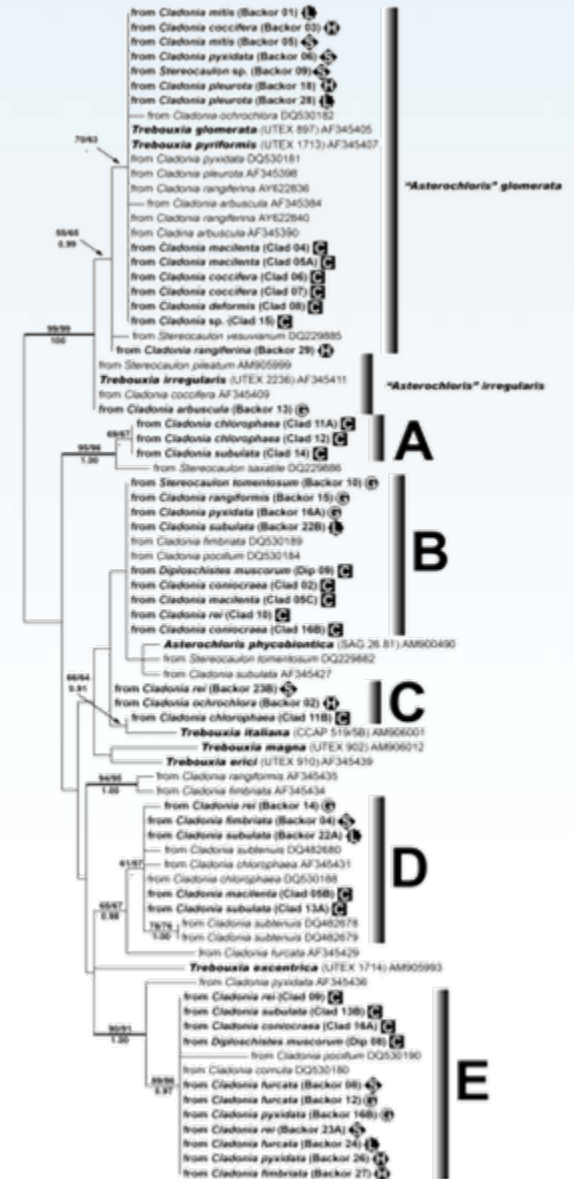
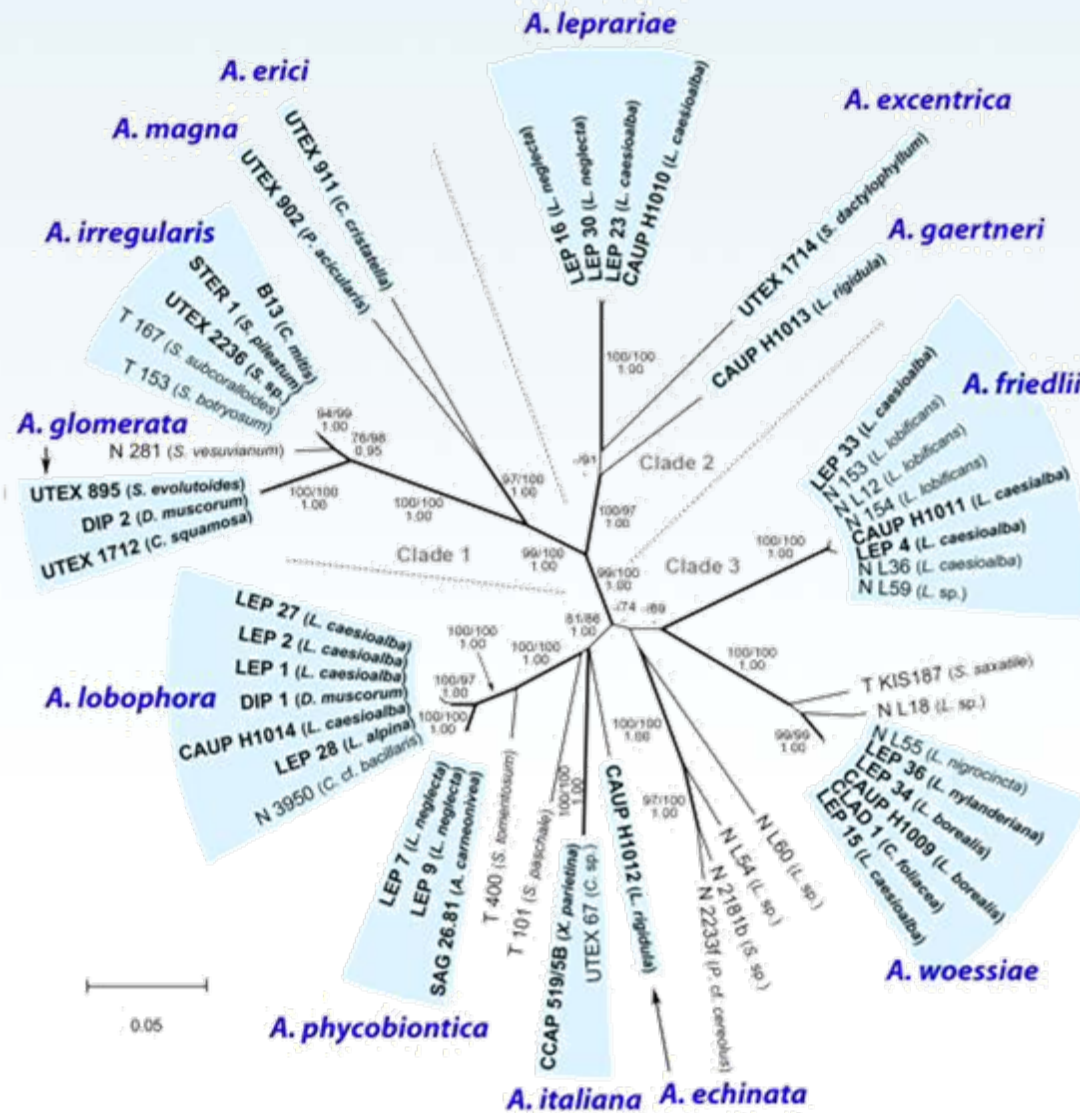
Koncepty druhů

