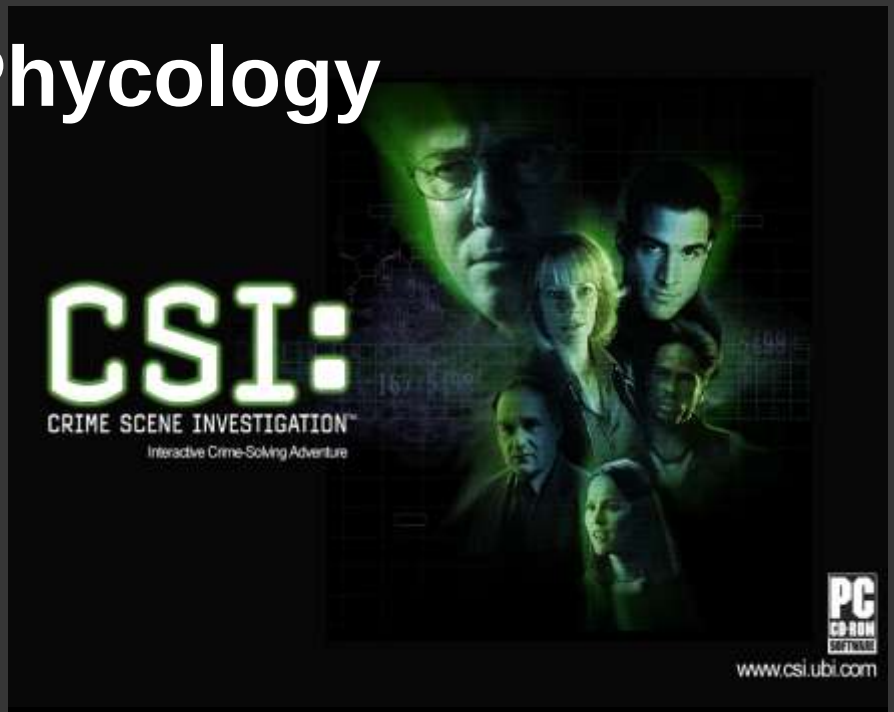
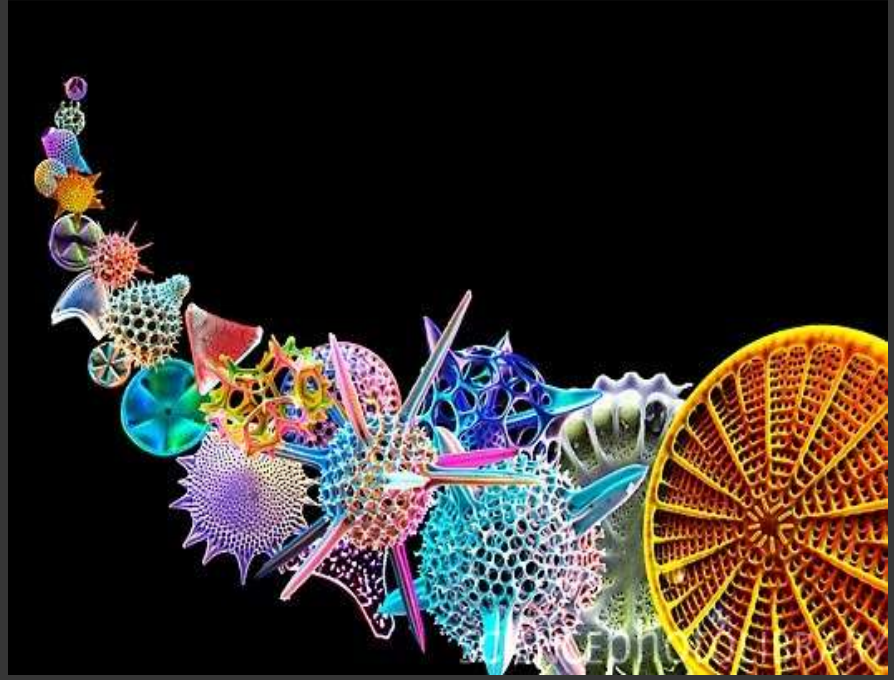
Forensic Phycology

- Algae are useful tools in forensic sciences

- Algae can be used as evidence by the defense or the prosecutor to convict or acquit the accused

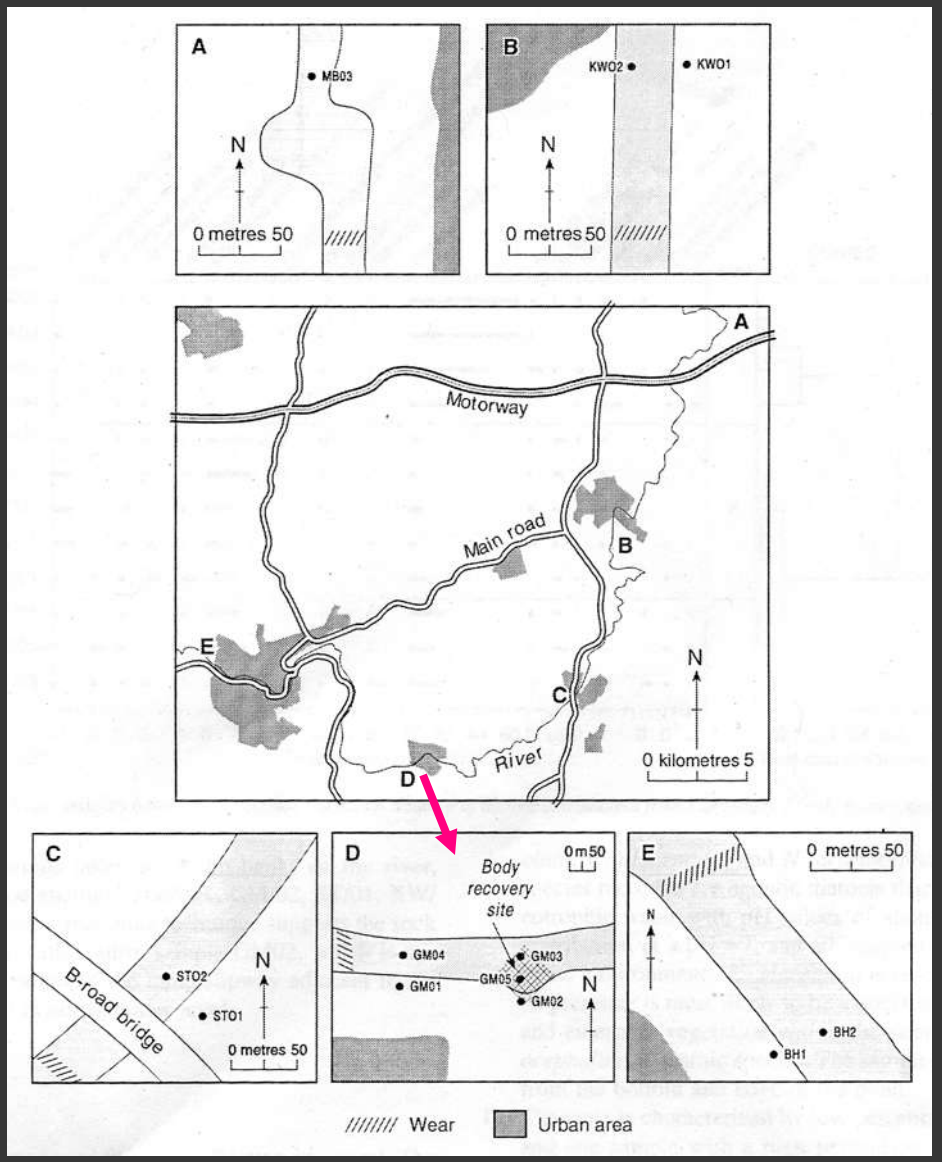
- We will study two real cases that used algae as legal evidence in court





CASE STUDY 1

- A body of a woman was found face down floating in a river
- Postmortem found the death to be suspicious
- Death was ruled as drowning due to homicide
- A suspect was identified
- A key aspect of the investigation was the precise site of drowning
- Samples were taken from
  - ✓ 12 sites along the river including the body recovery site
  - ✓ Lung fluid
  - ✓ Clothing belonging to the accused (training shoe, socks, T-shirt)



Results

Phycological results:

- 99 species of diatoms were identified from the river
- Diatom density and distribution fit into 3 zones (I, II and III)

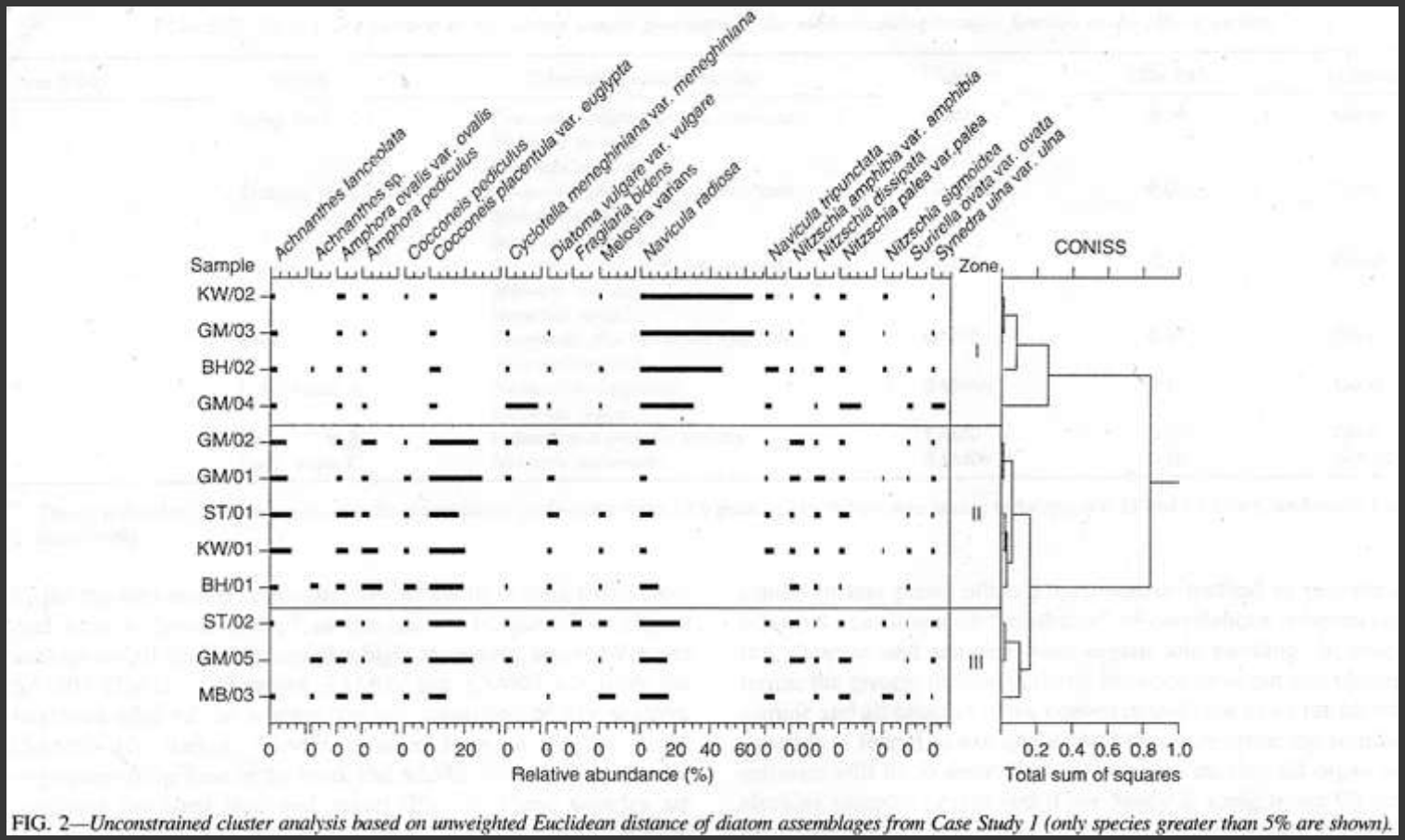


FIG. 2—*Unconstrained cluster analysis based on unweighted Euclidean distance of diatom assemblages from Case Study 1 (only species greater than 5% are shown).*

I: In-channel

II: river bank

III: Shallow water

Comparison between diatoms from control samples *vs.* lung fluid and clothing:

• Lung fluid, training shoe, and T-shirt diatoms matches GM05 point, the body recovery site: *C. placentula var. euglypta, Melosira vartians,* and *Navicula radiosa*

• Sock diatoms match GM02 point, a ramp adjacent to the body recovery site: low in *N. radiosa*, but high in *C. placentula var. euglypta*

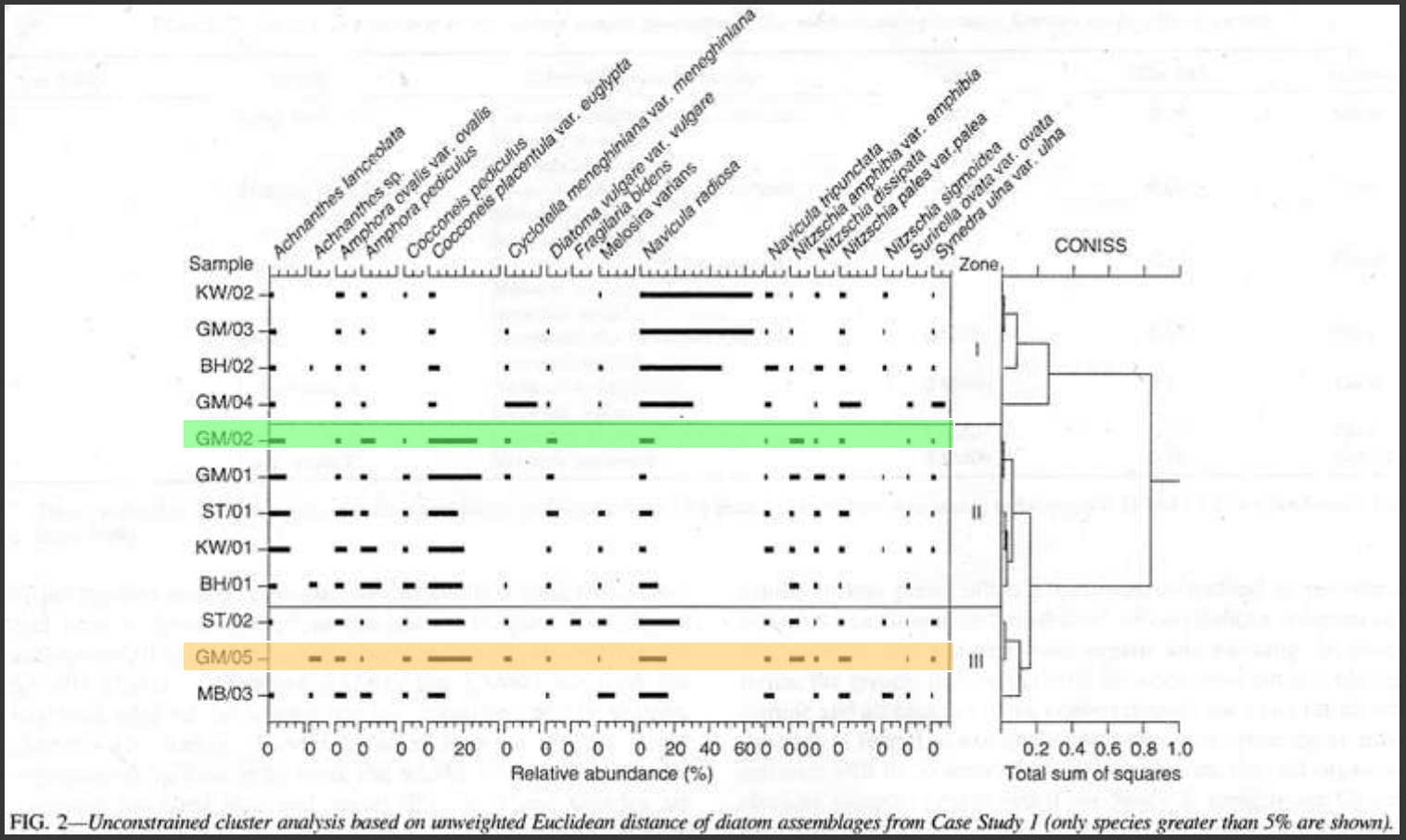


FIG. 2—*Unconstrained cluster analysis based on unweighted Euclidean distance of diatom assemblages from Case Study 1 (only species greater than 5% are shown).*

