The World of Phytoplankton

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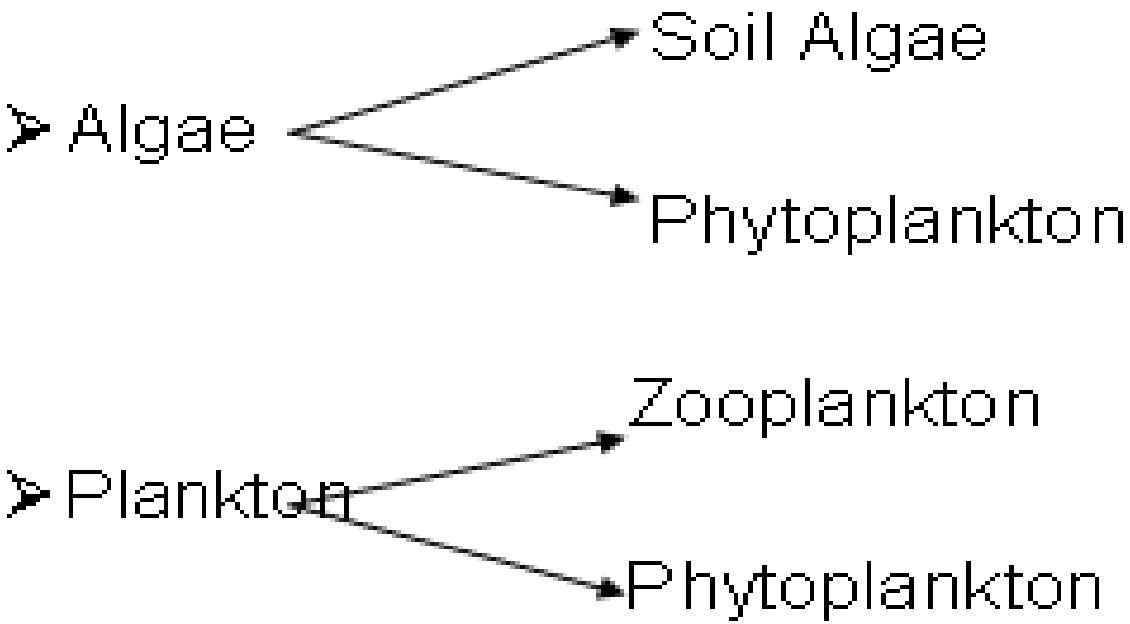
National Research Centre

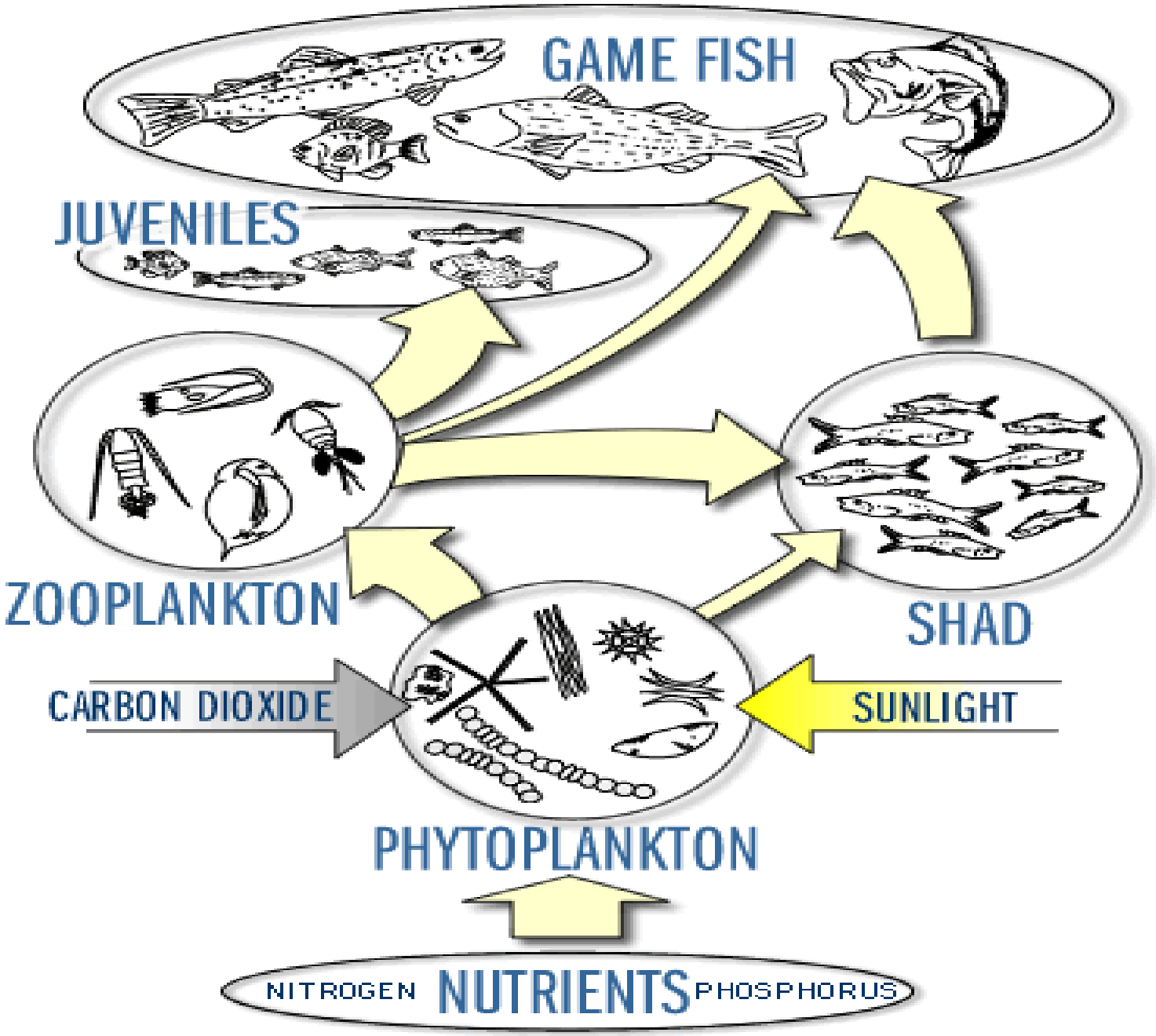
This material was prepared with significant inputs from the GTZ Water and Wastewater Management program

Phycology=Algae



Phytoplankton are found in relatively shallow waters and are usually found in temperate coastal regions. Phytoplankton (microscopic algae) need light and nutrients (e. g. nitrogen, phosphorus and carbon) to grow.

Phytoplankton are the primary producers of the aquatic ecosystem and are the basis of aquatic food chain. Therefore incredibly important to the aquatic ecosystems.


GAME FISH
JUVENILES
ZOOPLANKTON
SHAD
CARBON DIOXIDE
SUNLIGHT
PHYTOPLANKTON
NITROGEN
NUTRIENTS
PHOSPHORUS

Phytoplankton Taxonomy

Taxonomic Composition of Algae (Divisions and Classes):

Prokaryotic algae

Division Cyanophyta blue green algae

Eukaryotic algae

Division Chlorophyta (Green Algae)

Division Euglenophyta (Euglenoids)

Division Phaeophyta (Brown Algae)

Division Chyrsophyta

Division Bacilariophyta

Division Pyrrhophyta

Divsions Rhodophyta

CYANOPHYTA
(Cyanobacteria or Blue-green Algae)

- Only alga with prokaryotic cells (undifferentiated) and only group able to fix atmospheric N.
- Cells lack mitochondria, chloroplasts, internal membranes
- Most are filamentous
- Pigments consist of chlorophyll a, β - carotene, some xanthophylls, and phycobilins, particularly phycocyanin-C (gives them blue- green colour)