- Biologický druhový koncept
- nepoužitelný u asexuálních organismů



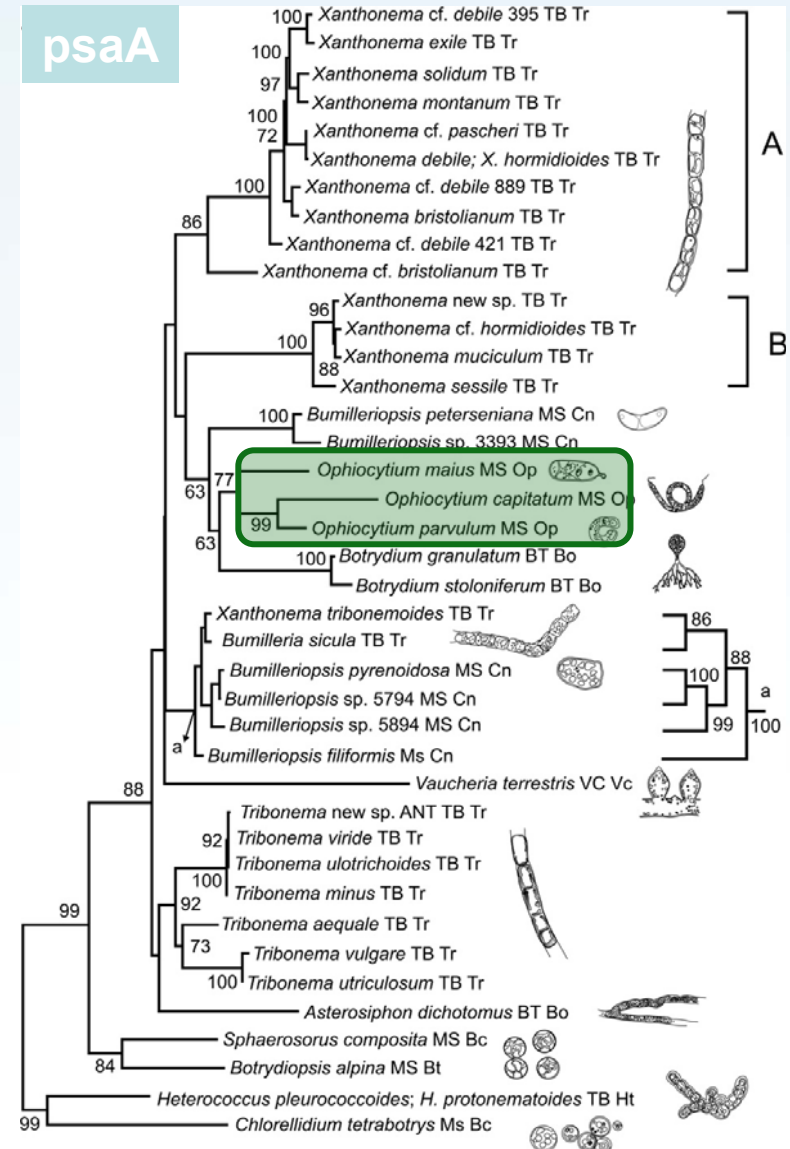
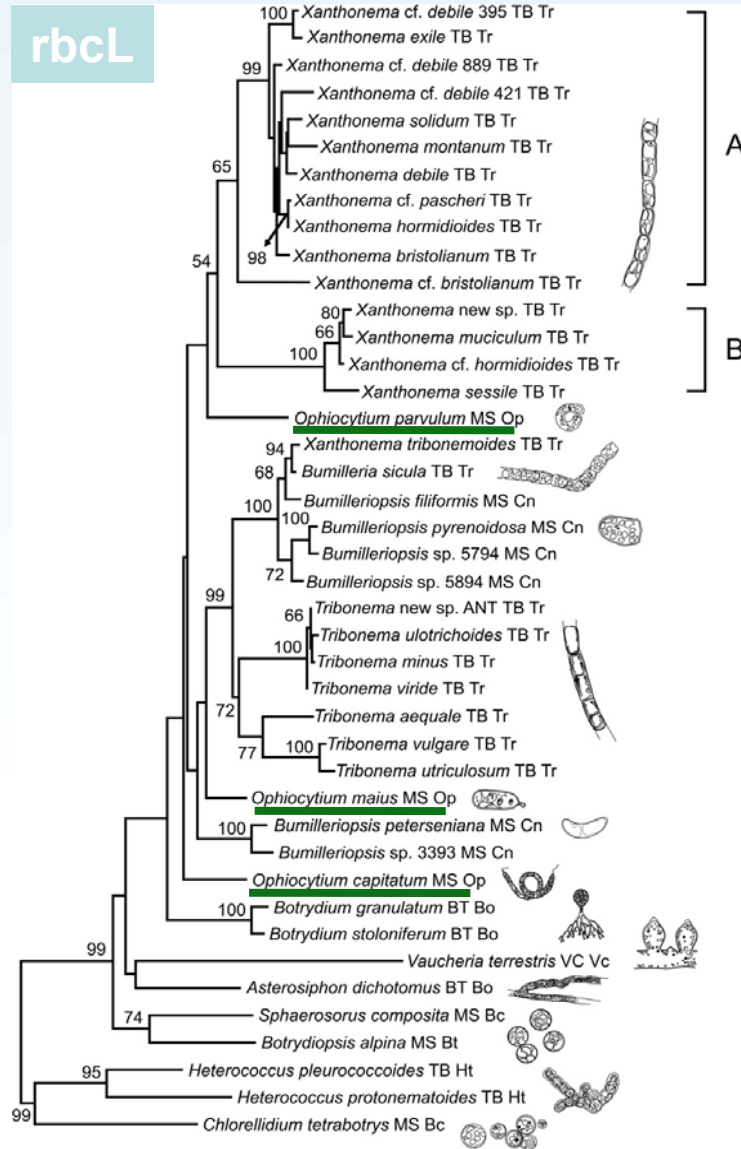
Koncepty druhů