I: In-channel

II: river bank

III: Shallow water

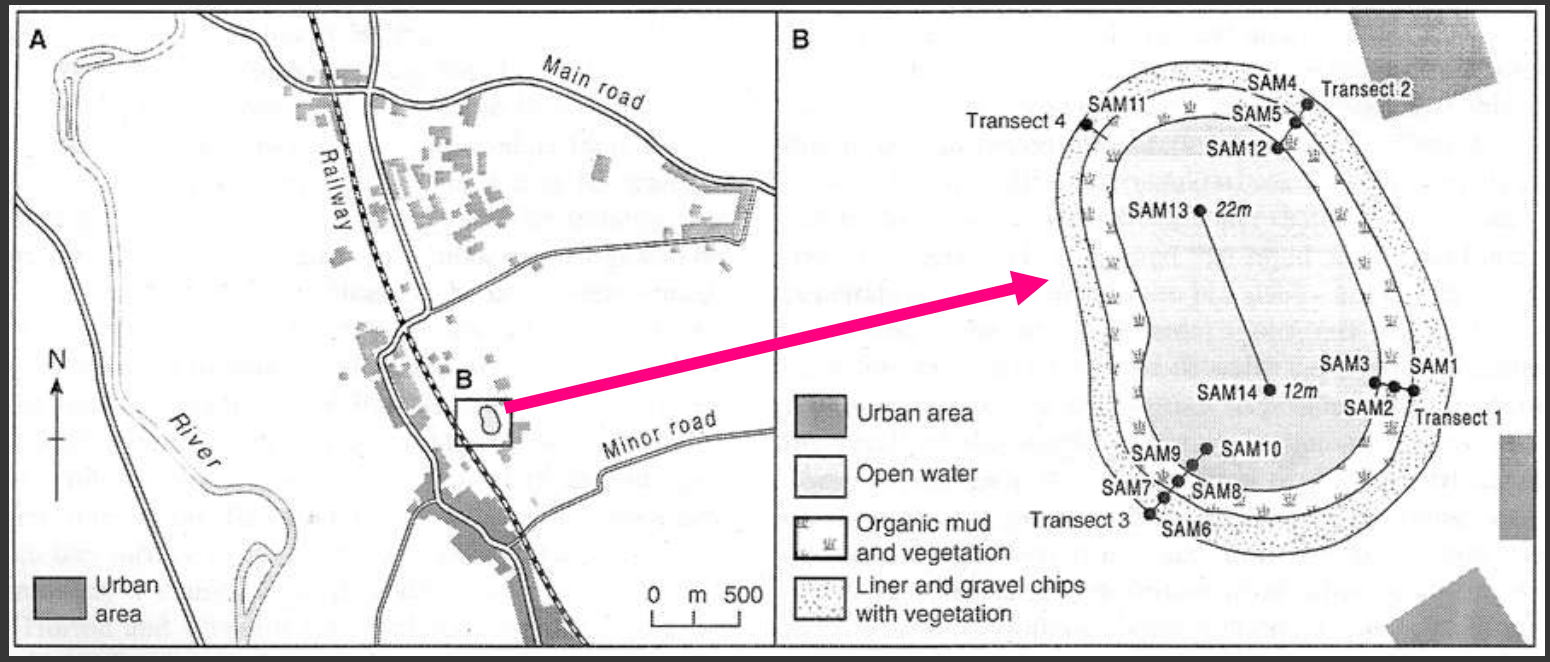
What do you think?

Is this man guilty or innocent?

Why?

CASE STUDY 2

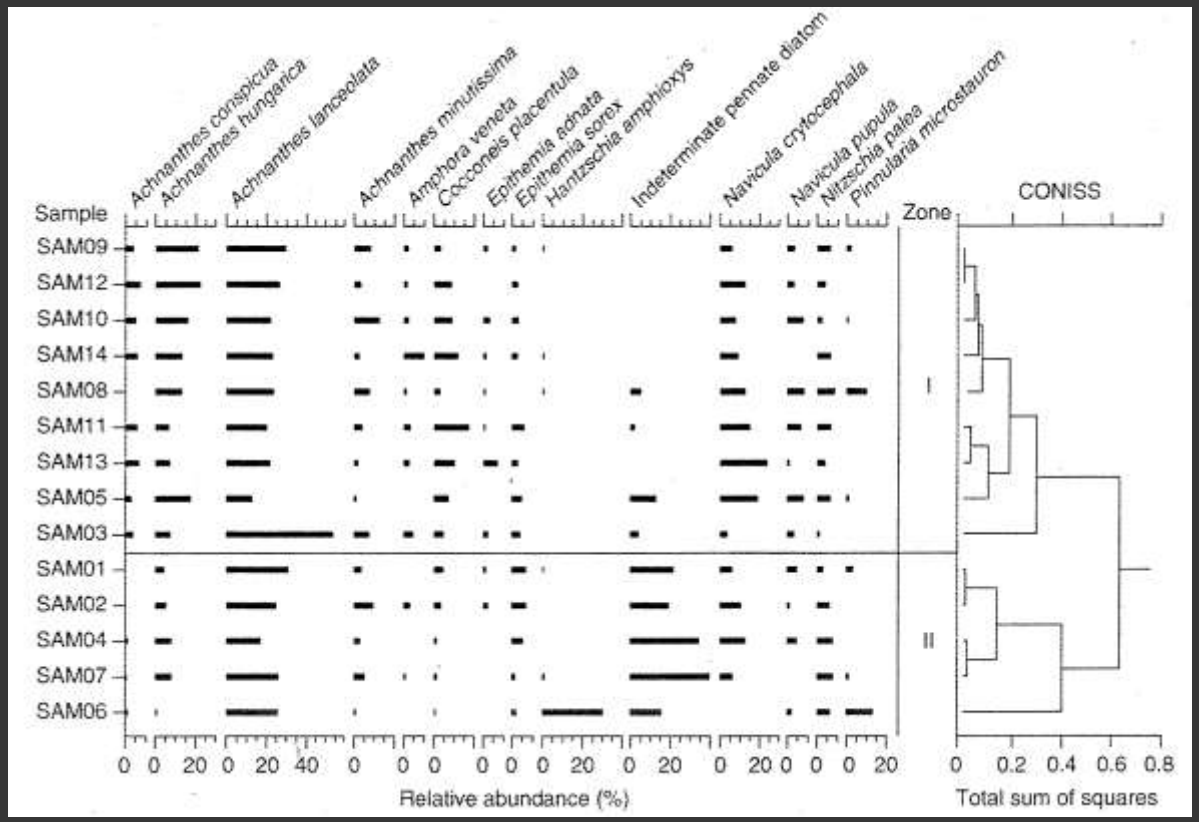
- The body of a boy was found face down floating in a pond
- Postmortem found the death as a result of cold water immersion
- Death was ruled as drowning and not suspicious
- The case was reopened - may have been homicide by the child's mother
- It was suggested that the drowning took place in a domestic bath and the body subsequently placed in the pond
- Samples were taken from: 4 transects along the pond, the center of the pond, and lung tissue



Results

Phycological results:

- 37 species of diatoms were identified from the pond
- The dominant diatom species include *Achnanthes lanceolata, A. hungarica*, and *Navicula cryptocephala*
- Diatom density and distribution fit into 2 zones (I and II)



I: Bottom and edge of pond, eutrophic water with period exposure to subaerial environments

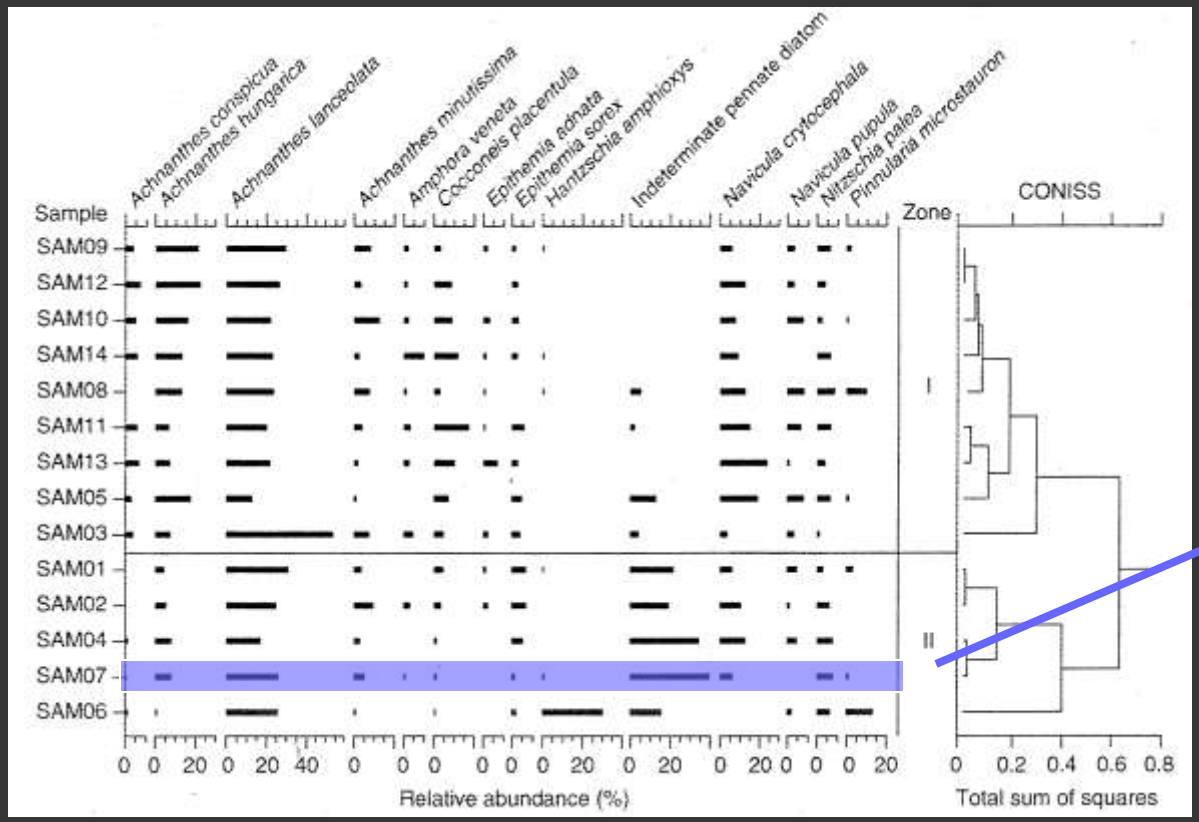
II: Ephemeral habitats at edge of pond, prone to dessication

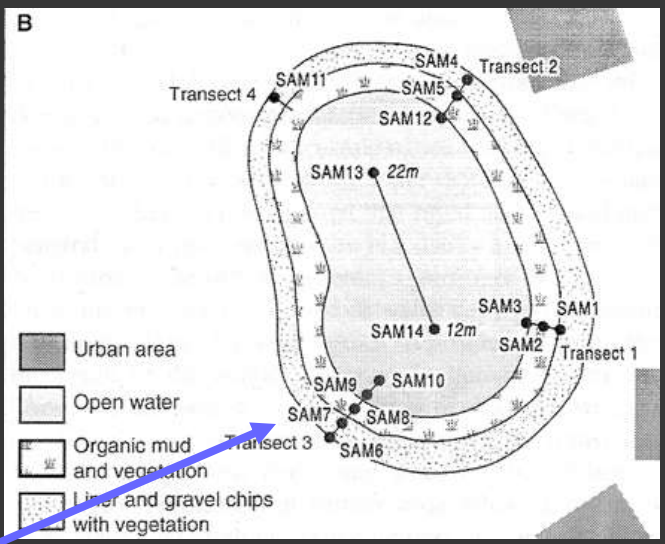
Comparison between diatoms from control samples *vs.* lung tissue and clothing:

• Diatom flora from lungs comprises many species also found in the pond

•The habitat preferences of the diatoms found in the lungs are: eutrophic-mesotrophic, prone to frequent desiccation, and with changes in water depth

• Lung diatoms match SAM07 point, from the edge of one of the pond transects





What do you think?

Is this mother guilty or innocent?

Why?

VERIDICTS

Conclusions for Case Study 1:

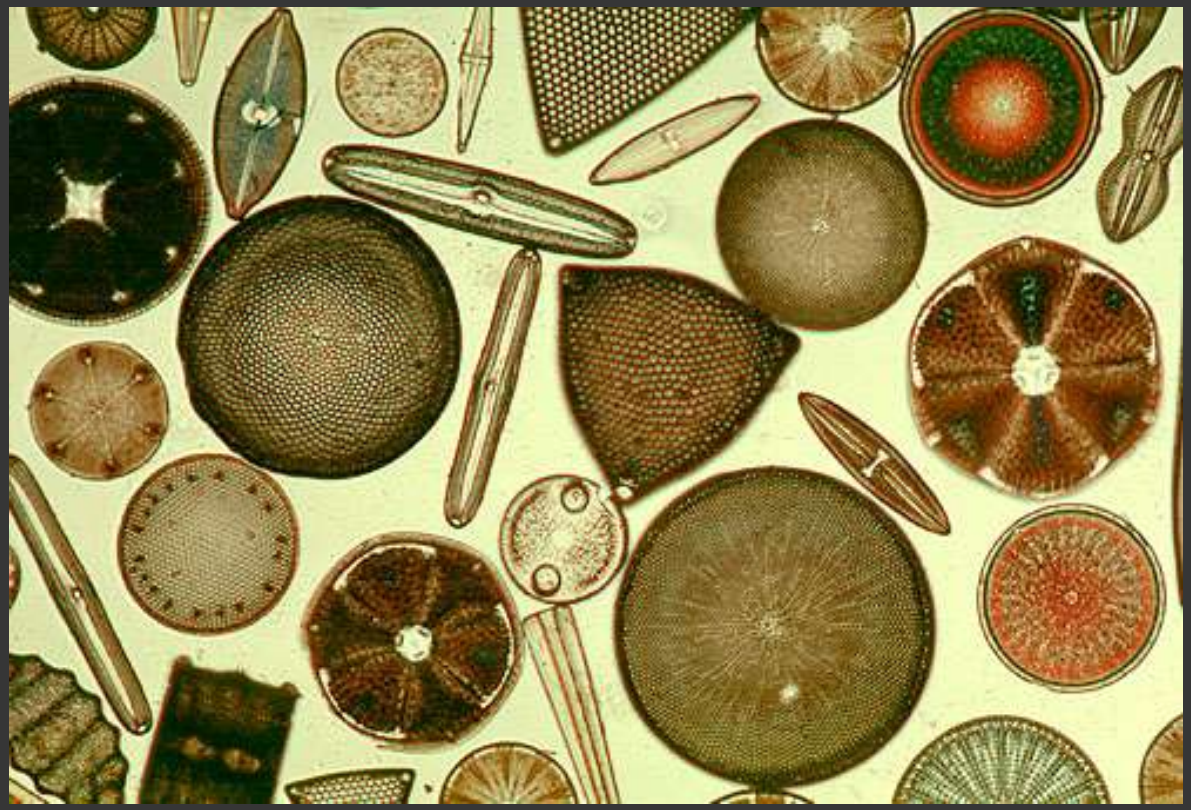
GUILTY

- The diatom analysis suggested strong similarities between lung from the victim and clothing samples from the accused, and control samples from shallow water habitats
- These evidence placed the accused at the same site of the crime
- Diatom samples also implied that the site of drowning was at the body recovery site
- These and other pieces of evidence assisted in the conviction of a man for murder

