Res. Assist. Carmen Aoncioaie, Ph.D.

PHOTO: http://www.adventure-journal.com/2011/07/some-critters-win-some-lose-as-polar-food-webs-undergo-radical-change/

FRESHWATER PHYTOPLANKTON (generalities, importance & utility)

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http://www.geos.ed.ac.uk/facilities/sem/diatoms.html

WHAT IS THE PHYTOPLANKTON ?

DEFINITION

- **According to NASA Earth Observatory**

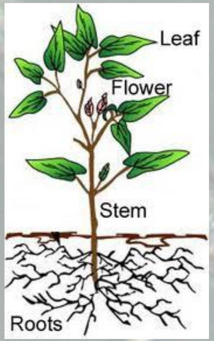
  http://earthobservatory.nasa.gov/Features/Phytoplankton/

“Derived from the Greek words phyto (PLANT) and plankton (made to wander or drift), phytoplankton are microscopic organisms that live in watery environments, both salty and fresh.”

- **Are a category of aquatic *ALGAE* and *bacteria***
- **Phytoplankton – microscopic organisms**

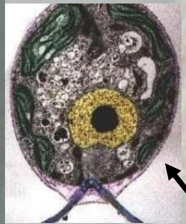
http://www.micromagus.net/microscopes/pondlife_plants01.html

In open water bodies (especially in oceans, deep lakes and fast rivers), *the algae* are the primary producer and have the main role in the trophic chain representing the basic food source as the "superior" plants, bound to be fixed in the soil, are limited by the depths to which light can penetrate.

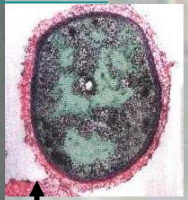


•http://8mso.wordpress.com/2012/02/01/drawing-scientific-diagrams/

"superior plants" – the CORMOPHYTES
= the vegetal organisms (*phyta*) that have a "*CORM*":
= root + stem + leaves + reproductive cells in reproductive structures
:mosses, ferns and seed plants;
:terrestrial and aquatic (fresh/saltwater)



http://www.rpi.edu/dept/chem-eng/Biotech-Environ/FUNDAMNT/streem/ese.htm



ALGAE

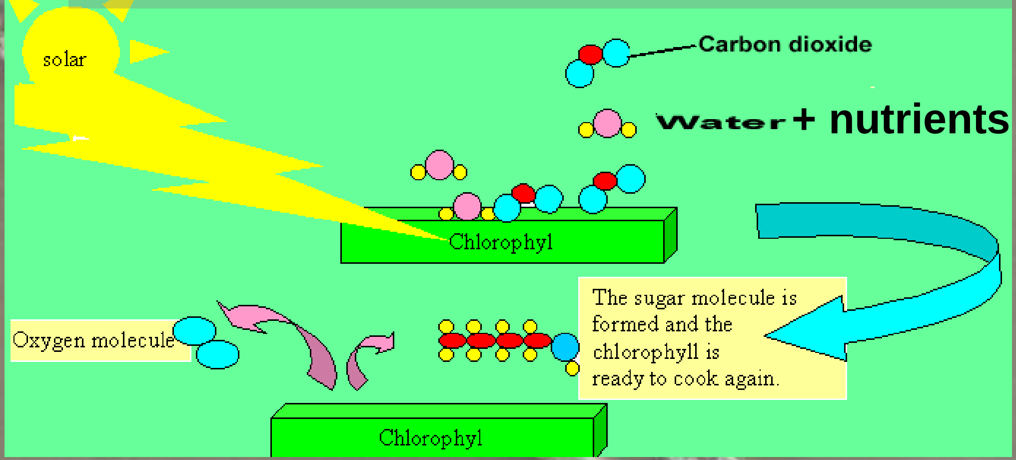
= single-celled to multicellular;
= eukaryotic organisms (the nucleus is formed, enclosed in membranes),
- microscopic (≥1μm) to macroscopic (mm-cm-m);
- chlorophyll containing
- most common phylums: Euglenophyta, Chrysophyta, Pyrrophyta, Chlorophyta, Phaeophyta, Cryptophyta, Bacillariophyta and Rhodophyta

Phylum Cyanophyta/Cyanobacteria is a category of blue-green bacteria (prokaryots) often part of the phytoplankton, inhabiting in high densities the open water bodies.

http://www.micromagus.net/microscopes/pondlife_plants01.html

Cyanobacteria, algae and cormophytes use photosynthesis in order to feed (exception: parasitic cormophytes, phagocytic dinoflagellates – *Noctiluca scintillans*). They contain a basic pigment named *chlorophyll* in order to capture sun-light and using the process known as photosynthesis, to turn the irradiation into chemical energy. Like the cormophytes, the algae consumes CO2 (as C source) and release O2 and feed with the nutrients present in the water (nitrogen and phosphorous).

http://www.dynamicscience.com.au/tester/solutions/flight/photosynthesis.htm



Due to the aquatic environment and the various degree of light penetration and turbidity of the water, the algal cells developed a series of supplementary pigments in order to be able to use a higher range of the light spectrum. *Chlorophylls (a, b & c), phycobilines* and *carotenoids* through the variation in percentage and relative abundance, give algae their distinctive color and the capacity to survive where the cormophytes can not.

