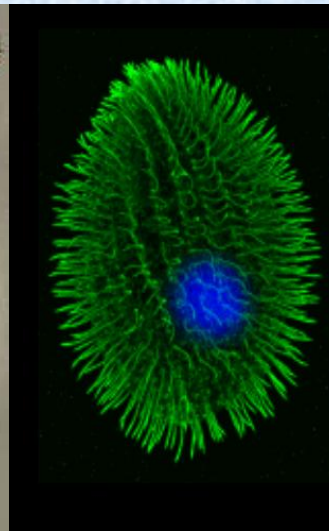
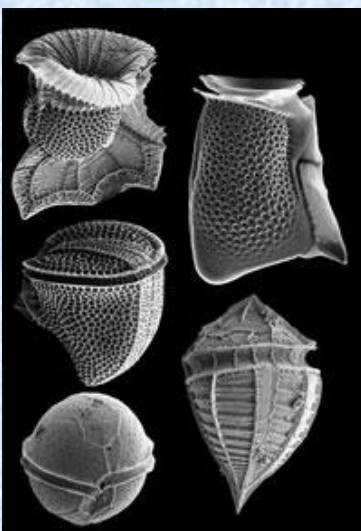
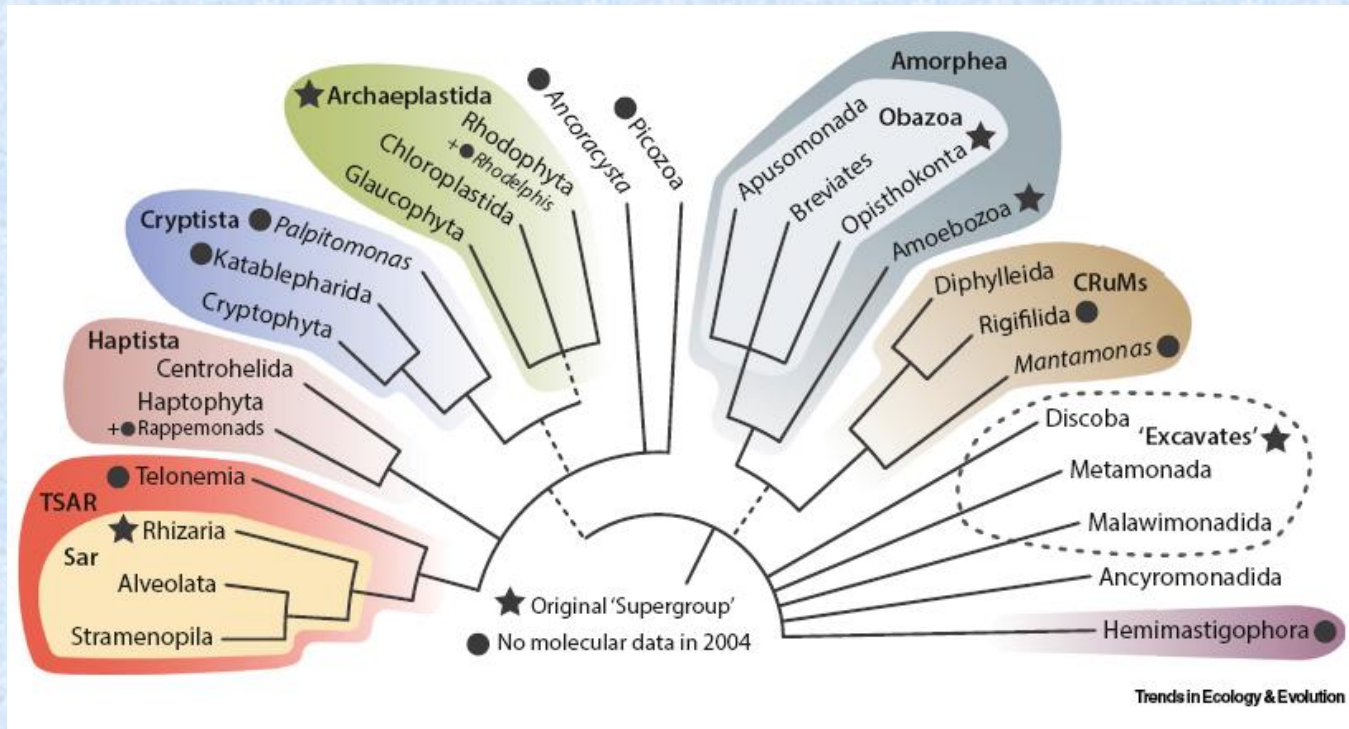


Alveolata



Alveolates

- large group of protists
- 3 main groups, distinct in morphology, life strategies...
- **Ciliata, Apicomplexa, Dinophyta**
- common ultrastructural features
 - micropores
 - cortical alveoli + extrusomes (ejectosomes)

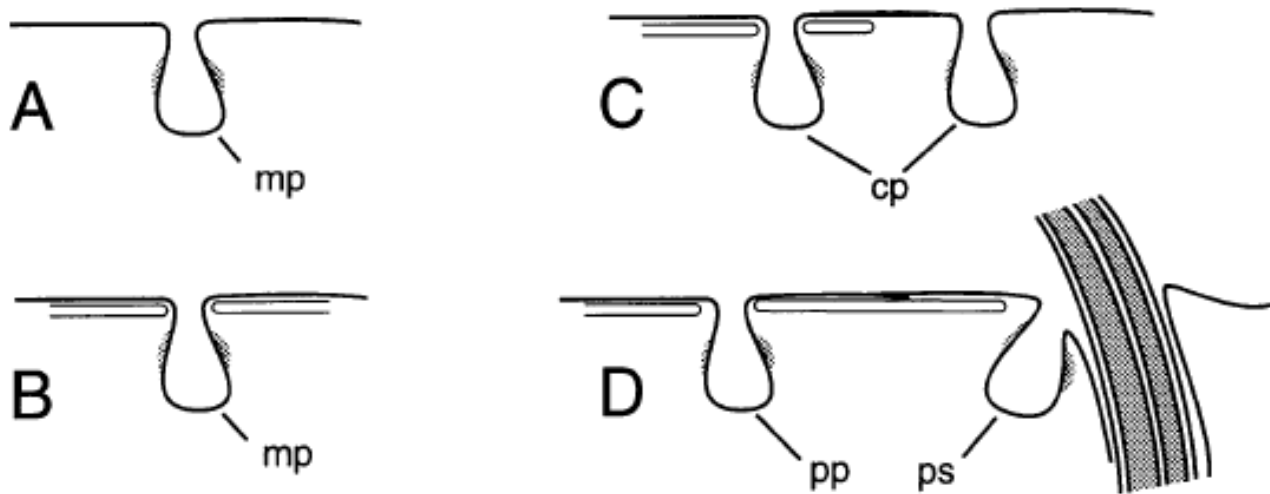
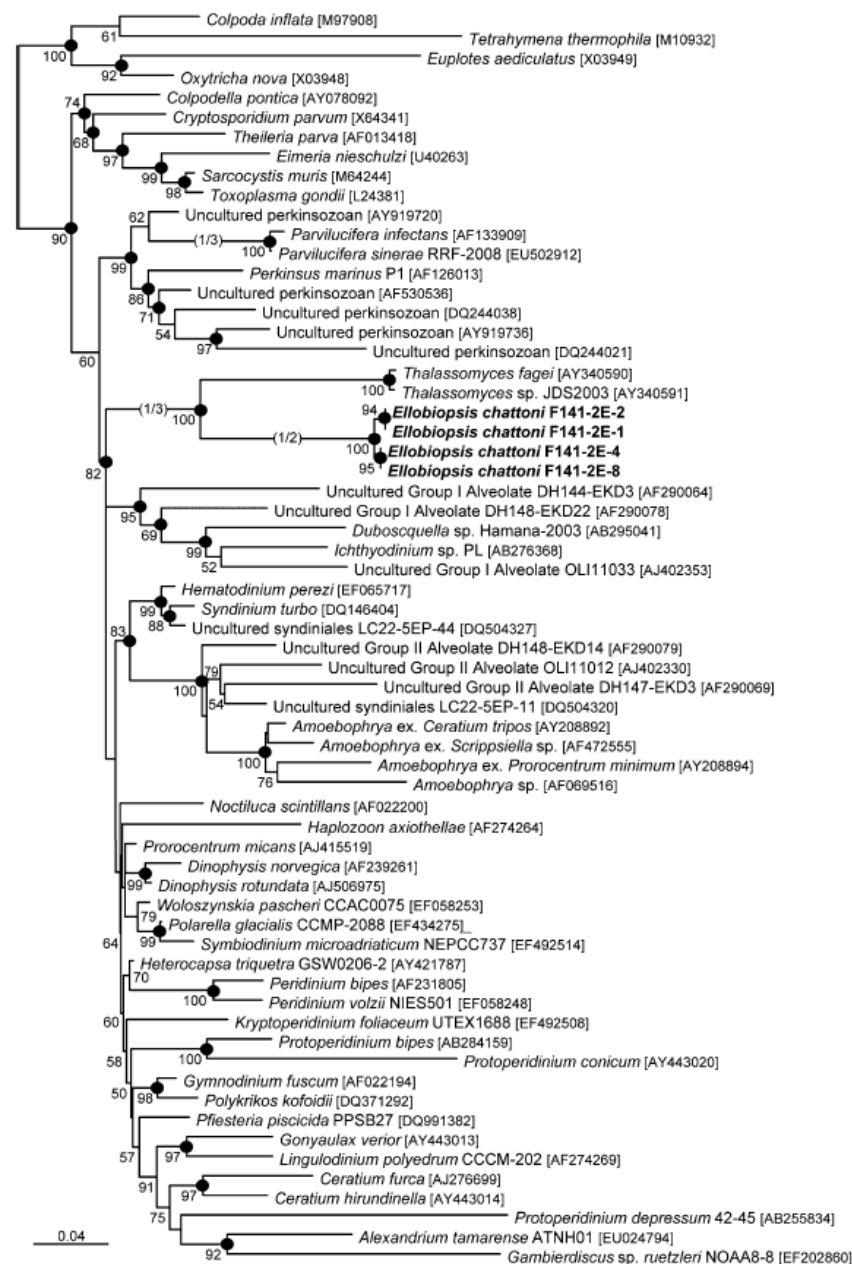


Fig. 2. Ultrastructural characteristics of pinocytic structures in the Alveolata including micropores (mp) of (A) apicomplexans and (B) *Perkinsus* species as well as (C) the collared pits (cp) of dinoflagellates and (D) the pellicular pores (pp) and parasomal sacs (ps) of ciliates.

Alveolates



Ciliophora

Apicomplexa

Perkinsia

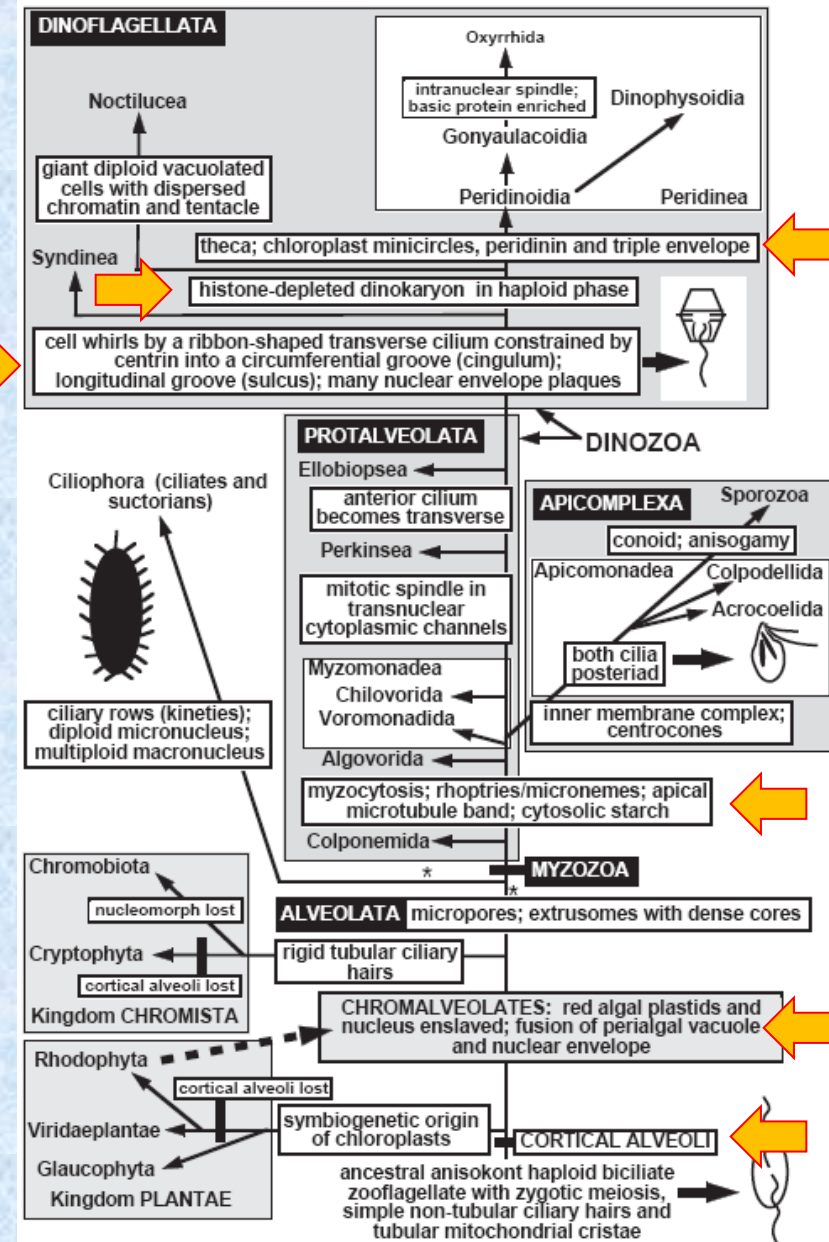
Ellobiopsea

Marine Alveolate Group I

Syndinea
MAGII

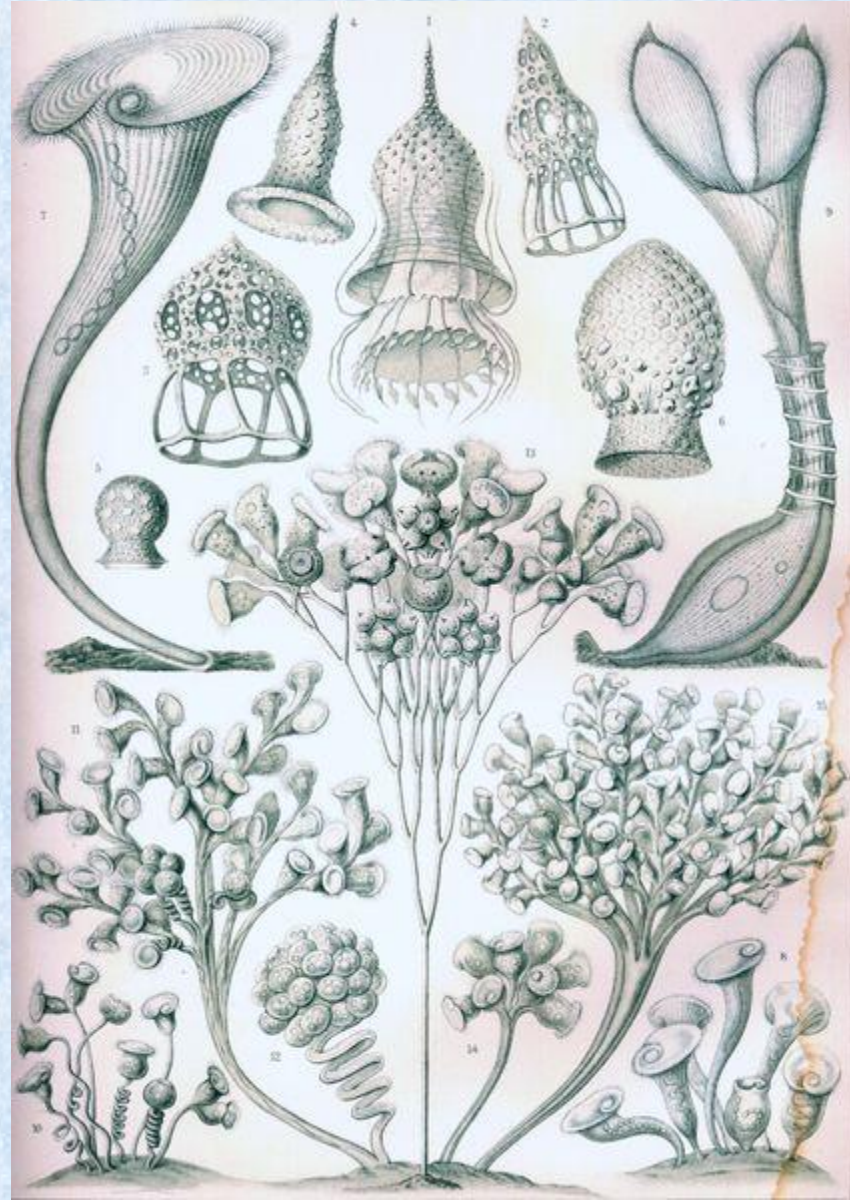
Noctiluca

Dinokaryota



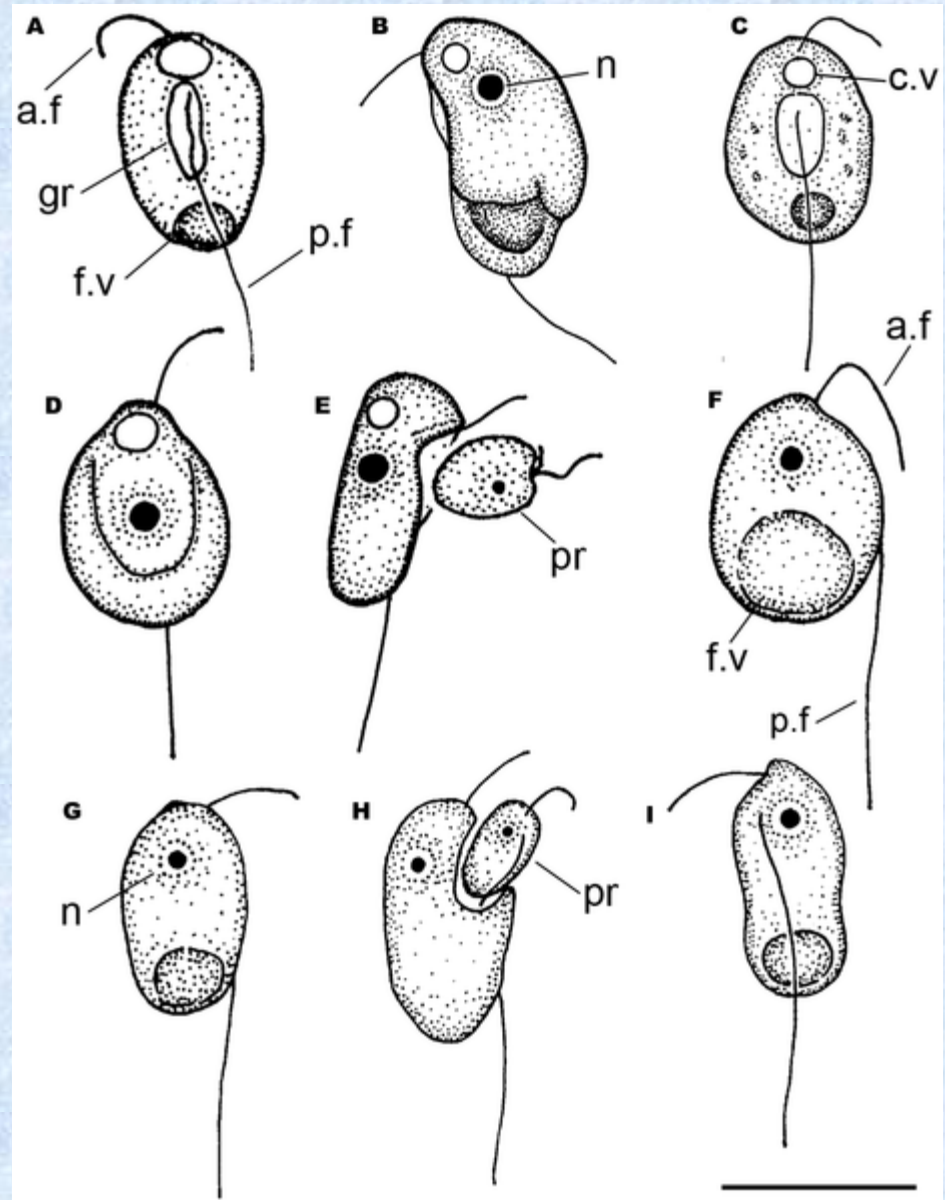
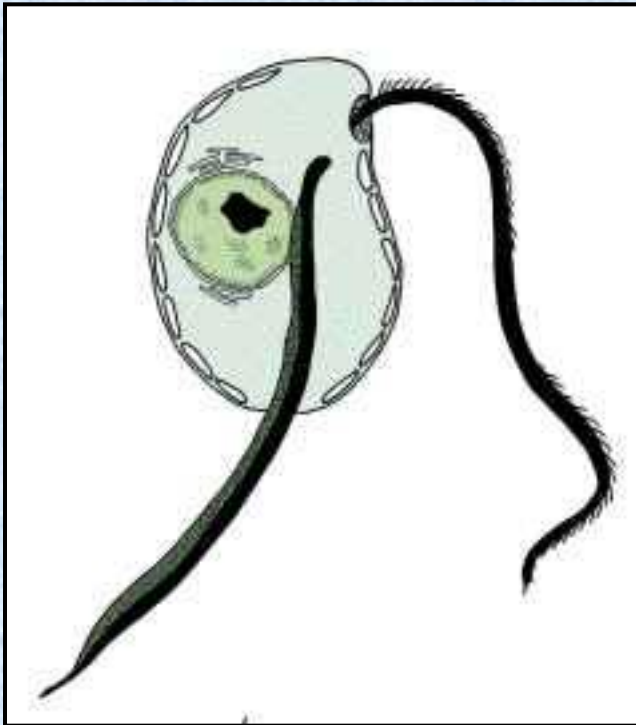
Alveolata, Ciliata

- one of the most common group of protists (nálevníci)
- cilia covering the cell surface
- lakes, ponds, oceans, soil
- free-living, symbionts, parazites
- 2 nuclei types: micronuclei, macronuclei



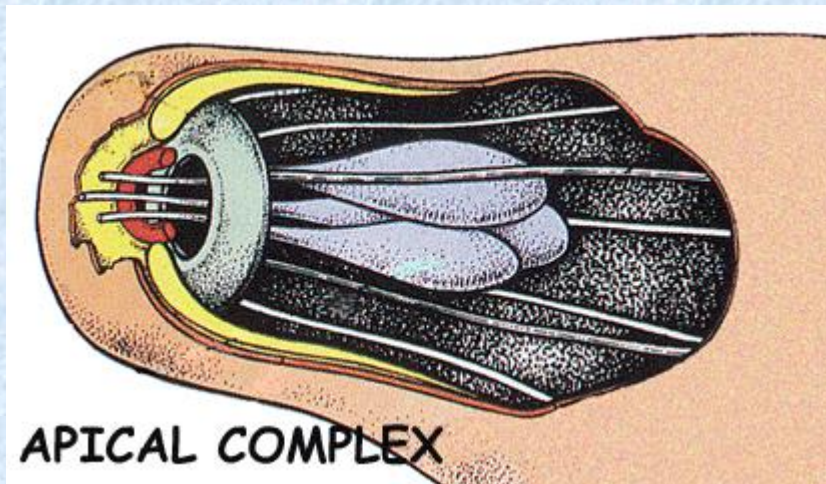
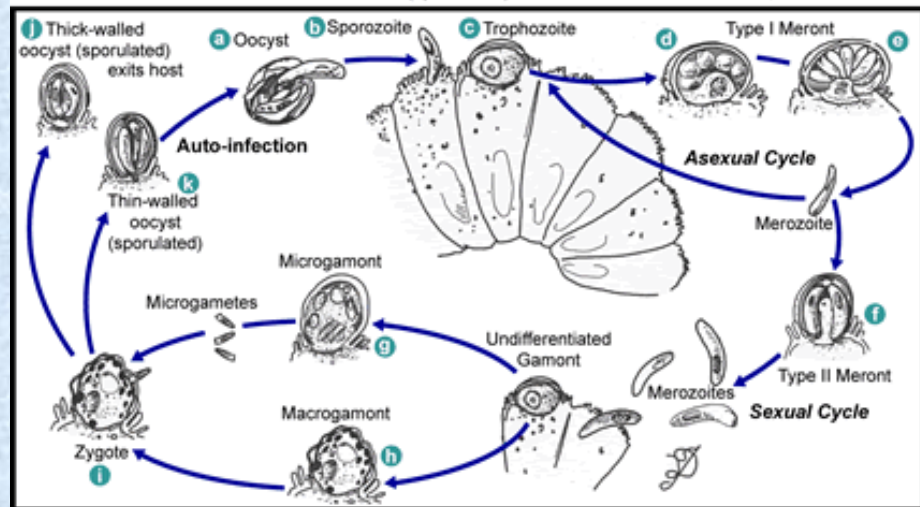
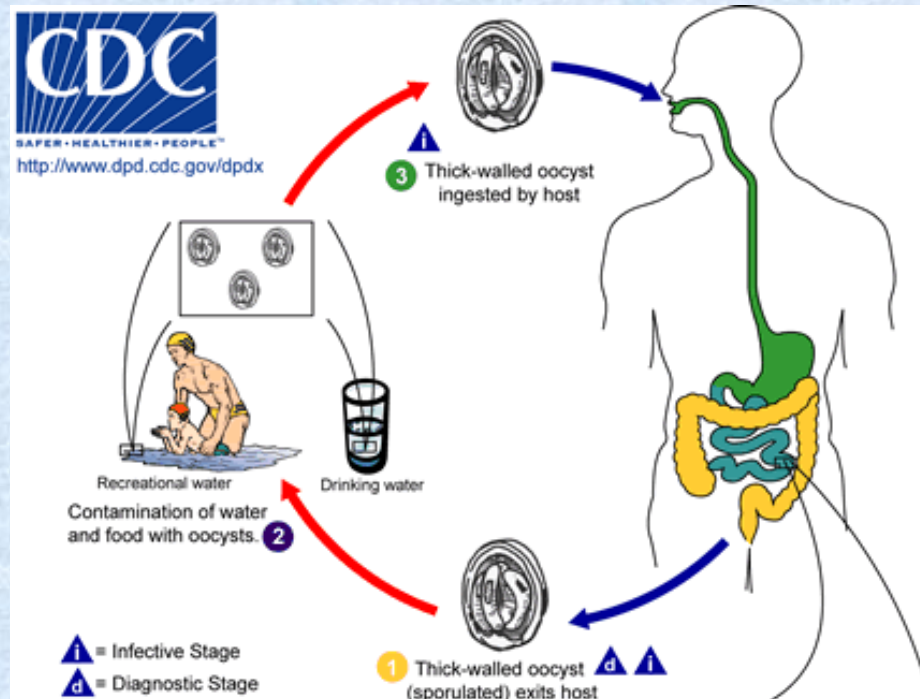
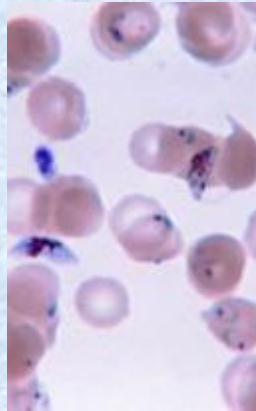
Alveolata, Colponemida

- *Colponema*
- ancestral Alveolate morphology

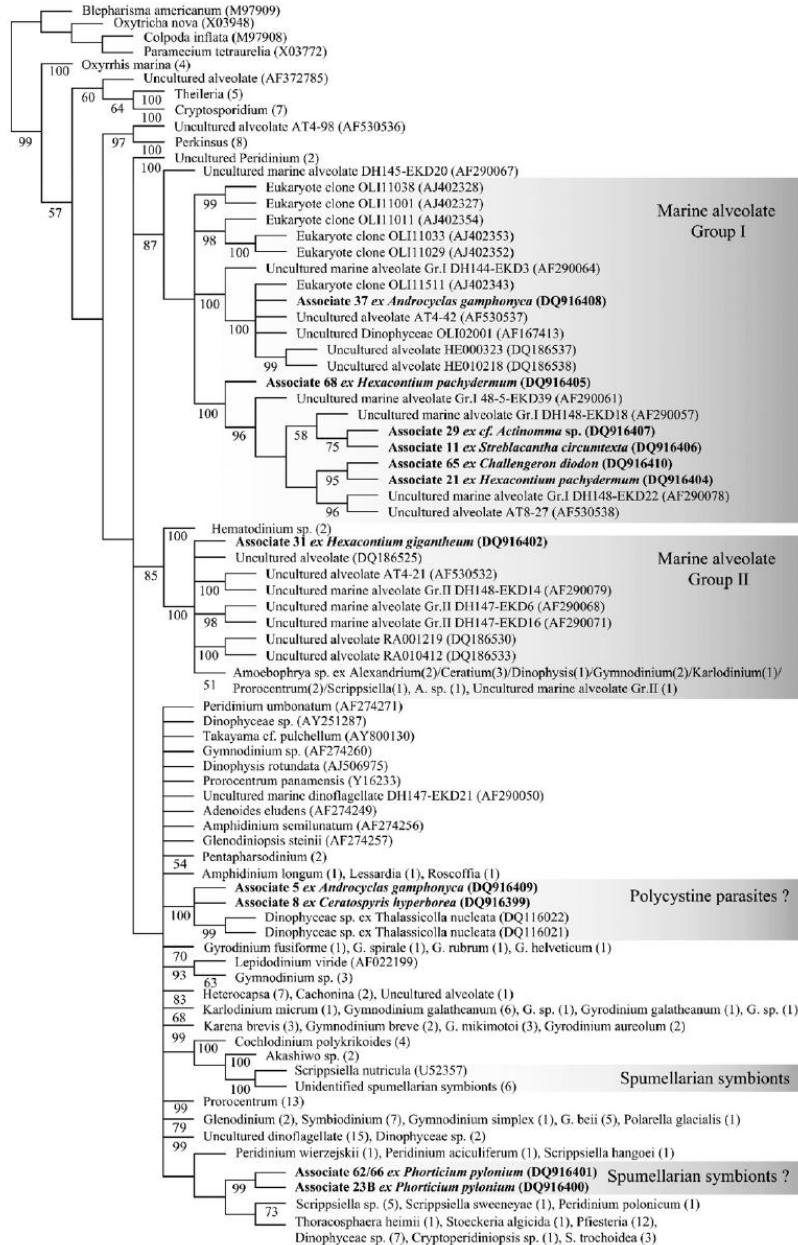


Alveolata, Apicomplexa

- apicoplast (organelle of plastid origin)
- animal parasites
- *Plasmodium* (malaria)
- *Toxoplasma*
- *Cryptosporidium*



Alveolata, MAG I a II



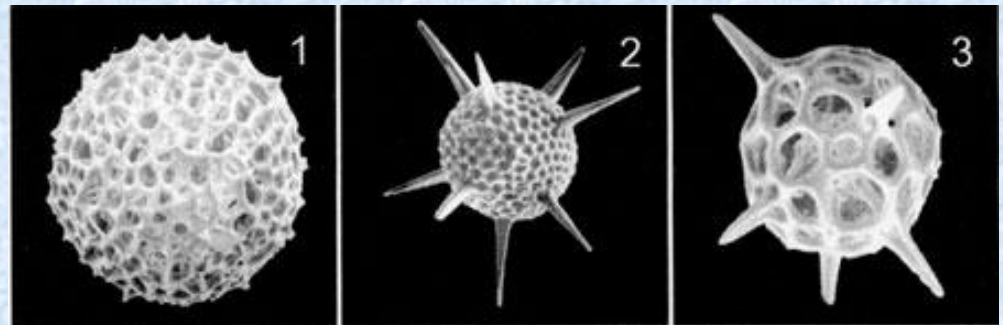
Protist, Vol. 158, 65–76, January 2007
<http://www.elsevier.de/protis>
 Published online 7 November 2006

Protist

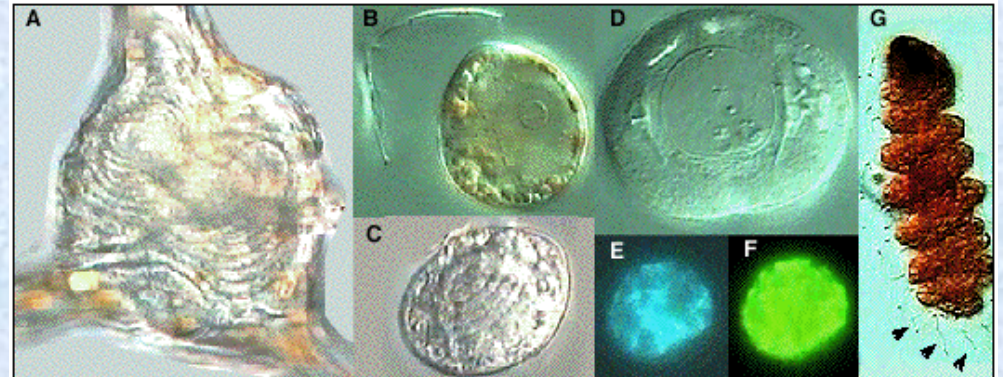
ORIGINAL PAPER

Molecular Diversity of Alveolates Associated with Neritic North Atlantic Radiolarians

Jane K. Dolven^{a,1}, Charlotte Lindqvist^a, Victor A. Albert^a, Kjell R. Bjørklund^a, Tomoko Yuasa^b, Osamu Takahashi^c, and Shigeki Mayama^d



Group I – symbionts of Radiolaria



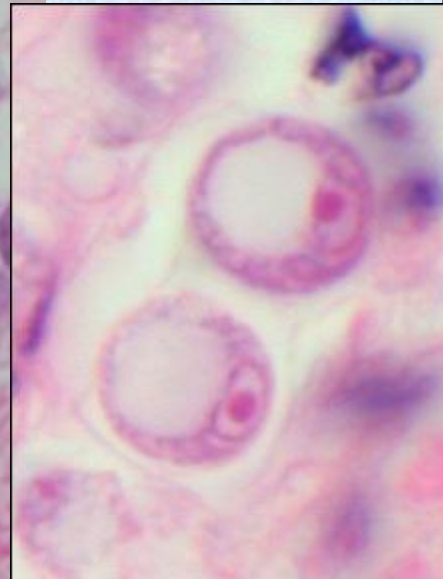
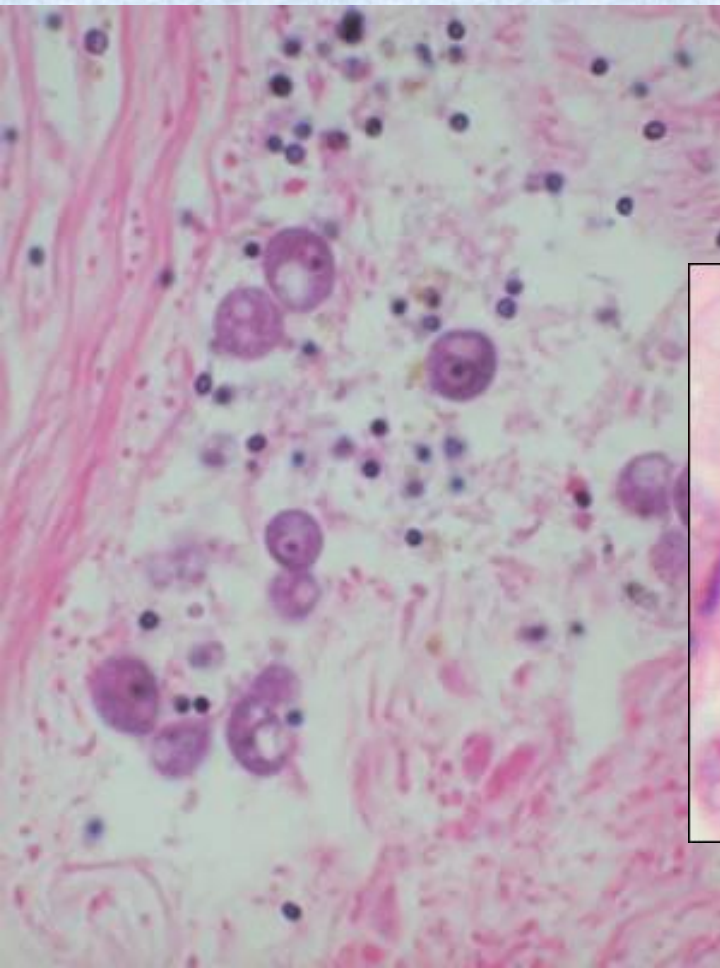
Group II – parasites of dinoflagellates

Alveolata, Perkinsea

- parasites of mussels



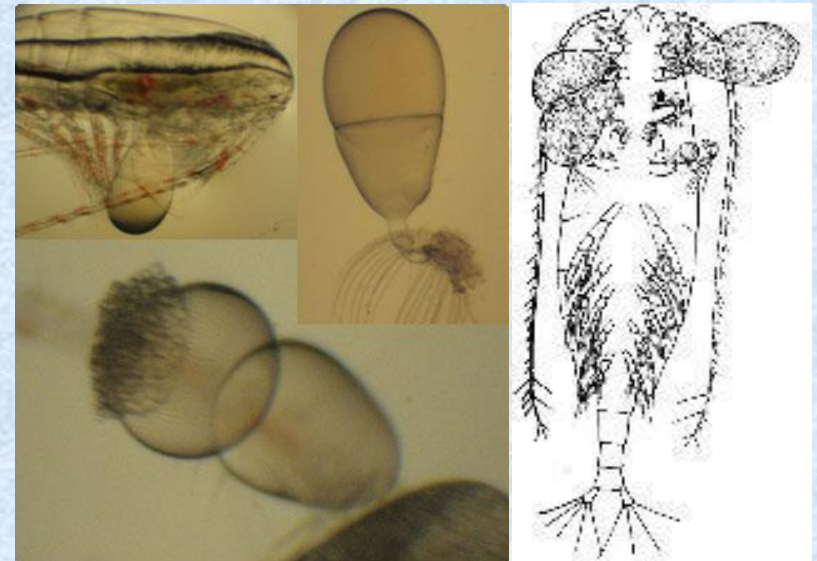
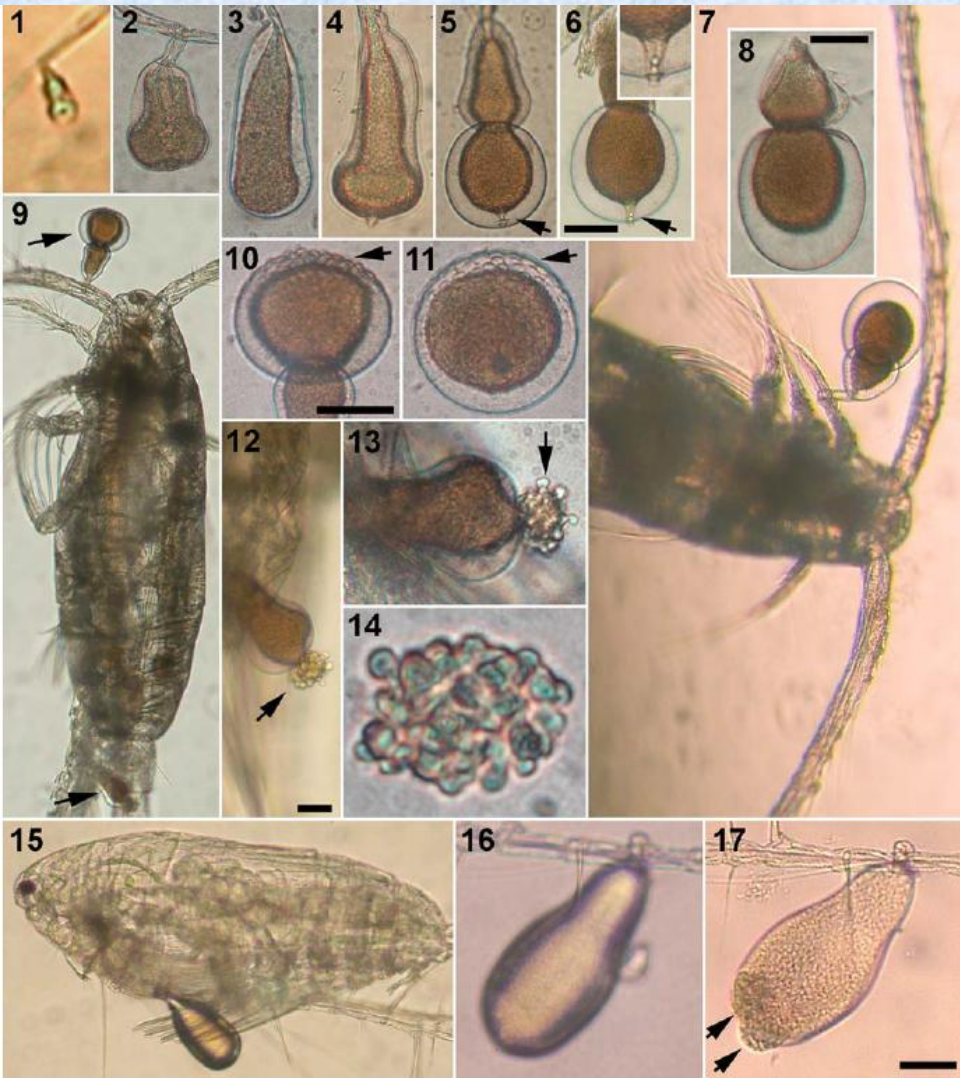
scallop (hřebenatka)



