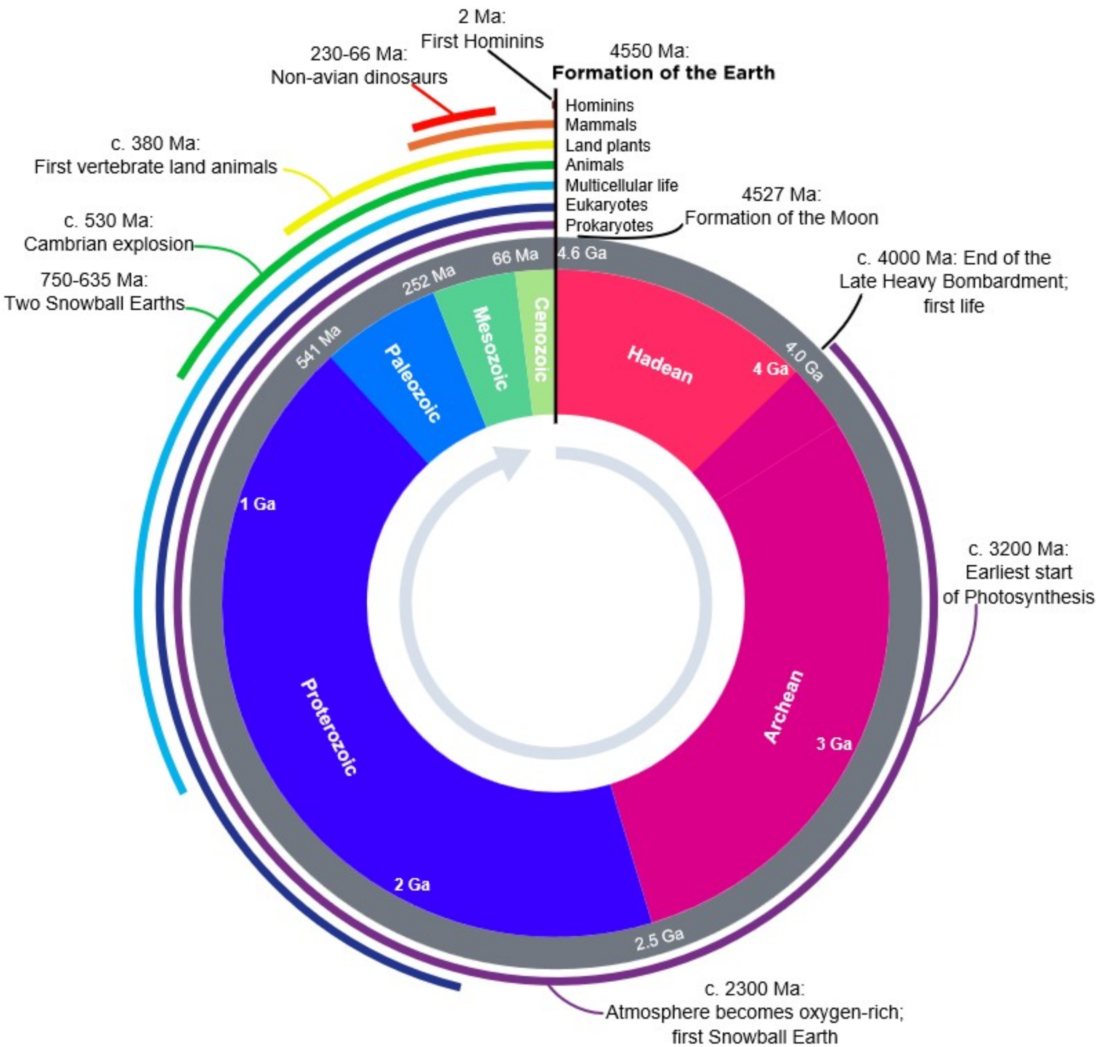
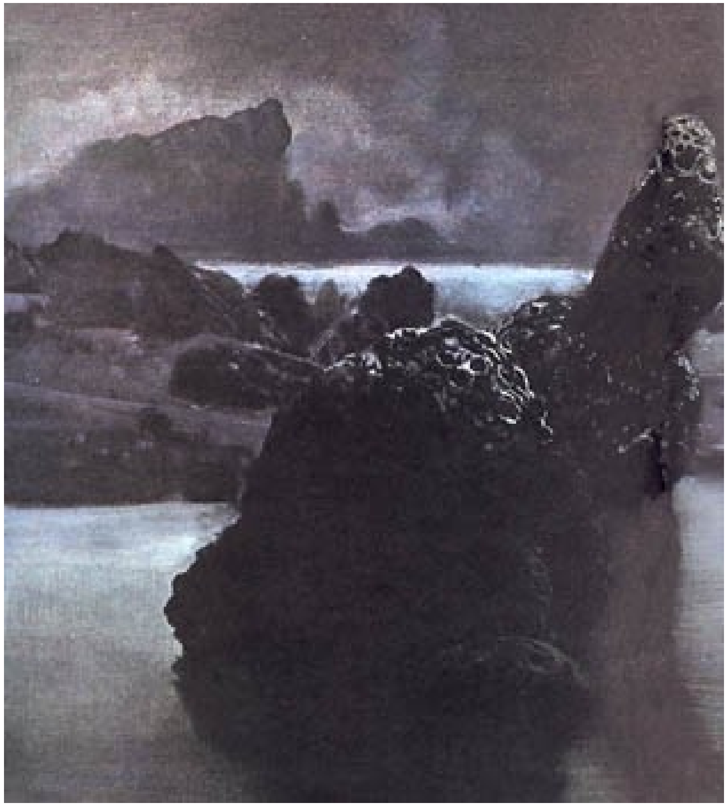

2 Ma:
First Hominins
230-66 Ma:
Non-avian dinosaurs
4550 Ma:
Formation of the Earth
Hominins
Mammals
Land plants
Animals
Multicellular life
Eukaryotes
Prokaryotes
c. 380 Ma:
First vertebrate land animals
4527 Ma:
Formation of the Moon
c. 530 Ma:
Cambrian explosion
c. 4000 Ma: End of the
Late Heavy Bombardment;
first life
750-635 Ma:
Two Snowball Earths
66 Ma
4.6 Ga
252 Ma
541 Ma
Paleozoic
Mesozoic
Cenozoic
Hadean
4 Ga
4.0 Ga
1 Ga
c. 3200 Ma:
Earliest start
of Photosynthesis
Proterozoic
Archean
3 Ga
2 Ga
2.5 Ga
c. 2300 Ma:
Atmosphere becomes oxygen-rich;
first Snowball Earth



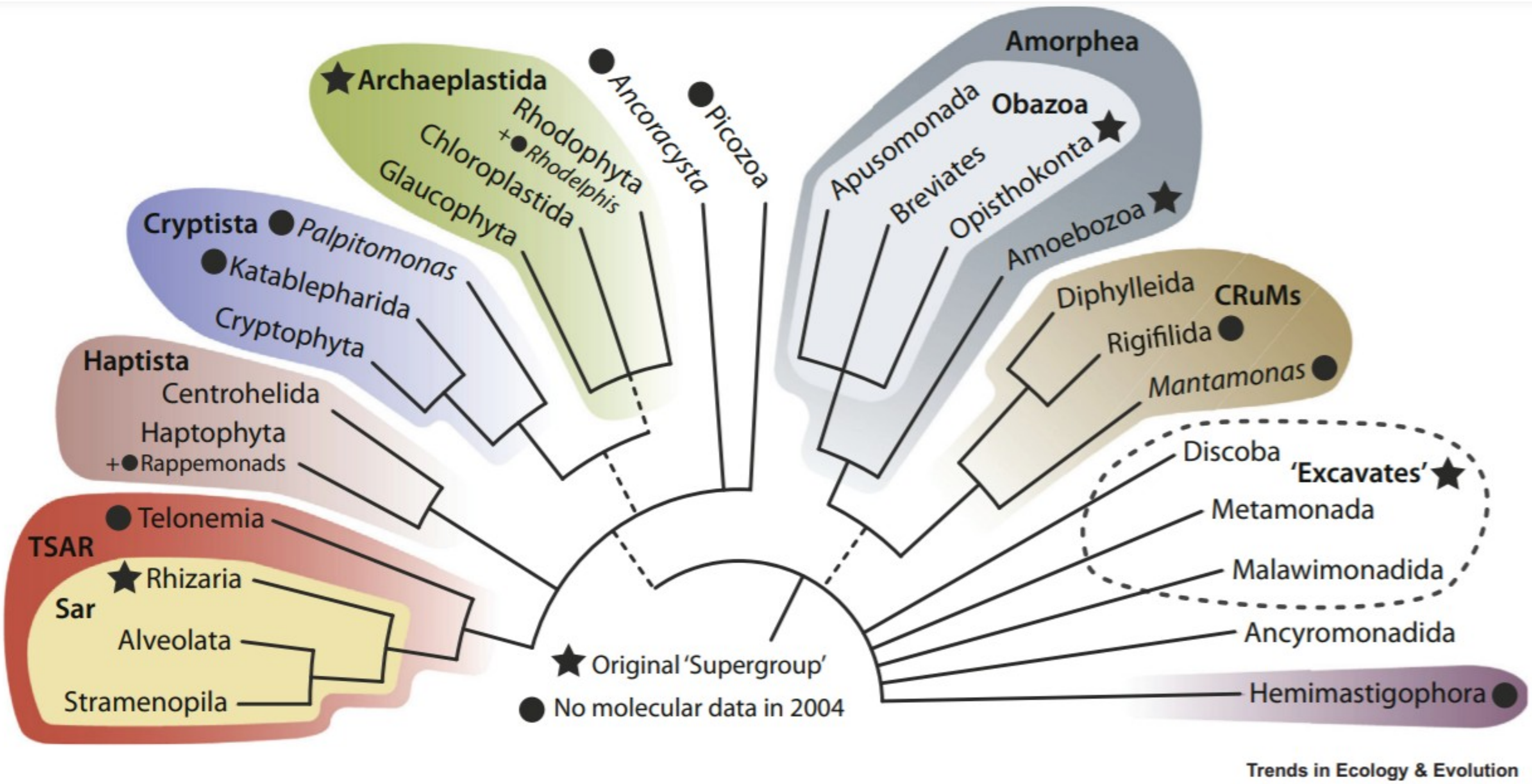
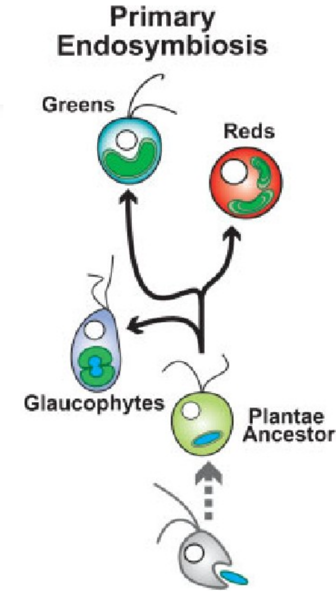
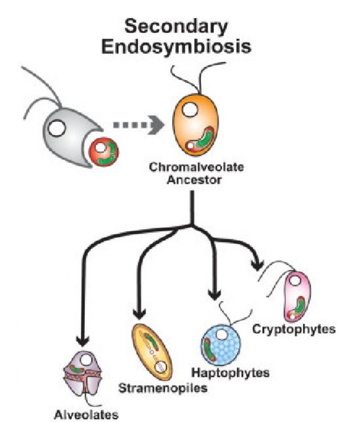


Figure 1. The New Tree of Eukaryotes.

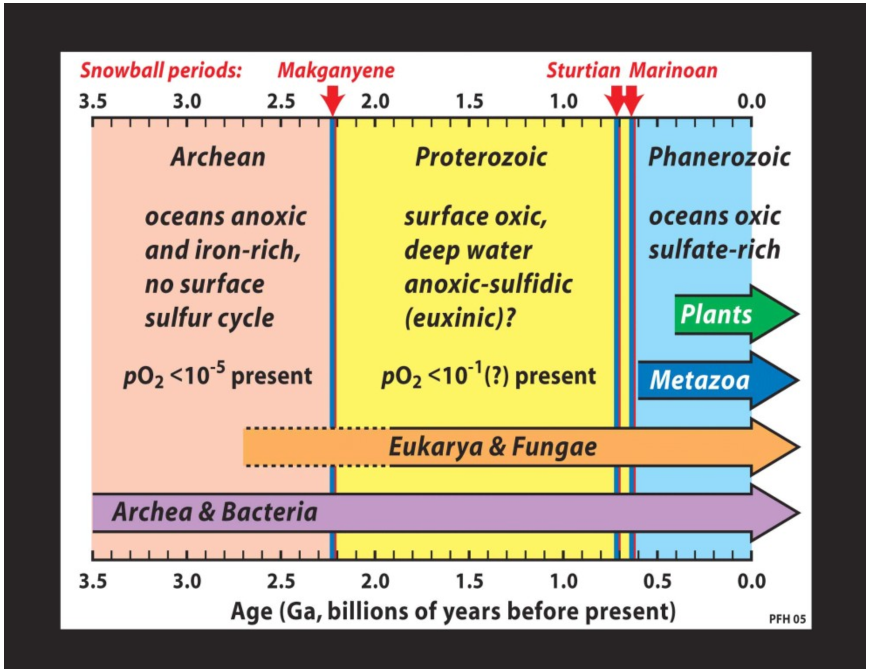
This summary is based on a consensus of recent phylogenomic studies. The colored groupings correspond to the current 'supergroups'. Unresolved branching orders among lineages are shown as multifurcations. Broken lines reflect lesser uncertainties about the monophyly of certain groups. Star symbols denote taxa that were considered as supergroups in early versions of the supergroup model; thus, all original supergroups except Archaeplastida have either disappeared or been subsumed into new taxa. The circles show major lineages that had no molecular data when the supergroup model emerged, most often because they had not yet been discovered. Rappemonads (in parentheses) are placed on the basis of plastid rRNA data only. The putative new major lineages *Microheliella* and *Anaeramoeba* are not shown due to the limited evidence that they belong outside all existing groups shown here (Table 1).

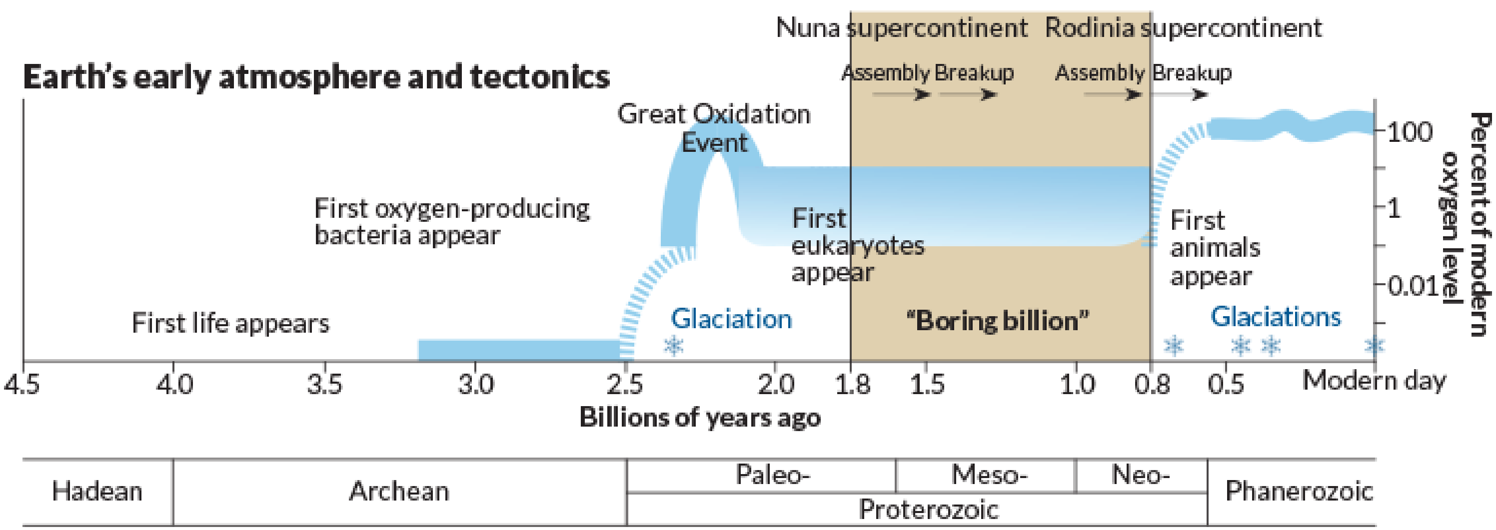


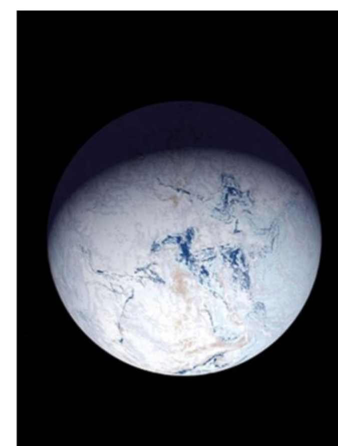


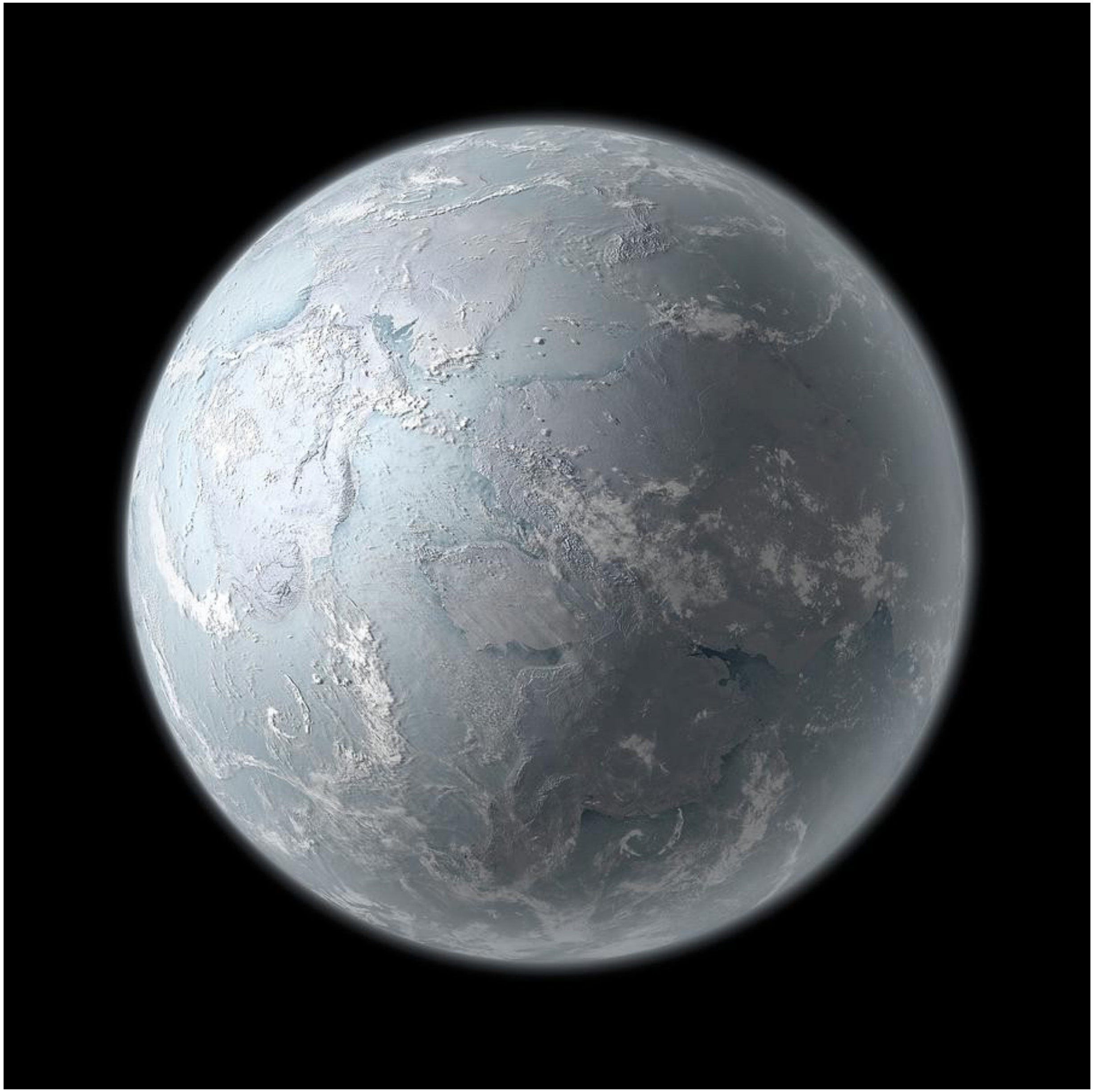
Burki et al., 2020, Trend Ecol Evol

Proterozoicum

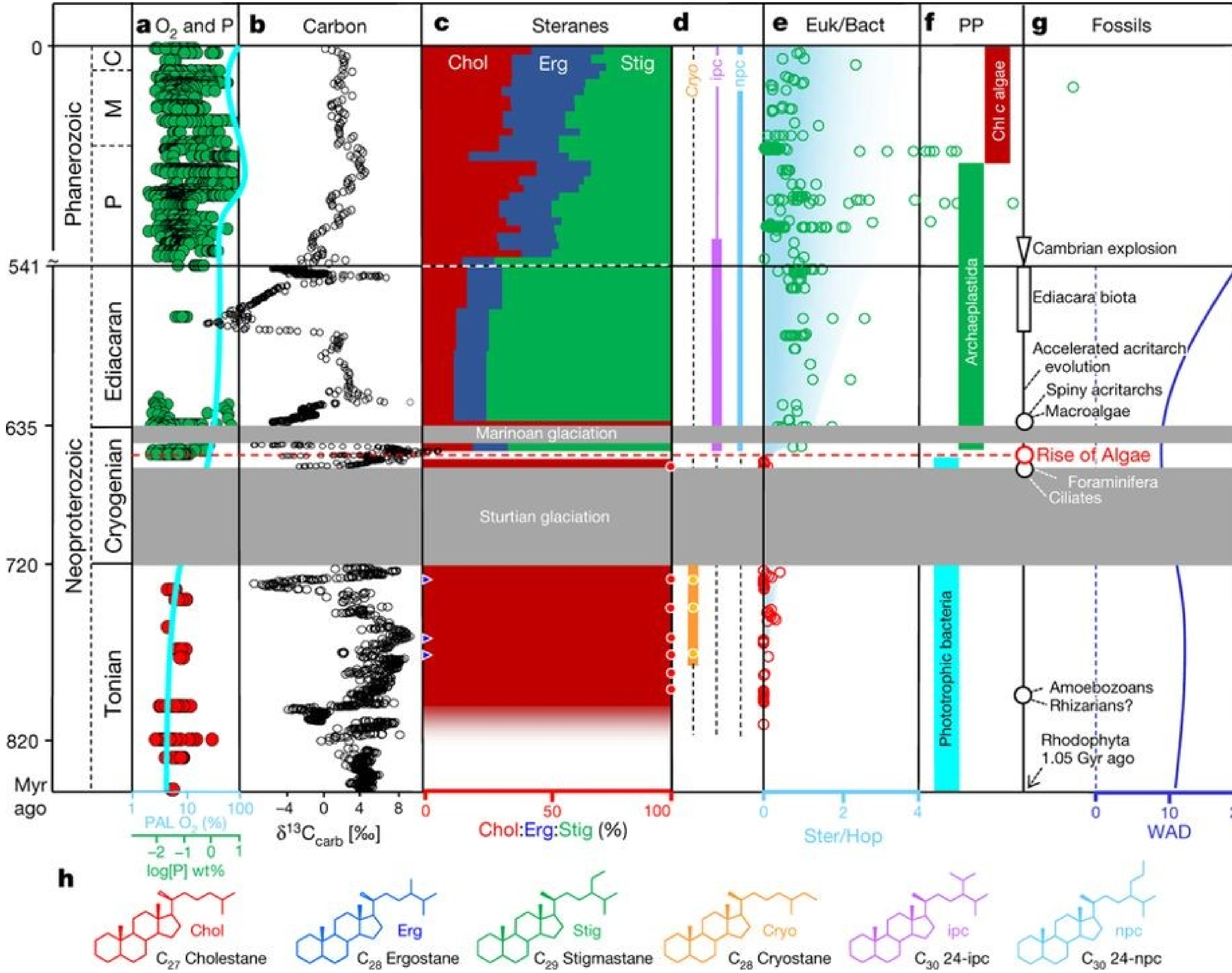








"The rise of Algae" in Cryogenian



Brocks et al., 2017, Nature

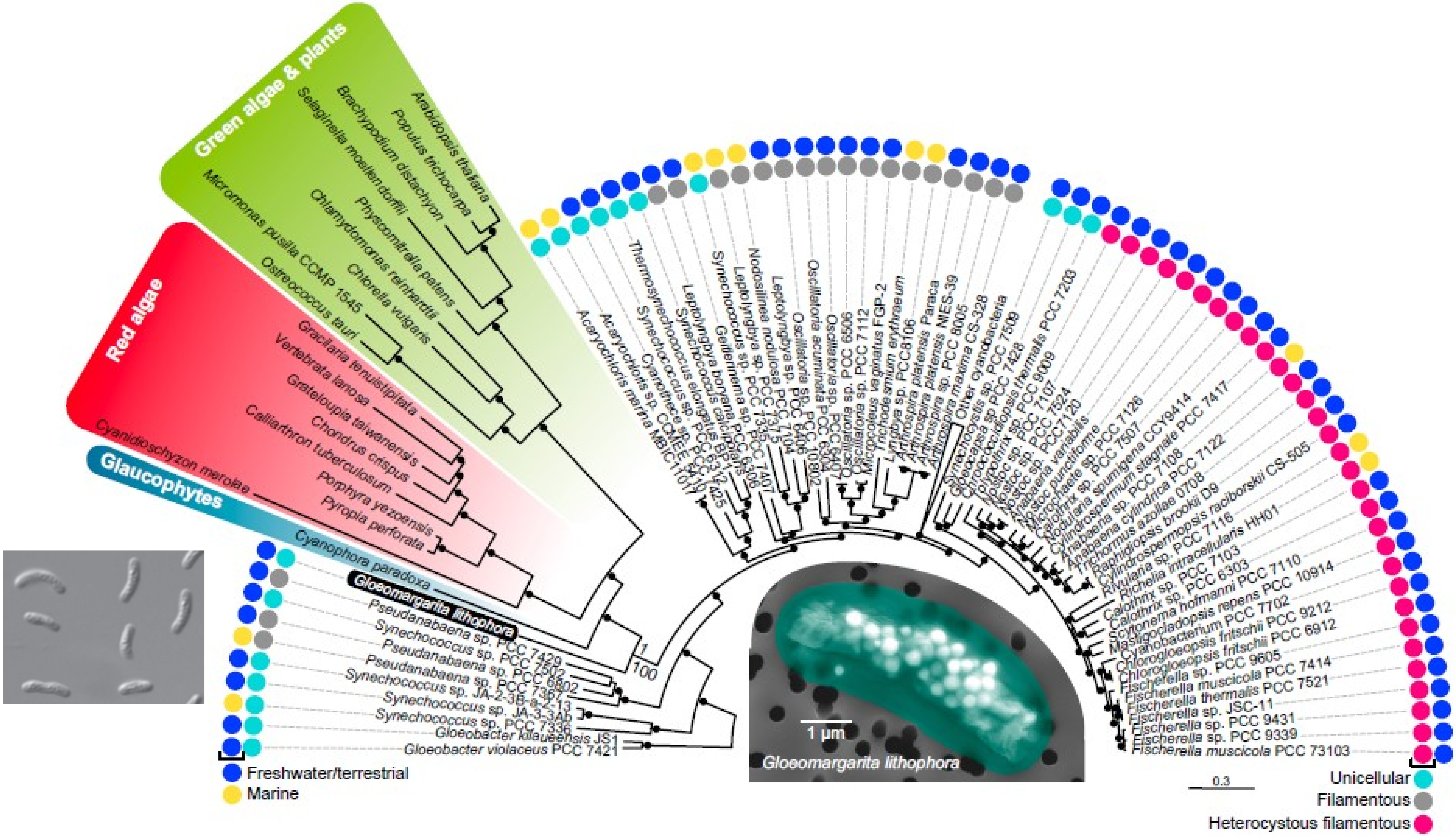


Figure 1. The Position of Plastids in the Cyanobacterial Phylogeny
This Bayesian phylogenetic tree is based on the concatenation of 97 plastid-encoded proteins and their cyanobacterial homologs. Branches supported by