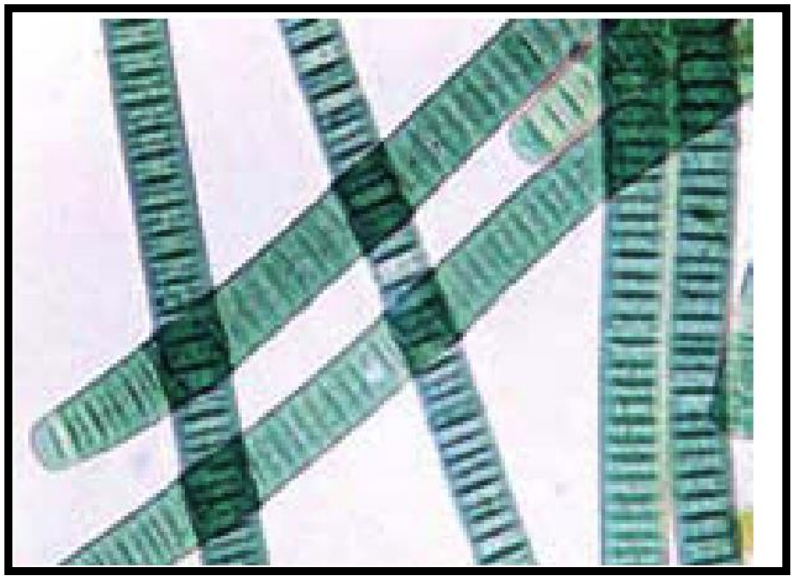
- Cell wall is mucopeptide and many species are surrounded by a gelatinous sheath

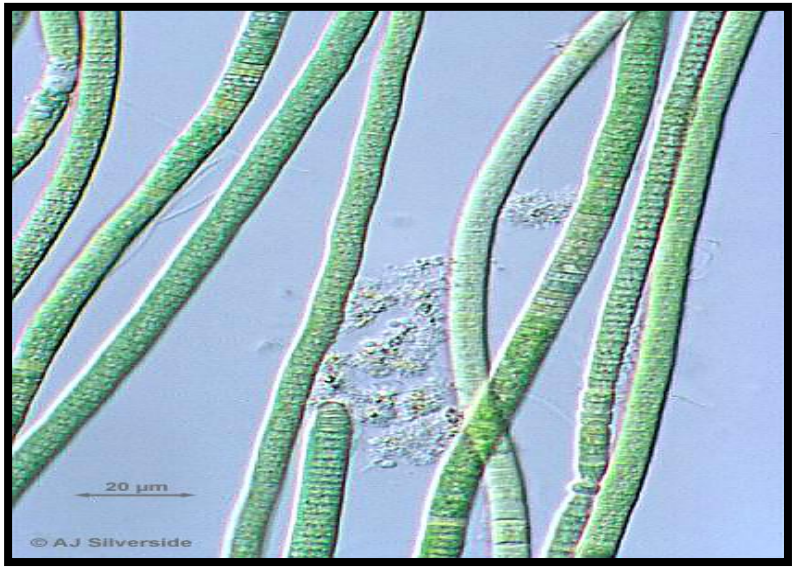
- Vegetative reproduction may be more rapid than in most other phytoplankton.

e.g., ***Anabaena, Oscillatoria, Microcystis, Gleotrichia, Aphanizomeno***n).

Prokaryotic algae

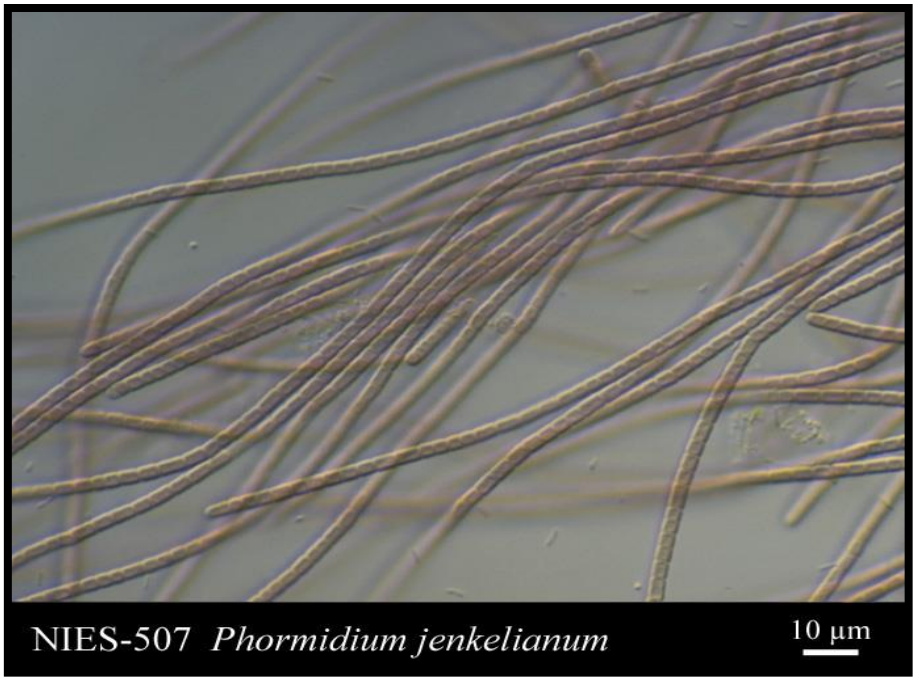
CYANOPHYTA (Cyanobacteria or Blue-green Algae)

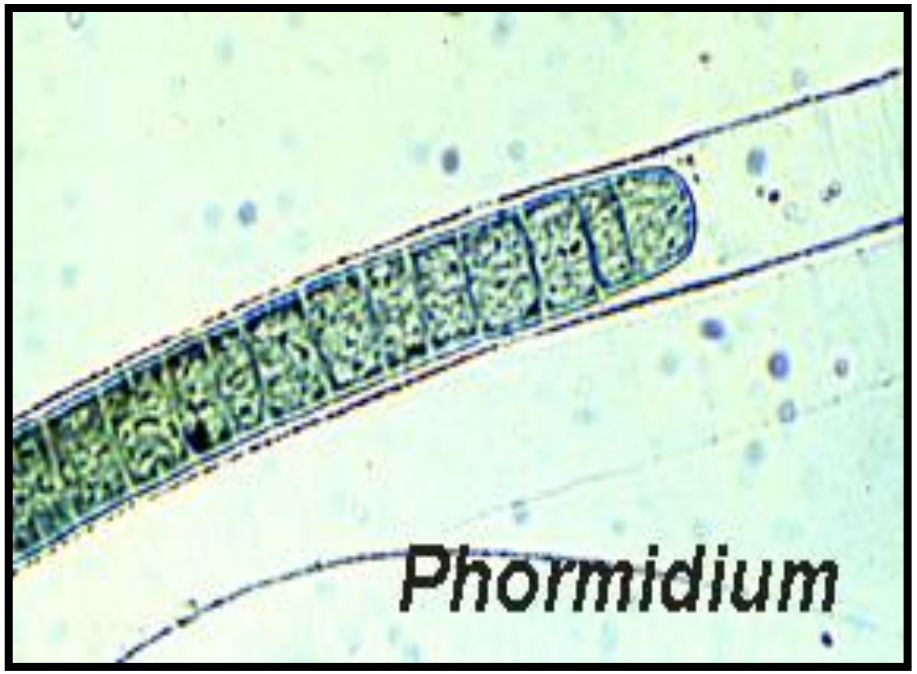




Prokaryotic algae

CYANOPHYTA (Cyanobacteria or Blue-green Algae)





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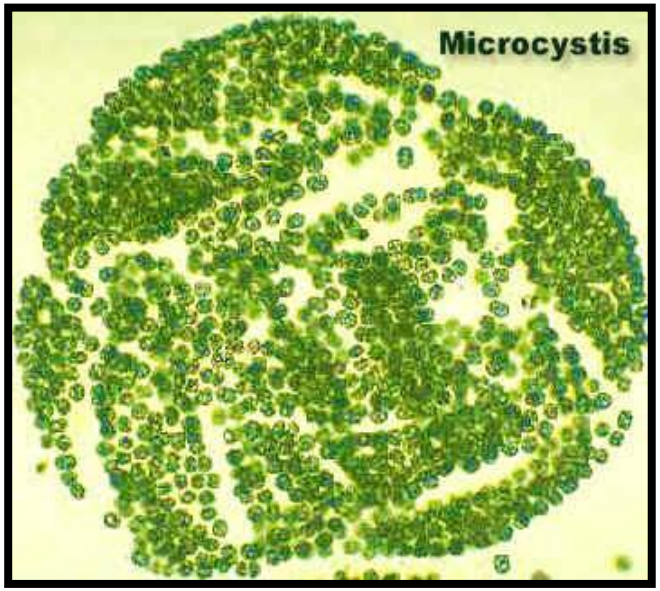