Perkinsus marinus

Alveolata, Ellobiopsea

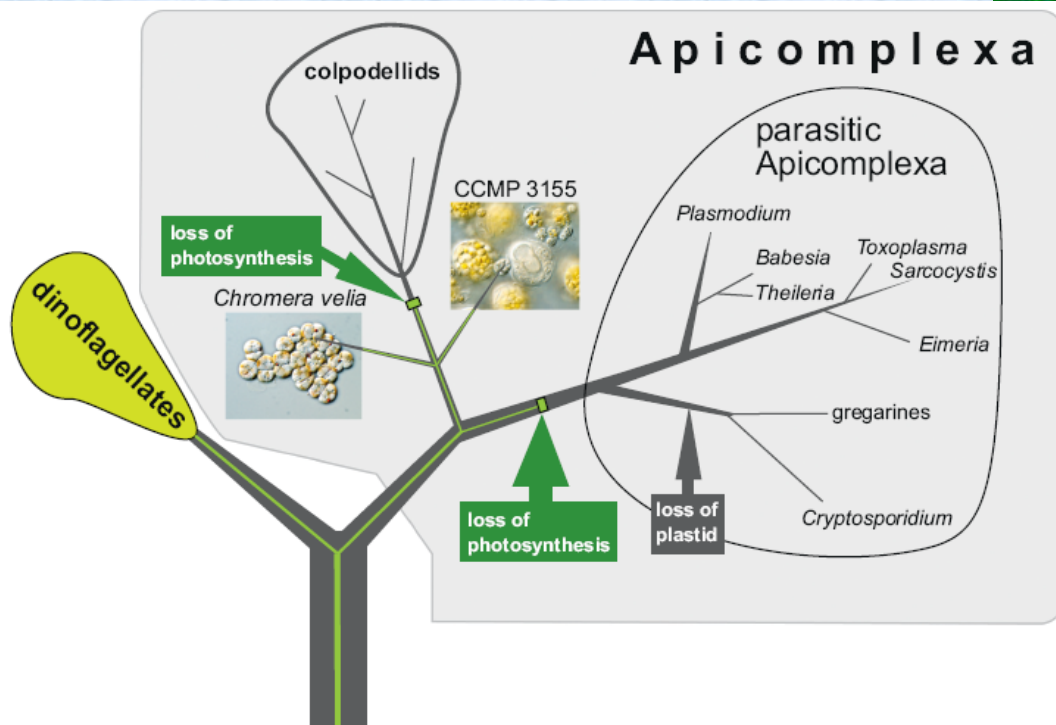
Ellobiopsis*, *Thalassomyces
- parasites of crustaceans



Figs. 1-17 Light micrographs of different life-cycle stages of *Ellobiopsis chattoni* parasitising copepods collected from the Bay of Marseille, NW Mediterranean Sea. 1-6. Different stages of the development; 5-6. the *arrows* indicate a tube-like structure in the distal part of the gonomere. 7-8. Specimen infecting *Acartia clausi* used for single-cell PCR. 9-14. Two parasites at different degrees of maturation in the same host; 10-11. the *arrows* indicate the irregular surface on the distal part of the gonomere; 12-13. the *arrows* indicate the budding of immature spores. 15-17. Live infected copepod; the *arrows* indicate the budding of spores formed after half an hour of observation. 1-14. Ethanol-fixed specimens collected on May 29th, 2008. 15-17. Live specimen collected on June 10th, 2008. Scale-bar: 50 µm

Alveolata, Chromerida

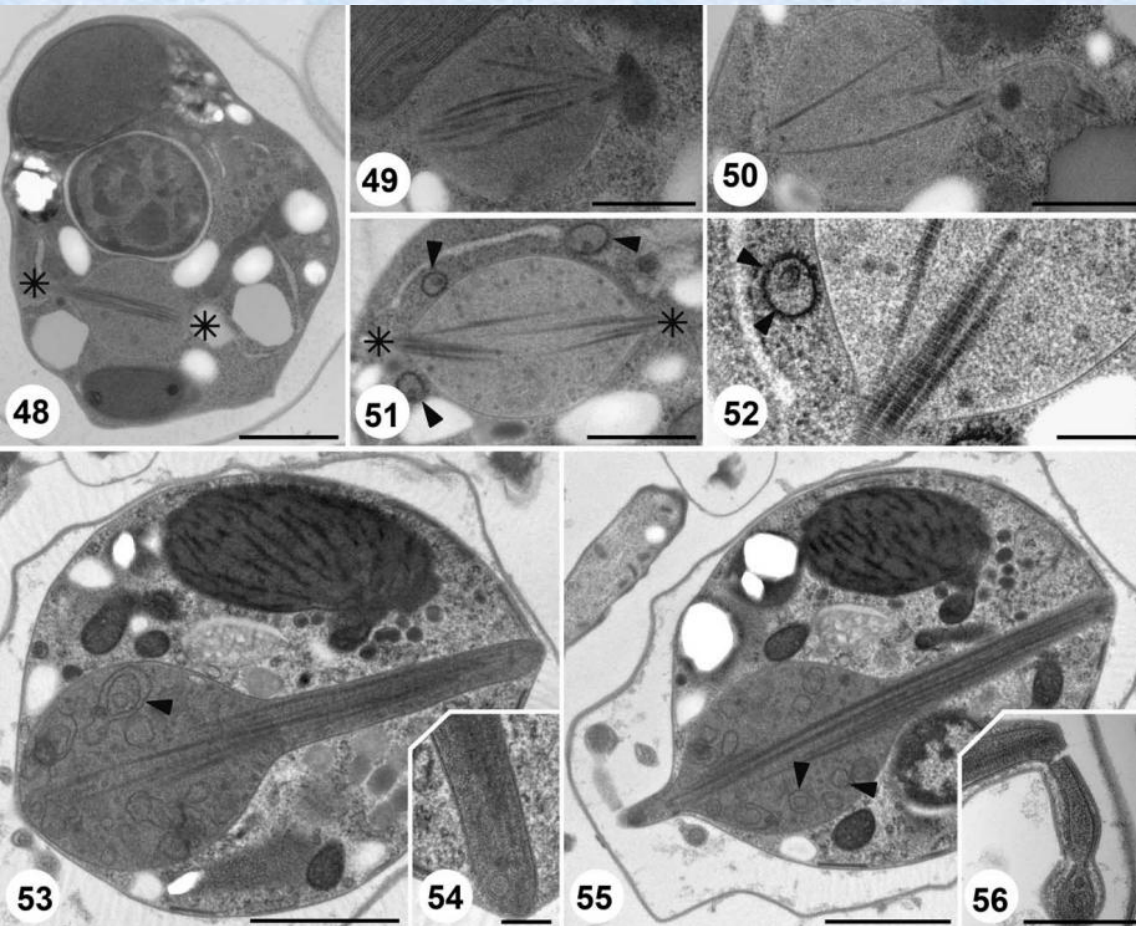
- phylogenetically related to Apicomplexa
- photosynthetic



originally isolated from a coral thallus in Sydney Harbour

simply cultivated (testing the anti-parasitic drugs?)

Chromerida, Chromera



Chromosome

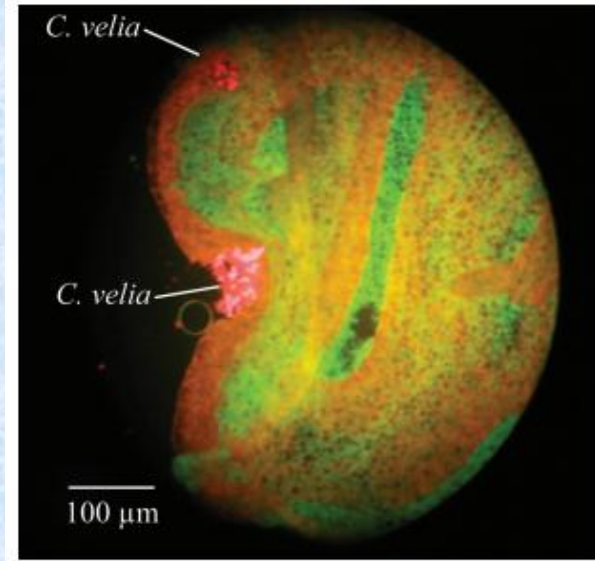
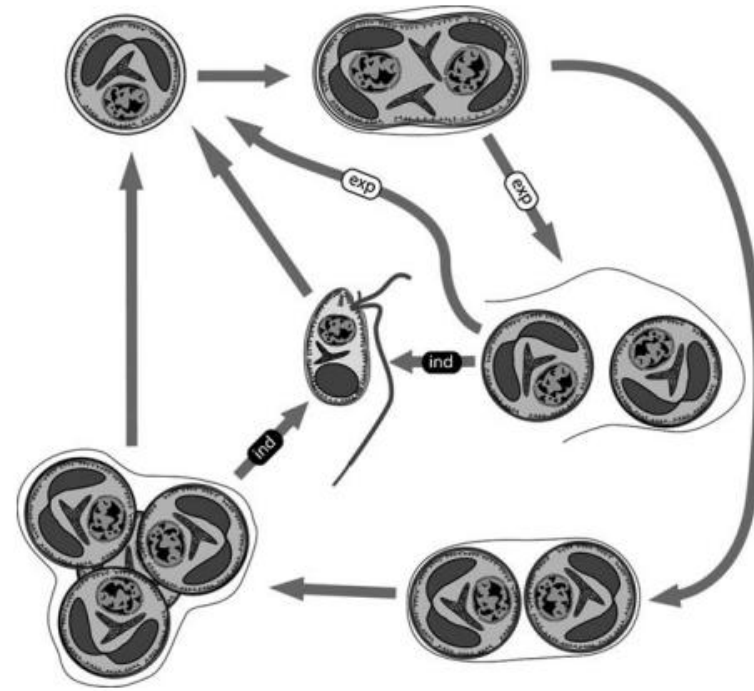
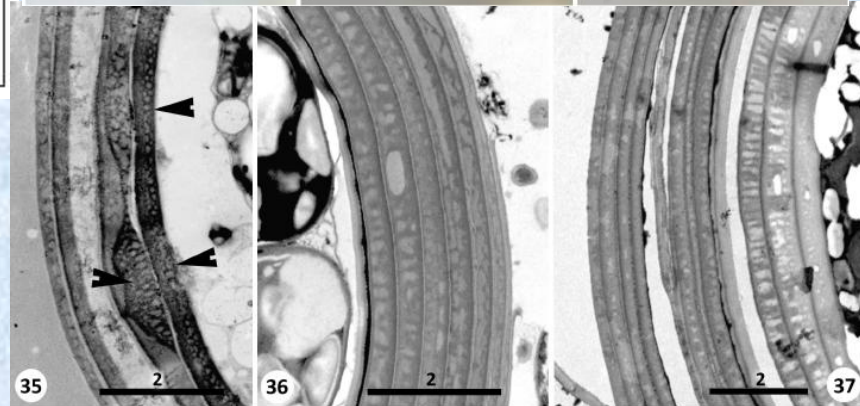
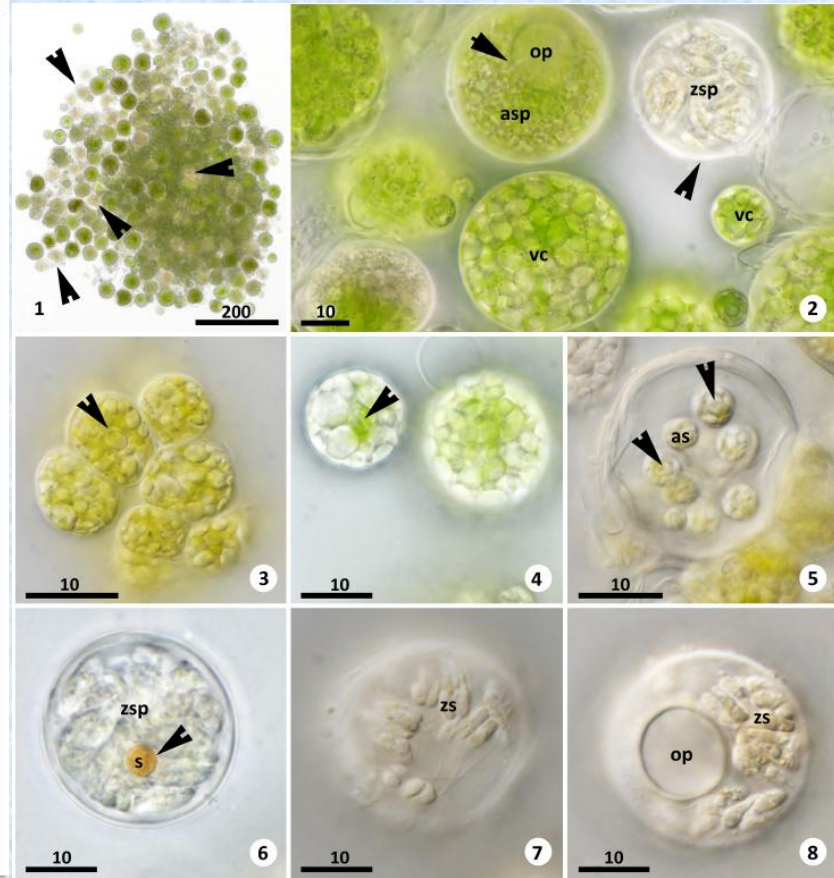
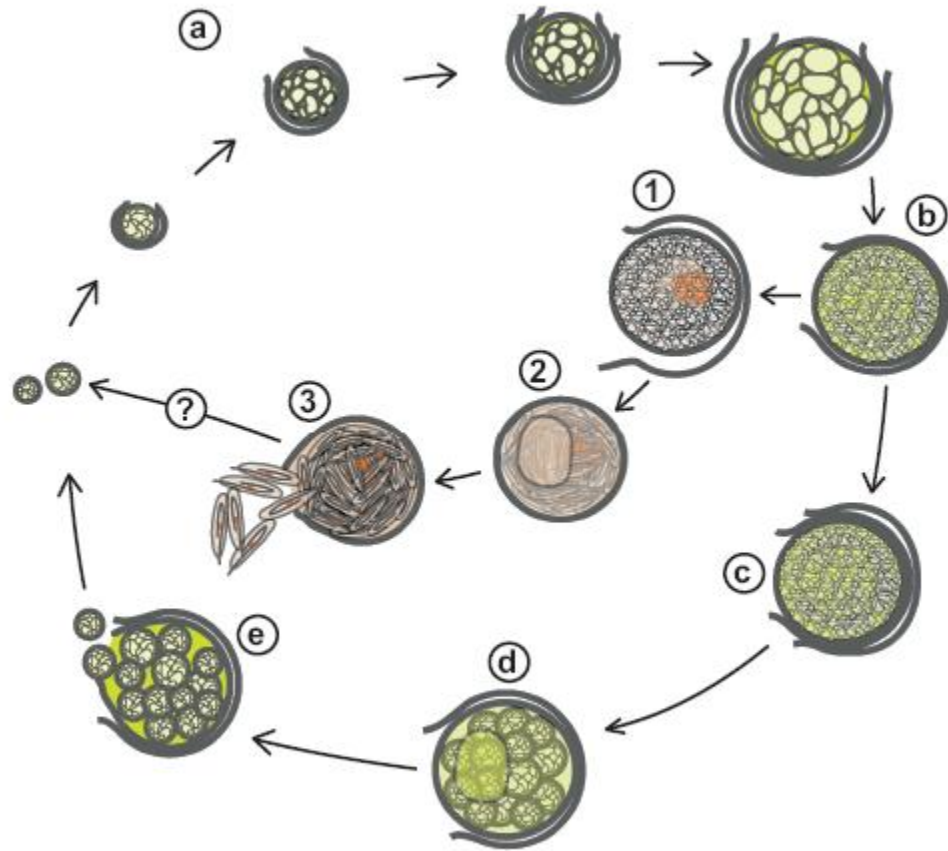


Fig. 1 Two *Chromera velia* clumps fluorescing bright red colliding with an *Acropora digitifera* larva. The larger clump appears to be digesting the ectoderm. The smaller clump has possibly been internalised. Green and red fluorescence proteins are also evident in the larva.



Chromerida, Vitrella



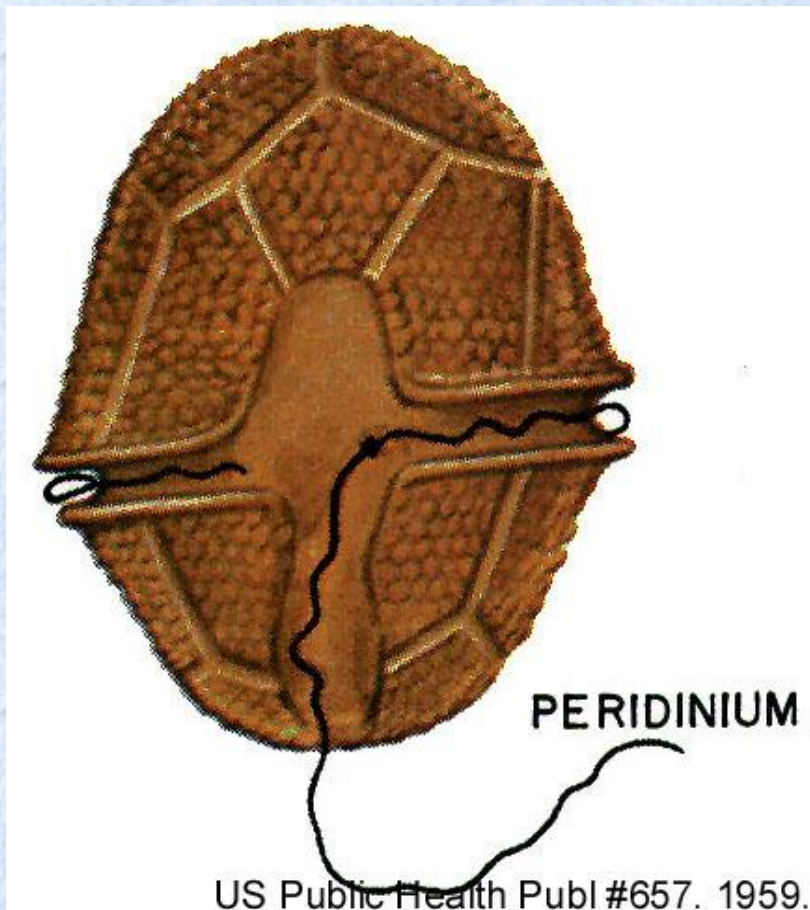
sporangia surrounded by a large number of cell wall layers

Alveolata, Dinophyta



Alveolata, Dinophyta

- marine and freshwater algae
- autotrophic and heterotrophic

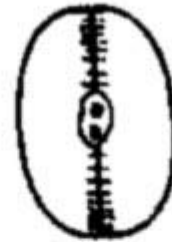


General characteristics

- cca 130 genera, 2000 species
- monanoid, amoeboid, capsal, coccal, or filamentous thallus
- 90% of known species marine
- autotrophic and heterotrophic
- enormous primary production

Cell organisation

Desmokont flagelltype



Prorocentroid



flagellipore plate

Dinokont flagelltype



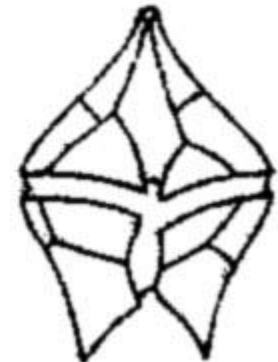
Dinophysoid



Gonyaulacoid

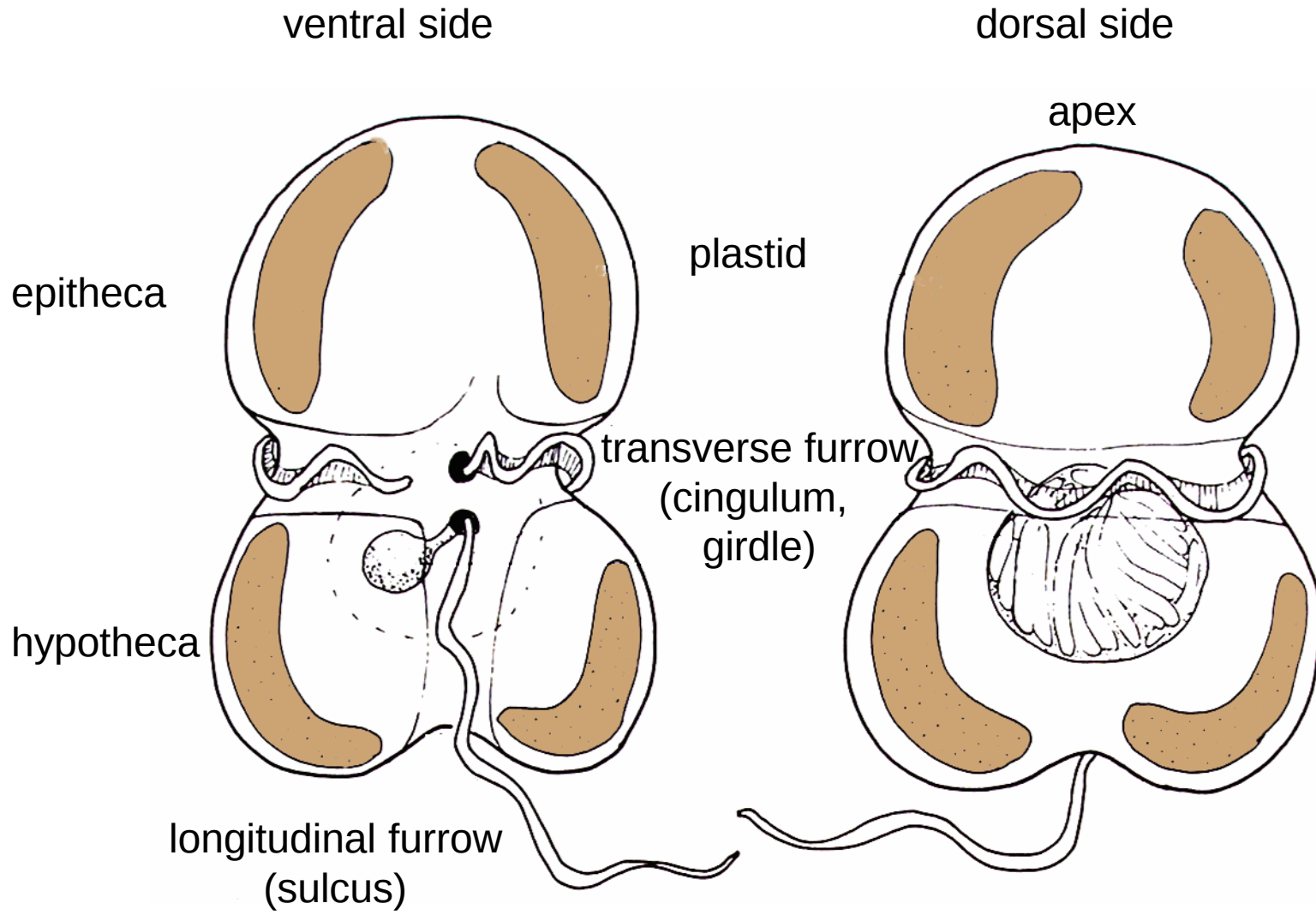


Gymnodinioid



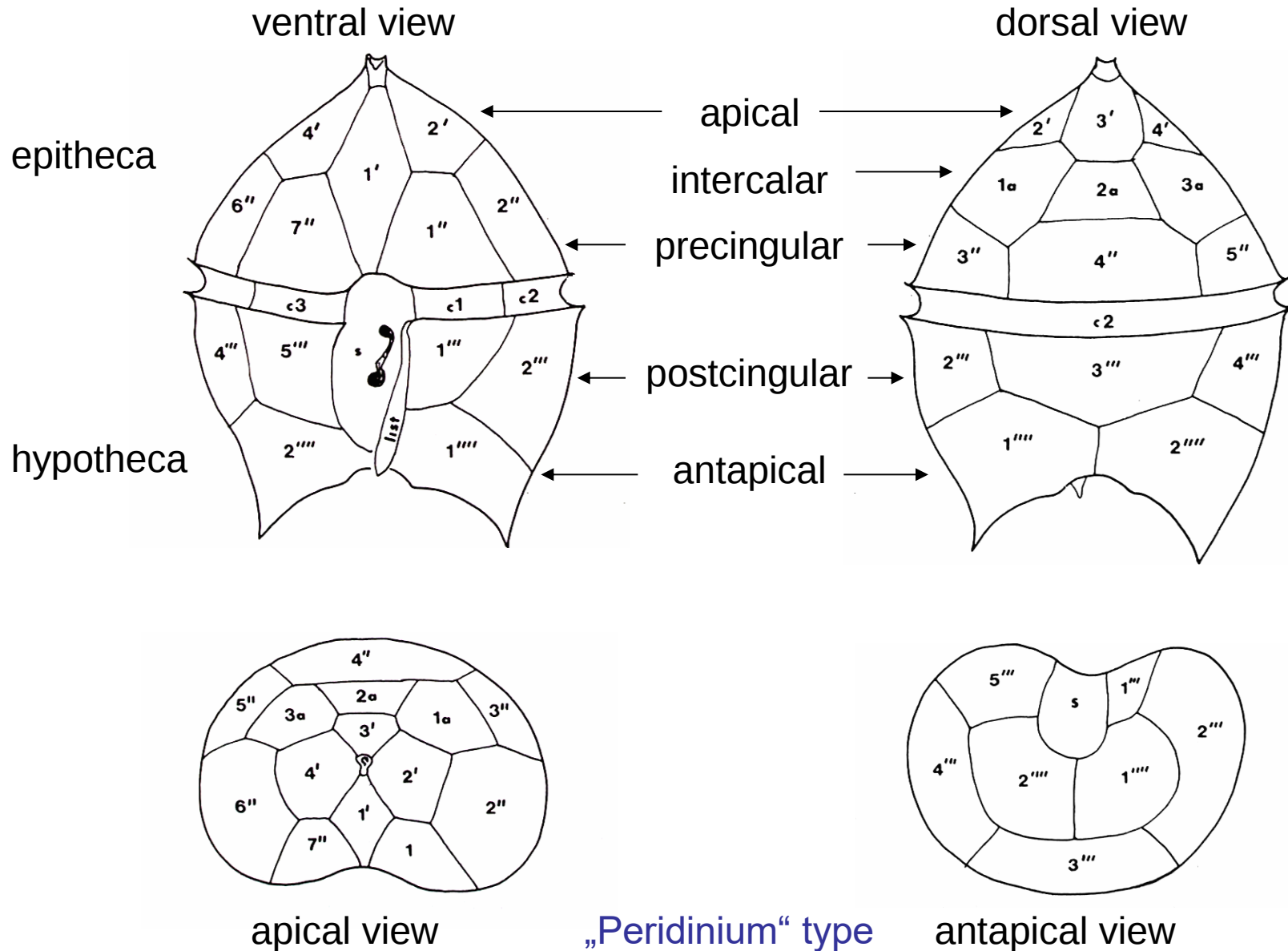
Peridinioid

Cell organisation

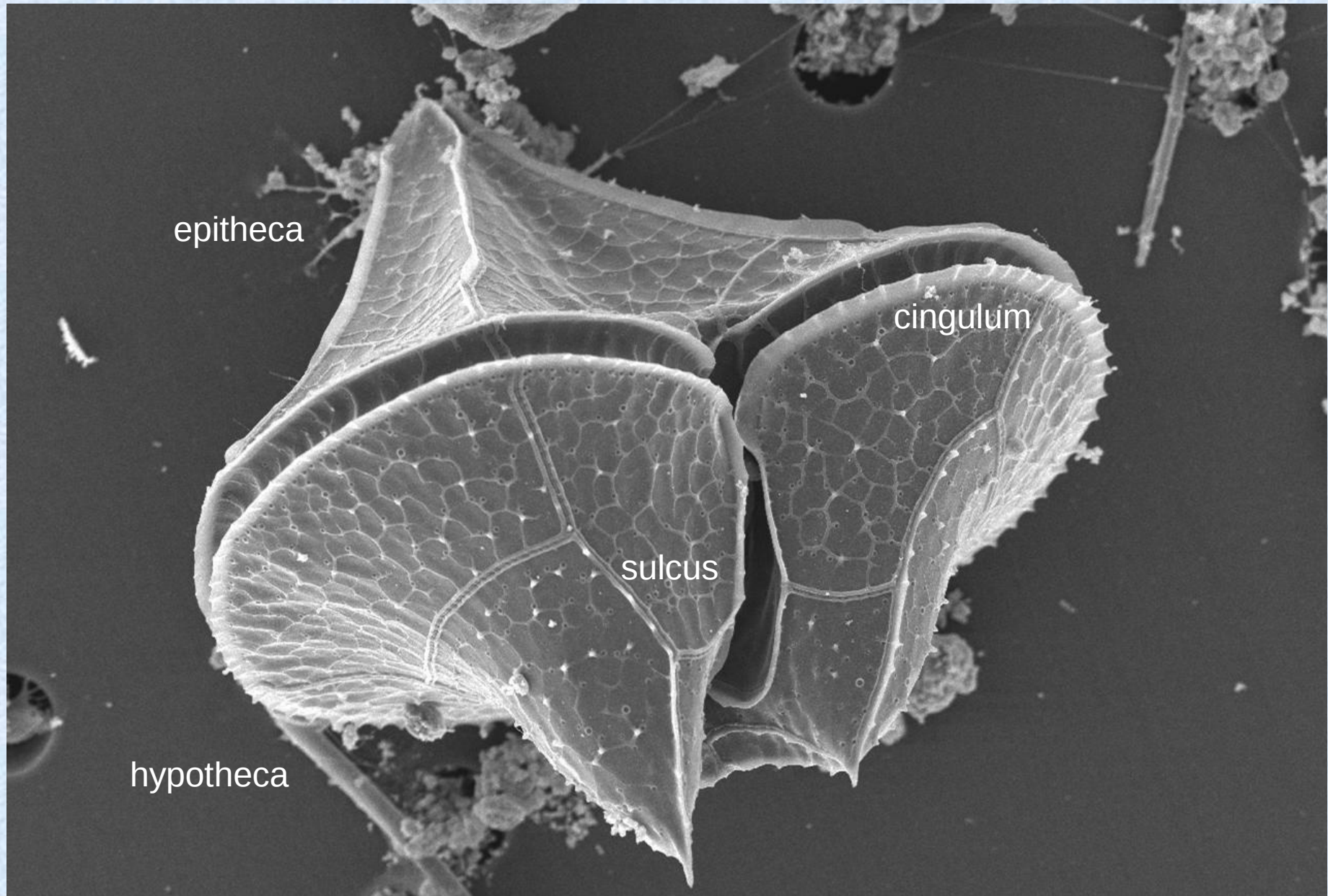


„Gymnodinium“ type

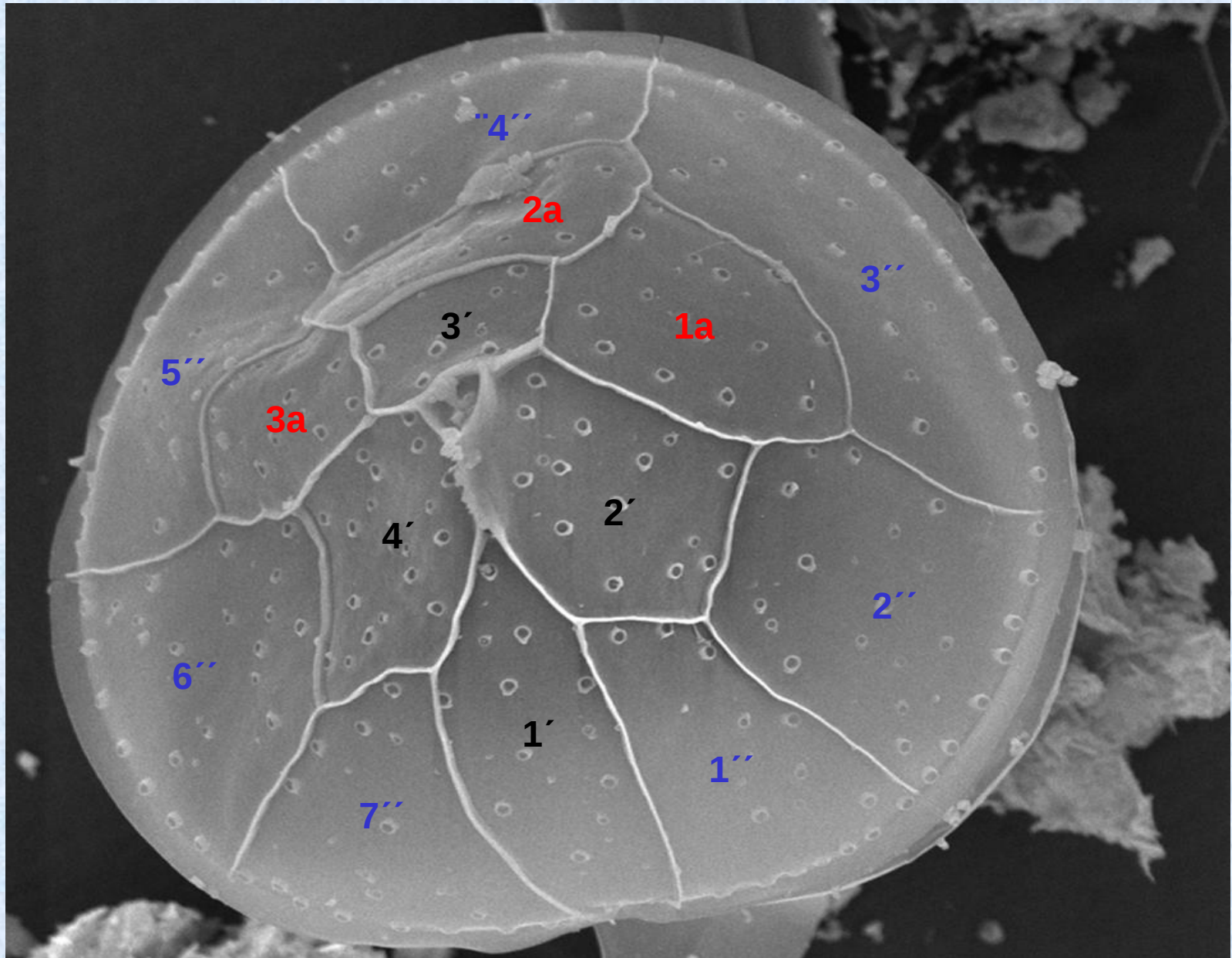
Cell organisation



Cell organisation



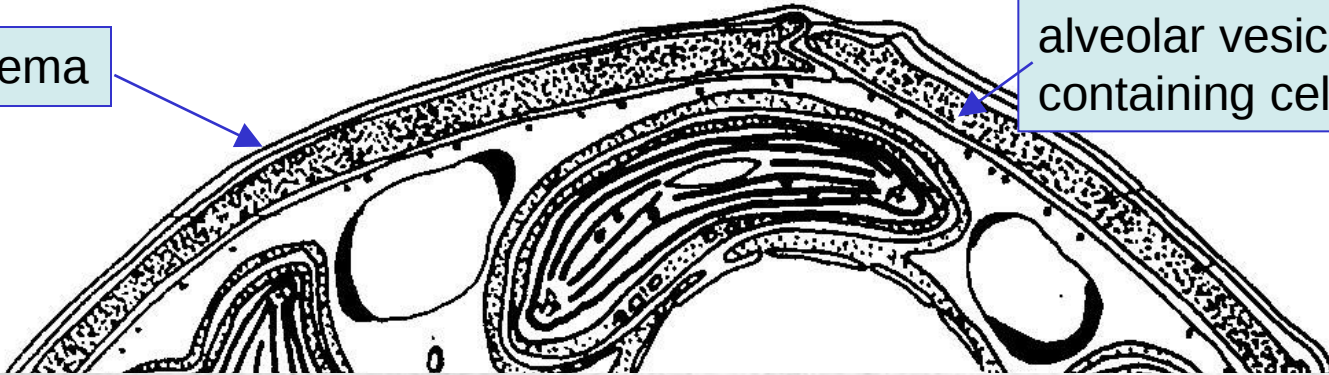
Cell organisation



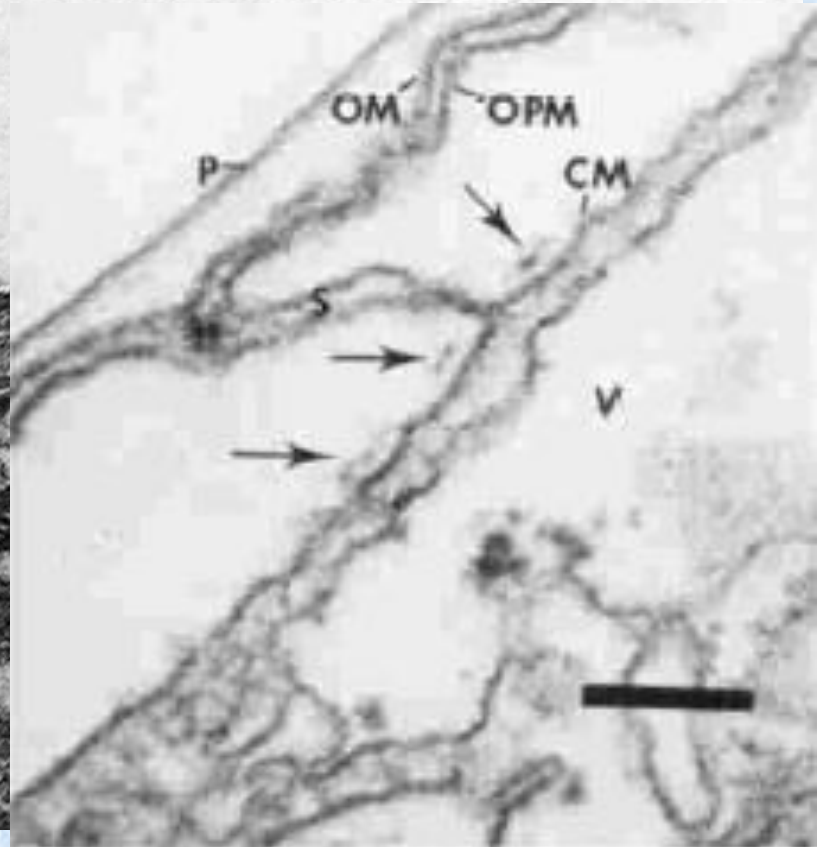
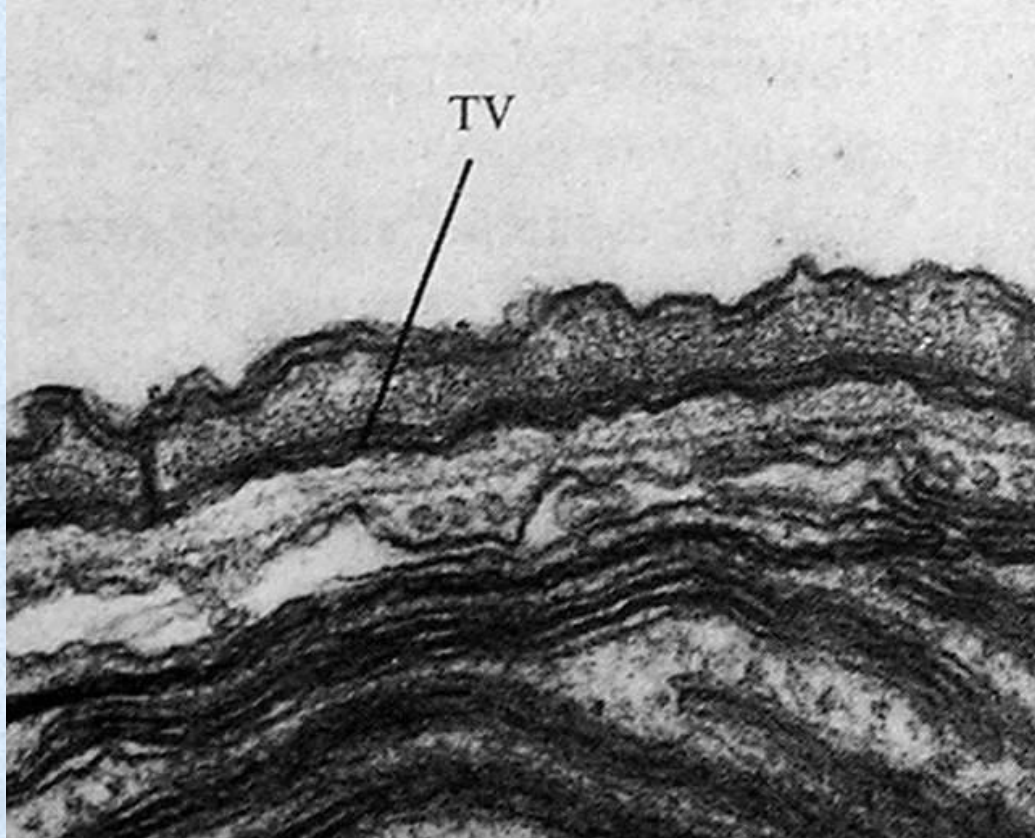
Cell organisation

