In 1988 researchers from NCSU noticed high mortality of fish in aquaculture facilities from coastal NC

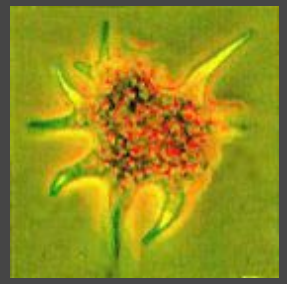
Small zoospores were found with the sick fish, but they disappeared after the fish were dead

Fish came from Pamlico and nearby estuaries were showing unexplained fish kills, involving thousands to millions of fish

It become evident that those zoospores were involved in these deaths and its study in culture was followed by Burkholder and others

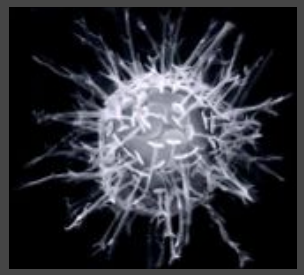
During these culture studies it was evident that this alga was stimulated by nitrogen and and phosphorous enrichment

Zoospores



Ameboid

What it was unknown until then was the toxic potential of toxins, especially to humans



Cyst

What it follows was one of the most dramatic and intriguing cases in phycology in the last 20 years…

Following the zoospore cultures in 1993, severe cognitive impairment was sustained by laboratory workers, nobody knew why and how the sickness was attacking people lab/offices non-related to the zoospore labs

Later, research workers in the same area became more sick with dark skin sores!!

- ✓Narcosis
- ✓Skin sores
- ✓Headache
- ✓Blurred vision
- ✓Nausea
- ✓Asthma-effects
- ✓Kidney/liver dysfunction
- ✓Memory loss
- ✓Cognitive impairment

In 1997, profound learning disabilities in people were found in fishing villages after a high mortality of fish out in the estuaries in NC

Severe but reversible short-term memory loss requiring 3-6 months for recovery!!!

A dinoflagellate *Pfiesteria piscicida:* The alga from Hell !

Memory loss and *Pfiesteria's* toxins?

Could be related to Alzheimer's disease or multiple sclerosis?

A Toxic *Pfiesteria* research laboratory is a biohazard level III containment facility, similar level for tuberculosis, anthrax, HIV, encephalitis viruses

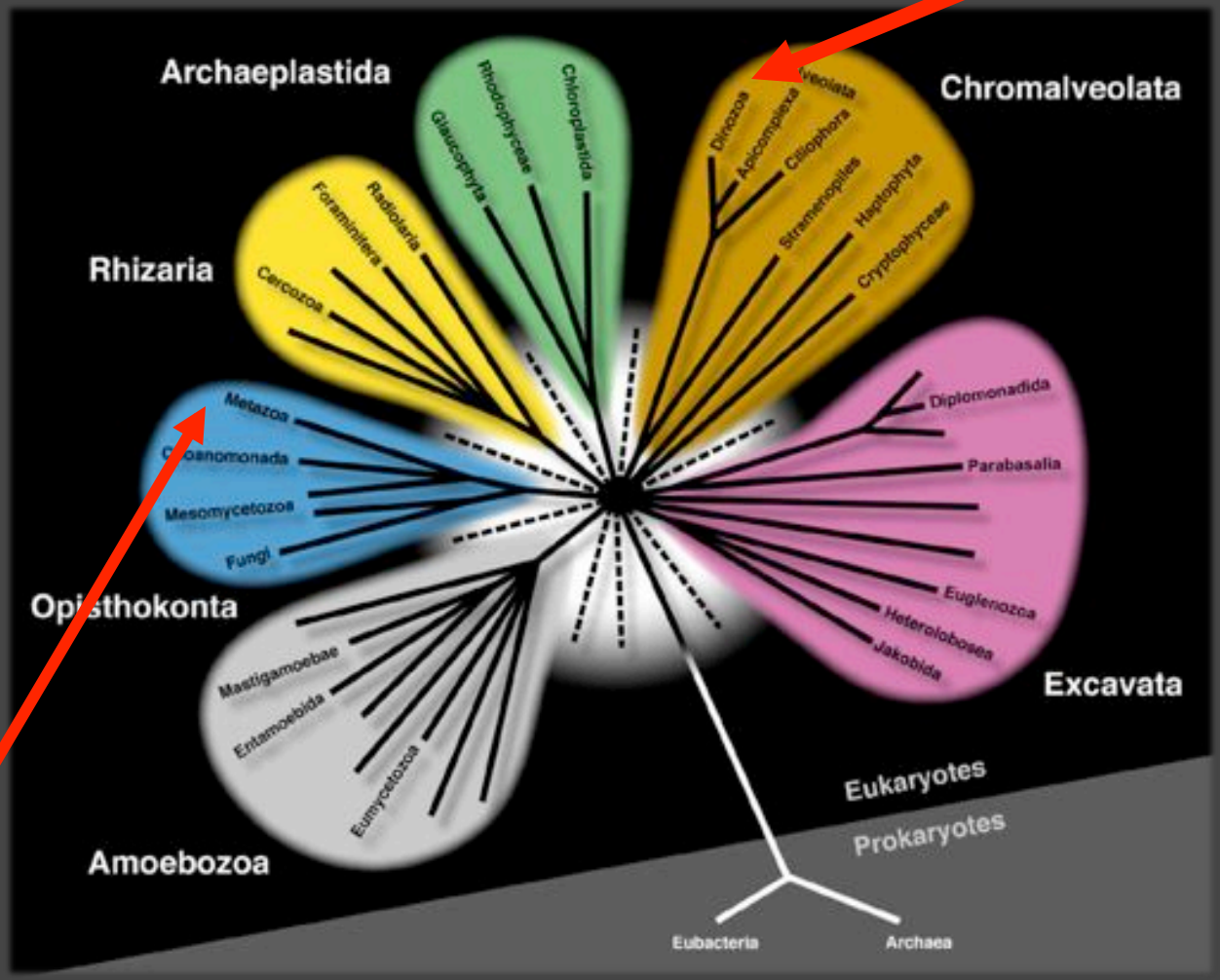

Pathology
Environmental Monitoring
Larval Fish Bioassay
Bio-Toxicity Assays
Great Wisconsin Study
Isolation and Culture
Scanning Electron Microscopy
Molecular Characterization
and Identification

The algae from Hell !!!