- Fylogenetický druhový koncept



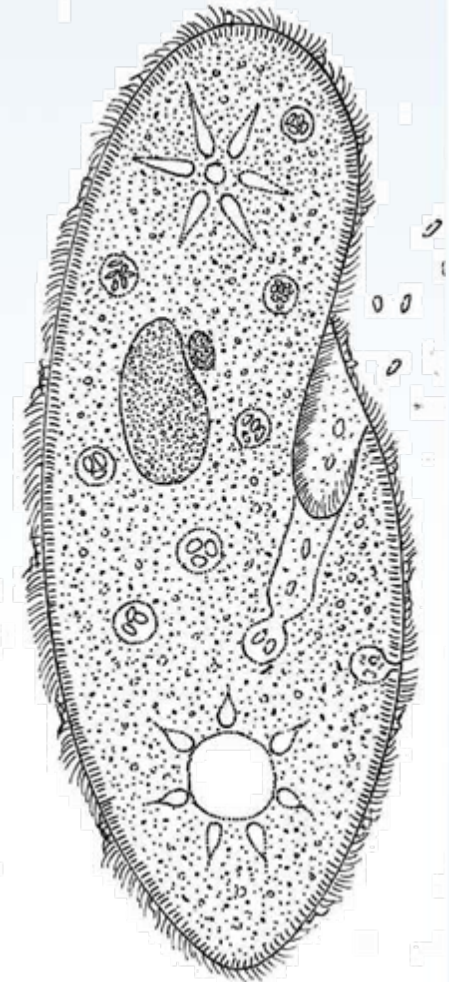
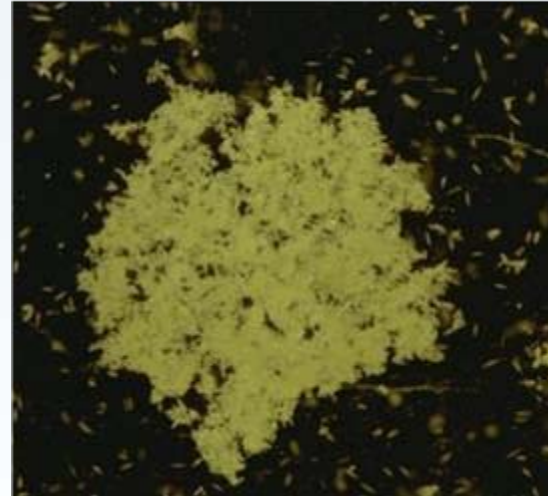
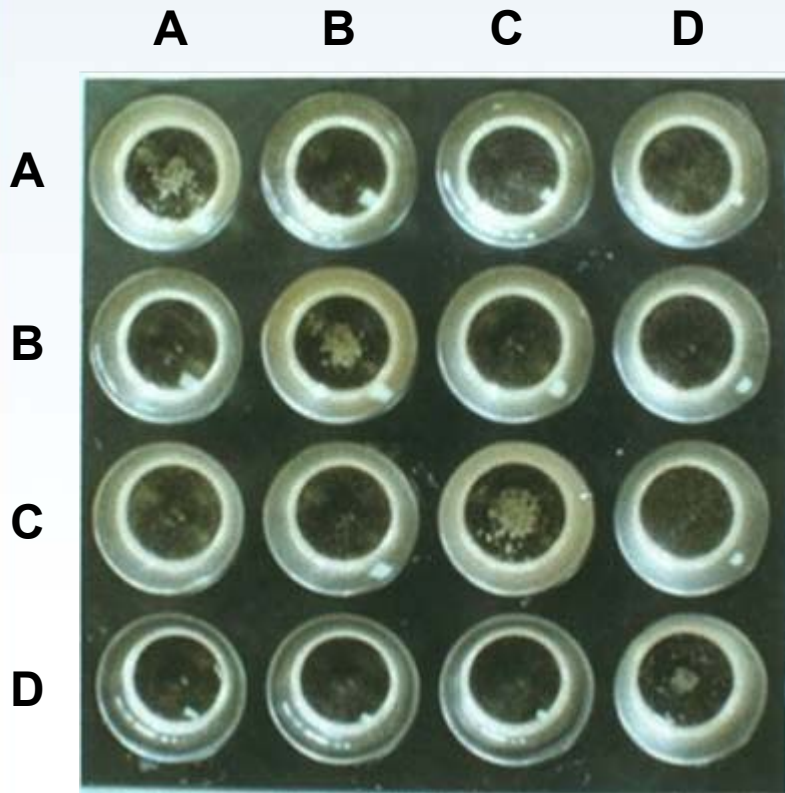
Koncepty druhů