http://www.micromagus.net/microscopes/pondlife_plants01.html

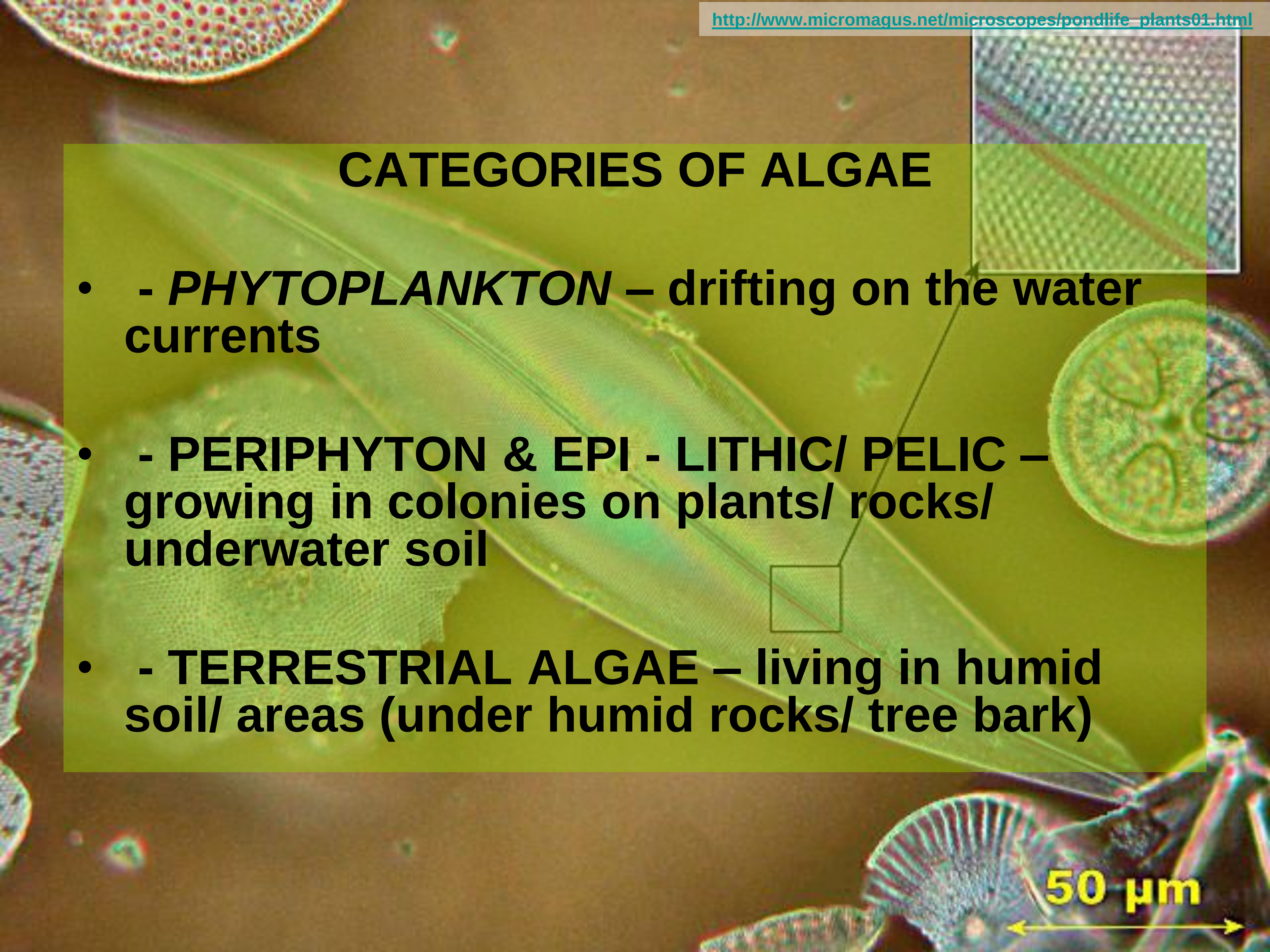
- Also like the cormophytes (Cyperaceae, Poaceae), certain groups of algae need silicate and calcium at various high levels in order to grow an exterior “coat”, a protective shell (diatoms – Bacillariophyta – silica frustule).

- Algae photosynthesize, but some get additional energy by consuming other organisms (dinoflagellates) – similar to carnivorous plants that need nitrogen (Drosera sp.).

- Like certain categories of cormophytes (Fabaceae: clover, lucerne, black locust), some groups can fix nitrogen (Cyanobacteria) and thus can grow in areas where the nitrate concentrations are low, enriching the environment in nitrate after their death and decomposition.

- The algae growth depends on the availability of carbon dioxide, sunlight, and nutrients. Some species also require trace amounts of iron which limits algal growth in large areas of the oceans.

- Other factors influencing algal growth rates are: water temperature, depth, salinity, the wind and the allelopathic substances secreted by the algae themselves in the war against each other for food and sunlight.