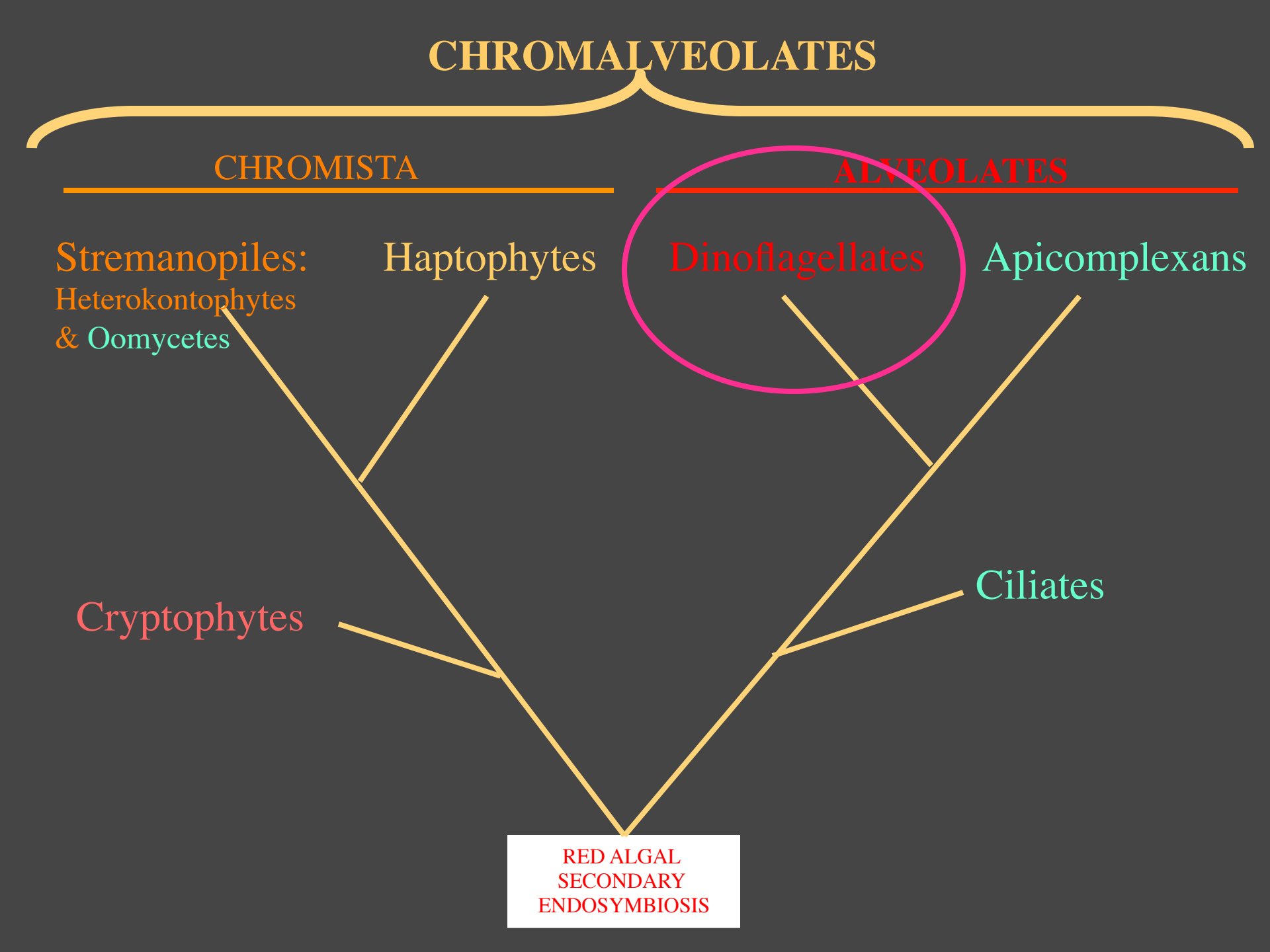
Pfisteria is a Dinophyta or dinoflagellate

DINOPHYTA
The Dinoflagellates or Dinos

Dinos are here



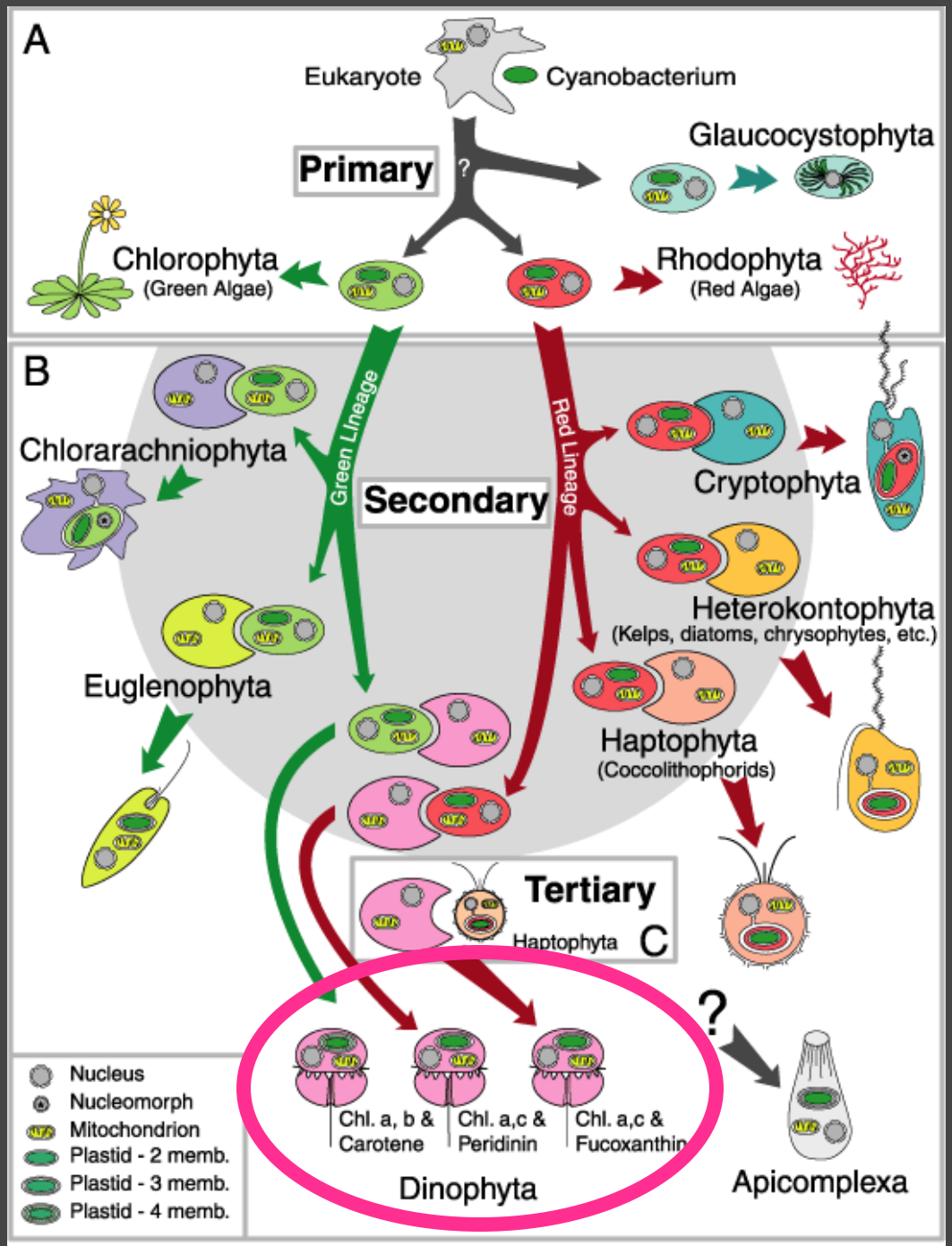
You are here!


CHROMALVEOLATES
CHROMISTA
ALVEOLATES
Stremanopiles:
Heterokontophytes
& Oomycetes
Haptophytes
Dinoflagellates
Apicomplexans
Ciliates
Cryptophytes
RED ALGAL
SECONDARY
ENDOSYMBIOSIS

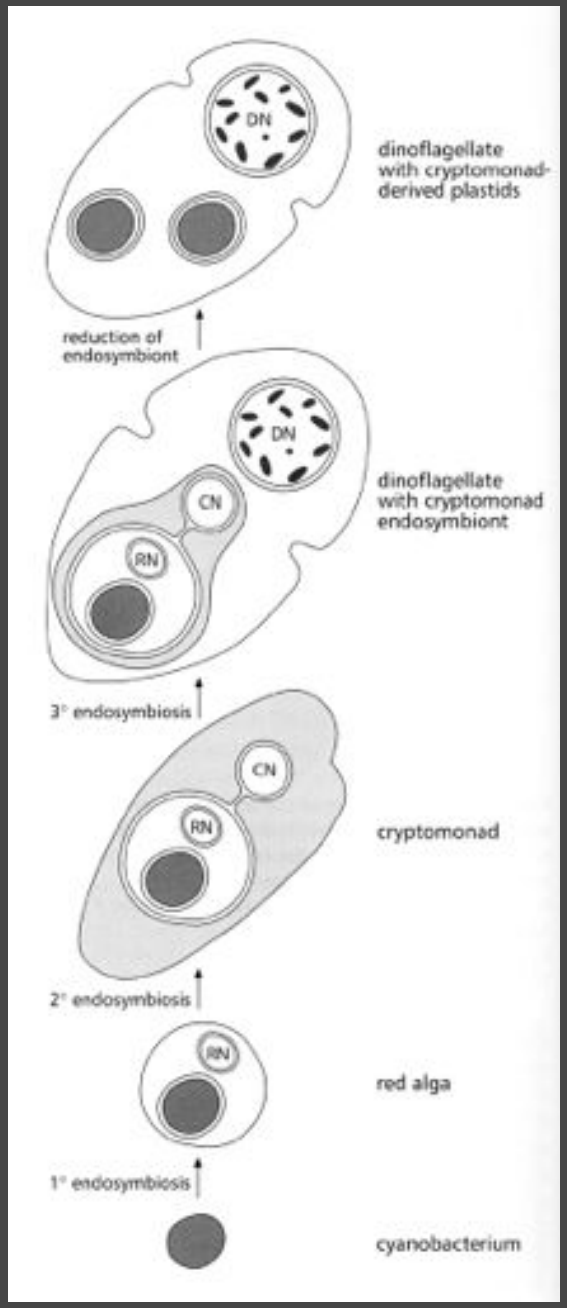
Dinoflagellates are the result of a secondary and tertiary endosymbiosis!