- Fylogenetický druhový koncept



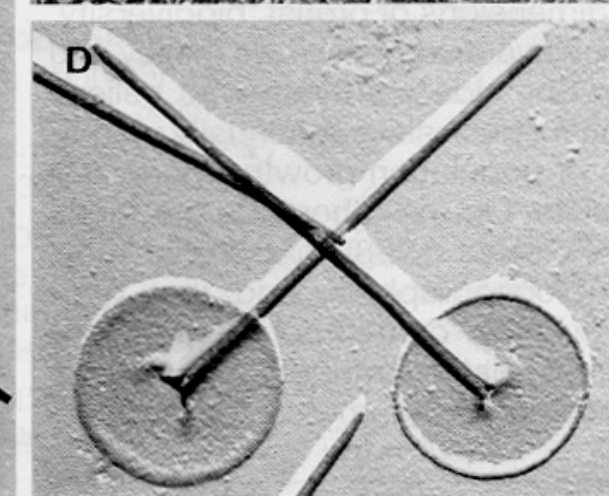
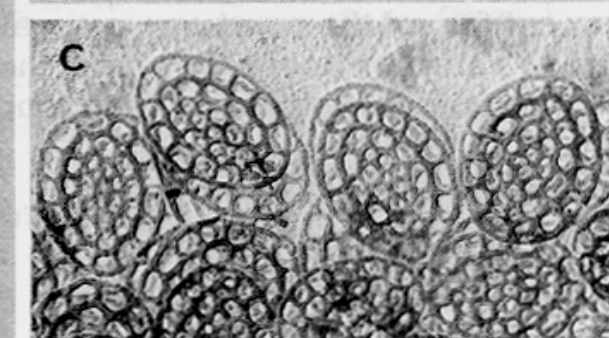
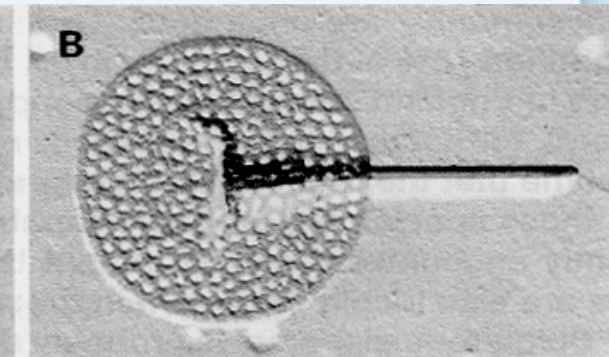
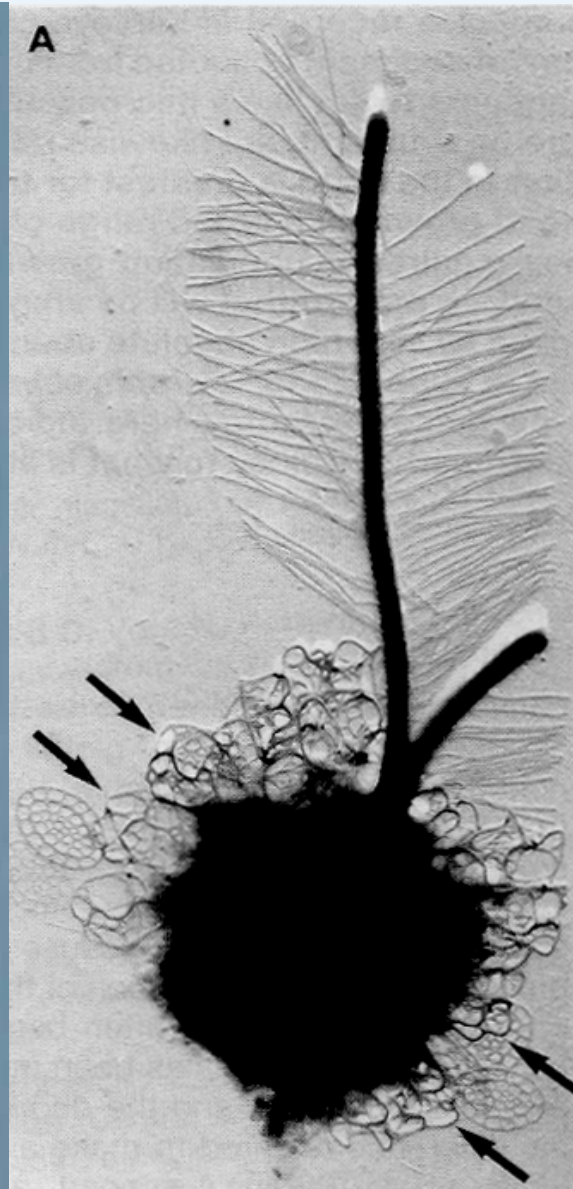
Koncepty druhů

- Fylogenetický druhový koncept
- syngeny u vířníka *Paramecium*: shodné sekvence, reprodukční izolace

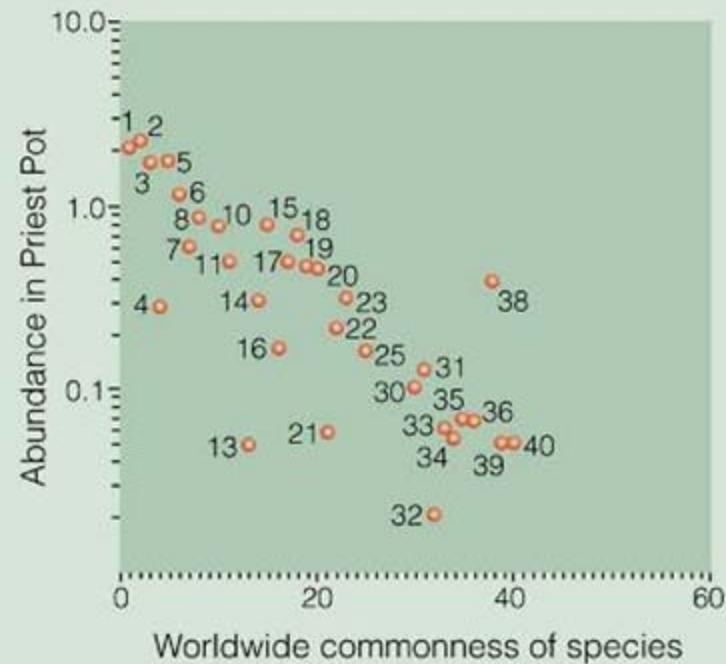
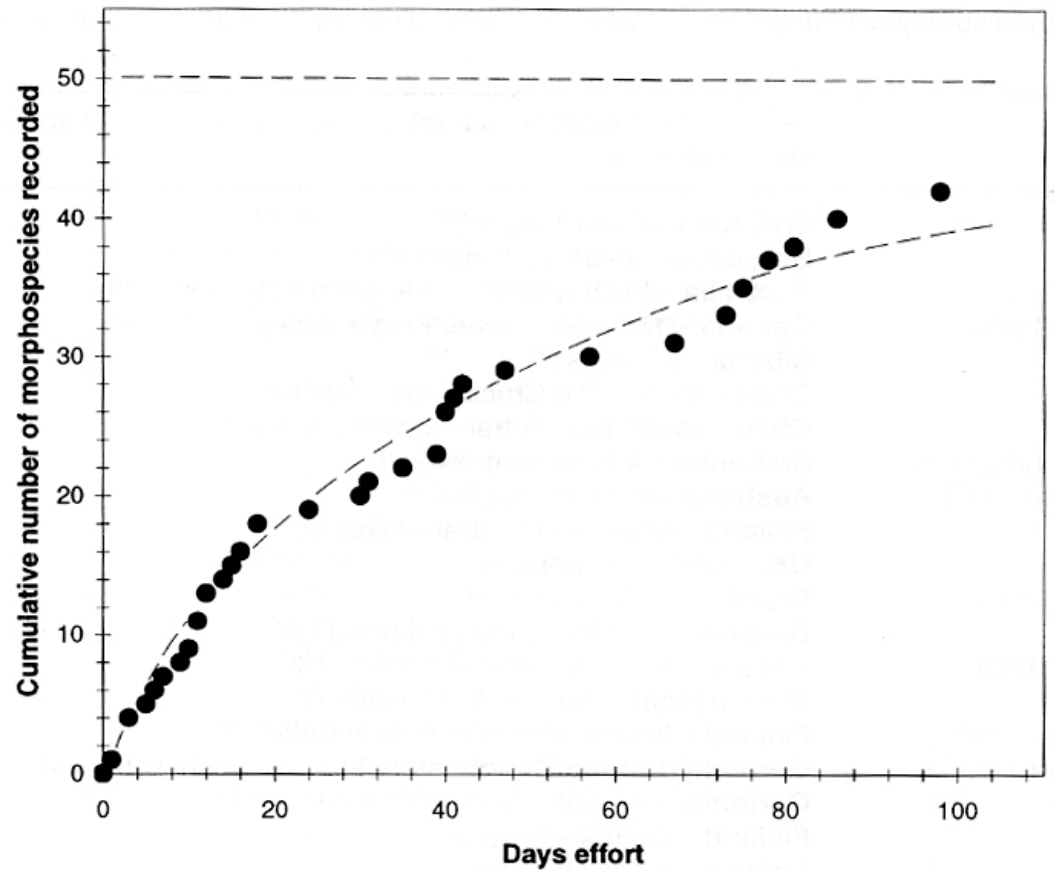