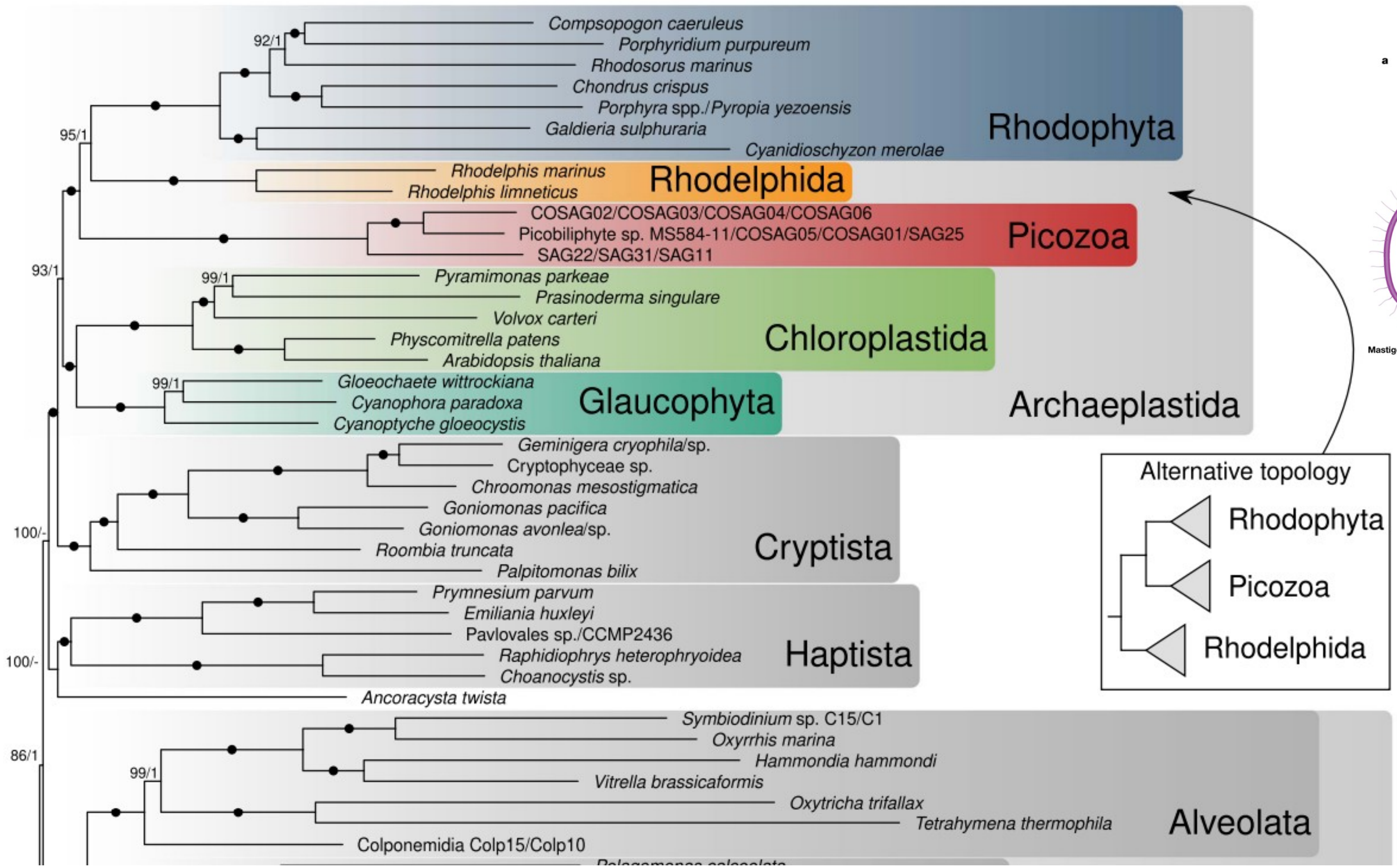
Gloeomargarita - discovered in a biofilm in the alkaline lake in Mexico

the closest known free-living relative of plastids

Ponce-Toledo et al., 2017, Curr. Biol.
Moreira et al., 2017, IJSEM

Archaeplastida are not just red and green plants/algae and glaucophytes

Picozoa and **Rhodelphidia** represent heterotrophic protist lineages distantly related to Rhodoplantae



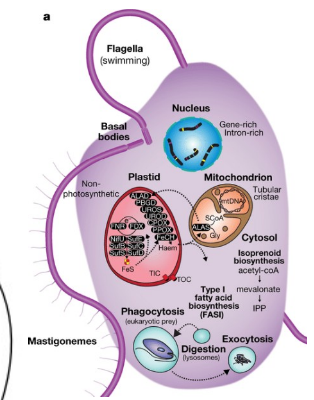
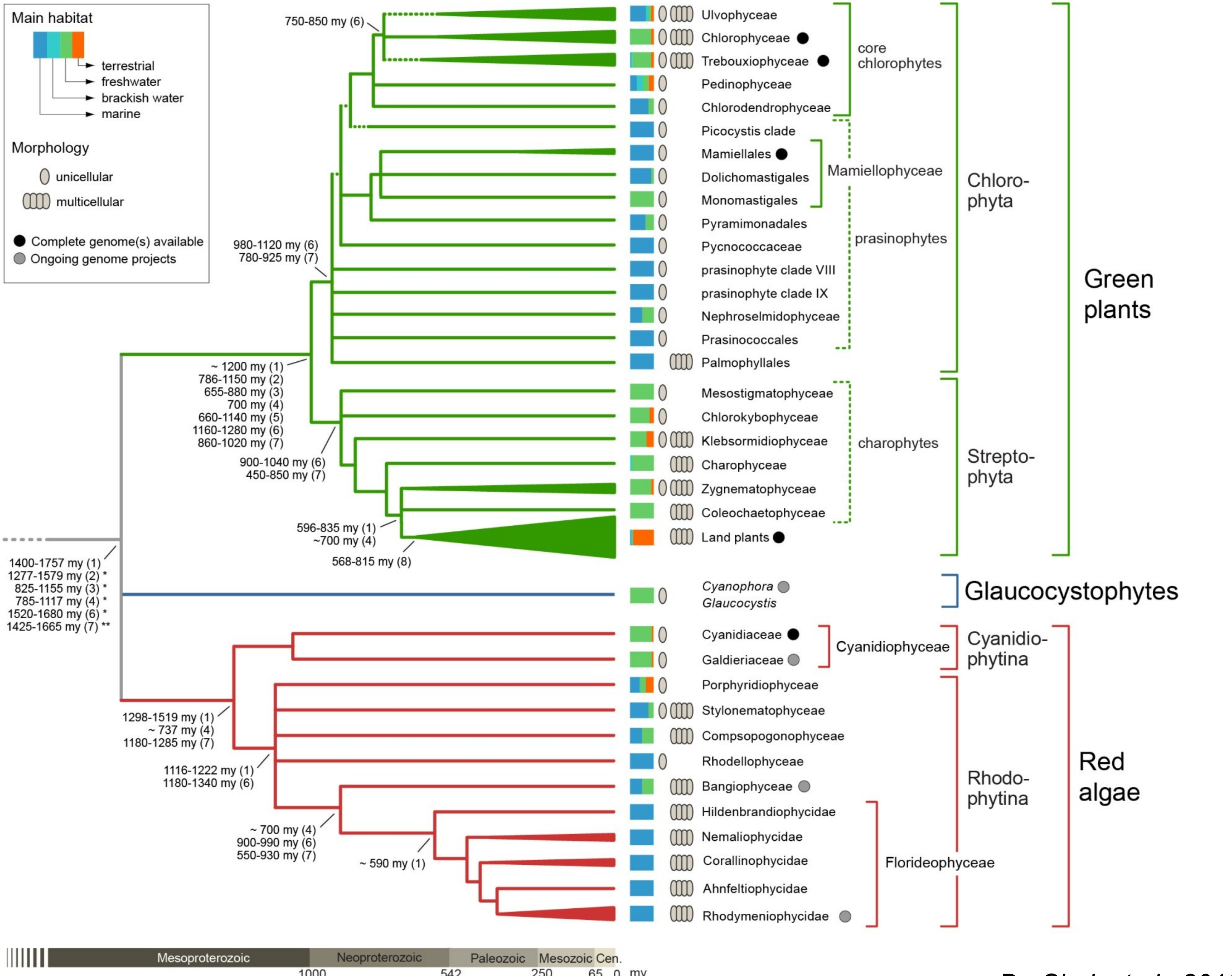


Fig. 2 Maximum likelihood tree of eukaryotic species showing the position of Picozoa. The tree is based on the concatenated alignment of 317 marker genes and was reconstructed using the site-heterogeneous model LG + C60 + F + G-PMSF. Support values correspond to 100 non-parametric bootstrap replicates/posterior probability values estimated using PhyloBayes CAT-GTR + G. Black circles denote full support (=100/1.0). Insert shows the only other topology not rejected in an AU topology test, which was also recovered when trimming the 50% most heterogeneous sites of the alignment.

více o tom v předmětu **Protistologie**!

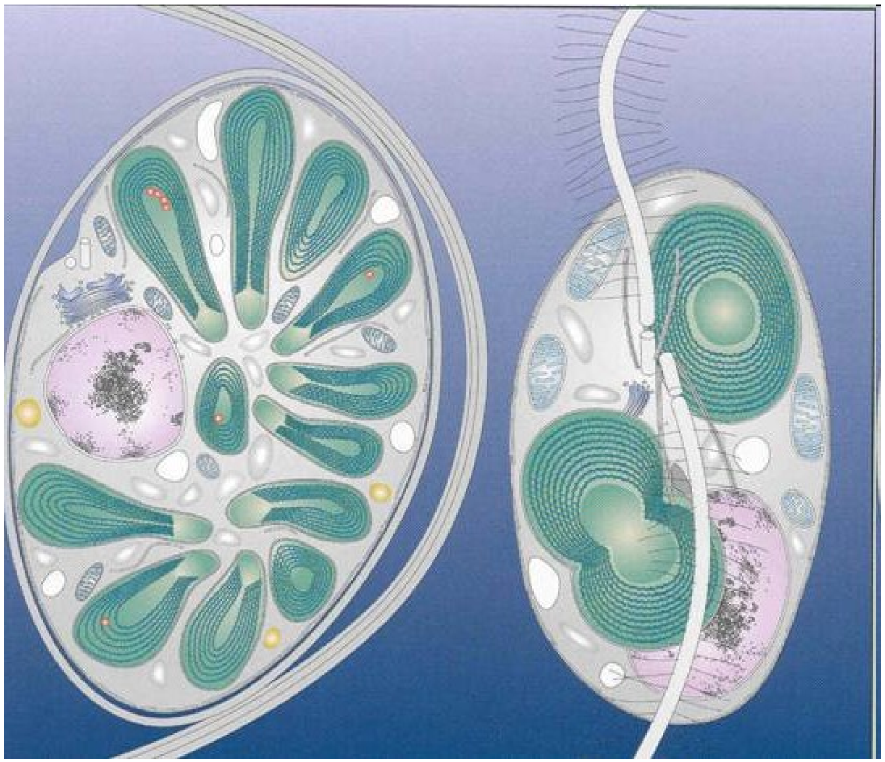
Schön et al., 2021, Nature Comm.

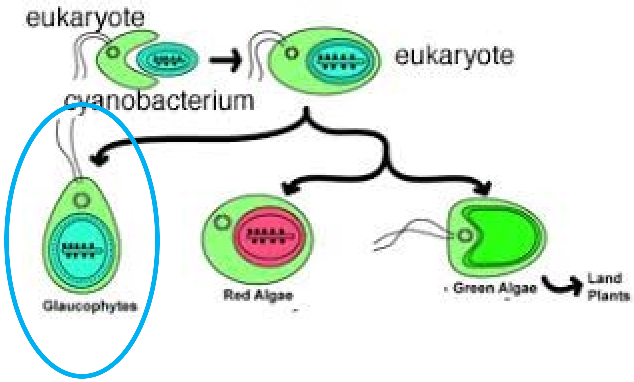


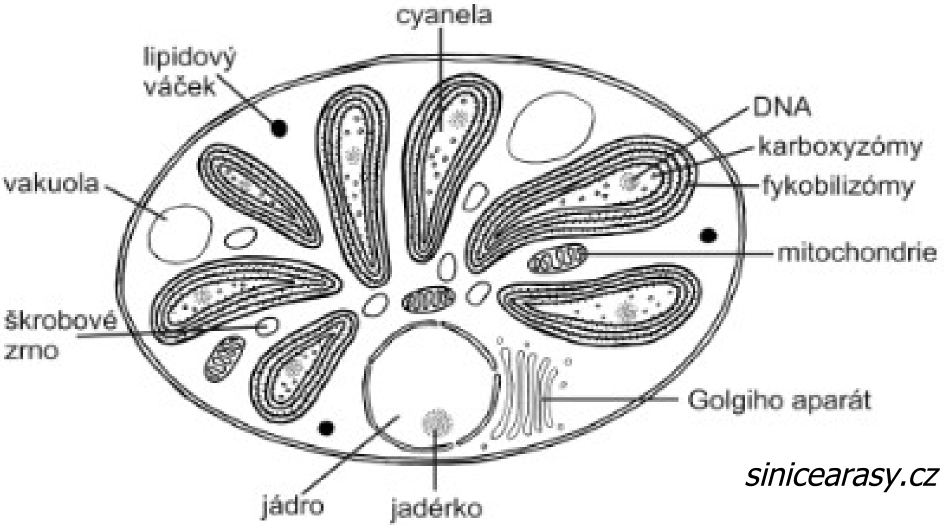
De Clerk et al., 2016

Glaucophyta

the smallest and possibly the most plesiomorphic "plant" lineage





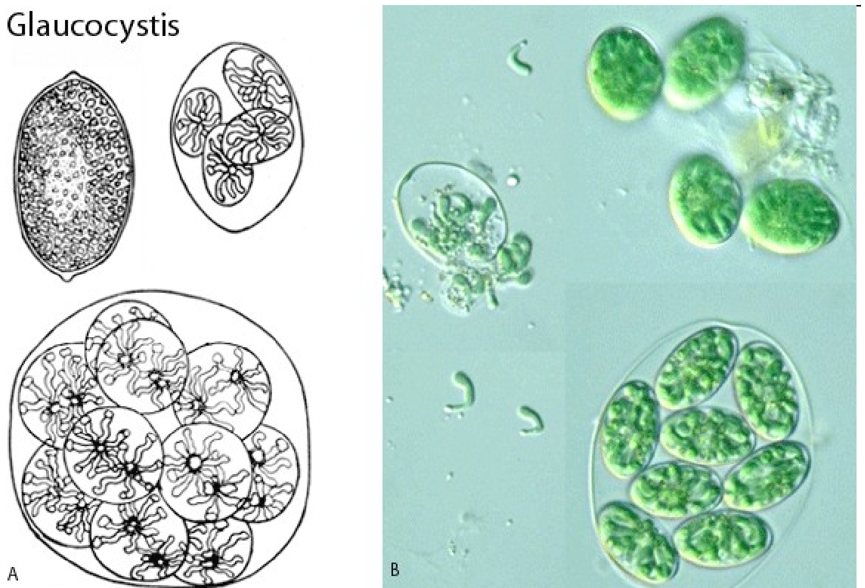


sinicearasy.cz

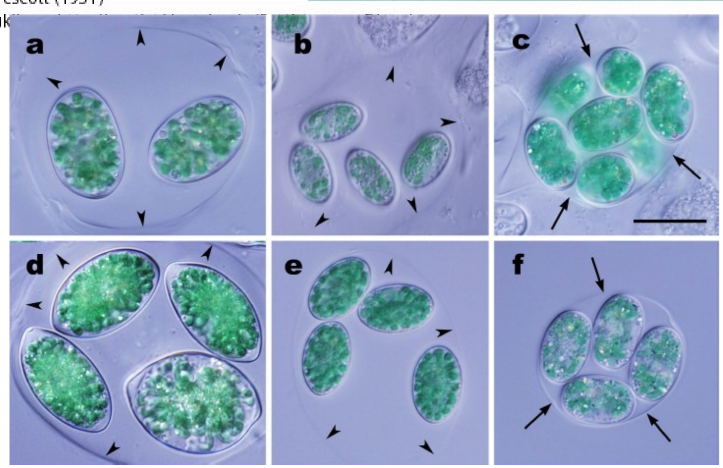
multiple "primitive" features of cyanobacterian origin

Glaucocystis

- coccoid genus, reproduction by autospores
- typical for acidophilic benthic microhabitats (peat bogs)
- also known from eutrophic microphytobenthos

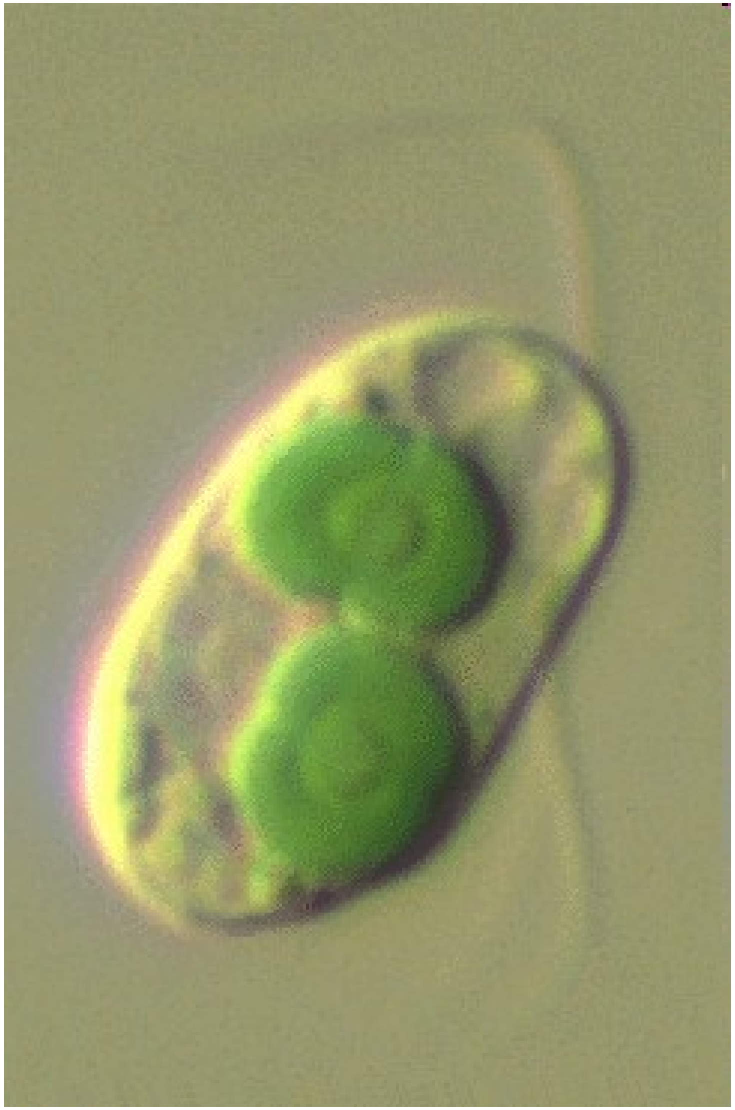


A after Prescott (1951)
B © Y.Tsuk



G. nostochinearum

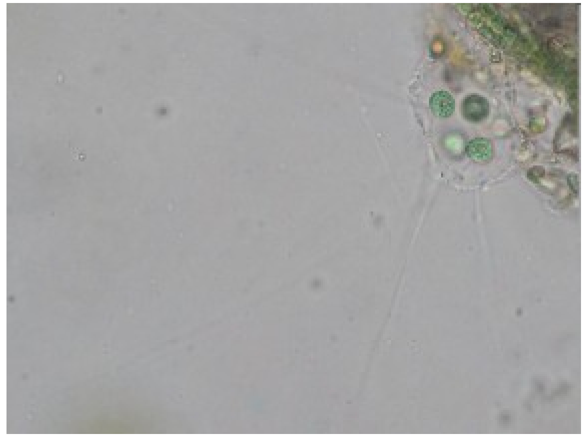
Cyanophora

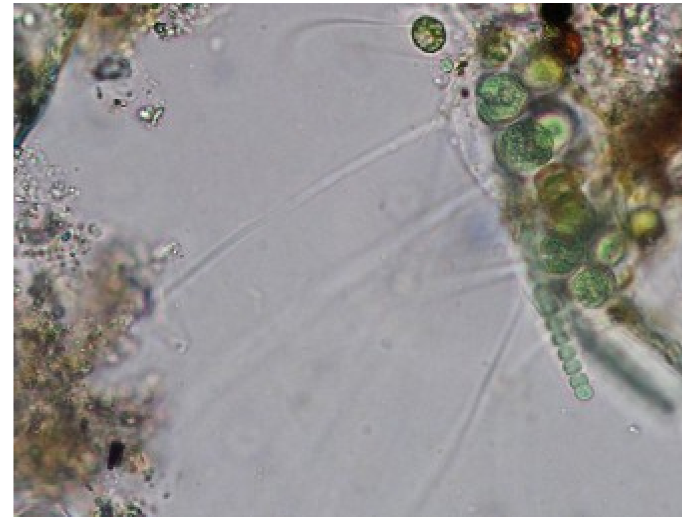


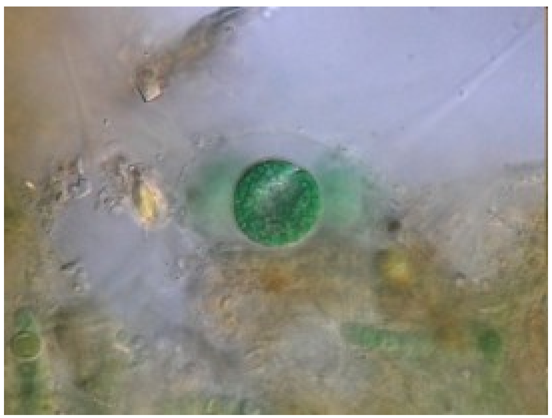
C. paradoxa

plankton of acidic freshwaters

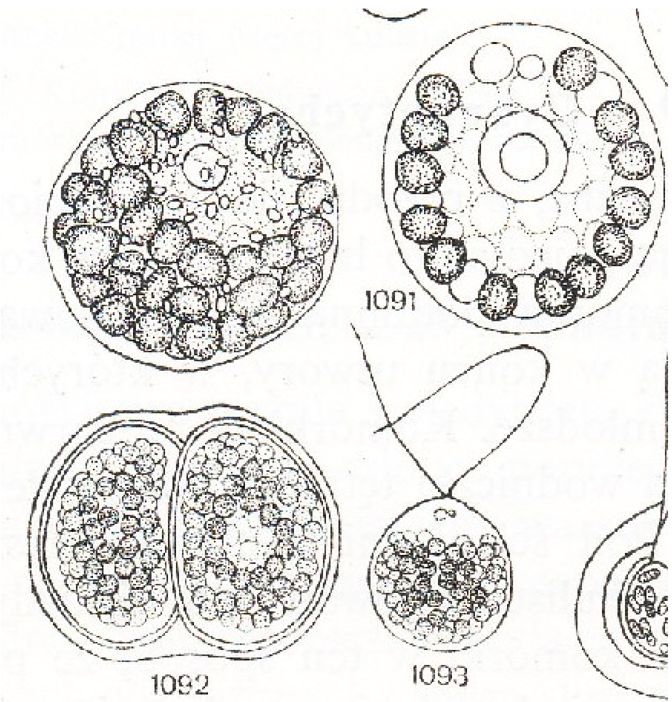
Gloeochaete wittrockiana

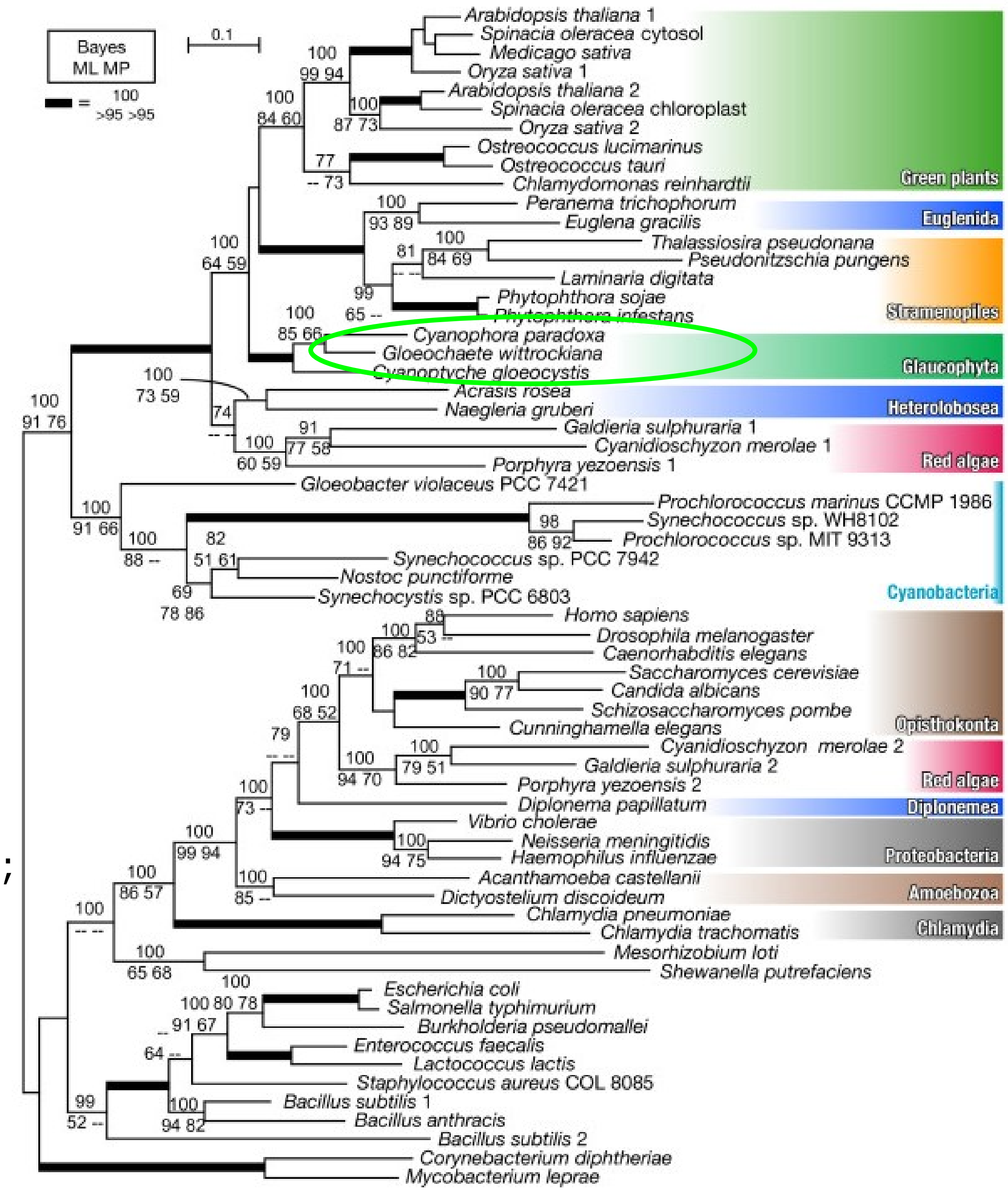






Cyanoptyche gloeocystis

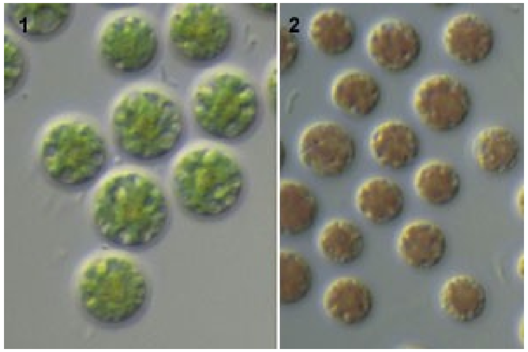




- originally described by A. Pascher from a peatbog pool in Doksy (Hirschberg);
- nowadays known from peatbogs in Ukraine, Poland, Canada
- two strains exist (in SAG) (one from a pool in Prater(!), the second from a mountainous pool in Portugal

Maruyama et al., 2008, BMC Evol. Biol. 8:151.

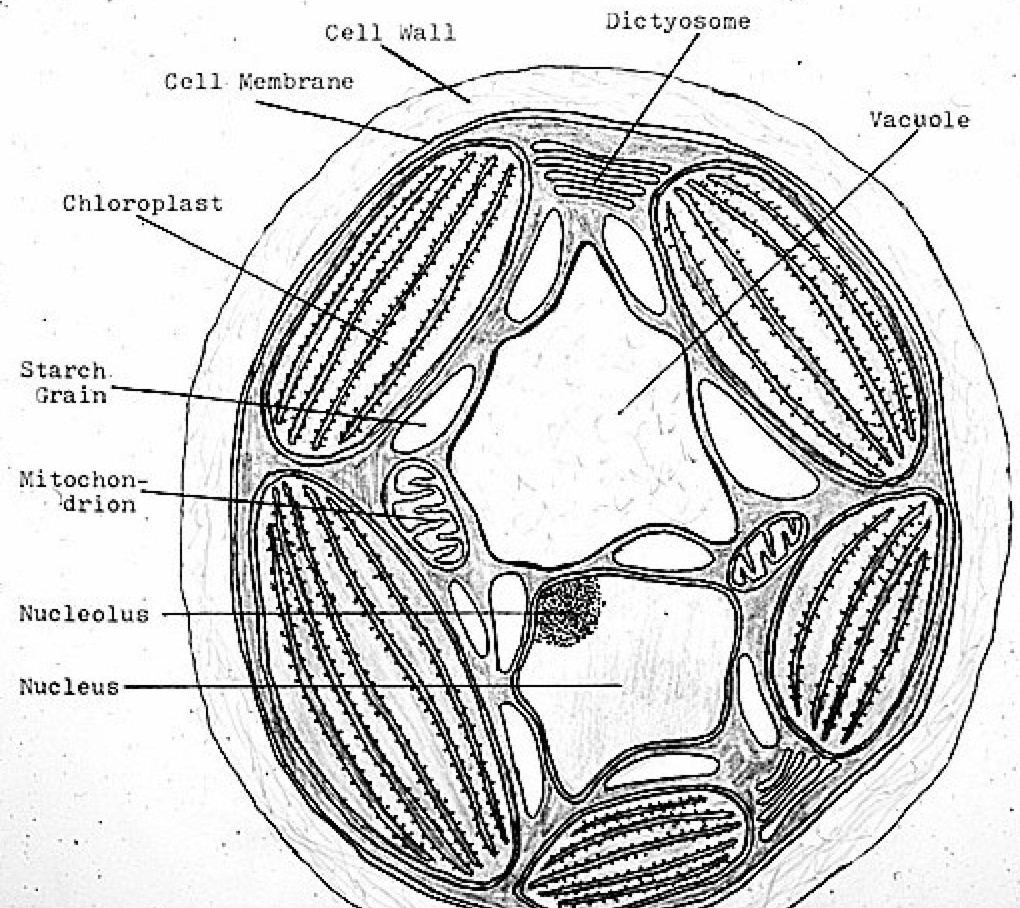
the red plant lineage – subkingdom ***Rhodoplantae***



<u>evolutionarily important features</u>: Golgi apparatus associated with ER, mitochondrion, and nuclear membrane, presence/absence of thylakoidal lamella beneath plastid membrane (relation to evolution of secondary rhodoplasts), phycobilins, absence of any flagellates stages (but *Rhodelphis* !)