Ancestral green, red, cryptomonad, diatom, and haptophyte cells are represented as plastids in dinophyta!!!

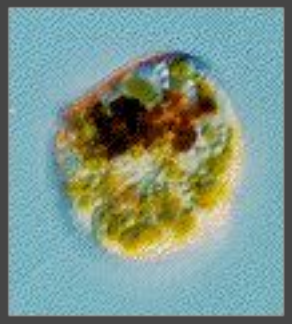
Dinoflagellates are related to the Apicomplexans which include malarial parasites and other human pathogens



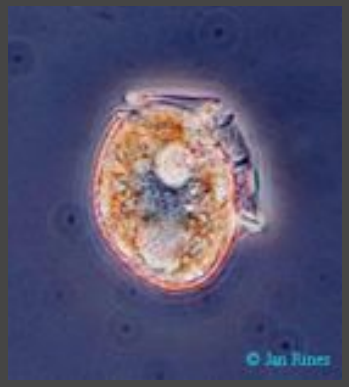
Modified from Delwiche, C.F. 1999. Tracing the thread of plastid diversity through the tapestry of life. Am. Nat. 154:S164-S177.



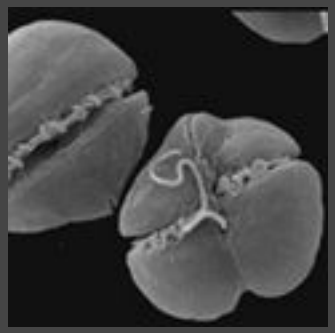
The diversity of photosynthetic pigments in dinoflagellates is an indication of the diverse origin of their plastids:



Peridinium foliaceum, with a diatom!



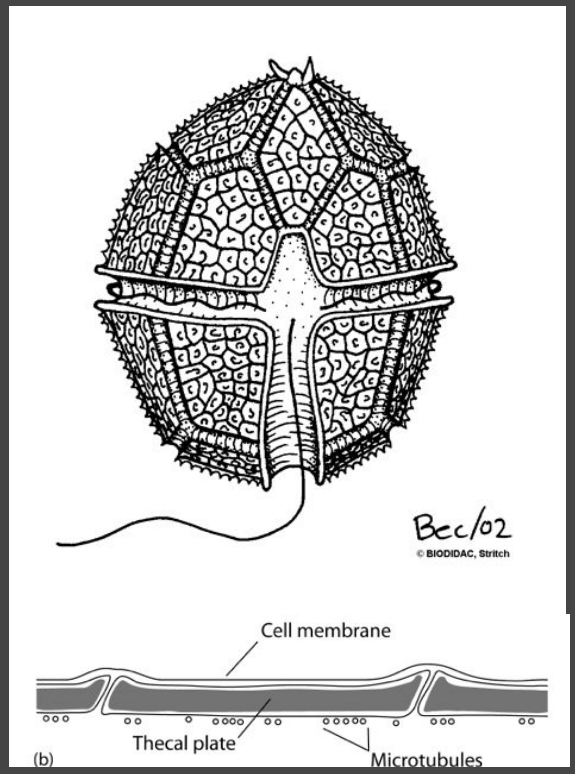
Dinophysis acuminata, with a cryptomonad!

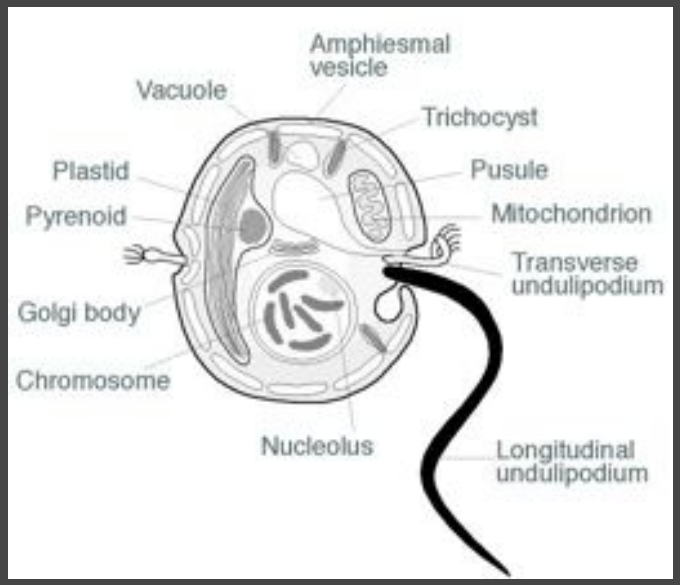


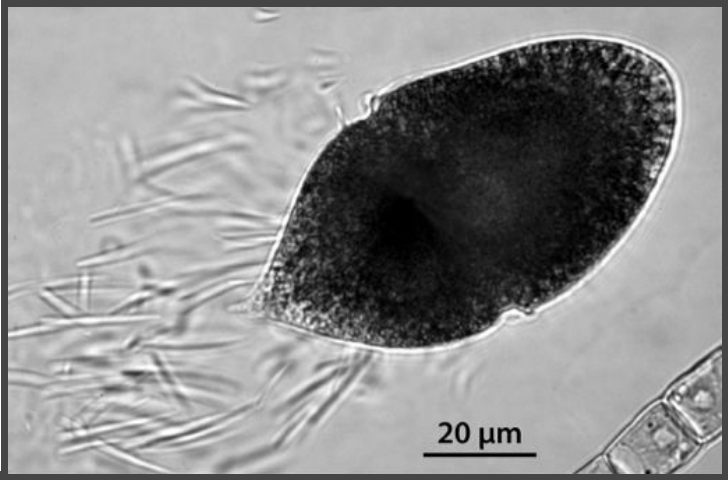
Gymnodinium breve, with "coccolithophorids"

Dinophyta (aka Pyrrhophyta) - the Dinoflagellates

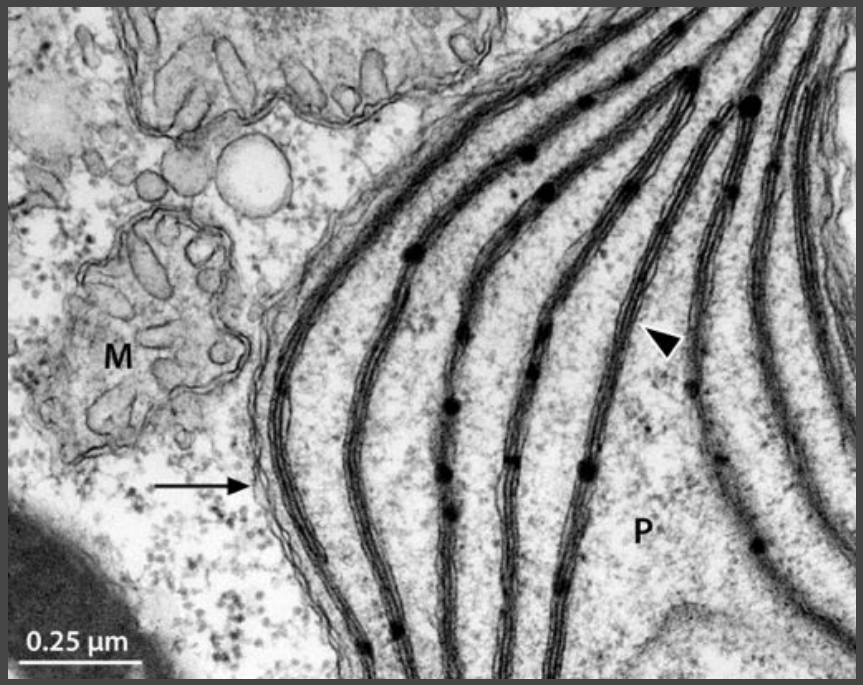
1. Mostly unicellular
2. Cell with epicone (epitheca), hypocone (hypotheca), cingulum, and sulcus
3. Mitochondria with tubular cristae
4. Pusule
5. Plasmalemma with sacs or alveoli (thecal vesicles) forming the amphiesma
6. Alveoli forming theca plates (cellulose) united at sutures
7. Trichocysts, Nematocysts, and Mucocysts