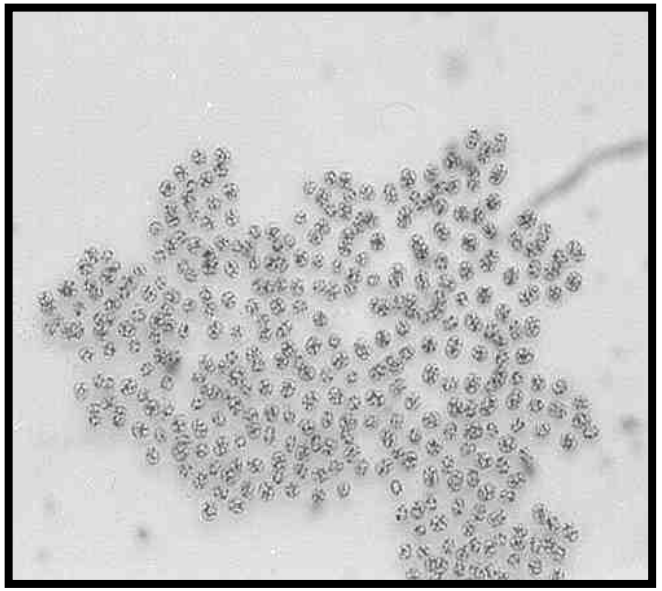

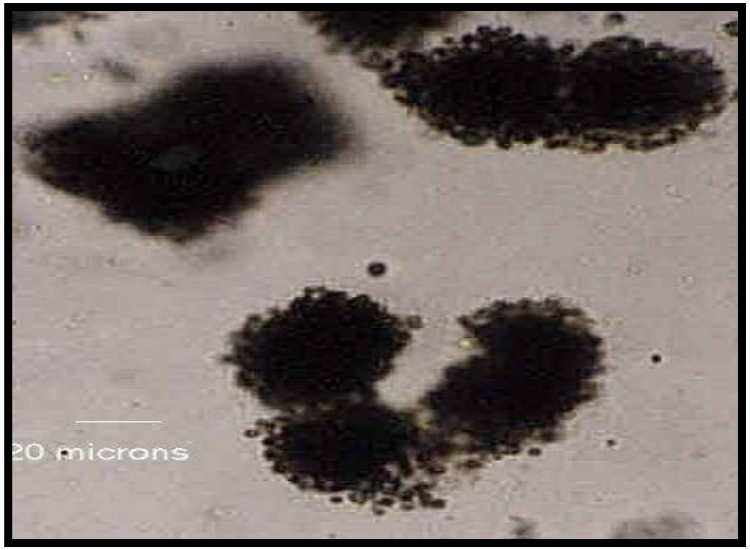

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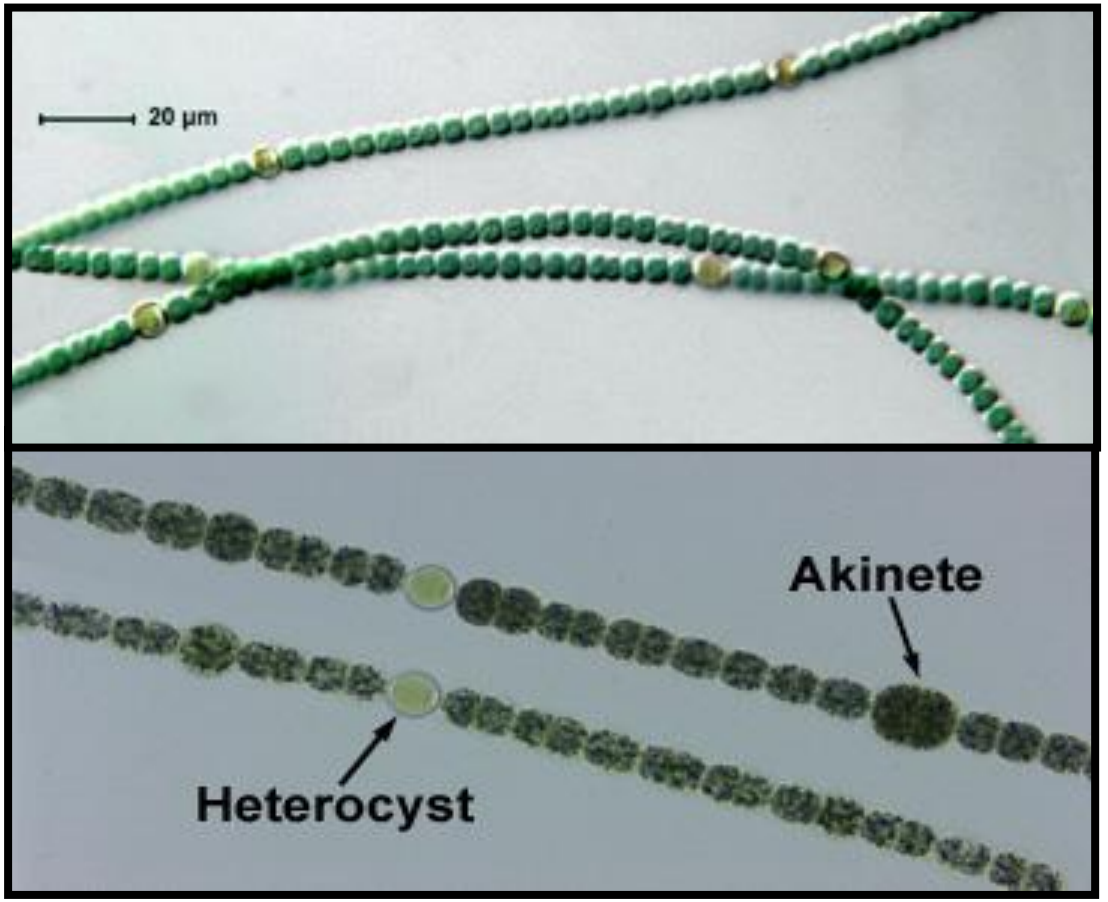

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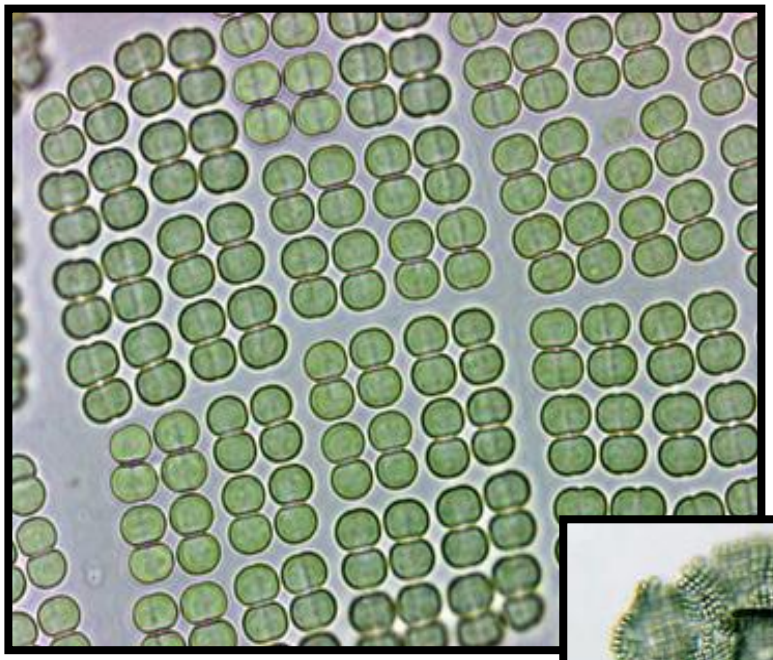