plasmalema

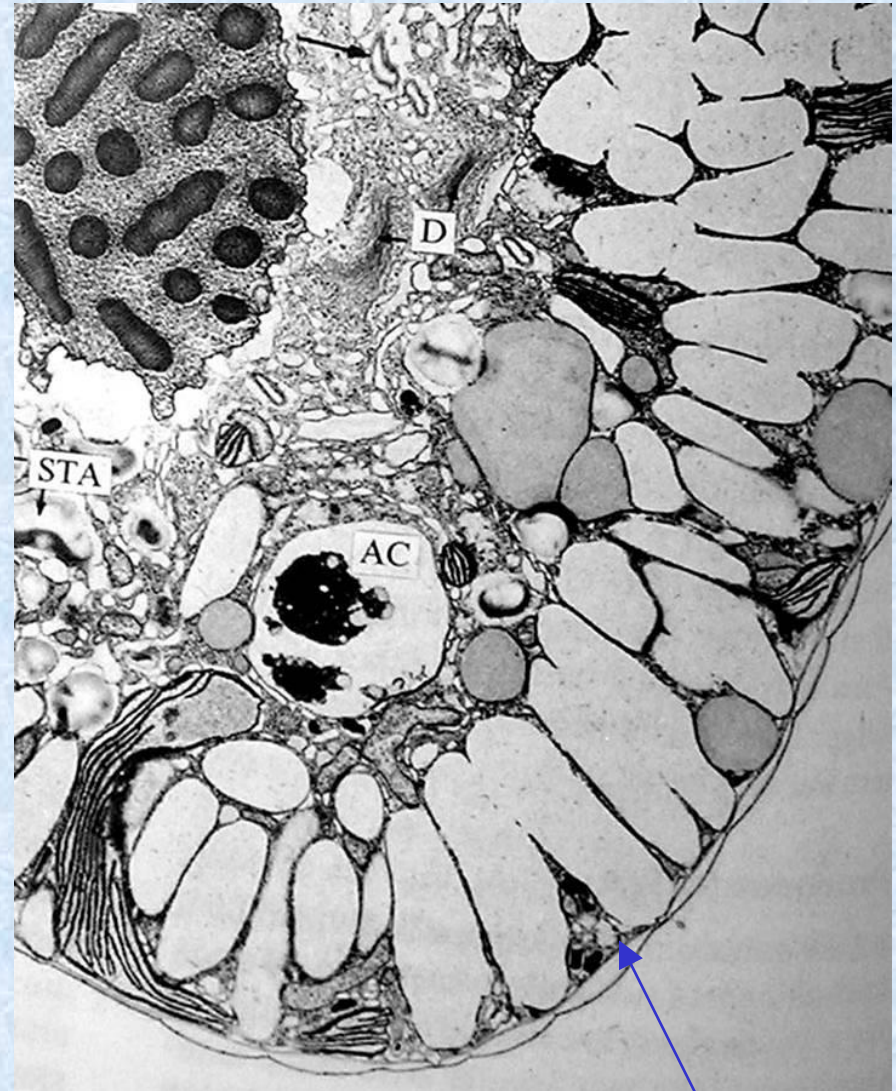
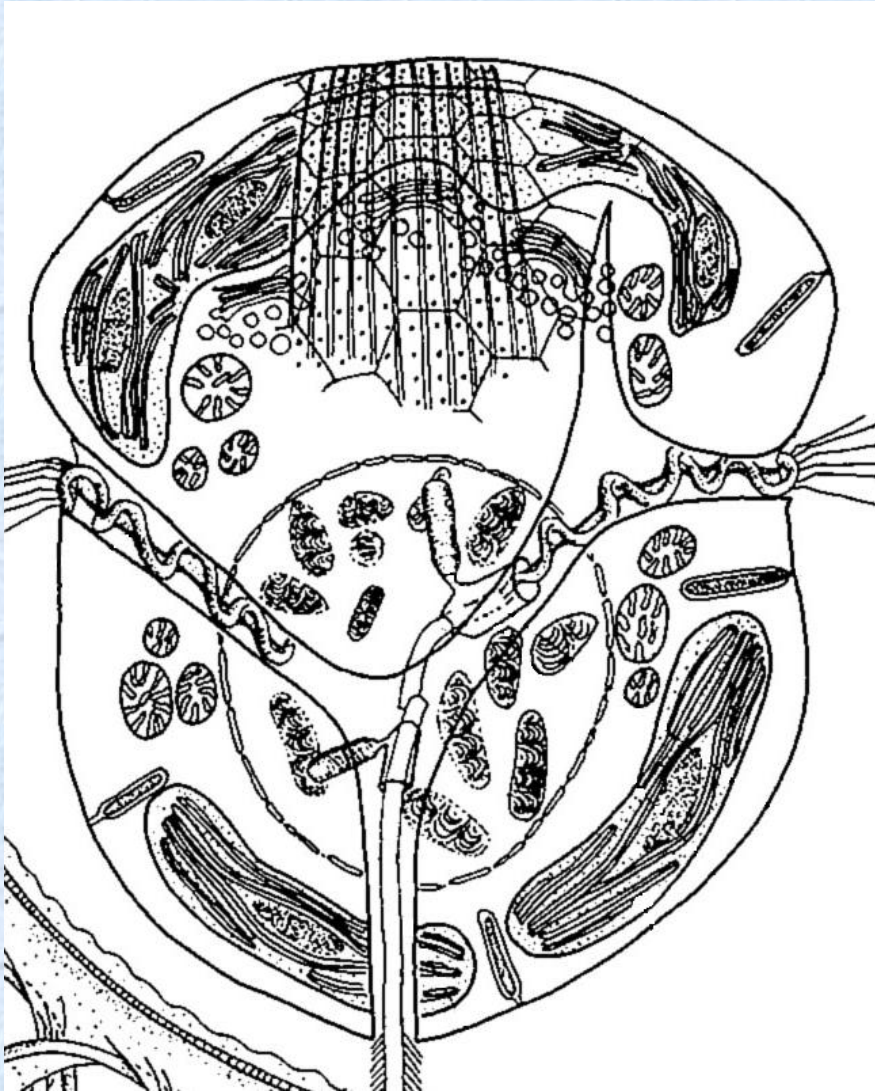
alveolar vesicles
containing cellulose plate



TV

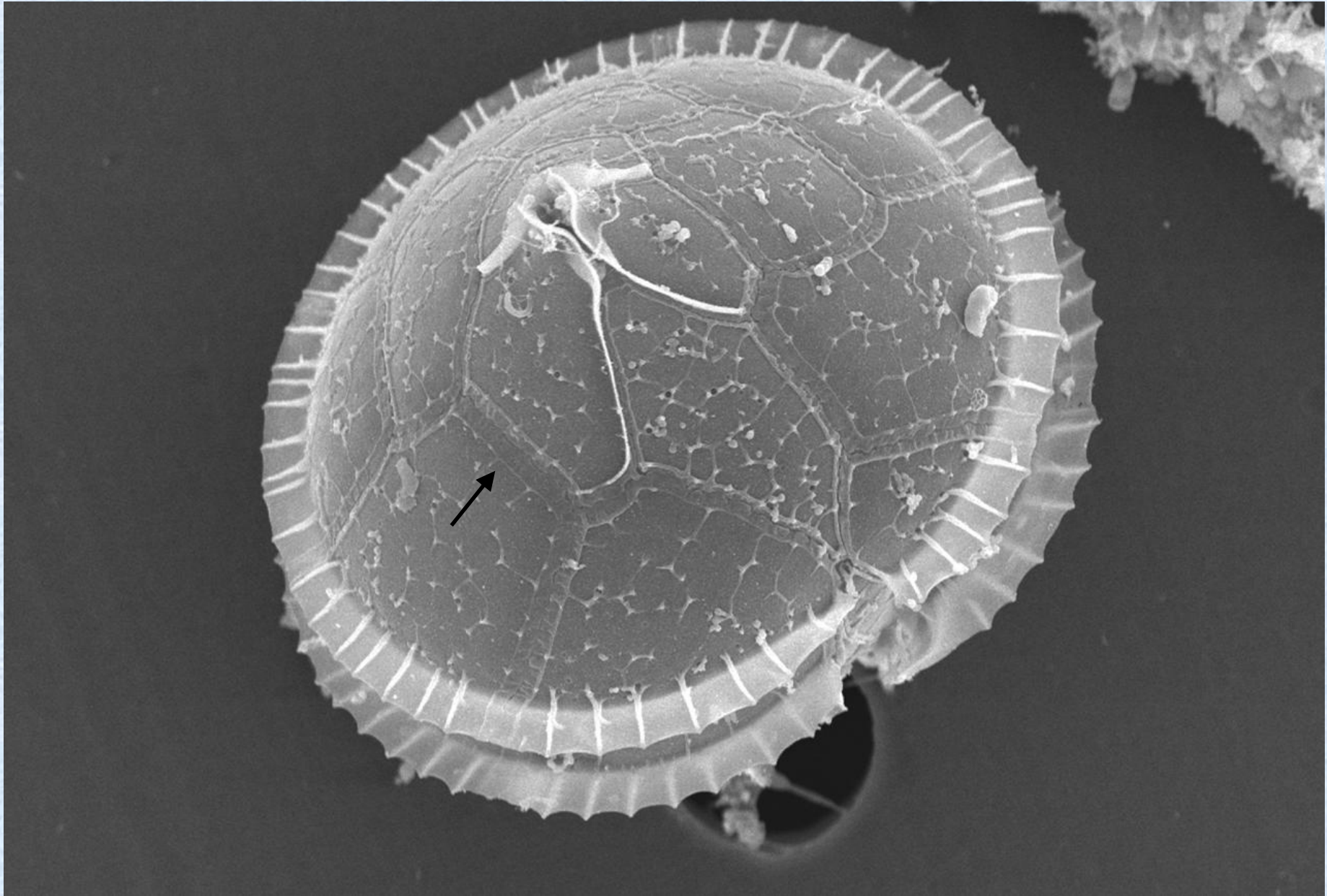


Cell organisation



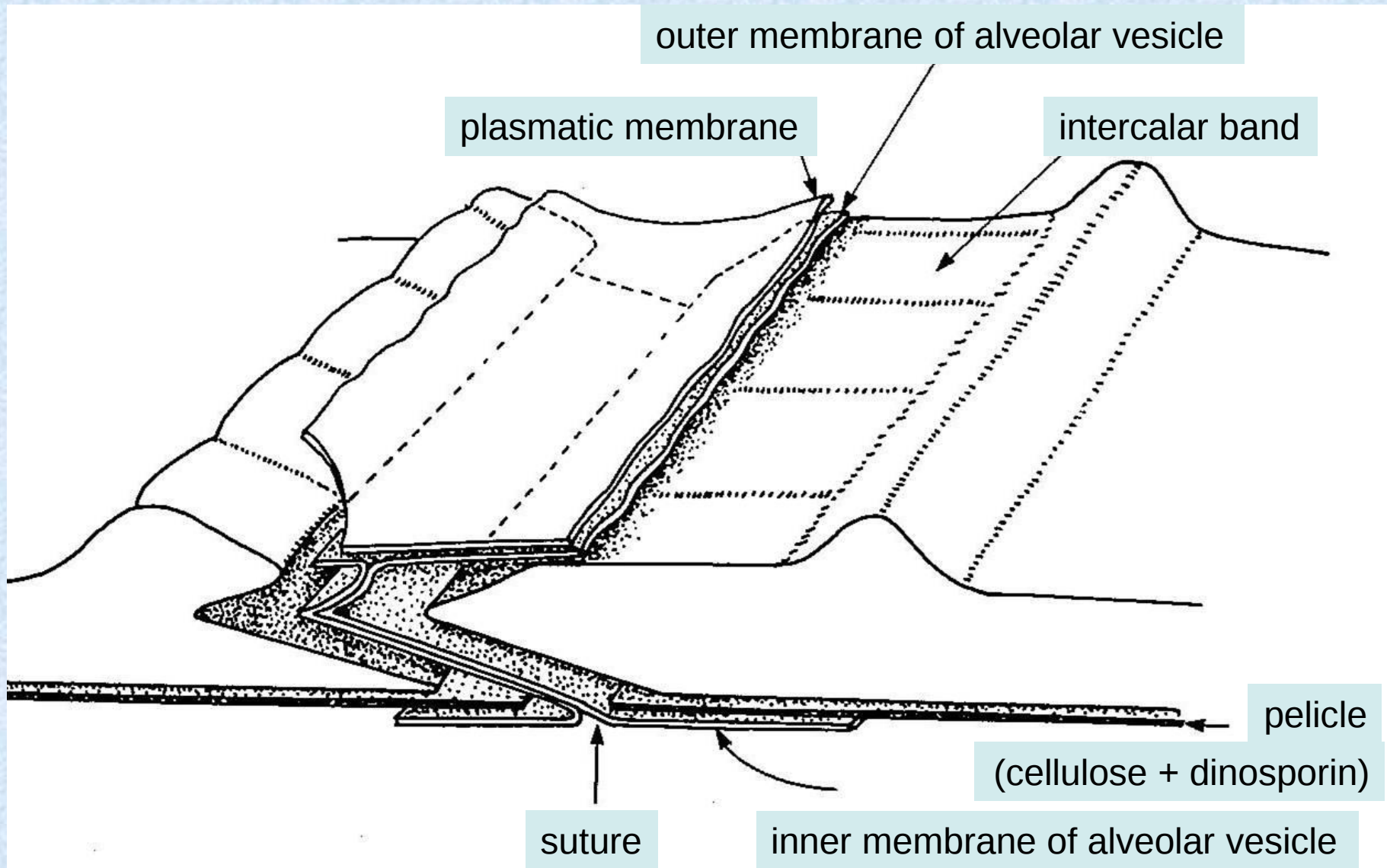
alveolar vesicles with amorphous material

Cell organisation



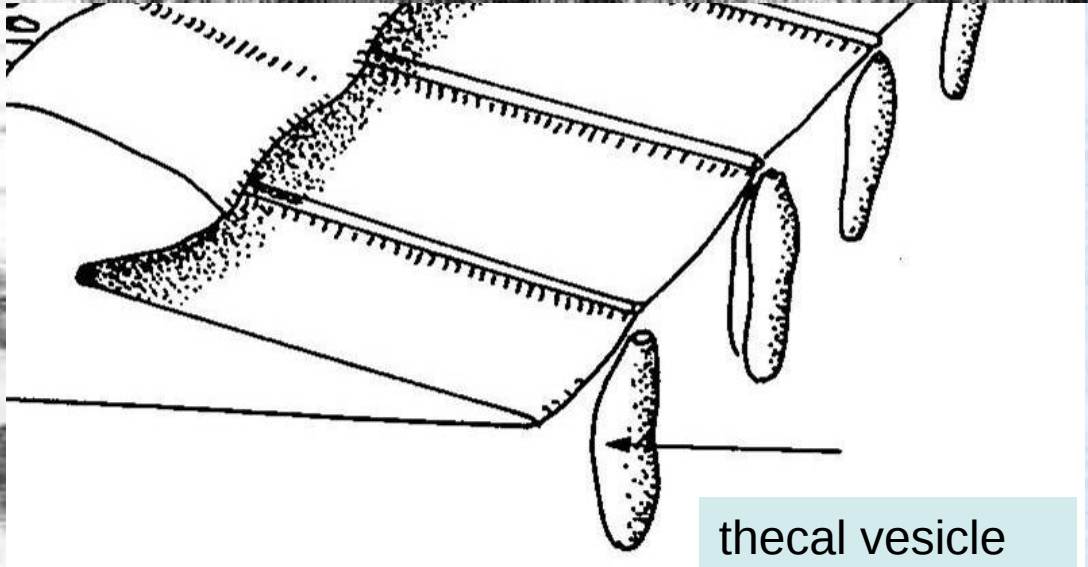
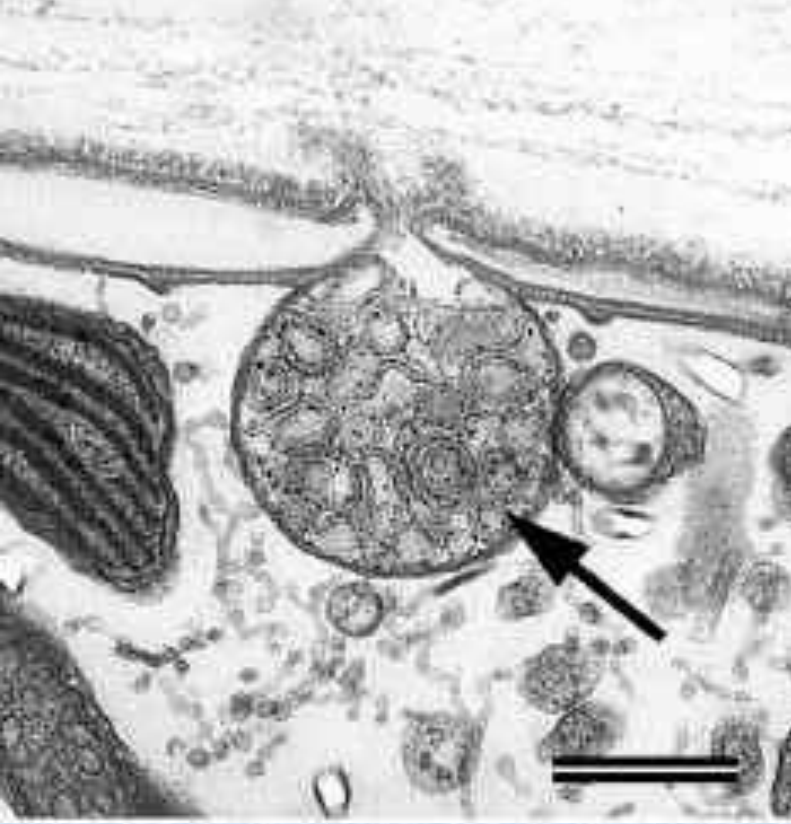
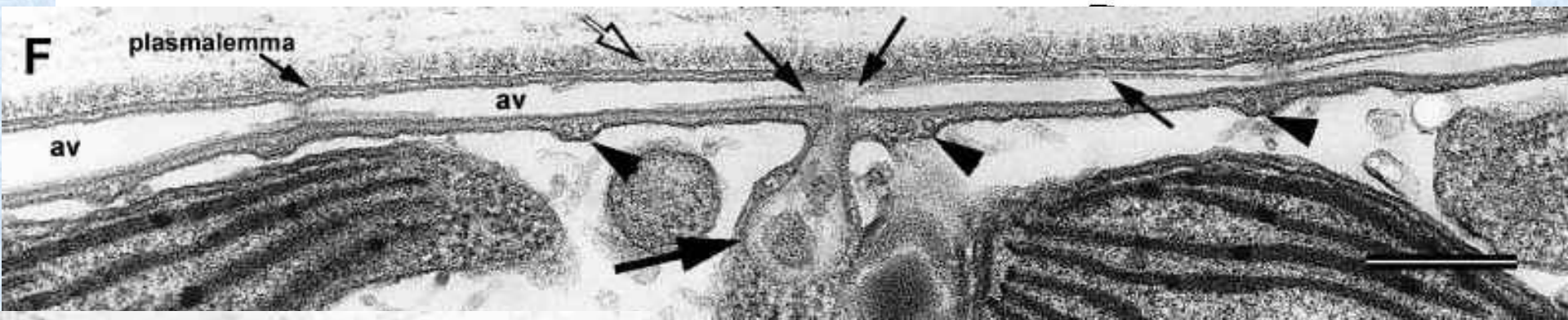
Cell organisation

connection of two adjacent plates



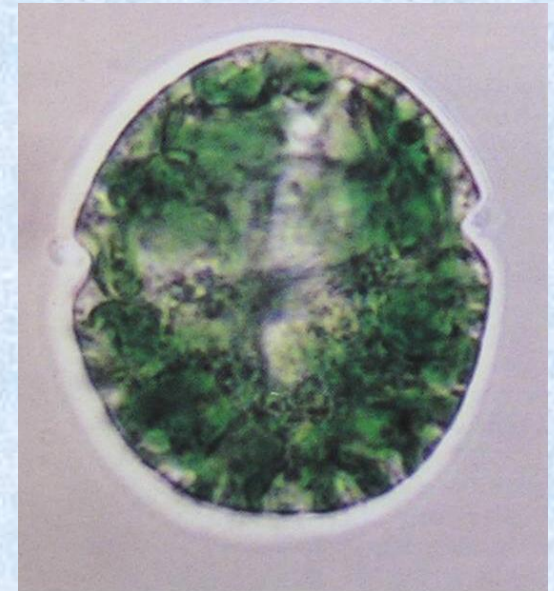
Cell organisation

structure of the thecal plate

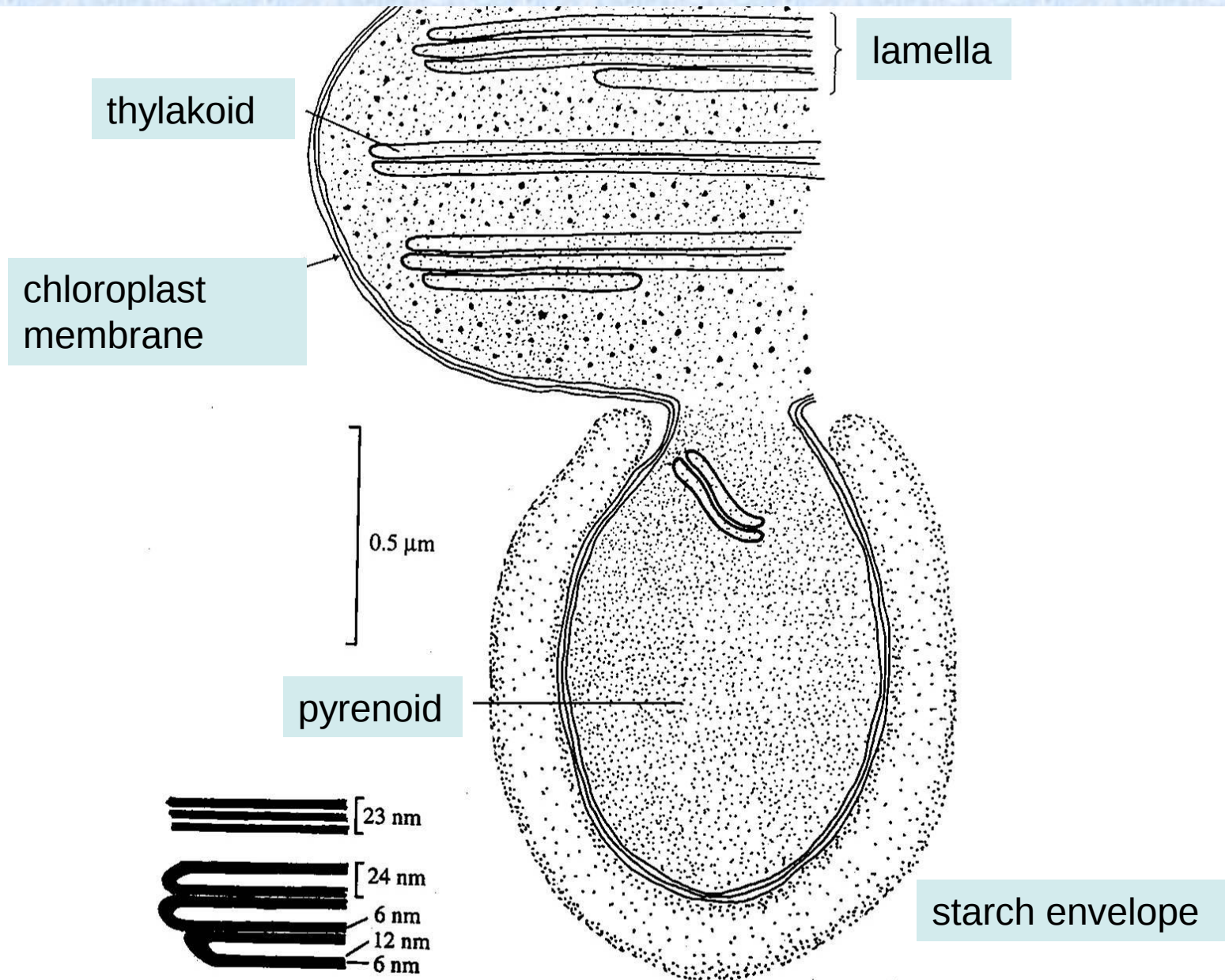


Plastids

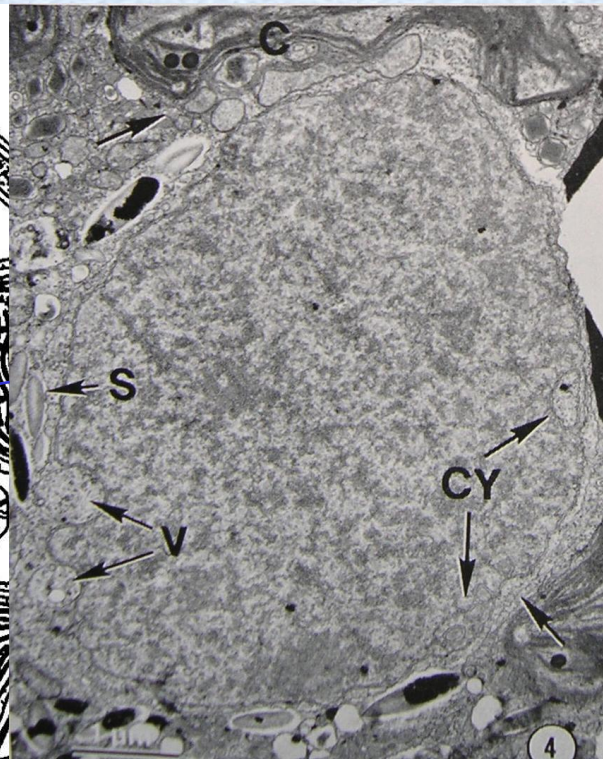
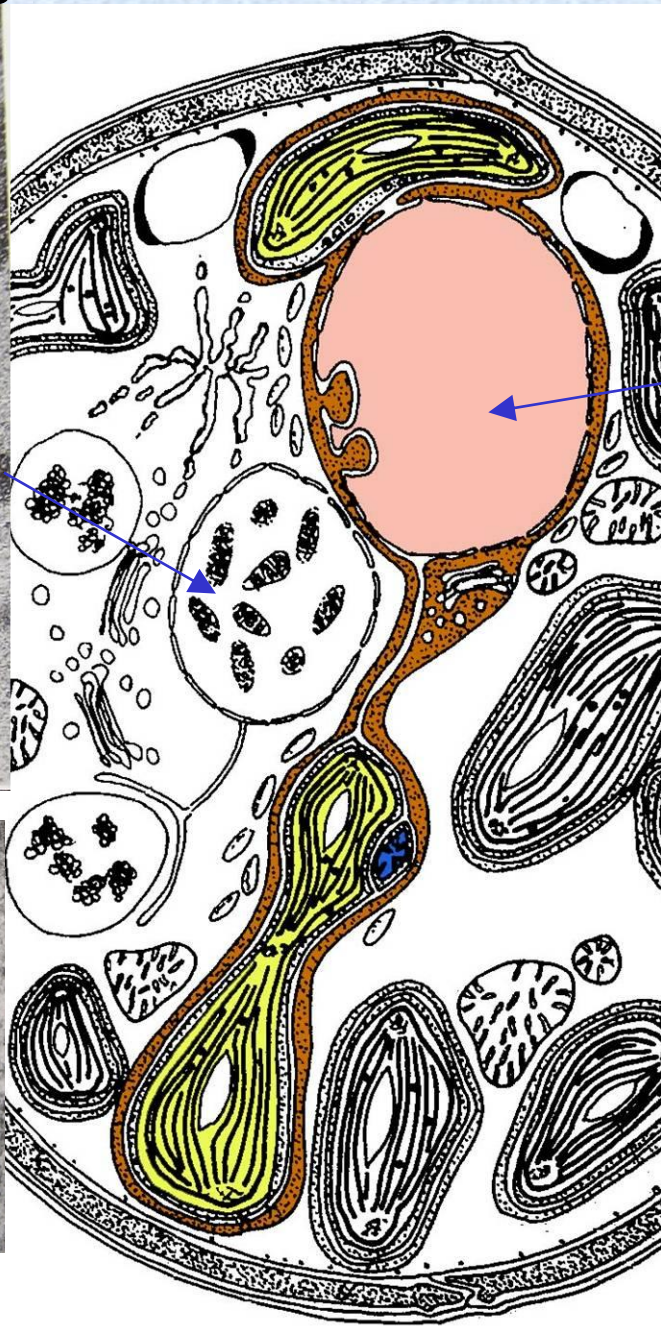
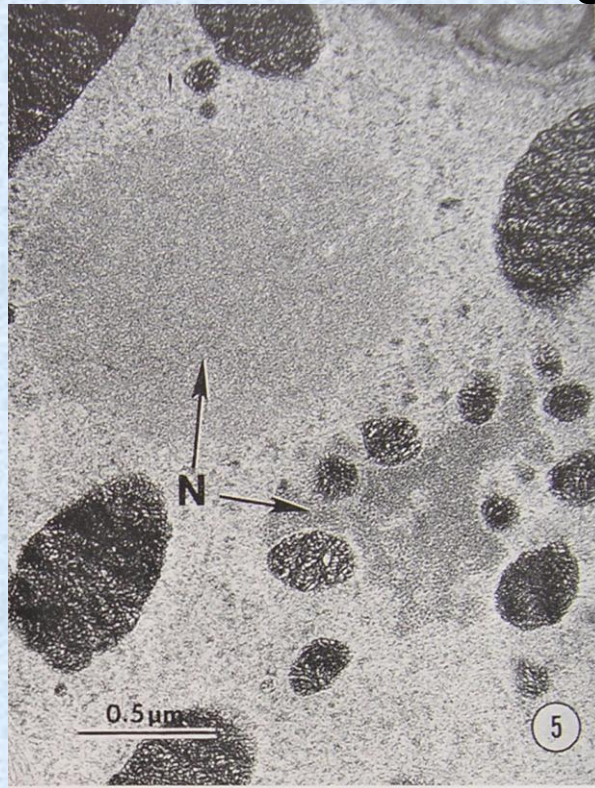
- only in 50% of species
- chl a, c₂, β -caroten, peridinin (or fukoxanthin), diadinoxanthin, dinoxanthin
- thylakoids stacked in triplets
- 3 membranes



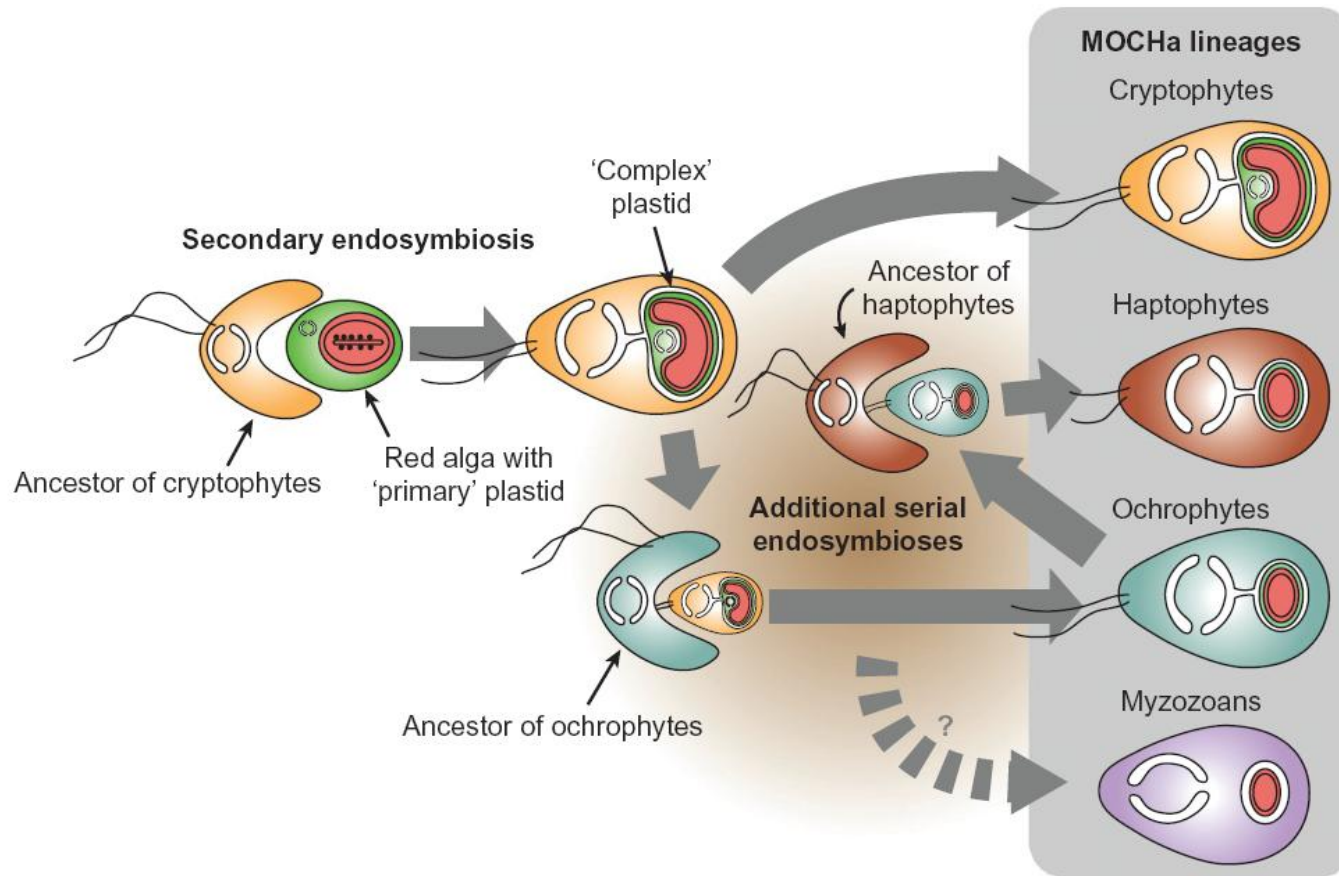
Plastids



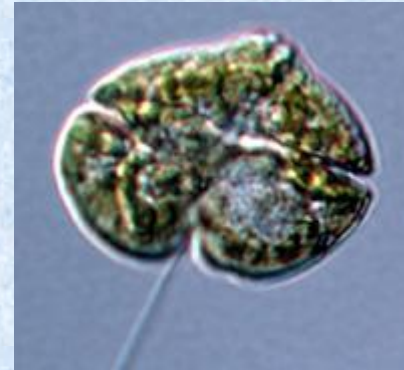
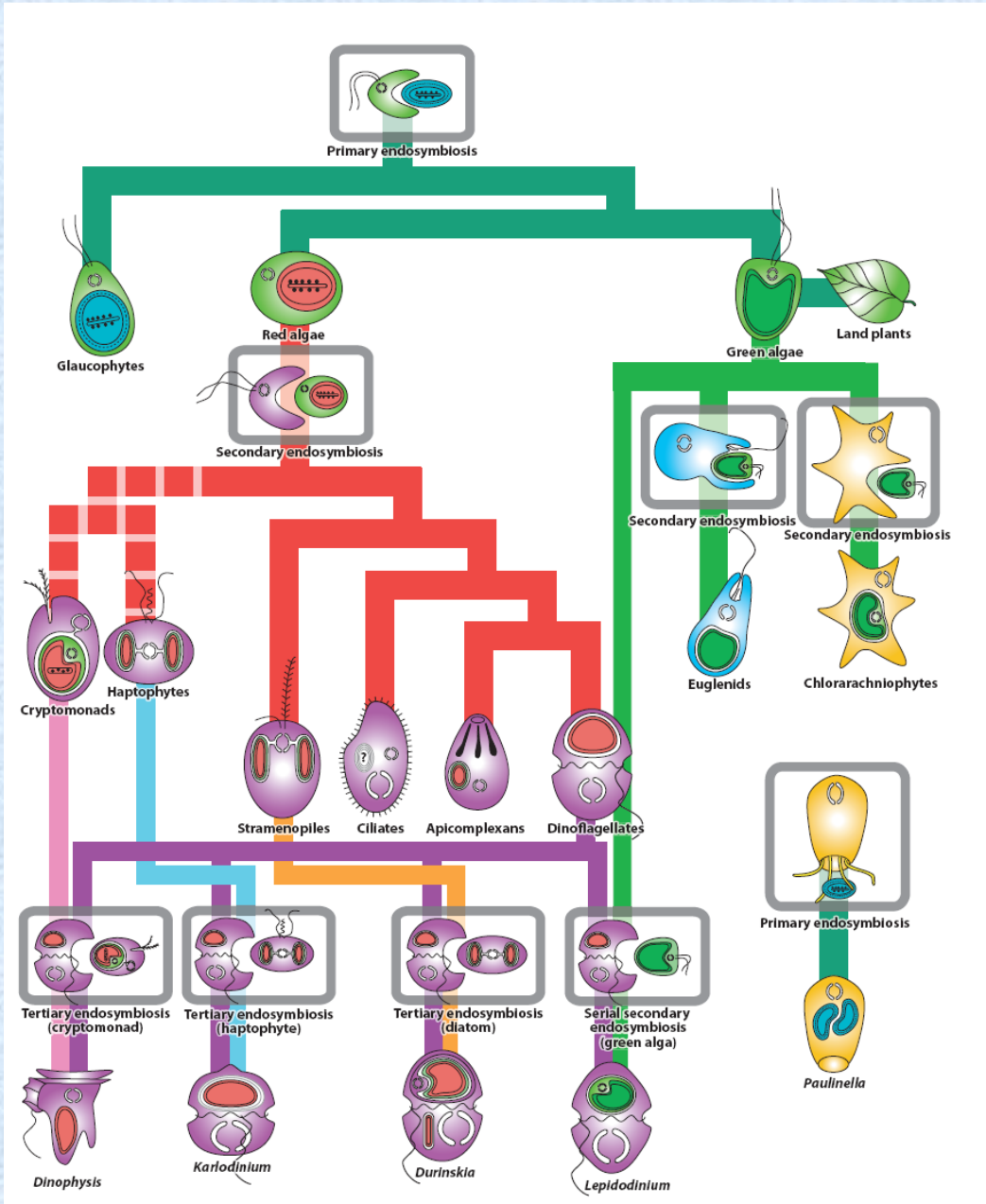
Cell organisation in *Peridinium balticum*



Complex endosymbioses



Complex endosymbioses



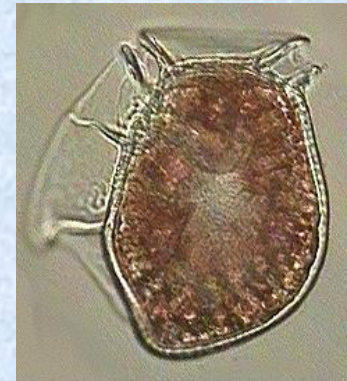
Karenia



Karlodinium



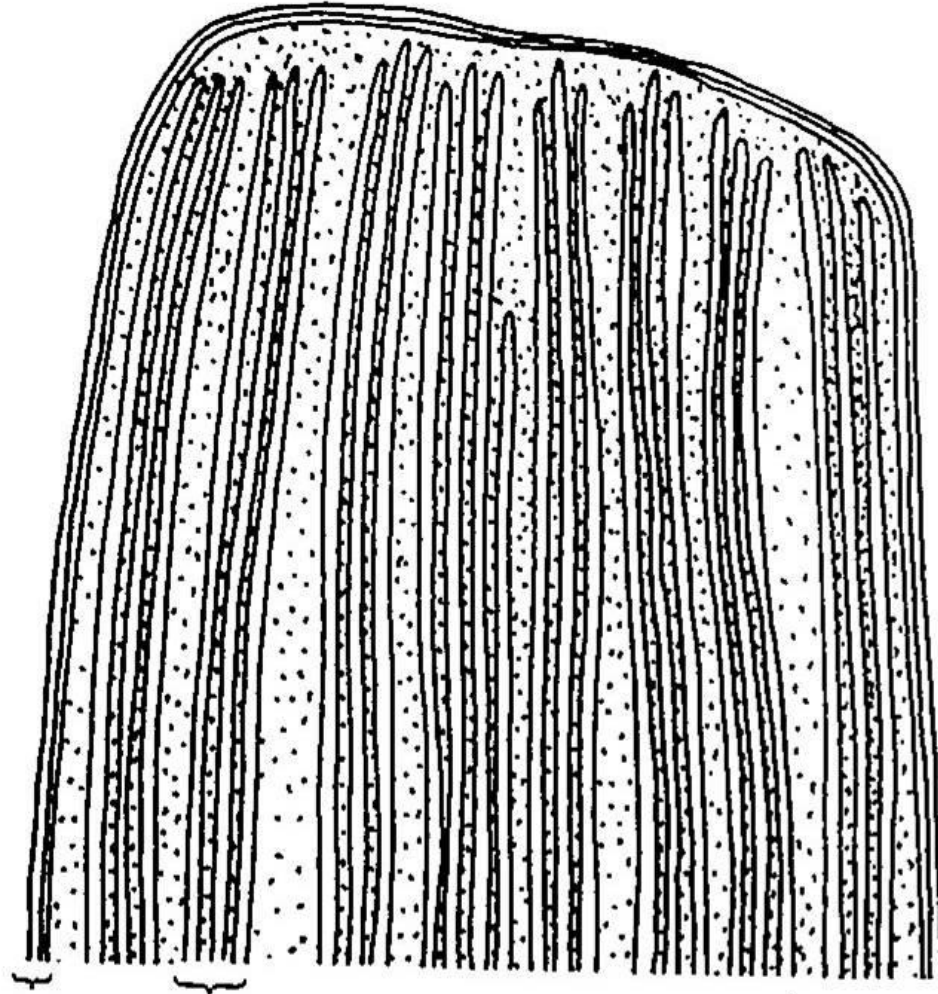
Lepidodinium



Dinophysis

Plastid types

Type I. – typical plastid (peridinin)