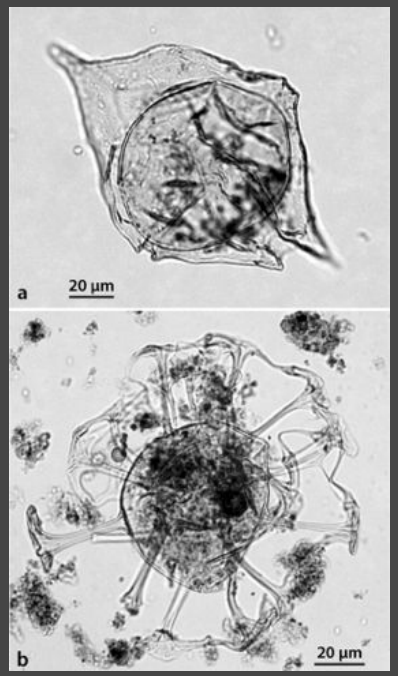






8. Chlorophylls *a* & *c*, peridinin & other pigments
9. Starch and lipids
10. Chloroplasts with three membranes
11. Thylakoids stack in 3's
12. Two flagella:
    Desmokonts: apical flagella
    Dinokonts: lateral flagella, 1 smooth and one hairy/ribbon-like
13. Nucleus is "Dinokaryon" or "Mesokaryotic" w/o histones
14. Closed mitosis with an spindle entirely extranuclear
15. Abundant in phytoplankton
16. Well known fossils : Acritarchs (very old, 600 mya) and Hystrichospheres (more recent, 200 mya)



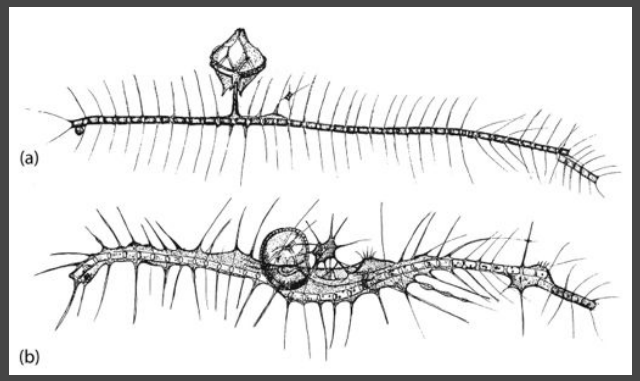


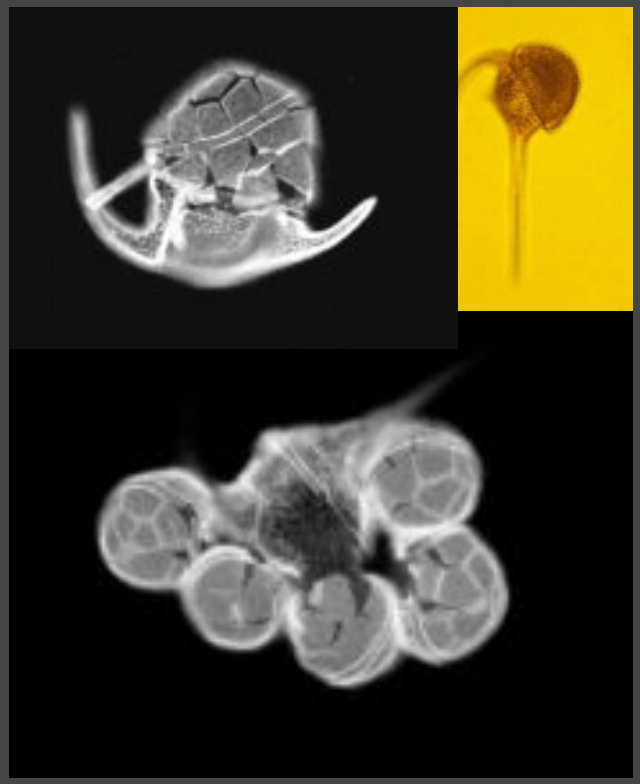
Prey Capture Adaptations

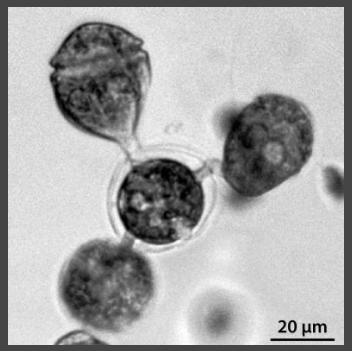
Phagotrophy is common in all types of dinos engulfing ciliates, nematodes, even fish

Diverse feeding mechanisms:

- Engulfment of prey
- Feeding tube or peduncle (phagopod)
- Feeding veil of cytoplasm (pallium)

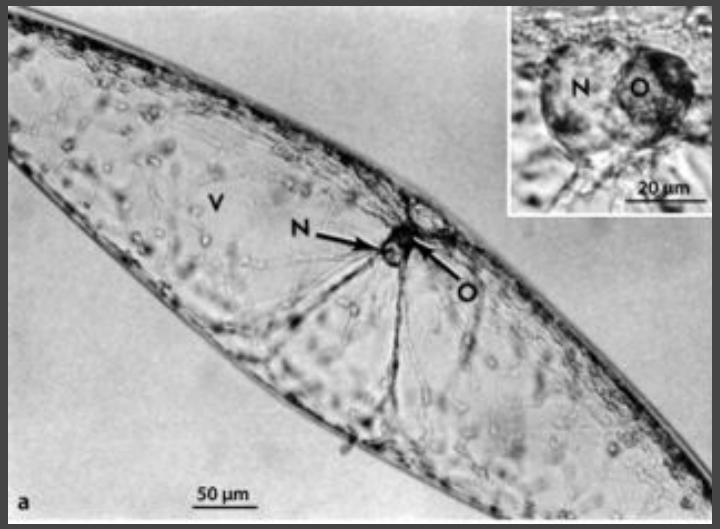






Bioluminescence and Scintillons

- Many dinos are producing light
- Scintillons or microsources: spherical intracellular structures containing luciferin and luciferase
- *Lingulodinium polyedrum* 540 scintillons/cell at night (46 at daylight)
- Daily (circadian) rhythm of synthesis and destruction of scintillons



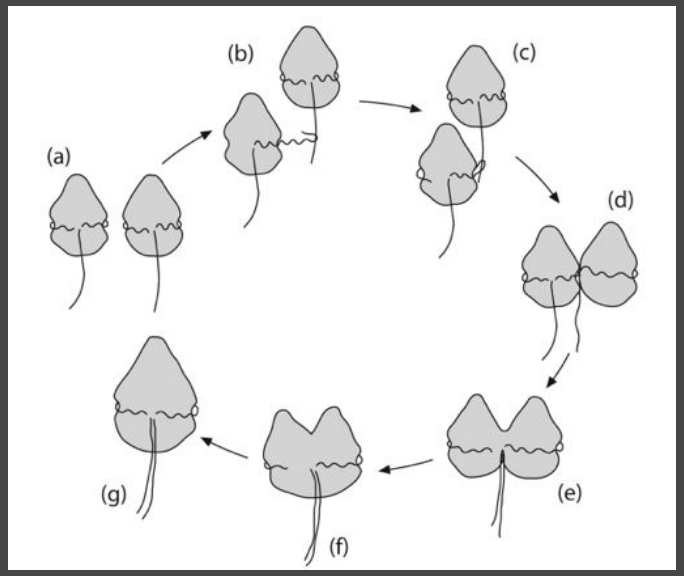
http://www.youtube.com/watch?v=T2xh9-UPSlU