CATEGORIES OF ALGAE

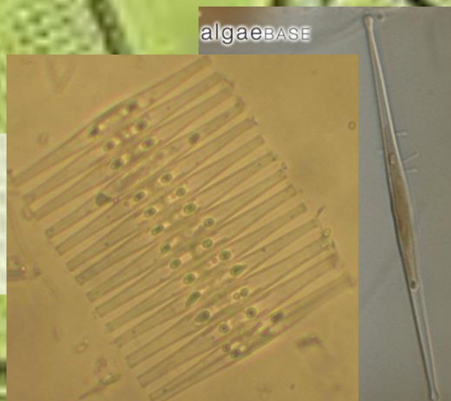
- **- *PHYTOPLANKTON* – drifting on the water currents**
- **- PERIPHYTON & EPI - LITHIC/ PELIC – growing in colonies on plants/ rocks/ underwater soil**
- **- TERRESTRIAL ALGAE – living in humid soil/ areas (under humid rocks/ tree bark)**

The freshwater PHYTOPLANKTON

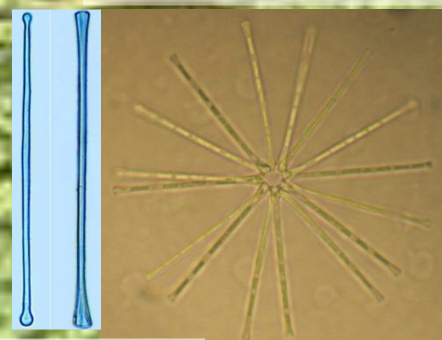
http://www.rsc.org/chemistryworld/News/2007/March/07030703.asp

Free-floating in the water (drifting); most have floatability adaptations but few have real mobility (and for short distances – can not oppose currents).

Fragilaria crotonensis
Original

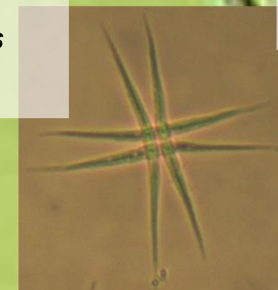


Asterionella formosa
Original

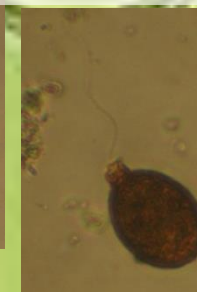


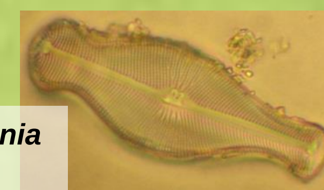
http://www.diatomloir.eu/Diatodouces/araphid.html

Ankistrodesmus fusiformis
Original

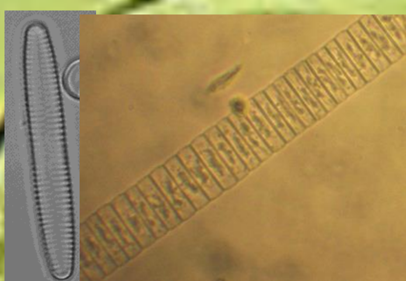


Trachelomonas
Original

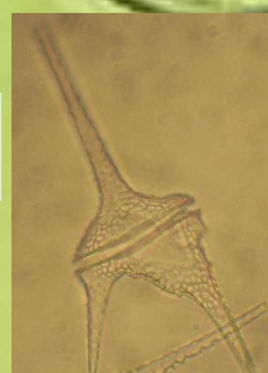




Didymosphenia geminata
Original



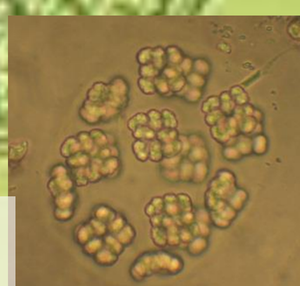
Fragilaria capucina
Original



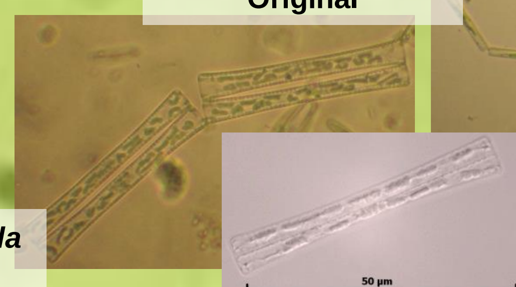
Ceratium hirundinella
Original

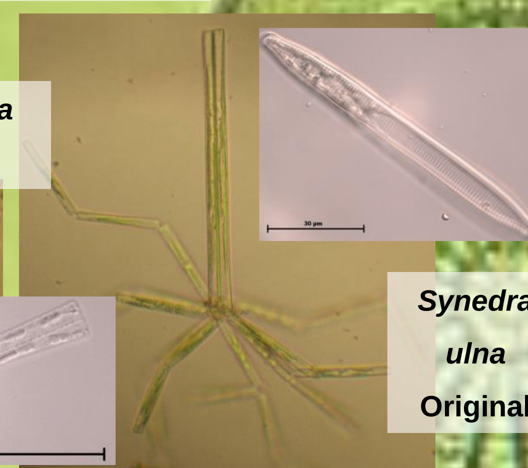
Chroococcus turgidus
Original

Pandorina morum
Original



Diatoma elongata
Original





Synedra ulna
Original

Most common groups identified in our studies

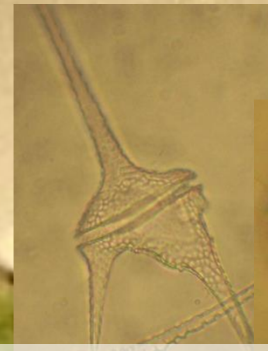
http://en.wikipedia.org/wiki/File:Pediastrum.jpg

Cyanophyta (Cyanobacteria)