Biogeografie protist

modelový rod – *Paraphysomonas* (Chrysophyceae)



Biogeografie protist



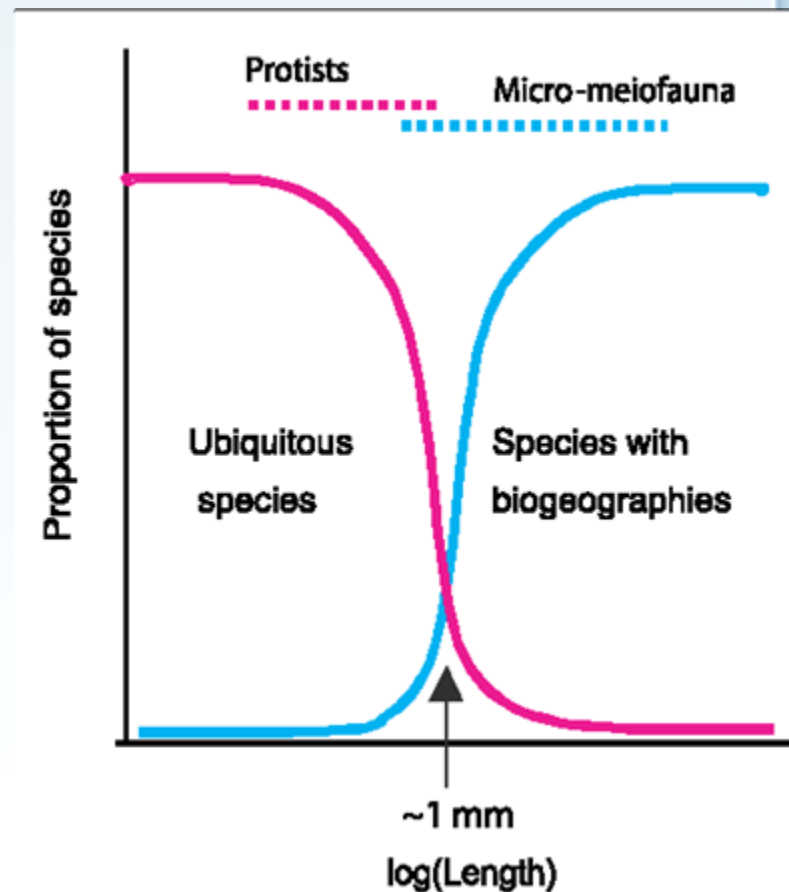
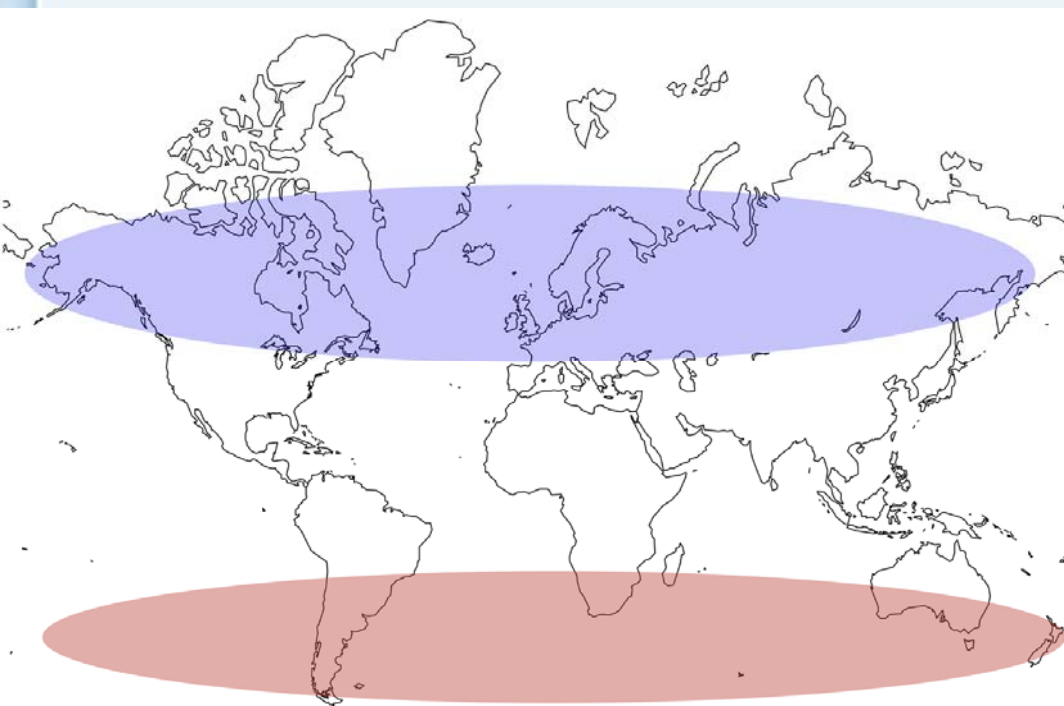
abundance paraphysomonád v 0,1cm²
povrchového sedimentu z lokality Priest Pot