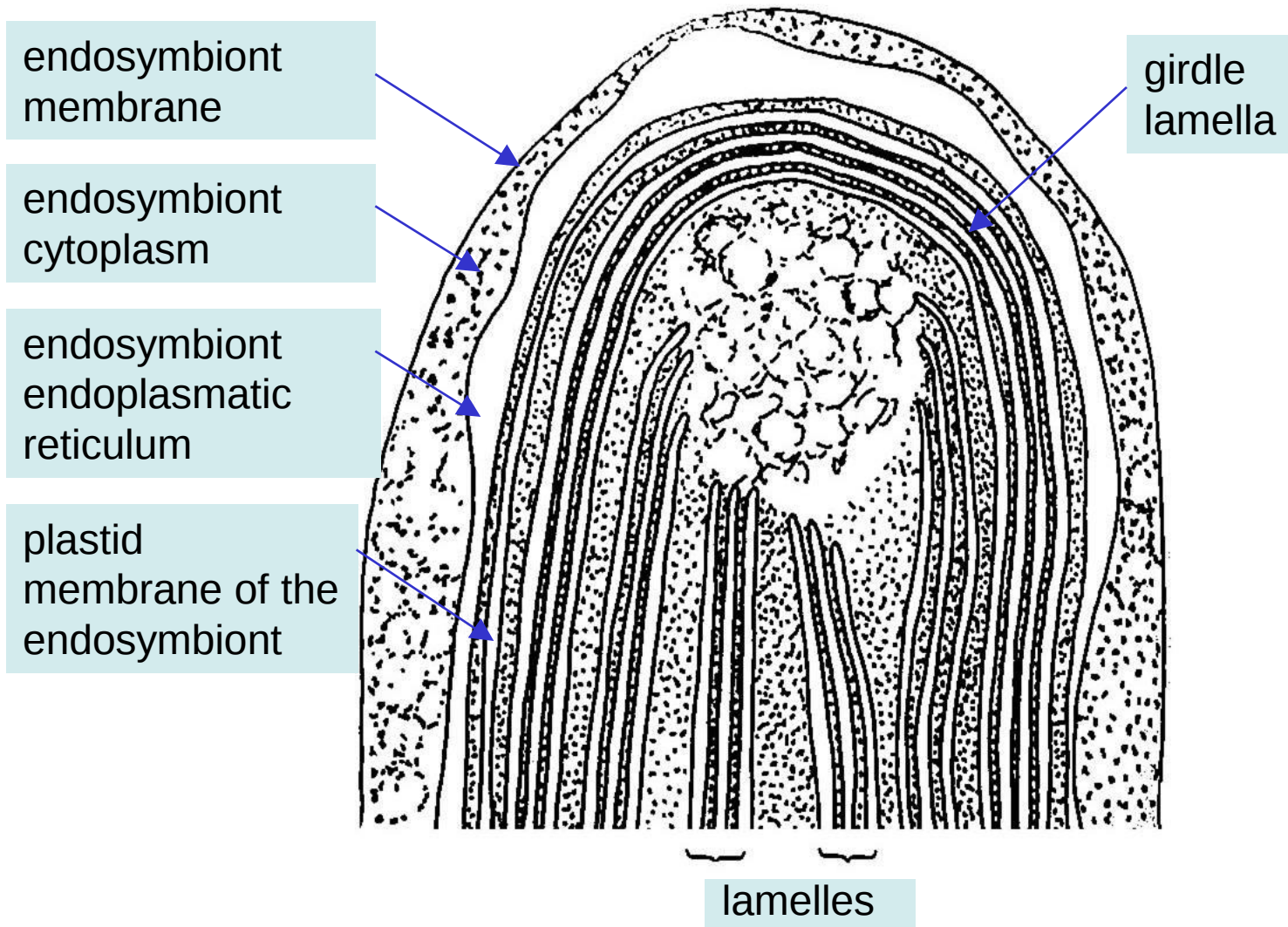


3 plastid
membranes

lamella

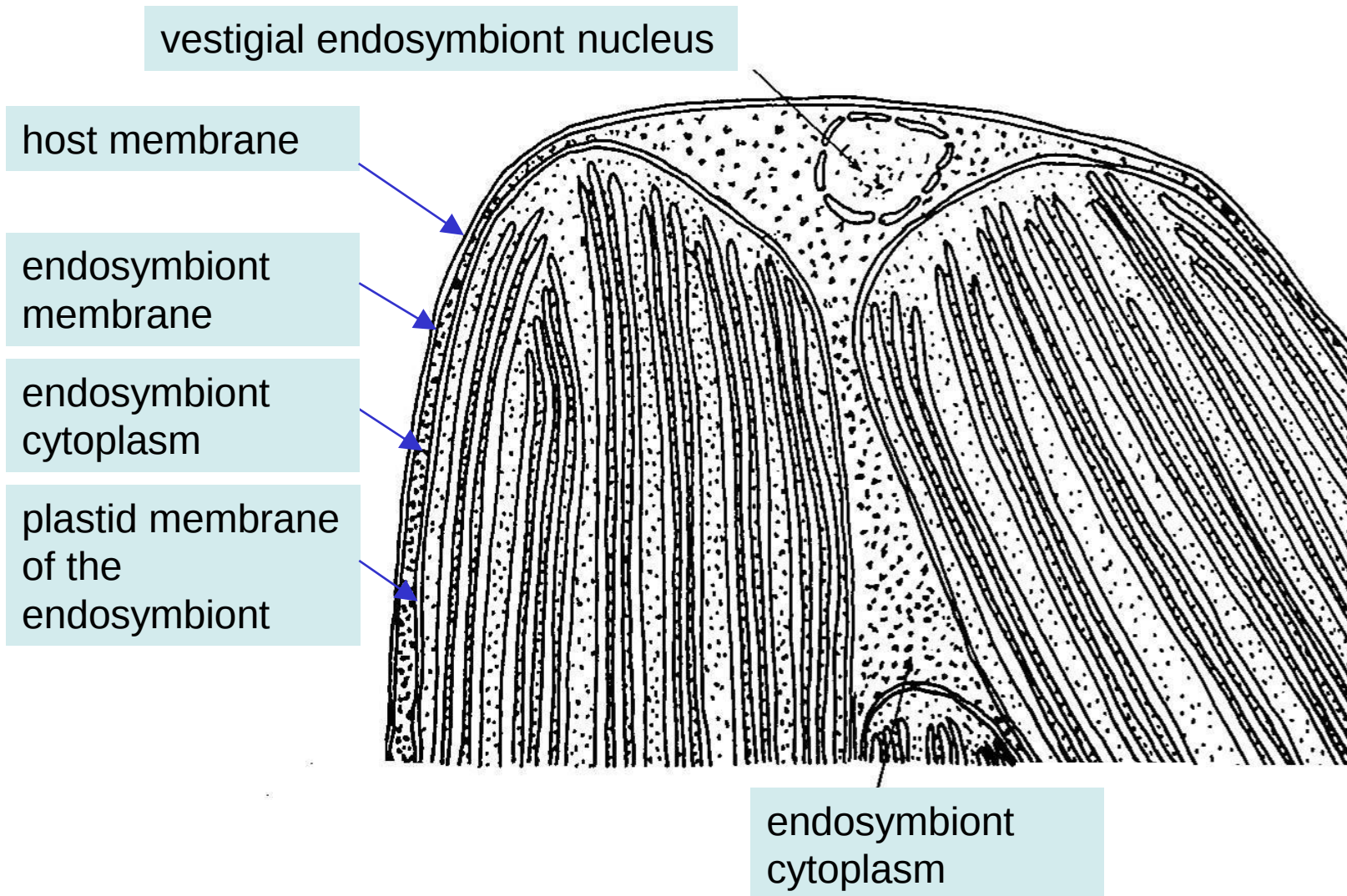
Plastid types

Type II. – reduced Stramenopile endosymbiont (fucoxanthin)



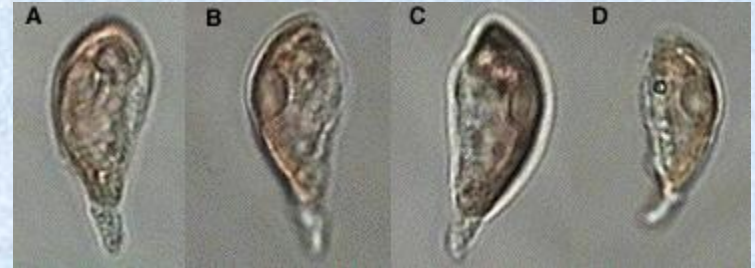
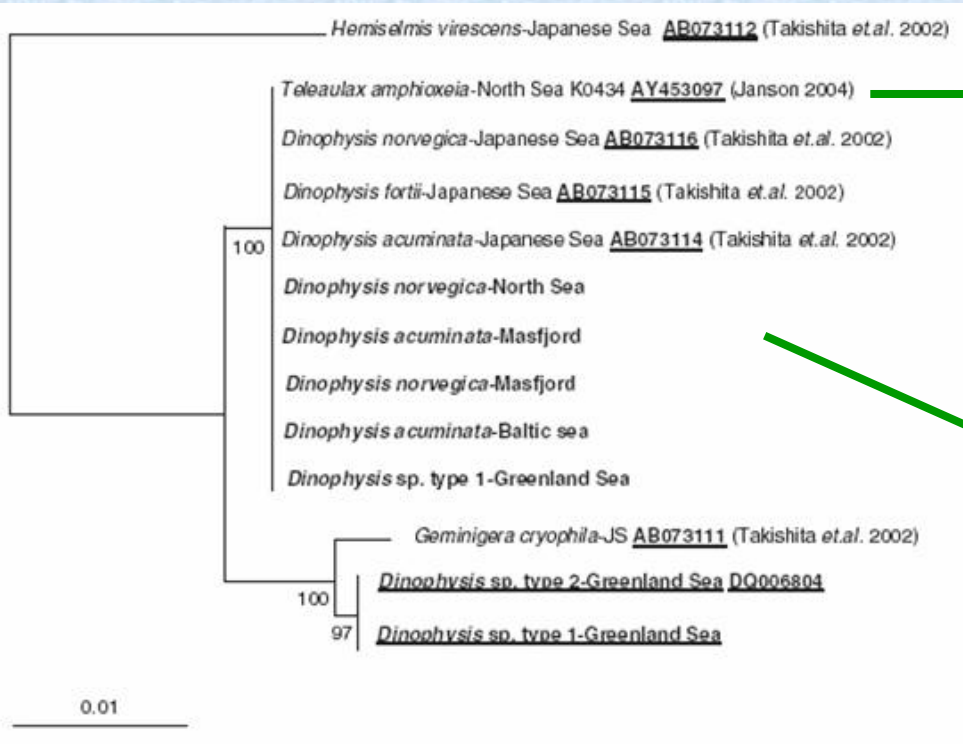
Plastid types

Type III. – reduced green endosymbiont (chl a + b)

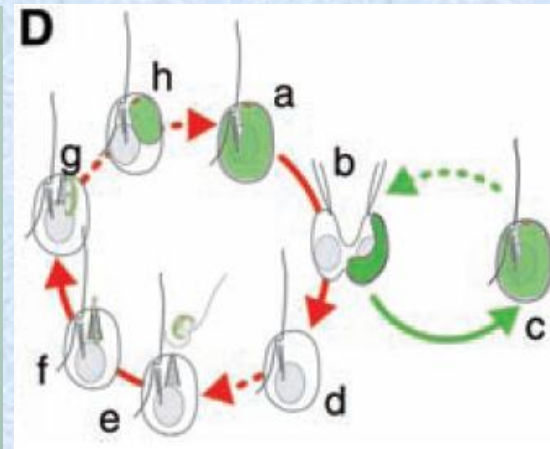


Recent endosymbioses

Dinophysis – plastids continuously replaces from Cryptophytes



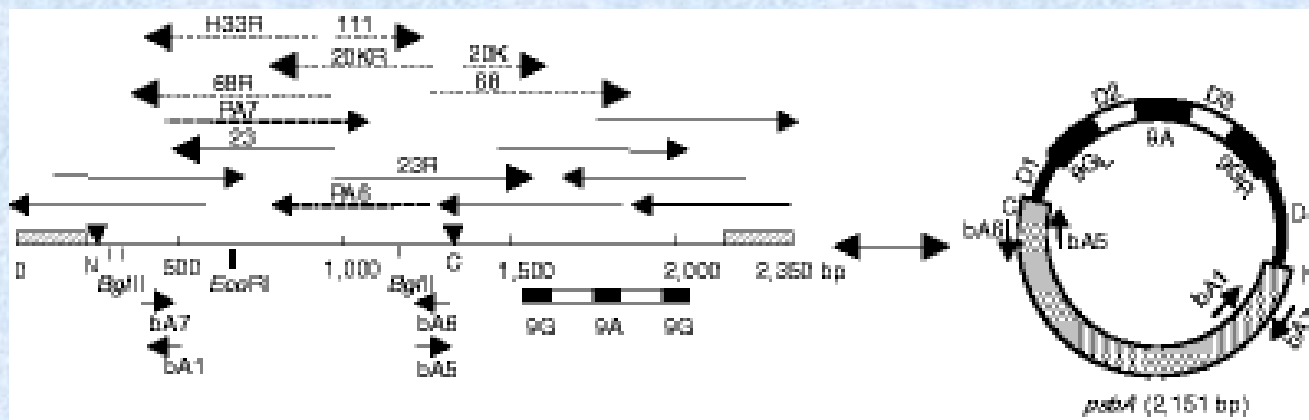
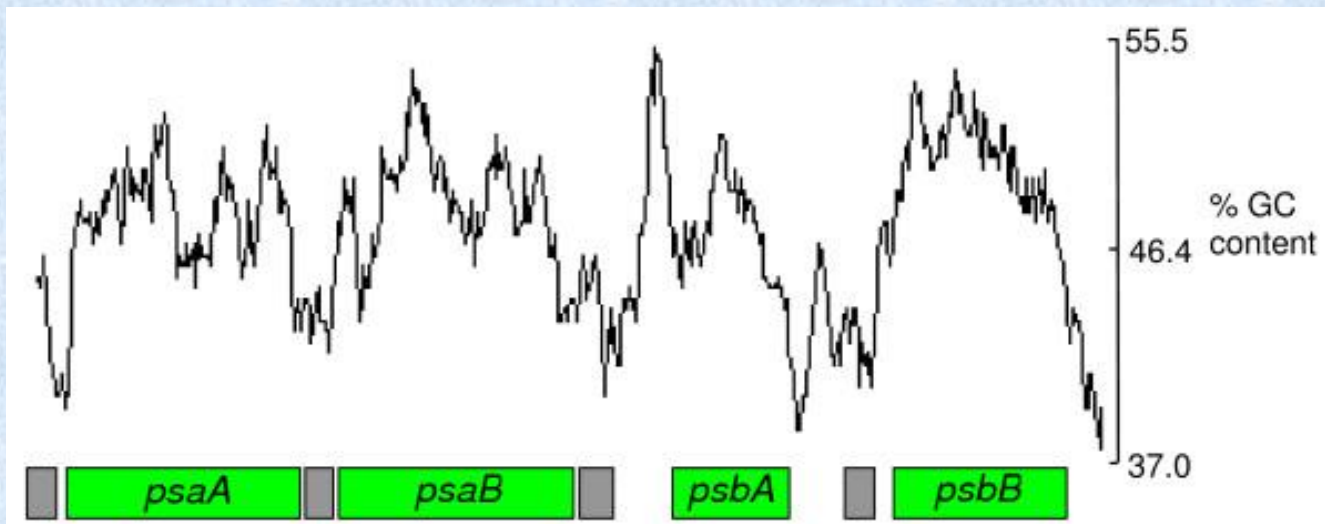
Hatena (Katablepharids),
plastids from the green alga
Nephroselmis



Chloroplast genome

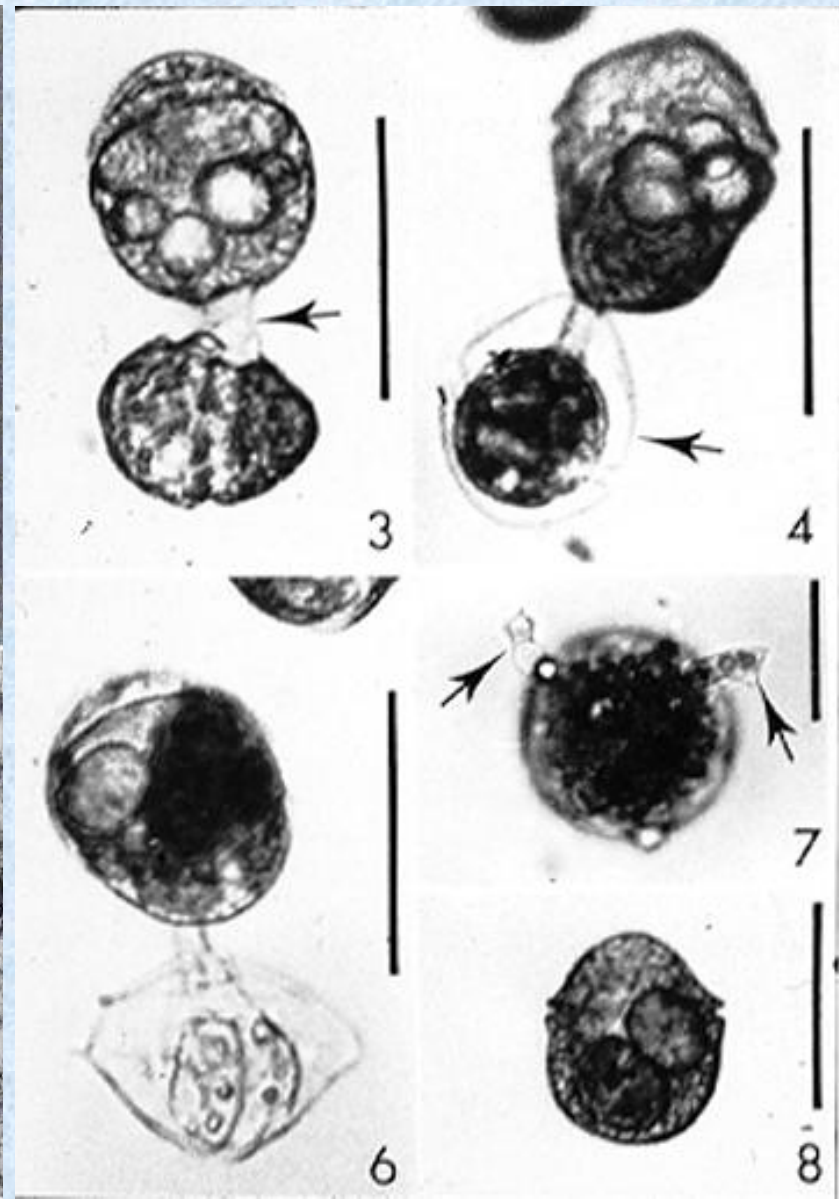
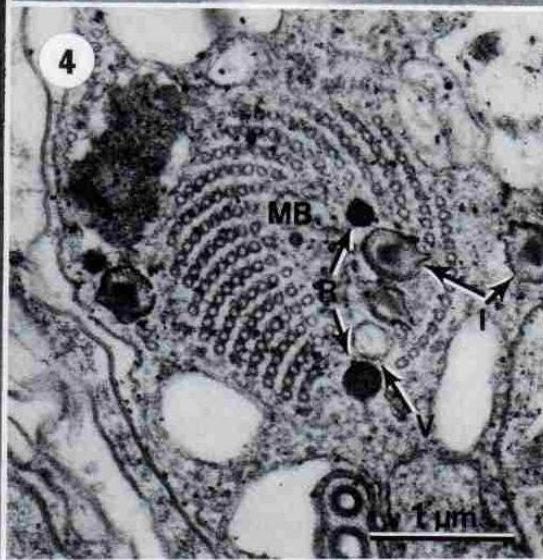
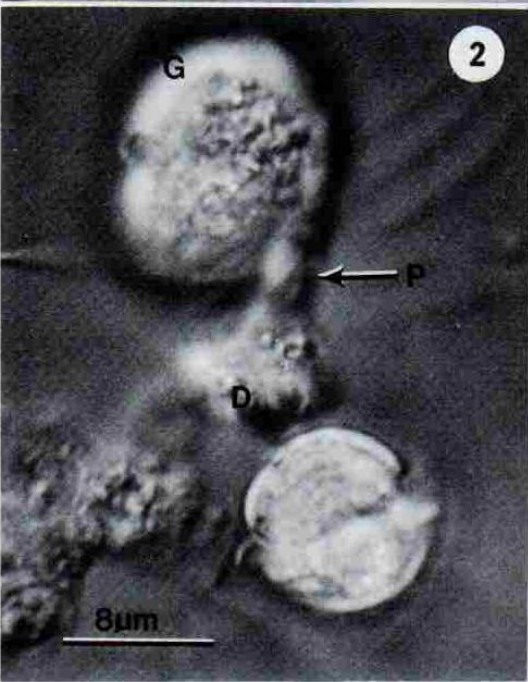
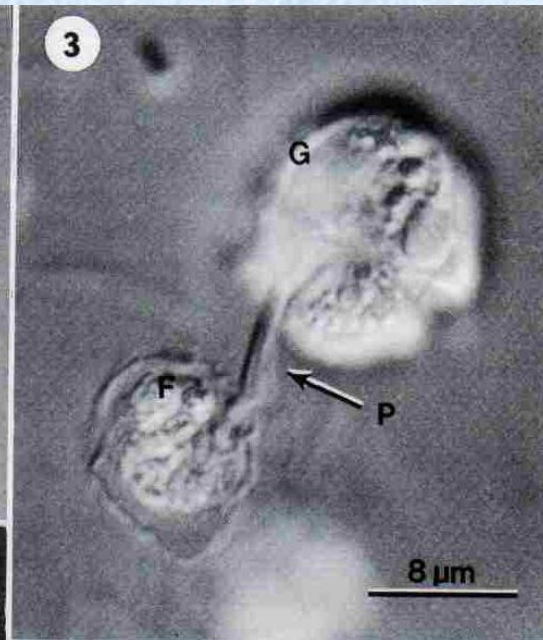
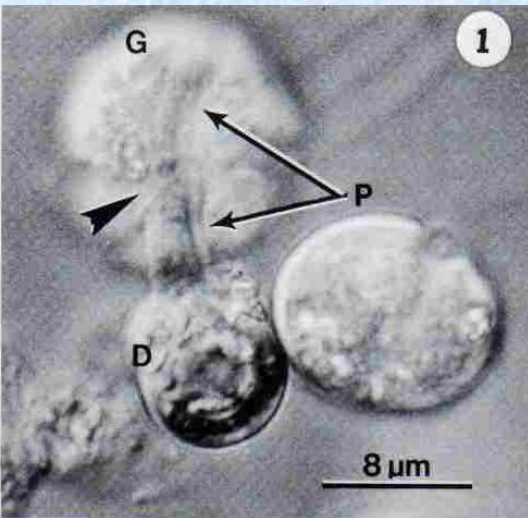
Minicircles – extremely reduced genome

- only 14 photosynthesis-related proteins coded
- Laatsch et al. (2004): minicircles found in the nucleus
 - facilitation of tertiary endosymbiosis



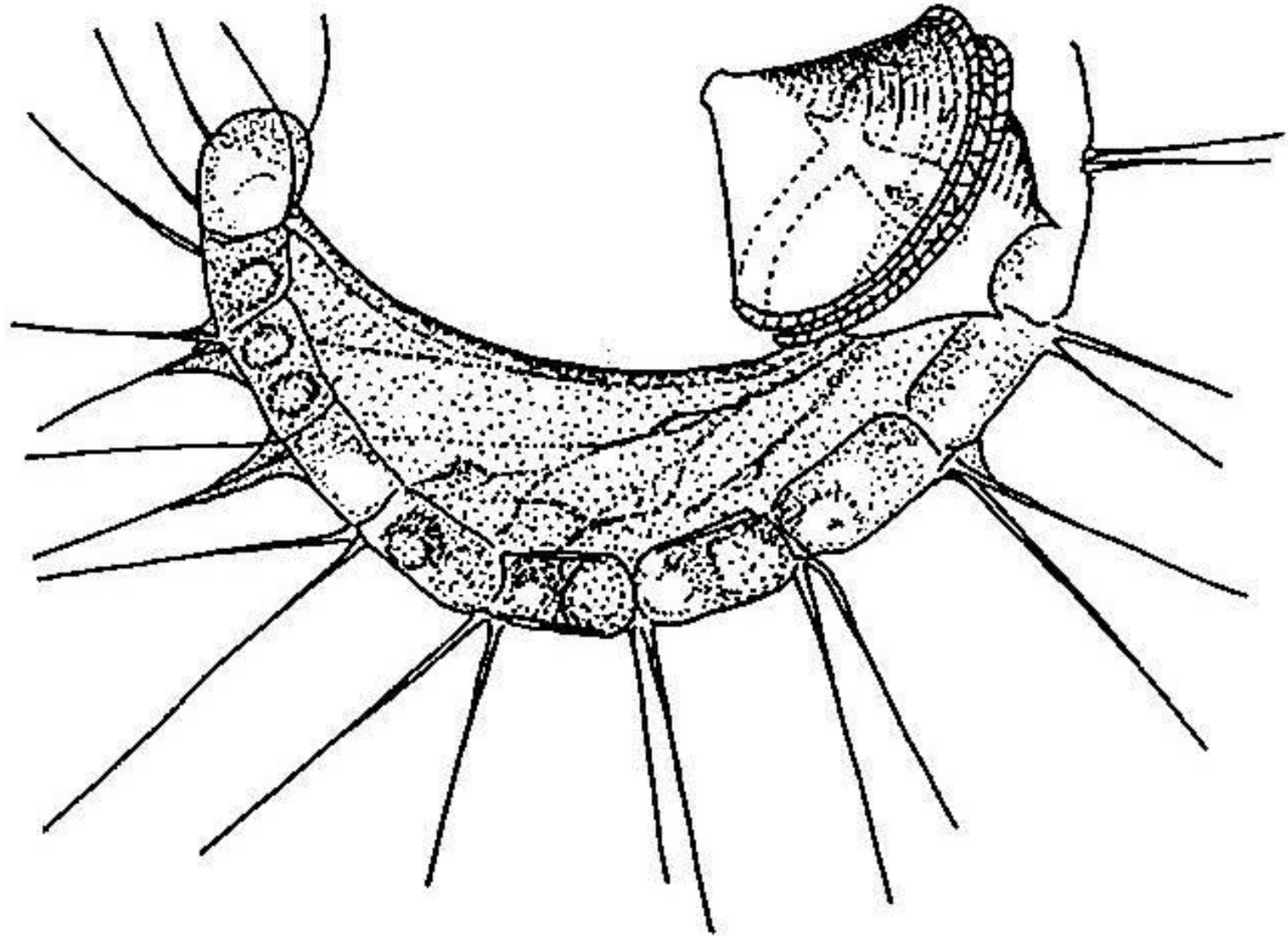
Heterotrophic nutrition

Katodinium, *Gymnodinium* – pedunculus



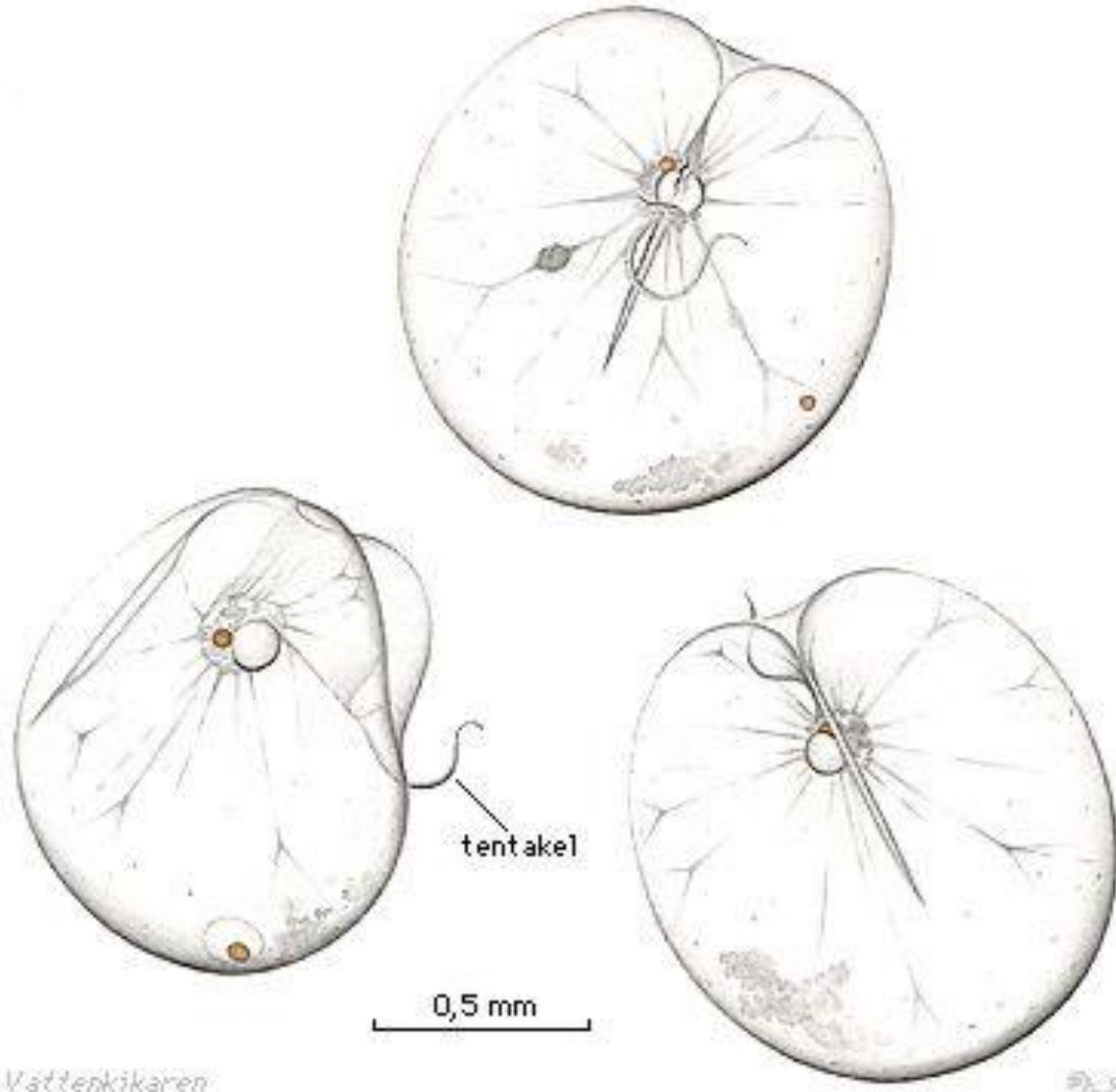
Heterotrophic nutrition

Protoperidinium – pedunculus, palium



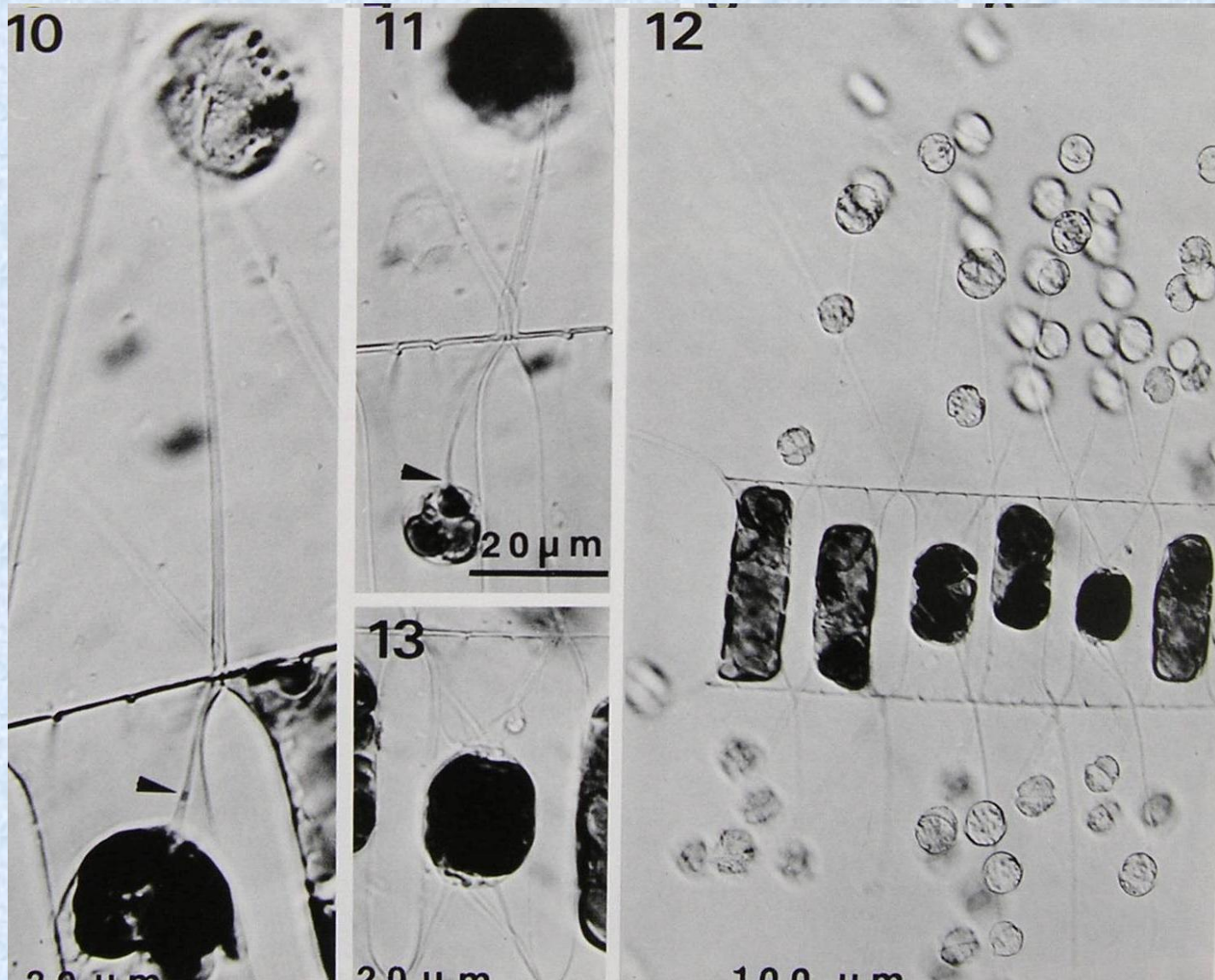
Heterotrophic nutrition

Noctiluca scintillans – tentacle (modified pedunculus)