Aphanizomenon ovalisporum & Anabaenopsis elenkenii BLOOM

Original

Dinophyta



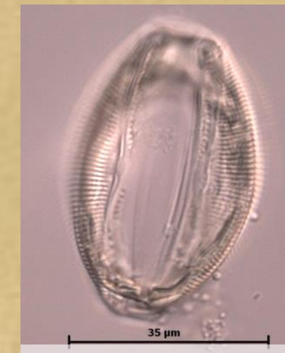
Ceratium hirundinella

Original

Peridinium cinctum

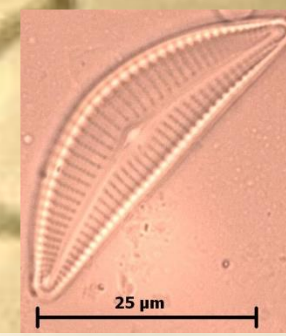
Original

Bacillariophyta



Amphora ovalis

Original



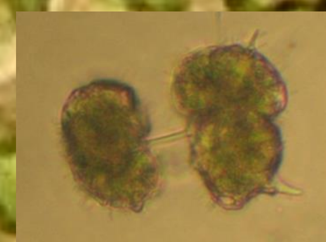
Cymbella ventricosa

Original

Chlorophyta

Cosmarium obtusatum

Original



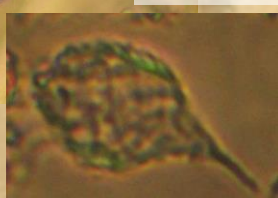
Botryococcus braunii

Original

Euglenophyta

Euglena oxyuris

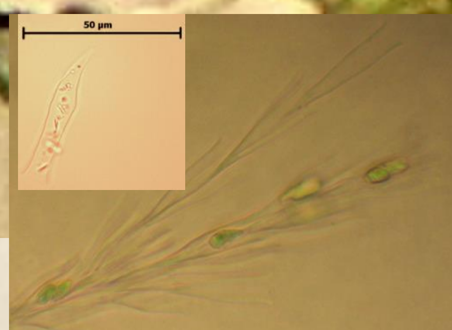
Original



Phacus pyrum

Original

Chrysophyta



Dinobryon divergens

Original

Mallomonas pseudocoronata

Original

Cryptophyta

Cryptomonas marssonii

Original

Characteristics

http://university.uog.edu/botany/Plant_Di/euglenophyta.htm

Horizontal and vertical distribution in correlation with the wind, currents, temperature and nutrient gradients.

Seasonal variability due to water temperature and intensity of light that leads to specific monthly/seasonal/annual dynamics.

Noticeable reaction to the environmental factors, expressed by the level of development (qualitative - taxa & quantitative - density).

- **abiotic factors (day duration, light intensity, temperature, thermal stratification of water, turbidity);**
- **chemical processes (pH, O.R.P., conductivity, salinity, nitrate, nitrite, ammonium, phosphate, biogenic demineralization);**
- **biotic factors (primary consumers, intra- & interspecific competition).**

Pourriot & Meybeck, 1995

IMPORTANCE

- Primary producer

Food source for the primary consumers (micro-zooplankton)

- Reaction to environmental factors
  - pH
  - Nitrogen
  - Phosphate
  - Salinity
  - Oxygen
  - Trophicity

BIOINDICATORS

UTILITY

WATER QUALITY ASSESSMENT

Phytoplanktonic species develop in correlation with their preferences, thus are included in groups like:

- *indicative valor of the ecological amplitude* starting with the most sensitive (stenoece - 5) and ending with the most tolerant (ubiquiste - 1).

- *water trophy state indicators*. The trophic state of a water body mainly means the power to sustain life - the mineral nutrient content necessary for the growth of the primary producers. There are five categories ranging from 1 (very poor) to 5 (rich). 1 – ultraoligotrophic, 2 – oligotrophic, 3 – mesotrophic, 4 – eutrophic and 5 – hypereutrophic. By concentration and filtration of water containing phytoplankton can be extracted the *chlorophyll a* present in the organisms. Depending on its concentration, the trophic level of water may also be assessed.

- *water saprobity indicators*. Saprobity is referring to the load in organic matter that is due to decompose. Ranging from 1 (poor) to 5 (rich). –oligosaprobe, 2 – oligo-meso, 3 – beta-meso, 4 – alfa-meso and 5 – polysaprobe.

PHYTOPLANKTON BLOOM

FAST REACTION TO HIGH AMOUNTS OF MINERAL NUTRIENTS !!


Bloom
Original

Phytoplanktonic groups like Cyanophyta, Chlorophyta and Euglenophyta react very fast by exponential development (Algal BLOOM) when the trophy level of the water increases (eutrophic to hypereutrophic) under the presence of nitrogen and phosphorous compounds. Waters from agriculture, waste water plants and from the fertilization process of aquaculture fish ponds (with super-phosphate and ammonium nitrite) lead to loaded waters, rich in phosphate, ammonia, nitrate and nitrite.

Blooms have a harmful effect on the other organisms living in water by concentrating toxins from the allelopathic processes, oxygen consumption during night (when photosynthesis is suspended), clogging fish gills, depleting the environment of nutrients, increasing the amount of decomposing organic matter (another oxygen depleting process). The result are the well-known phenomenon of heavy smell, impossibility of water usage for recreational activities or dinking and fish death.