Conclusions for Case Study 2:

INNOCENT

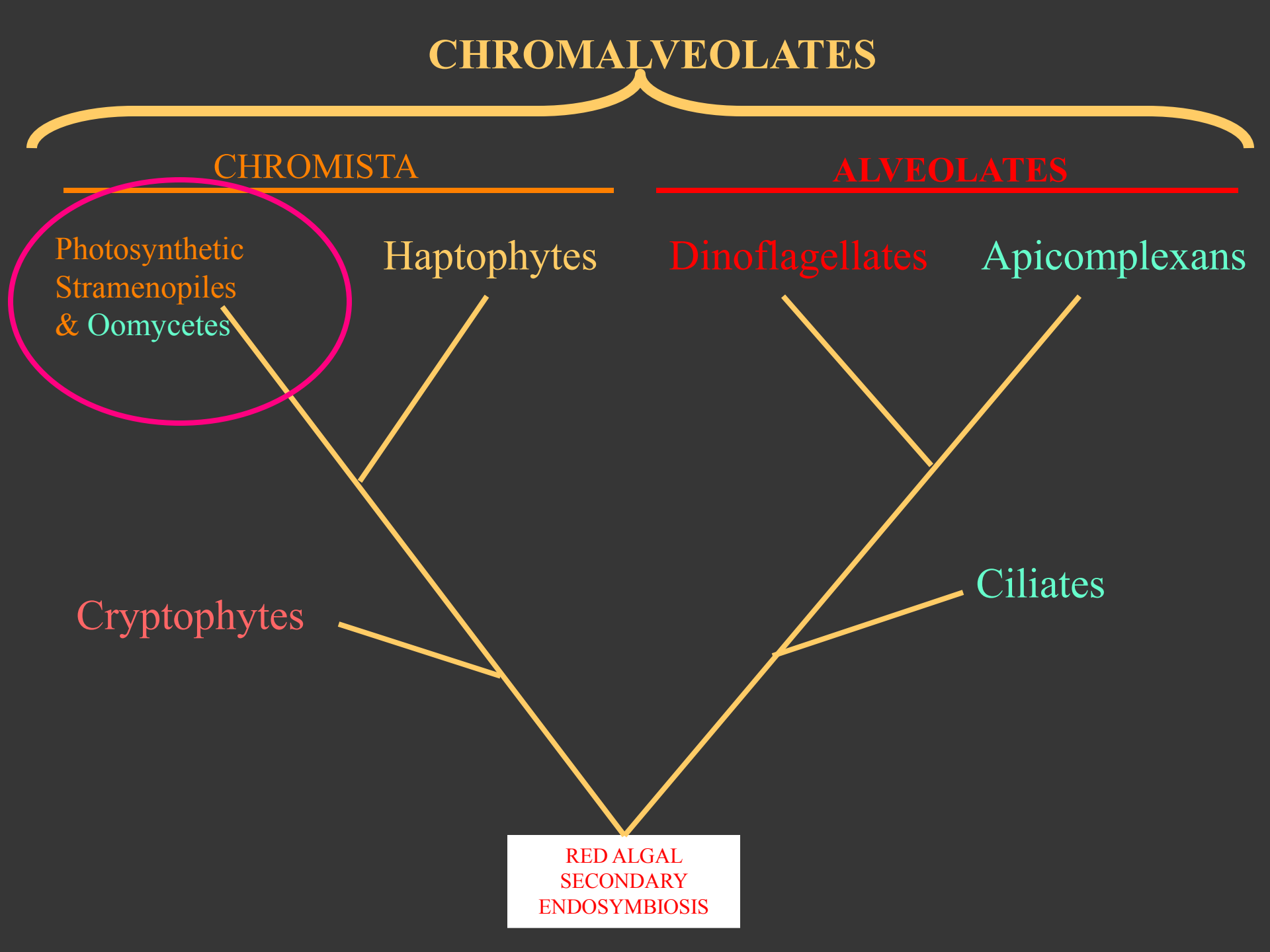
- Diatom flora analysis suggested that diatoms obtained from the victim's lung are significantly similar to diatoms from the pond
- Thus indicating that the pond was the location of the drowning
- This was an essential piece of evidence in the acquittal of the accused woman of drowning the boy in a bathtub



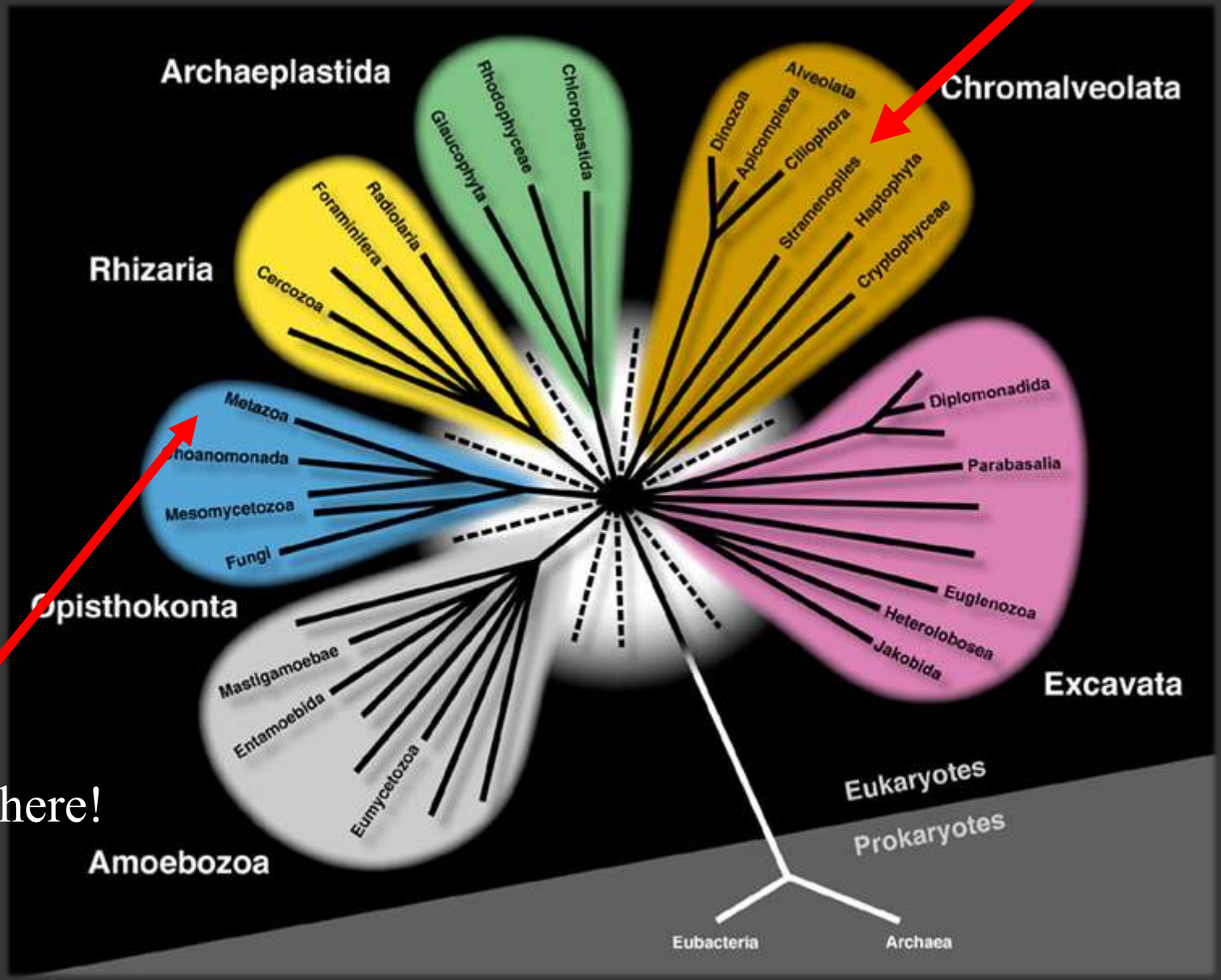
Diatoms are excellent subjects for forensic analysis

However, one serious limitations is the lack of well trained experts in diatom identification!

Thus, we need to be better informed about diatoms….


CHROMALVEOLATES
CHROMISTA
ALVEOLATES
Photosynthetic Stramenopiles & Oomycetes
Haptophytes
Dinoflagellates
Apicomplexans
Ciliates
Cryptophytes
RED ALGAL SECONDARY ENDOSYMBIOSIS

Stramenopiles are here



You are here!

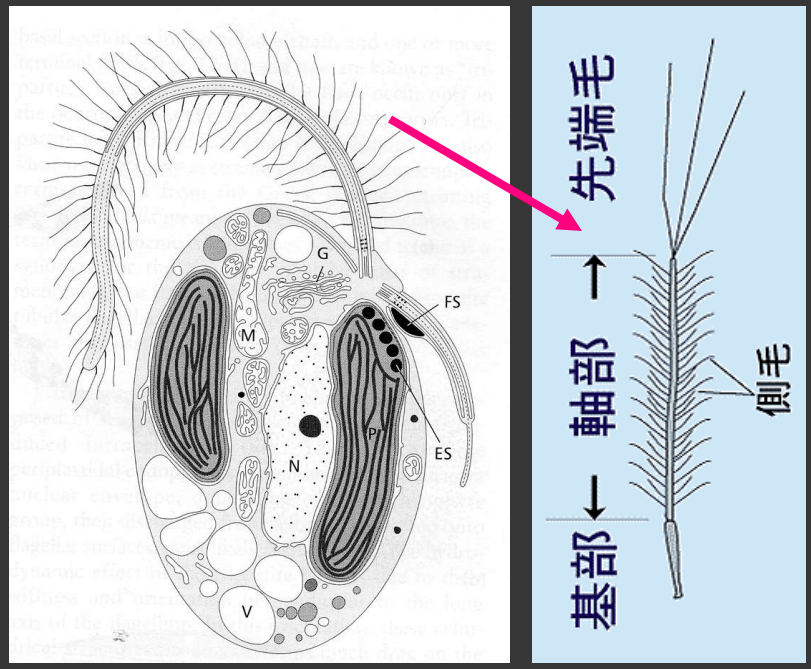
Who are the Stramenopiles?

- They are a diverse assemblage of protists forming a monophyletic group based on DNA analyses
- This group comprises: the Photosynthetic Stramenopiles or PS, as well as non photosynthetic organisms such as the Oomycetes, Thraustochytrids, Labyrinthulids, and Bicoecids
- Their closest algal relative is Haptophyta (Coccolithophorids)

All Stramenopiles have in common the tripartite hairs on their flagella

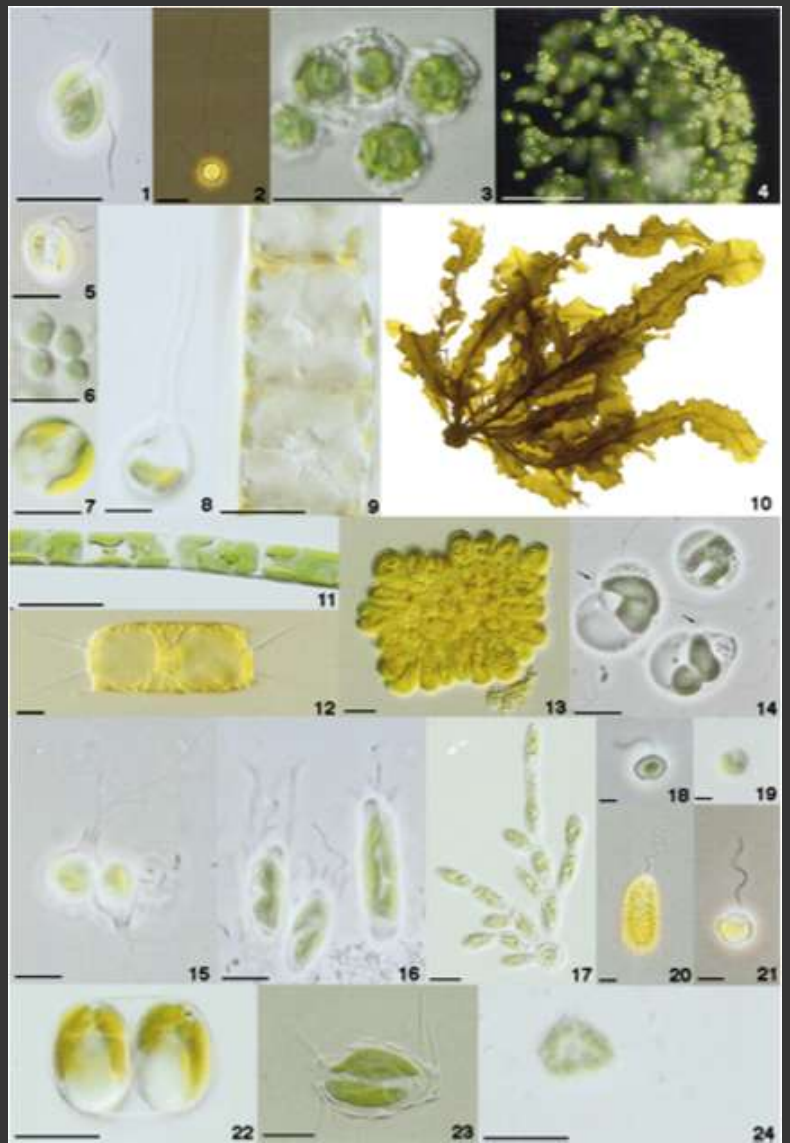
Flagella are heterokont:

- one long, forward-directed bearing two rows of stiff, three-parted hairs
- one shorter, smooth flagellum often with a flagellar swelling