Basic Rhodophytan Characteristics

1. Eucaryotic cells
2. Phycobilin pigments present as phycobilisomes on the thylakoids
3. Nuclear membrane present throughout mitosis
4. Floridean starch granules located outside the chloroplasts
5. Single thylakoid bands in the chloroplasts
6. Absence of flagella or cilia



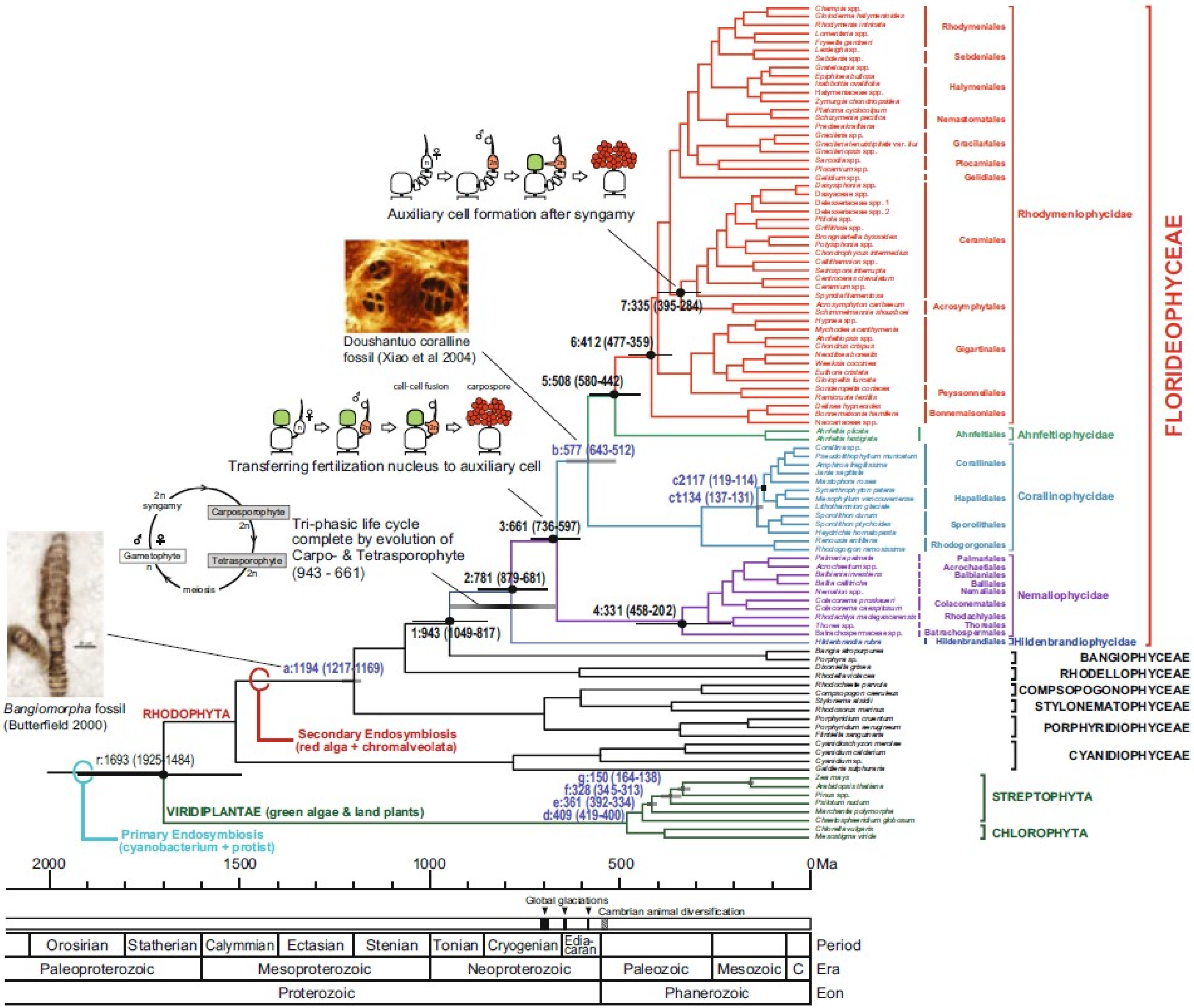


Fig. 6 Divergence time and evolution of the red algae. Primary and secondary endosymbiosis events are indicated with *cyan* and *red lines*, respectively. The three key evolutionary events are indicated with diagrams at the estimated evolutionary timeline. Triphasic life cycle, postfertilization "cell-to-cell fusion" mechanisms between carpogonium (fertilized egg) and an auxiliary cell, and the formation of an auxiliary cell after fertilization (syngamy) are indicated (Modified from Yang et al. 2016)

Yoon et al., 2017,
In: Handbook of Protists

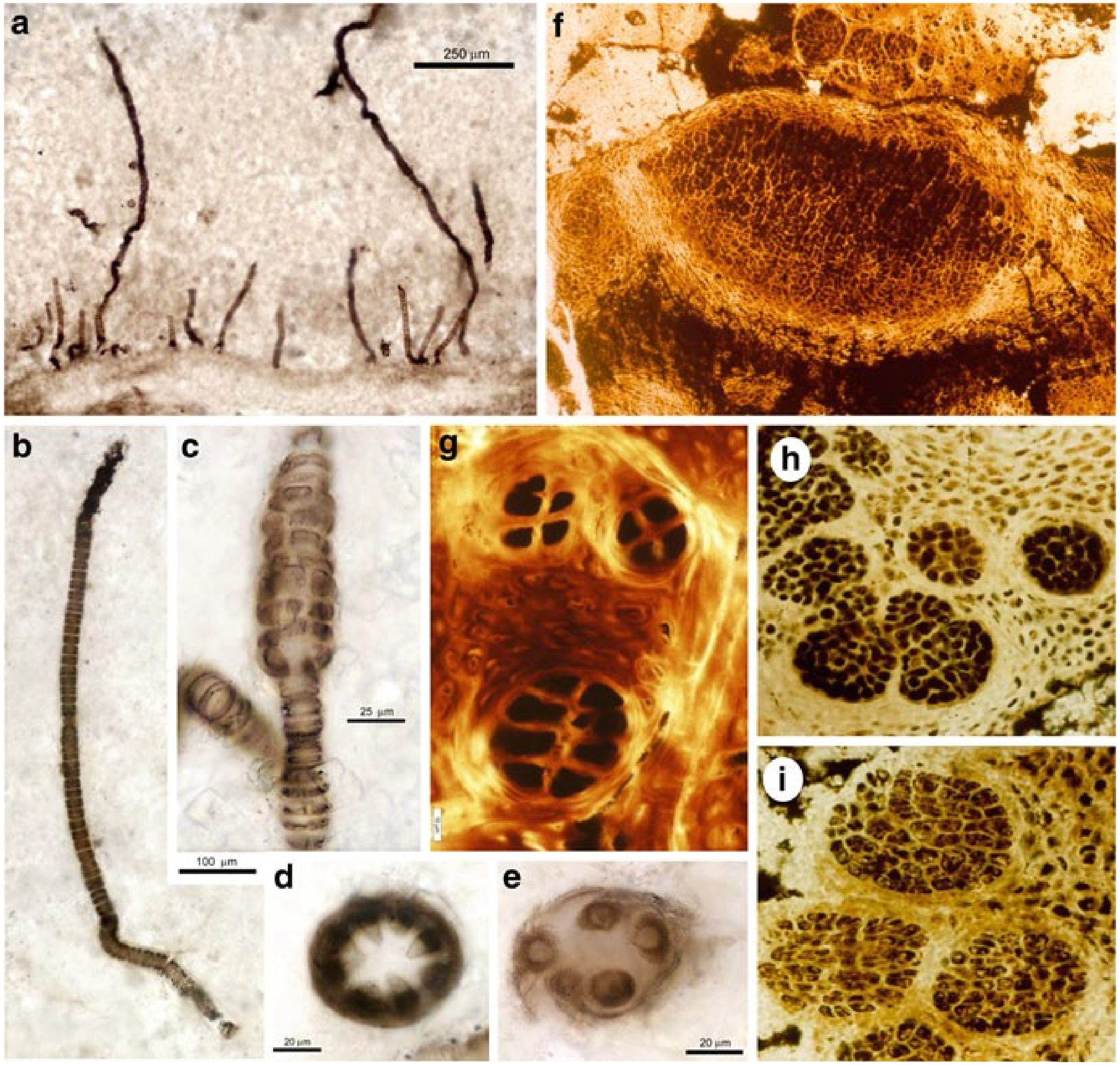


Fig. 5 Proterozoic red algal fossils. (**a–e**) *Bangiomorpha pubescens* fossils from the ca. 1200 million-year-old Hunting Formation, Somerset Island, arctic Canada (Courtesy of N. J. Butterfield). (**a**) Population of *Bangiomorpha* that clustered with up to 15 individuals. (**b**) Two paired cells reflecting transverse intercalary cell division. (**c**) Mature thallus showing both uniseriate and multiseriate portions of a filament. (**d**) Transverse cross-section of a multiseriate filament showing eight radially arranged wedge-shaped cells. (**e**) Spore-like spheroidal cells within multiseriate filaments from transverse cross-section. (**f–i**) Coralline fossils from the late Neoproterozoic 570 Ma Doushantuo Formation at Weng'an, southern China (Courtesy of S. Xiao). (**f**) A spermatangia-like reproductive structure with filaments. (**g**) Tetraspores and octaspores embedded in algal thallus showing possible tetrasporangium with subtending stalk cells. (**h, i**) Carposporangia

Bangiomorpha pubescens
-1047 mya

Yoon et al., 2017,
In: Handbook of Protists

synopsis of formal classification :
(**834** genera in **90** families in **32** order in **7** classes in **2** divisions)

subkingdom: **Rhodoplantae**

division: **Cyanidiophyta**

class: **Cyanidiophyceae** (6)

division: **Rhodophyta**

class: **Rhodellophyceae** (7)

class: **Stylonematophyceae** (ca 50)

class: **Porphyridiophyceae** (10)

class: **Compsopogonophyceae** (ca 70)

class: **Bangiophyceae** (ca 200)

class: **Florideophyceae** (> 7000)

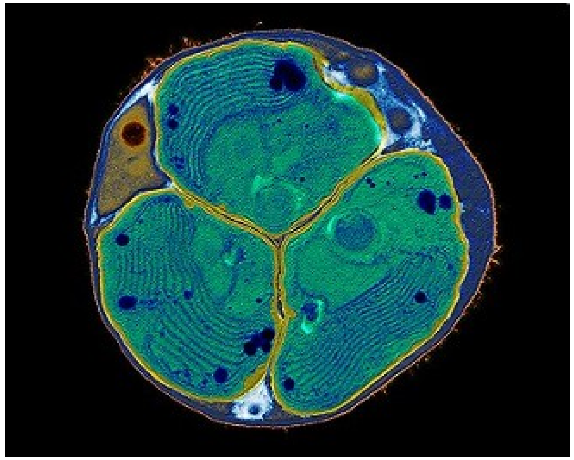
How many red algal species exist?
- ca 7500 described
- ca 20 000 presumed

(Adl et al., 2007, Syst. Biol.)

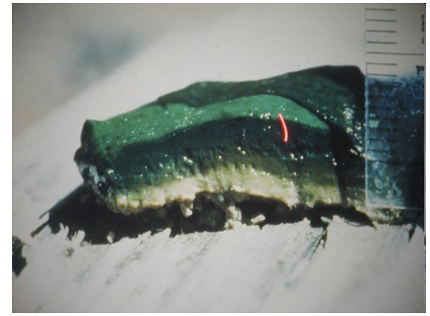
Schneider & Wynne, 2007, Bot. Mar. 50: 197–249
algaebase.org

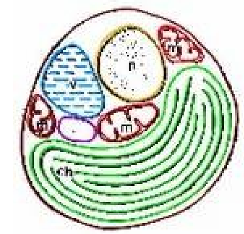
Cyanidiophyta

Cyanidium



Galdieria





extremely acidic habitats

Fig. 1. Photoautotrophic (left) and heterotrophic (right) *G. sulphuraria* cells. Cell cultures (top) and light microscopic images (bottom; bar represents 10 μm) of *G. sulphuraria* cells grown under continuous illumination in the absence of glucose (left) or in darkness in the presence of 200 mM glucose (right).

Yellowstone volcanic area

C. caldarium - hot (up to 57 C) and acid soils/waters

- capable of heterotrophic growth on at least 50 different carbon sources
- ca 5% of genes were acquired horizontally from extremophilic bacteria (dealing with heavy metals in acidic environments, etc.)

Ciniglia et al., 2004 Mol. Ecol. 13:1827-1838.
Schönknecht et al., 2013, Science 339

active volcanic areas (semi-terrestrial biofilms)
subaerial biofilms on rocks (maritime caves)
[heterotrophic metabolism]

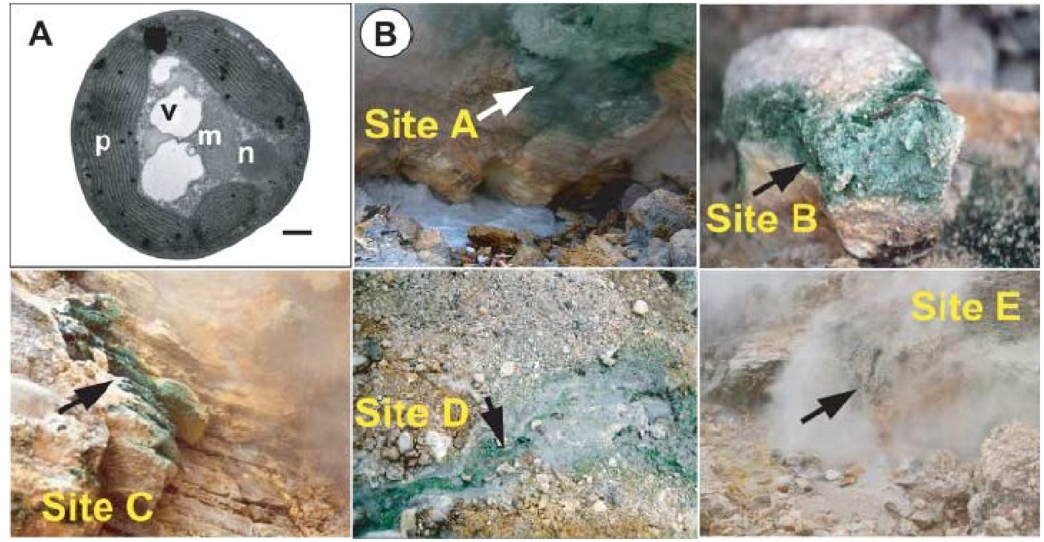
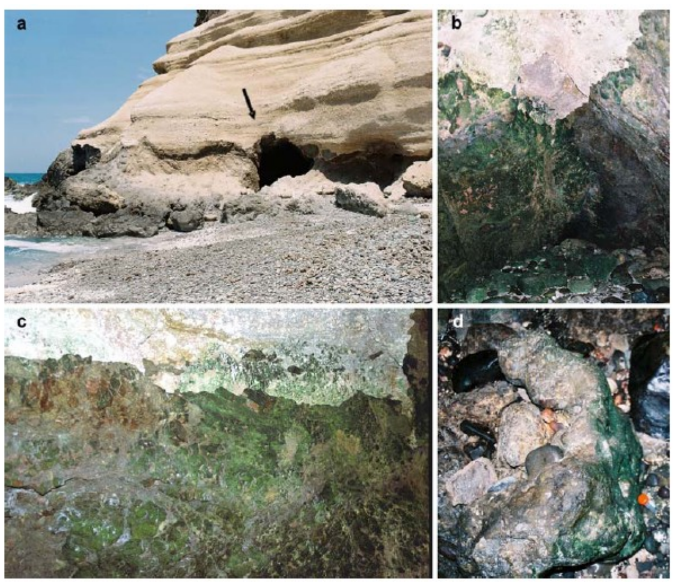
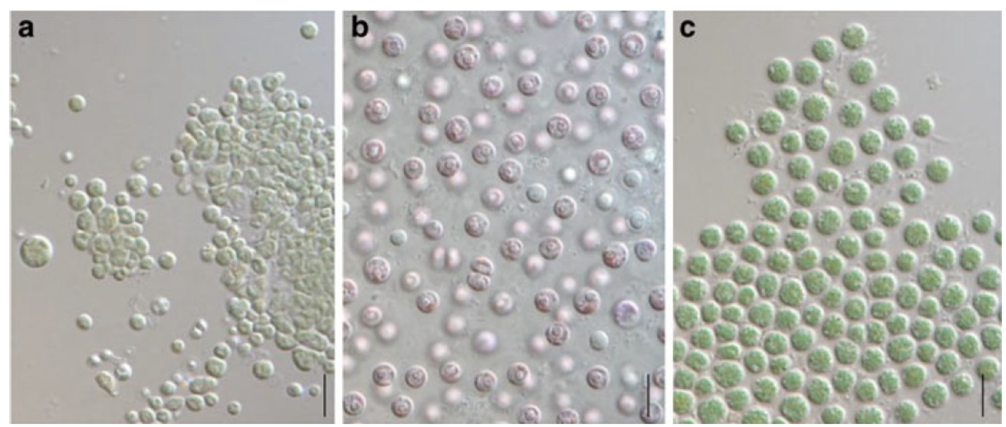


Fig. 1 The Cyanidiales red algae. (A) TEM micrograph of a crypto-endolithic strain of *Galdieria sulphuraria*. The abbreviations denote the following: m = mitochondrion, n = nucleus, p = plastid, v = vacuole. Scale bars = 1 μm. (B) The environmental Sites A–E used to collect Cyanidiales at Pisciarelli in the Phlegrean Fields, Italy (see text for details).

Figure 2 Atacama cave description. **a** East entrance. **b** View towards the bottom (north) of the cave. The biofilm area studied is located on the left side wall. **c** Detail of *Cyanidium* biofilm. **d** Biofilm on rocks at the bottom of the cave. Note the biofilm development only on the rock face oriented towards the east entrance. In both **a**, **b**, and **c**, the different geological origin of the walls and ceiling of the cave can be observed





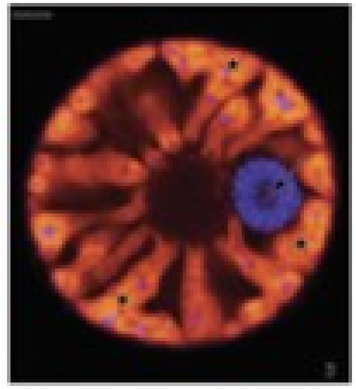
Yoon et al., 2017, In: Handbook of Protists

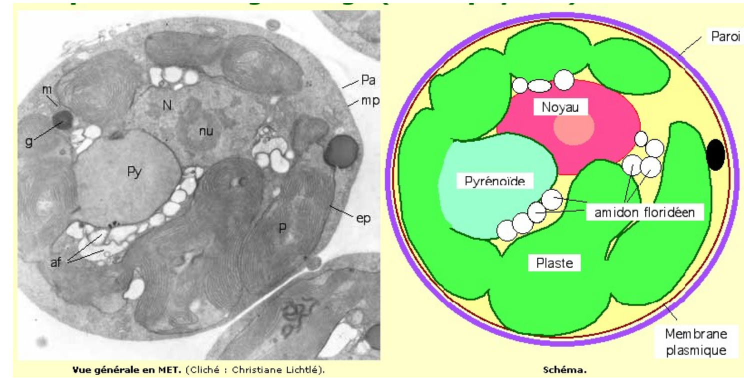
Ciniglia et al., 2004 Mol. Ecol. 13:1827-1838, Azua-Bustos et al., 2009, Microb. Ecol., 58:485–496

Rhodophyta

Rhodellophyceae

Rhodella





in the marine littoral – epifytically and in phytobentos

group-level synapomorphy:
Rhodellophyceae contain mannitol

Yokoyama et al., 2009, Phycol. Res., 57: 278–289

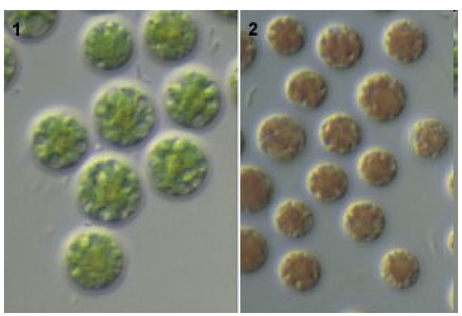
Stylonematophyceae

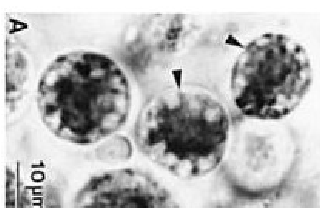
Chroodactylon, Chroothece, Purpureofilum

hydroterrestrial soil crusts (incl. acidic habitats)

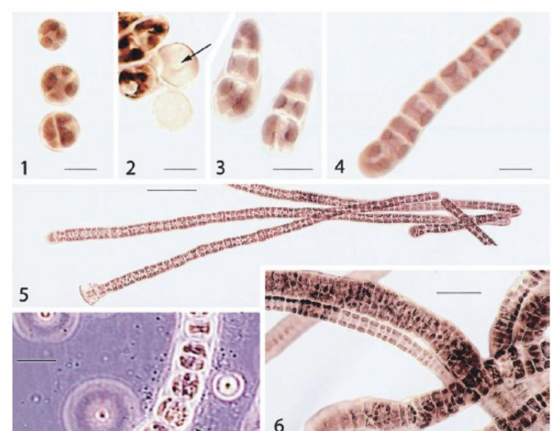
marine and freshwater habitats

Porphyridiophyceae





benthos, soil crusts/biofilms



mobile monospores

Compsopogonophyceae

primarily a freshwater lineage

Compsopogon

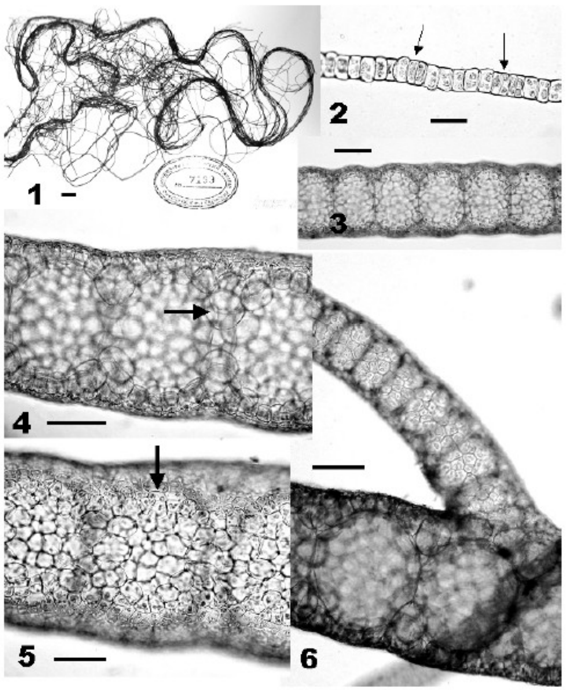
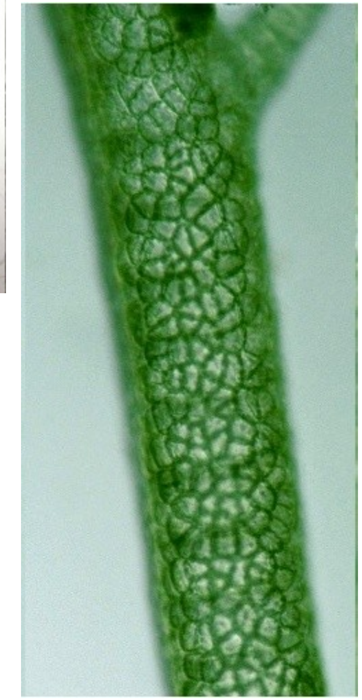
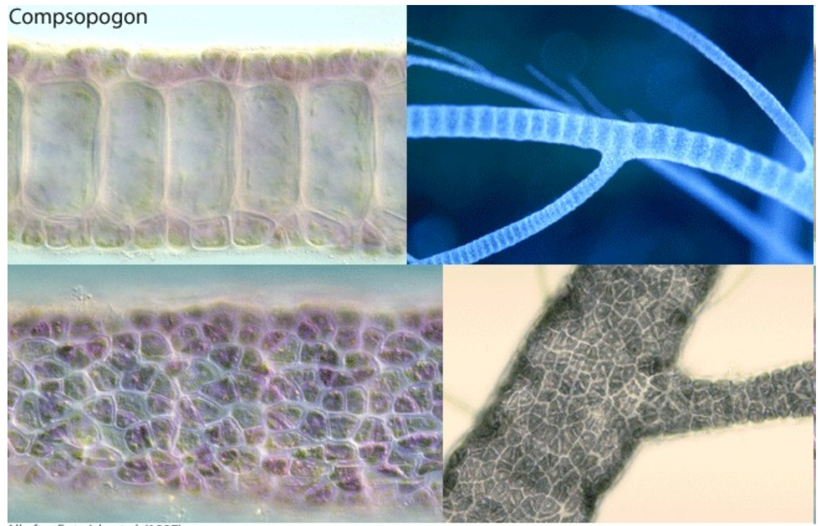


Fig. 1 Herbarium specimen of *Compsopogon coeruleus* from Wainivesi River, Tailevu, Fiji, 30 May 2001. SUVA-A 7199. Scale = 1 cm. **Fig. 2** Uniseriate terminal portion of branch, showing recent intercalary cell divisions





All after Entwisle et al. (1997)

often in aquaria

benthos of (sub-)tropical freshwater
(USA to ca Virginia and Kentucky)

subtropical/Atlantic Europe (E, F, MT, even GB)

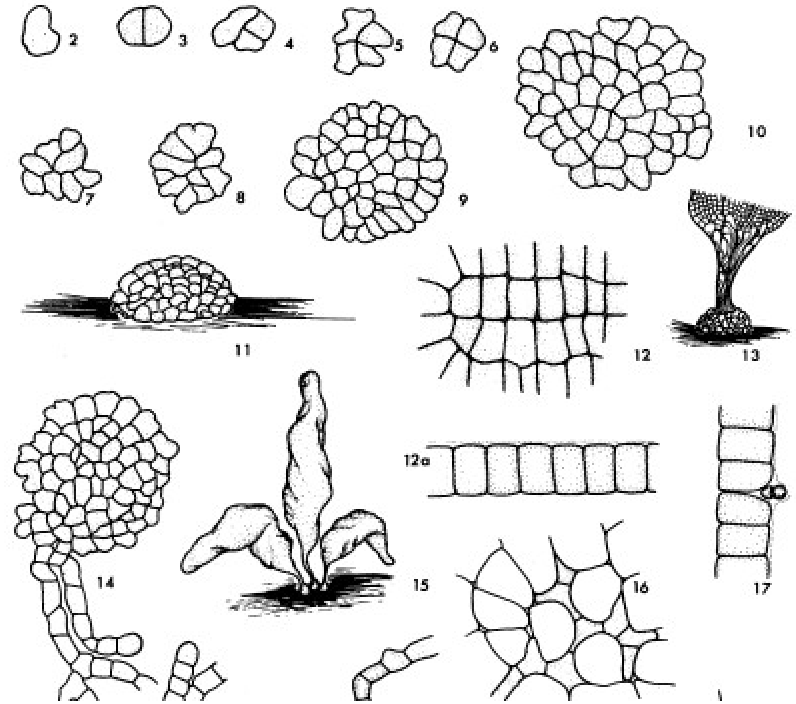
south Pacific island – source for (fishy) puddings

South & Skelton, 2002, N.Z. J. Mar. Fresh. Res. 36: 879–881.

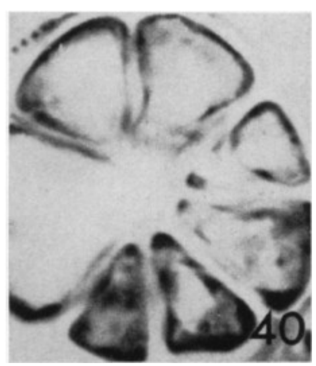
Boldia

B. erythrosiphon
streams and small rivers in N America
(Alabama to Quebec)
often on snails

Boldia on snails



thallus ontogenesis



Nichols, 1964, Am. J. Bot. 51: 653-659 .