vs.

jejich globální četnost

Biogeografie protist

- Neutrální teorie ubikvitního rozšíření eukaryotických mikroorganismů



silná formulace:

“všechno je všude, ale mnoho druhů je extrémně vzácných”

- evoluční (speciace), floristické či ochranářské konsekvence

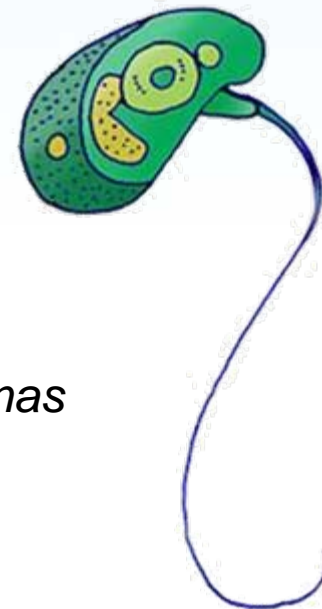
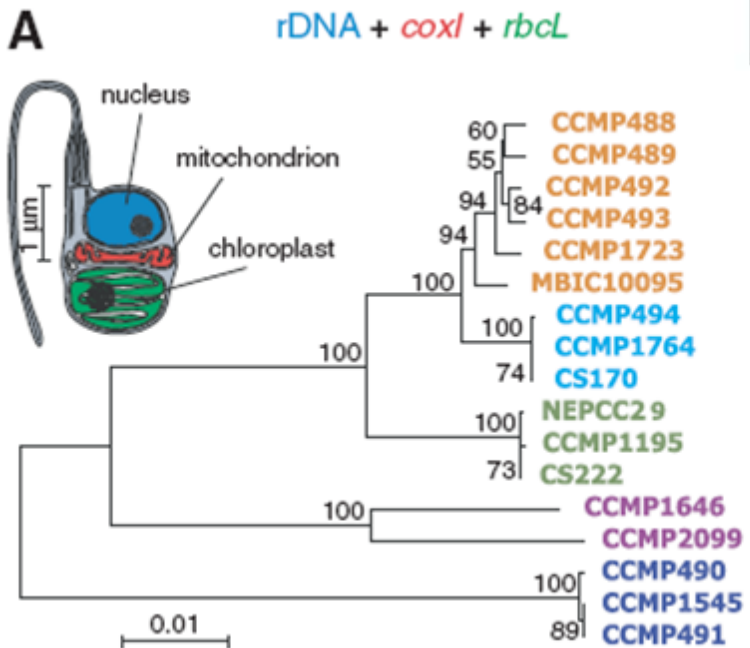
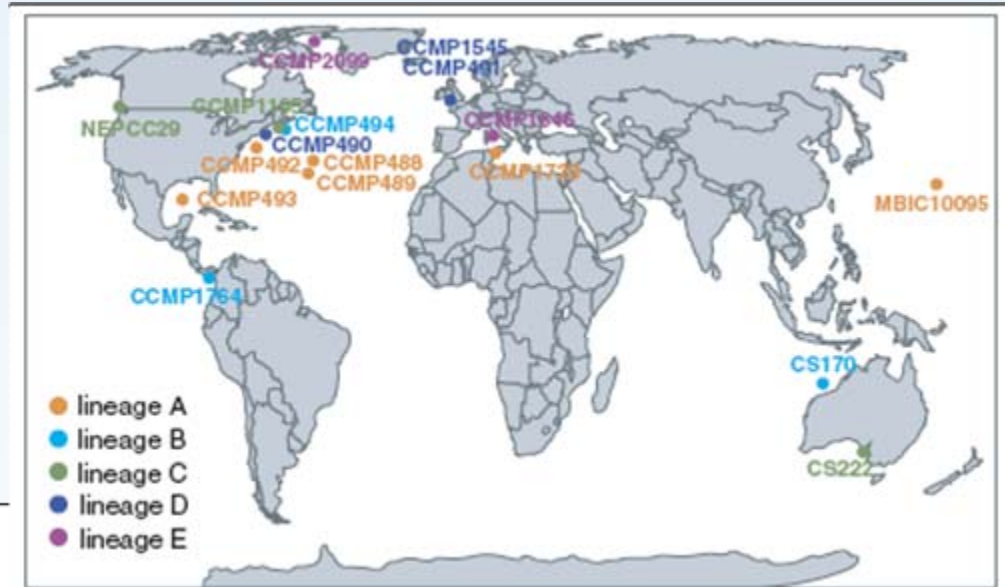
slabá formulace:

“environment selects – prostředí vybírá”

- nulová role historie v mikrobiální biogeografii

Biogeografie protist

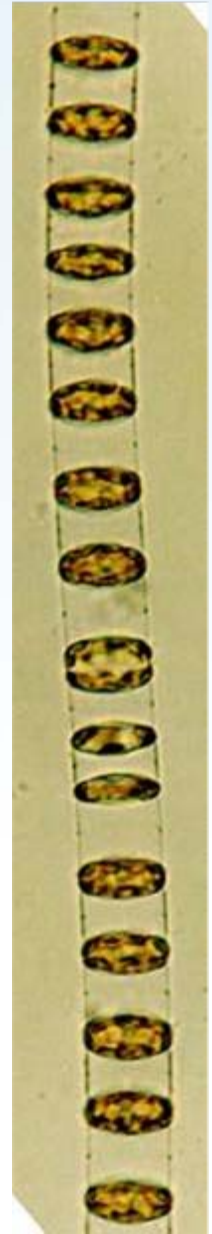
Co na to molekulární data?