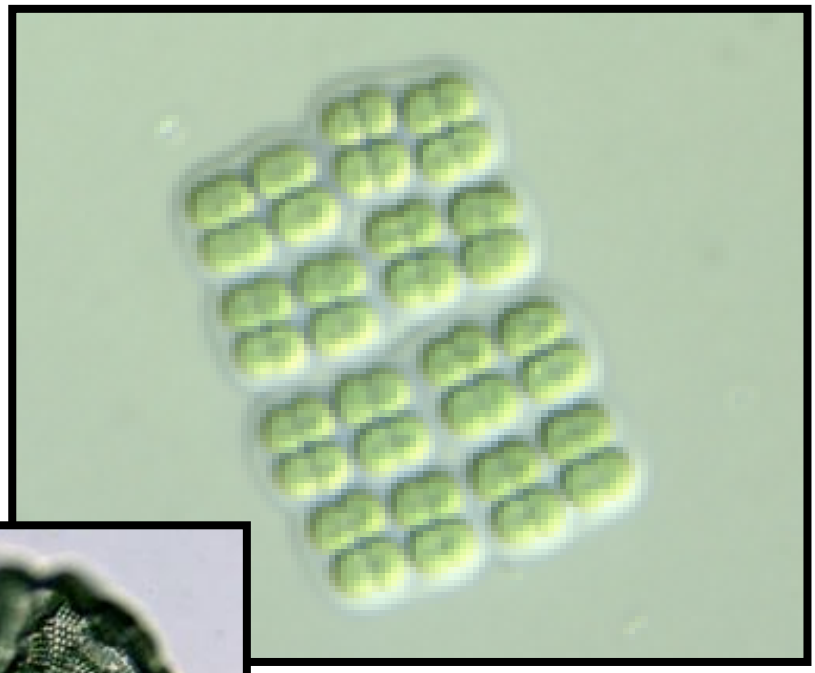

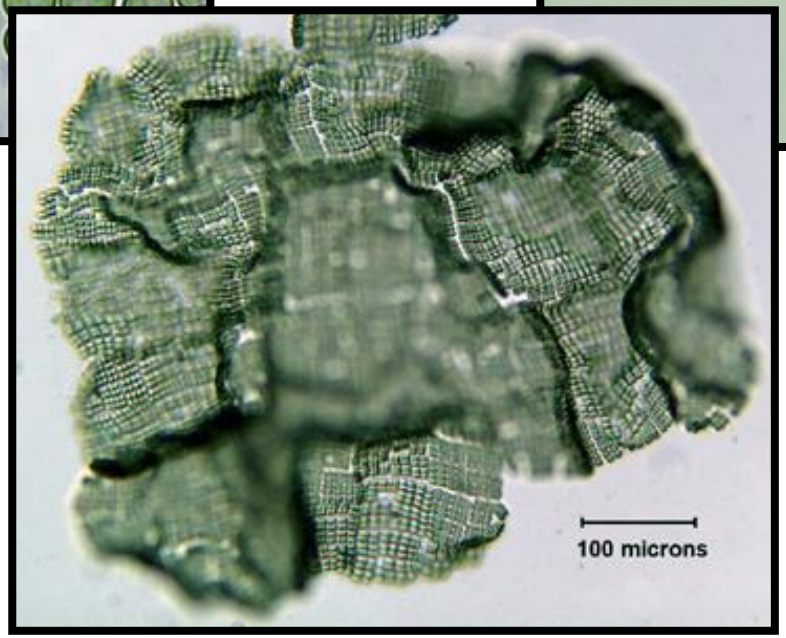

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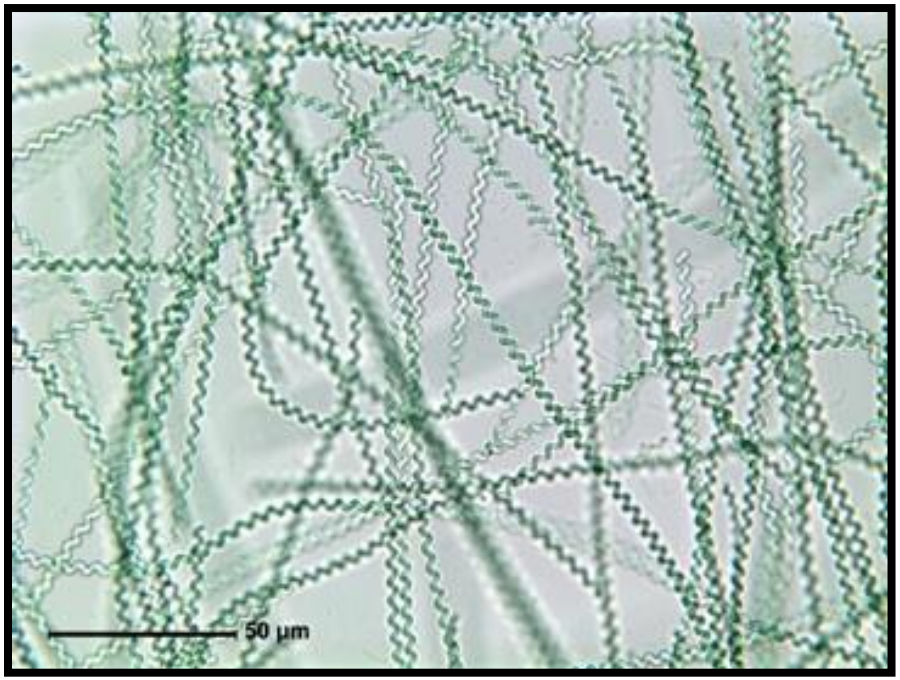