PARENTHESIS

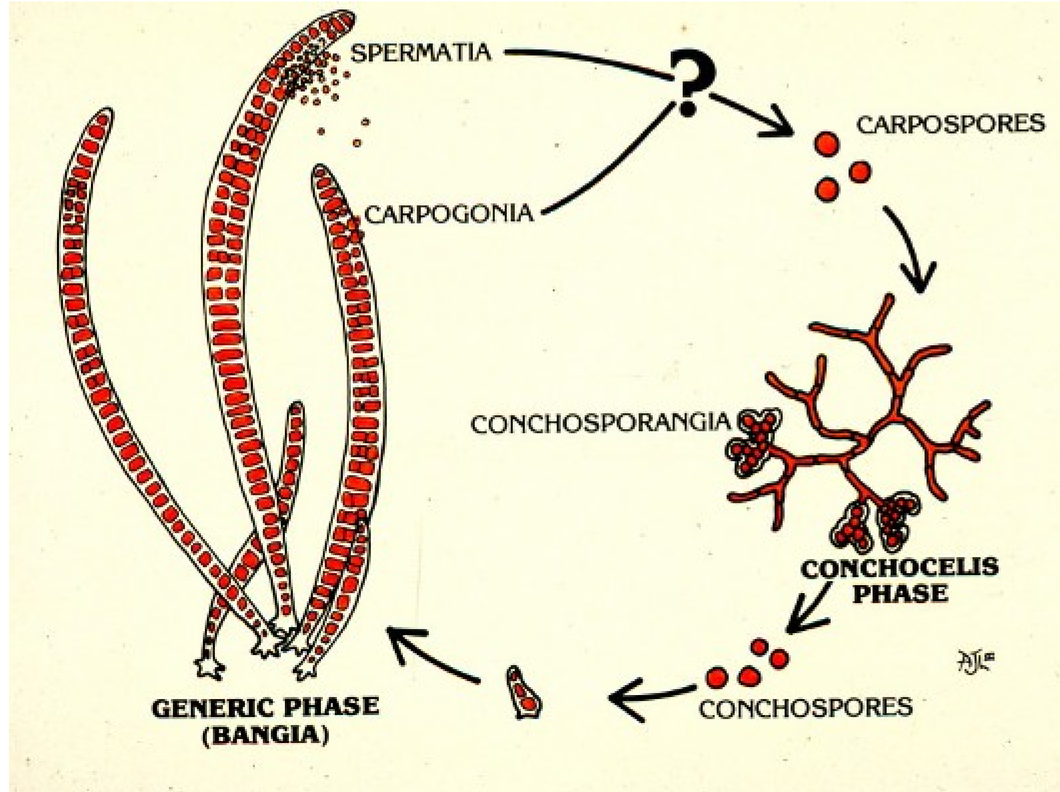
Marine vegetation

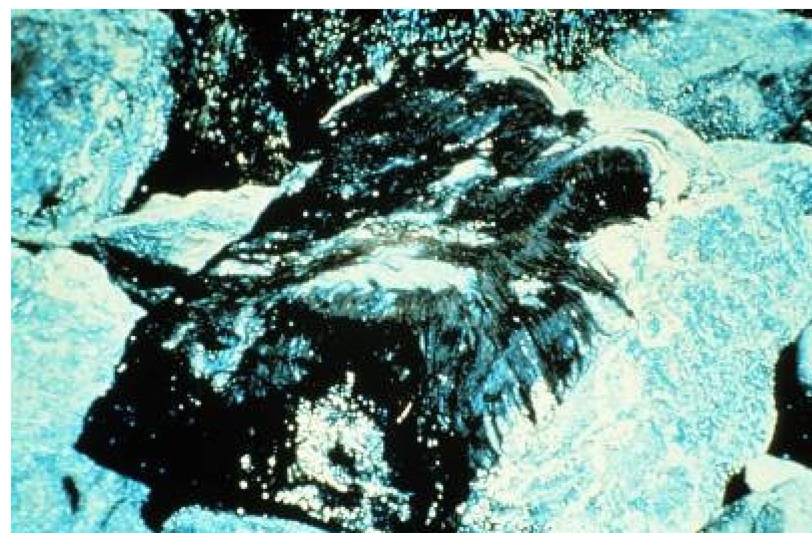
two-dimensional macroscale spatial structure of the habitats
large phylogenetic diversity
ecological diversity (temperature, light, nutrients, salinity)
key global importance (benthic calcification, keystone of marine biodiversity)
three major lineages – **R B G**

Bangiophyceae

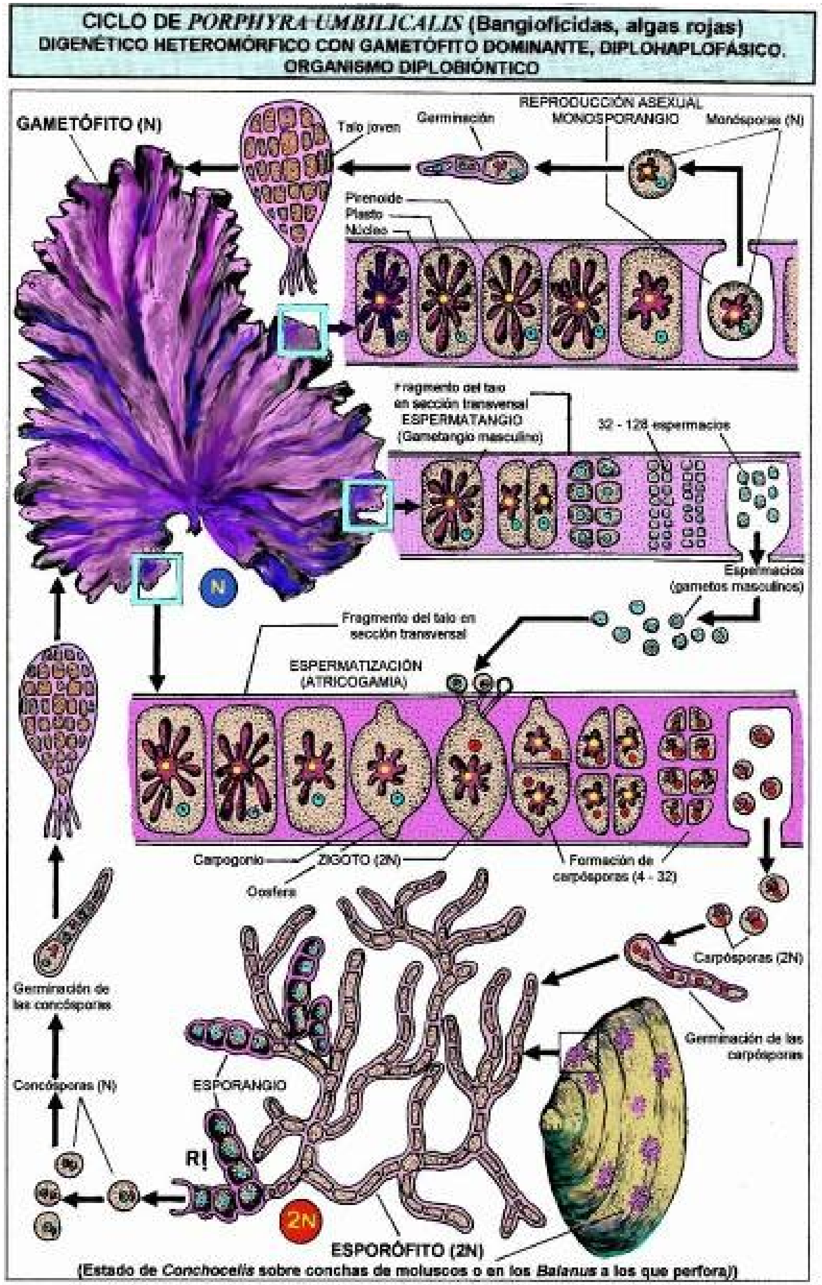
two main traditional genera,
morphological types: *Bangia* and *Porphyra*

"Bangia"





morphological type "***Porphyra***"



(sub-)tropical to subarctic seas

polyphyletic; ca 80 species desribed, so far

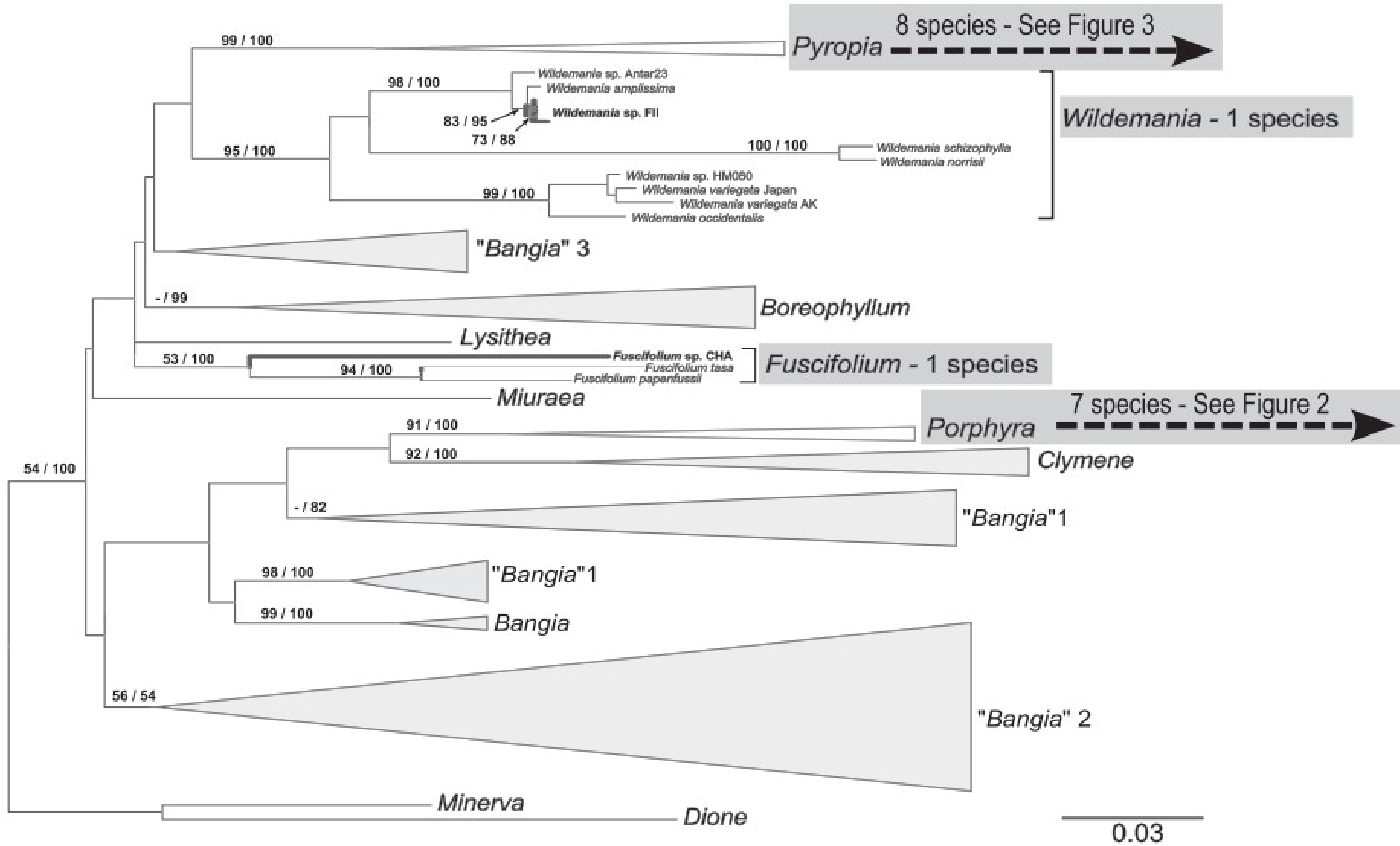
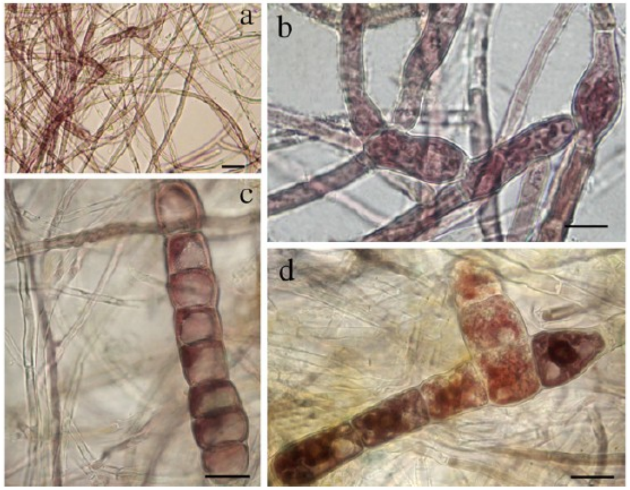
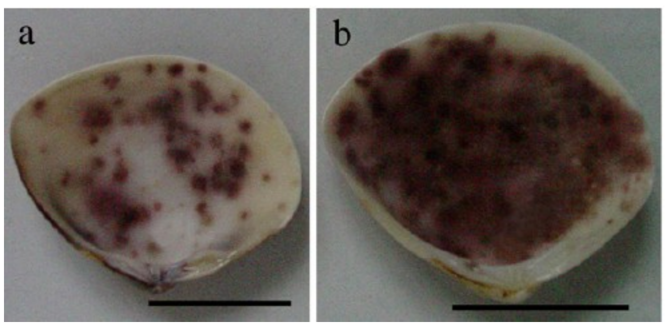


Fig. 1. Maximum Likelihood (ML) rooted tree for *rbc*L sequences (875 bp) of Bangiales. *Minerva* and *Dione* were used as outgroups. For each node, ML bootstrap values and Bayesian Posterior Probabilities are indicated (ML/BPP). Only high support values (>75) are shown; '-' = clade not observed in the Bayesian Inference. Next to collapsed branches are abbreviated genera names (as defined in Sutherland et al., 2011). Species of Chilean foliose Bangiales are shaded in gray. Since only the COI marker was sequenced for the *Porphyra* specimens assigned to the CHD group, only seven Chilean *Porphyra* were actually retrieved in the *rbc*L tree.

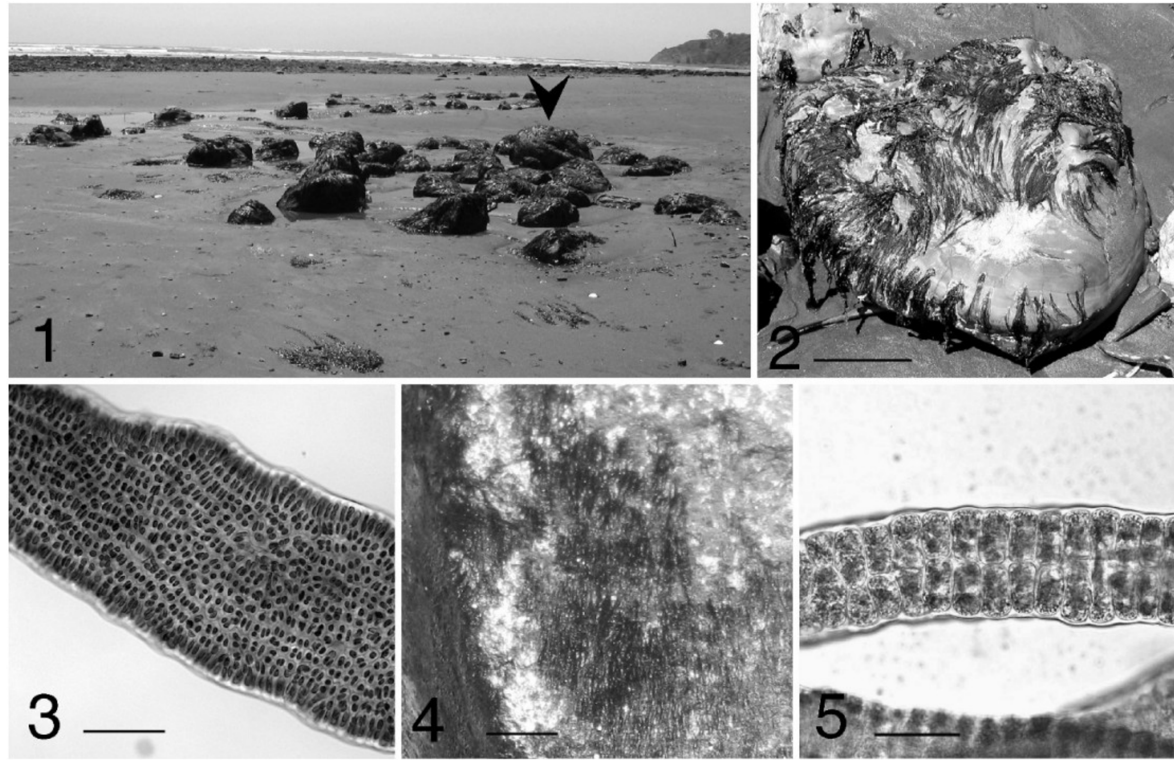
Guillemin et al., 2016, Mol. Phyl. Evol.

marine bangioid lineages





Conchocelis stages, often forming epizoic populations in shells

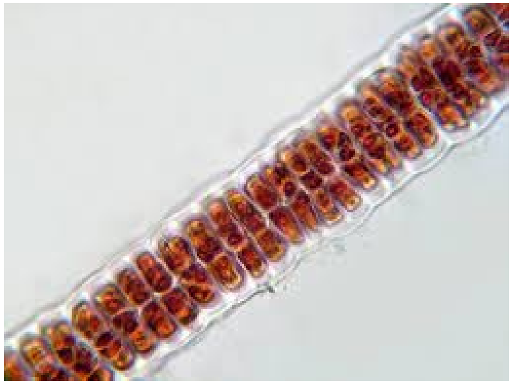


very often in supralittoral

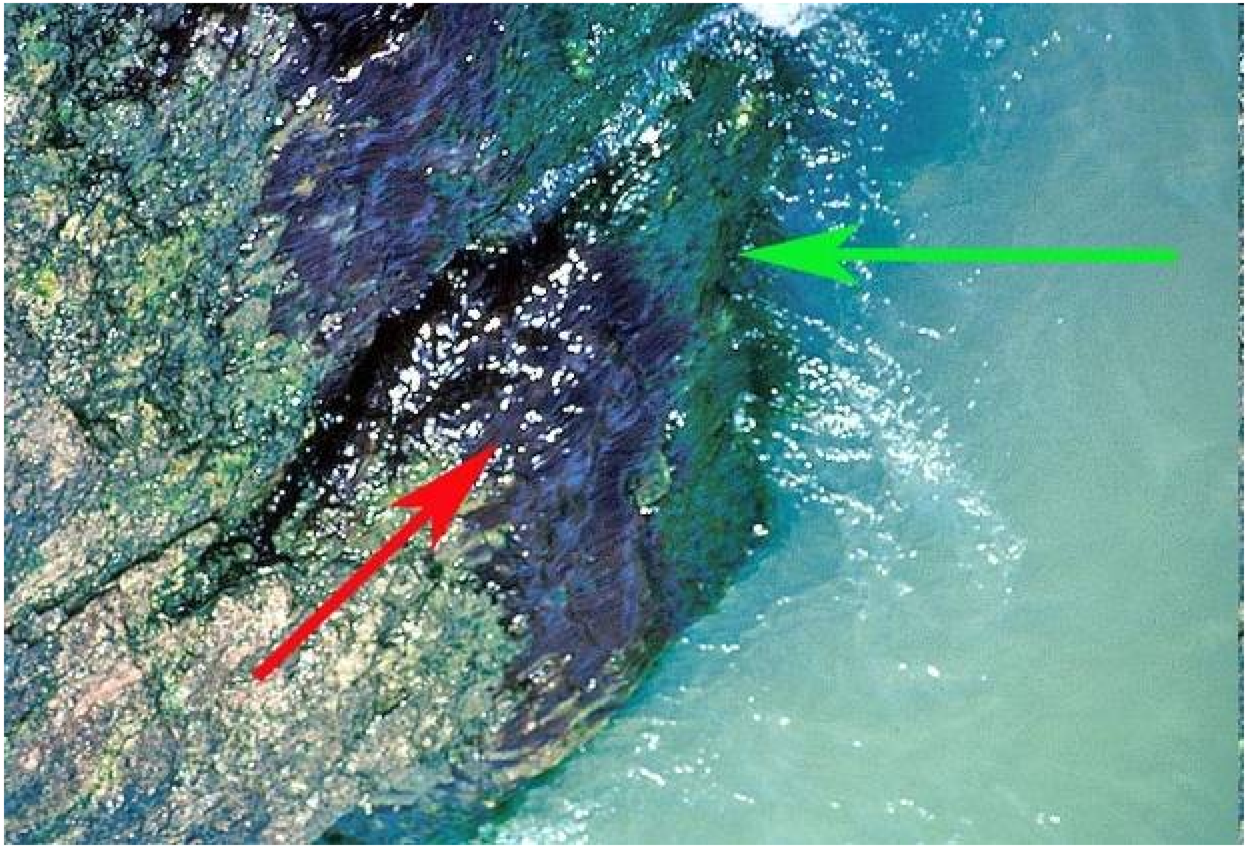
B. fuscopurpurea
ushike-nori [JP]
hangmaocai [CN]

Lynch et al., 2008, Phycologia
Wang et al., 2008, Aquaculture

freshwater *Bangia* (*B. atropurpurea*)

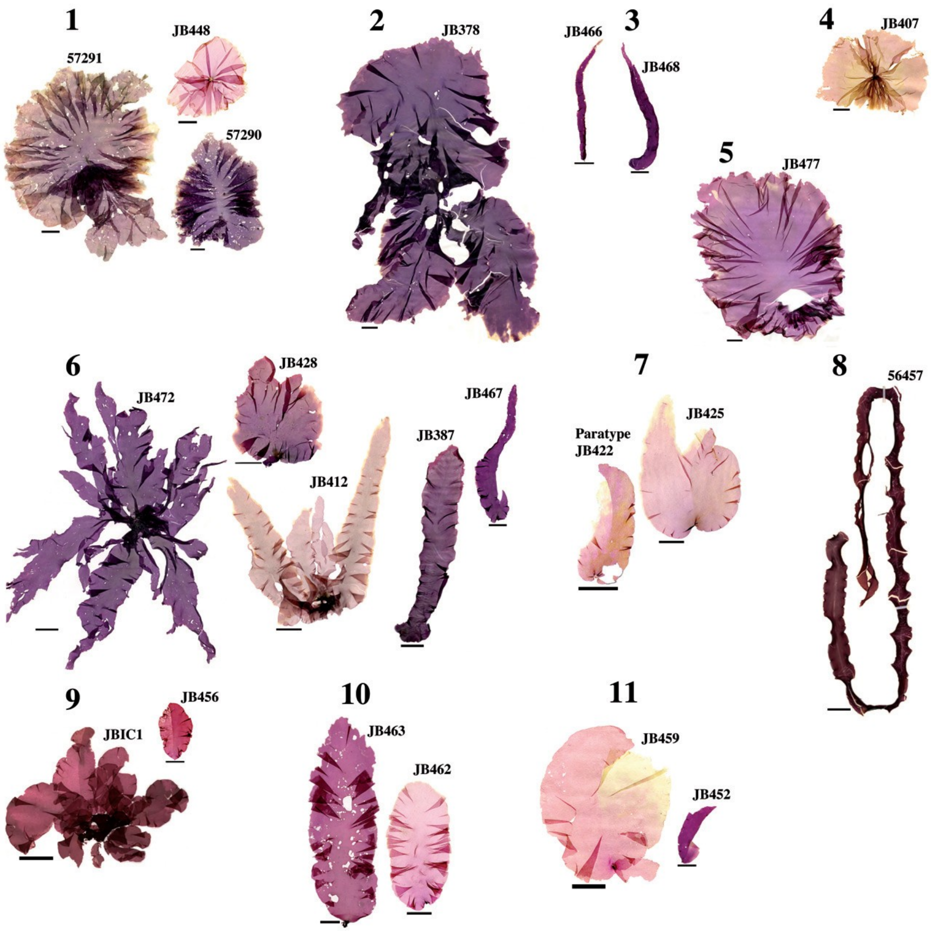


a frequent member of phytobenthos in large oligotrophic lakes (Ohrid Lake, Lago di Garda)



an invasive species in some lakes (e.g. Lake Erie)

marine porphyroid genera



Boreophyllum, Porphyra, Pyropia, Wildemania

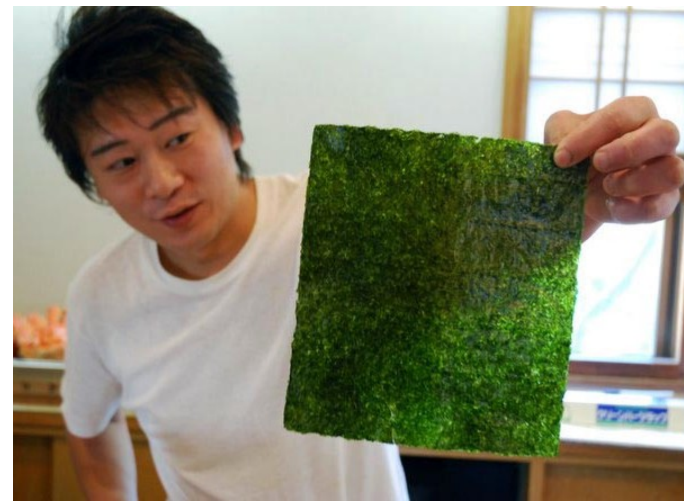
relatively homogeneous vegetative morphology across genera

profound plasticity

Mols-Mortensen et al., 2012, Eur. J. Phycol. 47 aquacultures of porphyres

E Asia –gametophyte harvest after ca 45 days from seeding

nori (JP), hai-tai (CH), gim (KR):
– *P. yezoensis, P. tenera*



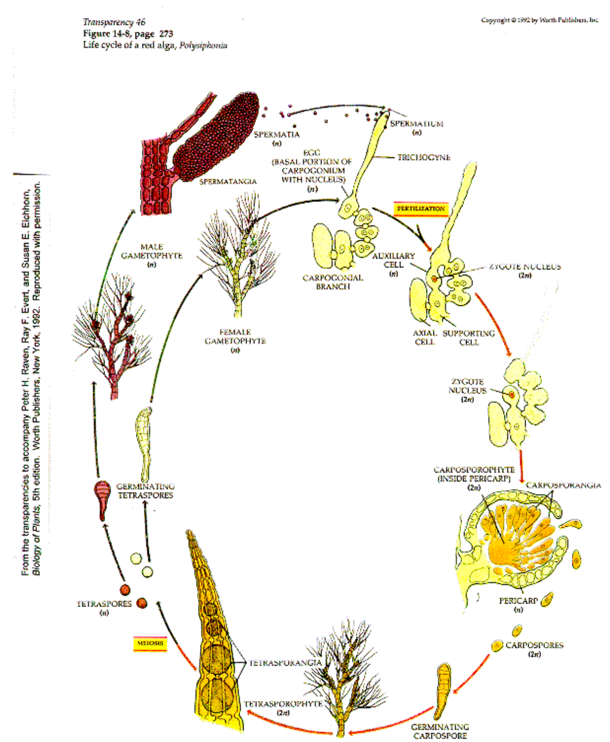
„seeding" of conchospores

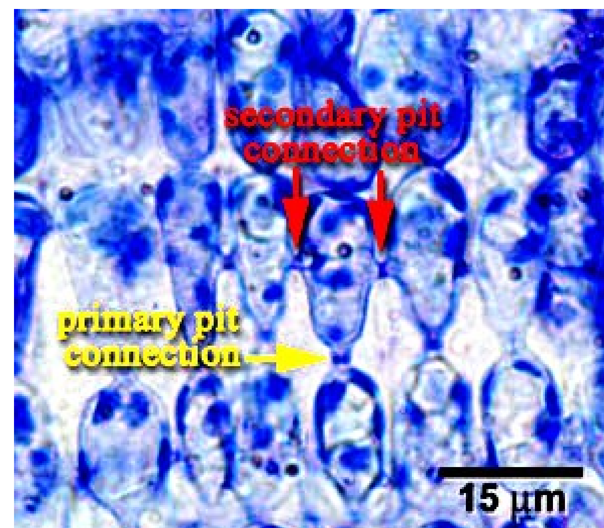
Florideophyceae

five subclasses:
Hildebrandiophycideae
Nemaliophycideae
Corallinophycideae
Ahnfeltiophycideae
Rhodymeniophycideae

age: fossils – ca 600 mya,
recent genera – up to 350 mya

ca 5500 species described, mostly marine

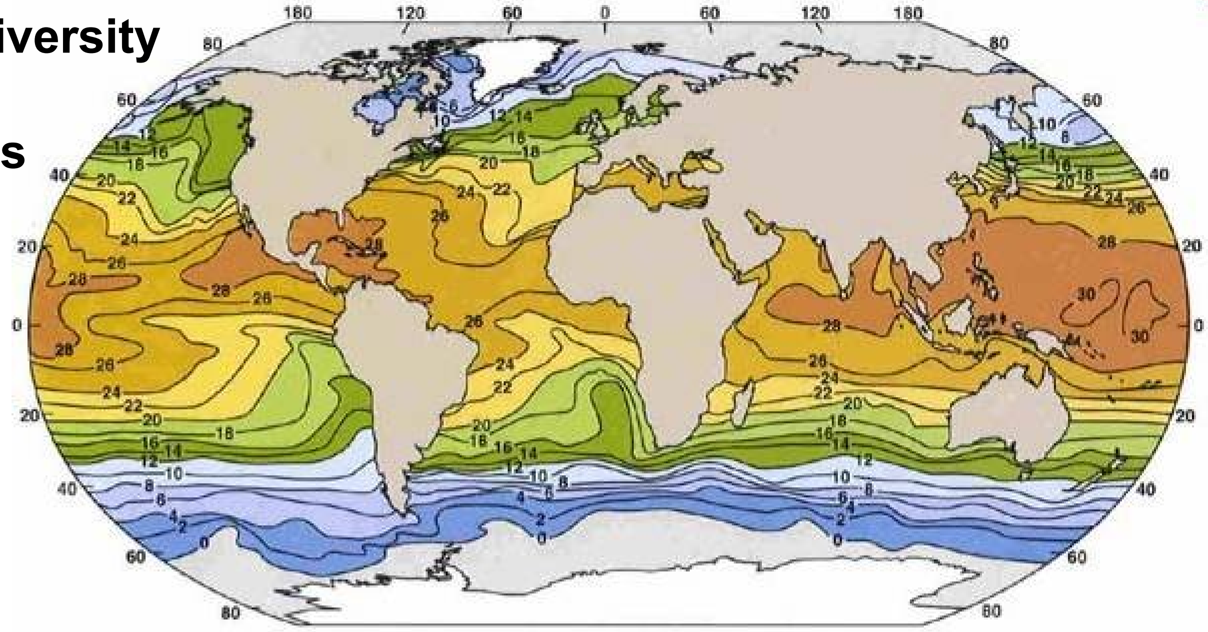




typical oogamy, pit connections

Most of the florideophycean diversity is found in tropical and subtropical marine ecosystems

(= pronounced latitudinal diversity gradient)
- it is primarily related to SST (sea surface temperature)



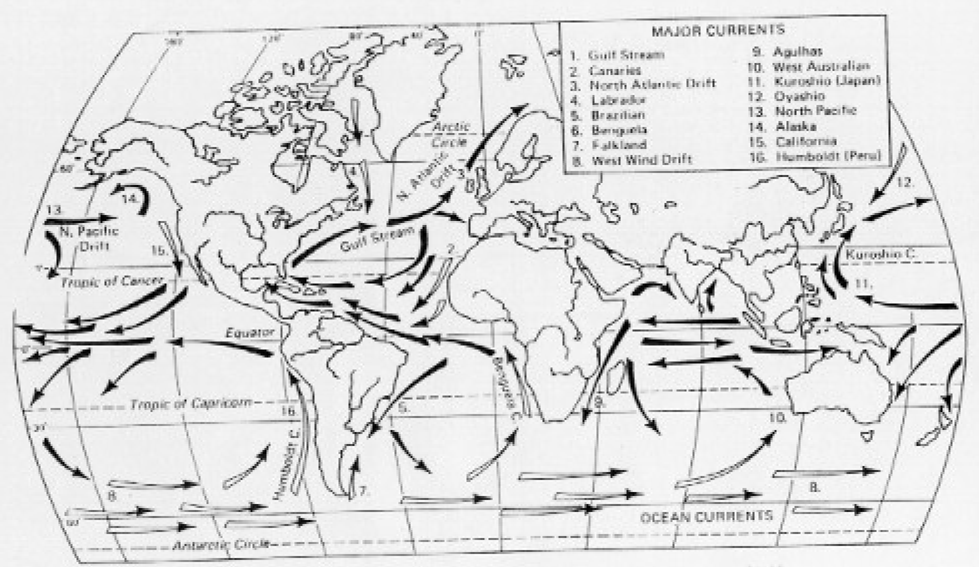
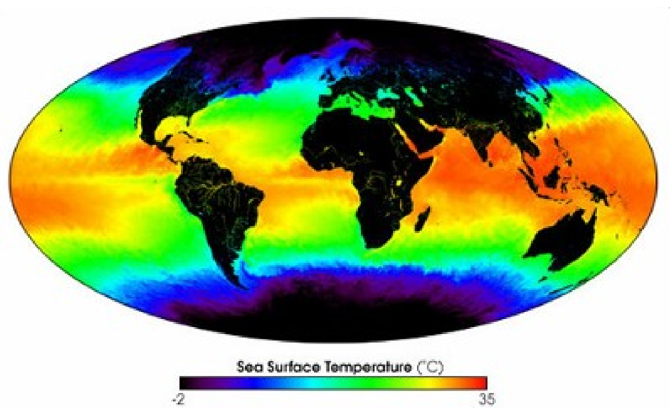


FIGURE 3-9 Major ocean currents. Warm currents are shown by dark arrows and cold currents by open arrows. (After J. B. Hoyt, *Man and the Earth*, 3rd ed., © 1973 by Prentice-Hall, Inc., reprinted by permission of the publisher.)