Heterotrophic nutrition

Paulsenella chaetoceratis – feeding tube penetrating into the diatom setae



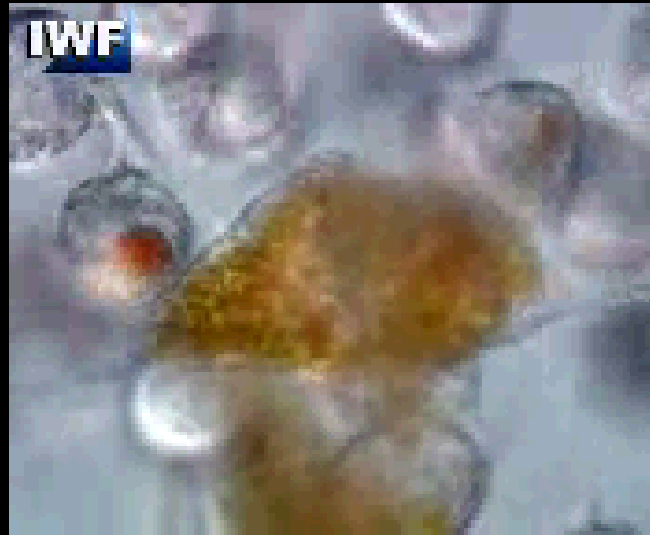
Heterotrophic nutrition

Peridiniopsis

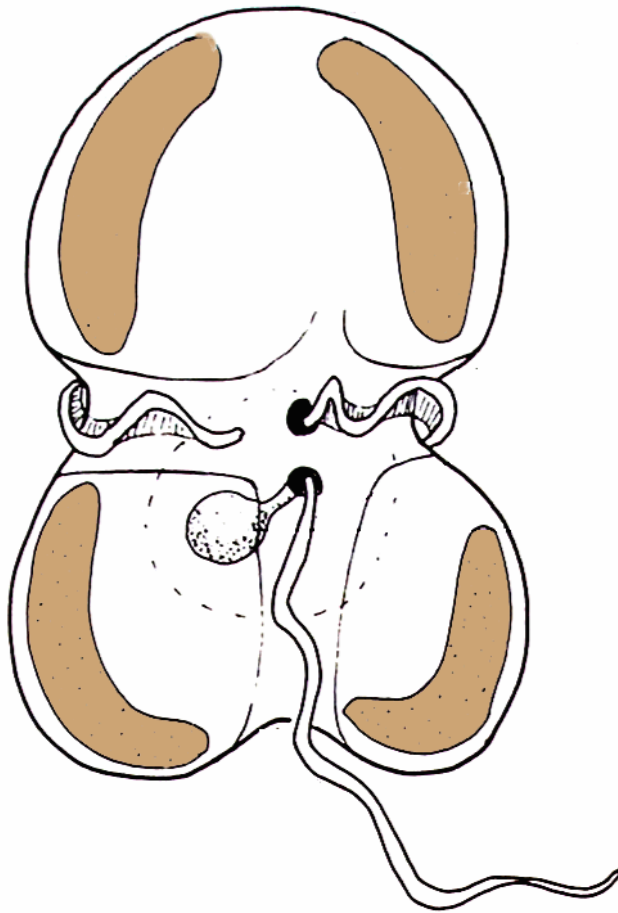


Heterotrophic nutrition

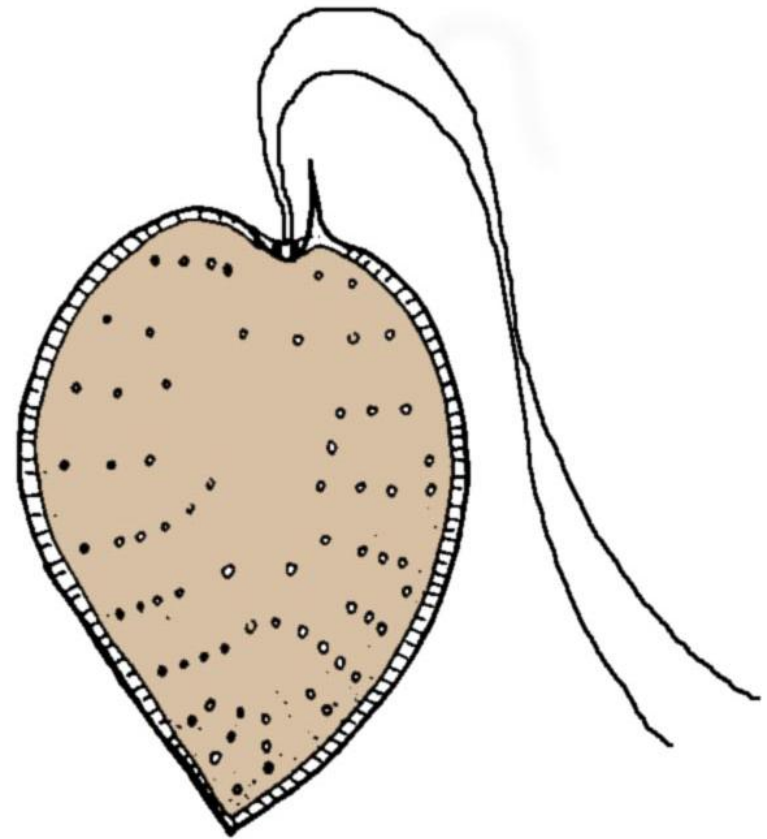
Peridiniopsis



Flagella

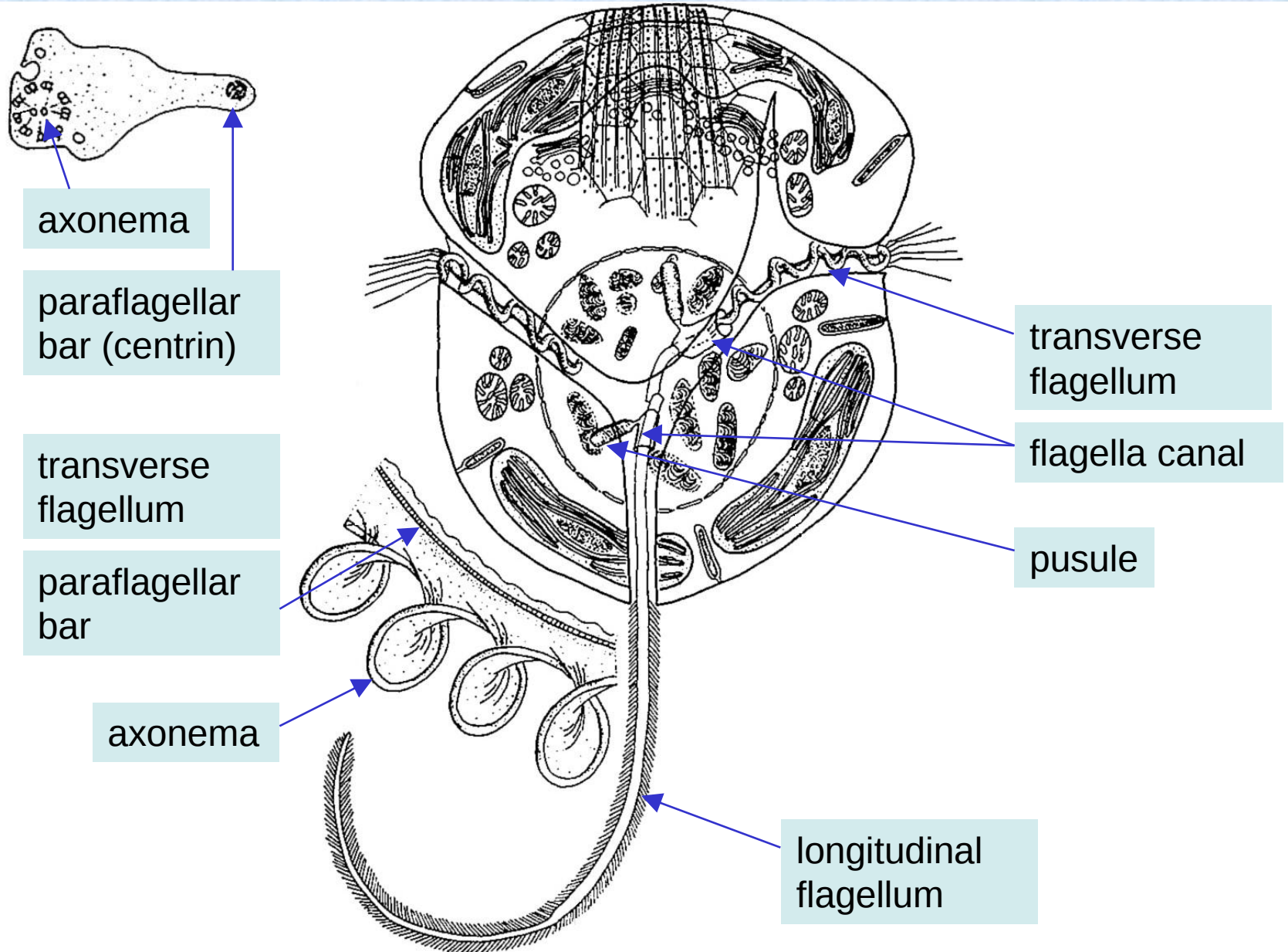


dinokont

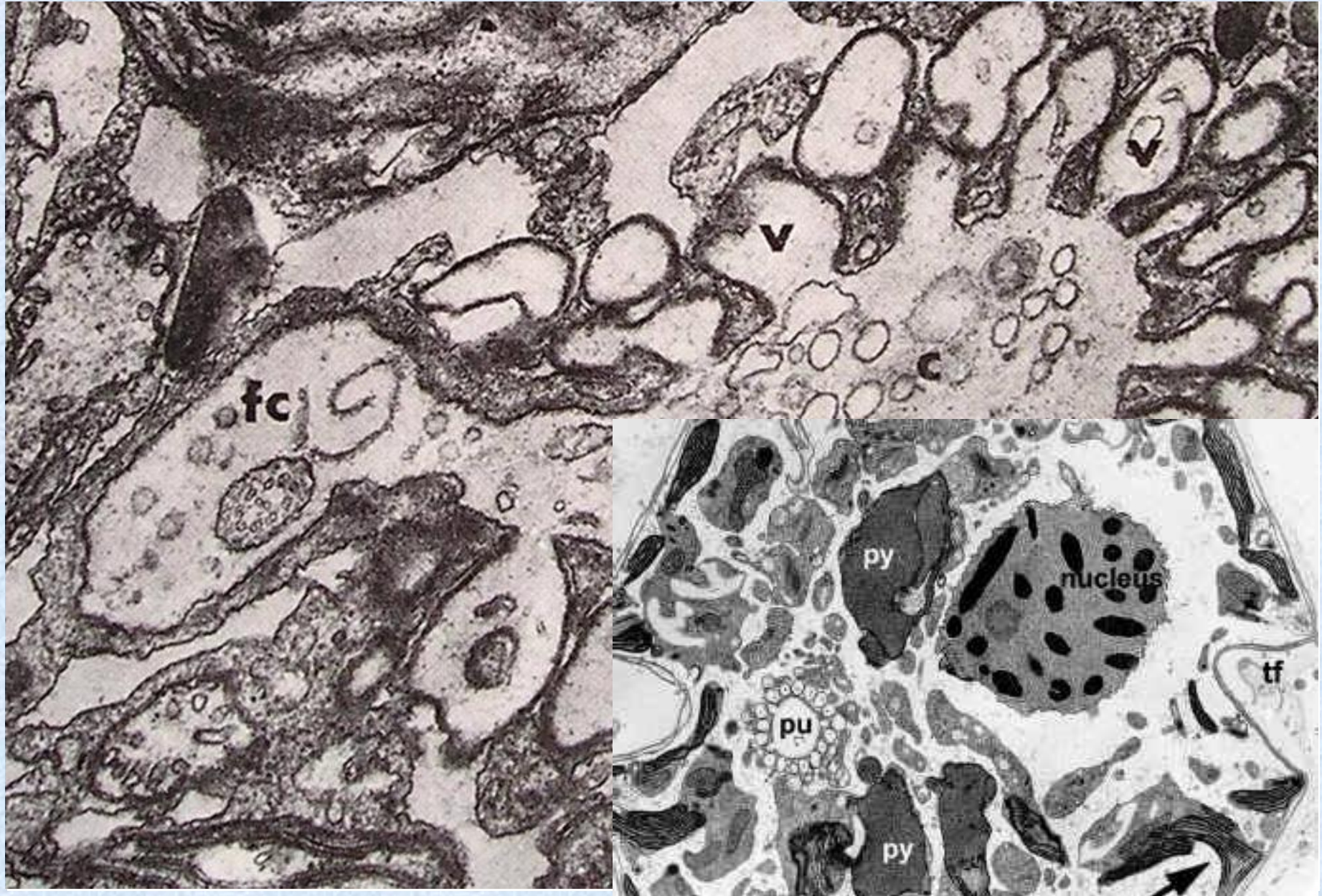


desmokont

Flagella

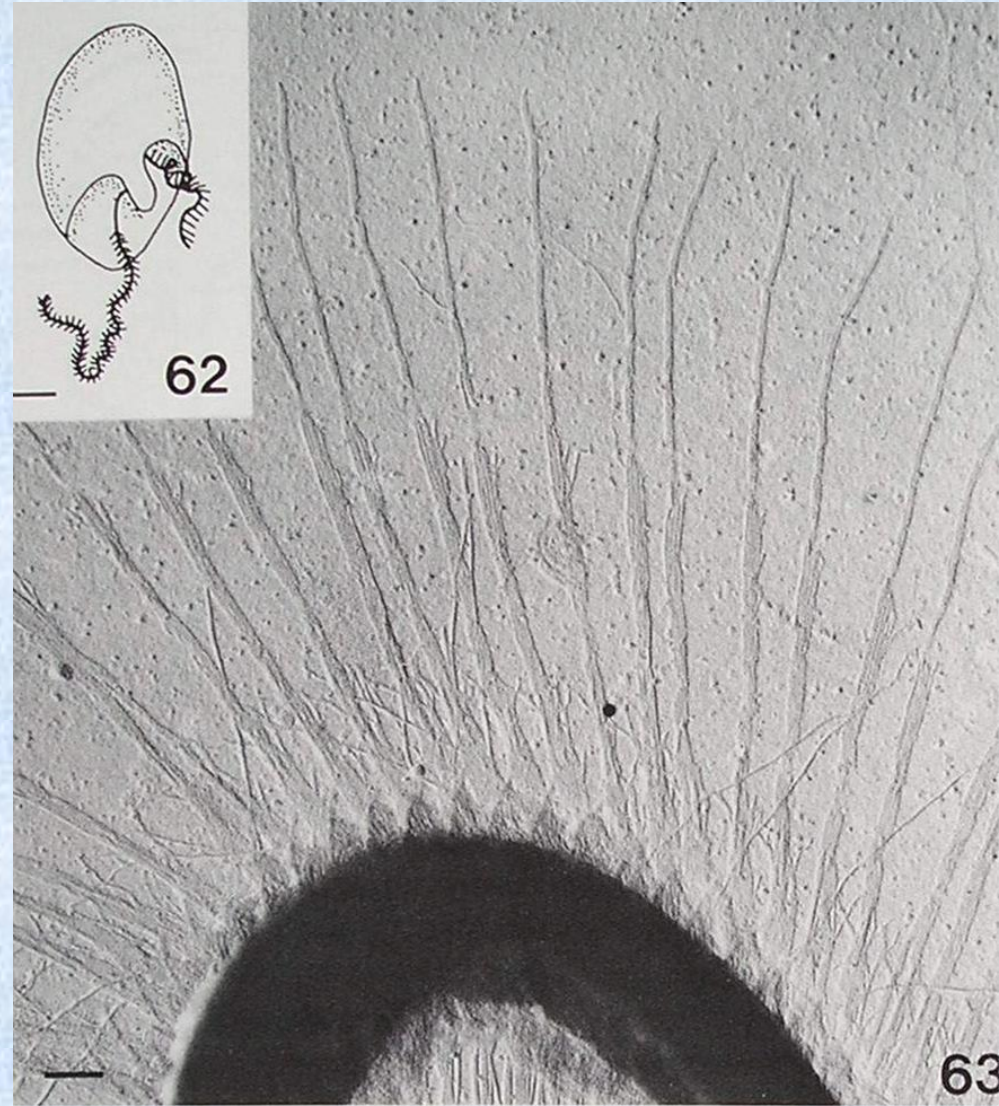
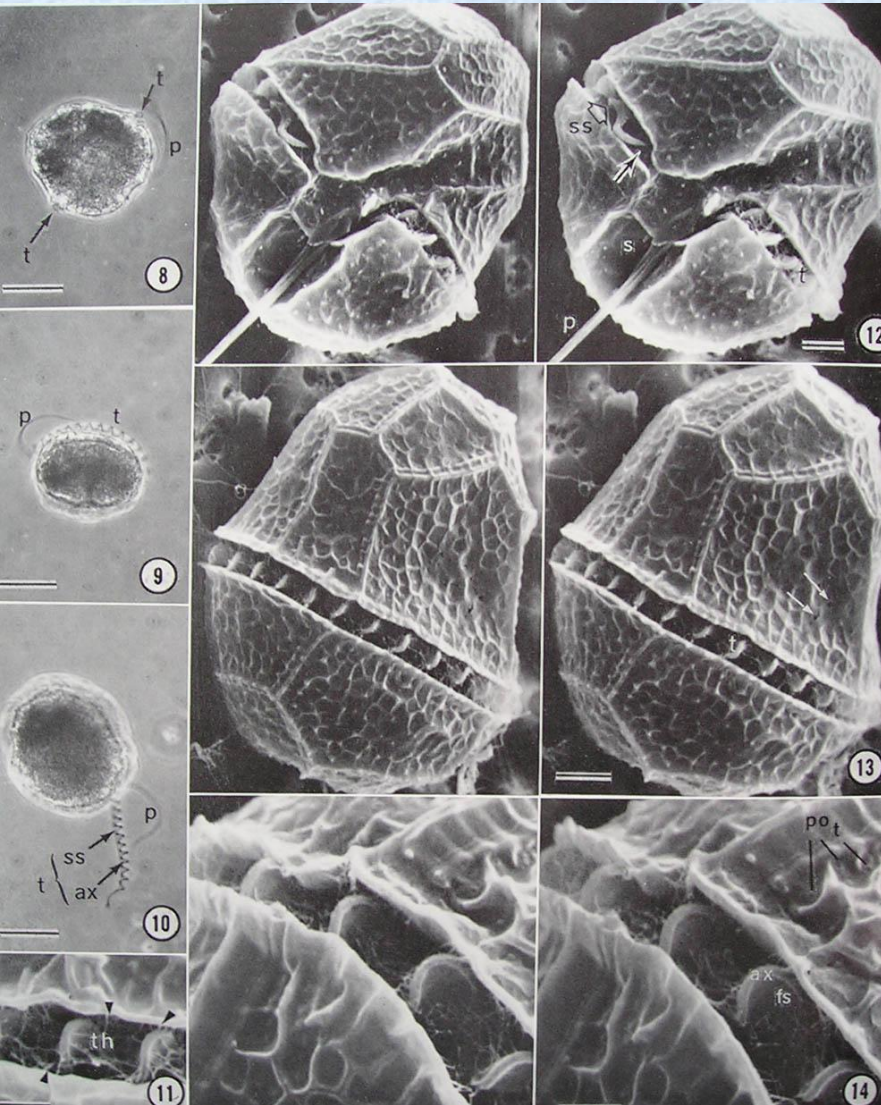


Flagella, pusule



Flagella

transverse flagellum



Flagella roots

flagella canal

transverse
flagellum

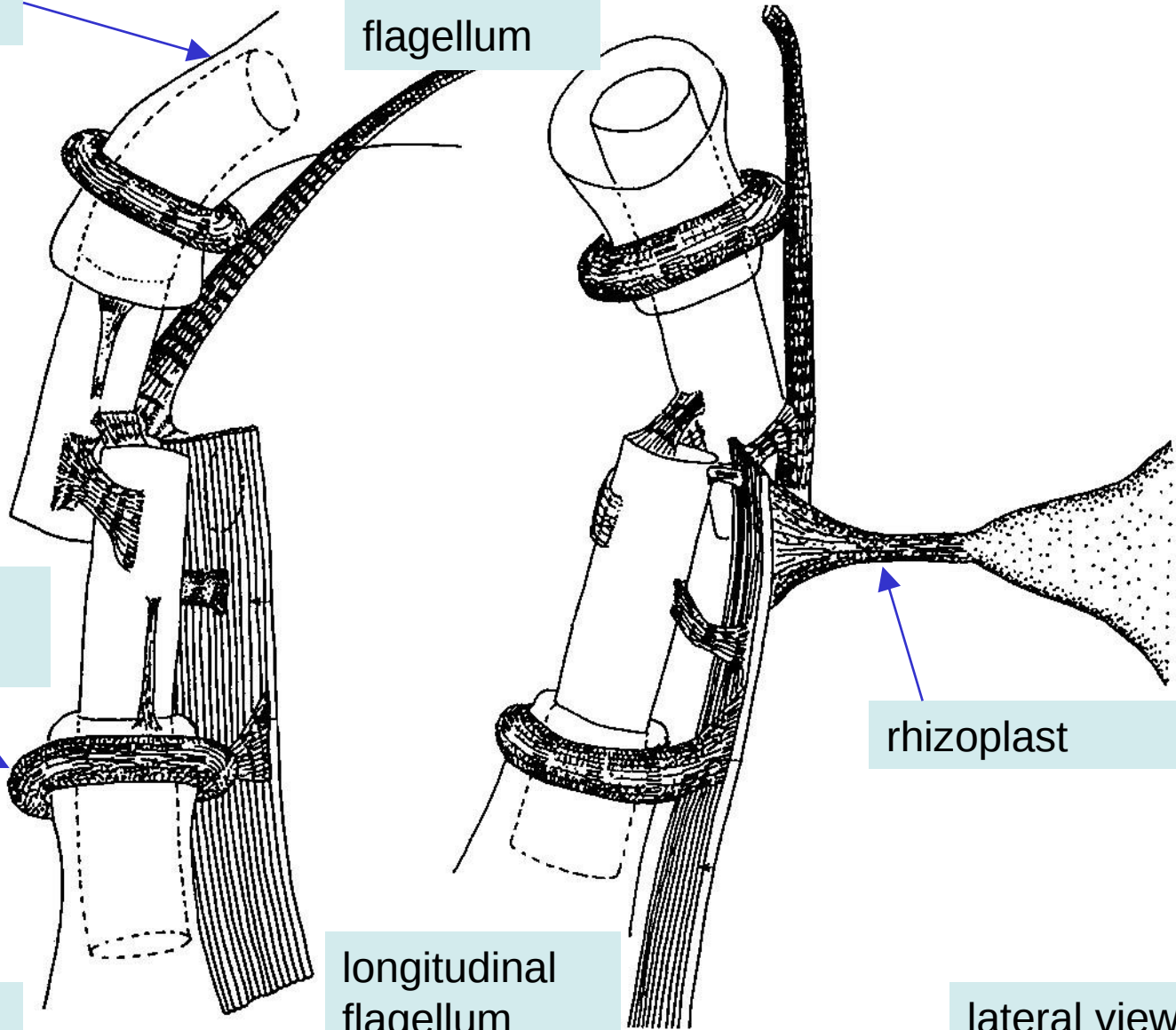
transversally
ribbed ring

ventral view

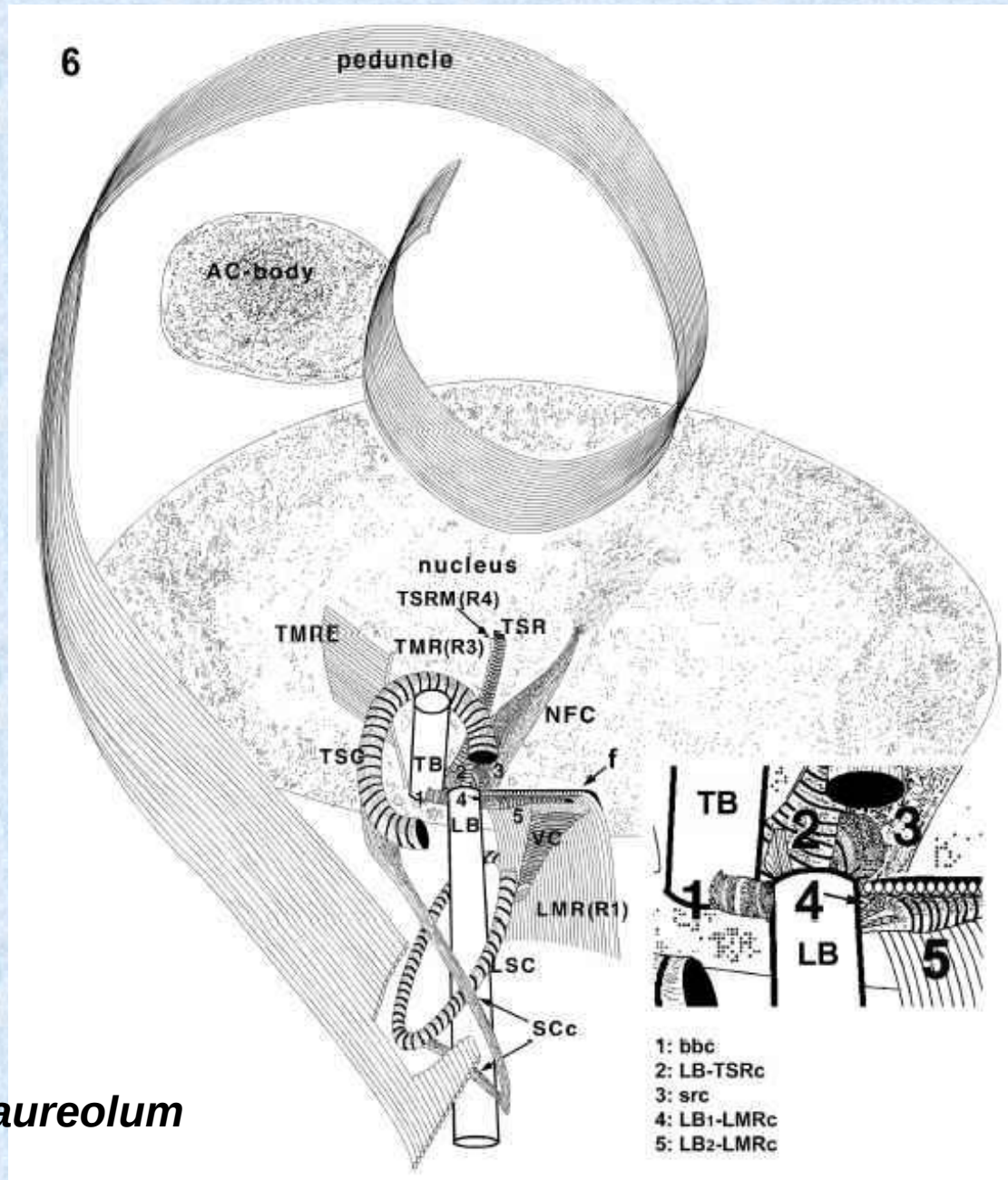
longitudinal
flagellum

rhizoplast

lateral view



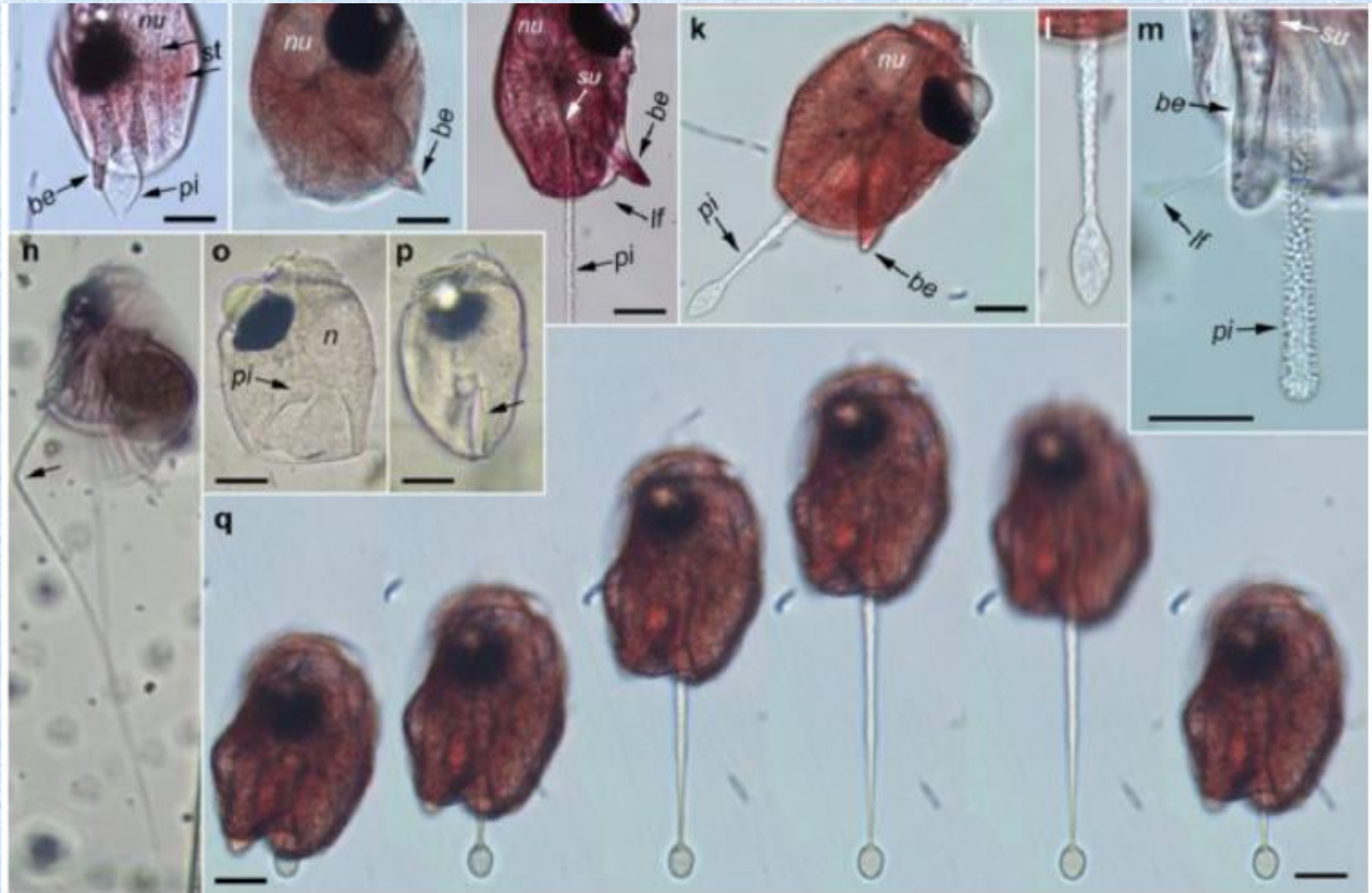
Flagella roots - peduncle



Gymnodinium aureolum

Piston

- repetitive and dramatic contractile motion
- suggested function for locomotion, prey capture or defense

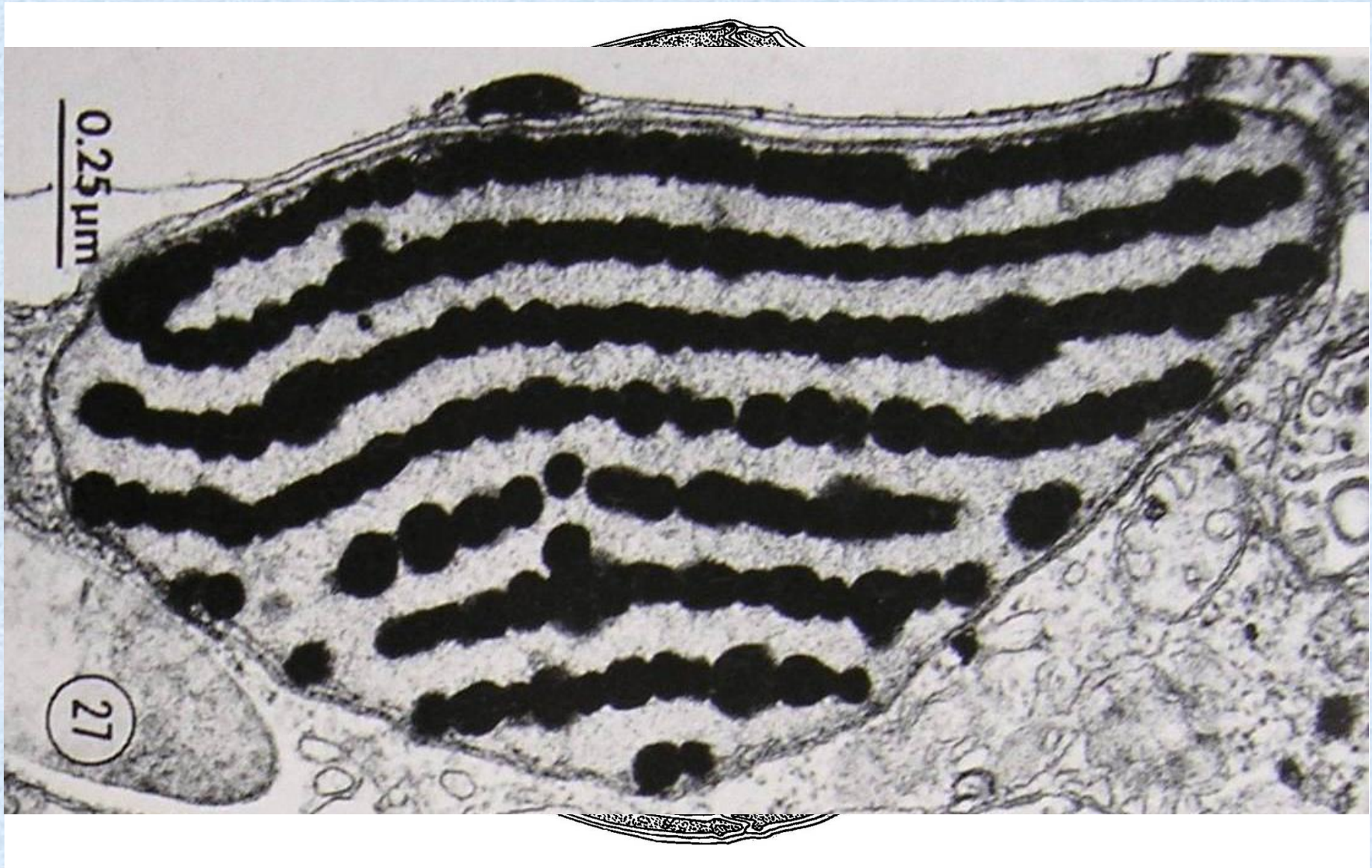


Piston



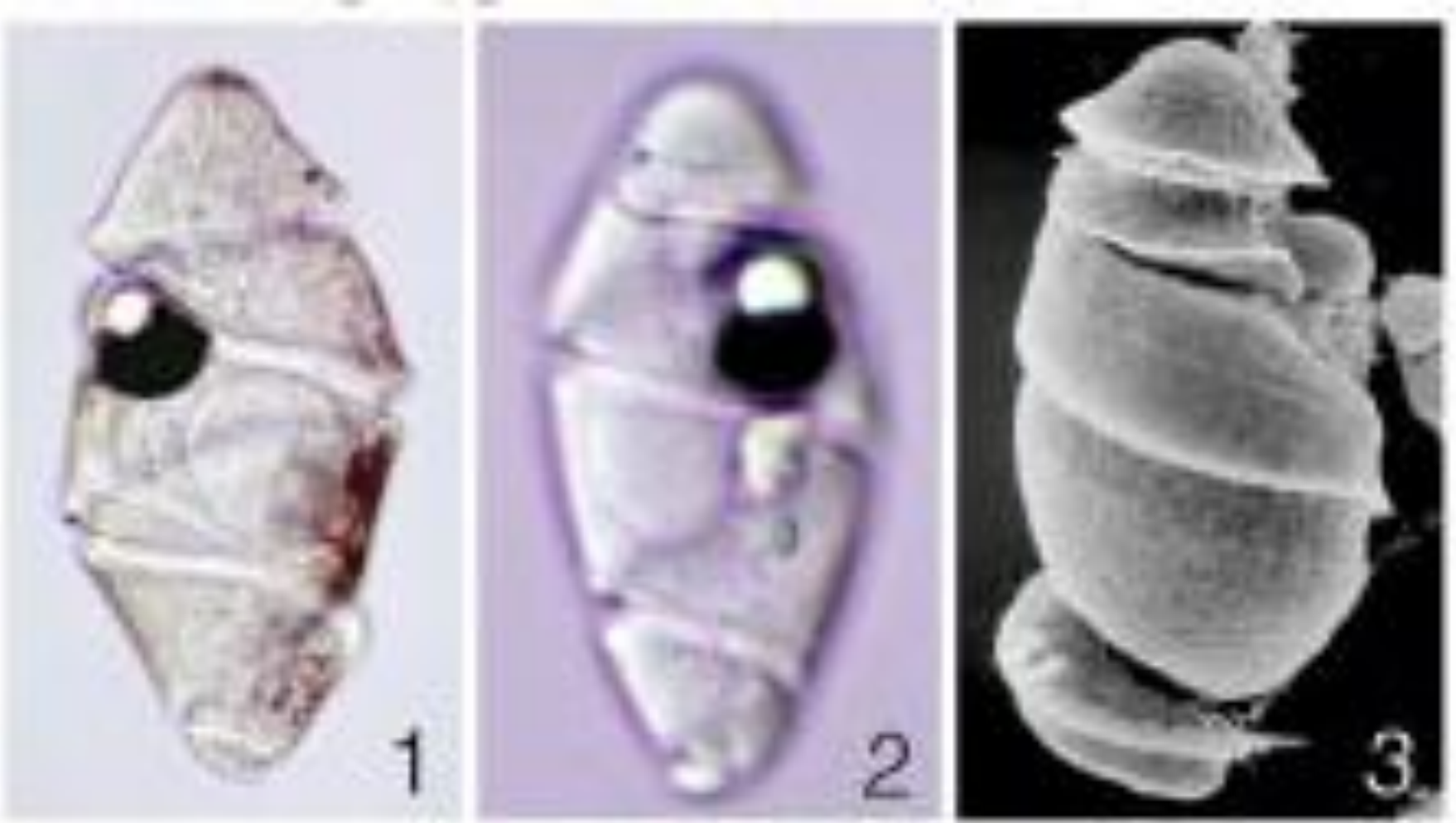
Stigma

Peridinium balticum – lipid granule

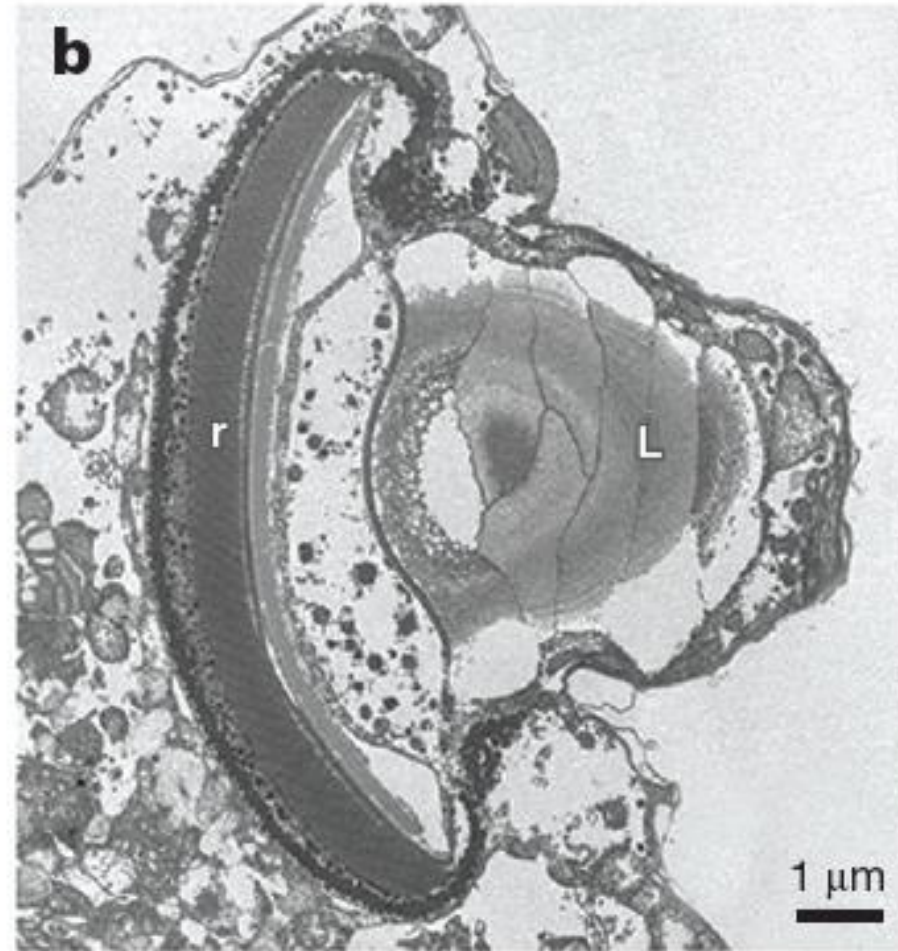
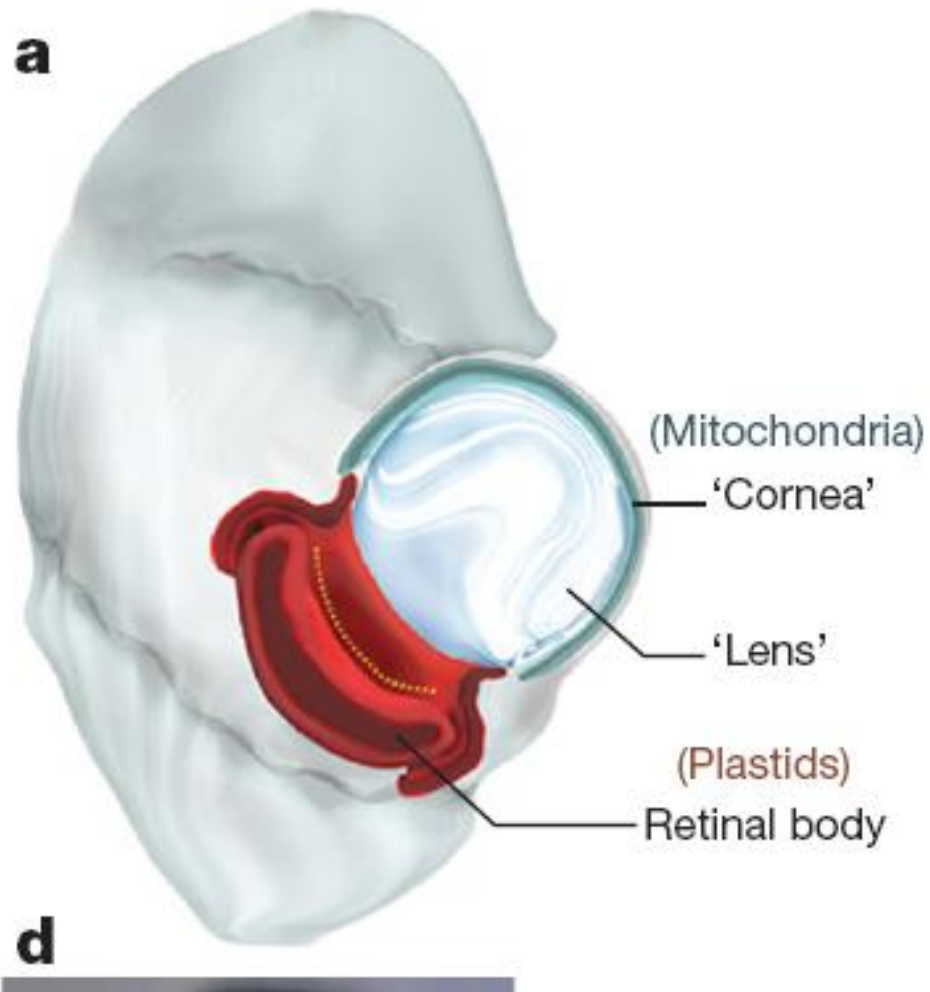