Micromonas pusilla

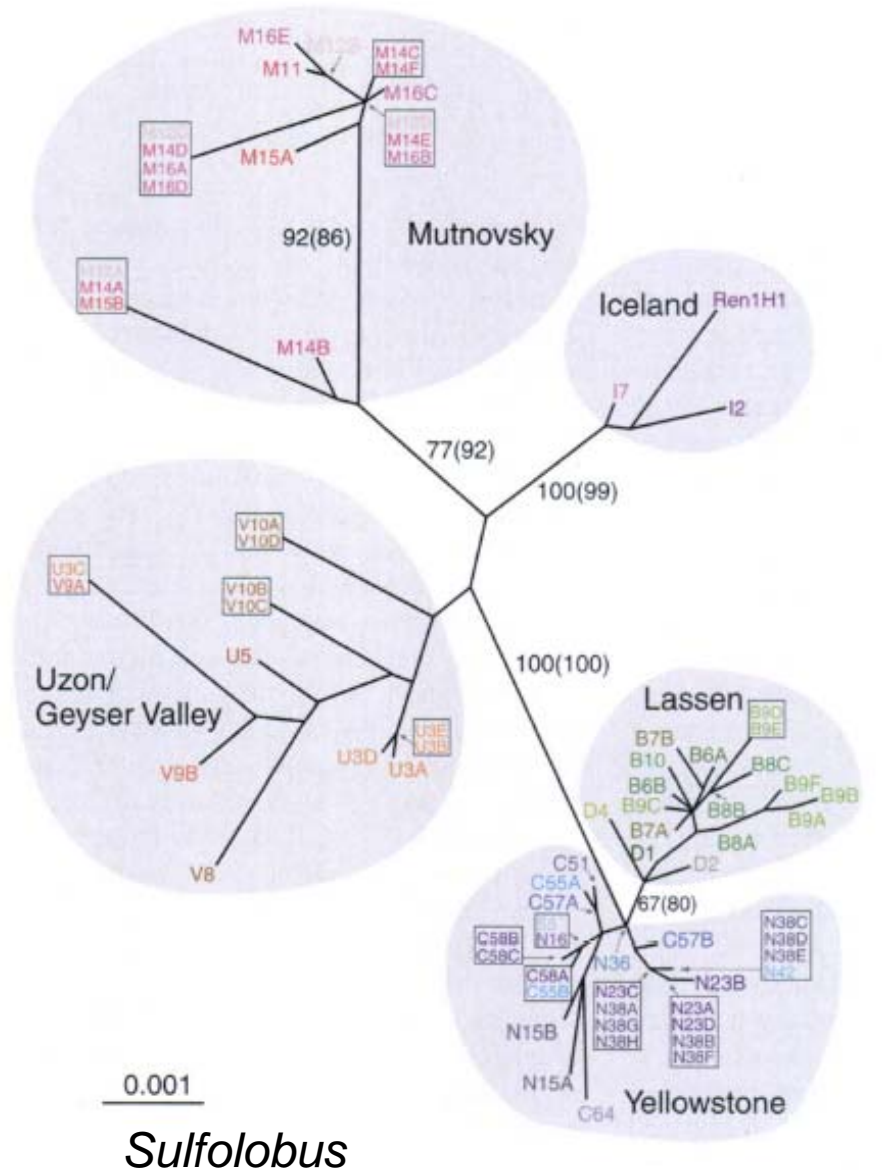
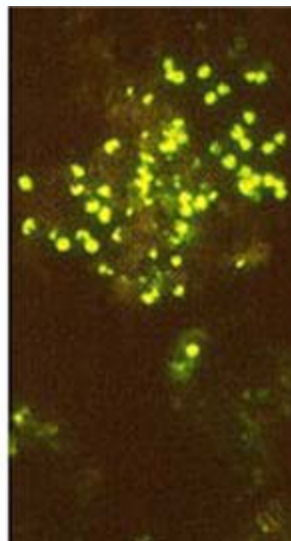
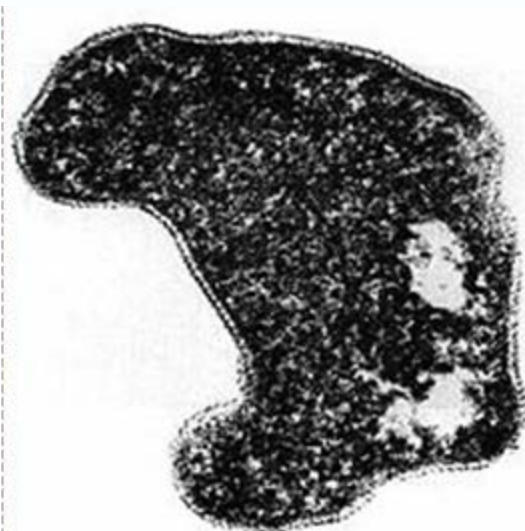
Biogeografie protist

Rozsivky – u některých druhů jasná biogeografie (*Skeletonema*)



Je všechno všude?