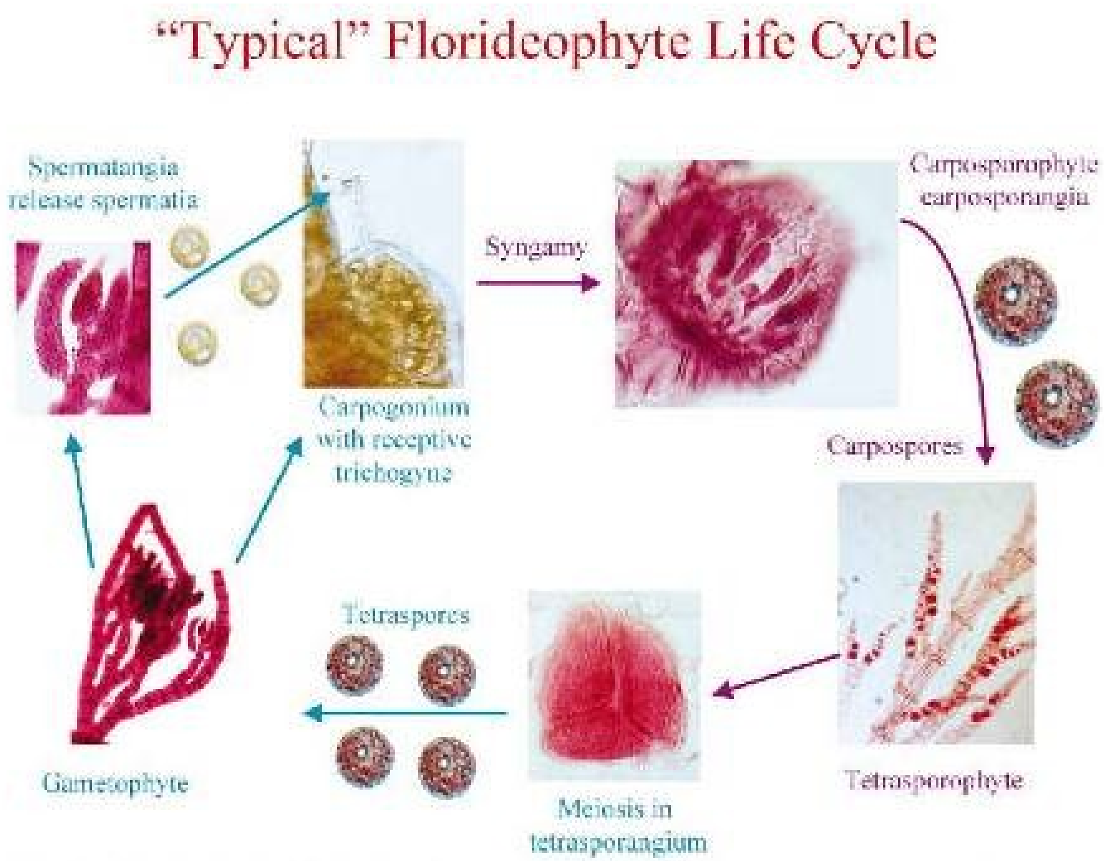
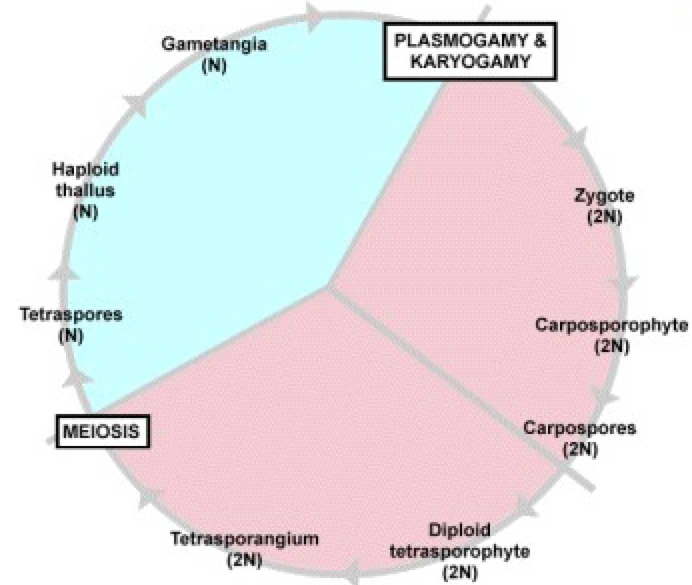
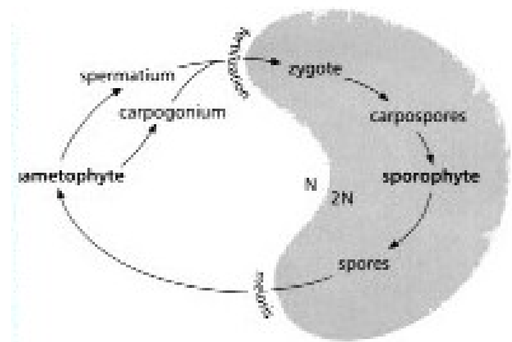
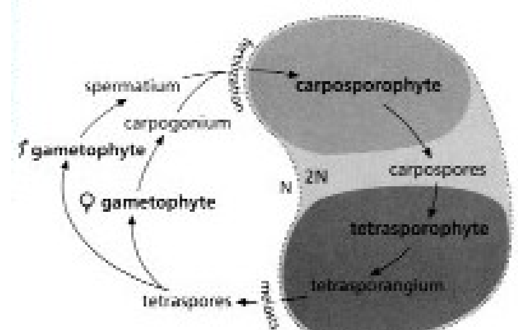


Fig. 3. A generic look at the "typical," albeit remarkable, florideophyte life history. Blue and purple text and arrows represent haploid and diploid stages, respectively. Consult text for a description of the structures.

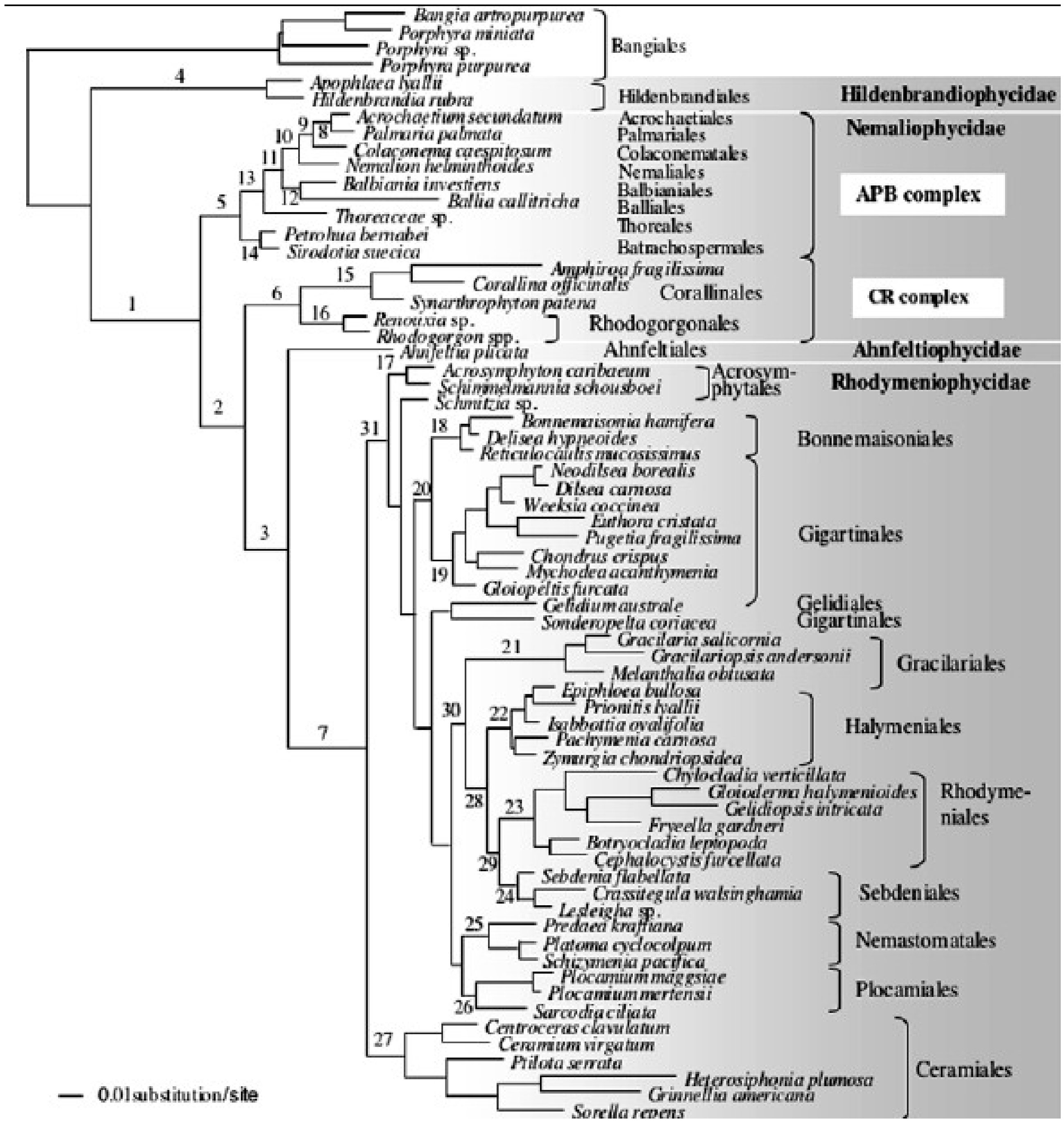






triphasic life cycle is considered evolutionarily derived

florideophycean phylogeny



EF2 at the amino acid level + SSU + LSU

Le Gall & Saunders, 2007, Mol Phyl Evol

Taxonomic structure of Florideophyceae

5 subclasses *(current no. species)*:

Hildenbrandiophycidae *(19)*

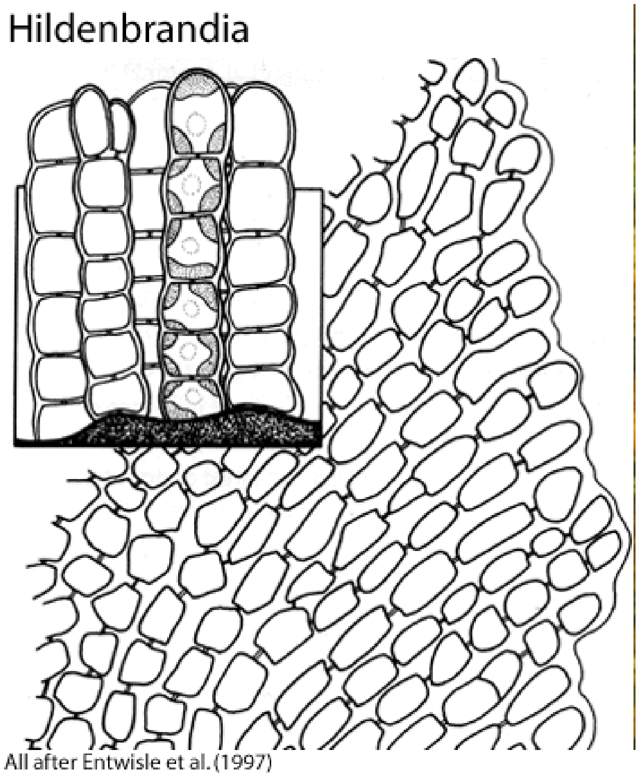
Ahnfeltiophycidae *(12)*

Nemaliophycidae *(ca 900)*
[selected orders: Batrachospermales, Nemaliales, Thoreales]

Corallinophycidae *(ca 900)*
[selected orders: Corallinales, Sporolithales, Hapalidiales]

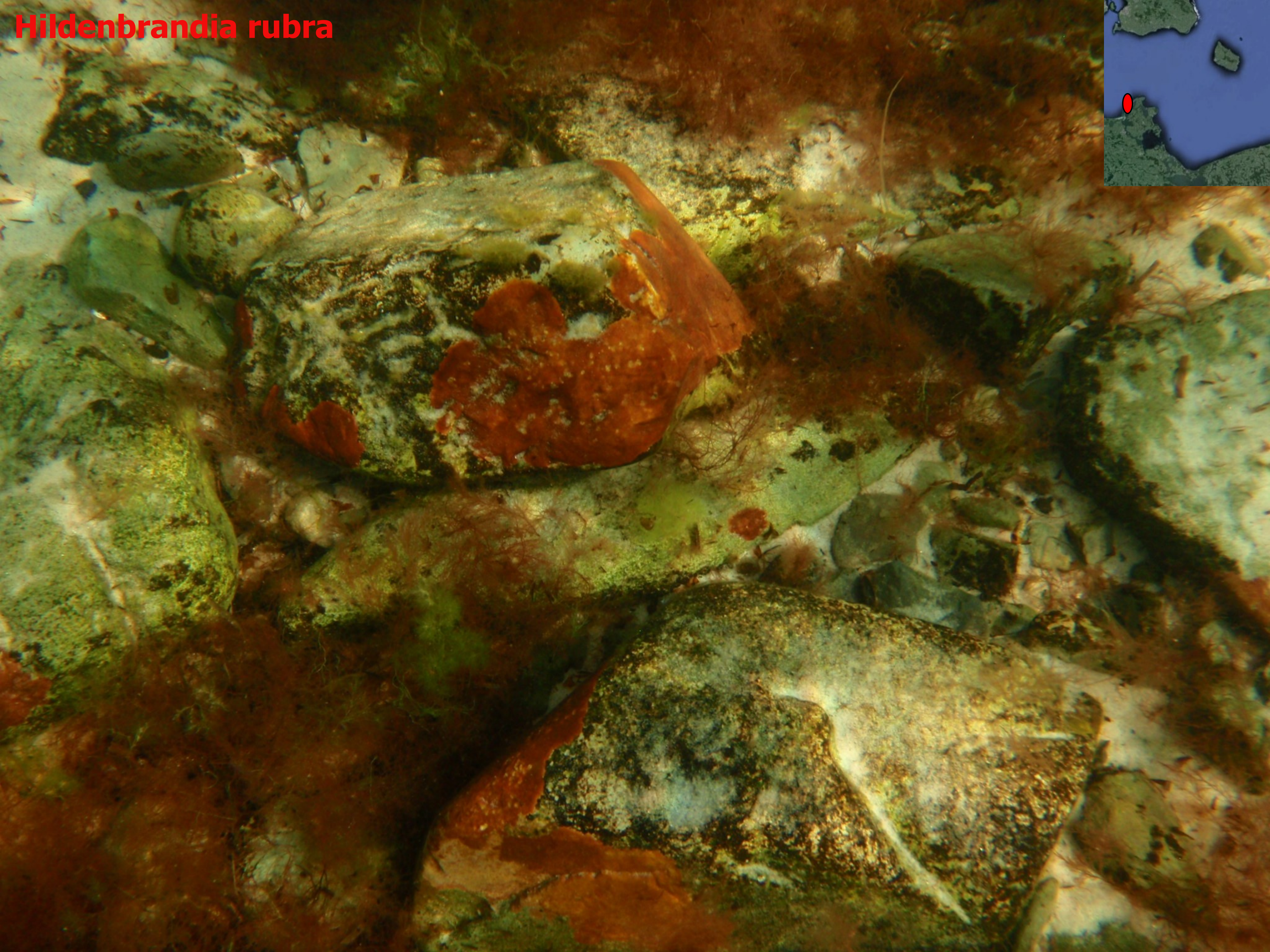
Rhodymeniophycidae *(ca 5300)*
[selected orders: Ceramiales, Gelidiales, Gracilariales, Gigartinales, Halymeniales, Plocamiales, Rhodymeniales]

Hildenbrandiophycidae

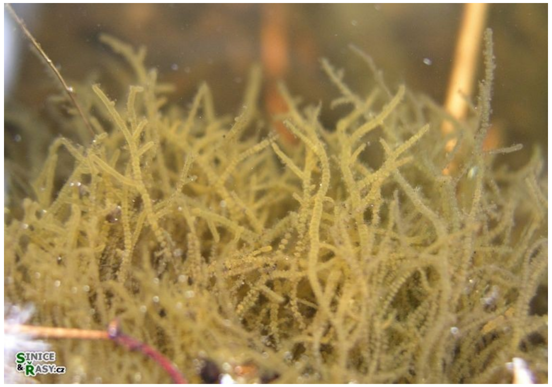


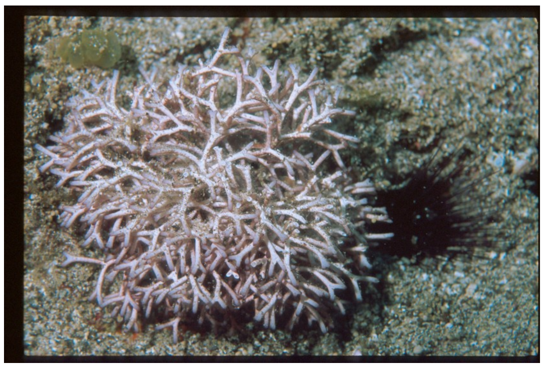
originated in marine habitats
probably just a single transition into the freshwater (*H. rivularis*)

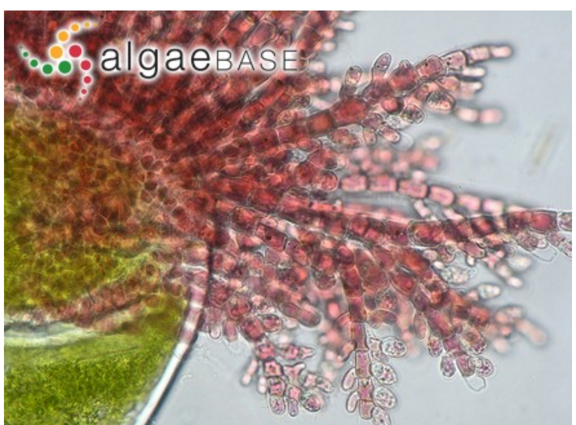
asexual reproduction: tetrasporangia in marine species, *gemmae* in freshwater *H. rivularis*
sexual reproduction also present

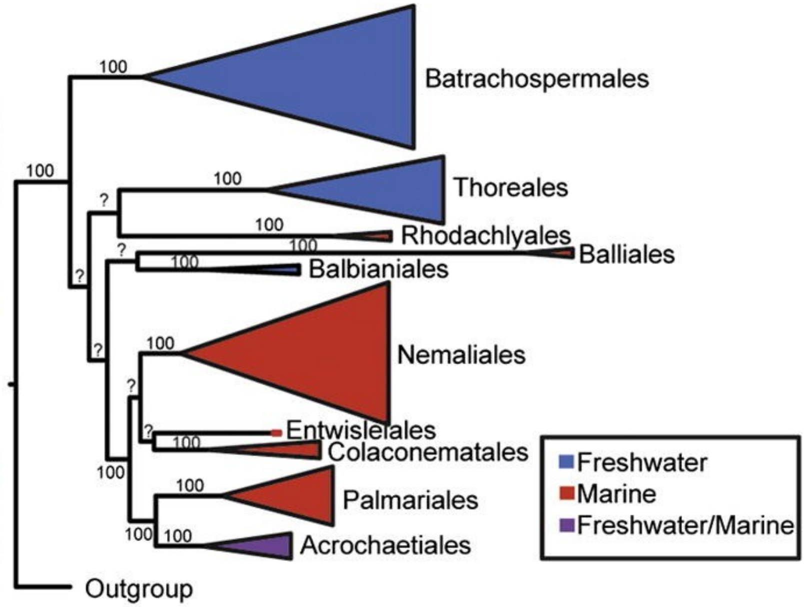

Hildenbrandia rubra

Nemaliophycidae







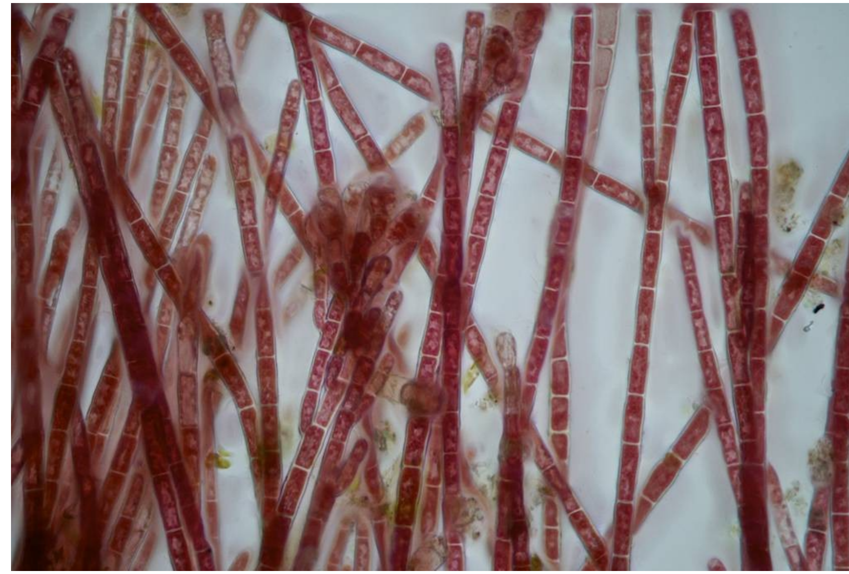


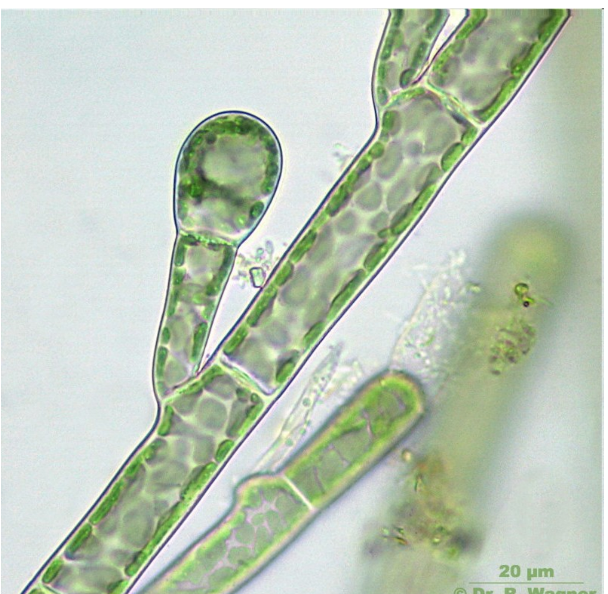
most freshwater red algae belong to this lineage

Lam et al., 2016, Mol. Phyl. Evol.
algaebase.org
sinicearasy.cz

uniseriate filamentous genera
- freshwater and marine

Audouinella (= Chantransia) + Rhodochorton





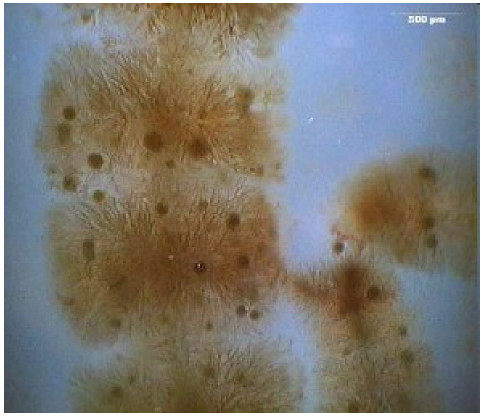
relatively tolerant
to pollution
(e.g. lower portions
of Vltava river)

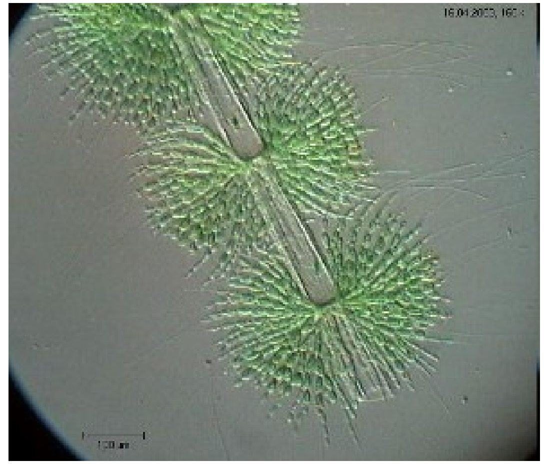
seaweed.ie

Audouinella has many freshwater species
morphologically it is very similar to sporophyte stages of genera *Batrachospermum* and *Lemanea*

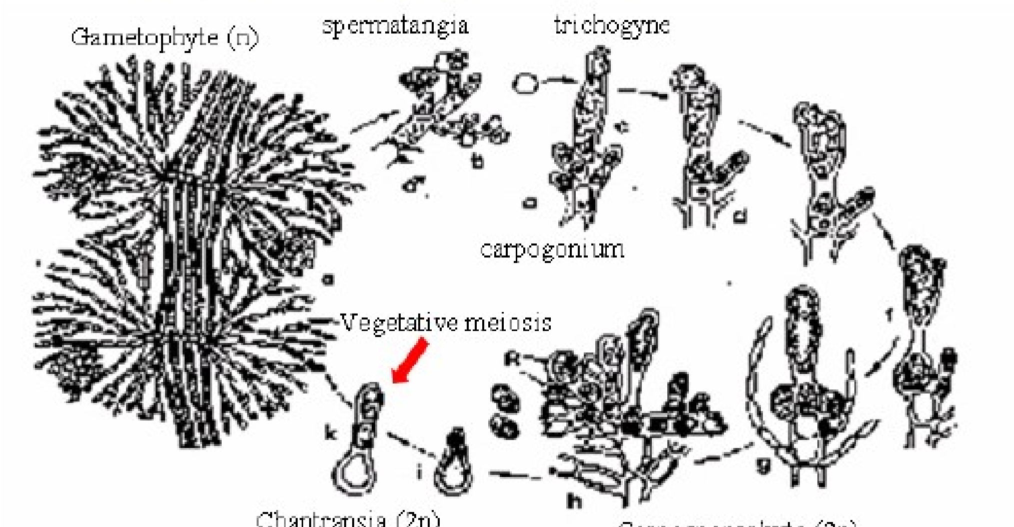
Batrachospermales – the main freshwater red algal lineage

Batrachospermum



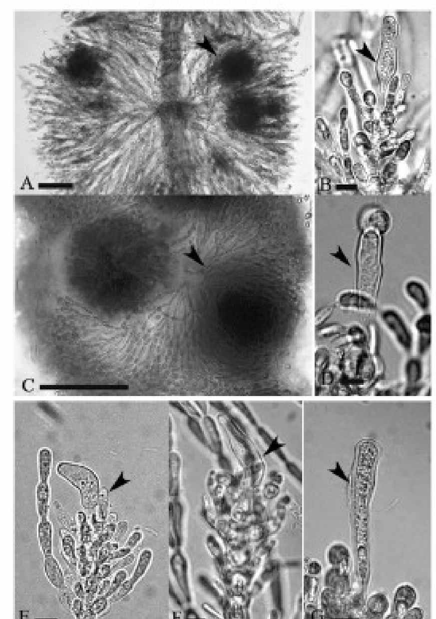


Life history of *Batrachospermum*. The macroscopic gametophyte produces male reproductive cells, spermatangia, and/or female reproductive structures, carpogonia. A spermatium fertilizes the carpogonium by attaching to the trichogyne. Following fertilization, a carposporophyte develops from the carpogonium. The carposporophyte produces carpospores, which germinate into the microscopic, filamentous chantransia. Vegetative meiosis occurs in the apical portions of the chantransia filaments, and a new haploid gametophyte is produced.
(Adapted from http://www.pmf.unsa.ba/biologija/talofiti/rhodophyta4.jpg.)



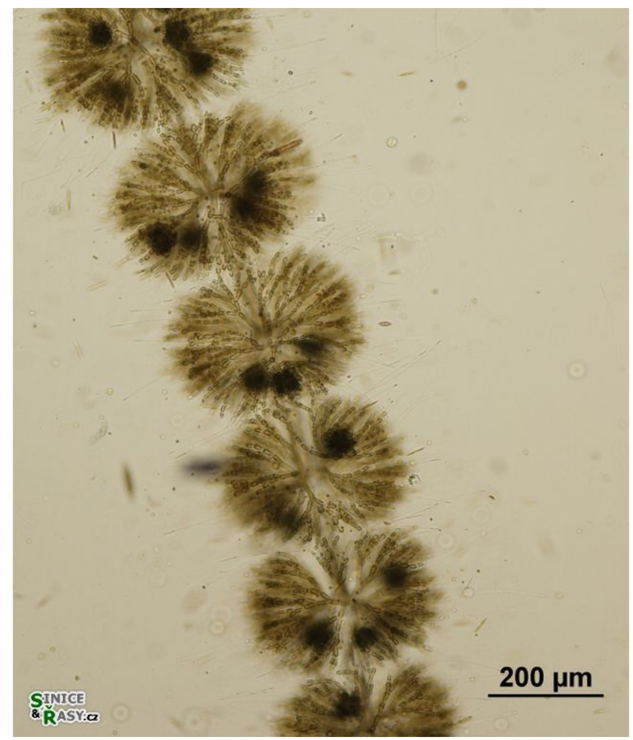
Stewart, 2006

Salient features of *Batrachospermum* species investigated: A. *B. pseudogelatinosum* (NZ1), axial cells and fascicle whorls with prominent, globose carposporophytes (arrowhead). Scale bar = 120 µm. B. *B. pseudogelatinosum* (NZ1) trichogyne, showing a variant that resembles *B. gelatinosum*. Scale bar = 8 µm. C. *B. campyloclonum* (NZ150), showing fascicle whorl with large, globose carposporophytes. Scale bar = 150 µm. D. *B. campyloclonum* clavate trichogyne. Scale bar = 7µm. E. *B. kraftii* (NZ7) showing characteristic scimitar-shaped trichogyne. Scale bar = 9 µm. F. *B. bourrellyi* (TJE3280) showing contorted or bent trichogyne. Scale bar = 10 µm. G. *B. theaquum* (TJE3050a) showing elongate, club-shaped trichogyne. Scale bar = 12 µm.