Stigma

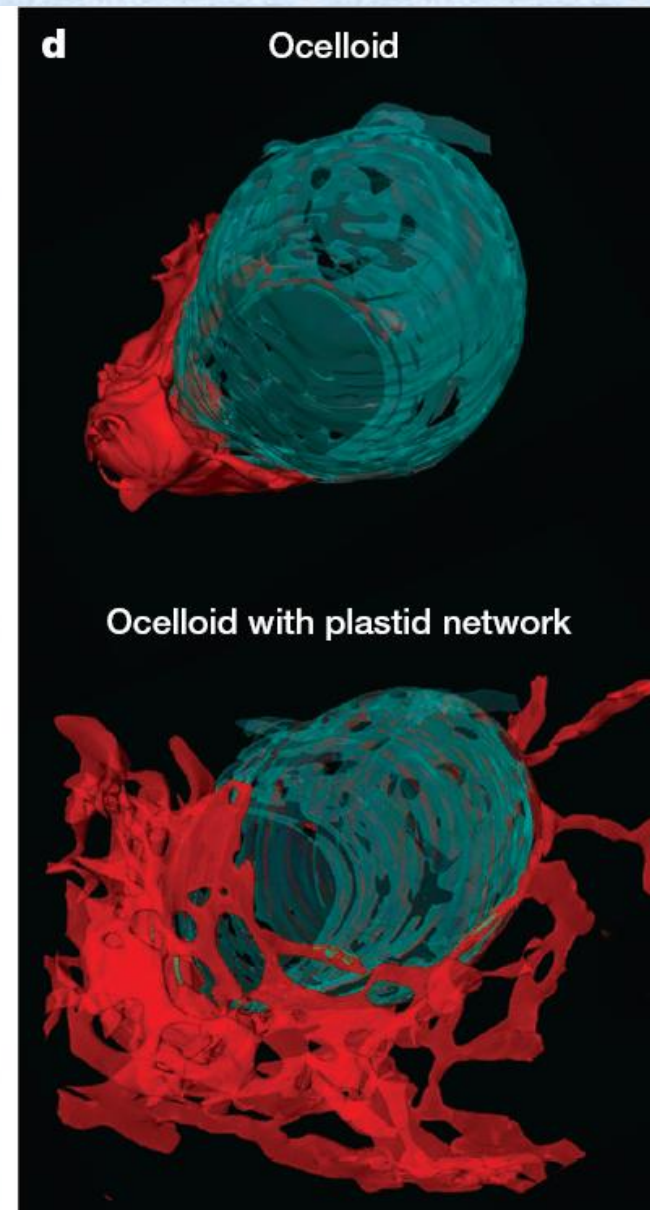
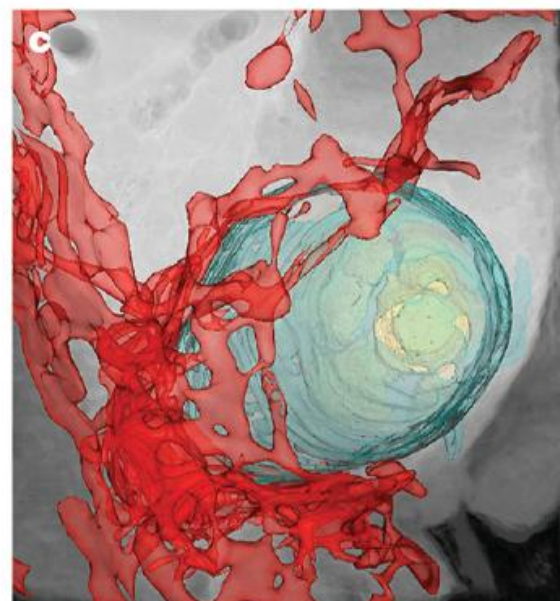
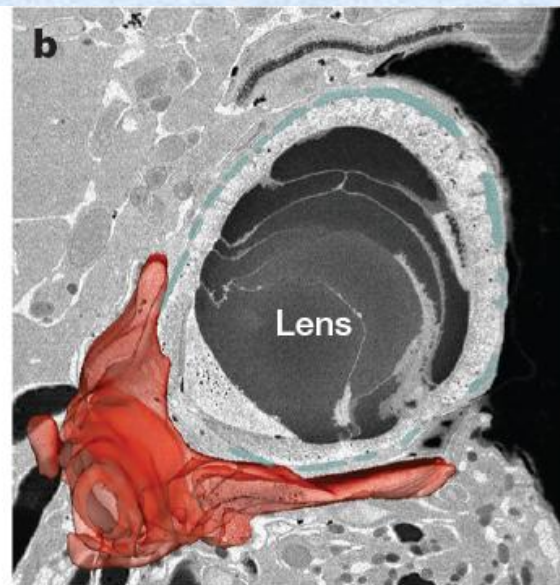
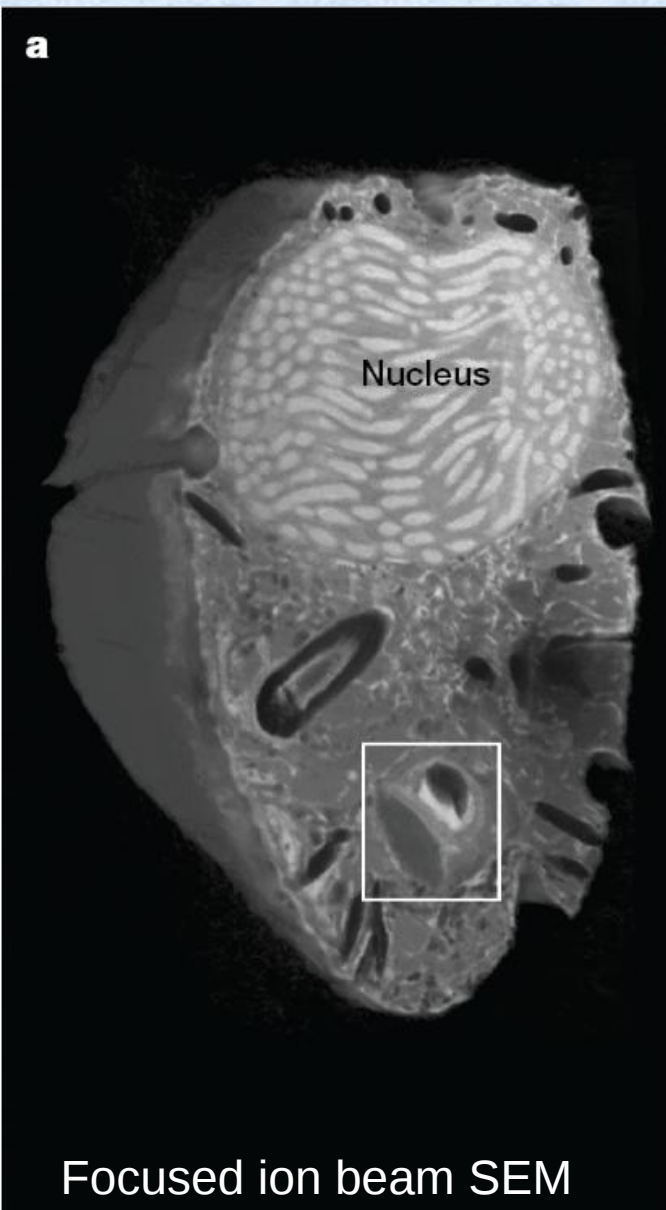
Warnowia – complex stigma (ocelloid)

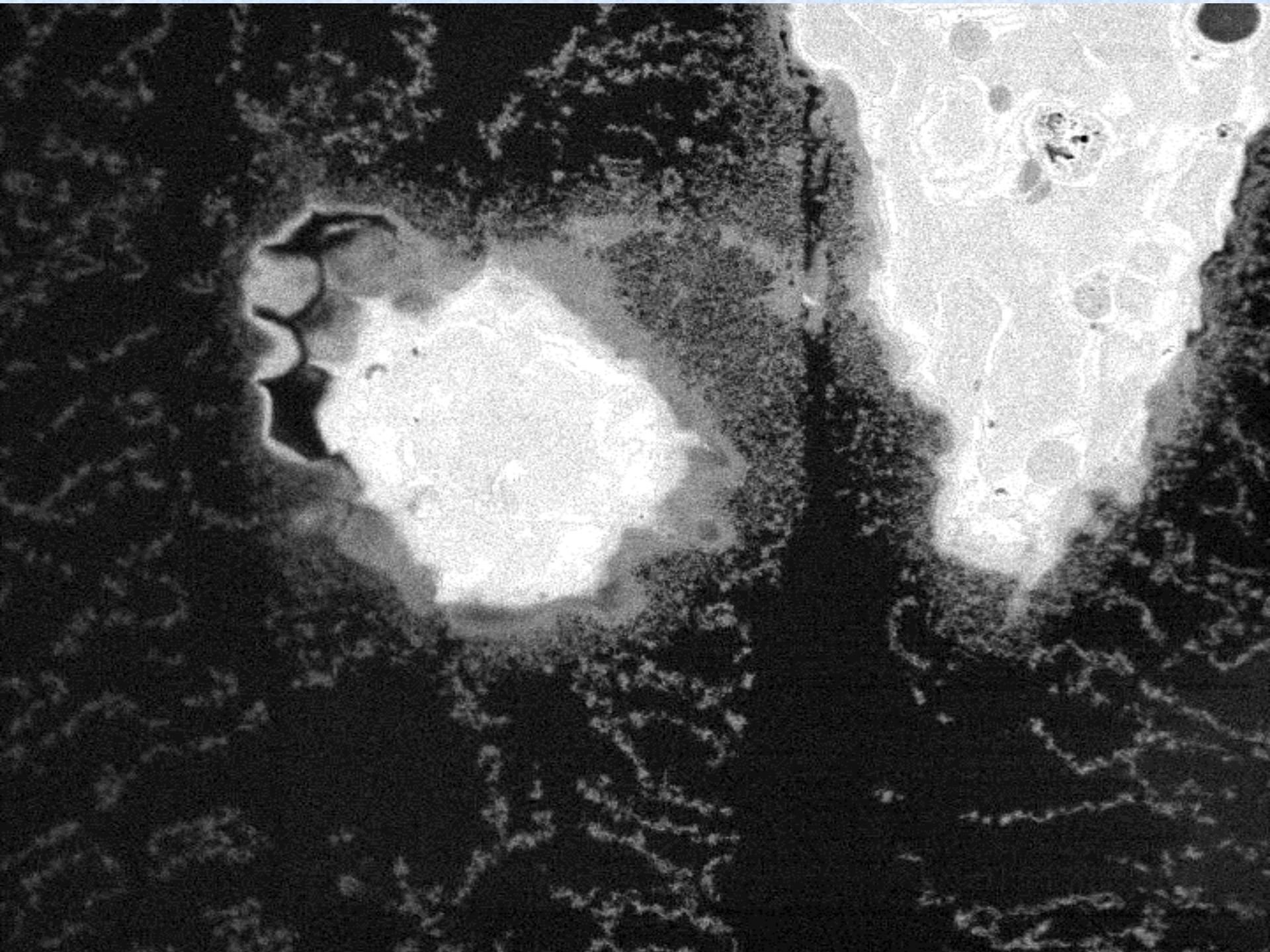


Ocelloid

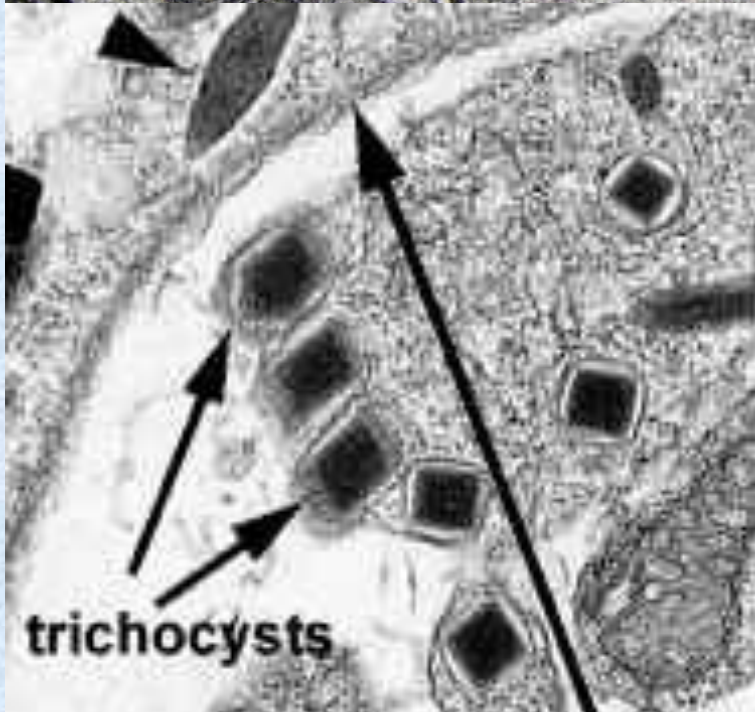
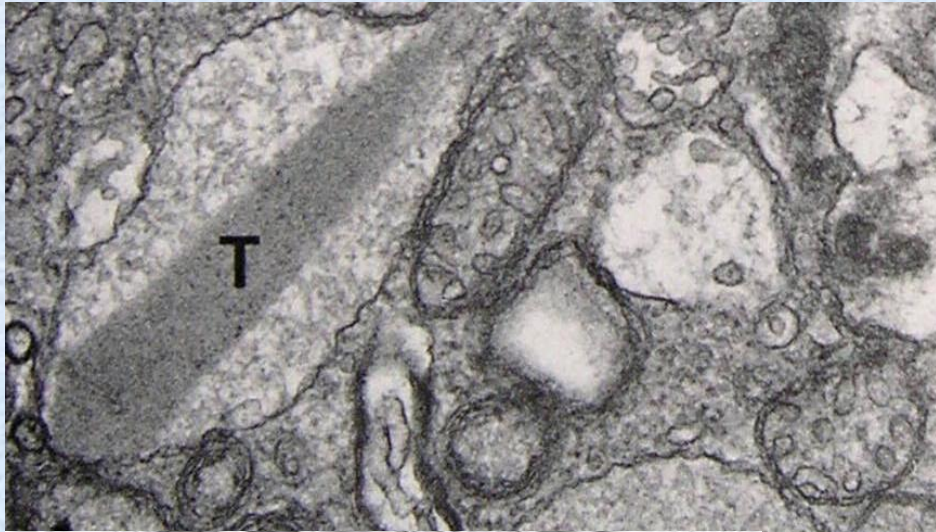


Ocelloid

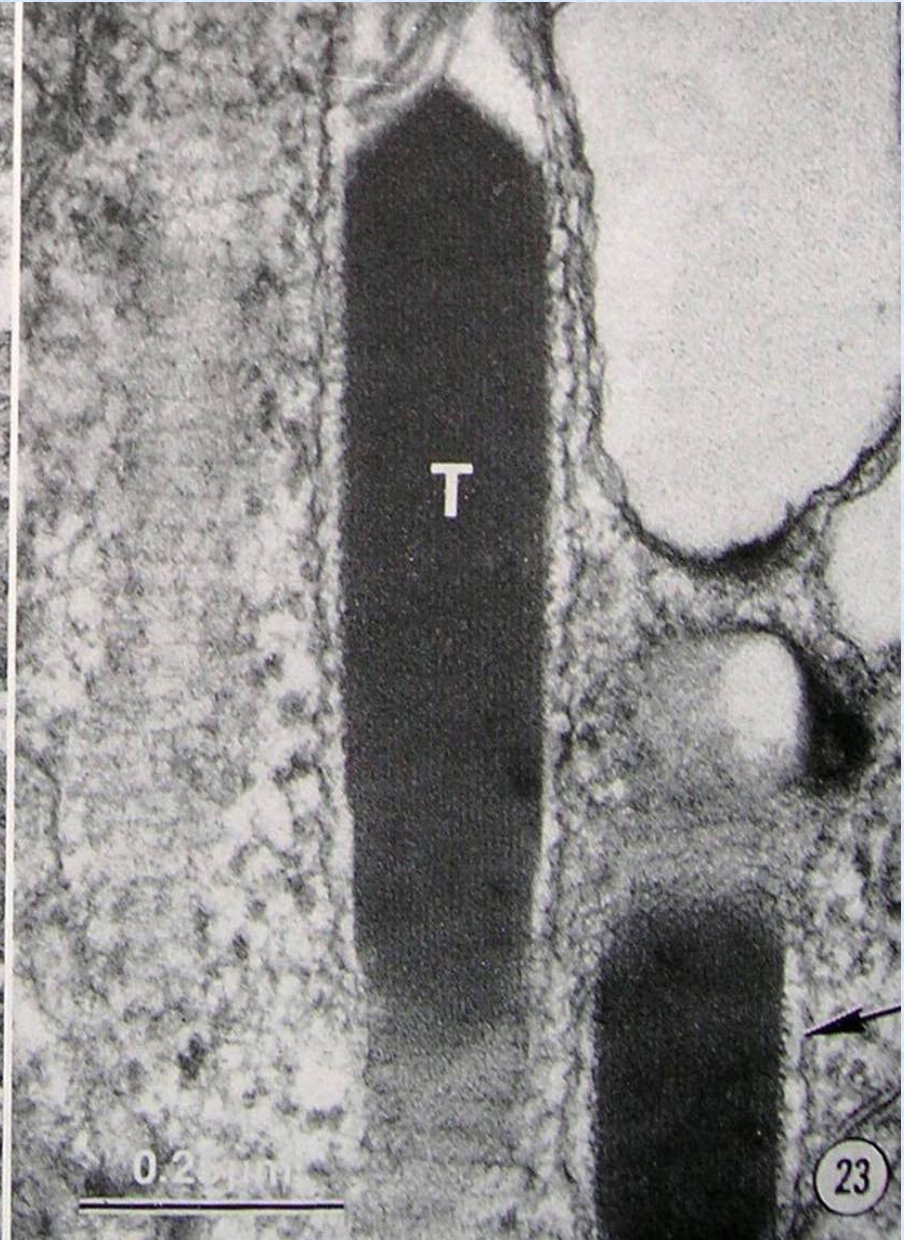




Trichocysts



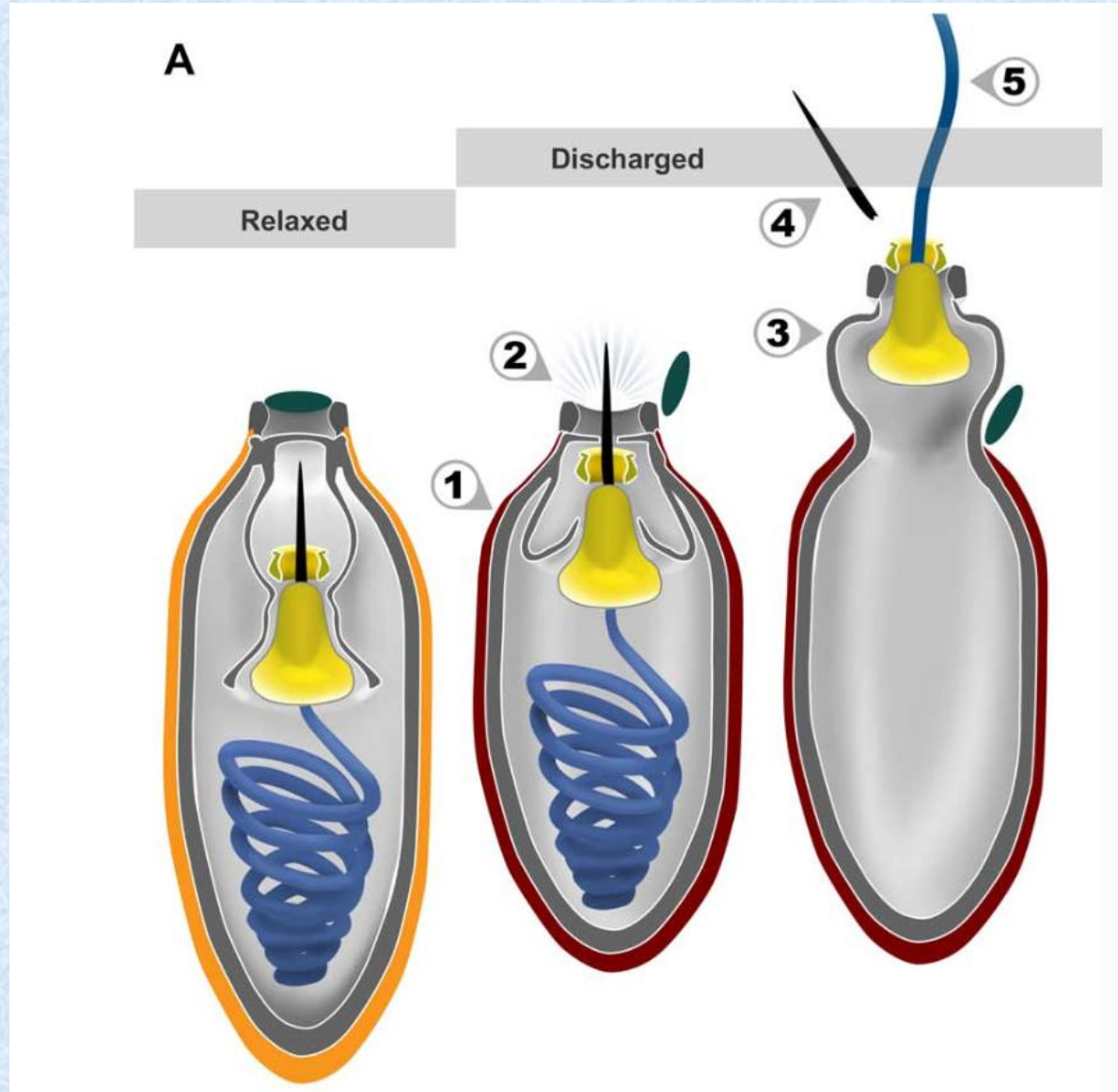
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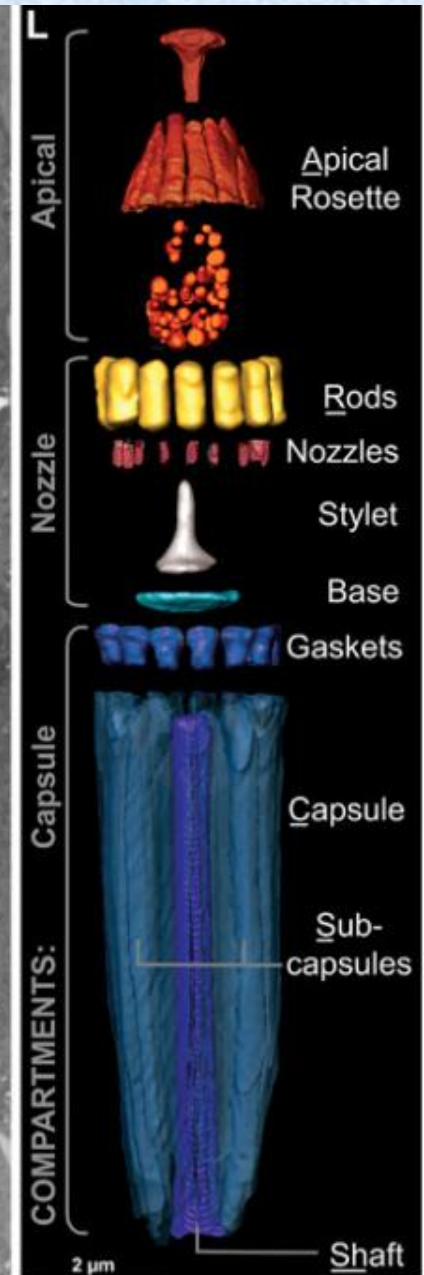
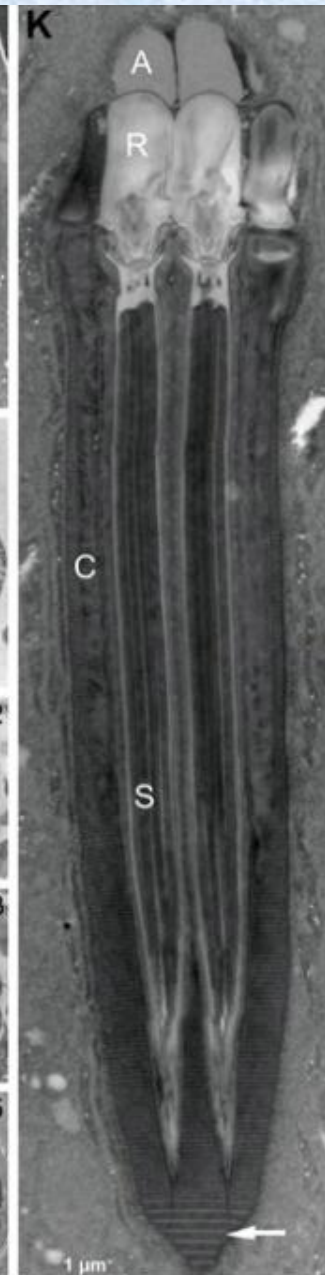
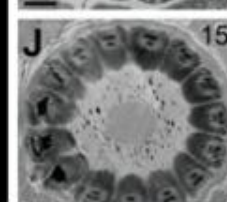
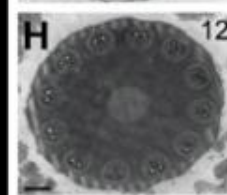
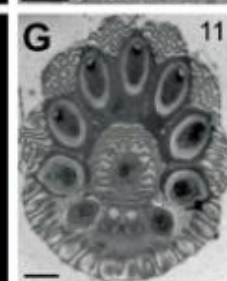
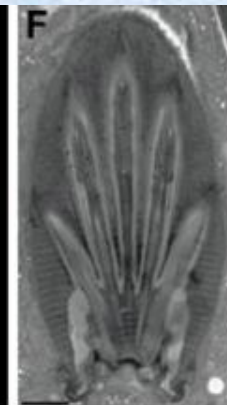
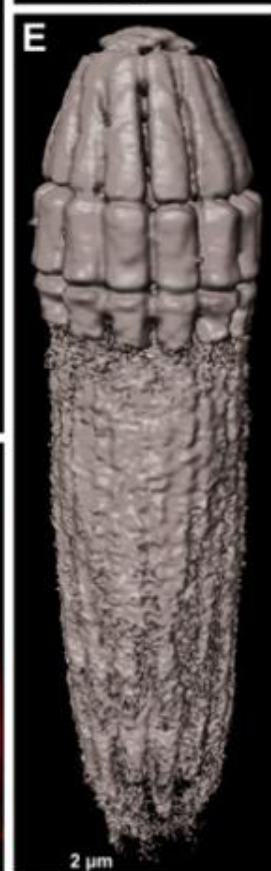
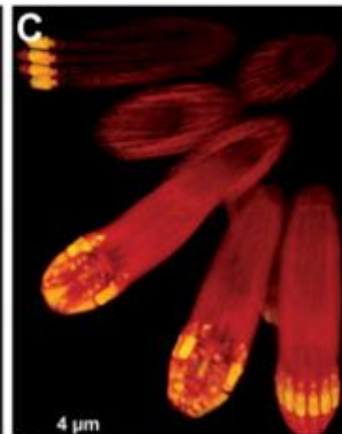
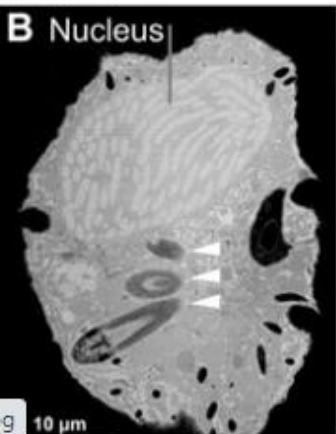
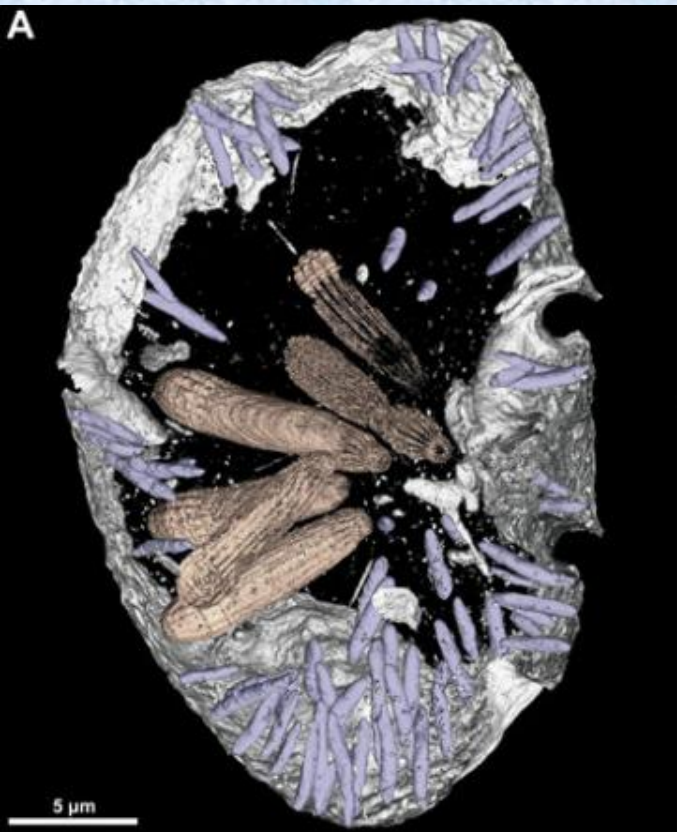
23

Nematocysts

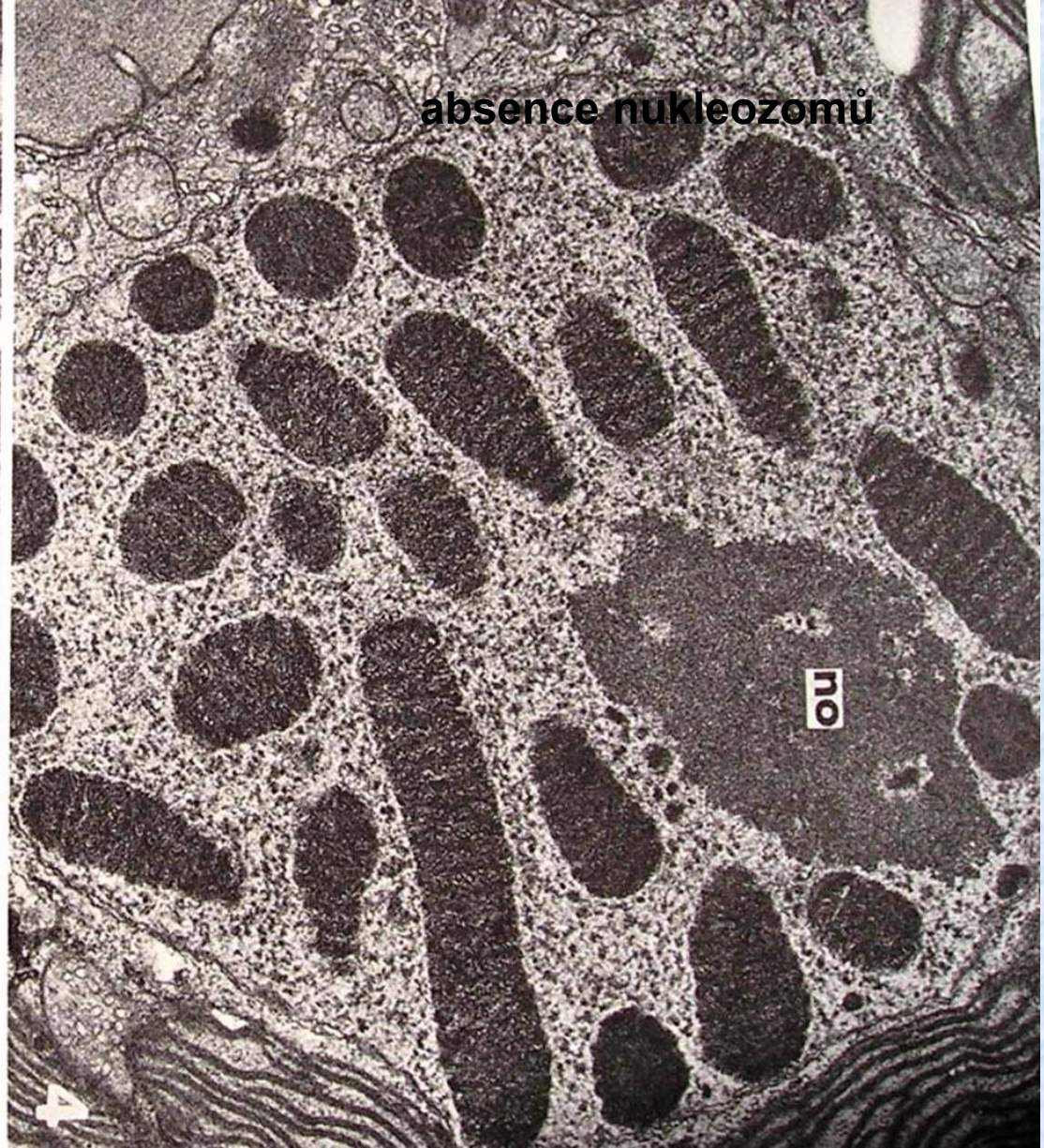
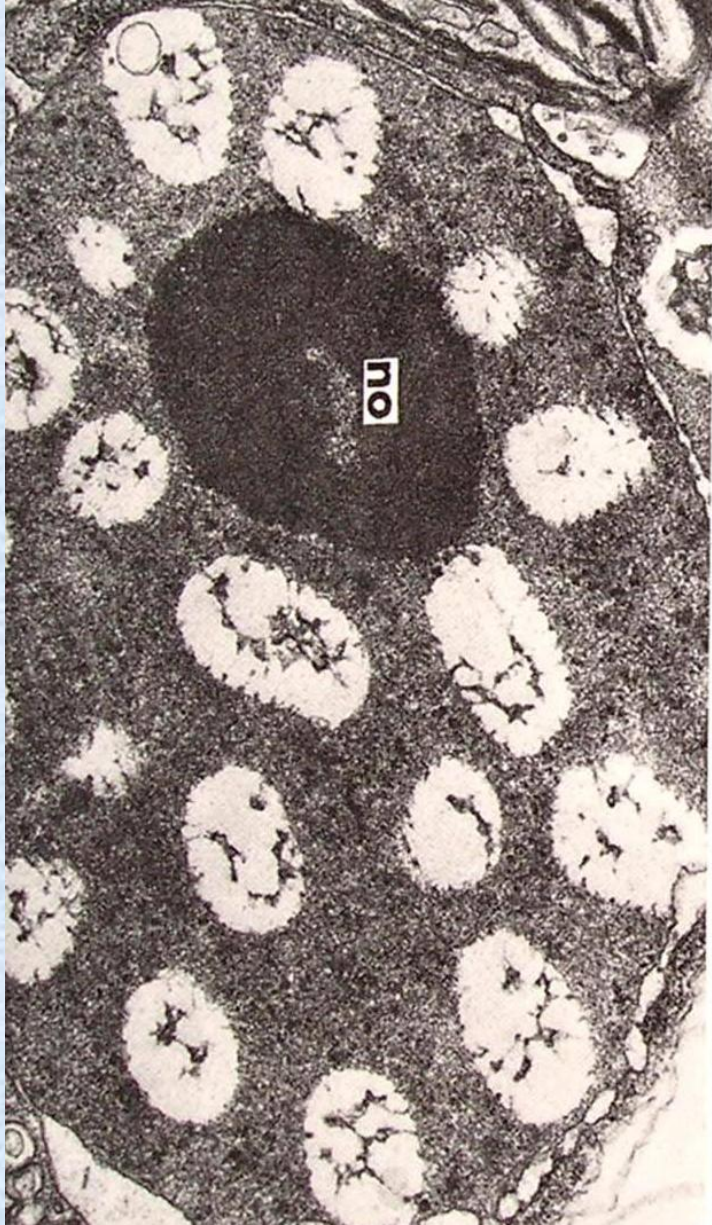
- ballistic multi-barrel guns for taking out prey



Nematocysts



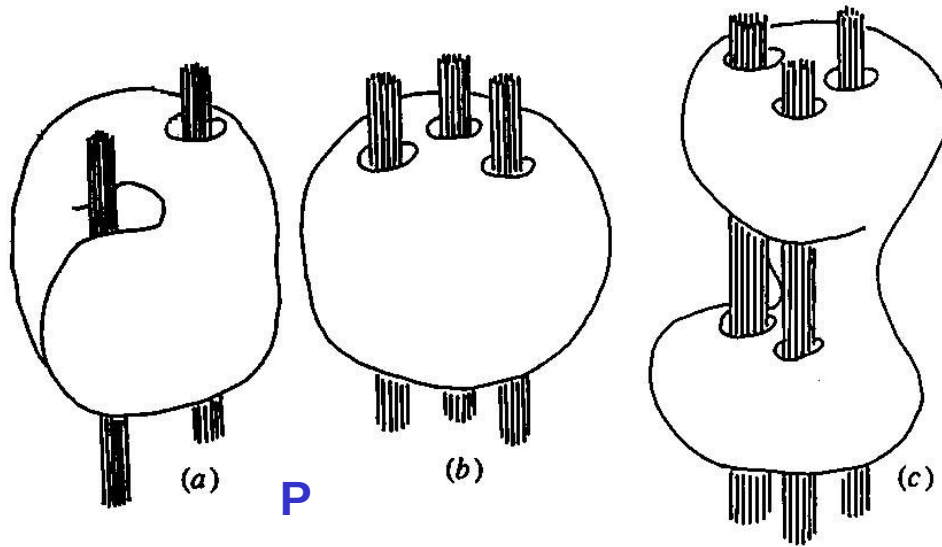
Dinokaryon



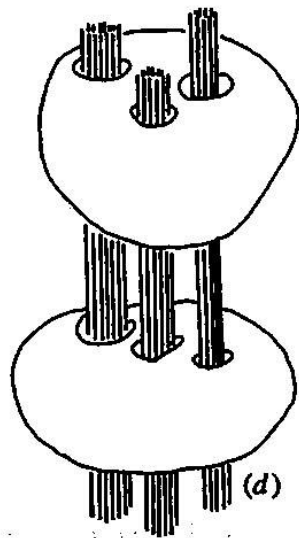
Dinokaryon



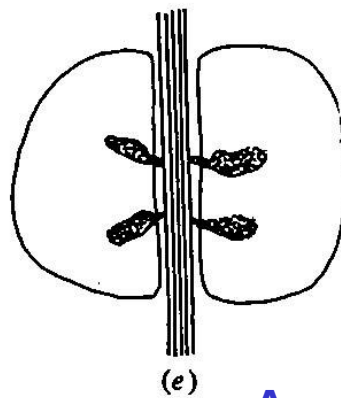
Mitosis



P

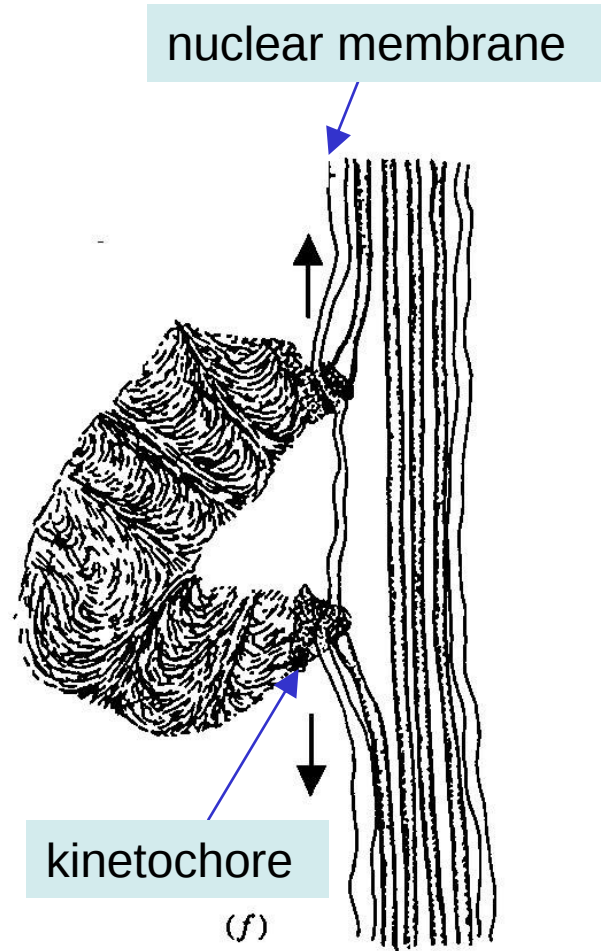


(d)



(e)