Sexual Reproduction and Cyst Formation

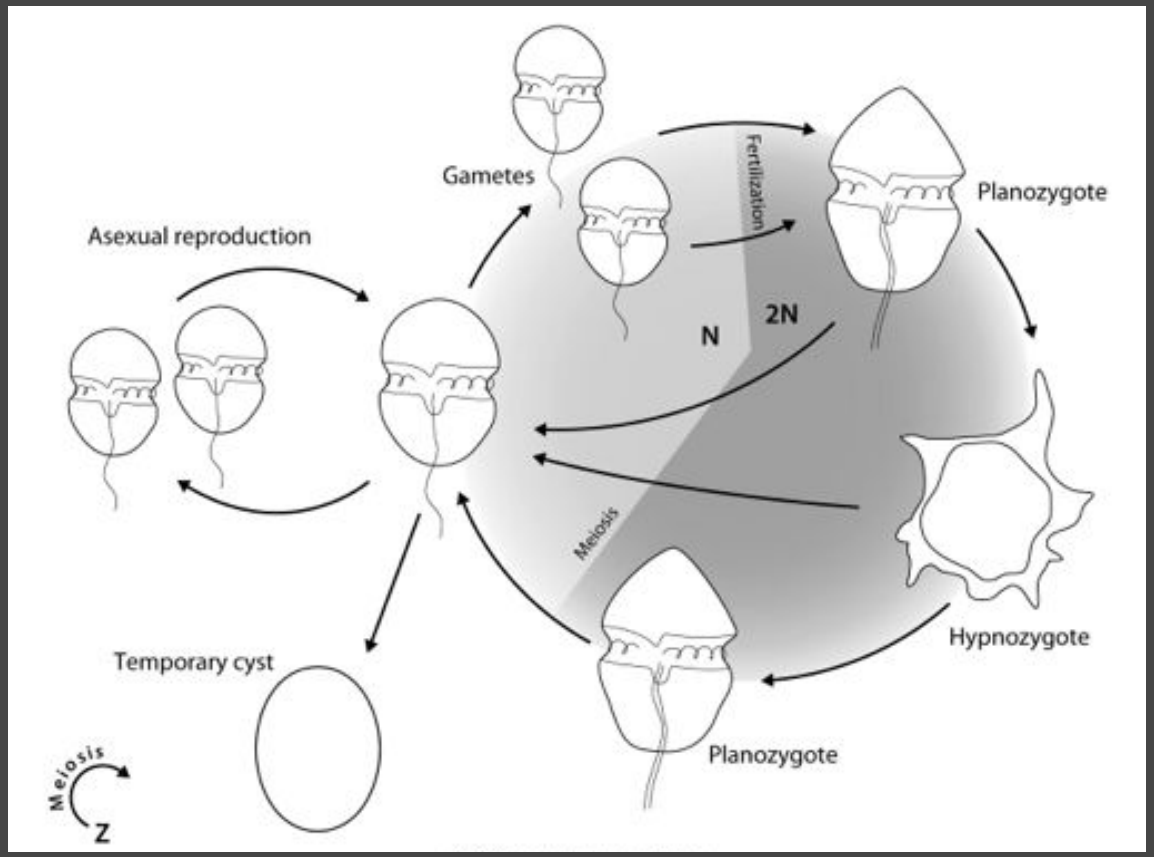
Sexual reproduction with isogametes, vegetative cells act as gametes, the planozygote can become into a nonflagellated resting zygote or hypnozygote

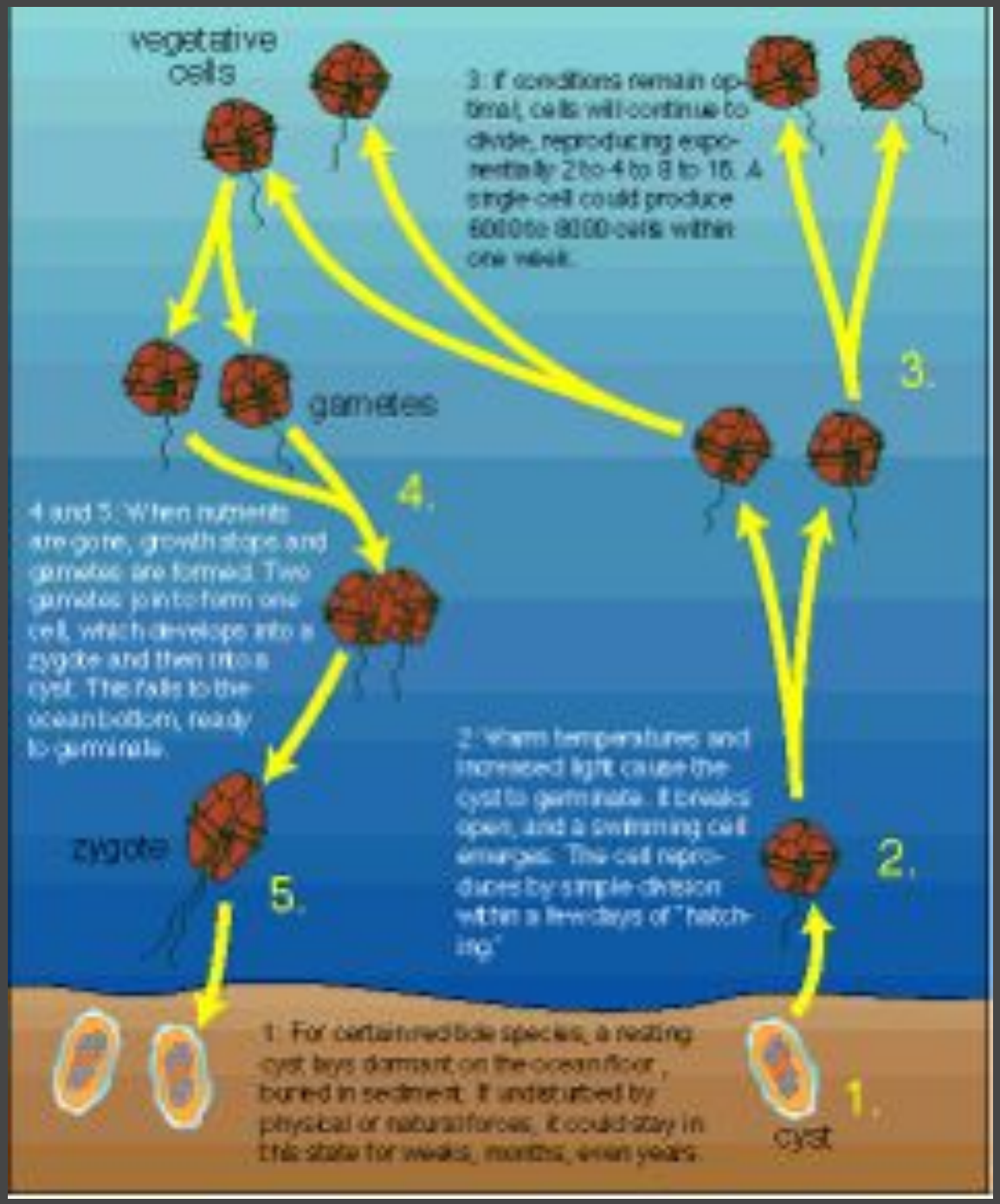
Zygotic meiosis with homothallic or heterothallic species

Asexual reproduction is by cell division or zoospores (dinospores) with dinosporin (organic material resistant to decay)