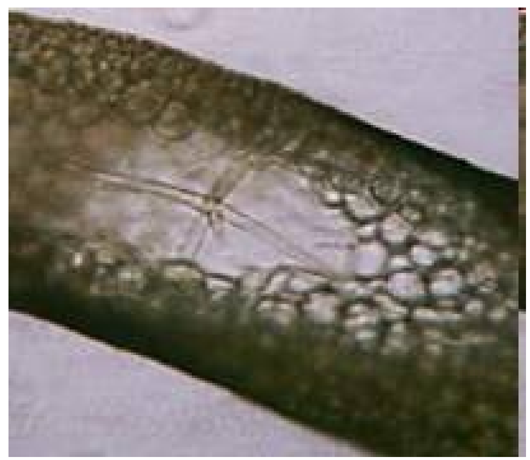

500 µm
SINICE & ŘASY.cz


SINICE & ŘASY.cz


200 µm
SINICE & ŘASY.cz

Lemanea

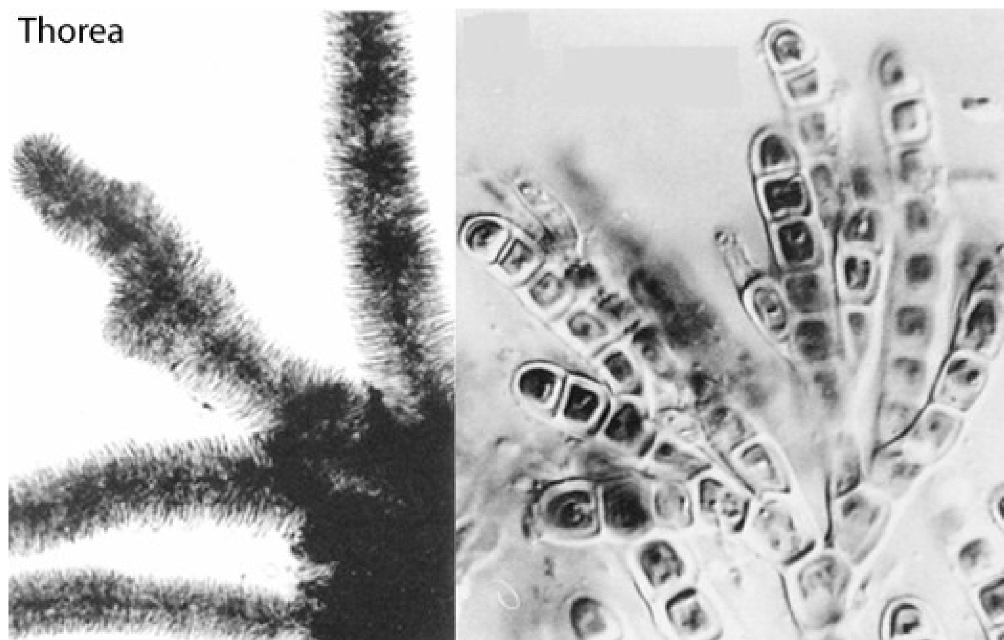
cortex



central filament with whorls of secondary branches

Thoreales
the second freshwater order

Thorea



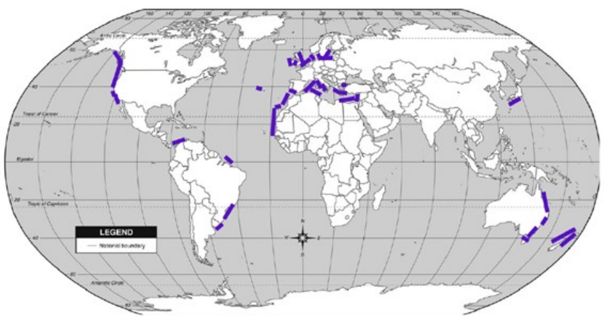
After Entwisle et al. (1999a)

Nemaliales

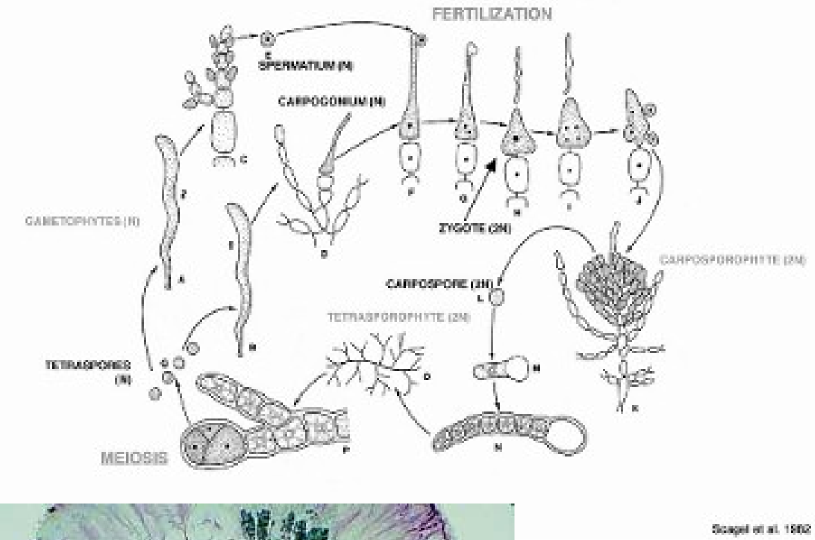
Nemalion

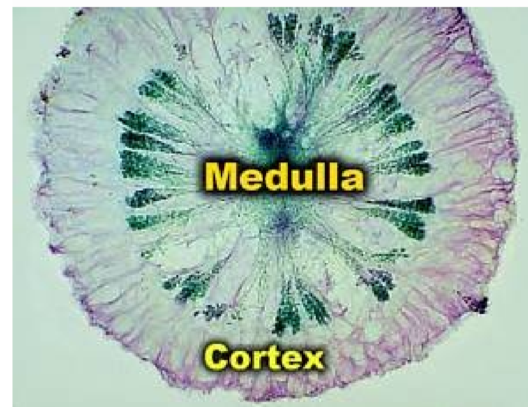
marine algae
often in supralittoral

(= emersed for the most time = subatmophytic life strategy)



N. helminthoides





Galaxaura

calcified marine lineage from subtropical and tropical habitats

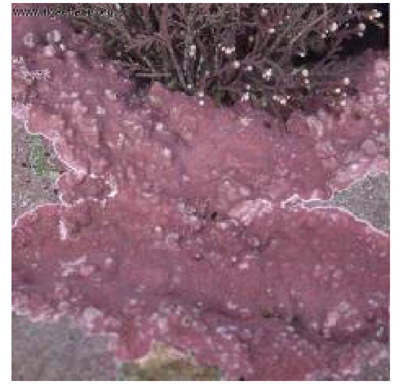
invasive in the E Mediterranean

G. rugosa
(photo: S Africa

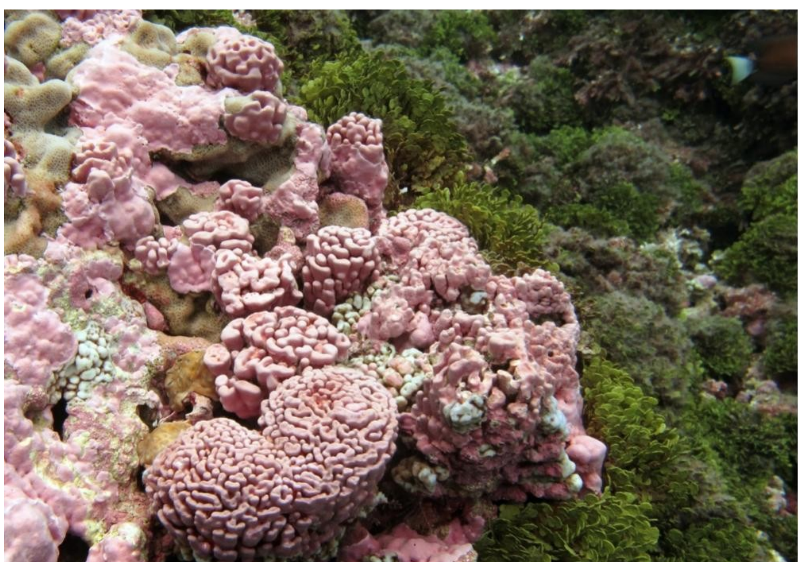
Corallinophycideae

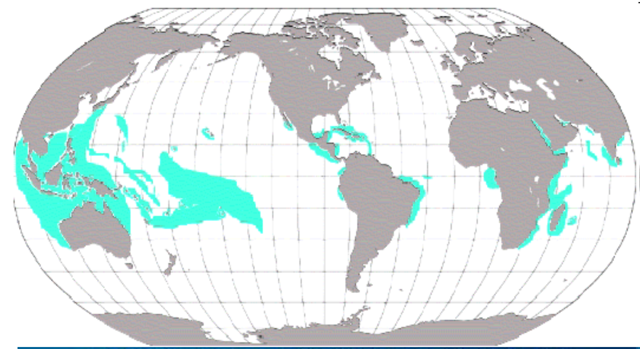
("coral red algae", "coralline red algae", "calcareous red algae", "CCA")

calcification (= biomineralization)
[biogenic calcite production]



rhodolites

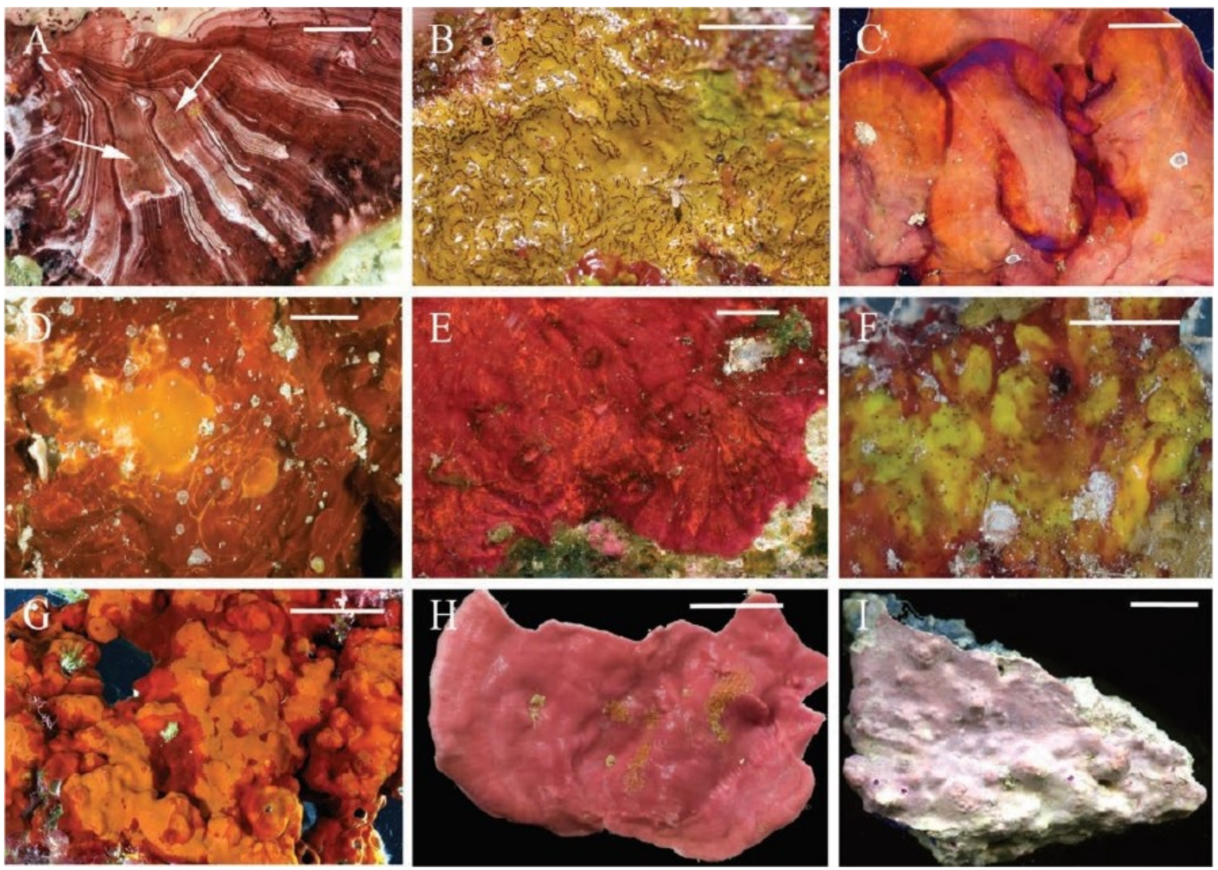


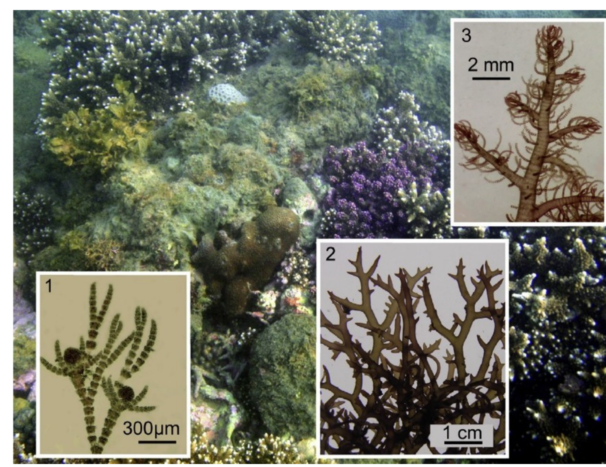


coralline red algae are one of the key components of coral reef ecosystems

coralline red algae of coral ecosystems

- key agent in cementation of the reefs
- dominant especially in mesophotic habitats
- high diversity with significant proportion of undescribed taxa
- facilitating distribution of multiple other non-calcified red algae





Loya et al., 2019,
Mesophotic Coral Ecosystems

Titlyanov et al., 2017

rhodolith beds [red algal ocean floor]

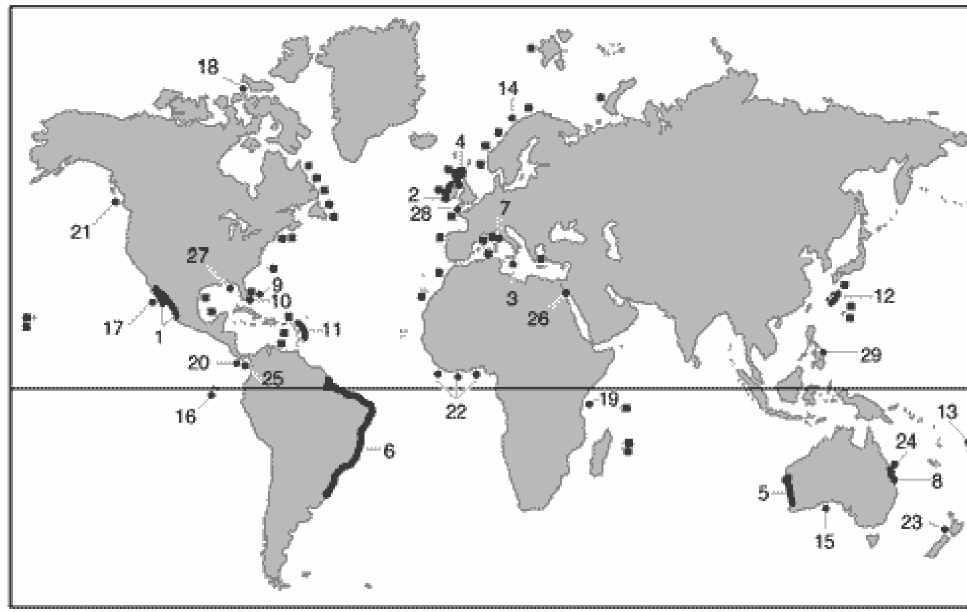


FIG. 4. The world distribution of living rhodolith beds. Squares are from map in Bosence (1983b; see for these references). Circles indicate locations of individual beds, and dark bands indicate large, continuous beds or numerous individual beds not included on the Bosence (1983b) map. No beds have been reported from Antarctica. Personal communication followed by more precise locations. 1. Foster et al. 1997, M. Foster, D. Steller & R. Riosmena, personal observation (eastern Gulf of California). 2. De Grave et al. 2000. 3. Borg et al. 1998 (Malta). 4. D. Donnan, Scottish Natural Heritage, personal communication (north & west Scotland). 5. James et al. 1999. 6. Kempf 1970, Milliman 1977. 7. Basso 1998. 8. Harris et al. 1996. 9. Littler et al. 1991. 10. Prager & Ginsburg 1989. 11. Reid & Macintyre 1988. 12. Tsuji 1993. 13. Scoffin et al. 1985. 14. Freiwald & Henrich 1994. 15. H. Kirkman, United Nations—East Asian Seas Regional Coordinating Unit, personal communication (Great Australian Bight). 16. C. Rigaud, Moss Landing Marine Laboratories, personal communication (Galapagos). 17. J. Harding, University of California at Santa Cruz, personal communication (Isla Cedros). 18. J. Oliver, Moss Landing Marine Laboratories, personal communication (Devon Island). 19. J. Waterbury, Woods Hole Oceanographic Institution, personal communication (Zanzibar). 20. T. Schaeffer, Moss Landing Marine Laboratories, personal communication (Costa Rica). 21. P. Thuringer, Archipelago Marine Research Ltd., personal communication (Queen Charlotte Islands). 22. Reviewed in John & Lawson 1991. 23. D. Schiel, University of Canterbury, personal communication (Kapiti Island). 24. A. Larkum, University of Sydney, personal communication (One Tree Reef). 25. Glynn 1974. 26. Piller & Rasser 1996. 27. McClintock et al. 1993. 28. Farnham & Bishop 1985. 29. D. James, Moss Landing Marine Laboratories, personal communication (Camiguin Island).

Riosmena-Rodríguez et al., 2017
Rhodolith Beds, Springer

two basic life forms - geniculate and non-geniculate coralline algae

non-calcified *geniculae*
typical erect and branched morphology

typical crustose or rhodolithic morphology

taxonomic structure of coralline red algae

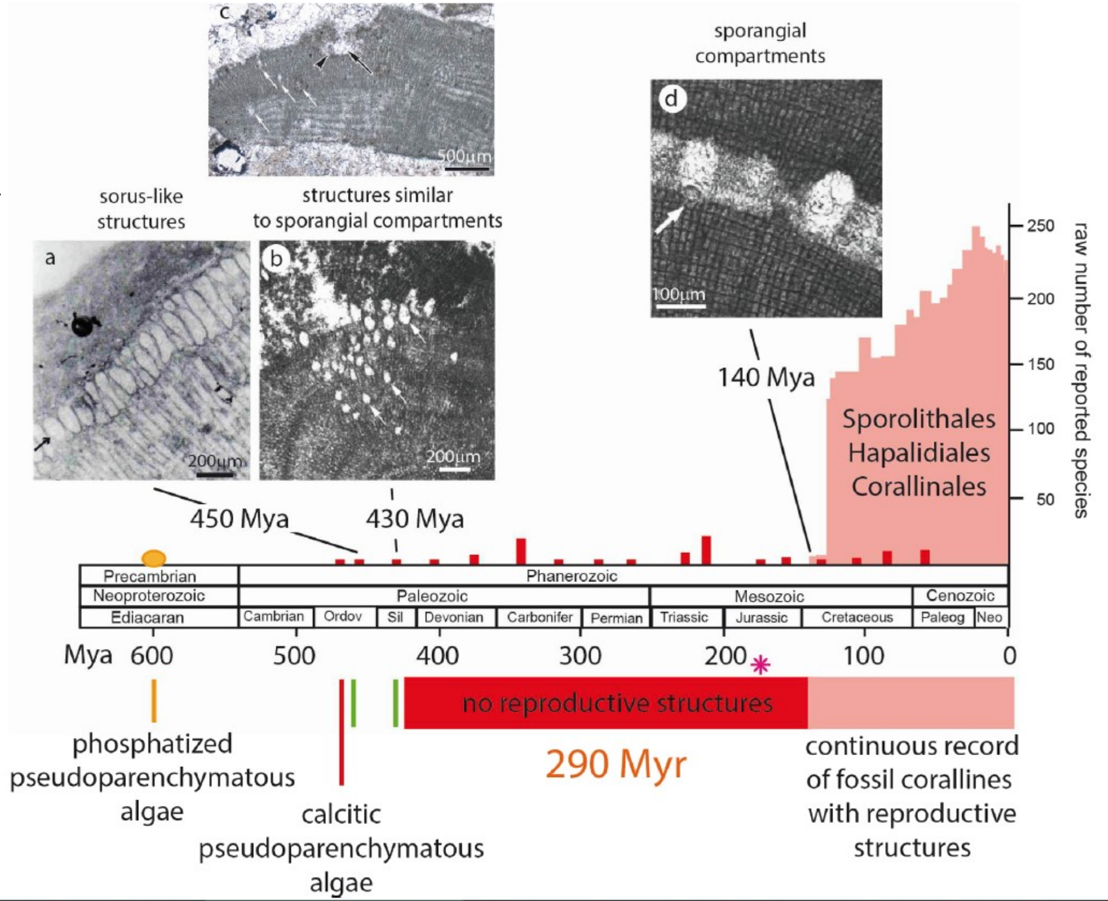
Corallinales (ca 830 species) (Corallina, Jania, Phymatolithon, Hydrolithon, etc.)
both geniculate and non-geniculate

Sporolithales (60) (*Heydrichia, Sporolithon*)
non-geniculate

Rhodogorgonales (ca 20)

Corallinapetrales (2) non-geniculate

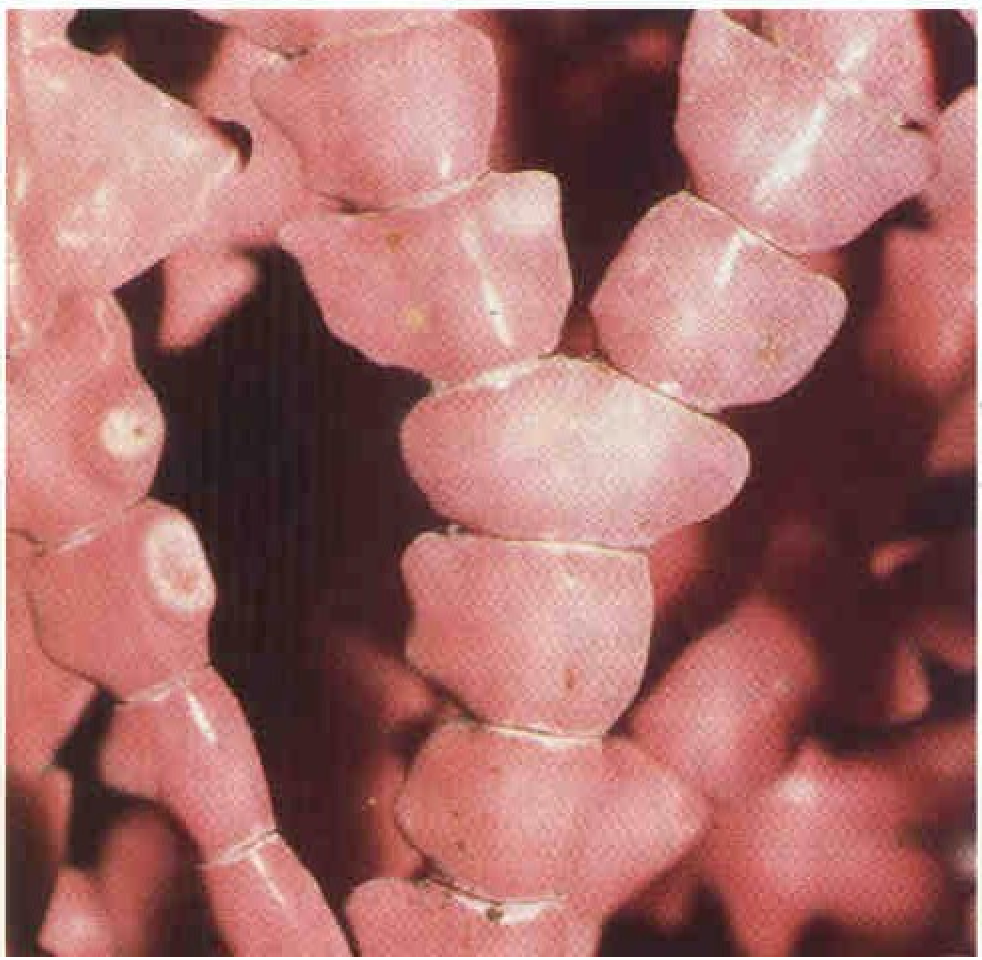
evolutionary timeline

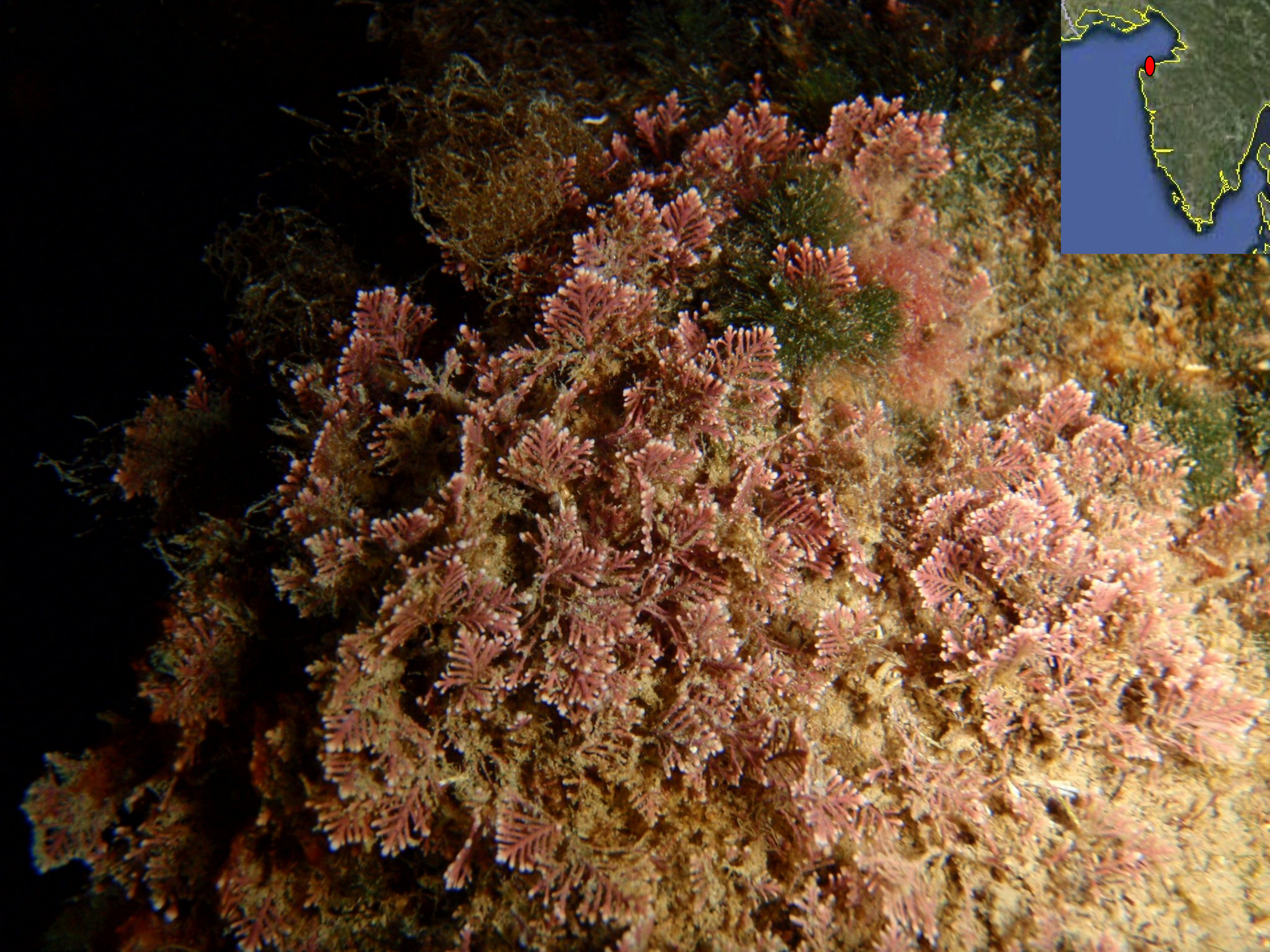


Pena et al., 2020, Mol. Phyl. Evol.