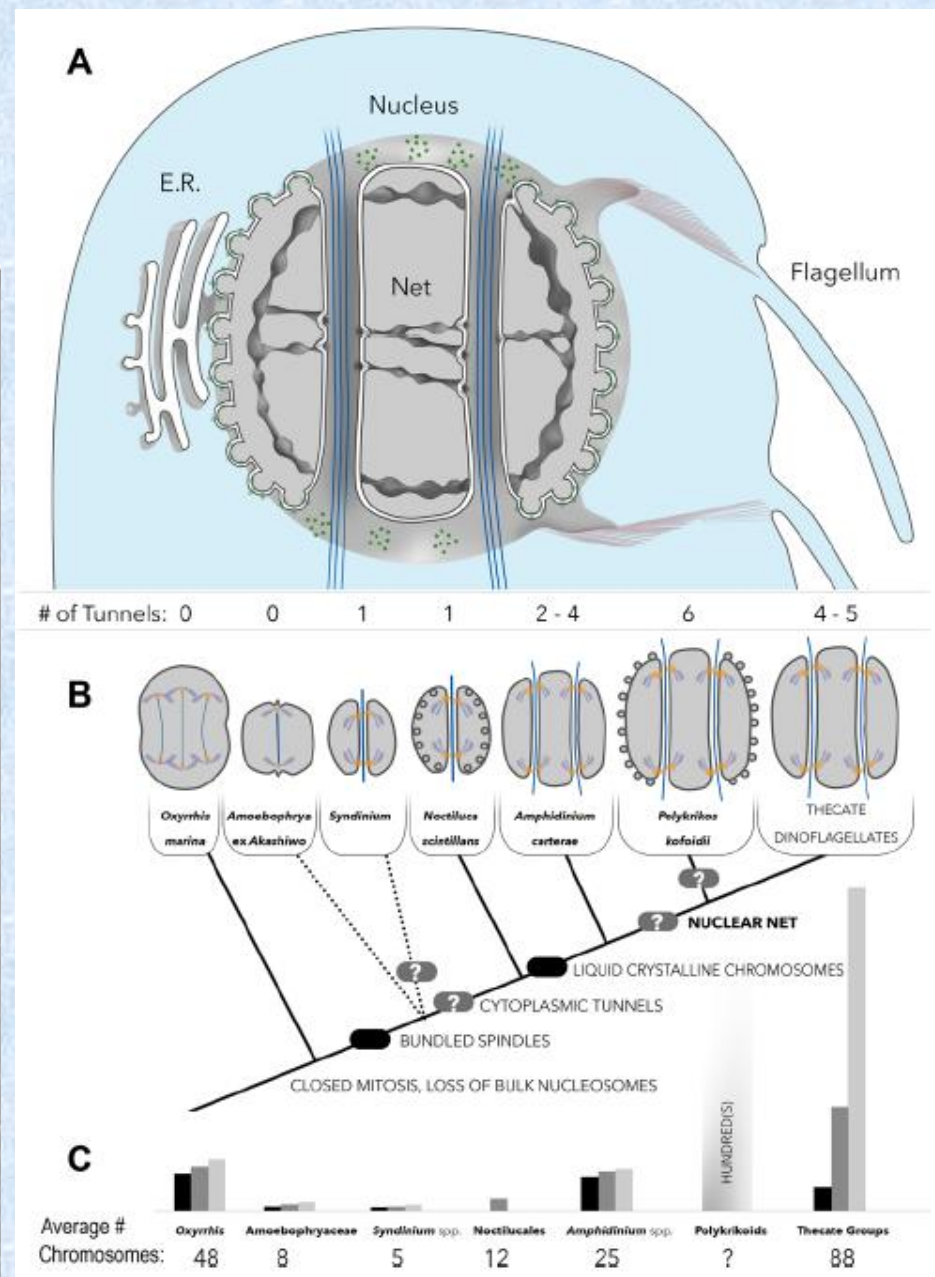
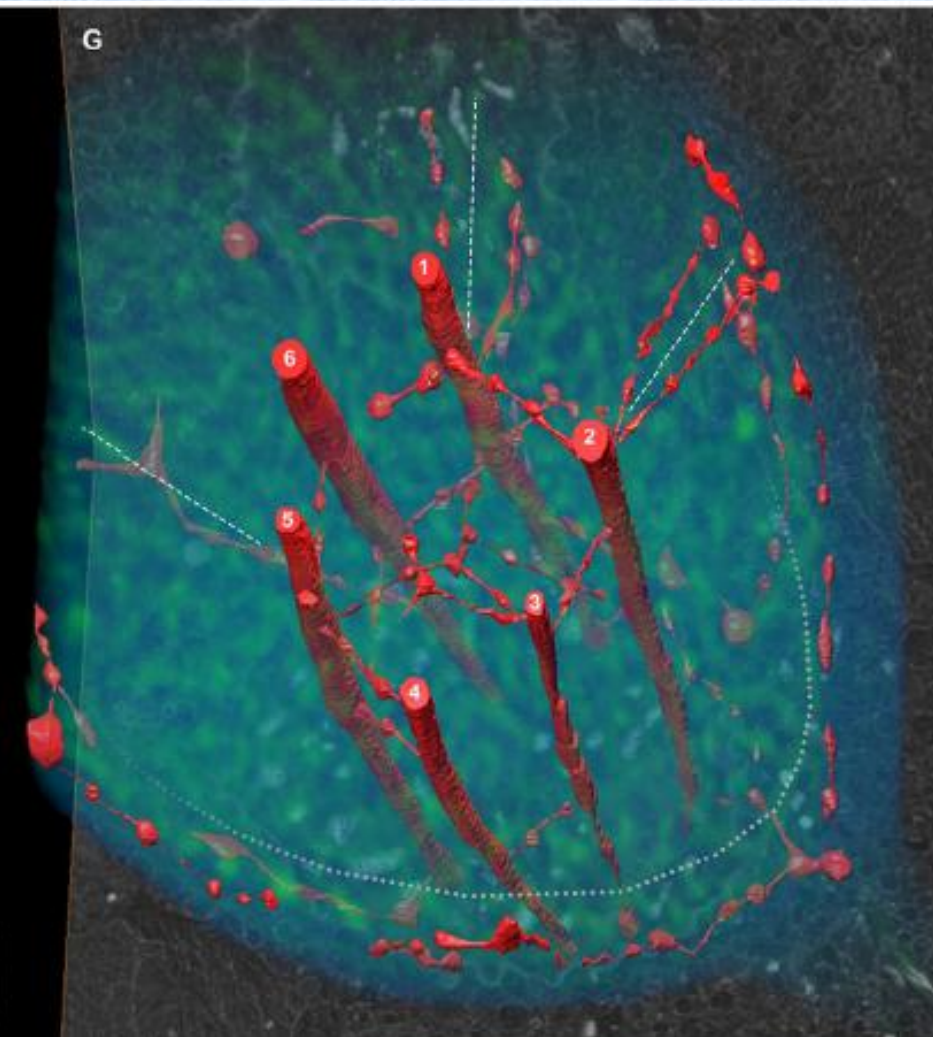
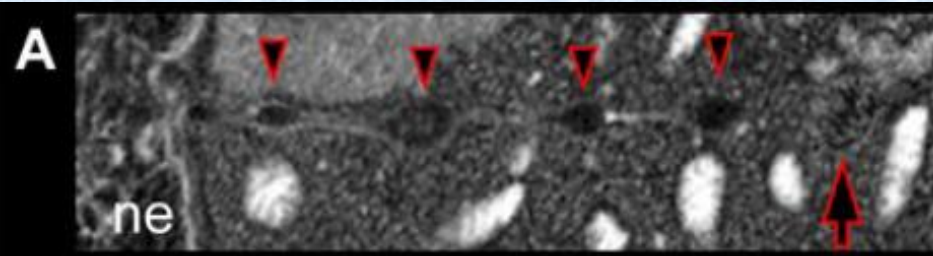
A



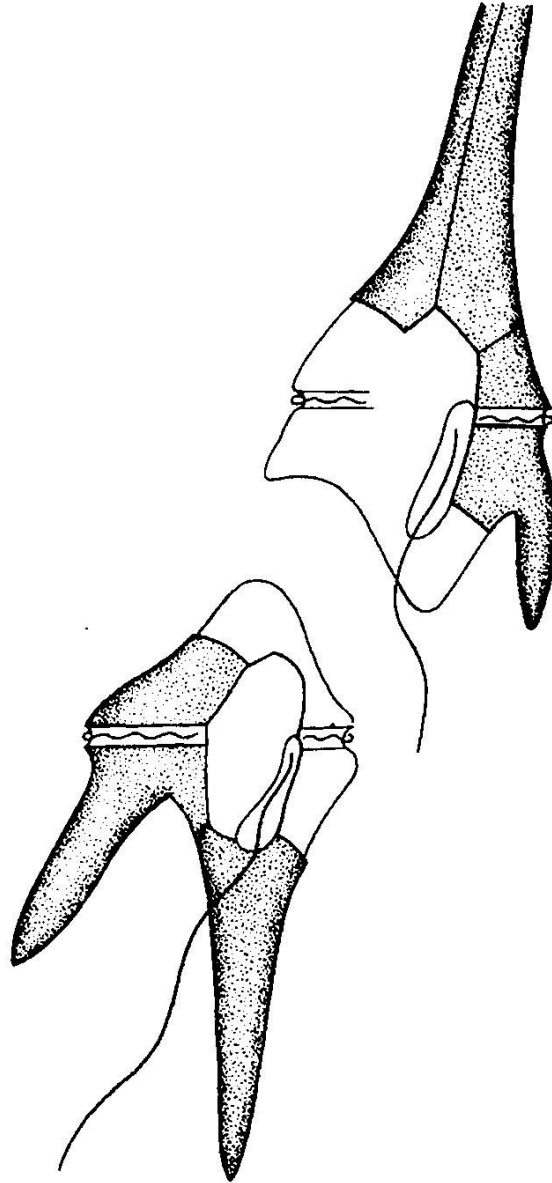
(f)

M

Nuclear net

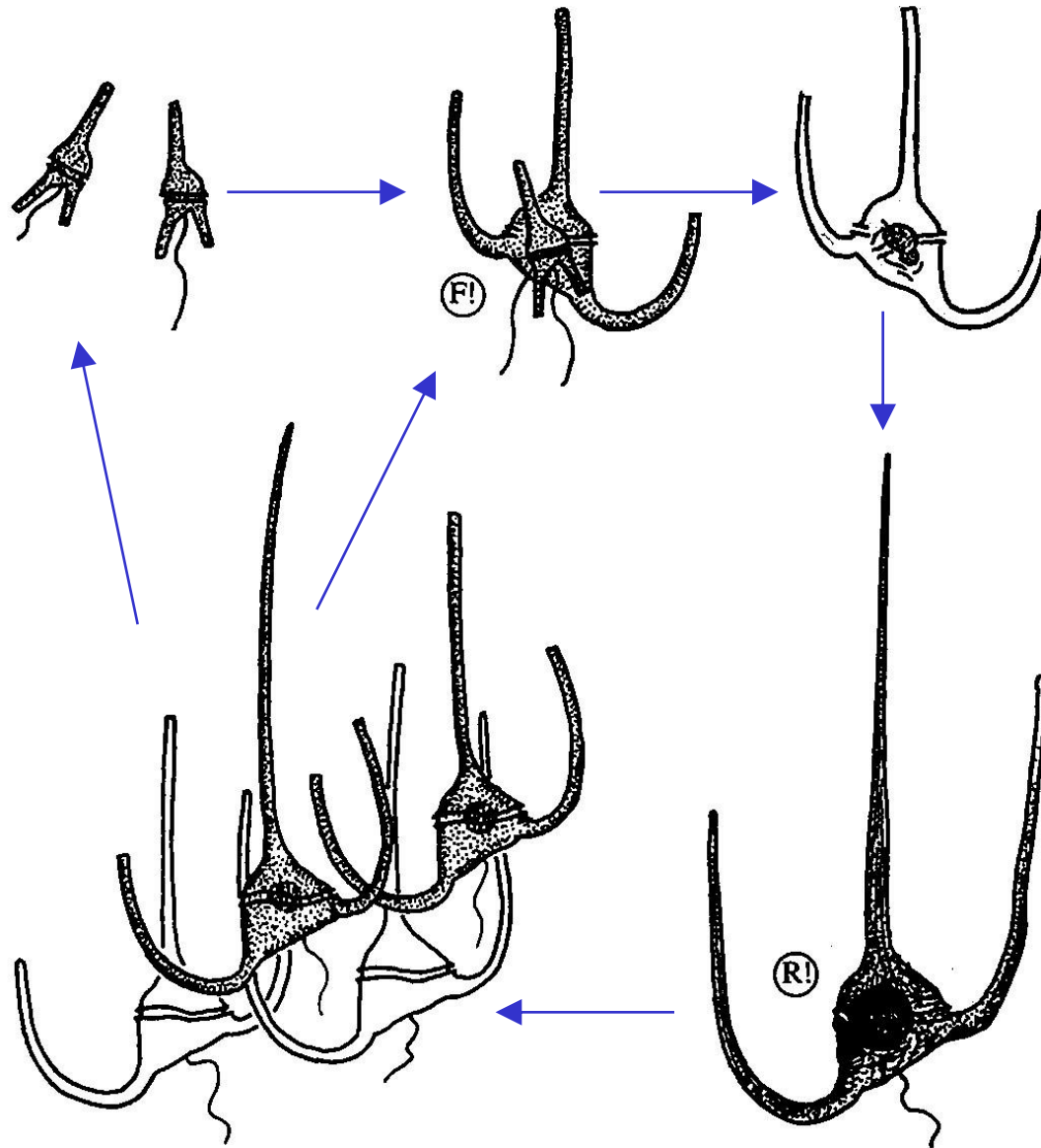


Asexual reproduction



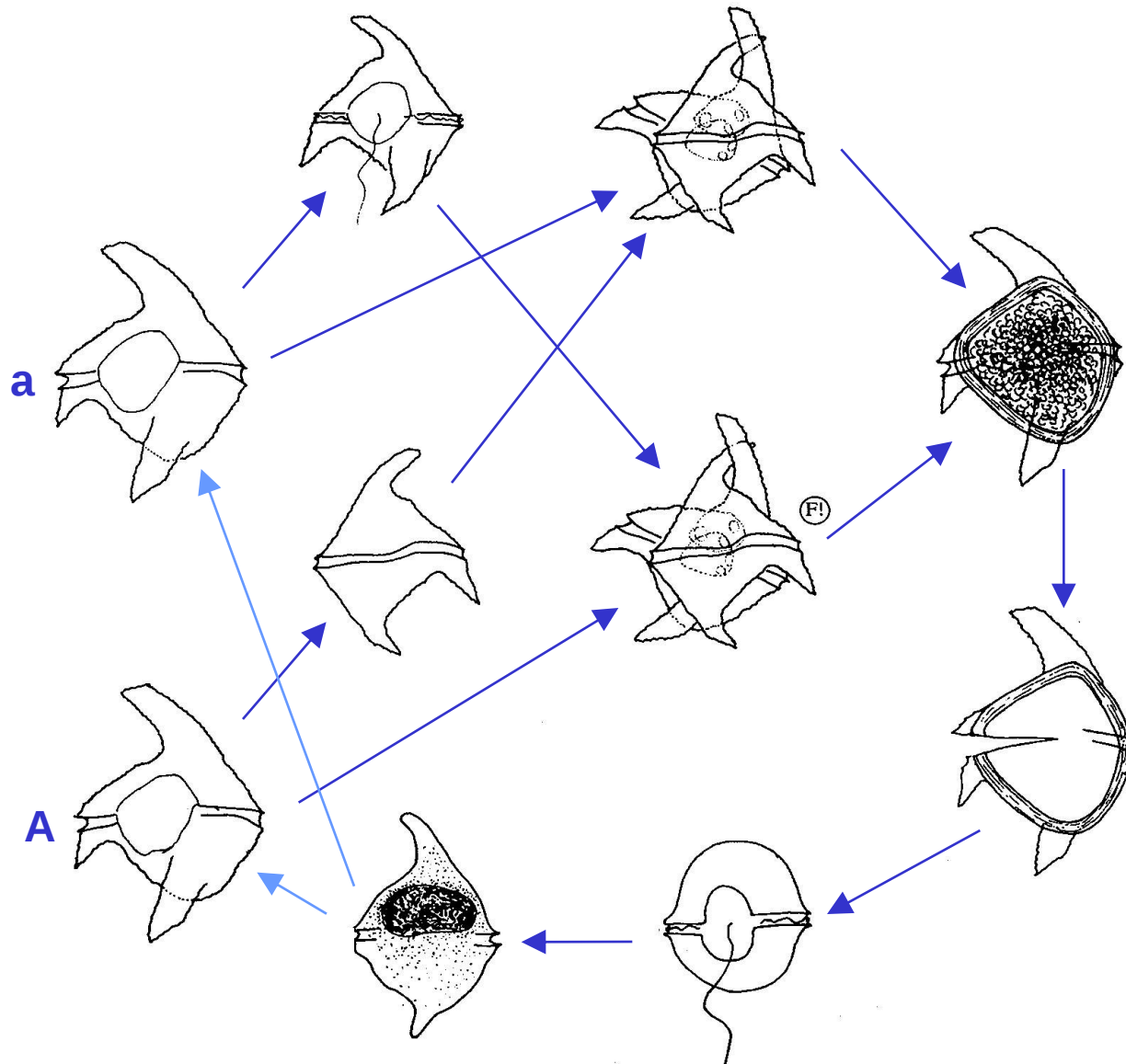
Sexual reproduction

Ceratium horridum – anisogamy, haplontic life cycle



Sexual reproduction

Ceratium cornutum – isogamy, haplontic life cycle

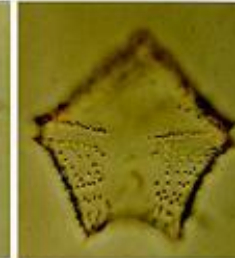
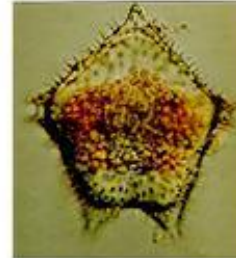


Cysts

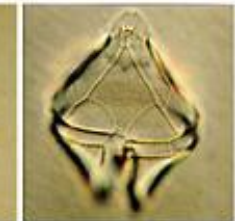
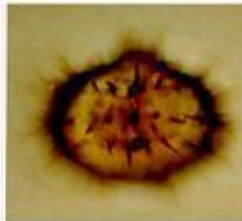
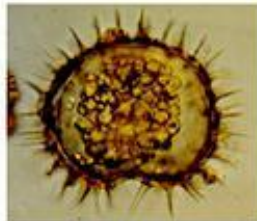
- surviving for many years
- large inocula in coastal water sediments



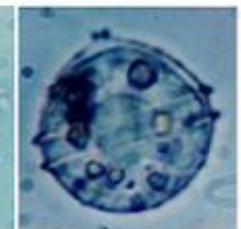
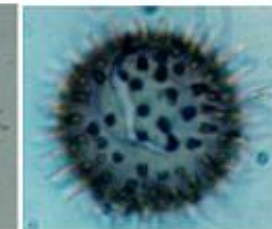
Protoperidinium claudicans



Protoperidinium sp.



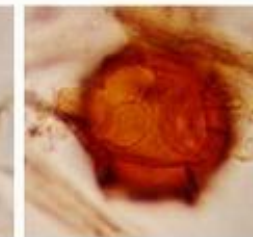
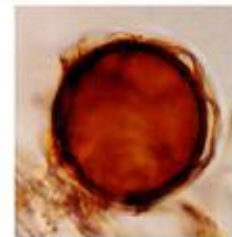
Protoperidinium conicum



Protoperidinium minutum



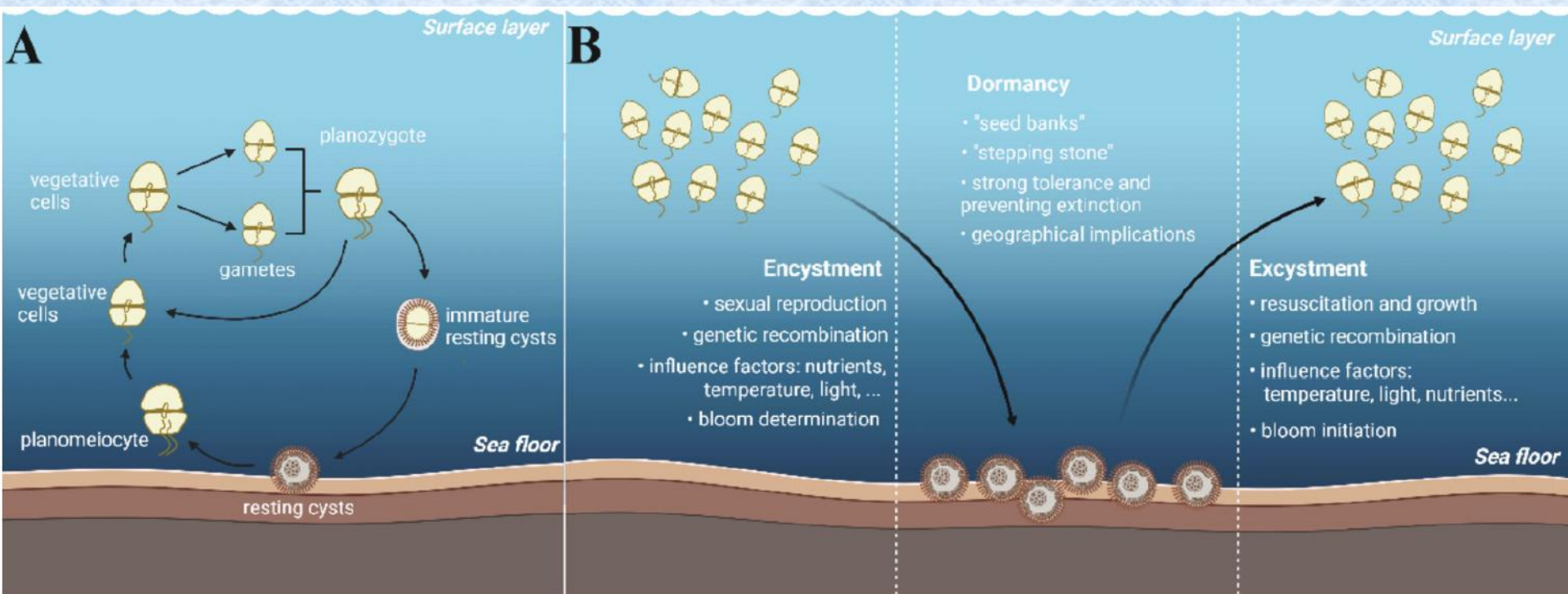
Protoperidinium sp.



Protoperidinium americanum

Cysts

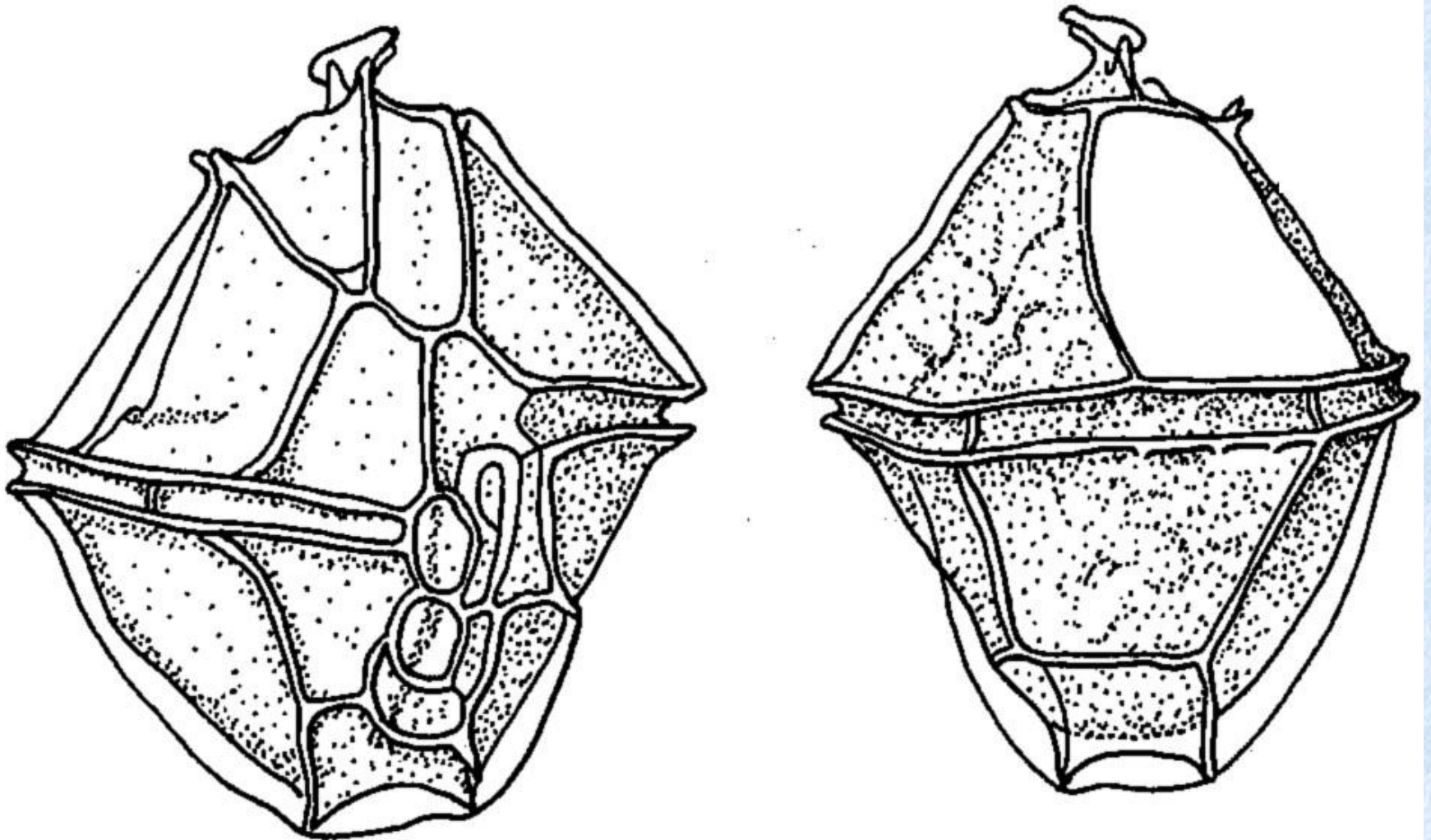
- surviving for many years
- large inocula in coastal water sediments



the life cycle process of cyst-forming dinoflagellates and (B) ecological implications of life cycle dynamics. *Note:* Created with

Fossil cysts - hystrichospheres

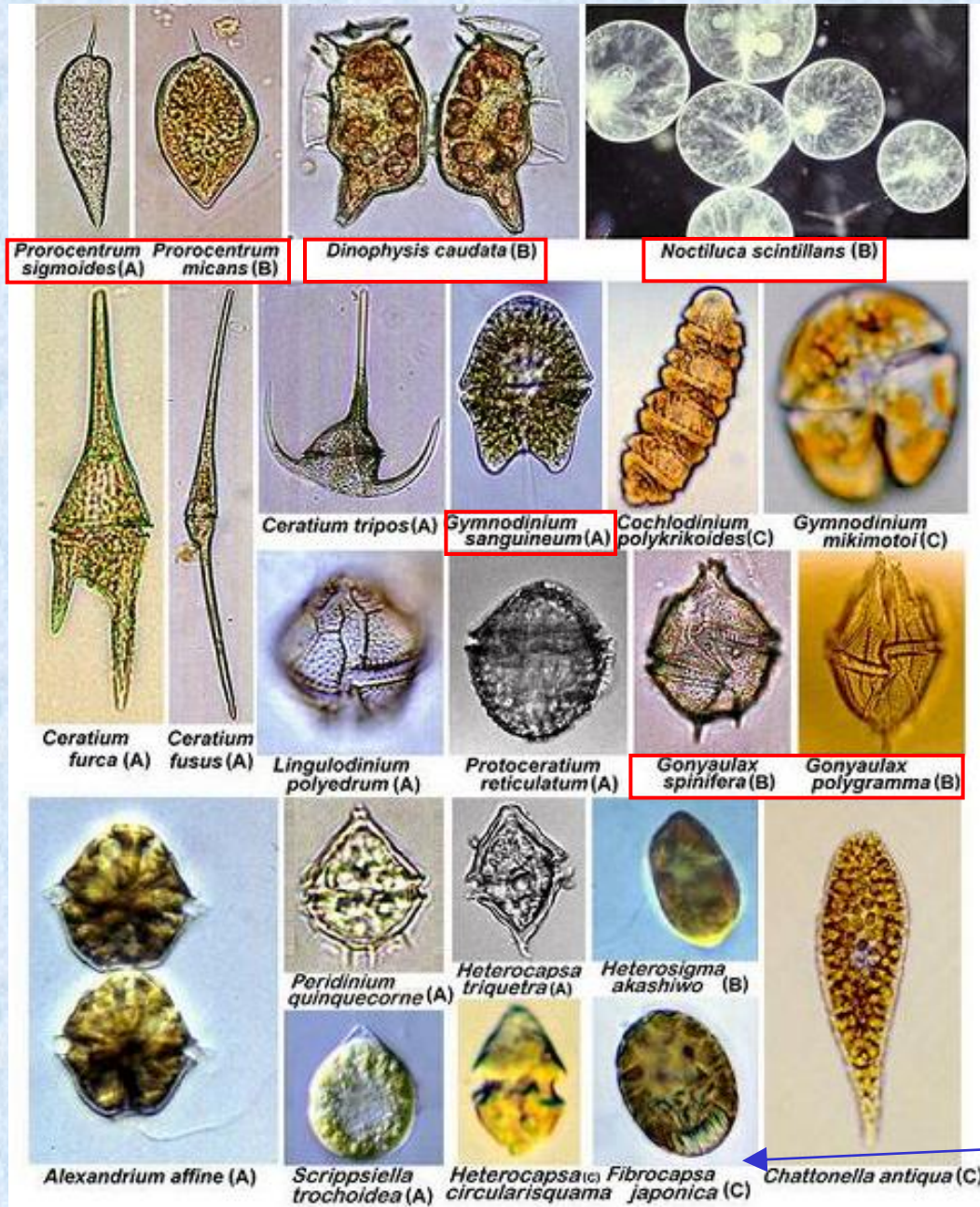
- age of up to 600 mil. years (precambrium)



Red tides



Red tides

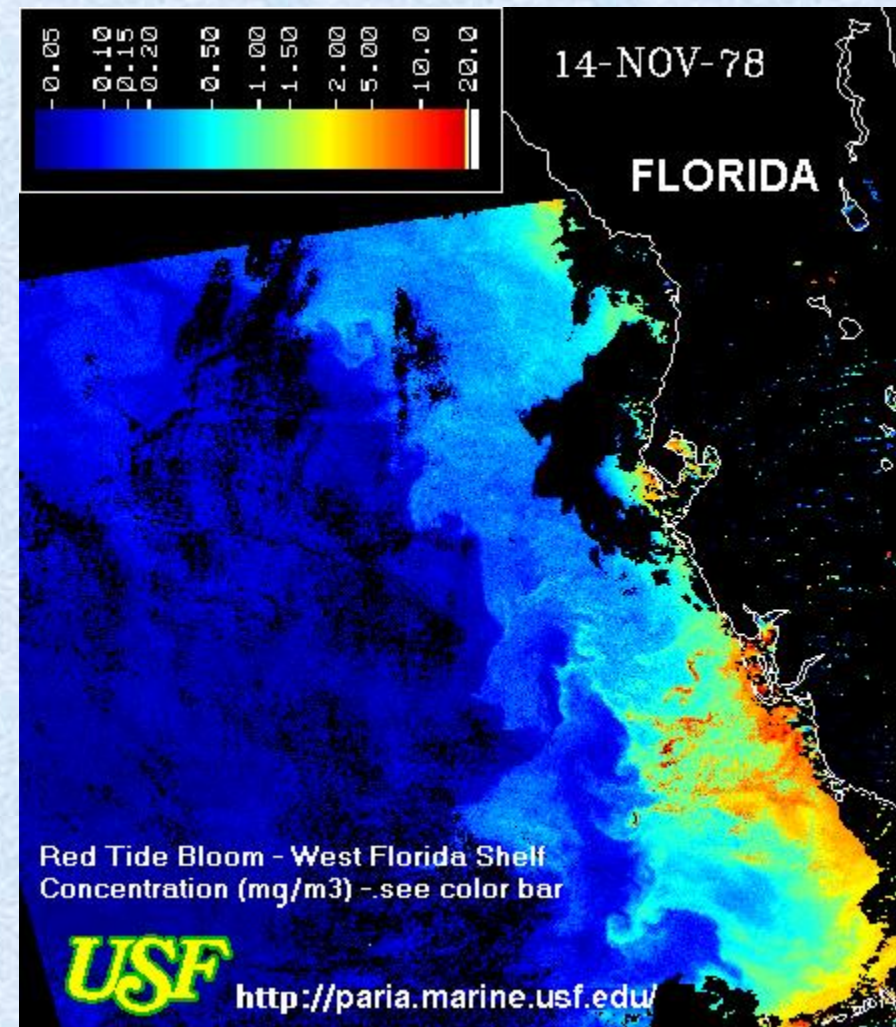
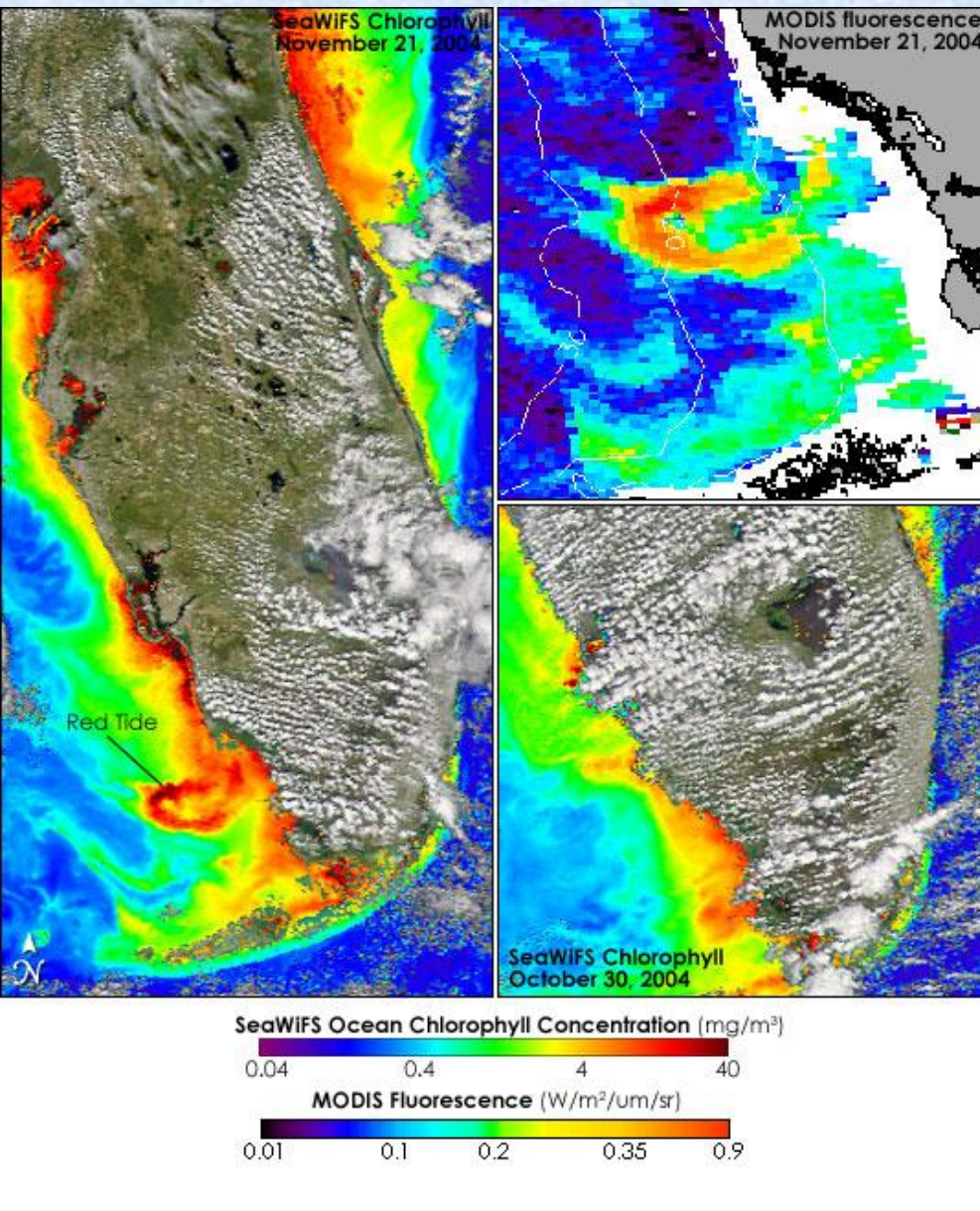


Raphidophyceae

Red tides



Red tides



Red tides



Red tides

Negative influence on marine organisms

- formation of anoxic environment
- poor light penetration
- plugging of fish gills
- production of toxins

Red tides



**Mass mortality of flat-fish by a red tide of
*Cochlodinium polykrikoides***

Red tides

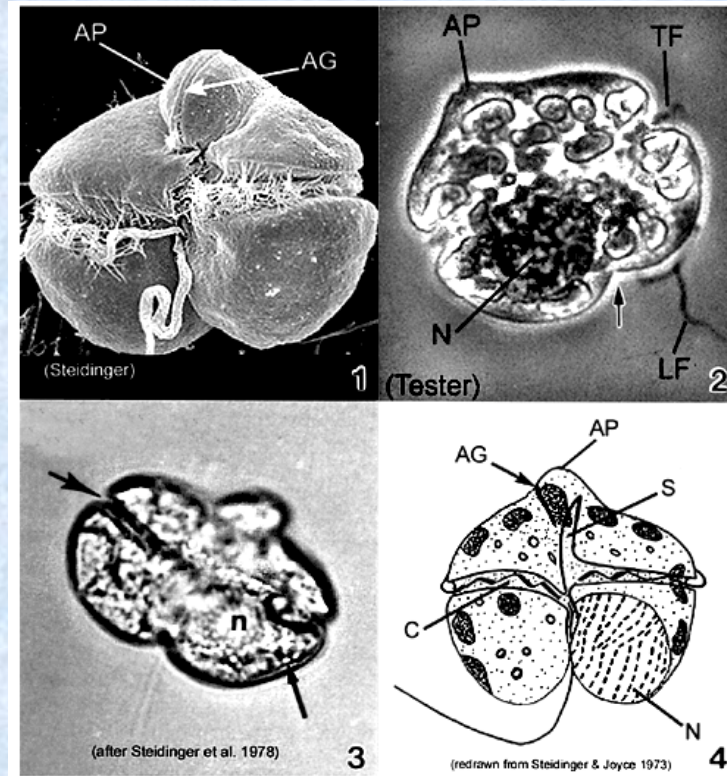
NSP - Neurotoxic Shellfish Poisoning



Red tides

NSP - Neurotoxic Shellfish Poisoning

- *Gymnodinium breve* – brevetoxin
- accumulation in mussel (water filtration)
- neurotoxin – influence on Na^+ canals
- gastroenteritis, neurological and respiratory problems (inhalation of aerosols)



Red tides

NSP - Neurotoxic Shellfish Poisoning



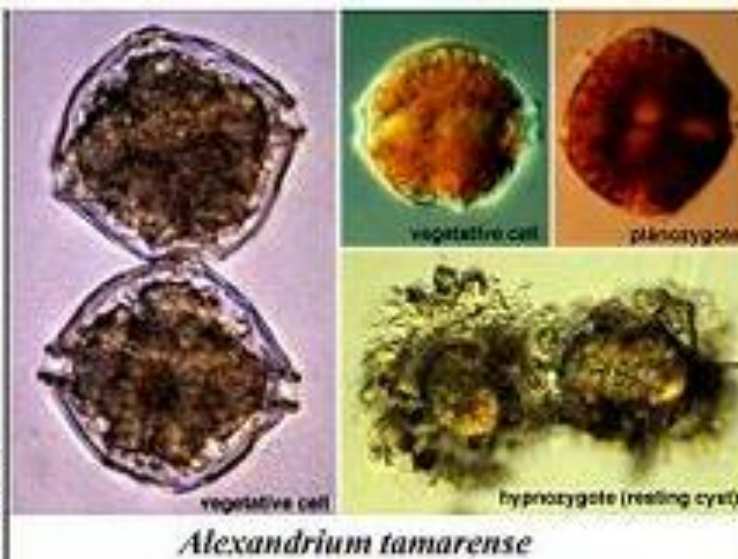
Red tides

PSP - Paralytic Shellfish Poisoning



Red tides

PSP - Paralytic Shellfish Poisoning



Red tides

PSP - Paralytic Shellfish Poisoning

- saxitoxin, neosaxitoxin
- accumulation in mussels
- nausea, vomiting, diarrhea, abdominal pain, brain dysfunction
- rarely complete paralysis, death by suffocation
- no antitoxin
- mortality 8,5 – 9,5 %



Red tides

PSP - Paralytic Shellfish Poisoning

Guatemala 1978: 50 % of all infected children died



**WARNING
TOXIC
SHELLFISH**

Shellfish from this area
are unsafe to eat due
to shellfish toxins.
**DO NOT EAT CLAMS,
MUSSELS, OR SCALLOPS**

¡CUIDADO! CRUSTÁCEOS TÓXICOS
CRUSTÁCEOS SACADO DE ESTA
ZONA SON INSEGUROS DE COMER Y
PUEDEN RESULTAR EN PARÁLISIS.
NO COME ALMEJAS, OSTRAS,
MEJILLONES OR MOLUSCOS.

**OREGON STATE DEPARTMENT OF AGRICULTURE
FOR FURTHER INFORMATION: (503) 986-4720**
English Hotline: 503-986-4720
The Oregon Dept. of Fish & Wildlife requires a clam
fishery be closed when health advisories are issued.