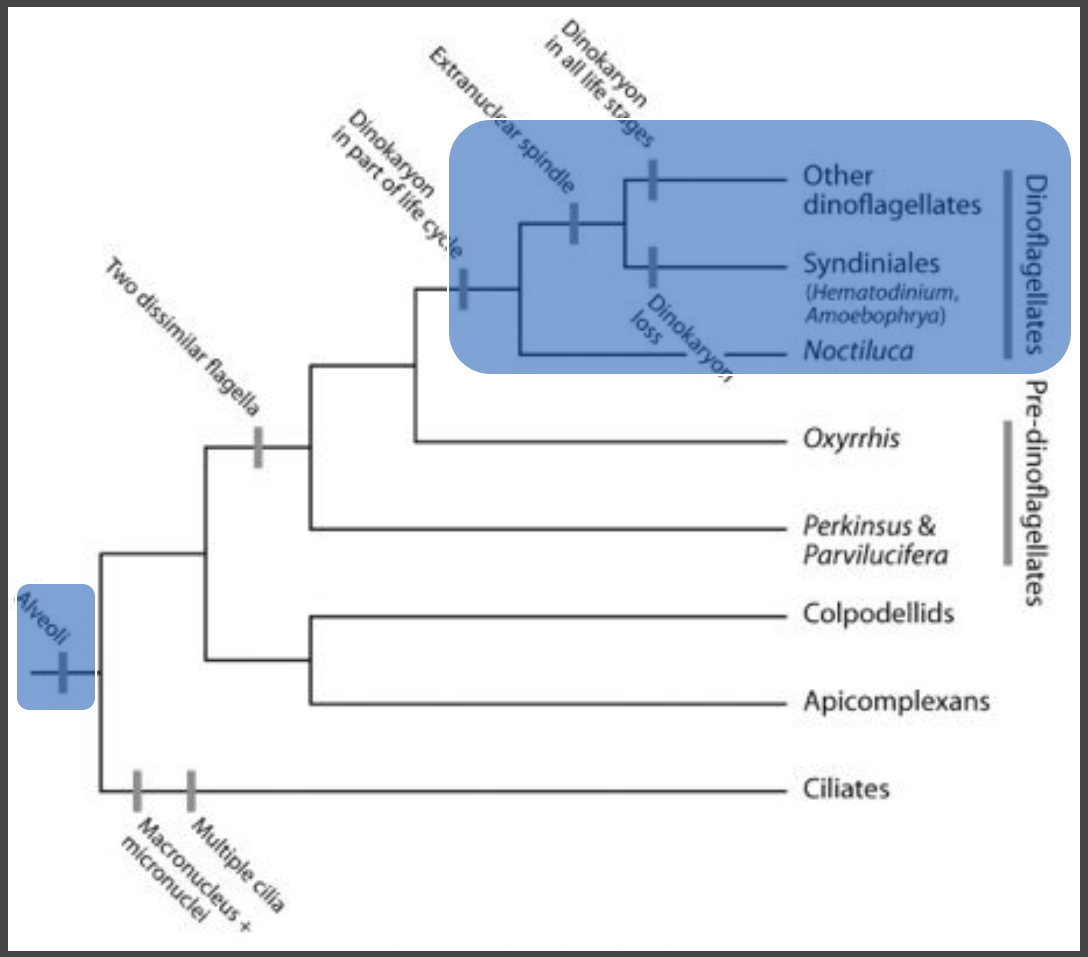
Mating with grabbing flagella




vegetative cells
3. If conditions remain optimal, cells will continue to divide, reproducing exponentially: 2 to 4 to 8 to 16. A single cell could produce 6000 to 8000 cells within one week.
3.
gametes
4.
4 and 5. When nutrients are gone, growth stops and gametes are formed. Two gametes join to form one cell, which develops into a zygote and then into a cyst. The falls to the ocean bottom, ready to germinate.
2. Warm temperatures and increased light cause the cyst to germinate. It breaks open, and a swimming cell emerges. This cell reproduces by simple division within a few days of "hatching."
2.
zygote
5.
1. For certain red tide species, a resting cyst lays dormant on the ocean floor, buried in sediment. If undisturbed by physical or natural forces, it could stay in this state for weeks, months, even years.
1.
cyst

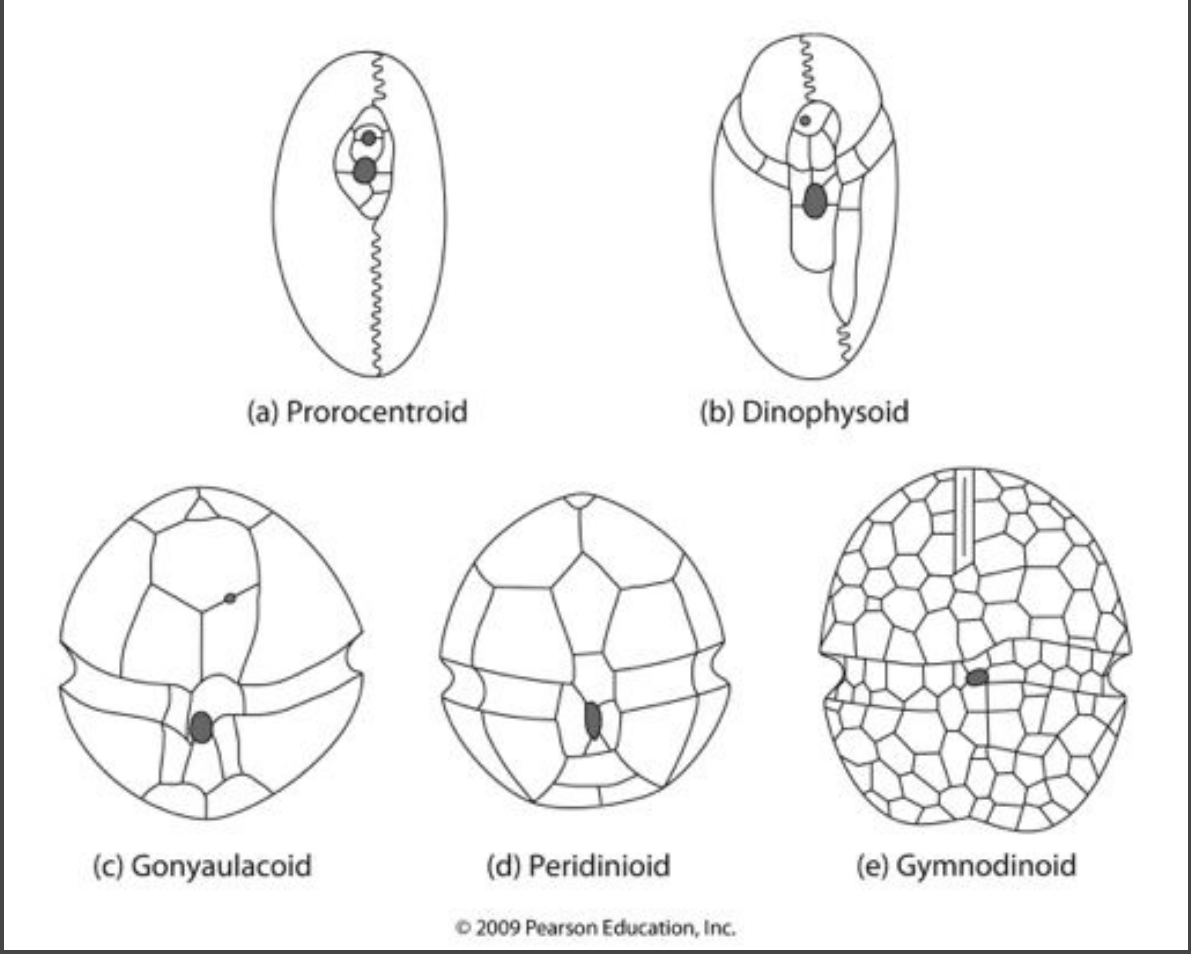
Diversity and Evolution

- Dinos consists of more than 550 genera and 4000 species
- They are closely related to heterotrophic protists (*Oxyrrhis* and others) usually called pre-dinoflagellates because they lacking of a dinokaryon nucleus
- Dinoflagellates along with ciliates and apicomplexans form the supergroup known as Alveolates