Bloom
Original

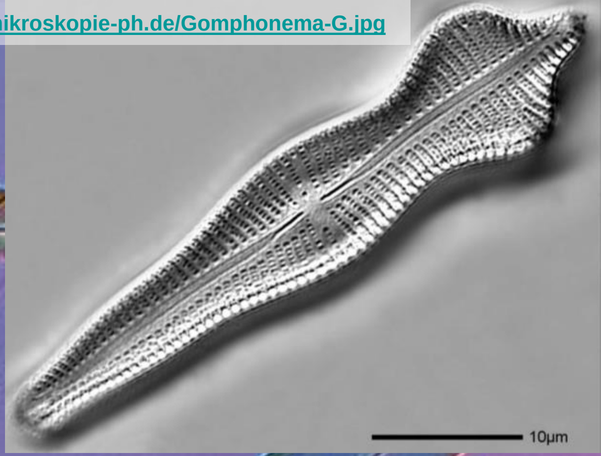
Background: Bloom of *Anabaenopsis elenkenii* and *Aphanizomenon ovalisporum* in Miletin swamp (Iaşi, Romania) Original


Bloom
Original

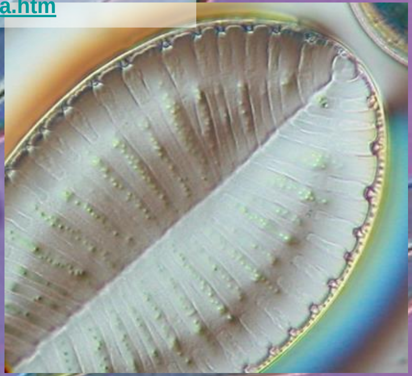
MOST SENSITIVE GROUP: THE DIATOMS (Phylum Bacillariophyta)

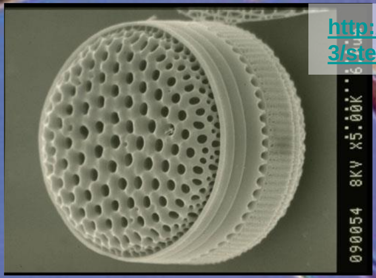
- Single-celled algae
- Round (Centric) or elongate (Pennate)
- Covered with a siliceous shell (*frustule*) made of two halves that fit tightly together like a box, one inside the other
- The frustules have pores that permit the nutrients and the residues to pass in and out of the cell.

http://www.mikroskopie-ph.de/Gomphonema-G.jpg

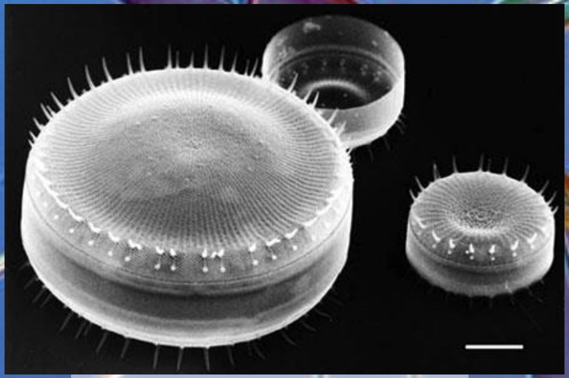


http://www.victorianmicroscopeslides.com/slidedia.htm



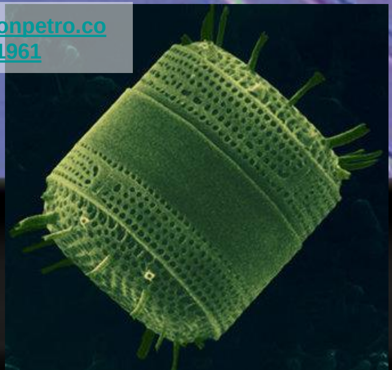


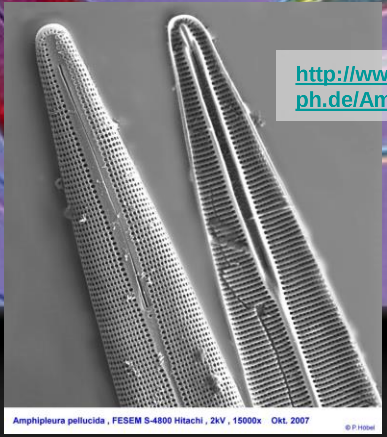
http://dtc.pima.edu/blc/183/03_183/step2/03_step2_page3.html



http://www.sciencebuzz.org/museum/object/2001_06_diatom_stephanodiscus_niagarae_ehrenberg