Corallina

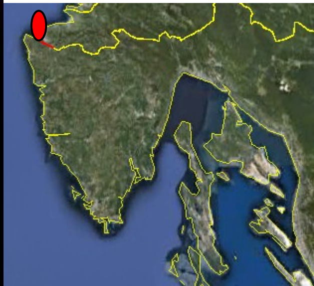
subtropical and temperate seas world-wide



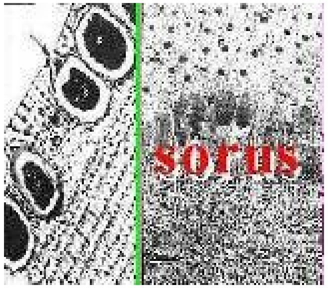


Jania

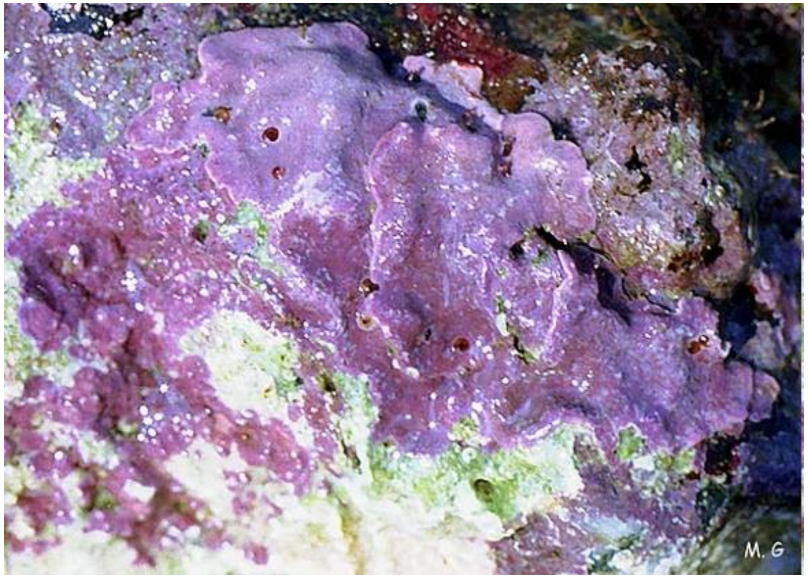
- dichotomically branched thalli
- cylindrical segments



non-geniculate corallines



Sporolithon

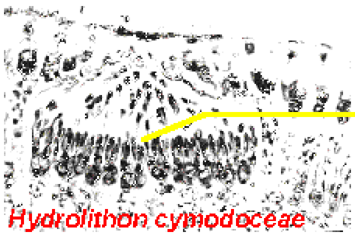


Lithophyllum

coral reefs, atoles – tropical Pacific and Carribean Sea

Hydrolithon

Hydrolithon

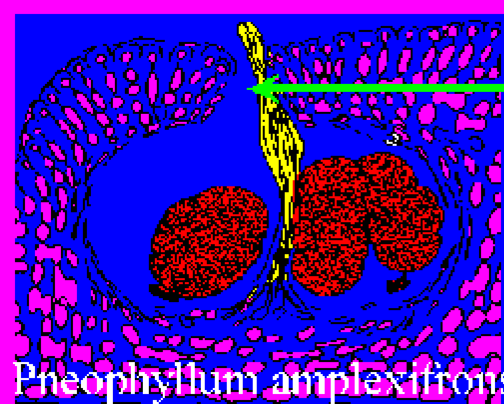


Simple spermatangial systems borne only on the floor of the male conceptacle

Hydrolithon

Pore canals of tetrasporangial conceptacles lined by a ring of conspicuous, elongate cells

Mastophoroideae



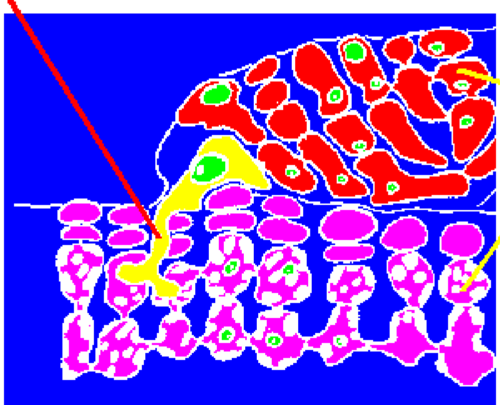
Tetrasporangial/ bisporangial conceptacles uniporate

atoles, coral reefs

Lithophyllum and *Ezo*

Haustorial cell

Ezo

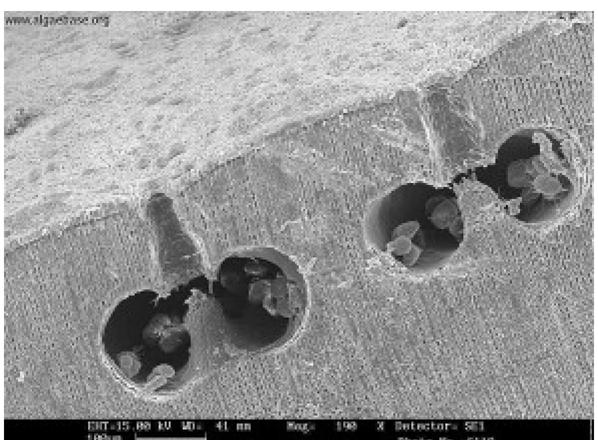


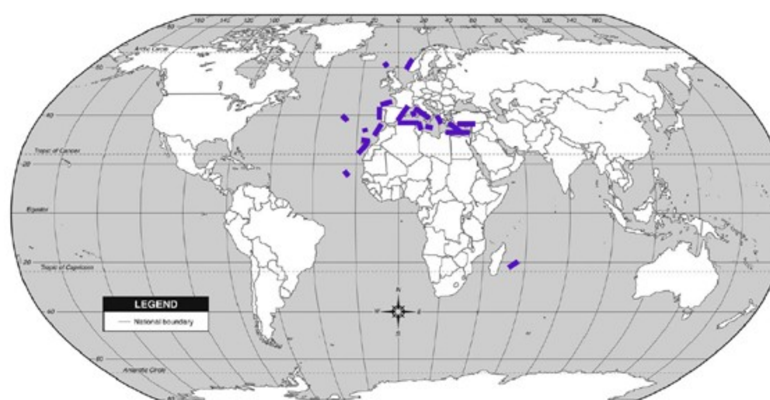
Ezo

Litho-phyllum

Lithophylloideae

Tetrasporangial/ bisporangial conceptacles uniporate





L. incrustans

Rhodymeniophycideae – typical "bushy" macroscopic marine red algae

multiple orders, such as:

Ceramiales, Gelidiales, Gigartinales, Gracilariales, Halymeniales, Plocamiales, Rhodymeniales, etc.

- they are almost entirely marine algae (except for *Caloglossa* in Delesseriaceae, Ceramiales)

- they are almost entirely non-calcified (except for several species in *Peyssonnelia*)

- a lot of perennial macroalgae but some important taxa are secondarily simplified to ephemerous filamentous morphology (e.g. *Callithamnion*, *Aglaothamnion* in Ceramiales)

- parasitic lineages in Ceramiales - typical for adelphoparasitism

- pronounced latitudinal diversity gradient

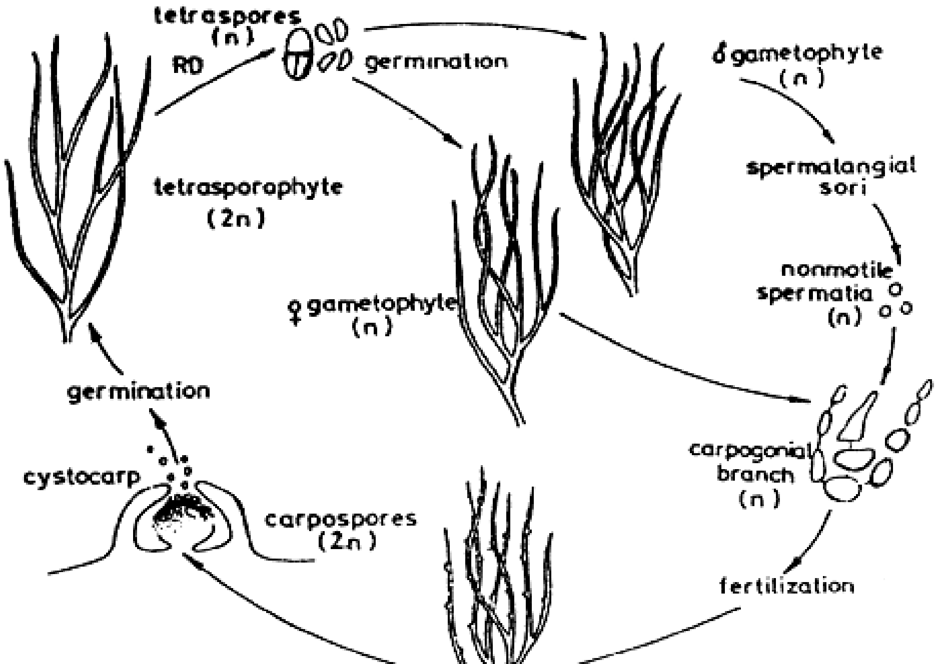
- higher proportion on marine vegetation with increasing depth

- several key invasive taxa in marine coastal habitats (e.g. *Asparagopsis, Bonnemaisonia*)

- multiple taxa used as food source (e.g. Gracilaria, Gelidium, Plocamium) but others are often poisonous

- key genera for agar and karagen production (e.g. *Gelidium, Pterocladiella, Furcellaria, Coccotylus*)

Gracilaria, Gracilariopsis

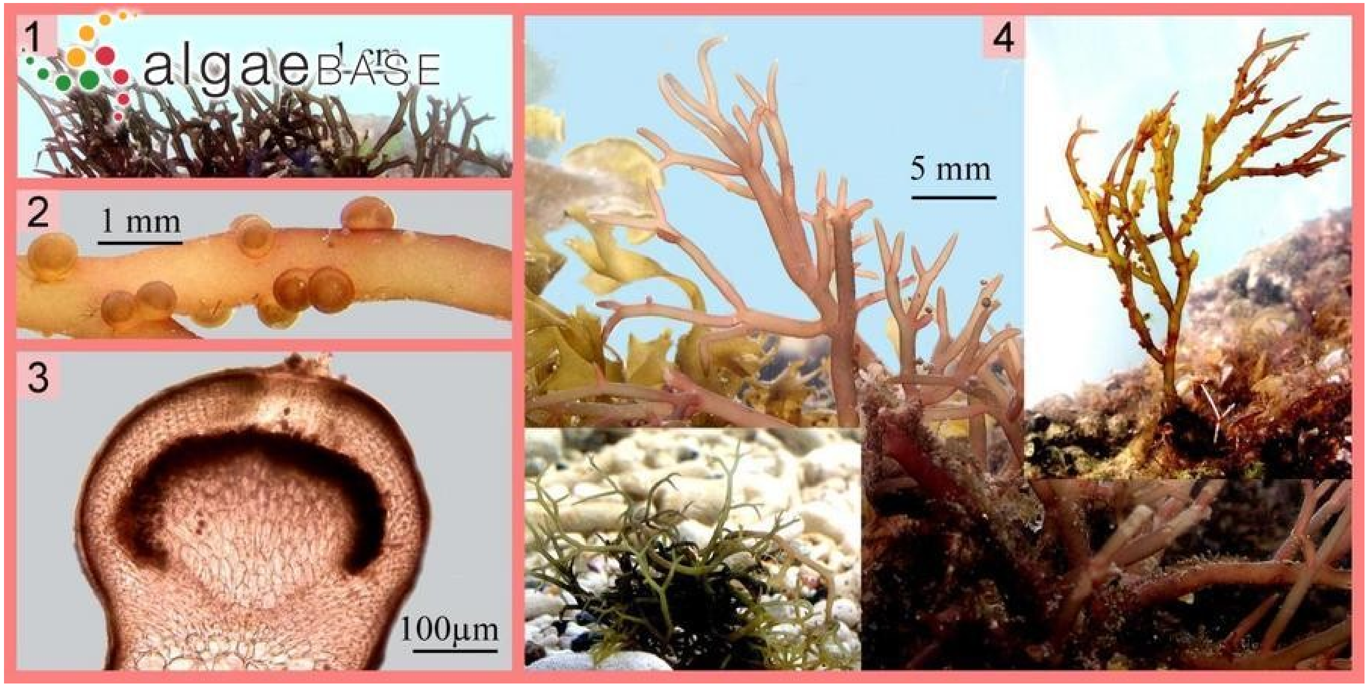


edible gracilarias - ogonori, hai tsai, nuoc-mam, Ceylon moss, etc.

Gracilariopsis vermicullophyla
an invasive species of European coasts

G. parvispora

(wikipedia)

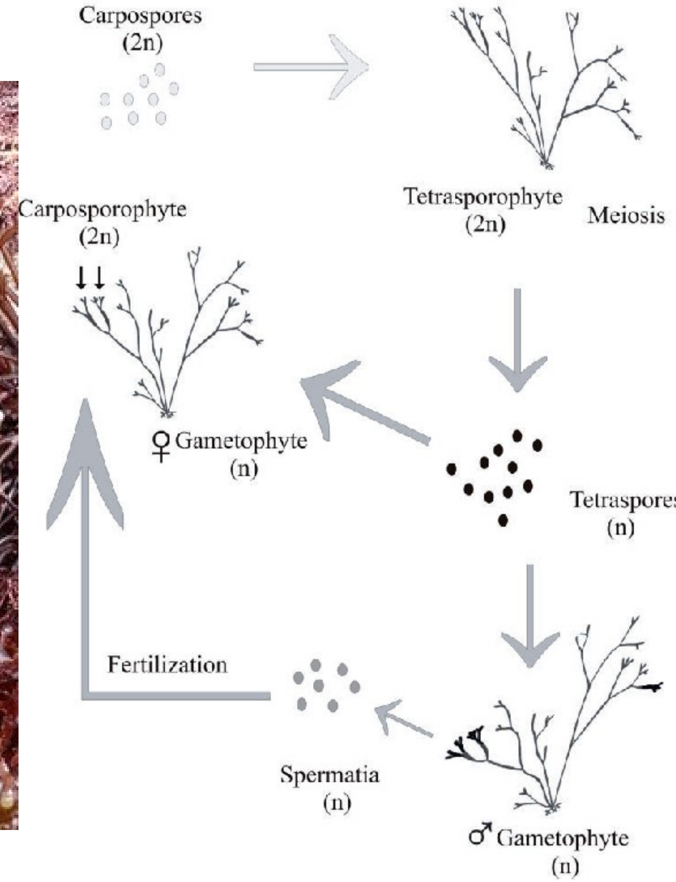


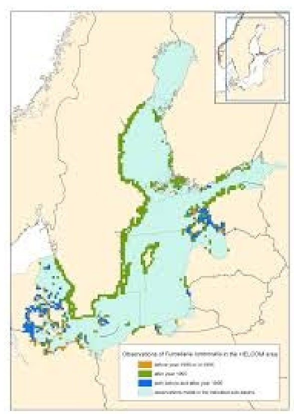
Hydropuntia (Gracilaria) edulis

Gigartinales - an examle from the Adriatic Sea

Sphaerococcus

Furcellaria





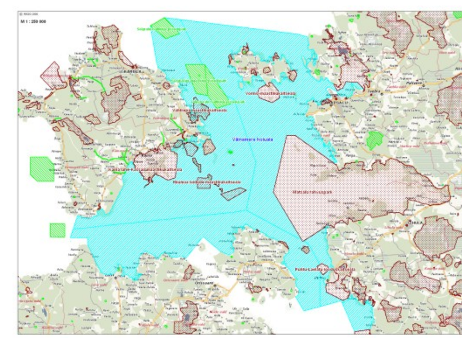
F. lumbricalis is one of the habitat forming species in the Baltic Sea

about 120 km^2 of *loose-lying* populations in lagoons around the W Estonian islands

distribution: W Mediterranean to Spitzbergen

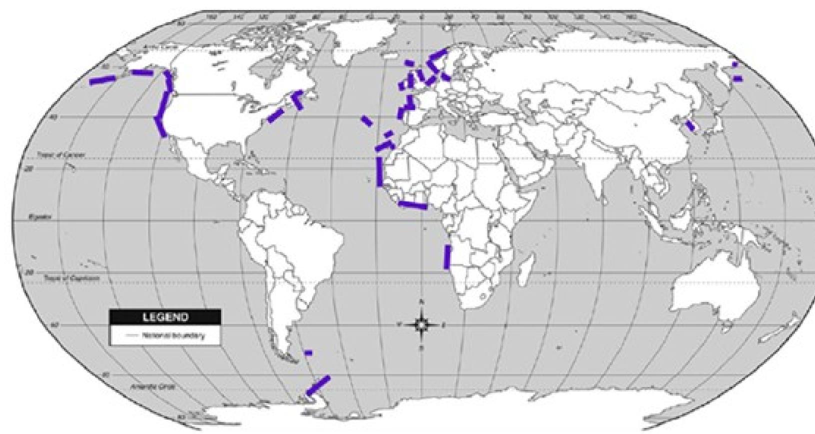
Coccotylus

(together with *F. lumbricalis*)



C. brodiei is an important component of loose-lying benthic communities in boreal brackish lagoons (e.g. Väinamere in NE Baltic Sea)

Chondrus



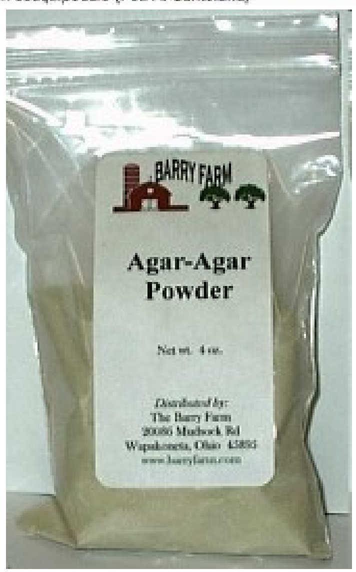
eulittoral of the cold temperate
European coasts

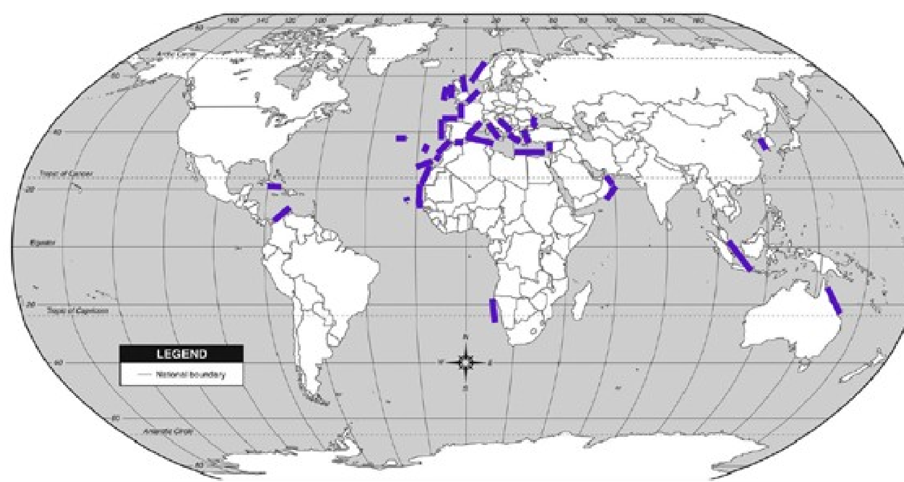
Ch.crispus

Gelidiales - e.g. *Gelidium, Pterocladiella, Gelidiella*

Gelidium sesquipedale (Foto: A. Santolaria)

Gelidium sesquipedale (Fot. A. Santolaria)

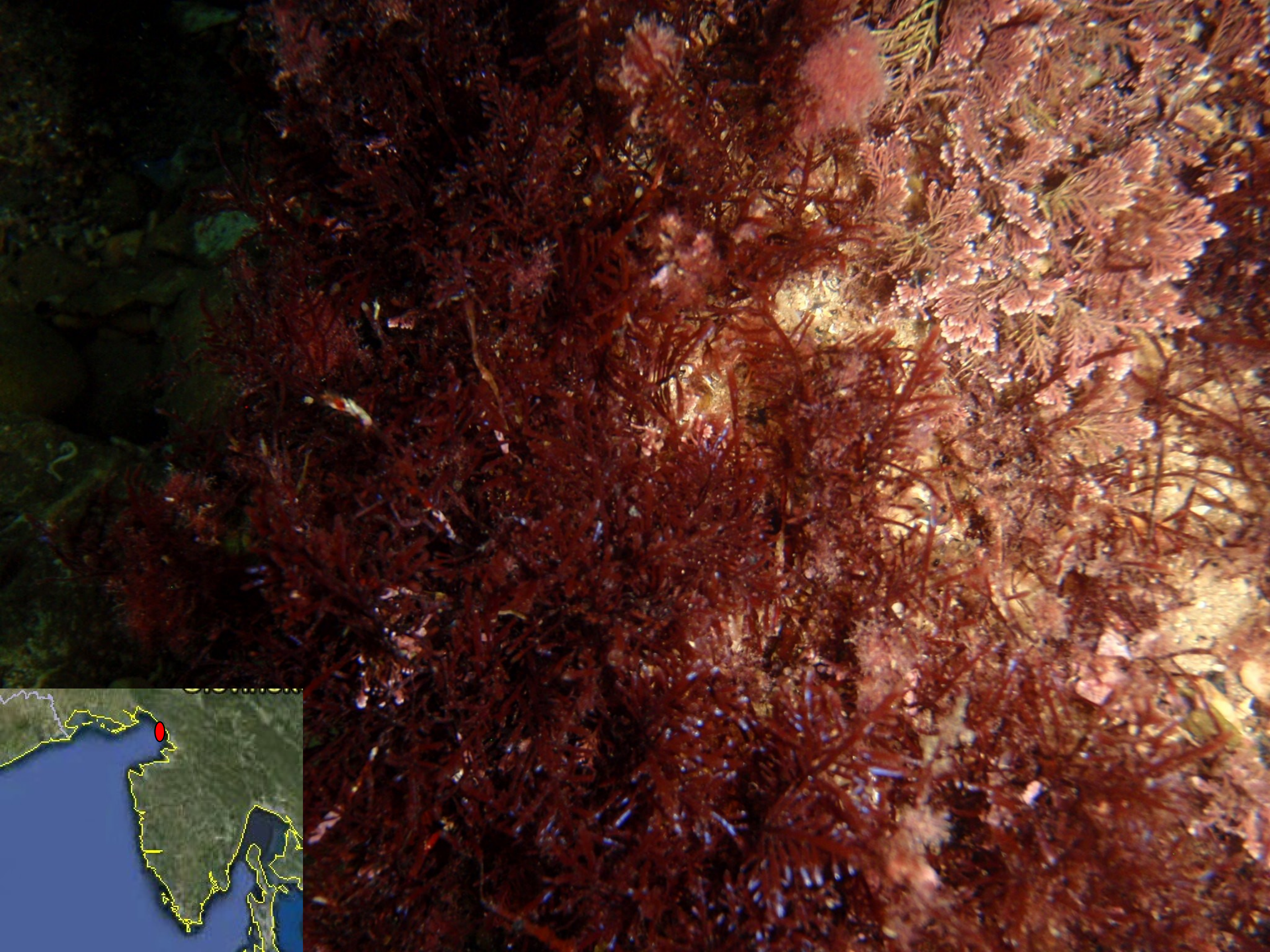




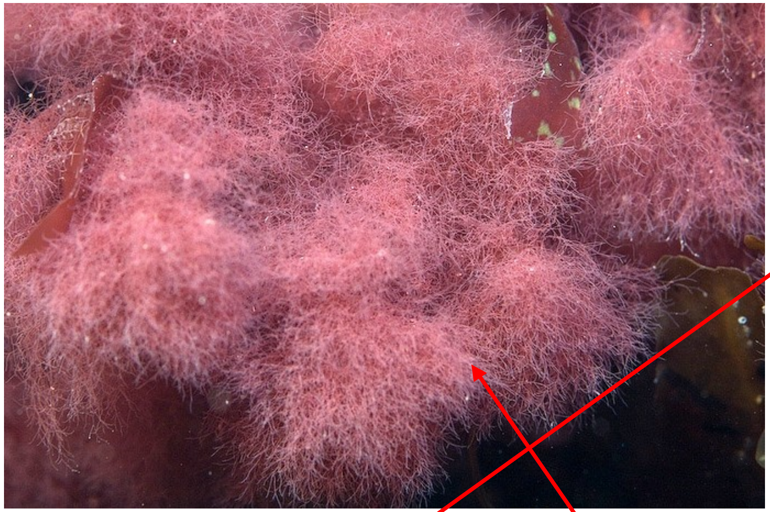
G. spinosum

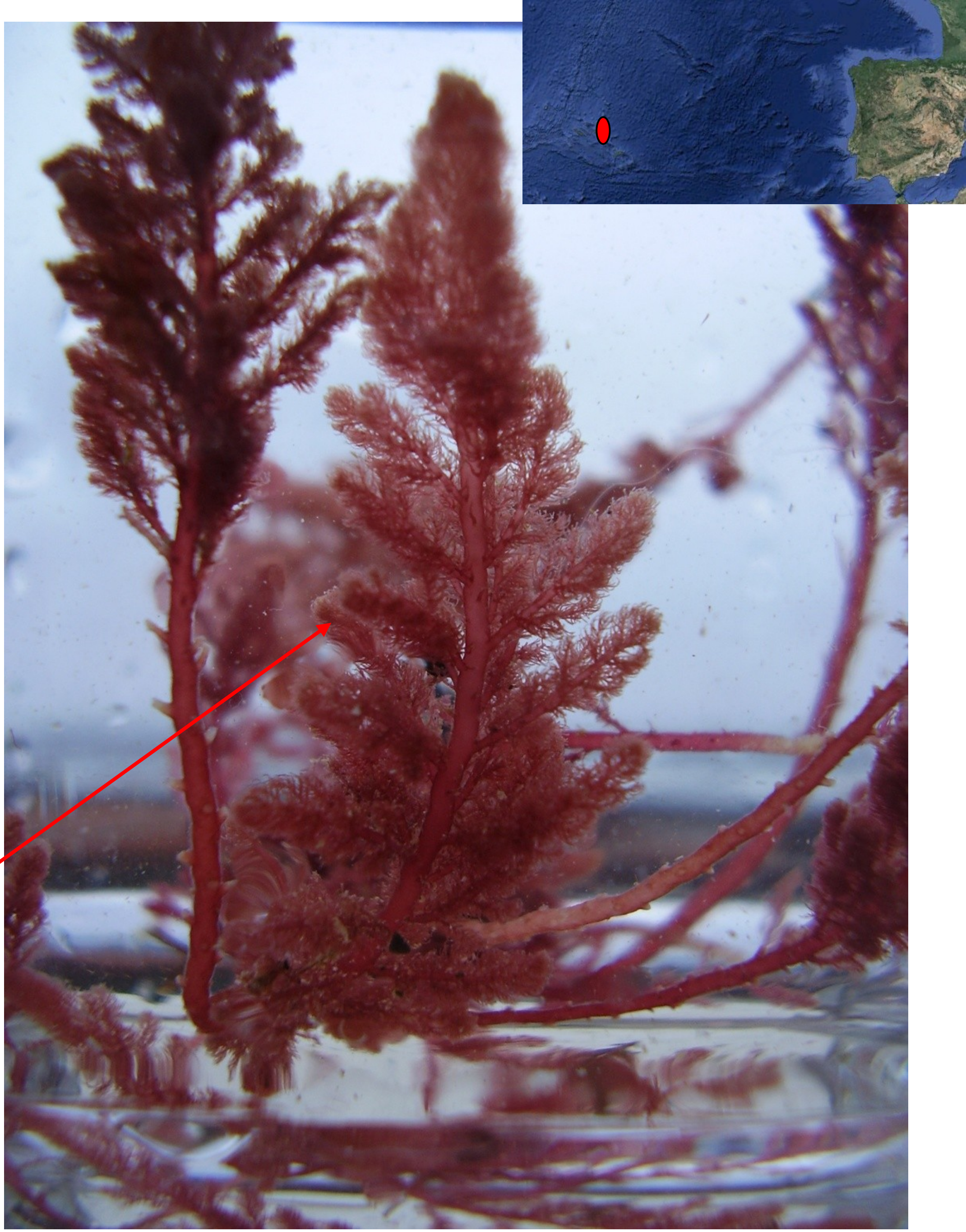
agar – from polysascharides of their cell walls


Jersey



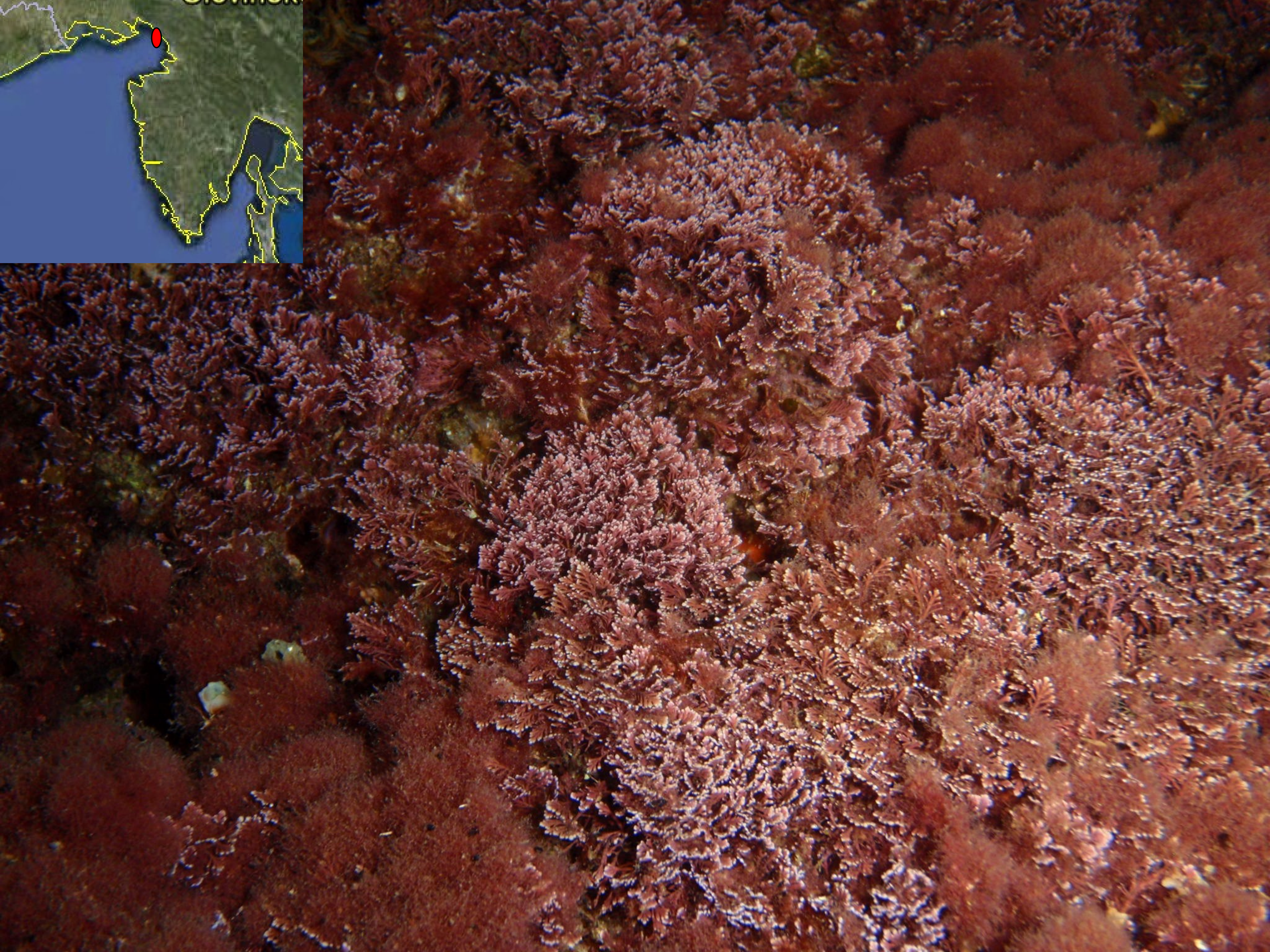
Asparagopsis (Bonnemaisoniales)