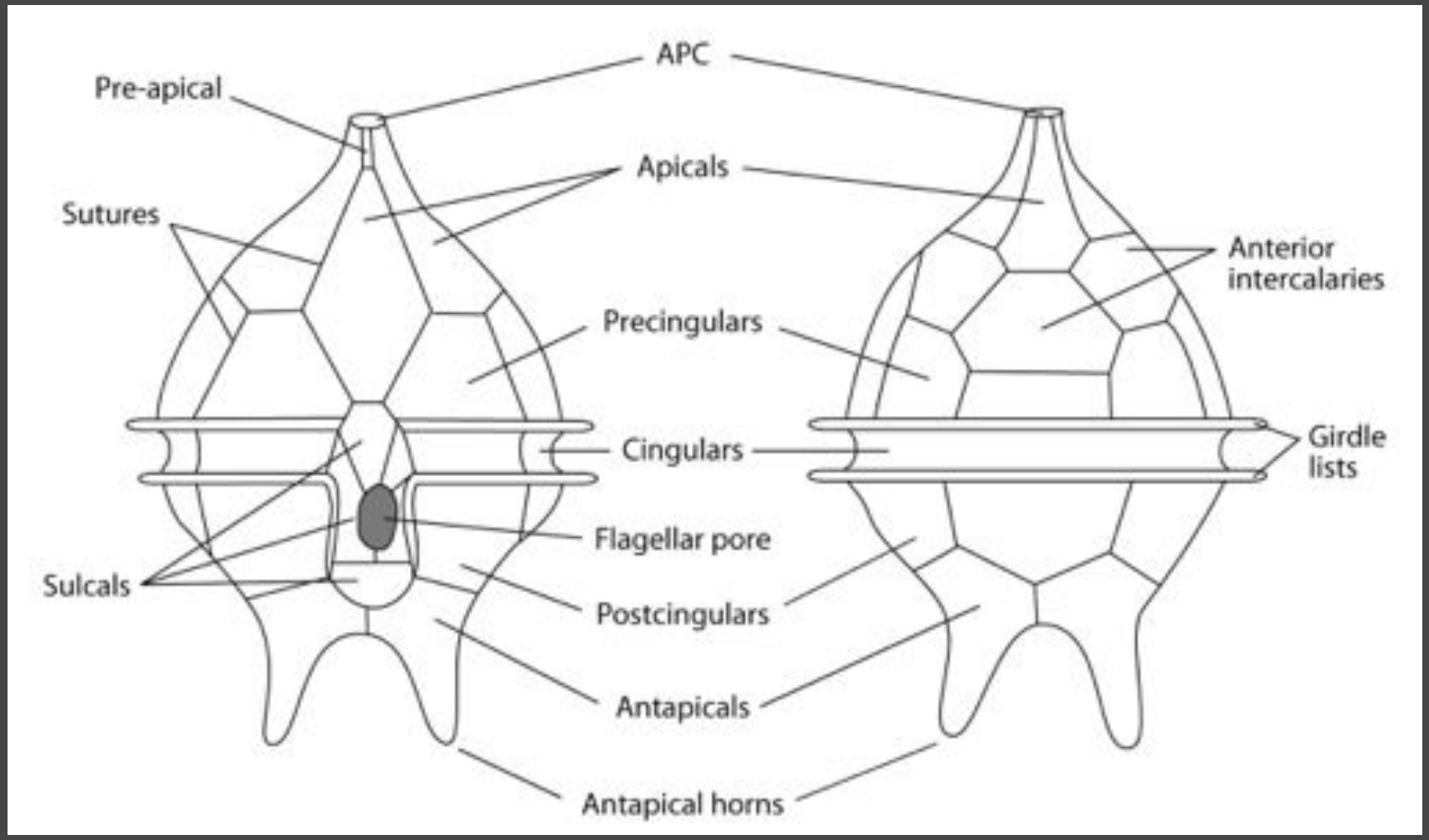
•Dinoflagellate genera and species vary predictably in the numbers, sizes, and shapes of thecal plates, so these features have been widely used in taxonomy

•Major types of plate organization are:



•Each species has a characteristic plate formula that begins with the anterior and moves toward the posterior of the cell

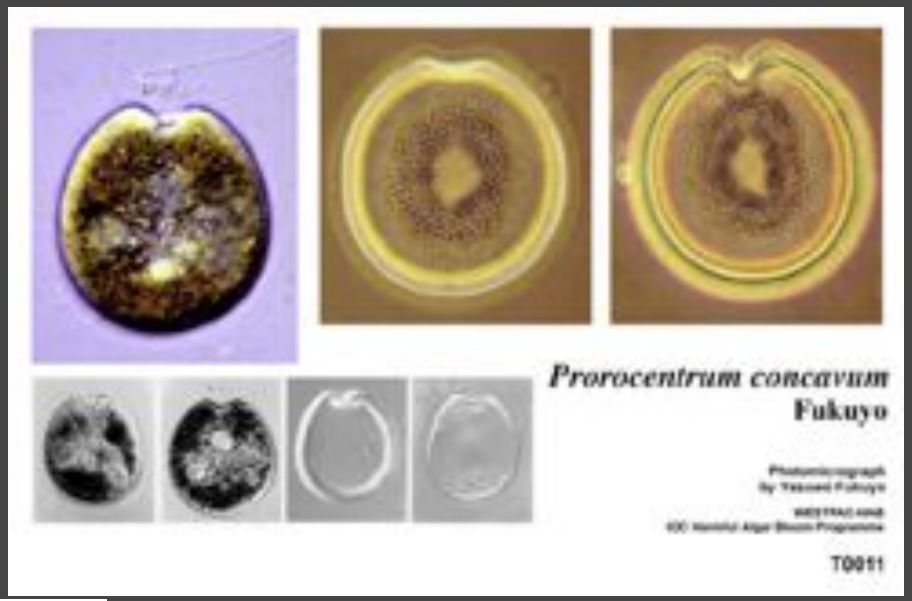
•Dinoflagellate identification often requires breaking cells open and spreading the plates flat in order to tabulate them