Photosynthetic Stramenopiles

a.k.a. Ochrophyta, Heterokontophytes, Chromophytes, or Chrysophytes



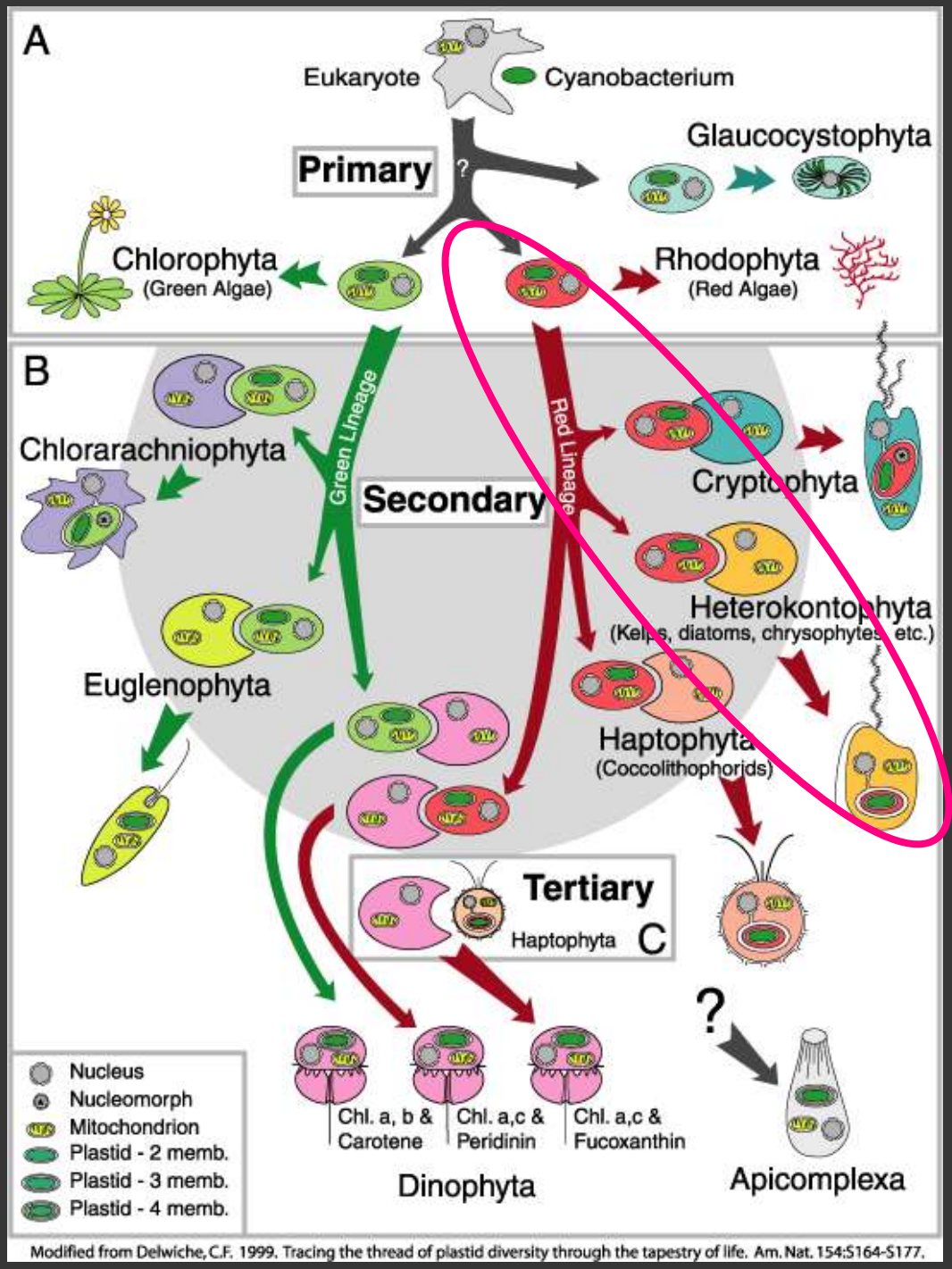
PS are the result of a secondary endosymbiosis

Ancestral red algae are represented as plastids in PS

PS is a monophyletic group

They are related to the Oomycetes, a group originally treated as fungi

Altogether they form the STREMANOPILES with the common feature of the tripartite hairs



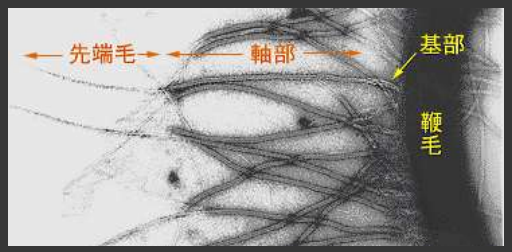
Modified from Delwiche, C.F. 1999. Tracing the thread of plastid diversity through the tapestry of life. Am. Nat. 154:S164-S177.

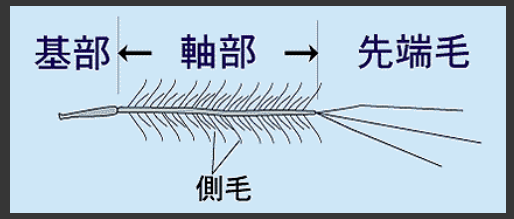
Characteristics of the PS

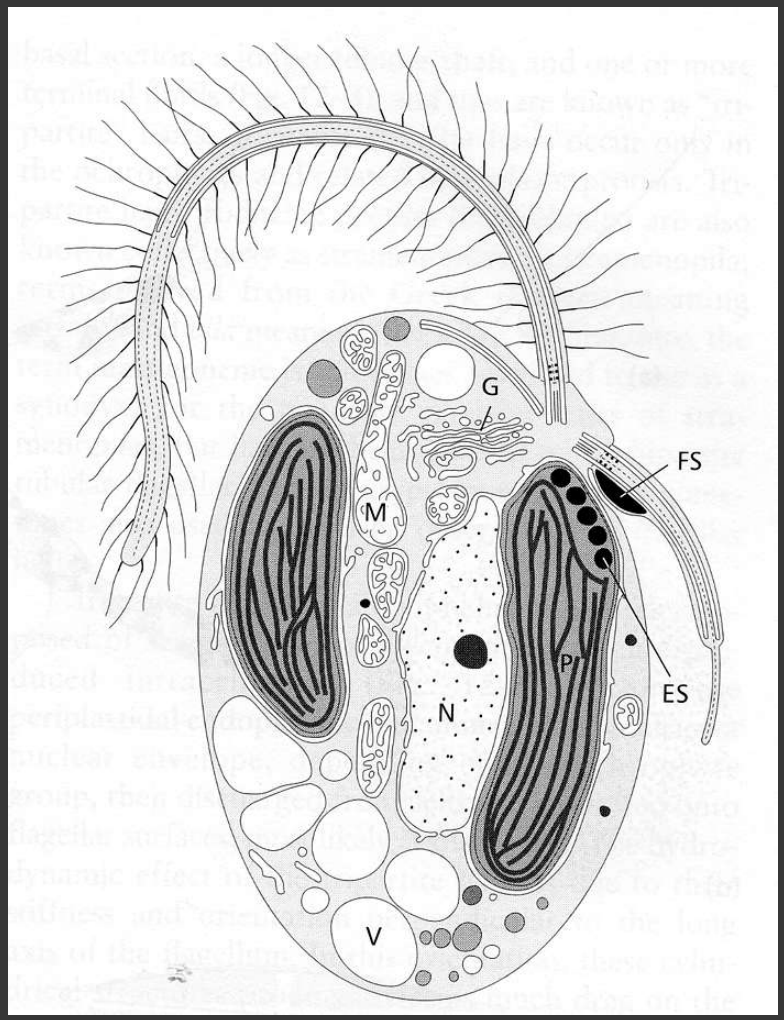
The main features of the PS are:

1. Algae with chlorophyll *a* & *c*
2. Heterokont flagella

Heterokont: one smooth flagellum and one flagellum with tripartite hairs

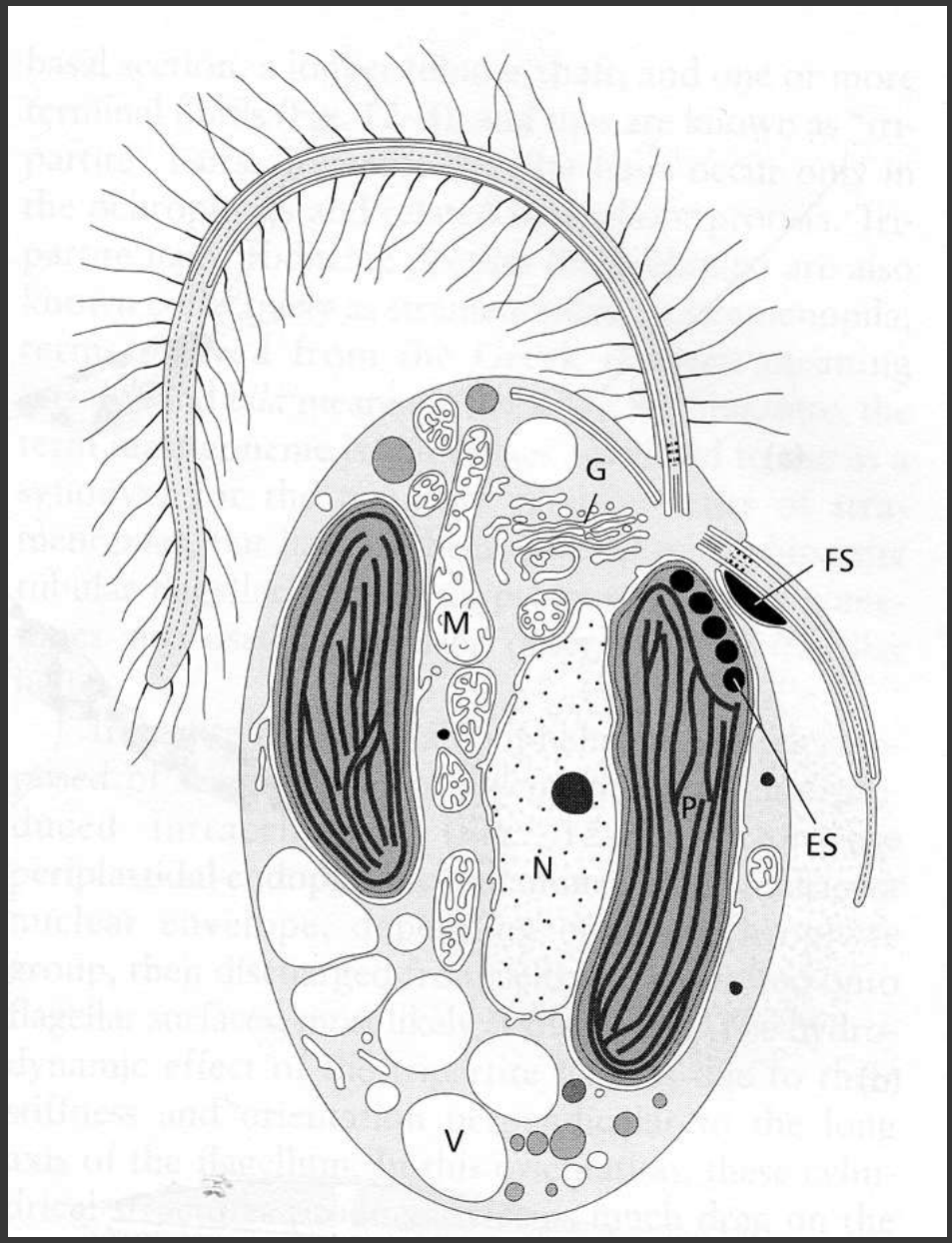






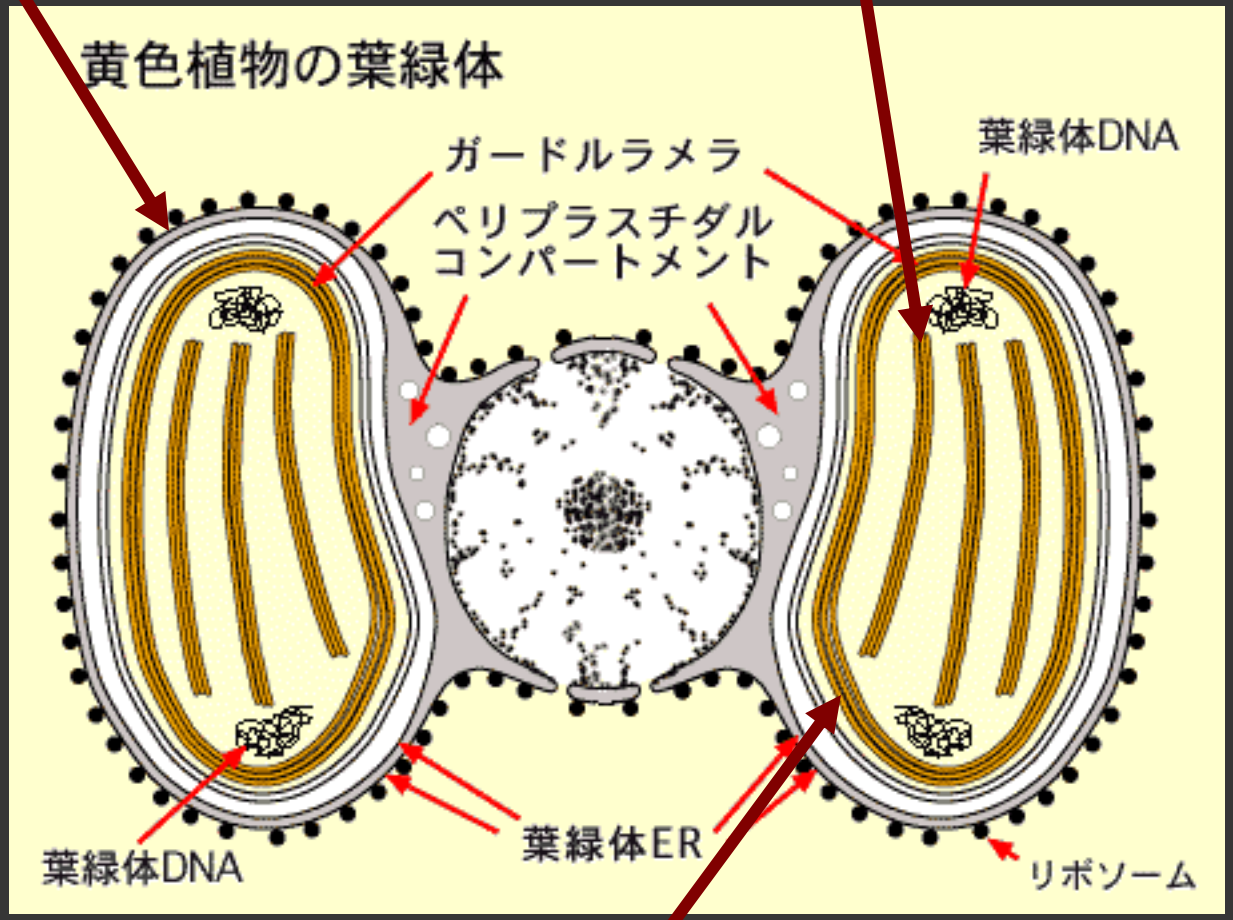
PS also have:

- A Beta-1,3-linked polymer as principal reserve (chrysolaminarin or laminarin)
- Sometimes fucoxanthine
- Chloroplast PER with thylakoids stacked in three & girdle lamella
- Cell covering is diverse from naked, siliceous scales, loricae, or typical cell walls
- Morphologically diverse, from unicellular to parenchymatic