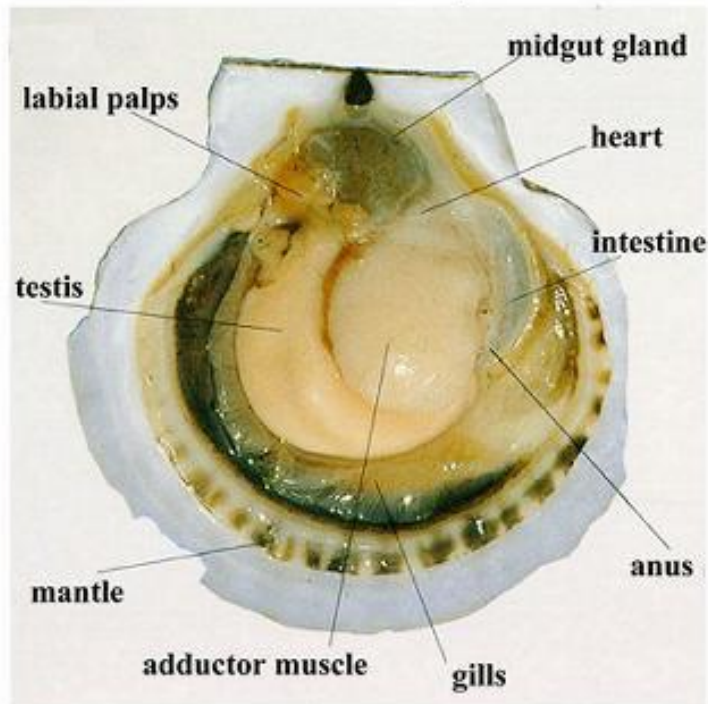
Red tides

Scallop *Patinopecten yessoensis*



left side shell

right side shell



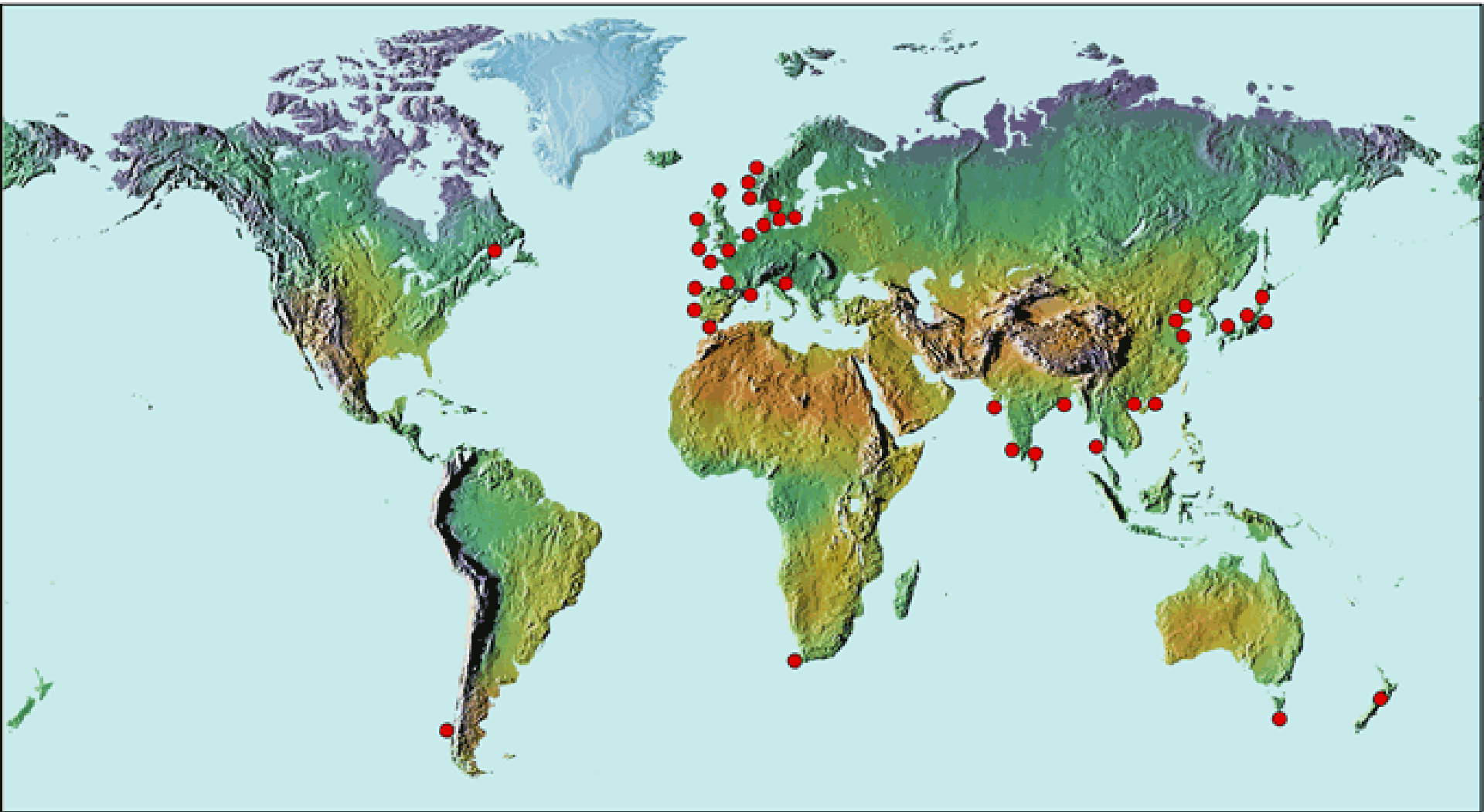
culture by
a string tied
to the rope



culture in cage net

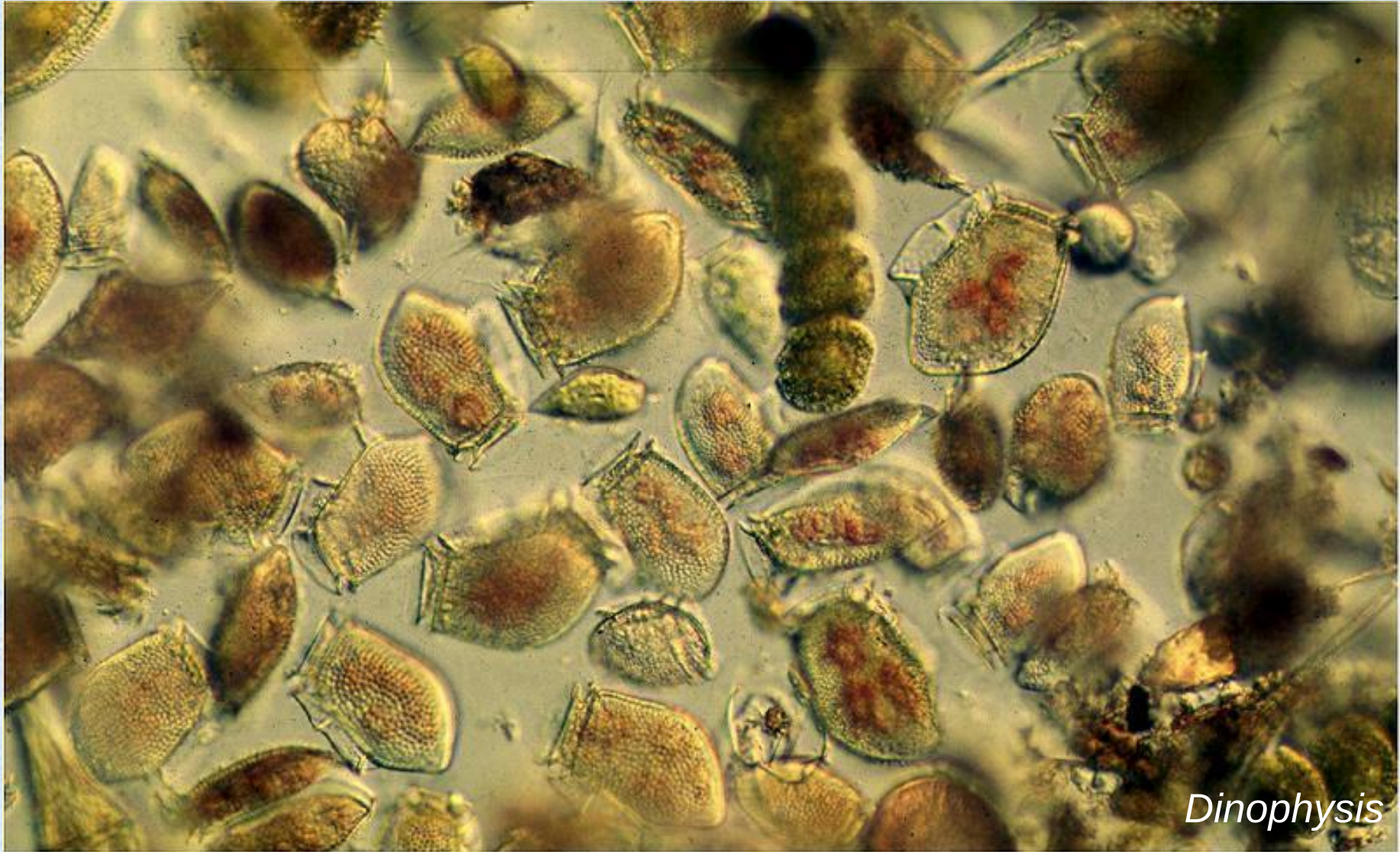
Red tides

DSP - Diarrhetic Shellfish Poisoning



Red tides

DSP - Diarrhetic Shellfish Poisoning

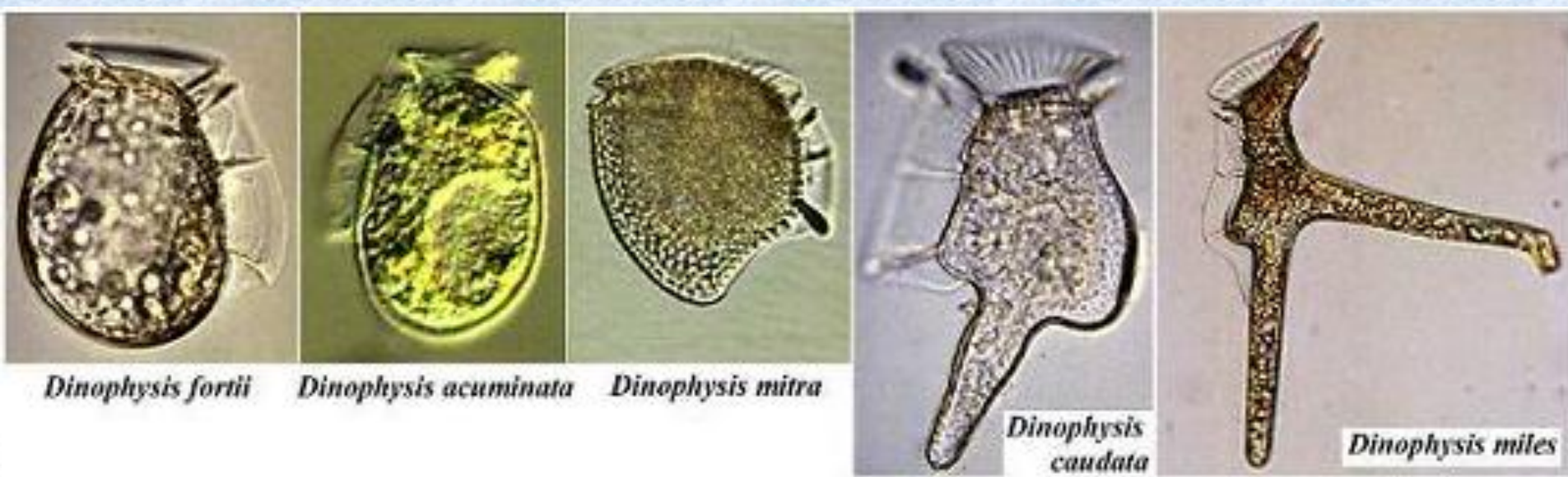


Dinophysis

Red tides

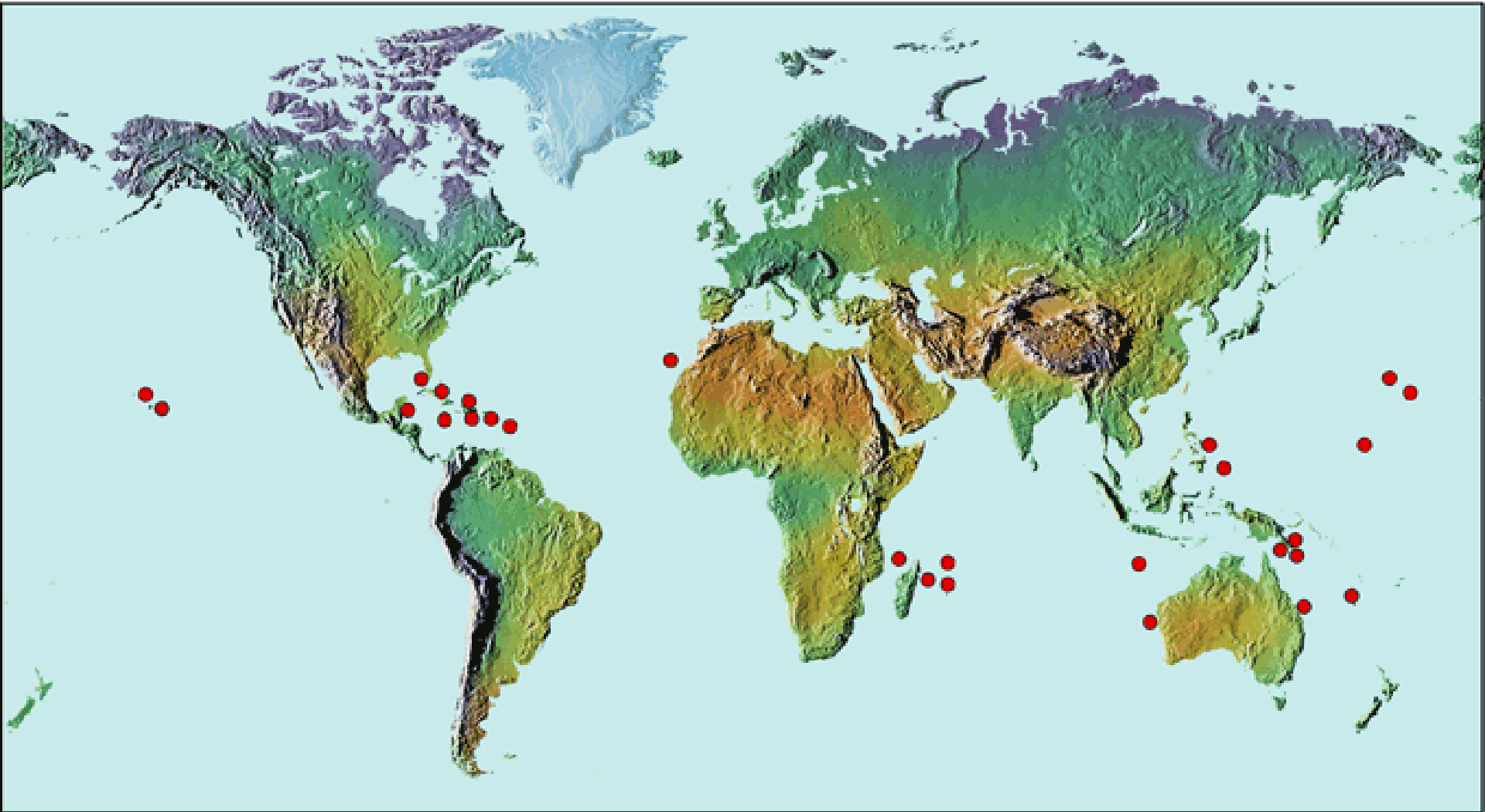
DSP - Diarrhetic Shellfish Poisoning

- gastrointestinal symptoms, no neurological symptoms
- accumulation in mussels
- diarrhea, vomiting, hospitalisation not needed



Red tides

CFP – Ciguatera Fish Poisoning



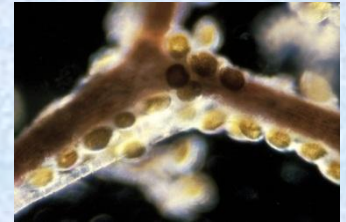


Red tides

CFP – Ciguatera Fish Poisoning



- the most common disease caused by marine toxins (50 000 cases per year)
- *Gambierdiscus toxicus*
- accumulation in marine tropical fish (barracuda, ...)
- gastrointestinal symptoms: diarrhea, vomiting
- neurological symptoms: hallucinations, burning sensation on contact with cold
- cardiological symptoms: arrhythmia, cardiac arrest
- mortality 0,1 – 12 % (pulmonary arrest, cardiac arrest)



Red tides

CFP – Ciguatera Fish Poisoning

Vector fish of ciguatera toxins

WESTPAC/IOC/UNESCO



Red tides



**Shrimp culture farms in mangrove
along the coast of the Gulf of Thailand**

Photo by Dr. Thaithaworn Lirdwitayaprasit
of the Department of Fisheries of Thailand

IOC-WESTPAC HAB R0006

Red tides



Red Tide Research

Red tide of *Noctiluca scintillans* in the
Basque Country (San Sebastian)

Photograph by Mr. Xavier Urrutia

WESTPAC-HAB R0015
IOC Harmful Algal Bloom Programme



Red alert . . . commercial fisherman Ted Allan with a sample of the red algae
at Little Manly yesterday PHOTO: Julian Andrews

Pollution alert

SWIMMERS were warned to stay out of the water yesterday as a tide of red algae washed into Manly Cove and storm-water pollution souled Queenscliff Beach.

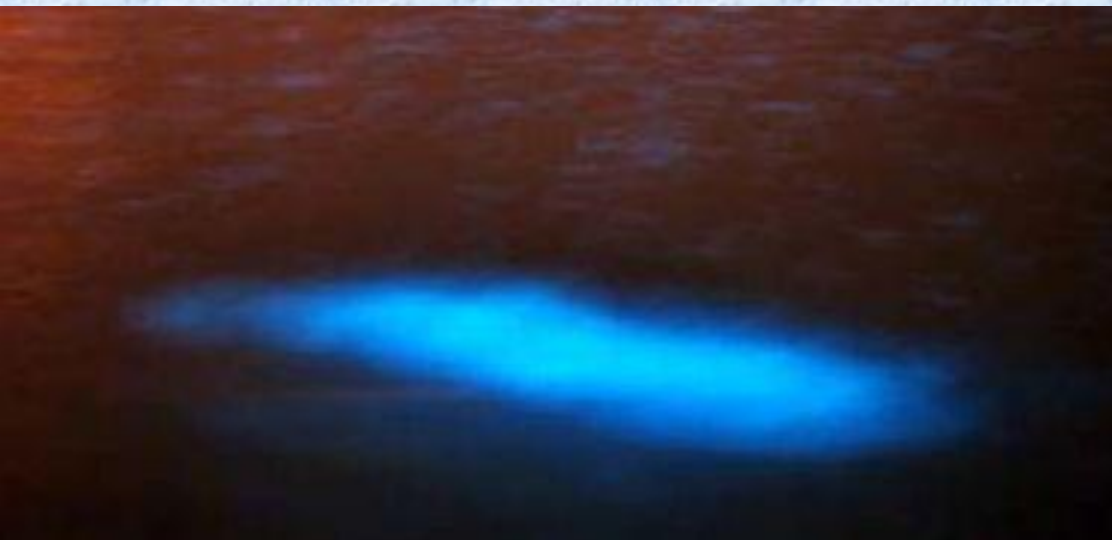
Beachwatch manager Steve Higham

and ocean beaches by recent heavy rain. Commercial fisherman Ted Allan said he was initially alarmed at the sight of the red substance, which he thought might have been ballast water dumped from a ship.

(The Manly Daily, 19th February, 1997)

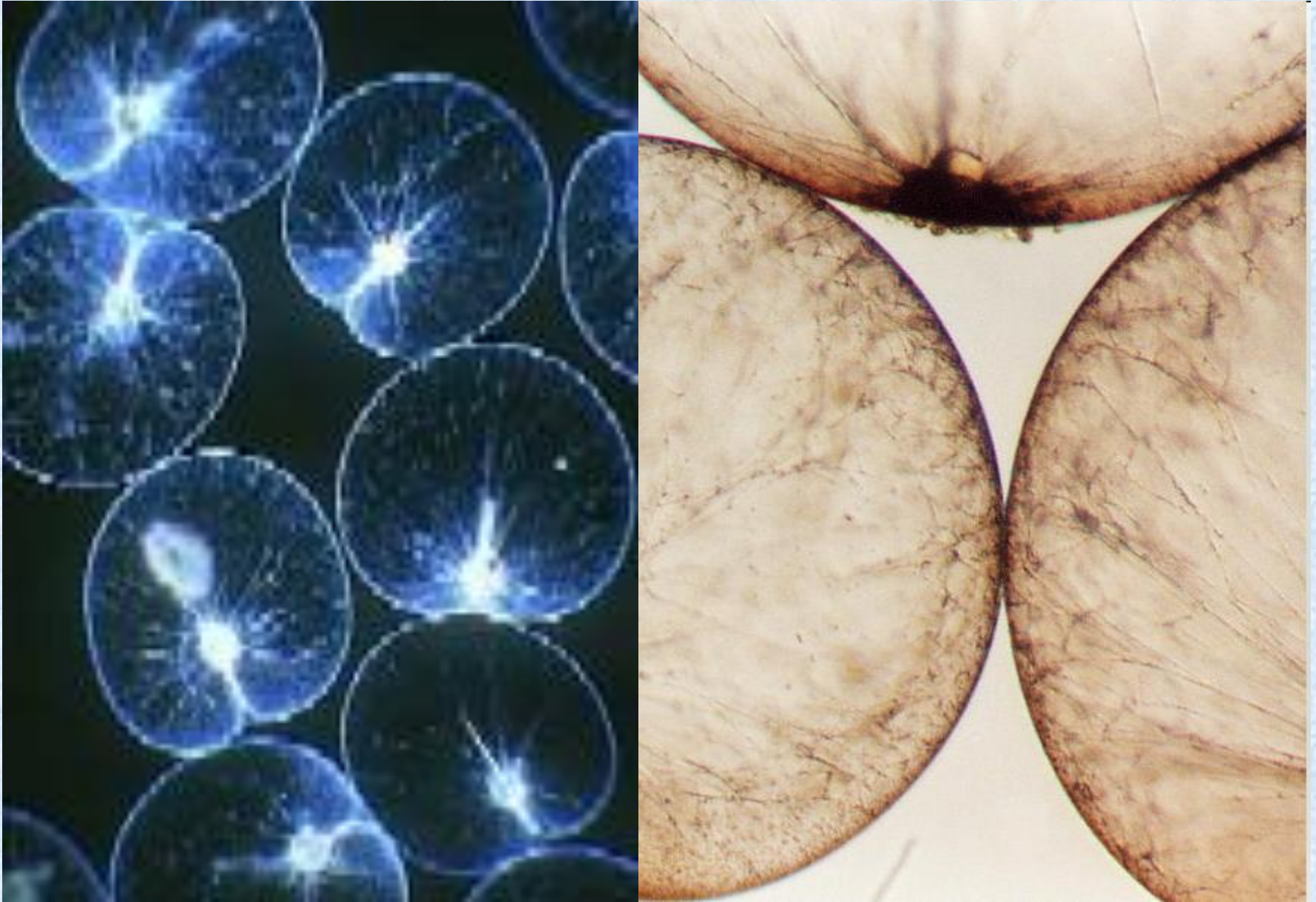
Bioluminescence

- animals, bacteria, ...; among autotrophic organisms only dinoflagellates
- luciferin (oxidation catalyzed by luciferase)
- reduction of predation
- mechanically, chemically or osmotically mediated



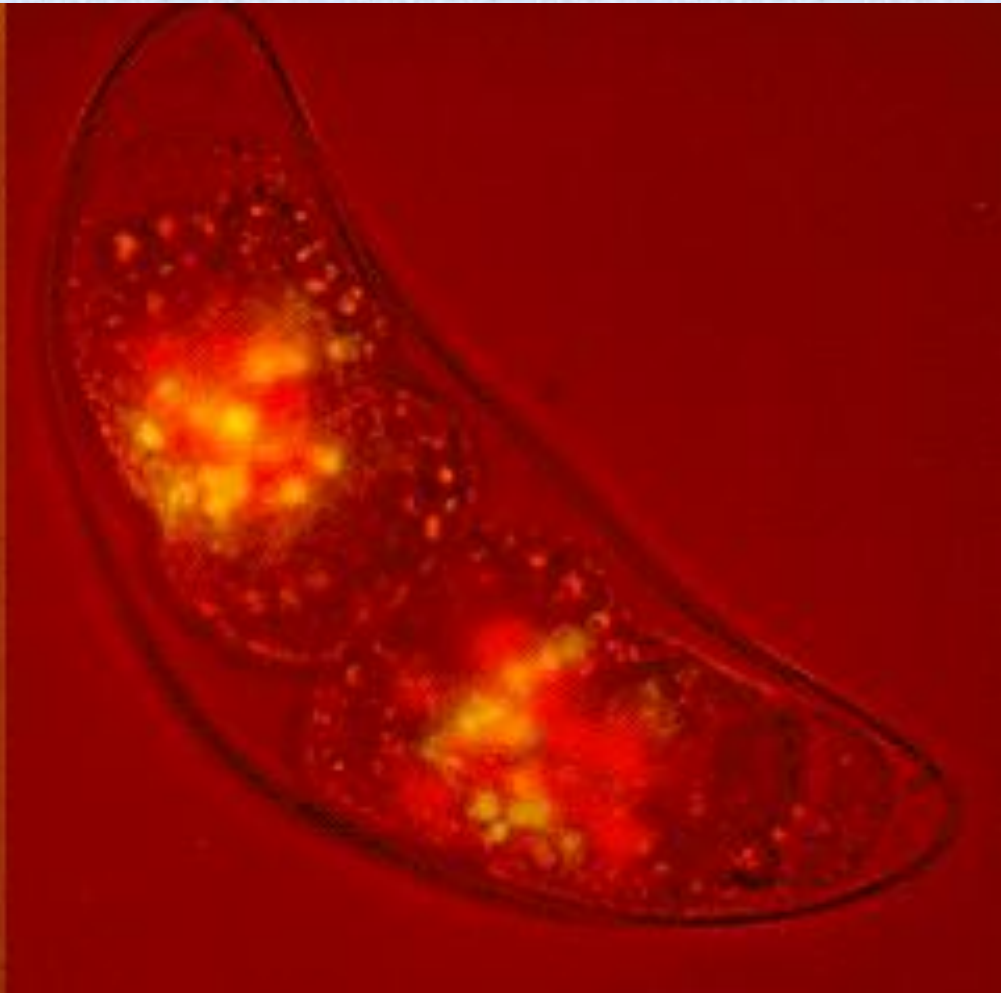
Bioluminescence

Noctiluca scintillans - scintillons



Bioluminescence

Pyrocystis - scintillons



Bioluminescence

Pyrocystis fusiformis



Bioluminescence

Pyrocystis fusiformis



Lights From The Sea (*Pyrocystis fusiformis*) is a study in Marine Science. These tiny plants live in the ocean. They are unicellular algae, which look like delicate, beautiful, golden eyes, and produce oxygen and sugars like all plants do. In the dark, Lights From The Sea produce glowing blue light. *Pyrocystis* sets its bioluminescence by a biological clock (just like our sleep patterns). At sunset the cells produce the chemicals that cause a luciferin-luciferase reaction. You can see the general shape of the plant through a magnifying glass. You do not need to feed them since they use the light in your room to photosynthesize producing their own oxygen and food. Lights From The Sea can last several weeks to months. You must treat them as you would a delicate plant or a bouquet of flowers. They need light but prefer to remain between 50 and 70 degrees Fahrenheit. *Pyrocystis fusiformis* is a visually exciting marine science, great for science fairs, classroom learning, and special events. [Lights From The Sea Price List](#)

QUANTITY/PRODUCT	SHIP U.S. PRIORITY
(3) 50 ml bags	\$20.00
(10) 50 ml bags	\$50.00
(30) 3 ml vials	\$30.00
(30) 10 ml tubes	\$45.00
(1) 1 liter container	\$80.00



Why the dinoflagellates shine?

- (A) startling predatory copepods
- (B) warning potential predators of toxicity,
- (C) drawing the attention of higher order visual predators to the copepod's location.



Why the dinoflagellates shine?

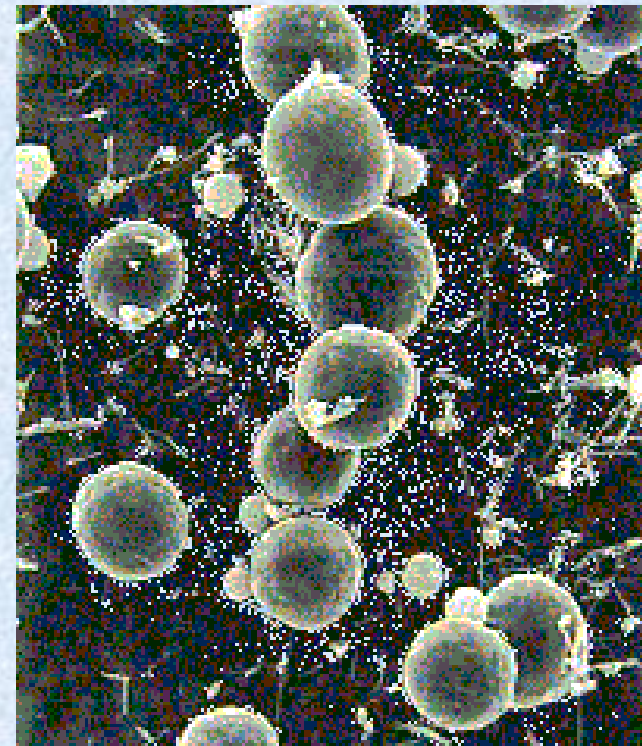
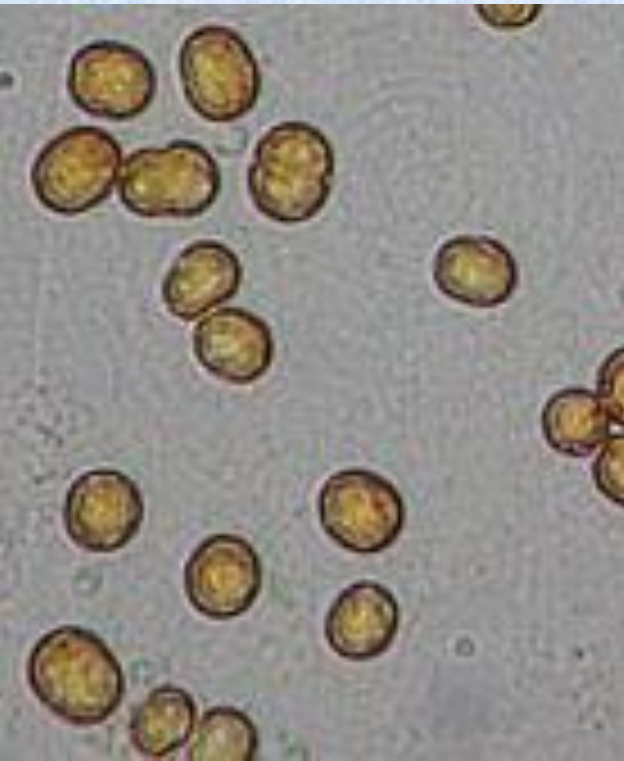


They probably produce the light to help predators preying herbivores of dinoflagellates

<http://www.youtube.com/watch?v=bCNjXaMPZxw>

Symbiotic dinoflagellates

- green algae (zoochlorells) - in freshwater habitats and terrestrial ecosystems
- dinoflagellates (zooxanthels) – in marine environments



Symbiotic dinoflagellates

cnidarians - corals



Symbiotic dinoflagellates

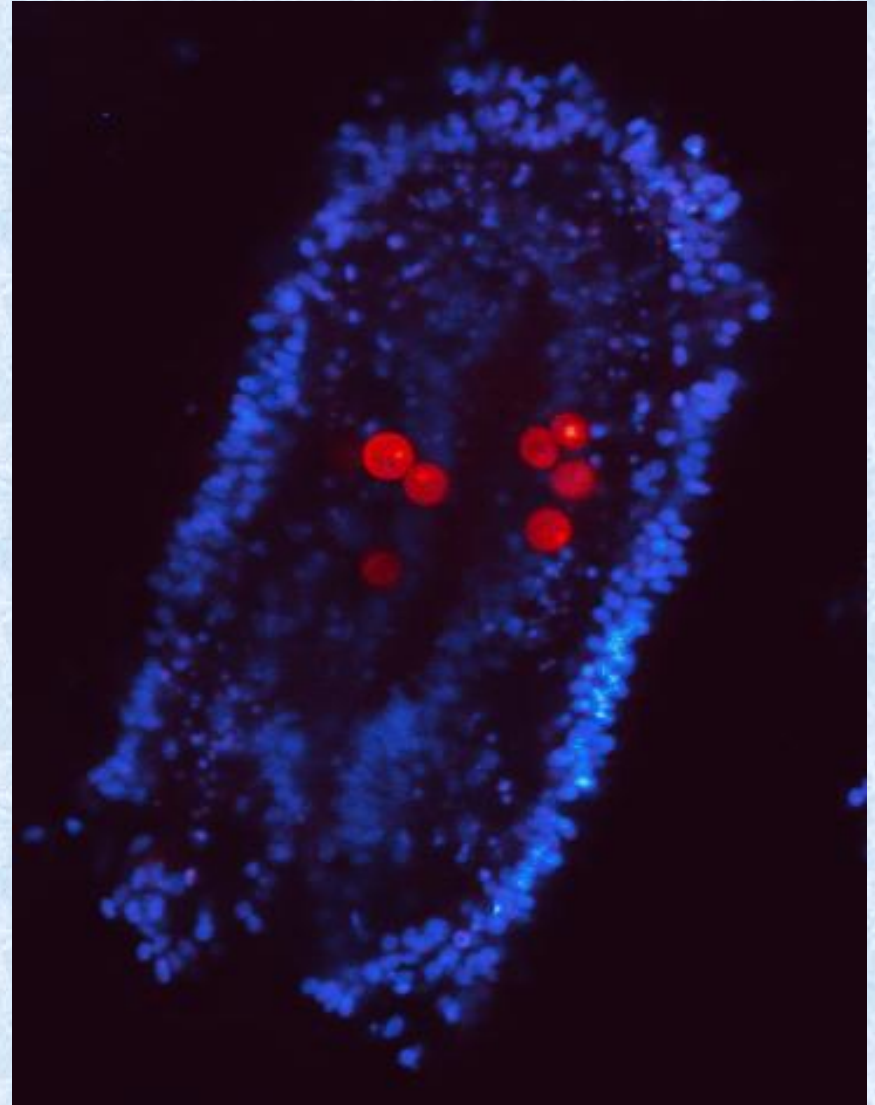
cnidarians – sea anemones



Anthopleura

Symbiotic dinoflagellates

Fungia scutaria, planula



Symbiotic dinoflagellates

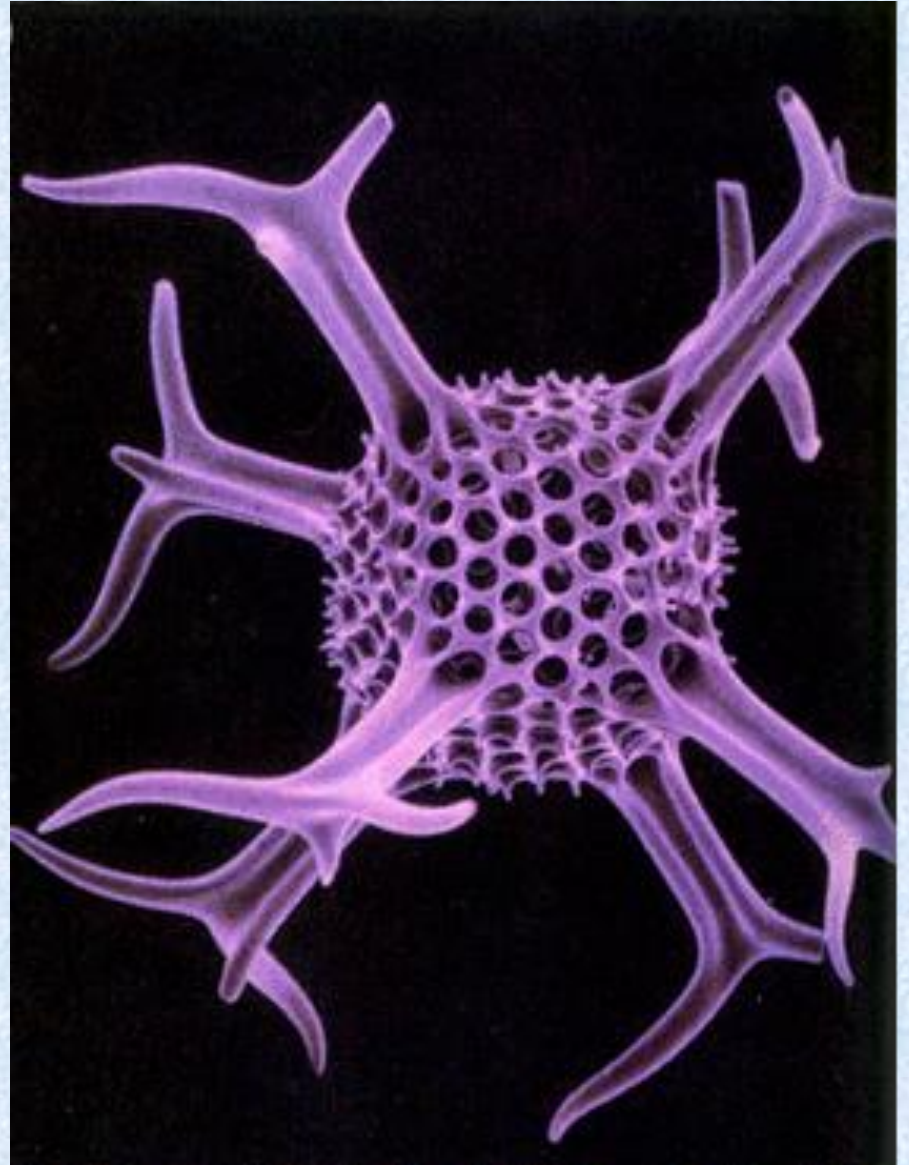
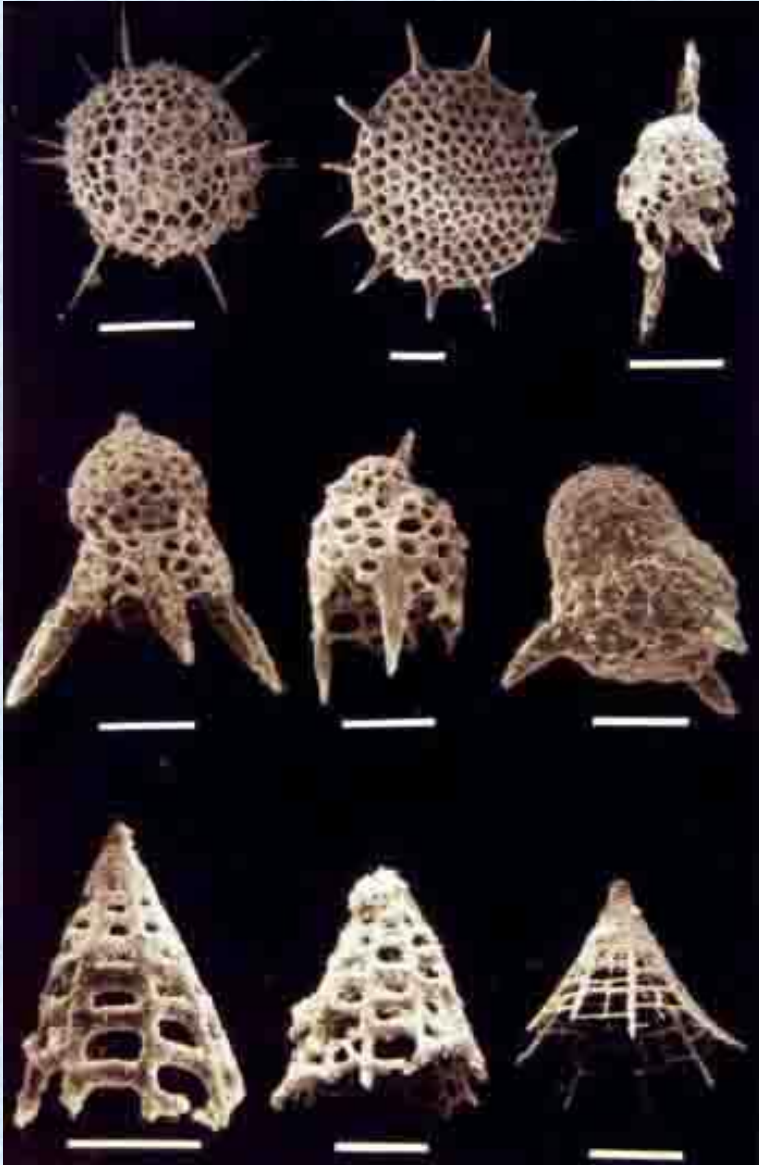
cnidarians - jellyfish



Mastigias papua

Symbiotic dinoflagellates

Radiolaria



Symbiotic dinoflagellates

Foraminifera