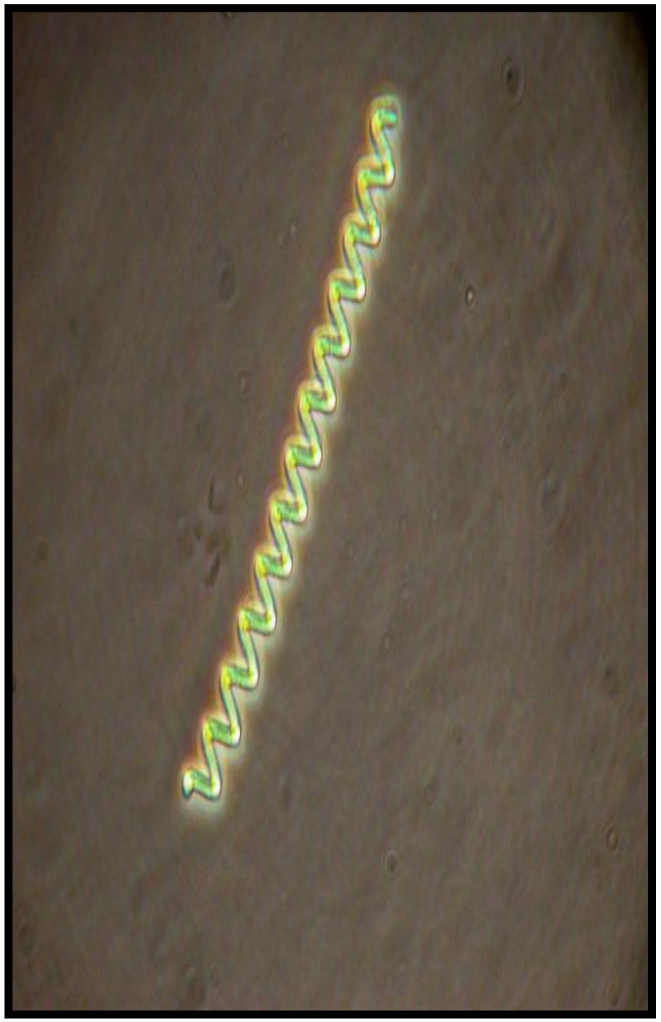

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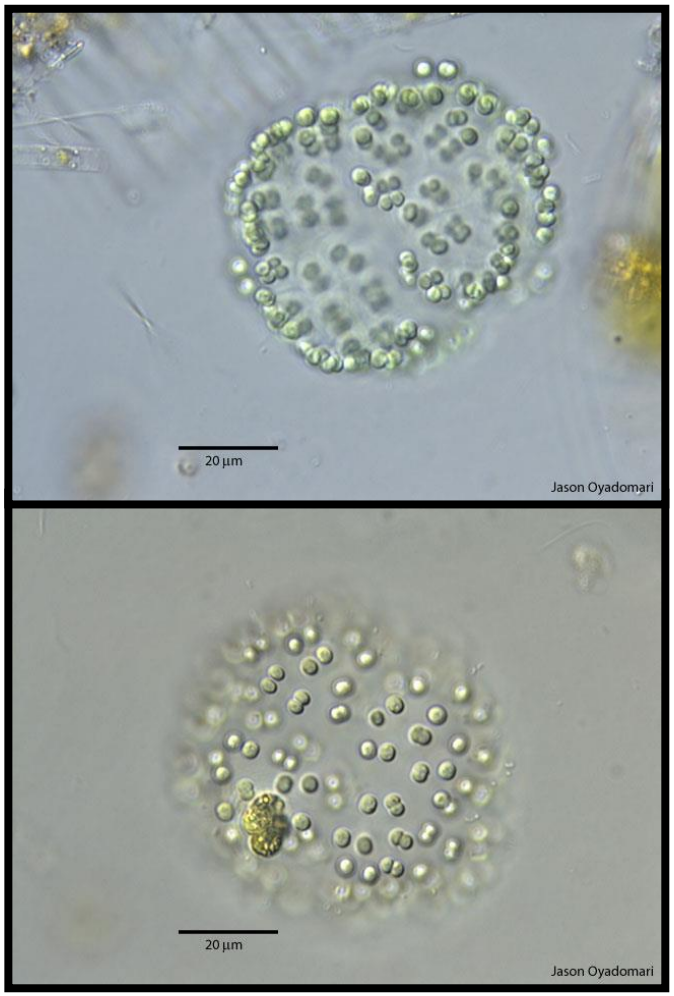
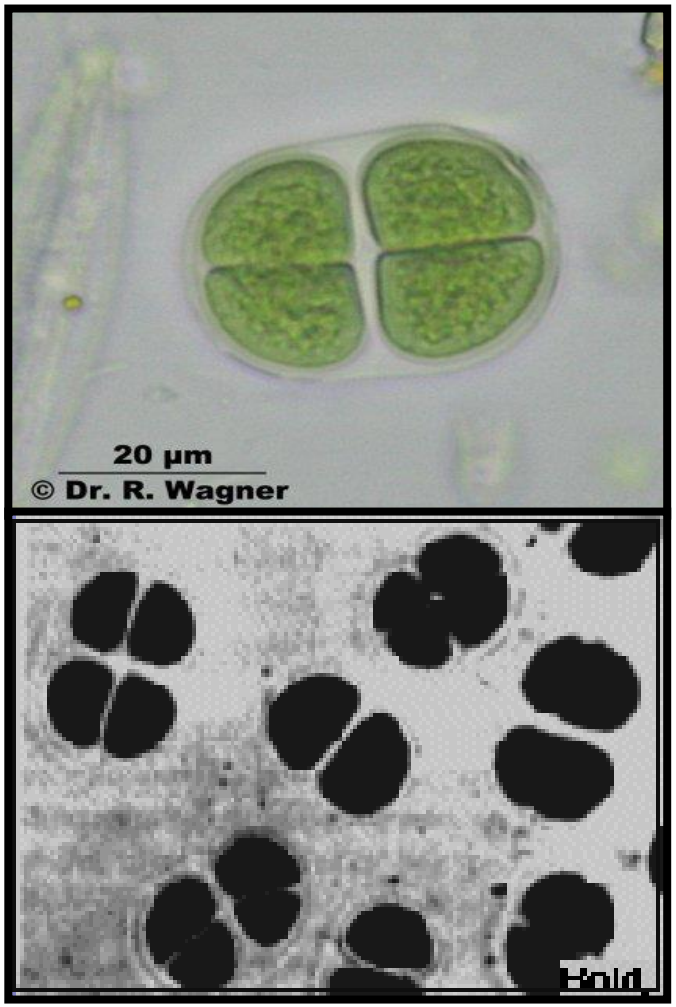




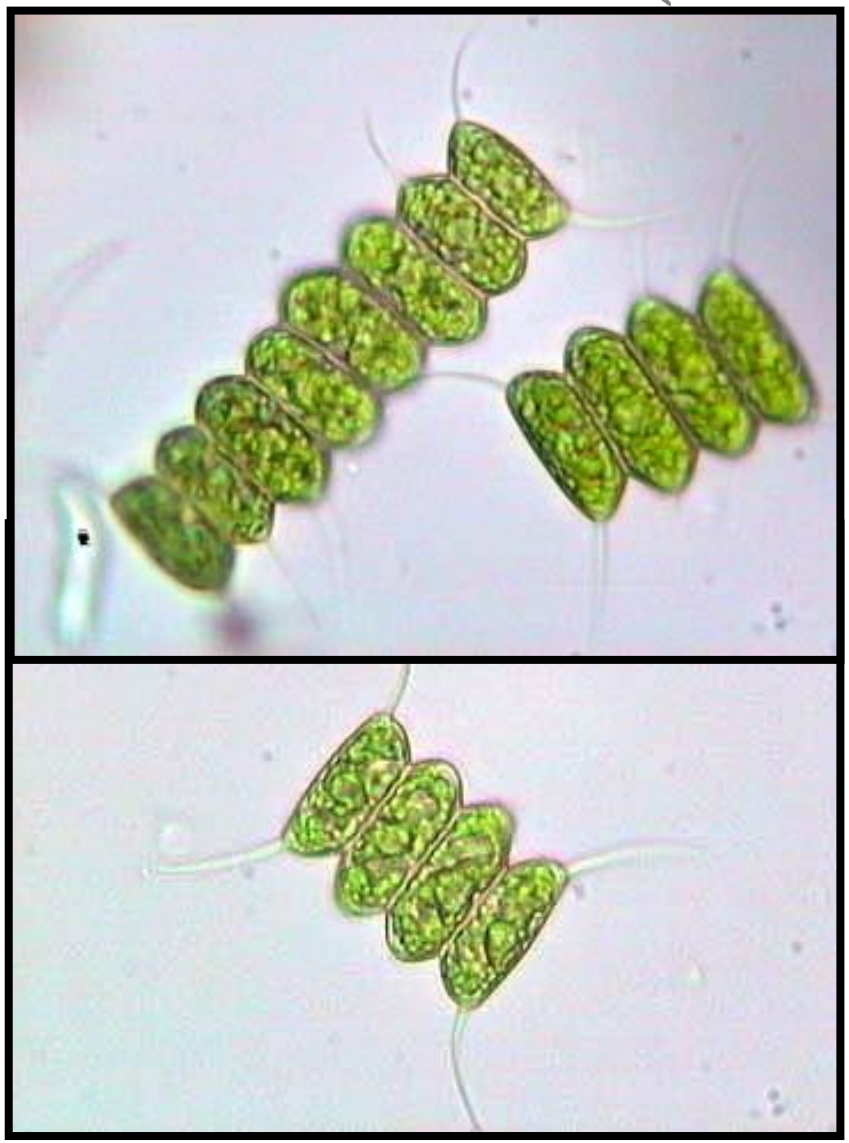
CHLOROPHYTA (Green Algae)

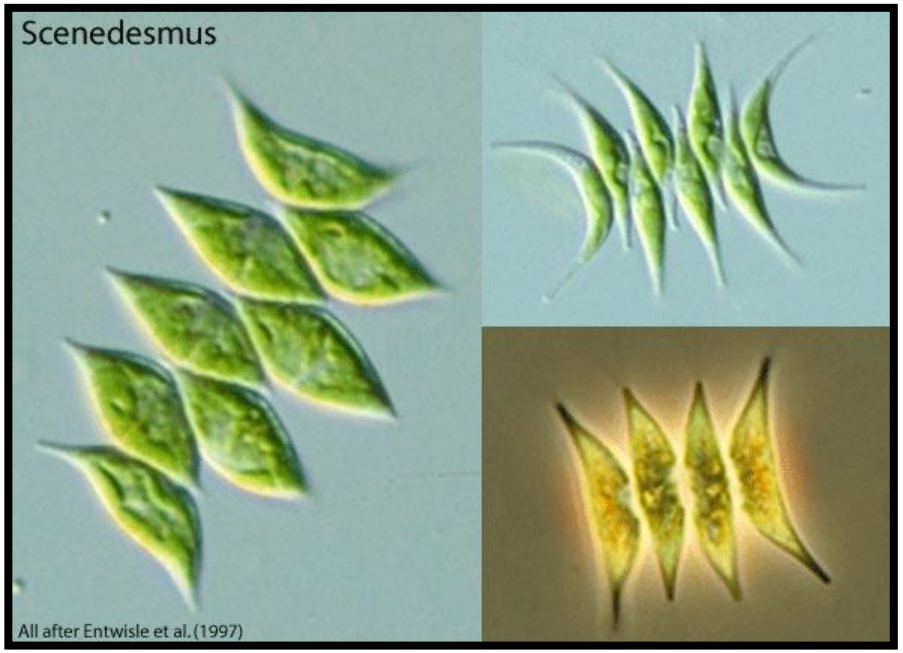
- large and diverse group.
- Pigments consist of chlorophyll a, b, carotenes, and some xanthophylls.
- Cell walls consist of inner cellulose and outer pectinaceous layers.

e.g. *Ulothrix, Chlamydomonas, Scenedesmus, Pediastrum, Eudorina, Ankistrodesmus*,*Spirogyra.*

Eukaryotic algae

CHLOROPHYTA (Green Algae)