PER membranes

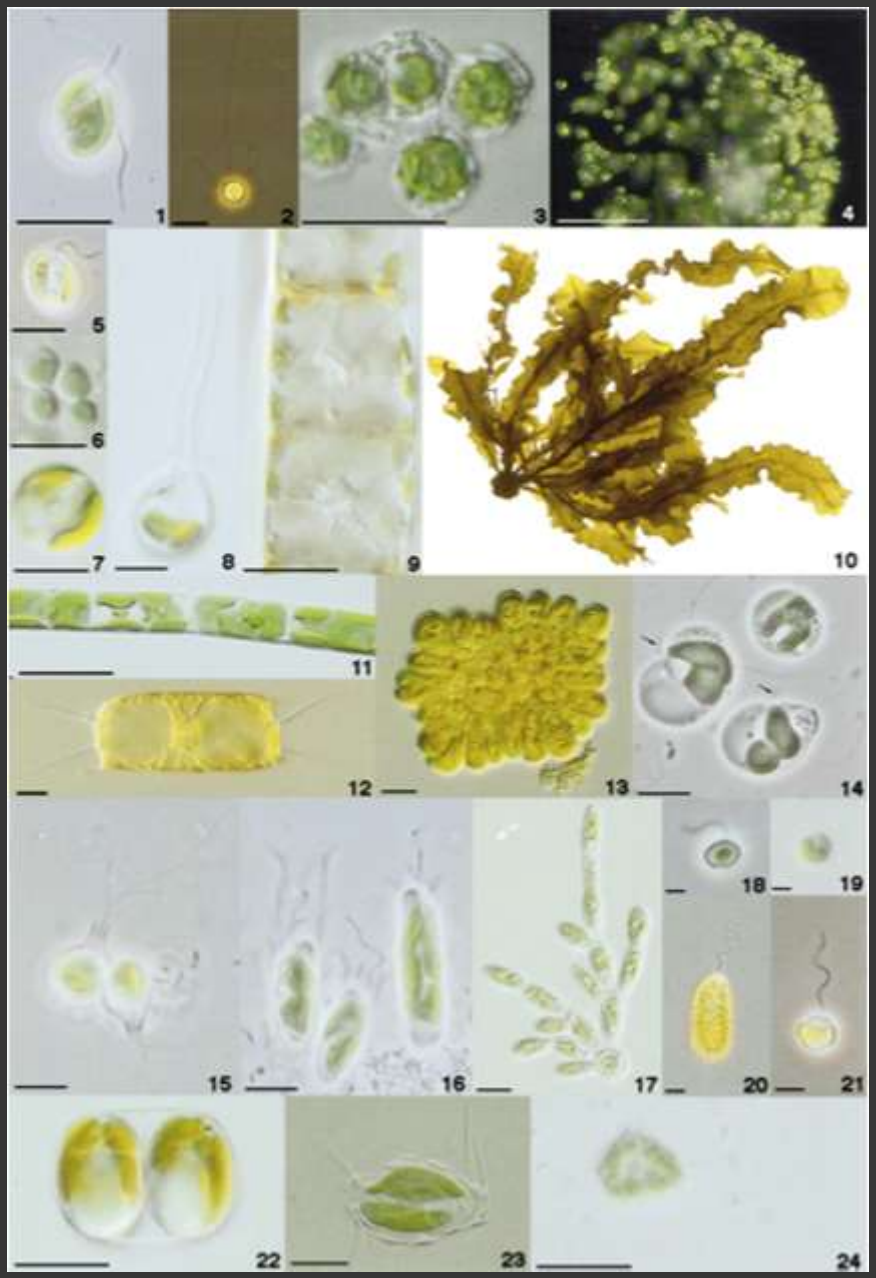
Chloroplast with thylakoids stacked in threes



Girdle lamella

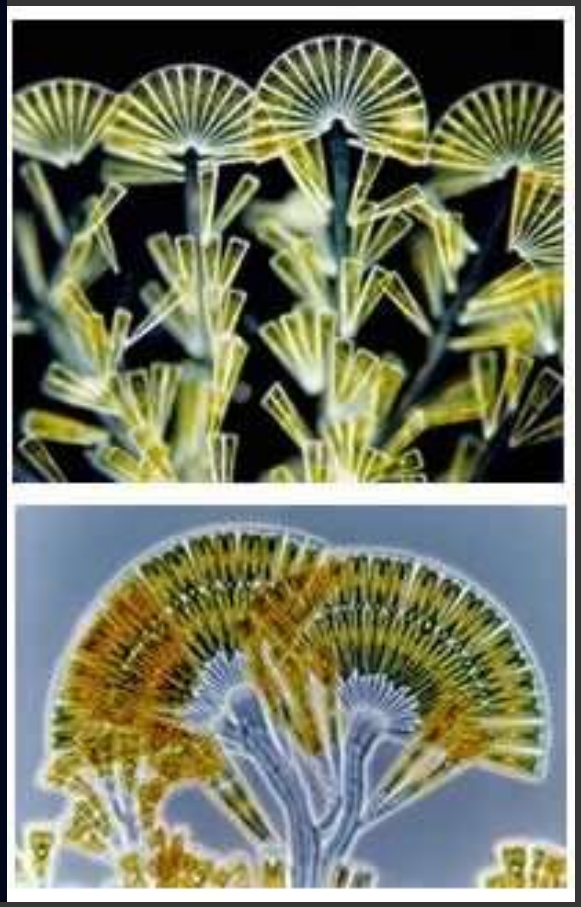
PS have more than 250 genera and >10,000 species:

- Bacillariophyceae or Diatoms
- Raphidophyceans
- Chrysophyceae or Golden Algae
- Synurophyceae
- Eustigmatophyceans
- Pelagophyceans
- Silicoflagellates
- Pedinellids
- Tribophyceae
- Phaeophyceae or Brown Algae
- And many many many other forms!!!……



DIATOMS

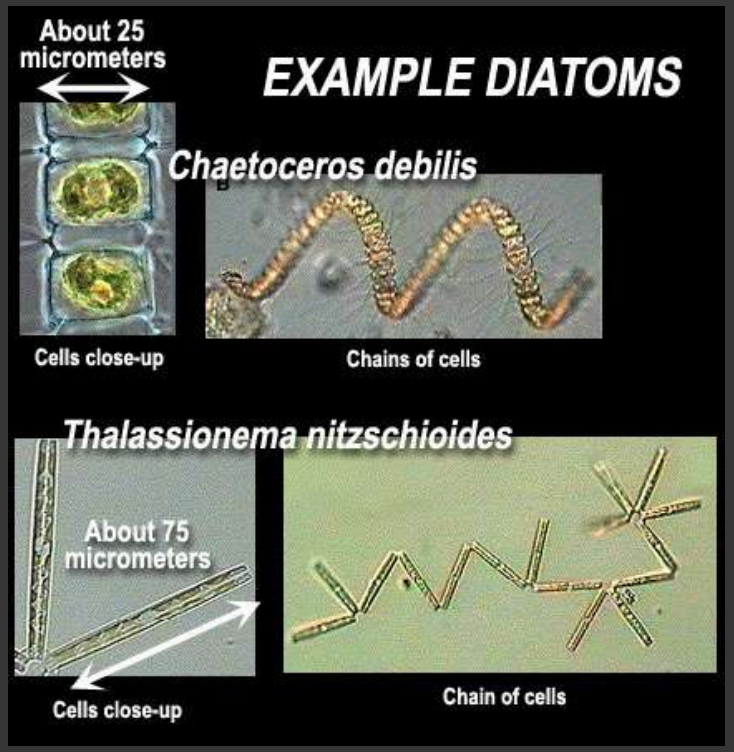
Or Bacillariophyceae



Kieselalgen = glass algae

Diatoms

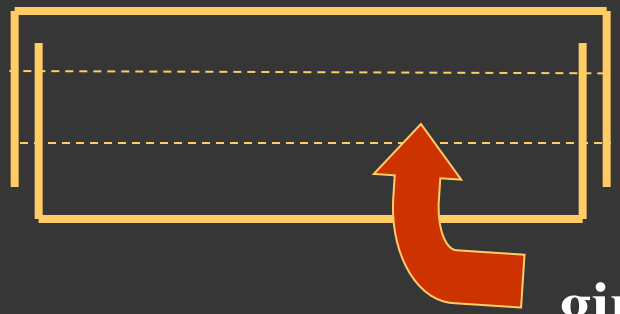
- FW and marine
- 80,000 or more species?
- Benthic and planktonic:
  marine diatoms > 25% of the world's total photosynthesis
- Unicells, filamentous chains, small colonies
- Silica (glass) walls or frustule
- Some are motile by gliding
- Some with flagellated stages
- Storage compounds:
  chrysolaminarin and oil
- Chlorophyll a & c, and Fucoxanthin
- Diatoms are diploid (2n) !!!