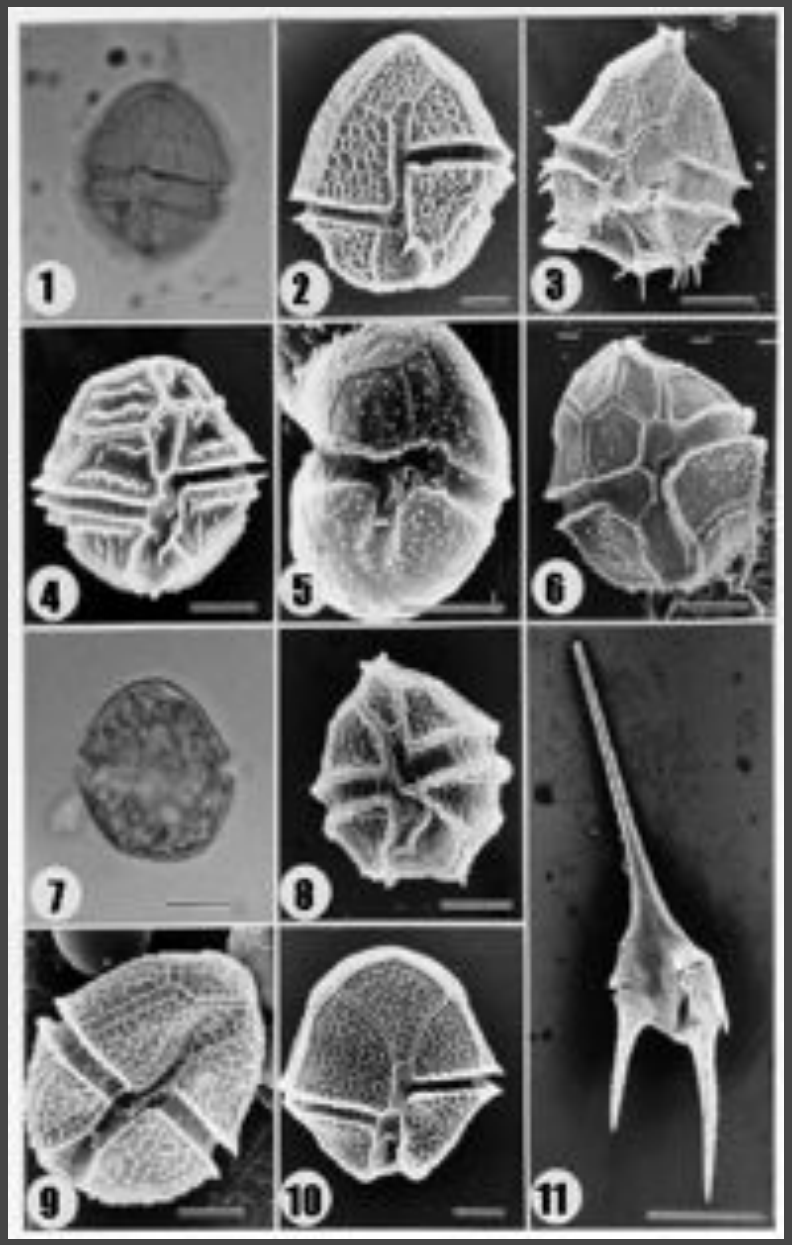
Desmokonts: *Prorocentrum*

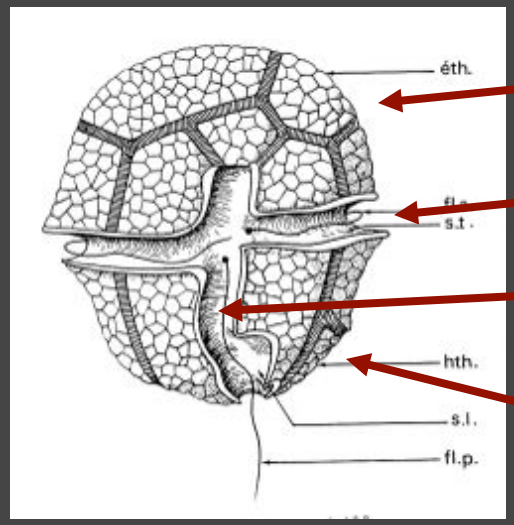
With 2 large plates

Apical flagella



Dinokonts: Armored forms: *Peridinum, Ceratium*





Epicone

Cingulum

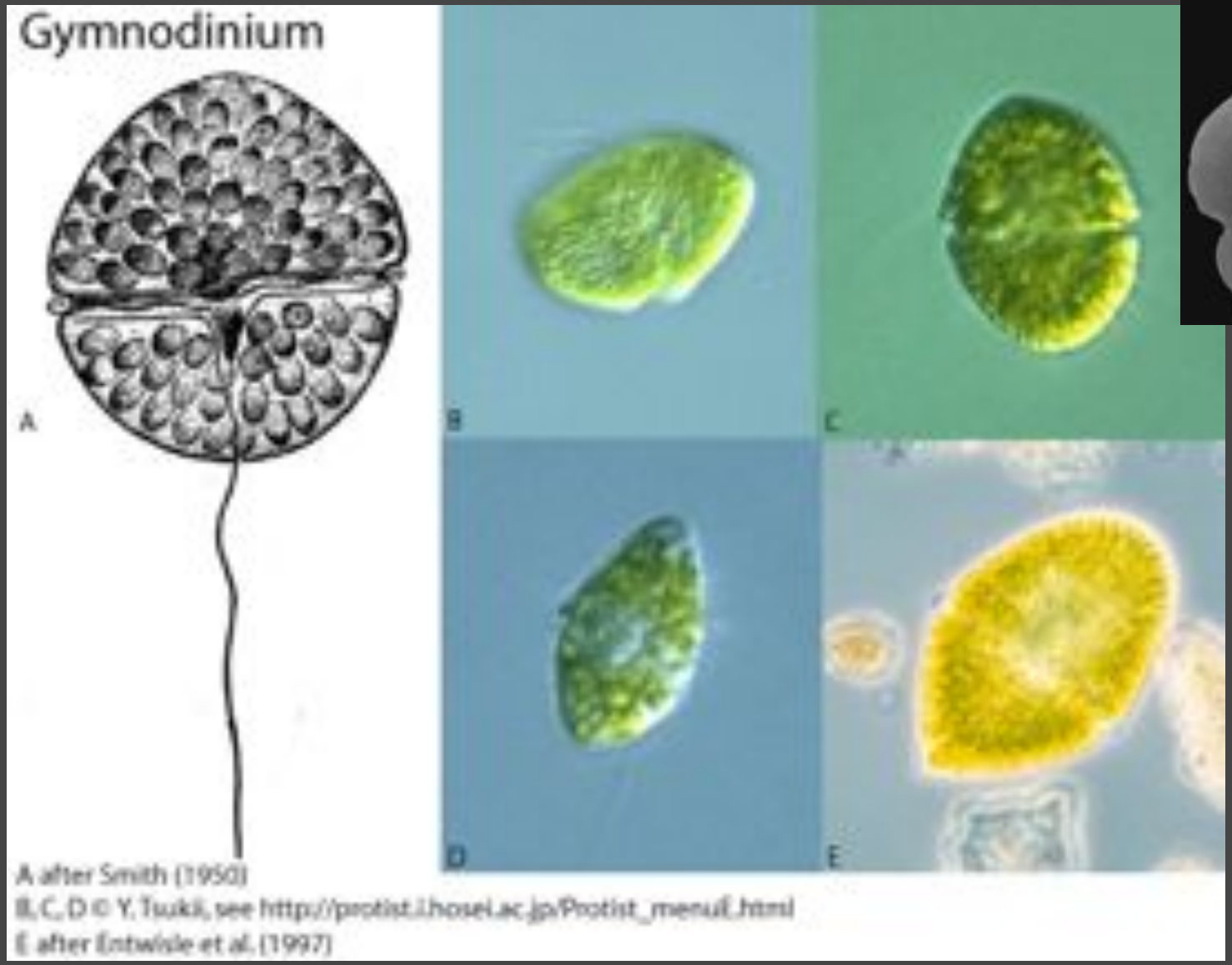
Sulcus

Hypocone

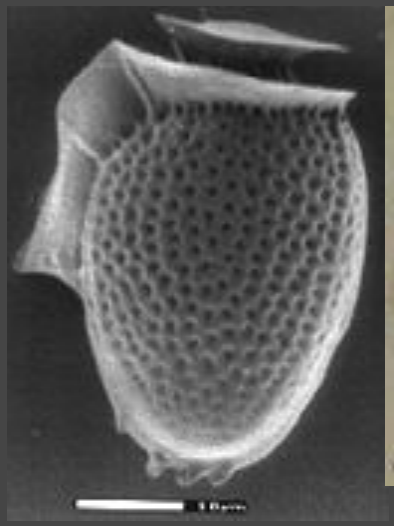
Two lateral flagella:

- one smooth
- one hairy/ribbon-like

Dinokonts: Naked forms: *Gymnodinium*



Morphological diversity in Dinoflagellates

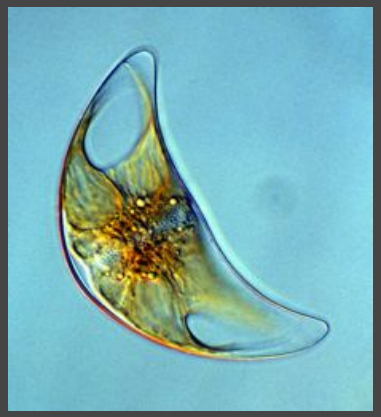


Dinophysis

Ornithocercus

Gonyaulax

Polykrikos



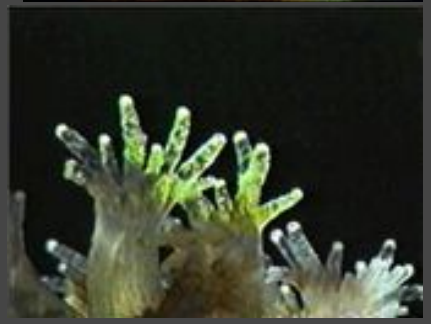
Pyrocystis

Noctiluca

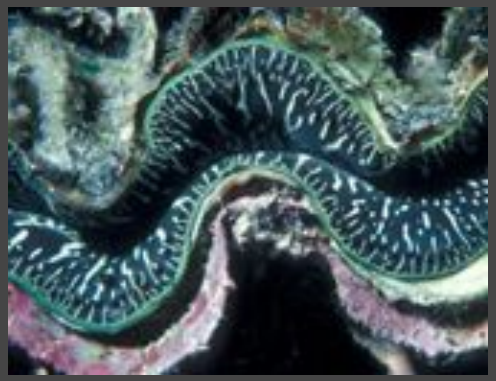
Oxyrris

Ecology

- Dinoflagellates vary in their nutrition from photosynthetic to heterotrophic and some parasitize fish or phagocytize other algae
- Auxotrophic
- Some forming red tides or HAB
- Only few are toxic (*Pfiesteria,* the alga from hell)
- Toxins: saxitoxin, brevitoxin and ciguatoxin
- Symbiotic dinoflagellates called zooxanthellae are found in protozoa, clams, flatworms, jellyfish, and reef-forming corals



Coral tentacle with zooxanthellae



Giant clam

Coral reef