Eukaryotic algae

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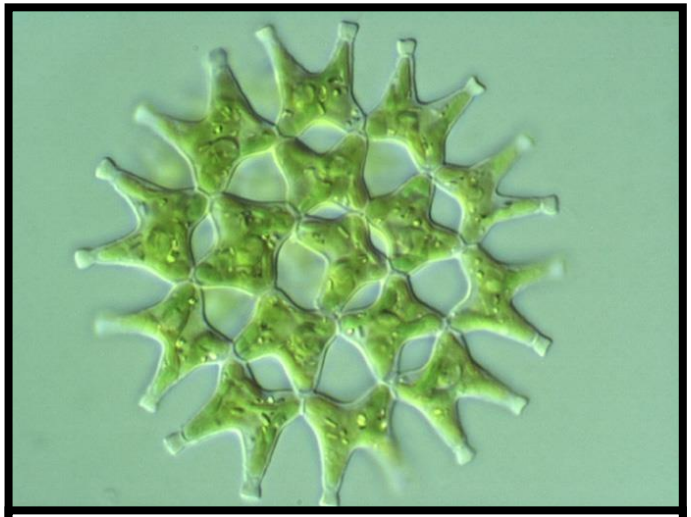

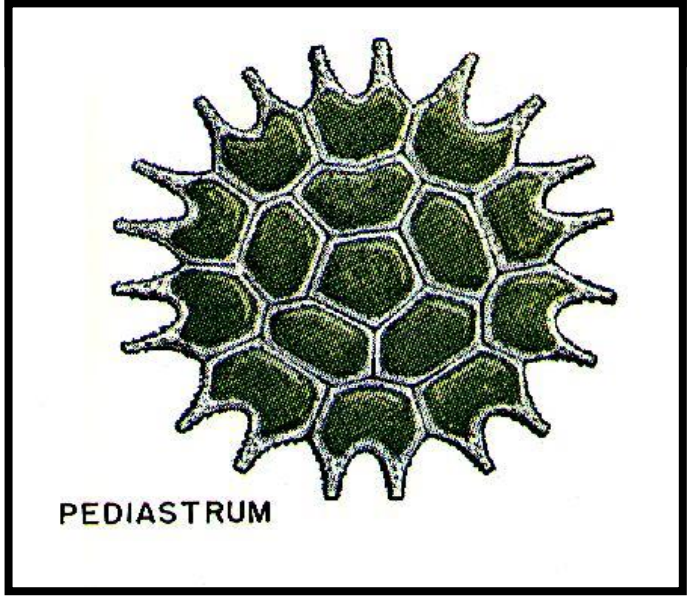

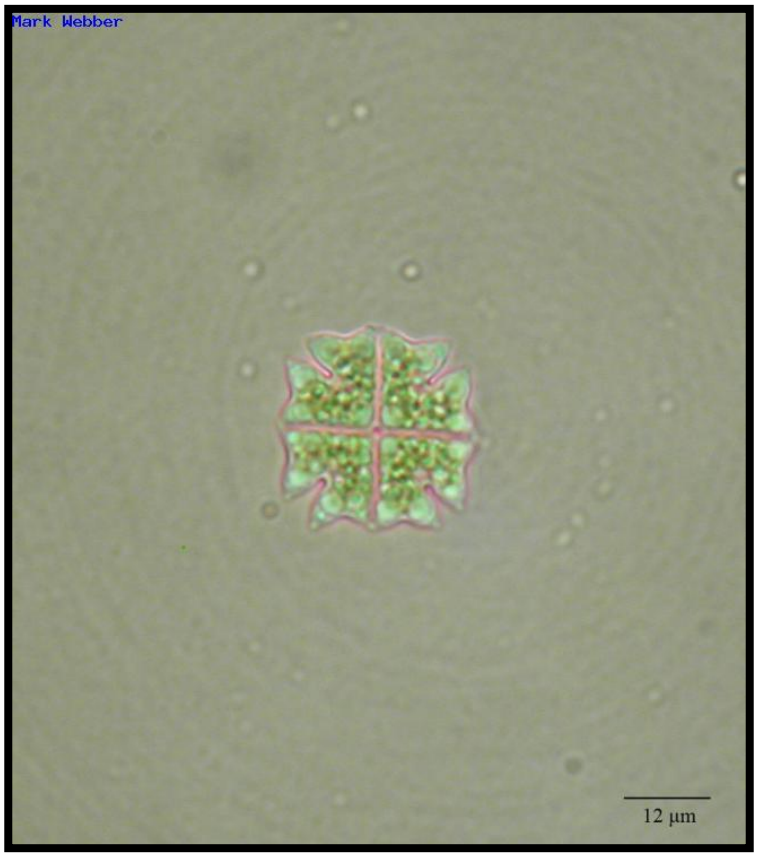

Eukaryotic algae

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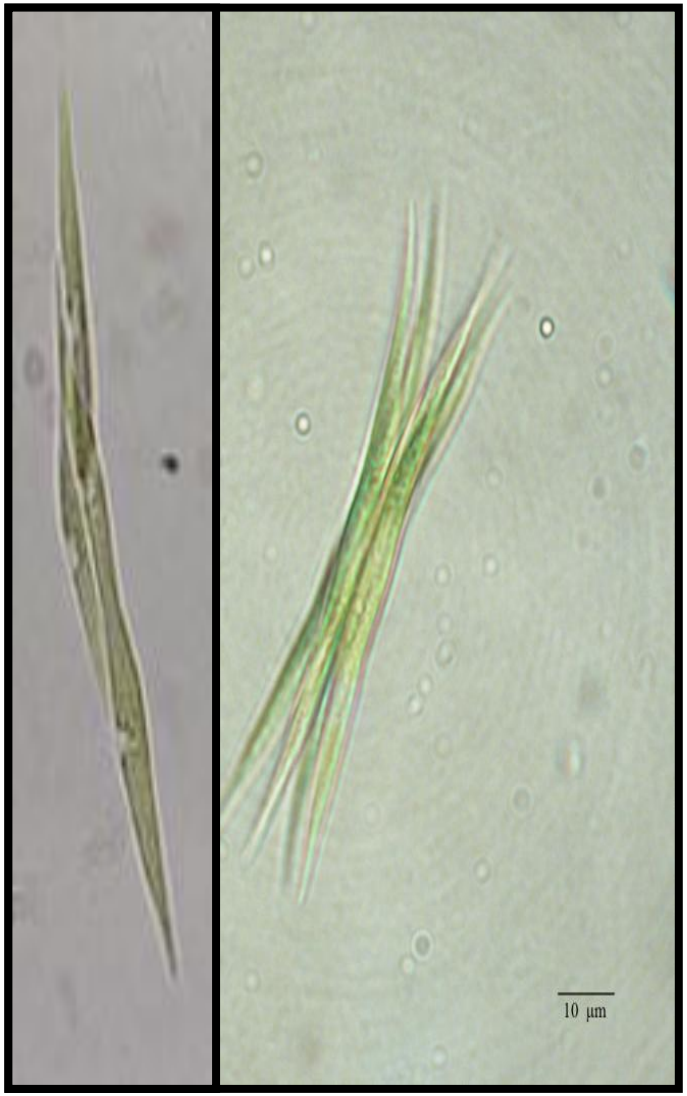