http://www.paysonpetro.com/19641/#more-1961



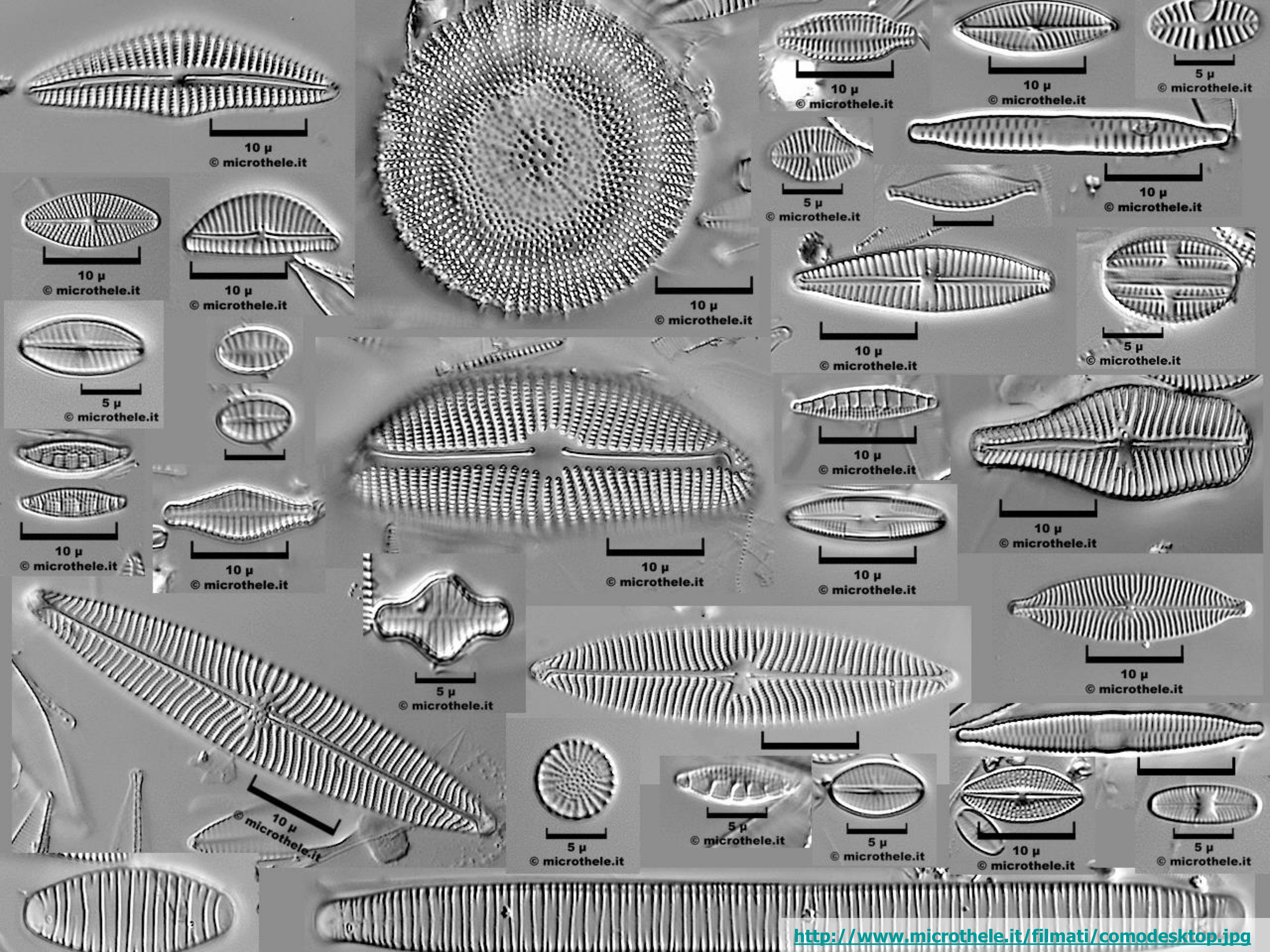


http://www.mikroskopie-ph.de/Amphi-FESEM-09.jpg

Photograph by Darlyne A. Murawski

NATIONAL GEOGRAPHIC

http://www.adventureandscience.org/diatoms.html



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http://www.microthele.it/filmati/comodesktop.jpg

http://photography.nationalgeographic.com/wallpaper/photography/photos/mysterious-earth/various-diatoms/

This group was subject to numerous studies and most of the species were analyzed and included in categories depending on the quantitative intervals they prefer.

pH
1 – acidobiontic (<5.5), 2 – acidophilous (<7), 3 – circumneutral (≈7), 4 – alkaliphilous (> 7), 5 – alkalibiontic (exclusivelly >7), 6 – indifferent. (Van Dam et al., 1994)

Dissolved oxygen
1 – continuously high (≈100% saturation), 2 – fairly high (>75%), 3 – moderate (>50%), 4 – low (>30%), 5 – very low (≈10%). (Van Dam et al., 1994)

Nitrogen
1 – nitrogen-autotrophic taxa, tolerating very small concentrations of organically bound nitrogen;
2 - nitrogen-autotrophic taxa, tolerating elevated concentrations of organically bound nitrogen;
3 – facultative nitrogen-heterotrophic taxa, needing periodically elevated concentrations of organically bound nitrogen;
4 – obligated nitrogen-heterotrophic taxa, needing continuously elevated concentrations of organically bound nitrogen. (Van Dam et al., 1994)

Trophicity
1 – oligotraphentic, 2 – oligo-mesotraphentic, 3 – mesotraphentic, 4 – meso-eutraphentic, 5 – eutraphentic, 6 – hypereutraphentic, 7 – oligo to hyopereutraphentic. (Van Dam et al., 1994)

Saprobity
1 – oligosaprobous (WQC: I, I-II; >85% oxygen; <2 mg/l BOD5-20),
2 – β-mesosaprobous (WQC: II; 70-85% oxygen; 2-4 mg/l BOD5-20),
3 – α-mesosaprobous (WQC: III; 25-70% oxygen; 4-13 mg/l BOD5-20),
4 – α-meso-/polysaprobous (WQC: III - IV; 10-25% oxygen; 13-22 mg/l BOD5-20),
5 – polysaprobous (WQC: IV; <10% oxygen; >22 mg/l BOD5-20). (Van Dam et al., 1994)
WQC – water quality class