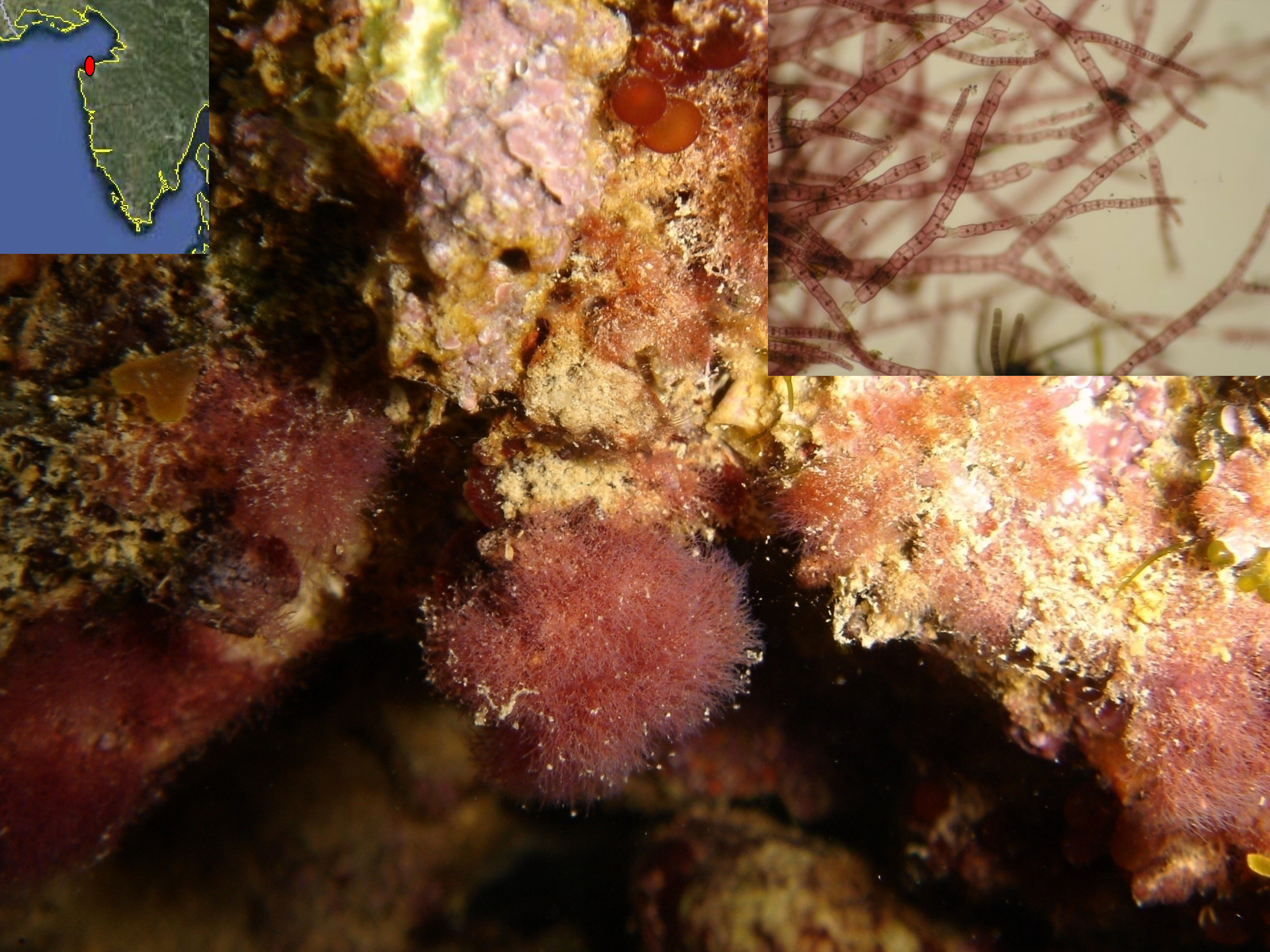




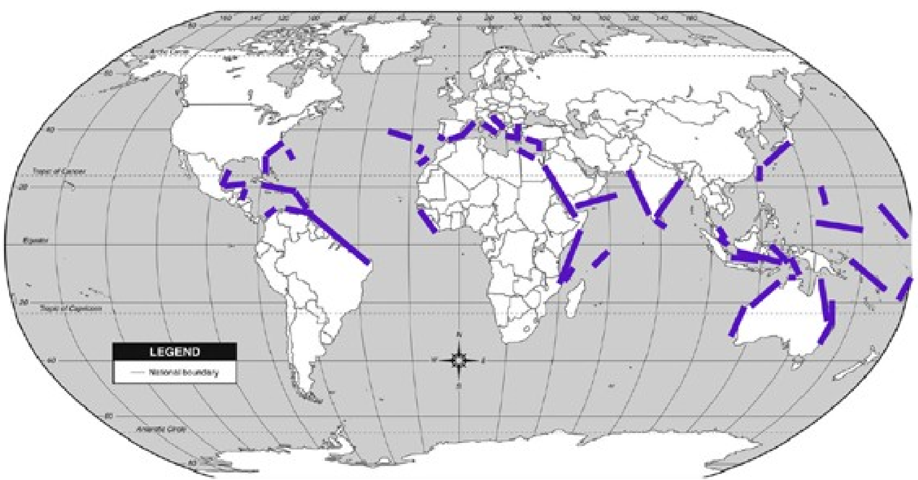
macroscopic gametophyte,
filamentous microscopic tetrasporophyte
(so called ***Falkenbergia* stage** – invading
in the Adriatic Sea)

A. armata - an example of invasive red algae in subtropical/warm temperate seas



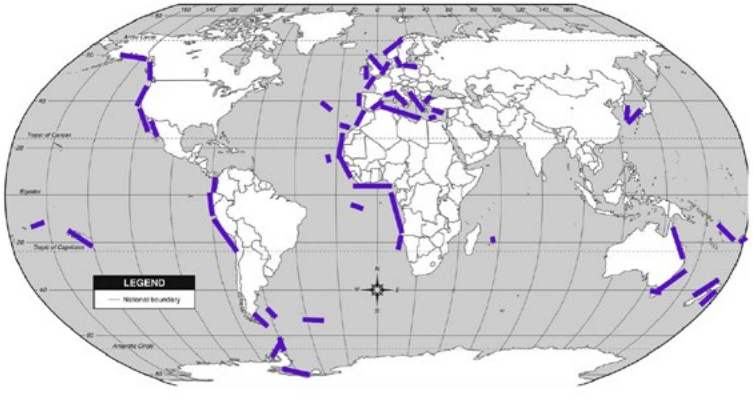


Halymenia (Halymeniales)



H. floresii
(dragons breath)

Plocamium (Plocamiales)

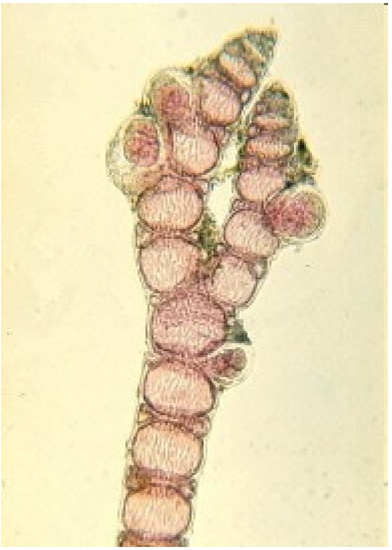


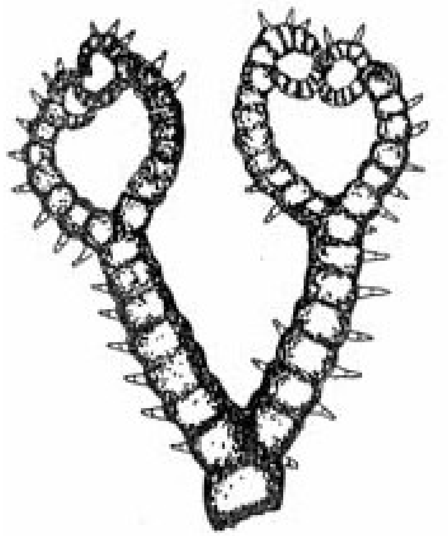
P. cartilagineum

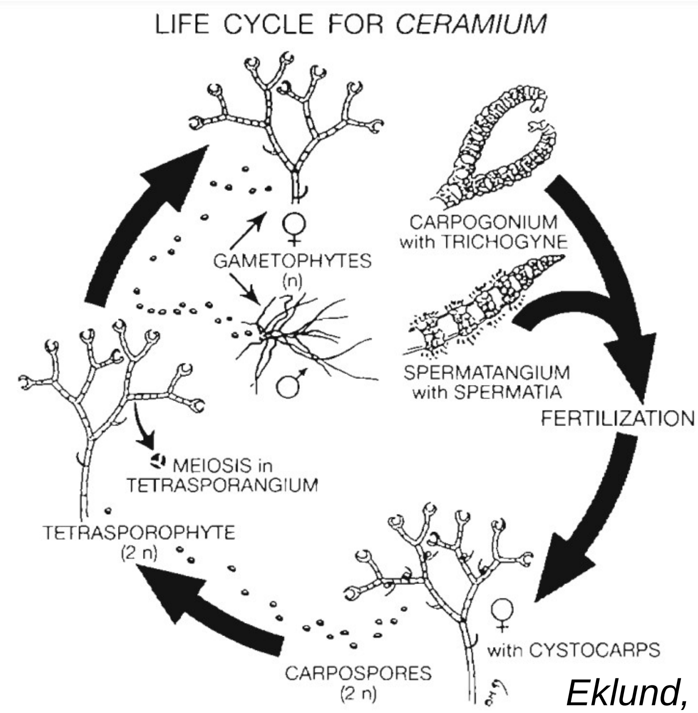

Jersey

Ceramiales - an order with general tendency to secondarily simplified thalli

Ceramium

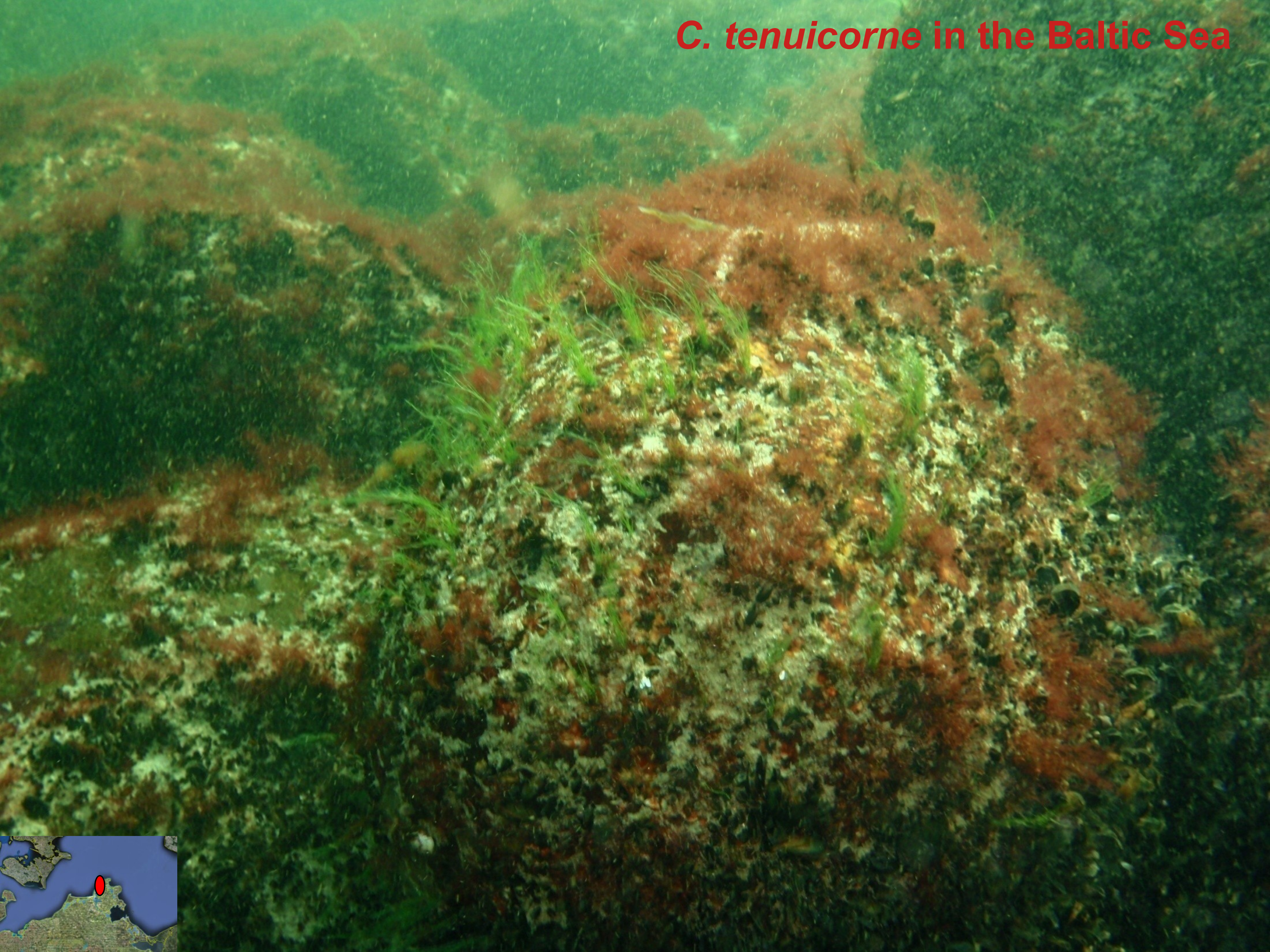




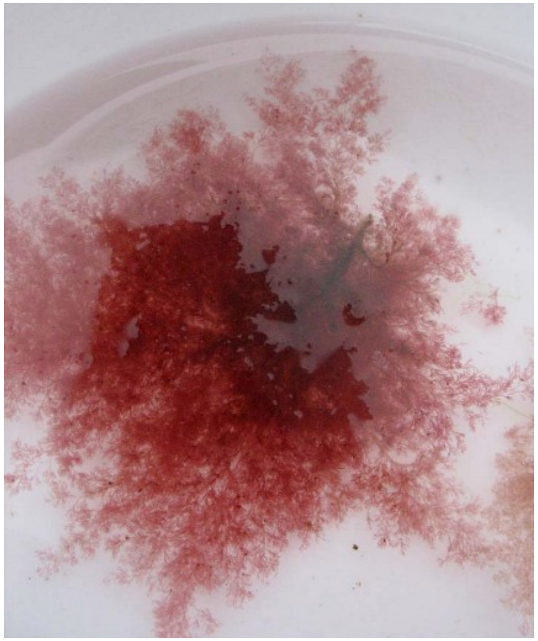


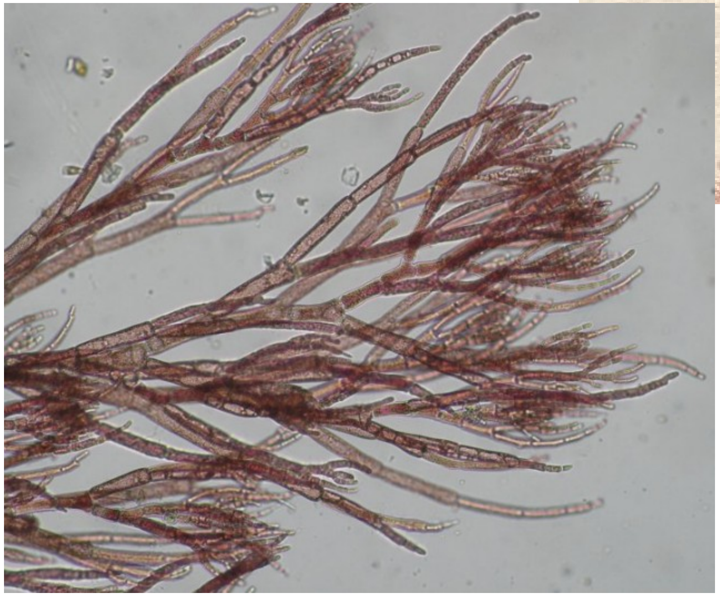
Eklund, 1998
Mar. Ecol. Progr. Ser.

ephemerous thalli


C. tenuicorne in the Baltic Sea

Callithamnion
Aglaothamnion





ephemerous thalli

epiphytically on perrenial macroalgae or epilithically on stones/rocks

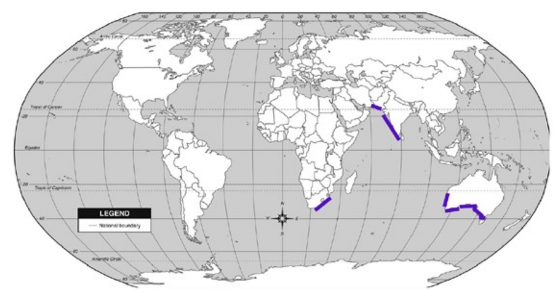
boreal to subtropical habitats

Delesseria

ephemerous phylloids continuously grow on perrenial cauloid

D. sanguinea inhabits lower sublittoral along the cold coasts of Europe; pseudoparenchymatous phylloids

Claudea



C. elegans

Polysiphonia complex

European coasts;
incl. brackish Baltic Sea

ephemerous and perrenial branched filamentous thalli
often in shaded conditions of lower sublittoral

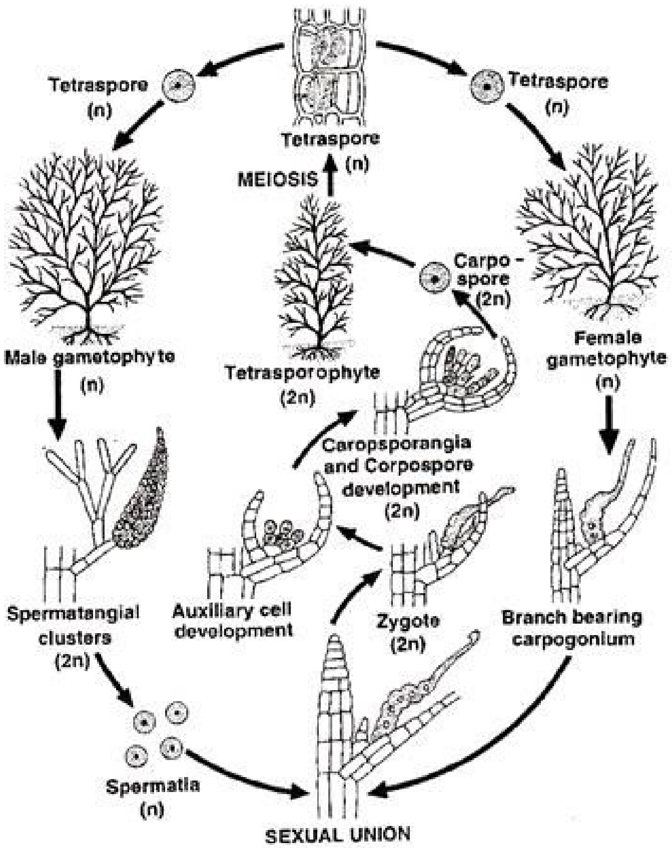
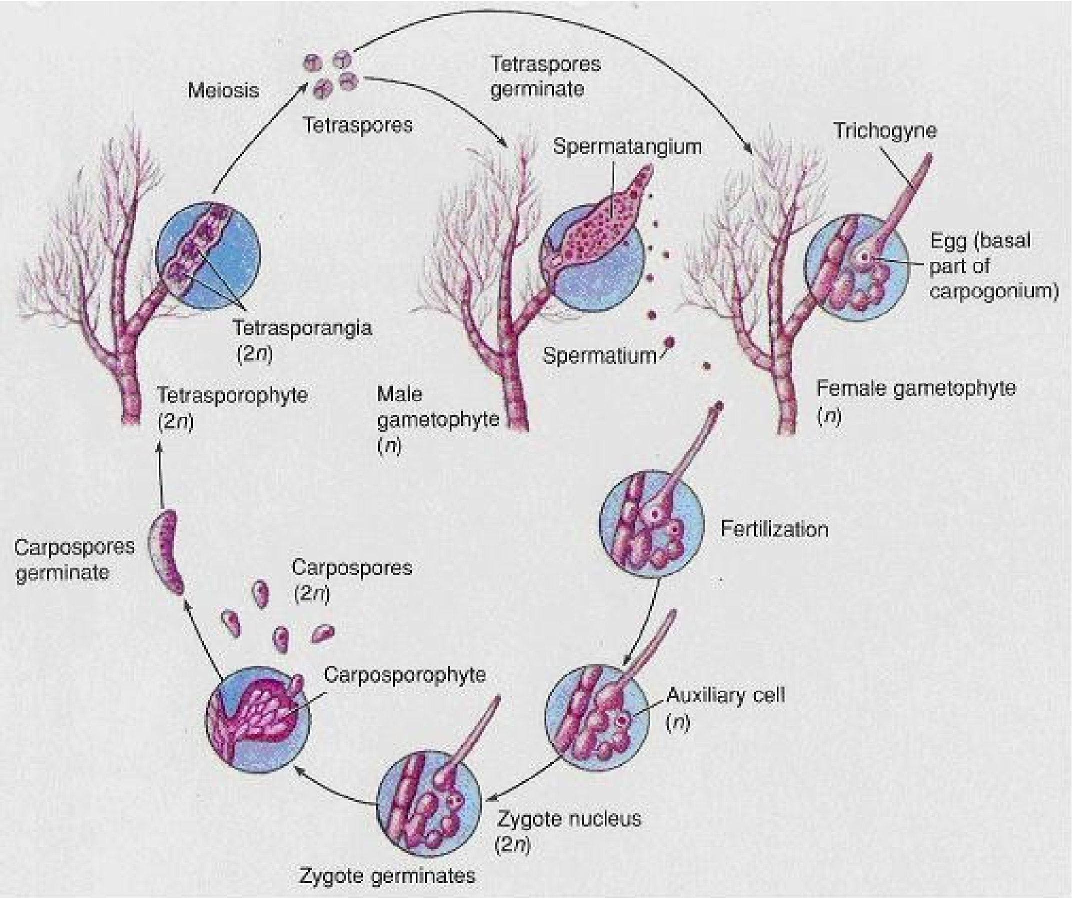
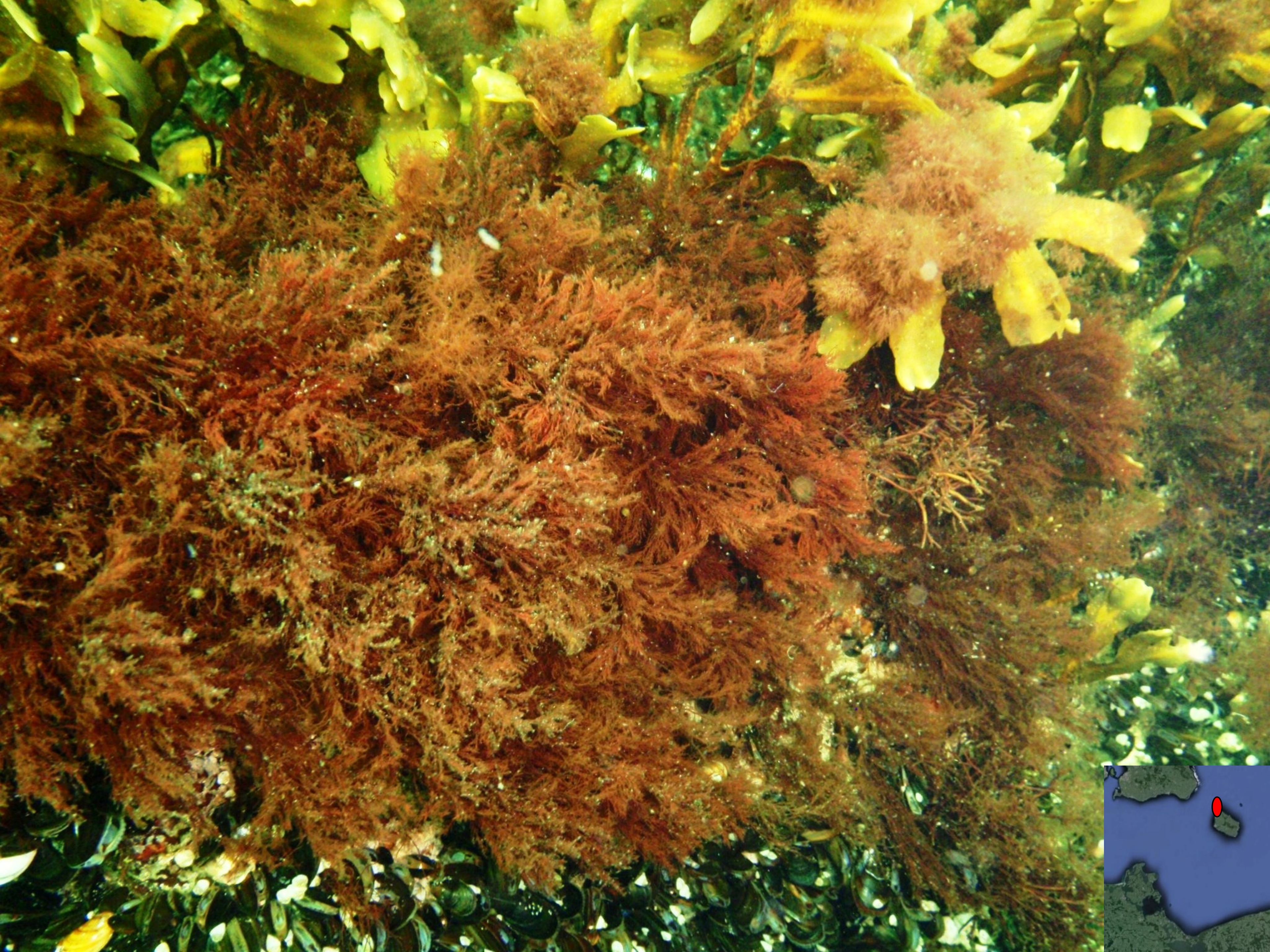


Fig. 8. *Polysiphonia*. Diagrammatic life cycle.

Vertebrata fucoides in the Baltic Sea

www.merebioloogia.ee

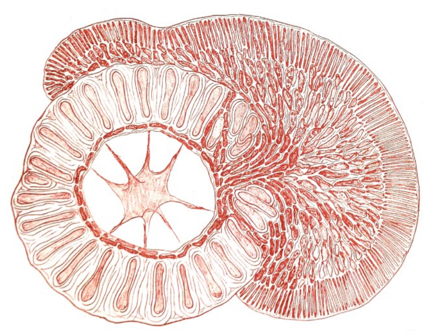

Meiosis
Tetraspores
Tetraspores
germinate
Spermatangium
Trichogyne
Egg (basal
part of
carpogonium)
Tetrasporangia
(2n)
Spermatium
Tetrasporophyte
(2n)
Male
gametophyte
(n)
Female gametophyte
(n)
Fertilization
Carpospores
germinate
Carpospores
(2n)
Carposporophyte
Auxiliary cell
(n)
Zygote nucleus
(2n)
Zygote germinates



Choreocolax and several related genera

- obligatory parasites of other red algae
- adelphoparasitism – ejection of their own nuclei (and mitochondria) into the host cells

Choreocolax polysiphoniae



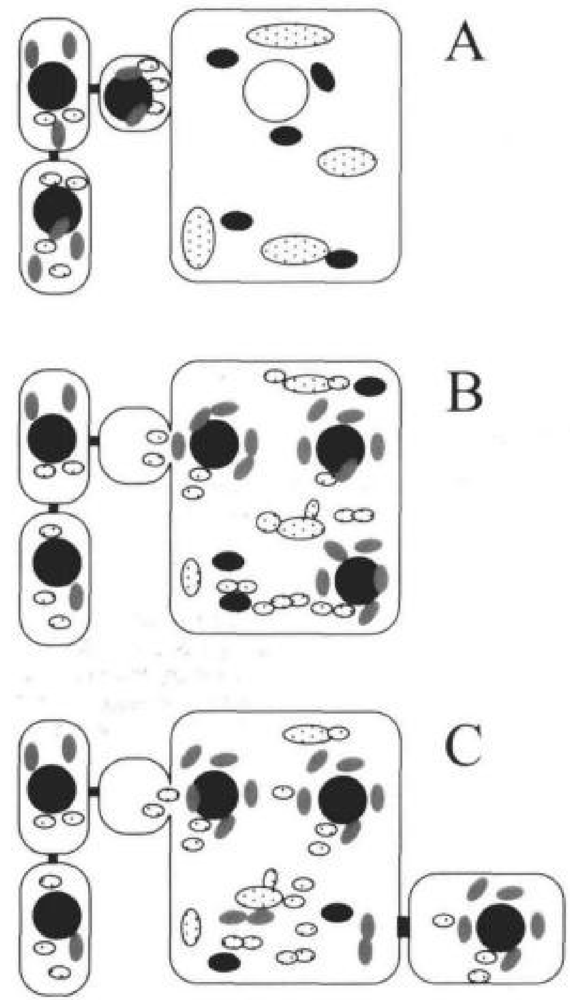


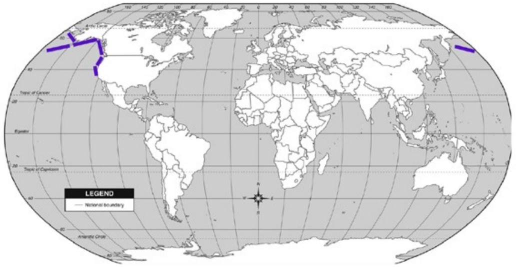
Figure 10. Transfer of Parasite Nuclei, Mitochondria, and Proplastids into a Host Cell.

(A) The parasite cells (left) have formed a conjunctor cell containing a parasite nucleus (black), mitochondria (gray), and proplastids (white with dots). This conjunctor cell fuses with the host cell (host nuclei are white, host plastids are dotted, and host mitochondria are black ovals) delivering the parasite organelles into the host's cytoplasm.
(B) The parasite nucleus and mitochondria replicate in the host cell, and the host plastids divide to form numerous proplastids. The host nuclei and mitochondria replicate in the host cell. The host nucleus may disappear or persist.
(C) Ultimately, a cell is cut off from the heterokaryotic host plus parasite cell. This cell contains a parasite nucleus, parasite mitochondria, and proplastids derived from the host plastids.

Goff & Coleman, 1995, Plant Cell
Salomaki et al., 2015, J Phycol

Odonthalia

O. floccosa
Pacific coast of N Am



O. dentata
circumboreal distribution, incl. European N Atl

a cold water genus