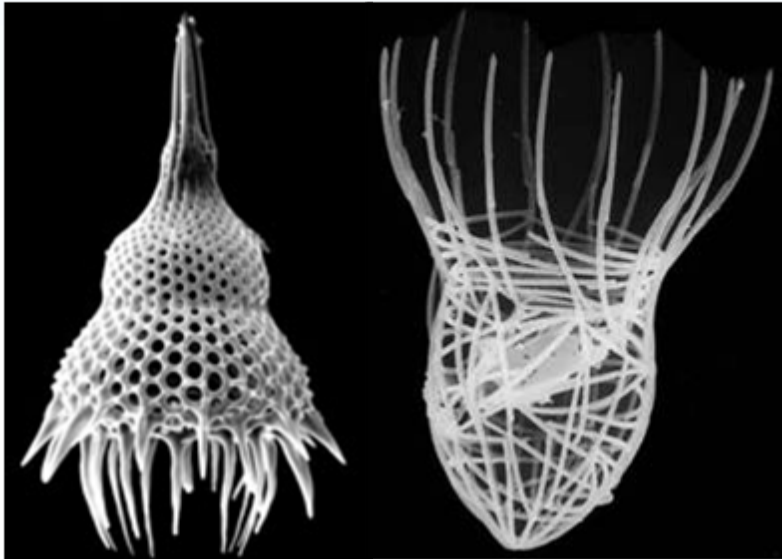
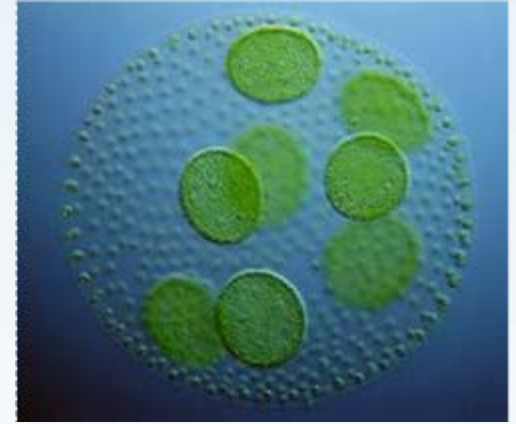
Biogeografie dokonce i u bakterií

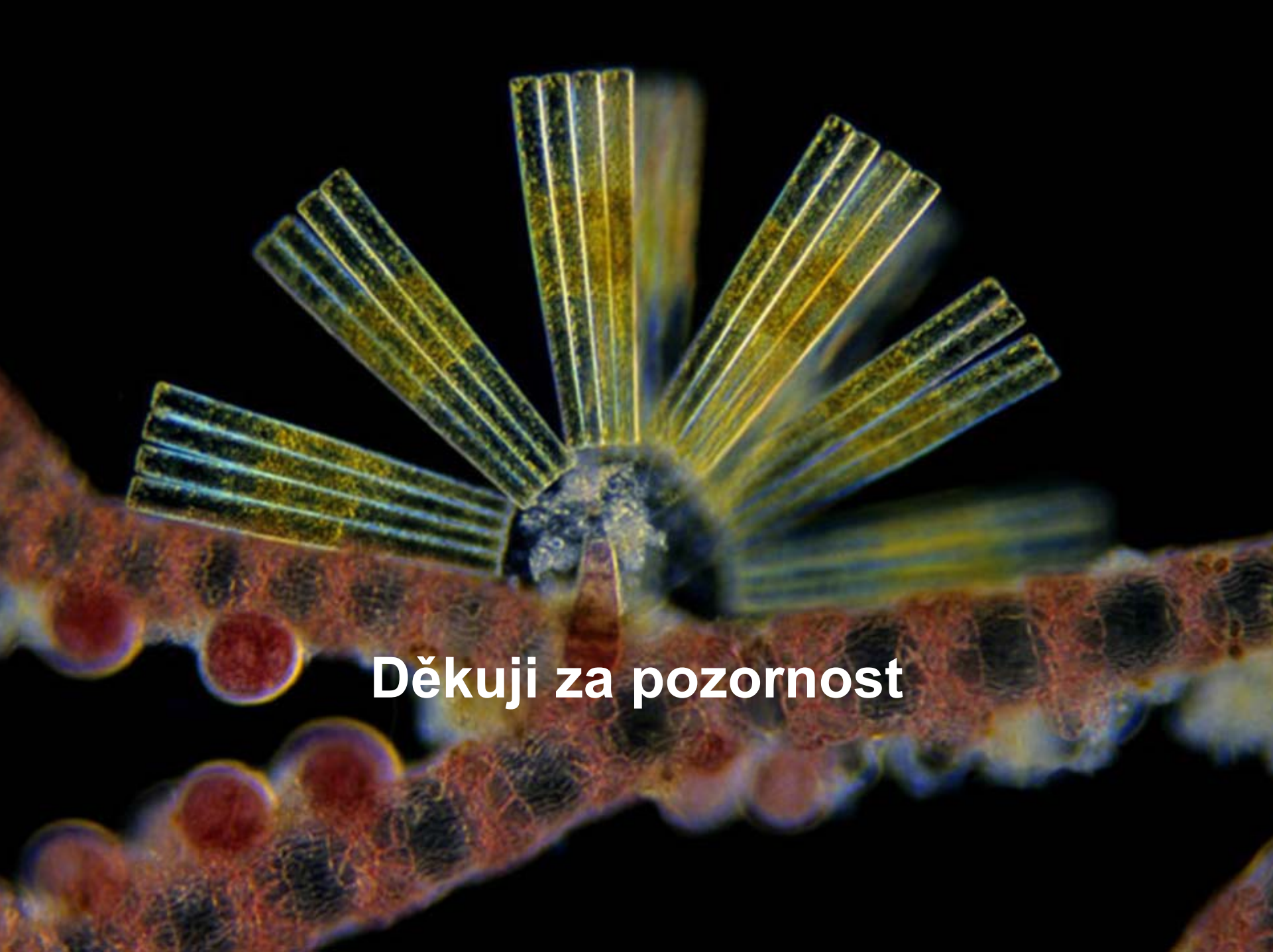


Ochrana protistů?

Až třetina protistů má omezené rozšíření

- V přírodě důležité ekologické role
- Biotechnologický potenciál
- Evoluční historie
- Estetické hledisko





Děkuji za pozornost