Salinity
1 – fresh (<100 mg/l Cl-, <0.2‰),
2 – fresh brackish (<500 mg/l Cl-, <0.9‰),
3 – brackish fresh (500-1000 mg/l Cl-, 0.9-1.8‰),
4 – brackish (1000-1500 mg/l Cl-, 1.8-9.0 ‰). (Van Dam et al., 1994)

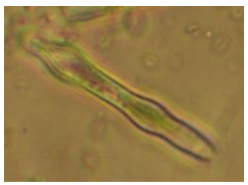
Phosphorous
1: <0.01mg/l PO4;
2: ≥0.01mg/l PO4, <0.0035mg/l TP;
3: ≥0.0035 mg/l TP, <0.1 mg/l PO4;
4: ≥0.1 mg/l TP, <0.3 mg/l PO4; 5: ≥ 0.3 mg/l PO4
TP – total phosphorous (Kelly & Whitton, 1995)

Based on the indicator value of the diatoms, a series of indexes were created in order to evaluate the trophicity and saprobity of waters (TDI – Trophic Diatom Index; GDI – Generic Diatom Index, IBD – l’Indice Biologique Diatomées – Prygiel & Coste, 2000).

Teratological forms of diatoms

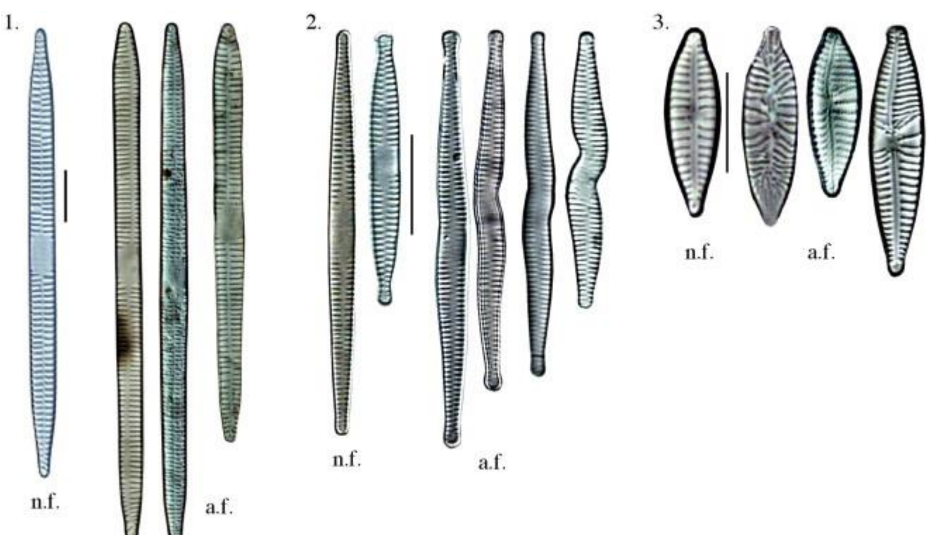
FAST REACTION TO POLLUTANTS !!

The reaction of diatoms to the environment is prompt. Many times can be noticed modification of the silica exoskeleton and anomalies of the ornamentation. These modifications are related to the presence of micro-pollutants and generally to the stress factors like strong variations of pH or water temperature, depletion of silica (Prygiel & Coste, 2000). Heavy metal pollutants (Cadmium: Duong et al., 2008; Da Silva et al., 2009 Plumbum and Zinc, Da Silva et al., 2009) are some of the most common micro-pollutants that have a visible morphological impact on the diatoms.



Diatoma elongata

Vlădeni pond evacuation stream, Iaşi (Romania)

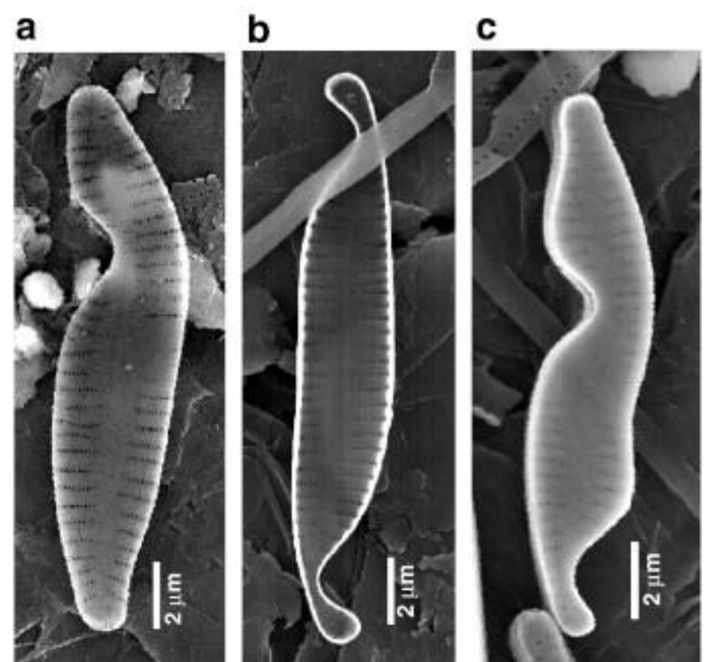


Abnormal forms of *Ulnaria ulna* (1), *Fragilaria capucina* (2) and *Gomphonema parvulum* (3) (nf: normal form and ab: abnormal form).