Morphology

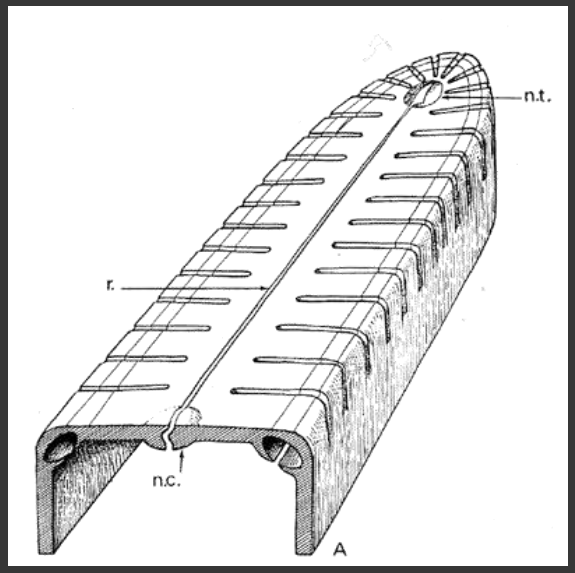
Girdle View

Epitheca

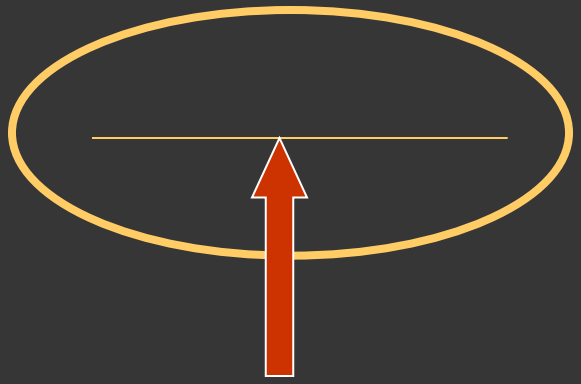


girdle bands

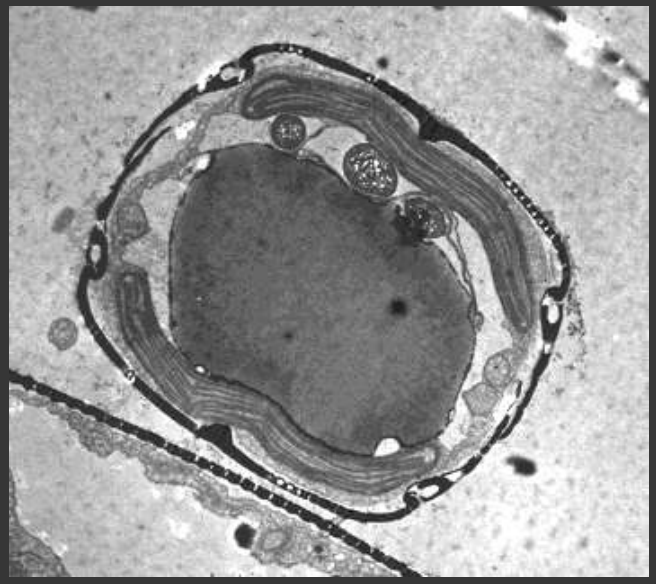
Hypotheca

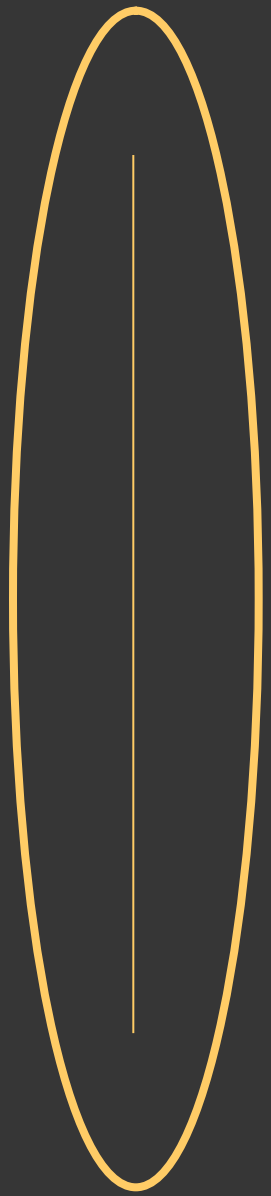


Valve View

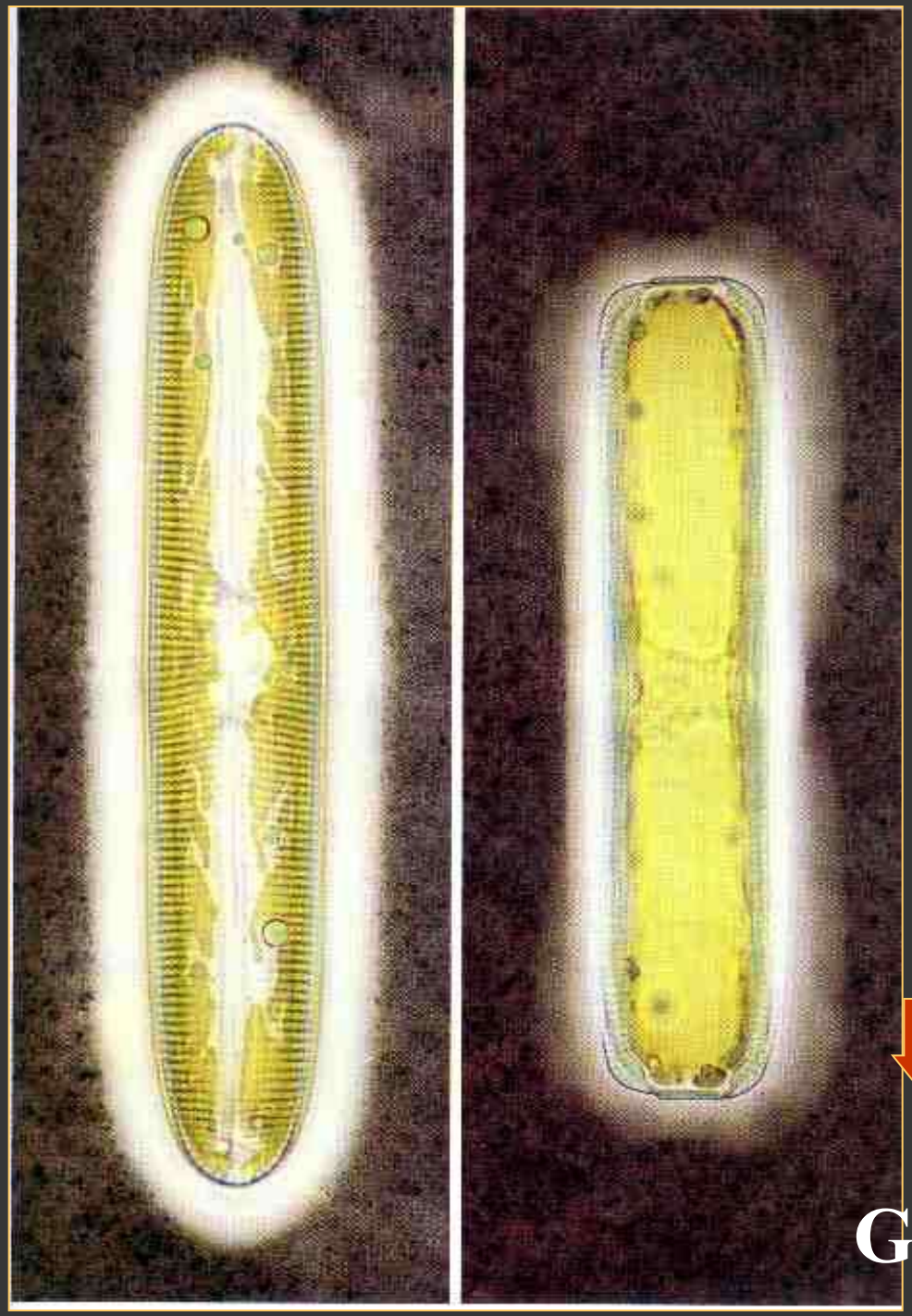


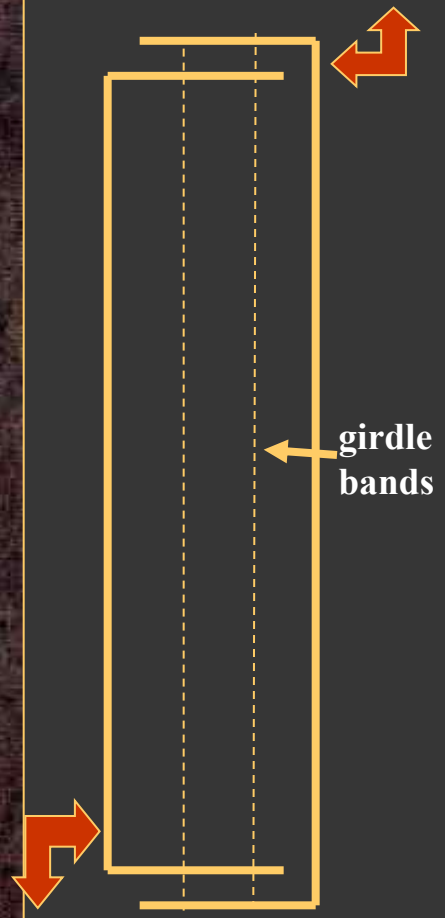
raphe





Valve View

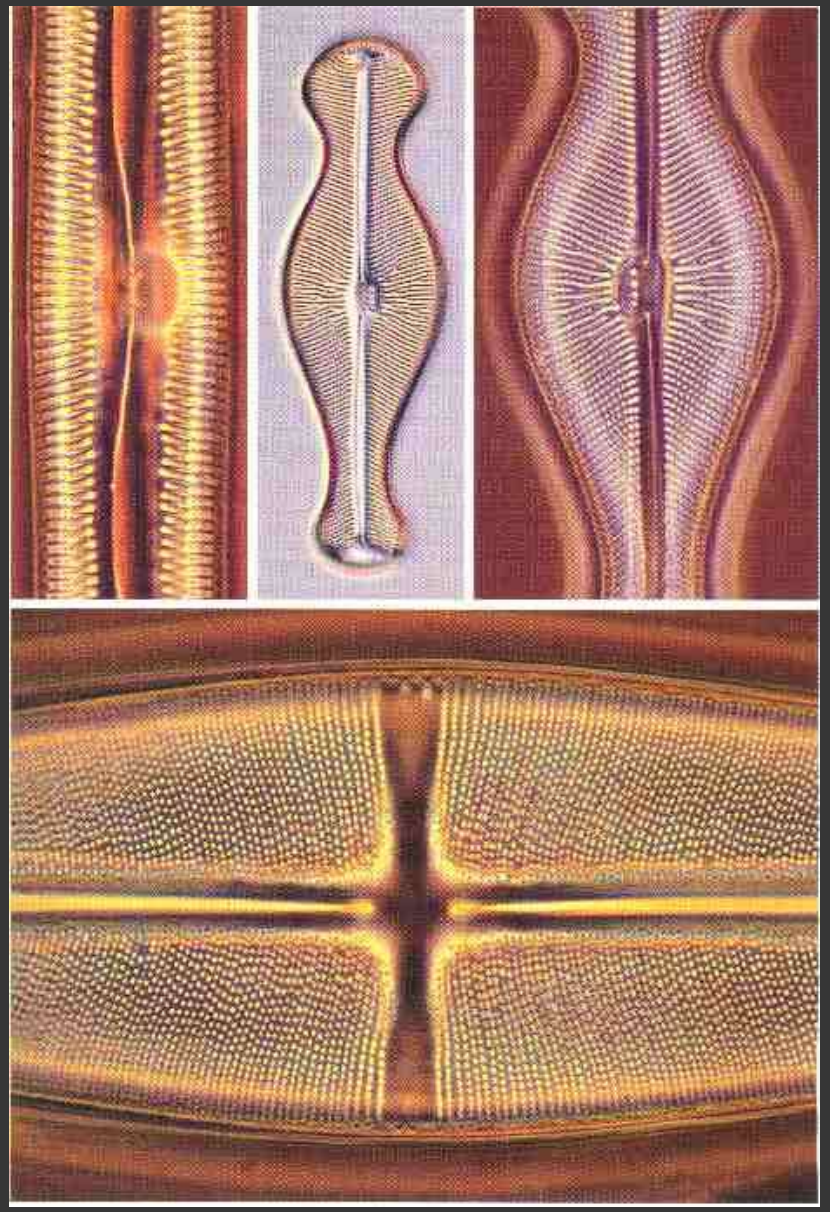




Girdle View

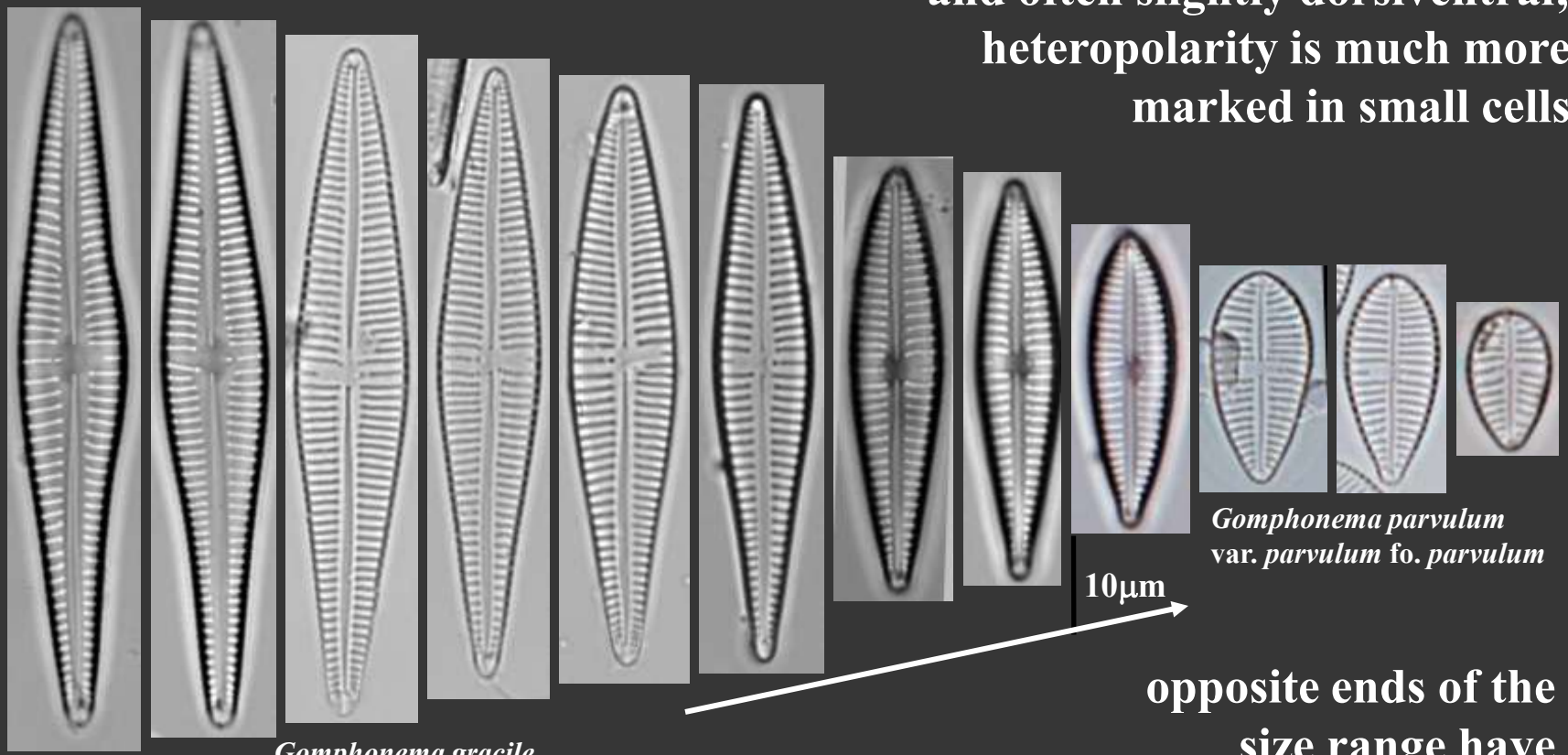
Diatom taxonomy is based on valve structure and markings:

costa(e): ribs or thickenings appearing as double lines
Areola(e): large pore-like structures or cavities
Raphe: a "V" shaped groove or slit on the valve surface
Stria(e) delicate, long, line-like markings
Stauros: central nodule appear as a cross
Puncta(e): Minute pores or dots
Pseudoraphe: A clear axial line w/o markings appearing as a raphe
Polar nodules: polar wall thickenings
Central nodule: central wall thickening
Hyaline rays or fields: areas w/o markings
Keel: wing-like structures
Process: any structure projecting as a spine



Diatom morphology can sometimes change markedly with size

Initial cells are almost isopolar and often slightly dorsiventral; heteropolarity is much more marked in small cells



Gomphonema gracile

Gomphonema parvulum var. *parvulum* fo. *parvulum*

opposite ends of the size range have been given different names

(micrographs courtesy of Dawn Rose, NHM; Slide courtesy of Dr. Eileen Cox, NHM London)

Morphology: Unicells, filamentous chains, small colonies

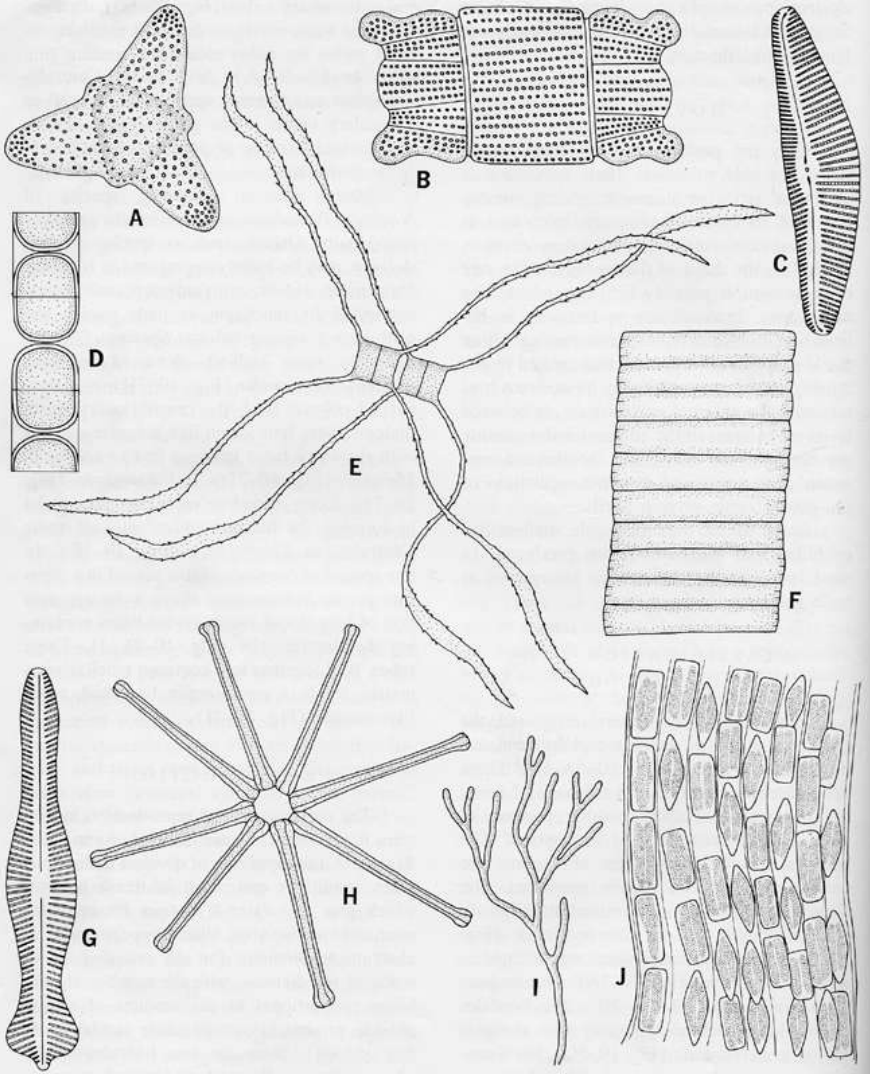
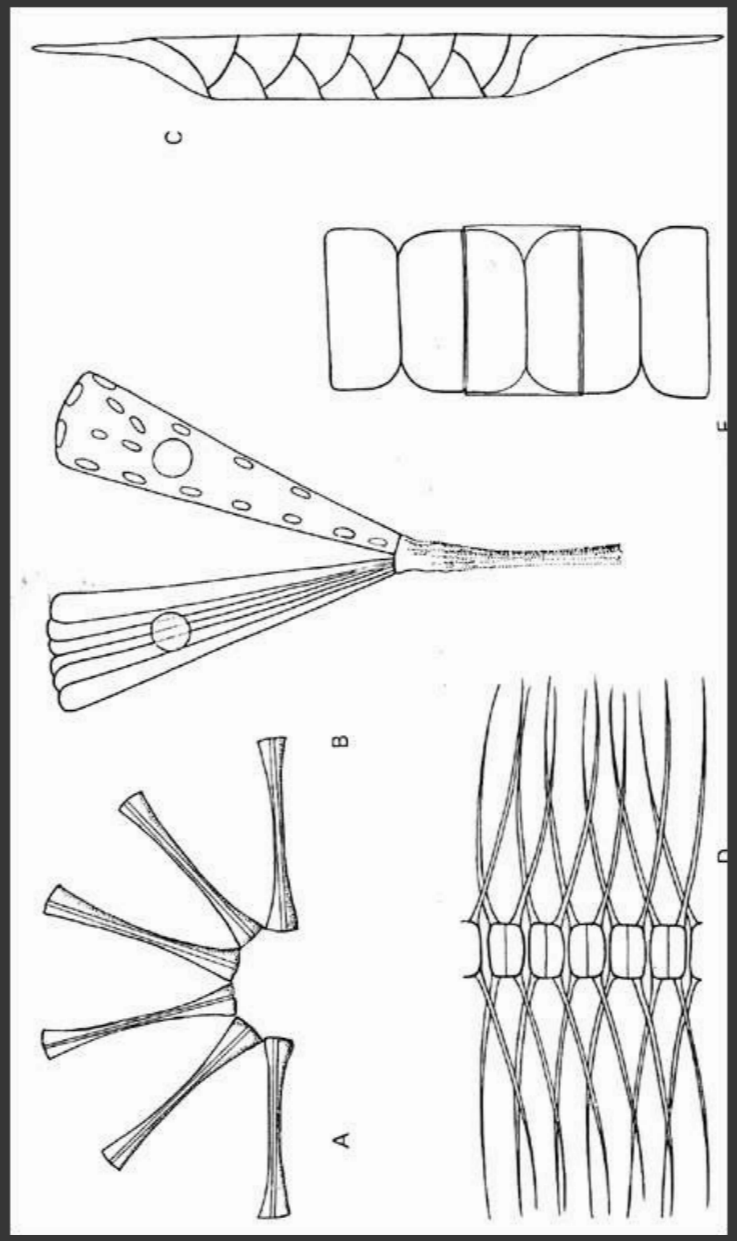


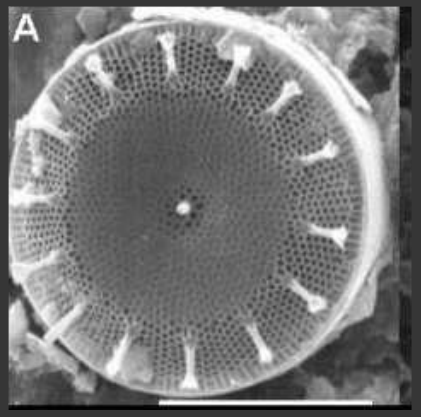
FIGURE 10–7 Morphological diversity in Bacillariophyceae (A, B, D, E, centric forms; C, F–J, pennate forms). A–C, G, unicellular representatives. A, *Triceratium,* valve view, ×545; B, *Biddulphia,* girdle view, ×475; C, *Cymbella,* valve view, ×545; G, *Gomphonema,* valve view, ×1,250. D–F, H–J, colonial representatives. D, *Melosira,* girdle view, ×640; E, *Chaetoceros,* girdle view, ×500; F, *Fragilaria,* girdle view, ×750; H, *Asterionella,* girdle view, ×1,000; I, J, *Navicula,* colonial species; I, habit, ×3.5; J, detail of colony, ×520.