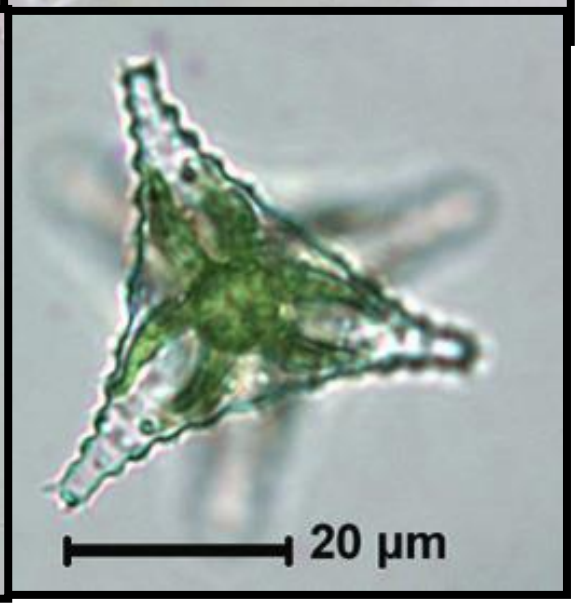

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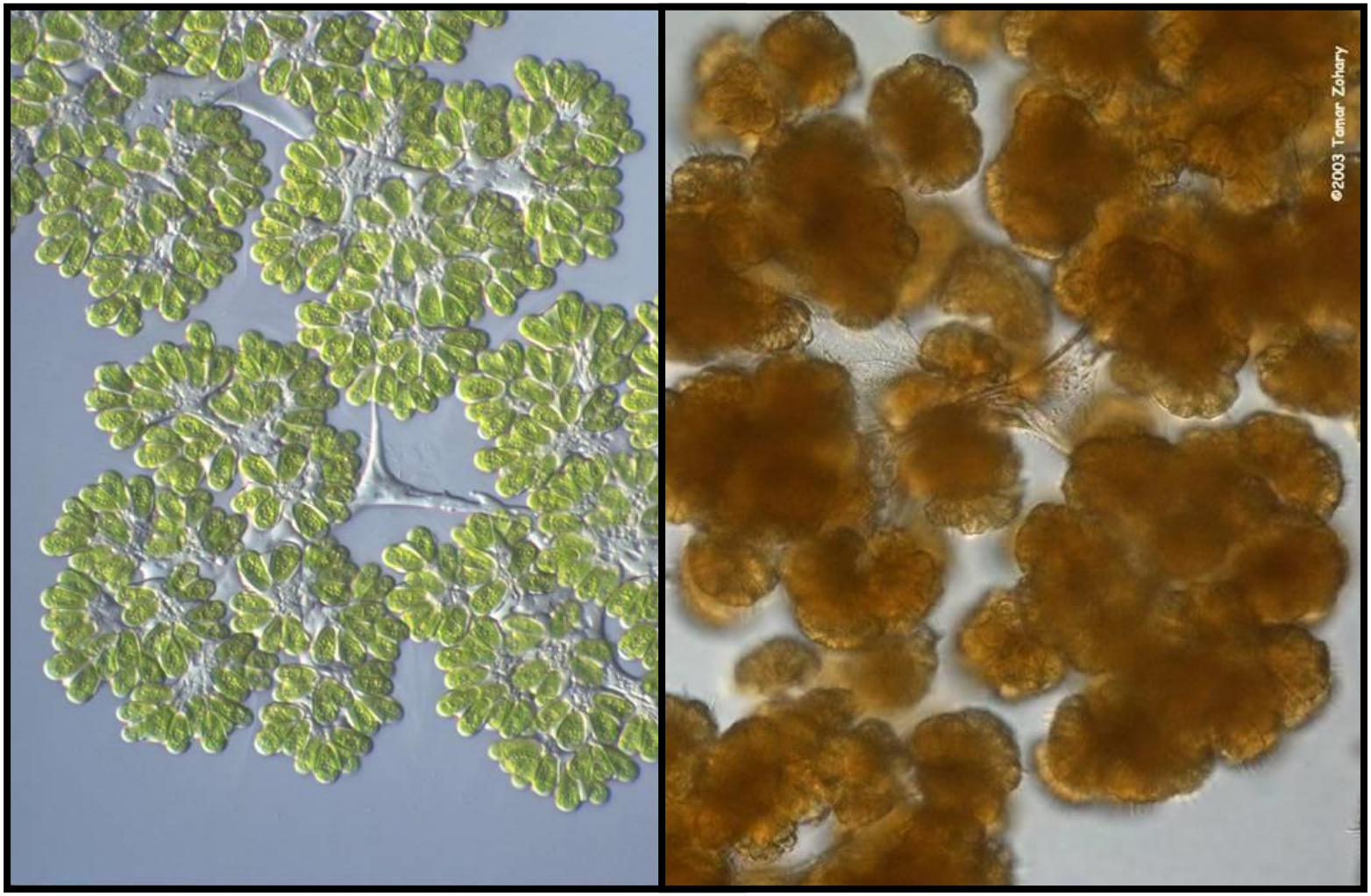

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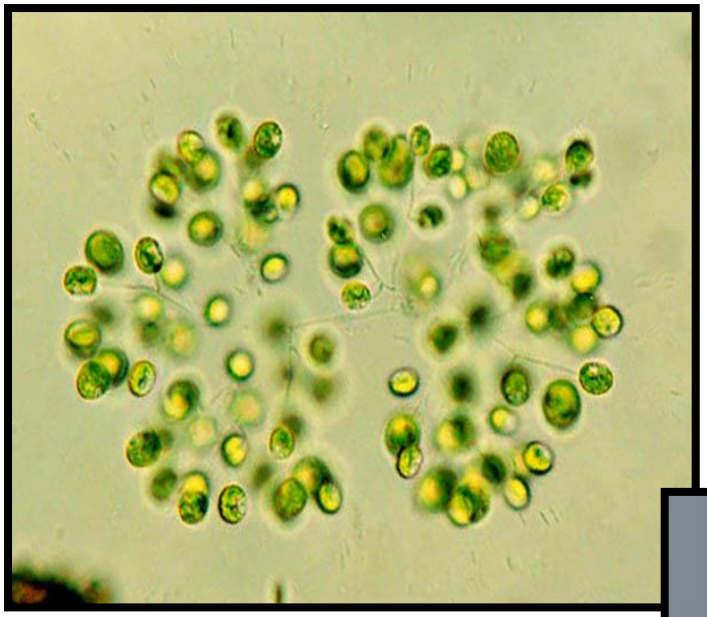

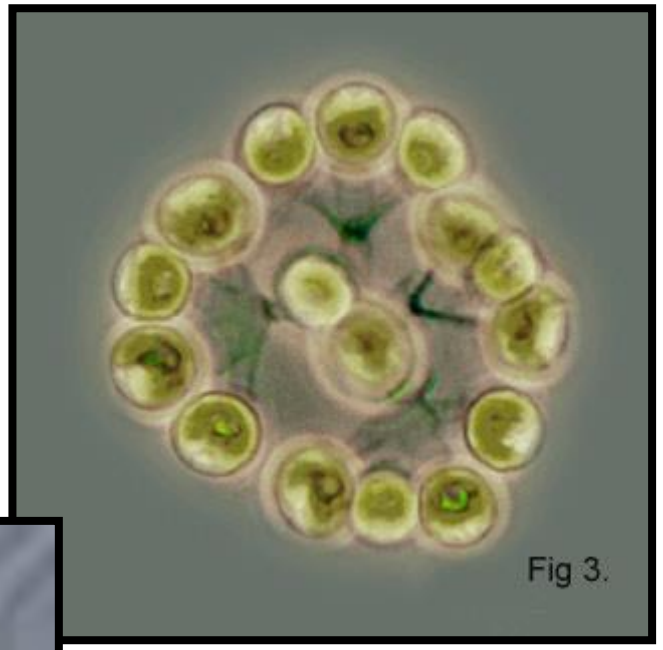

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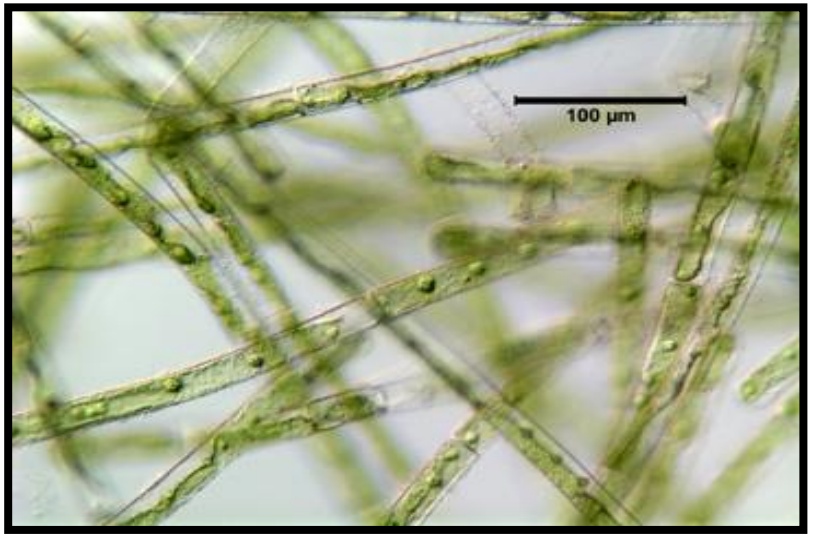