Duong et al., 2008

Scanning electron microscopic photos of teratological valves of *Fragilaria capucina* var. *rumpens* (a) and (c) external valve views; (b) internal valve view.

Da Silva et al., 2009



http://www.cellimagelibrary.org/images/41823

By qualitative (species, phylum) and quantitative (density) analysis of the phytoplankton followed by the bioindicators inventory, an open body of water can be defined from the point of view of the quality. Along with physical and chemical analyses there can be formed an image about the state of health of a water body which is used in the process of identifying a pollution event and its impact on the aquatic organisms used in human consumption; the possible uses of the water – agriculture, aquaculture, drinking, recreational activities; identifying the state of the healing process of an aquatic ecosystem after a pollution event; what measures are necessary to be taken in order to have clean and healthy waters.

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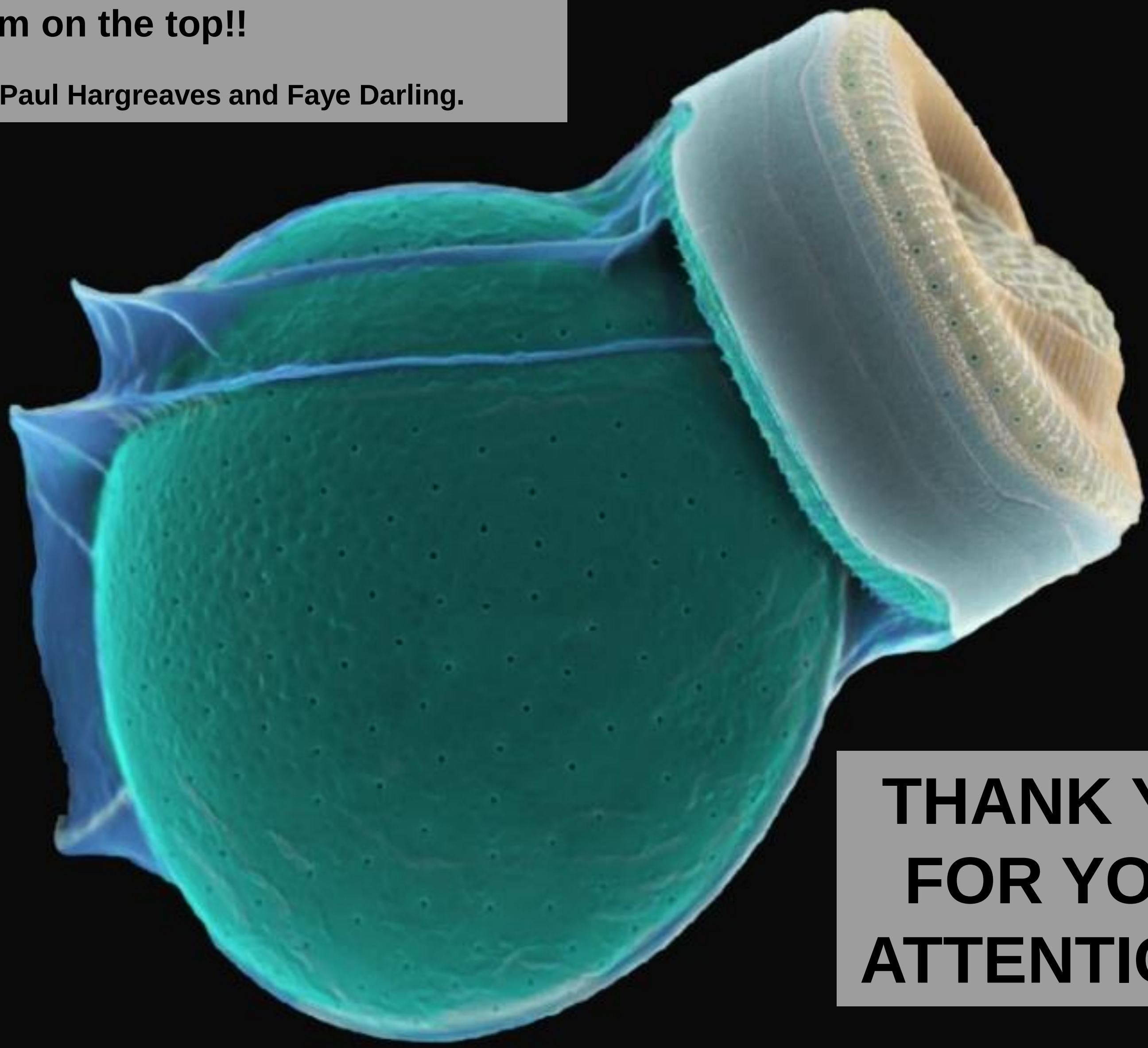
A dinoflagellate and a centric diatom combined!!
The dinoflagellate at the bottom will eventually consume the diatom on the top!!

Photo and caption by Dr Paul Hargreaves and Faye Darling.



THANK YOU FOR YOUR ATTENTION !!

http://www.theblogismine.com/2011/04/20/electron-microscope-images-of-diatoms-by-dr-paul-hargreaves-and-faye-darling-big-picture/