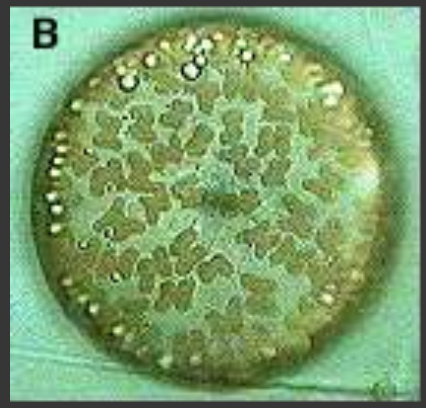


Diatoms are divided in two groups: Centric and Pennate diatoms

Centric Diatoms:

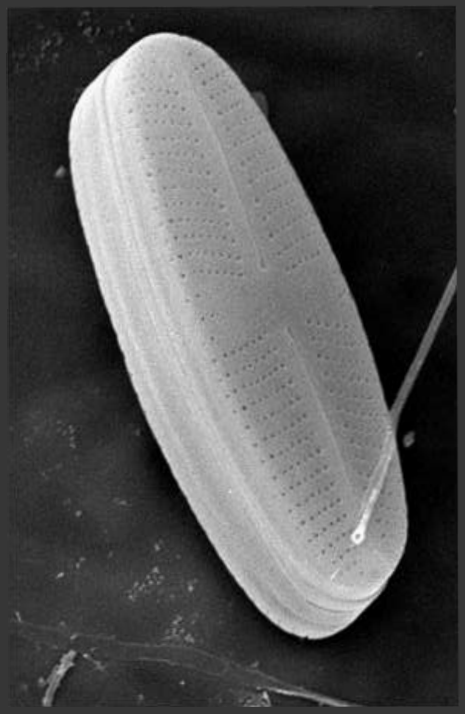
- Marks arranged radial
- Large central vacuole
- Numerous discoid plastids
- Sex by Oogamy with uniflagellated male gametes





Pennate Diatoms:

- Marks arranged bilaterally
- With a raphe: Raphid Diatoms
- W/o raphe: Araphid Diatoms
- Fewer elongated plastids
- Sex by conjugation (no flagellated stages)
- Mostly benthic



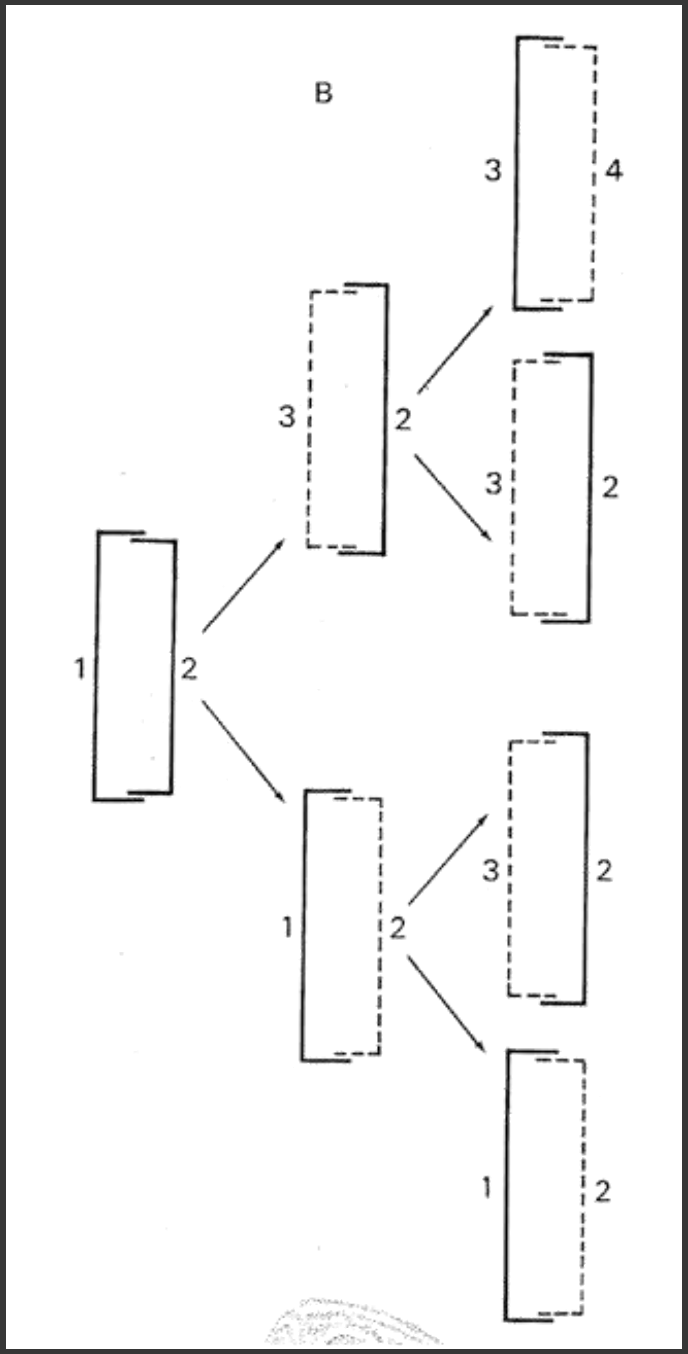
Reproduction in Diatoms

<u>Asexual</u> reproduction by cell division:

Each cell receive one of the valves and forms a new valve <u>within</u>

Once an epitheca, always an epitheca!

The daughter cell with the original epivalve is the same size as the parent, but the hypovalve of the parent becomes the epivalve of the other daughter cell

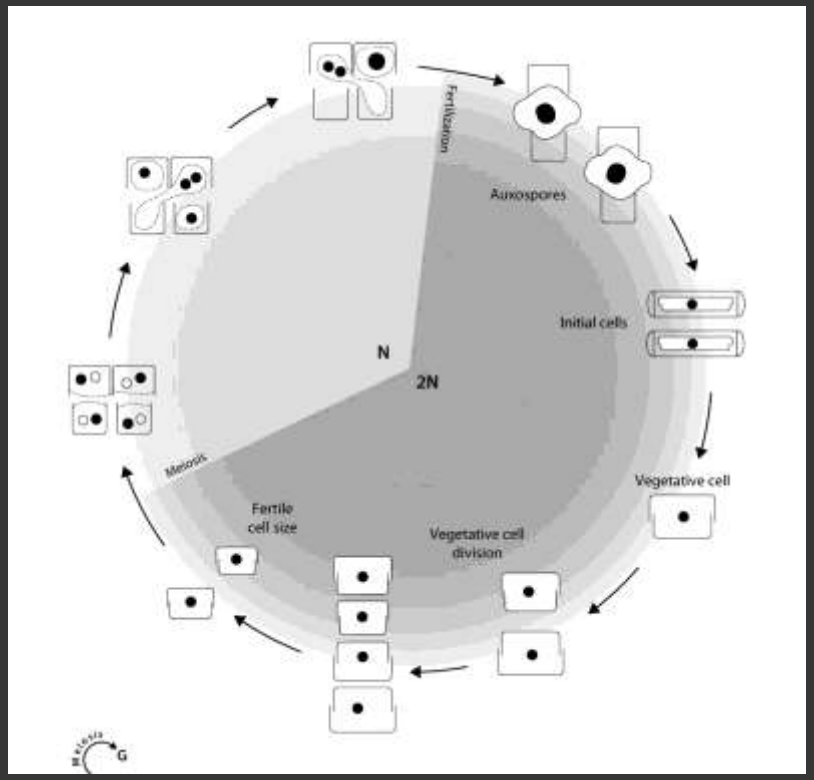


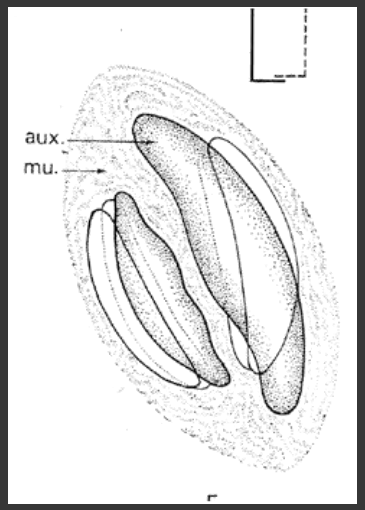
Reproduction in Diatoms

- Decrease in size and environmental conditions determine the timing of sexuality
- When less than half the maximum size for the species
- Life cycle is Gametic Meiosis
- Vegetative cells are diploid
- Gametes are haploid

Sexual reproduction in Pennate Diatoms

- Gametes are amoeboid and the process resembles that of desmids and *Spirogyra*
- Cells pair up in mucilage
- Meiosis take place
- Only one or two gametes are formed
- Two zygotes are formed
- Zygote becomes an Auxospore



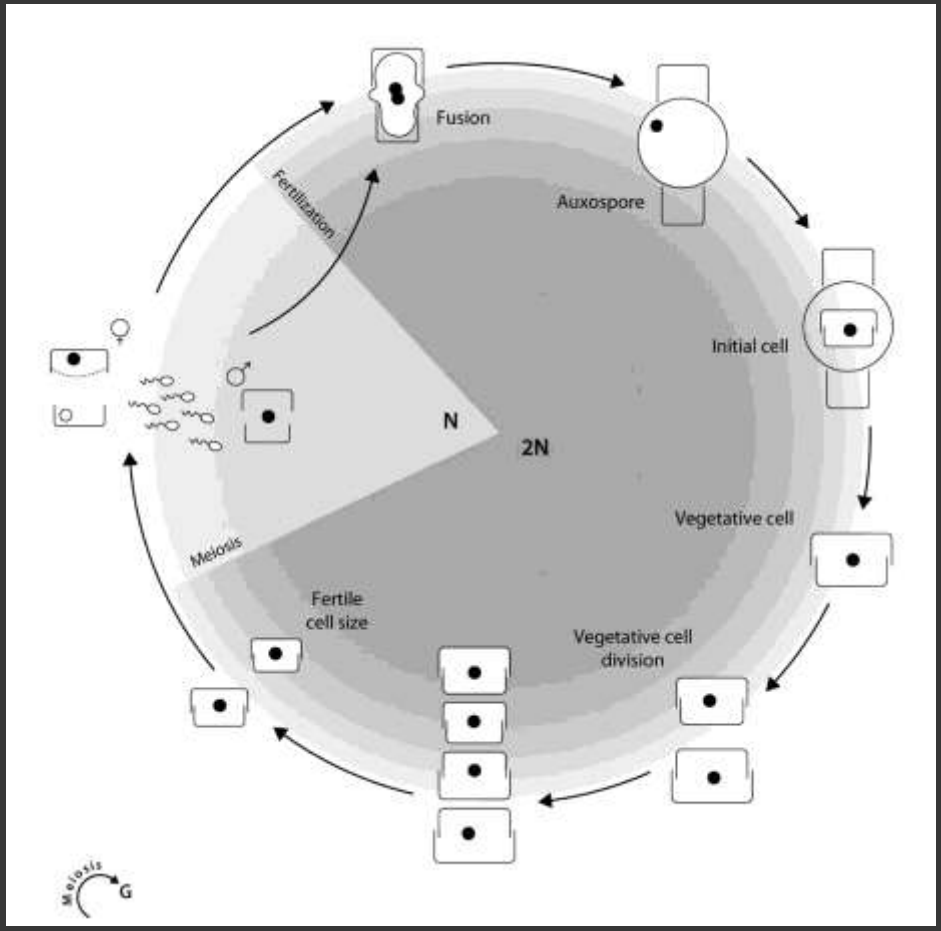


Zygote enlarges to become an elongated auxospore, enclosed by the frustule

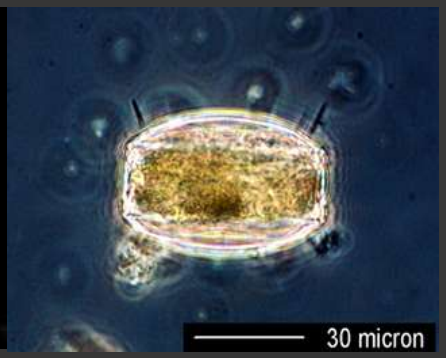
The maximum size is attained and restored!

Sexual reproduction in Centric Diatoms

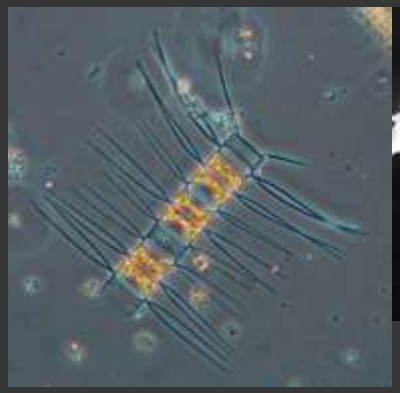
- Gametes are formed by meiosis
- Antheridial cells produce sperm
- Each sperm has a single flagellum
- Oogonial cells produce one egg
- Both eggs and sperm are released into the water
- Zygote becomes an Auxospore

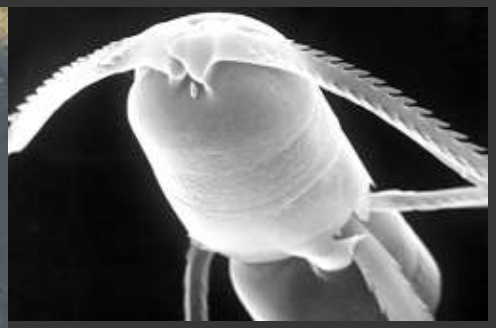


Examples: Centric Diatoms in Marine environments

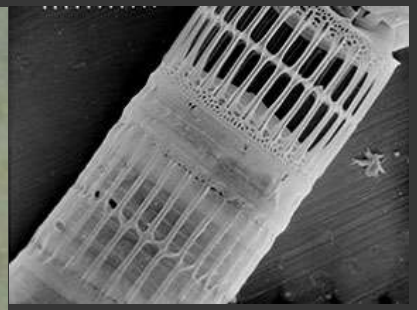


Thalassiosira

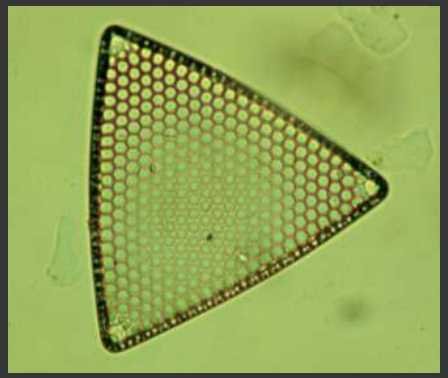




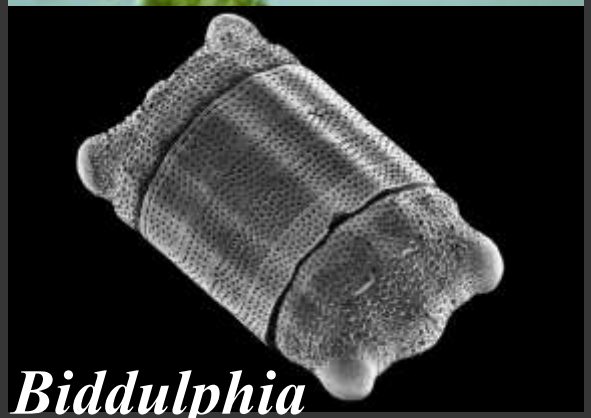
Chaetoceros



Skeletonema



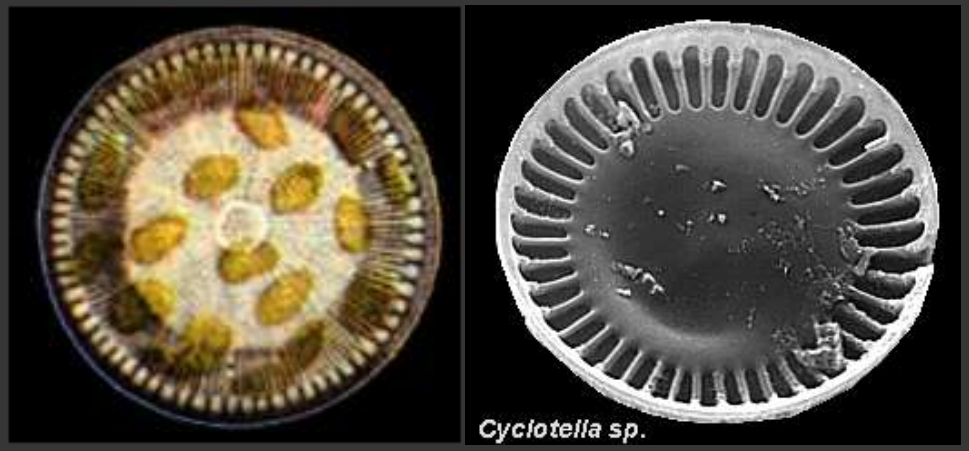
Triceratium



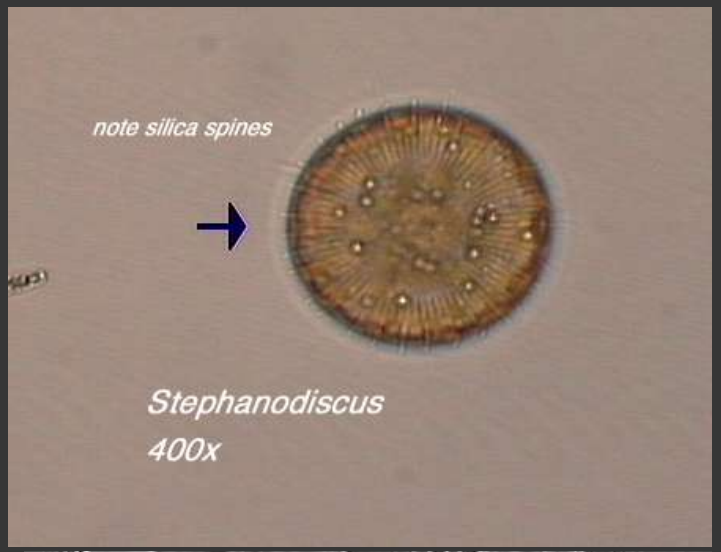
Biddulphia

Rhizosolenia

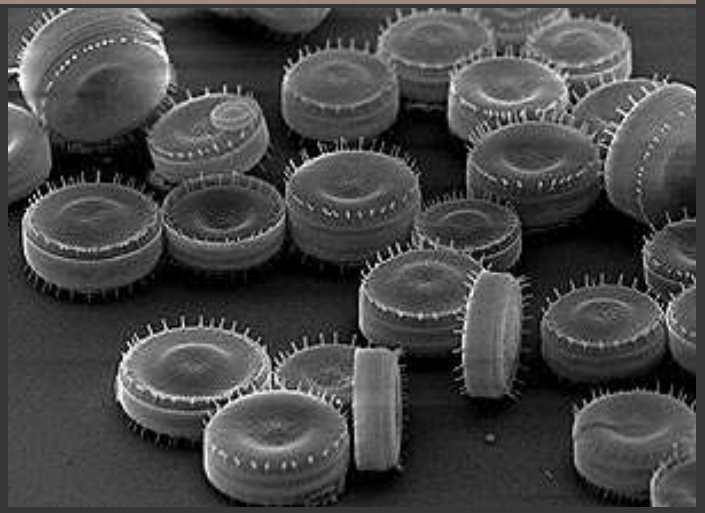
Examples: Centric Diatoms in Freshwater Environments



Cyclotella



Melosira

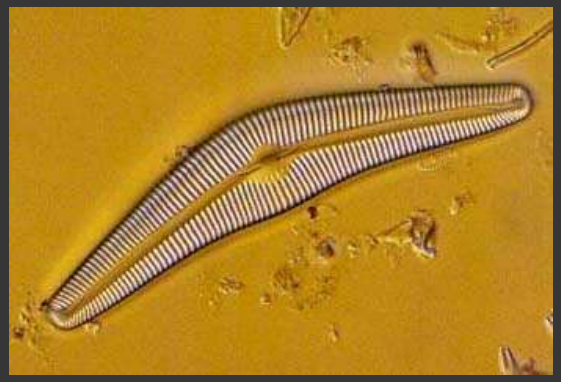


Stephanodiscus

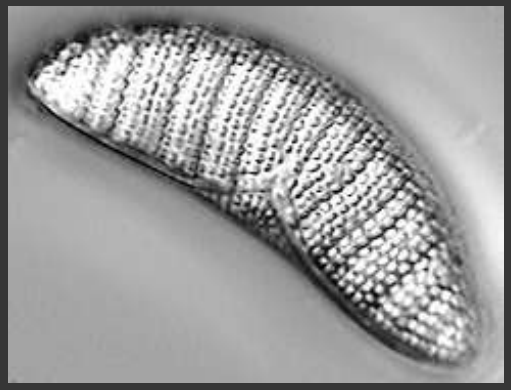
Examples: Pennate Diatom in Marine Environments

Licmophora

Examples: Pennate Diatoms in Freshwater Environments

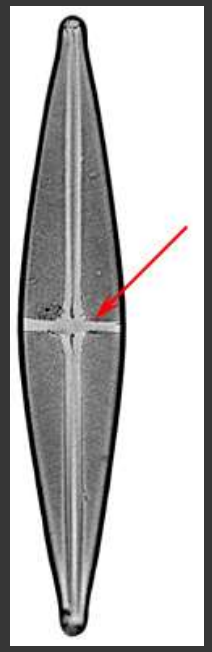


Cymbella



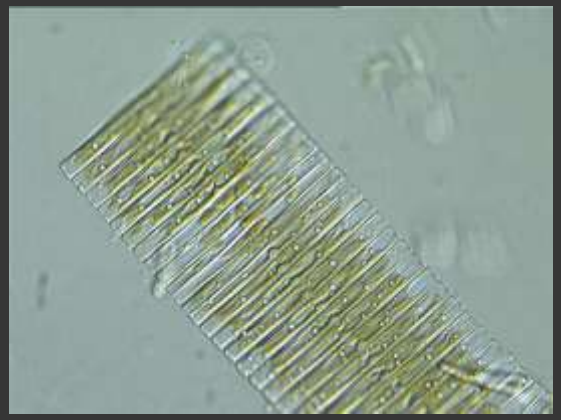
Epithemia

Gomphonema

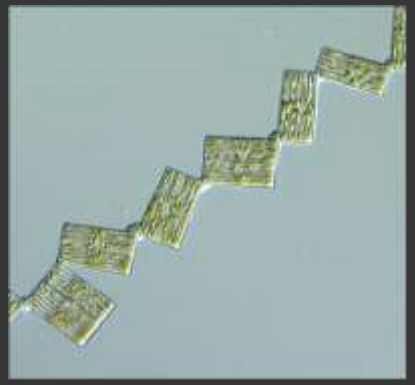


Stauroneis

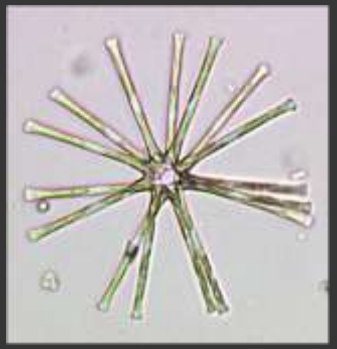
Pinnularia



Fragilaria

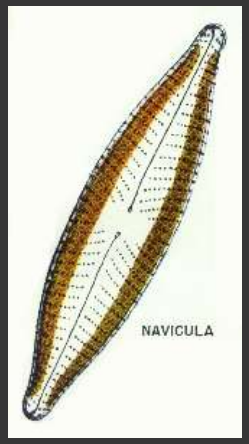


Tabellaria



Asterionella

Examples: Pennate Diatoms in Marine & Freshwater Habitats

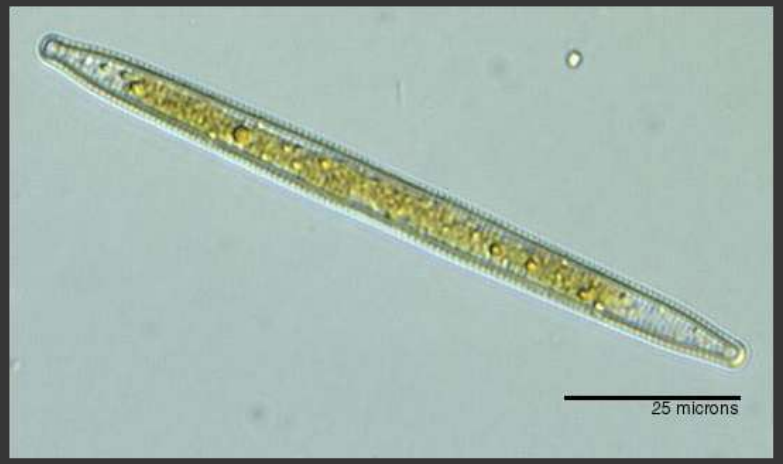


Navicula

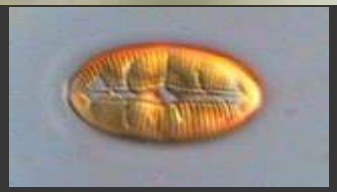
Nitzchia

Pseudo-nitzchia

Rhopalodia



Synedra



Cocconeis

Gyrosigma

Additional interesting/important points:

•Diatomite: fossil deposits, important econ;
200 m thick (Lompoc, CA) &
135-205 mybp (Jurassic) reported

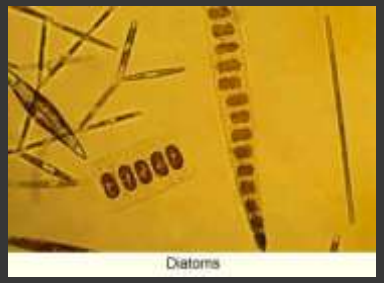
•Environmental quality indicators

•“Few objects are more beautiful than the minute siliceous cases of the diatomaceae: were these created that they might be examined and admired under the higher power of the microscope?” Darwin, The Origin of Species, Chapter 6

Ecology

- Major components of planktonic and benthic habitats
- Most diatom blooms are beneficial
- Some species are harmful such as *Chaetoceros* to fish
- Most benthic diatoms are pennates
- Diatoms cover the ice in the Arctic and Antarctic

Collecting diatoms



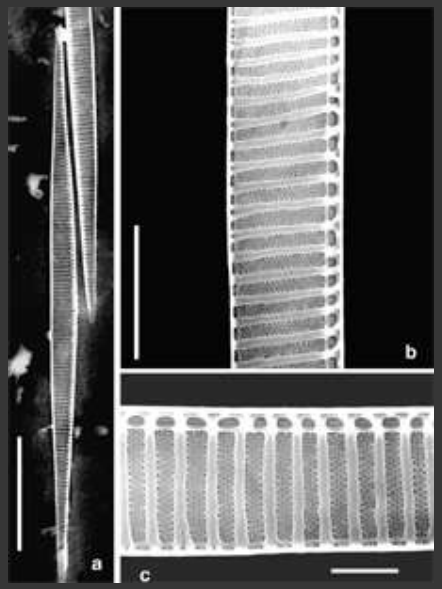
Diatoms

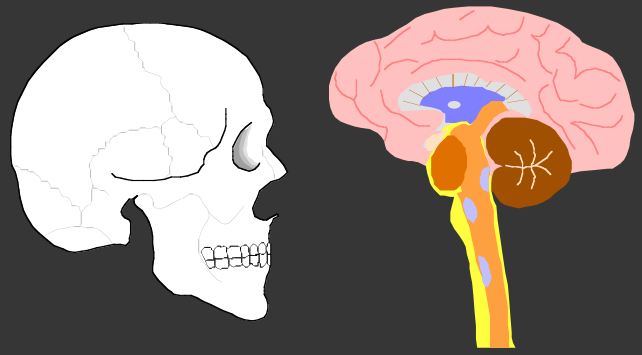
Poisonous Diatoms

Some *Pseudonitzschia* spp. produce domoic acid which causes amnesic shellfish poisoning

Domoic Acid overexcite neurons!

Accumulation in the shellfish -> permanent loss of memory & death in humans

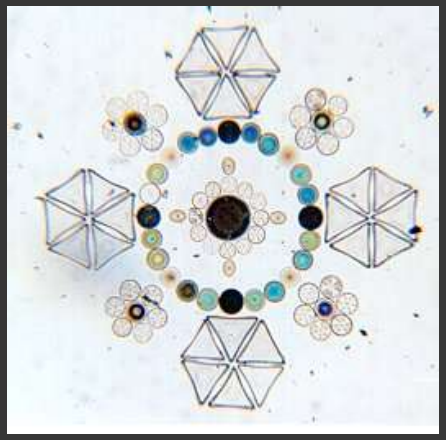




Diatom Art!


From Bori Hungary


Group of Diatomaceæ
Darkfield Illumination
Brightfield illumination
Rheinberg illumination




P. MÖLLER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