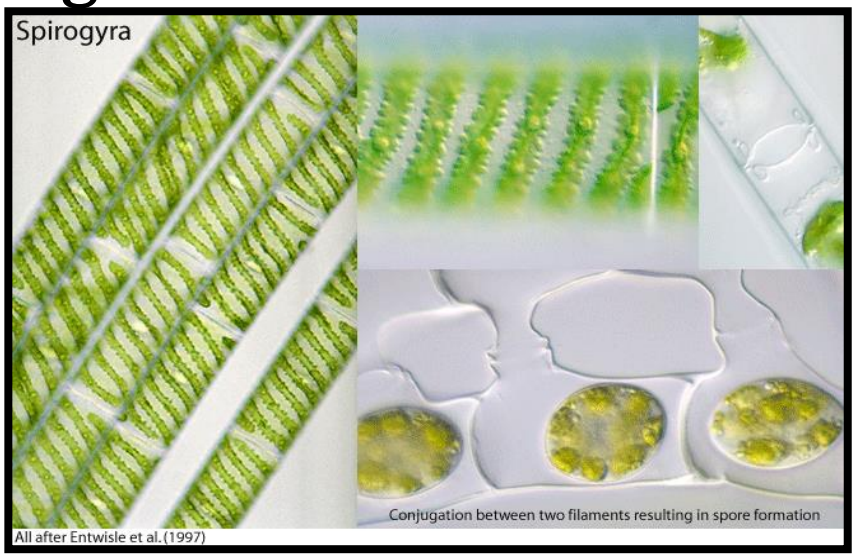

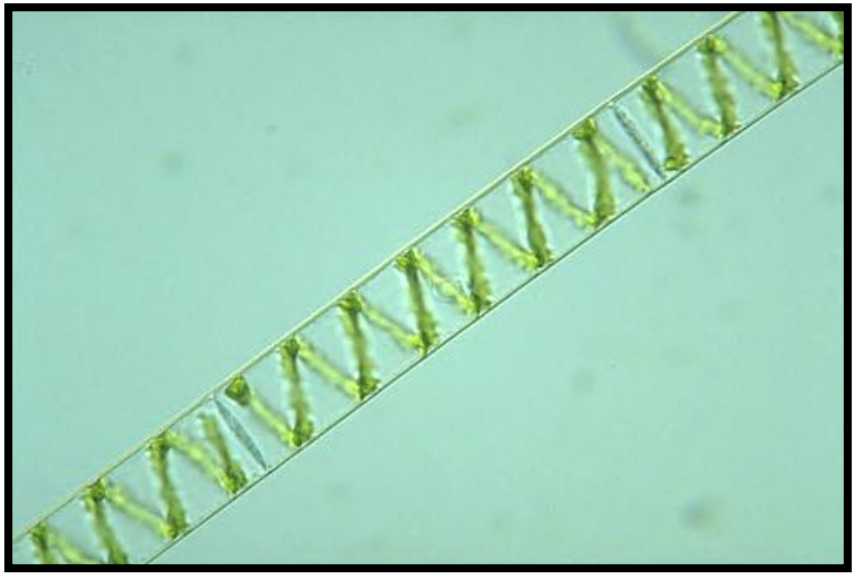

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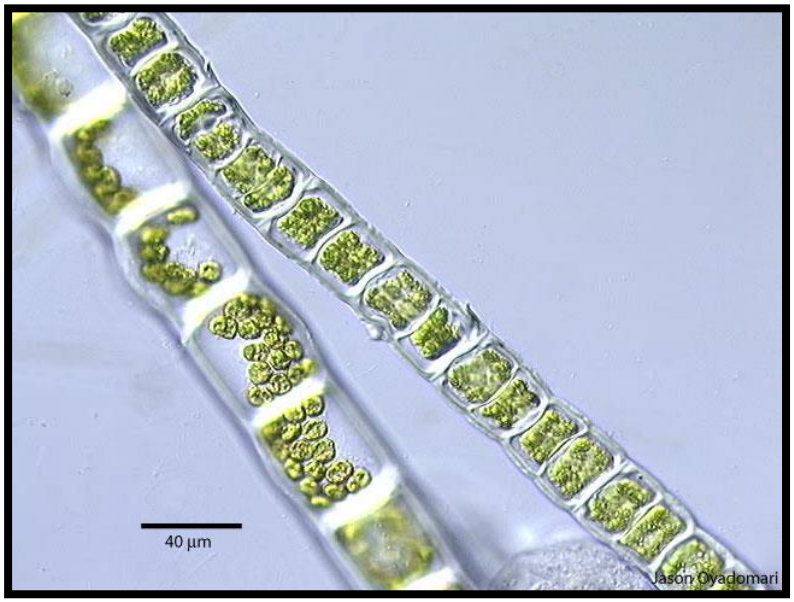

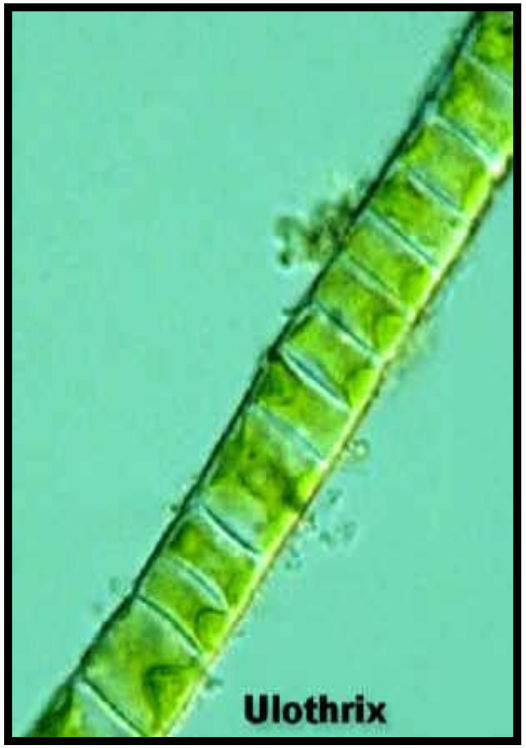

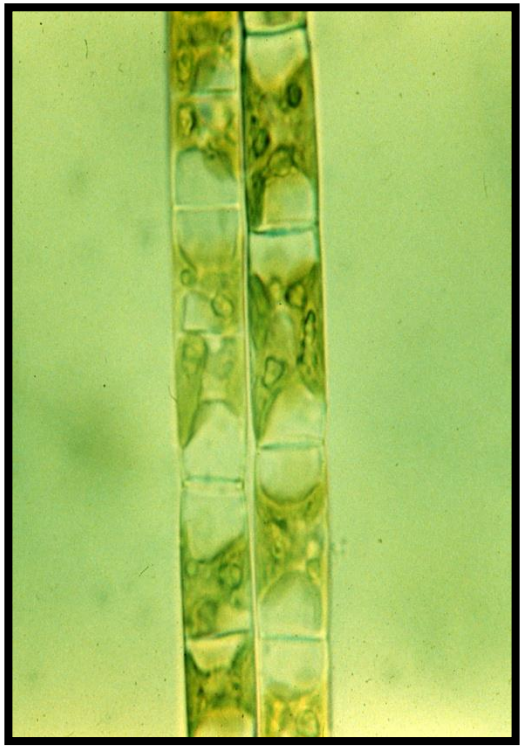

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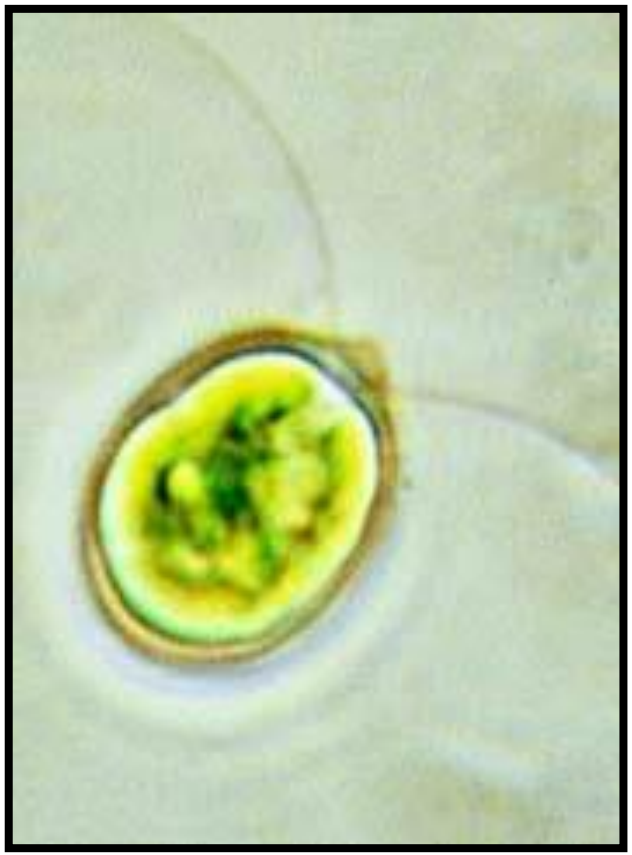

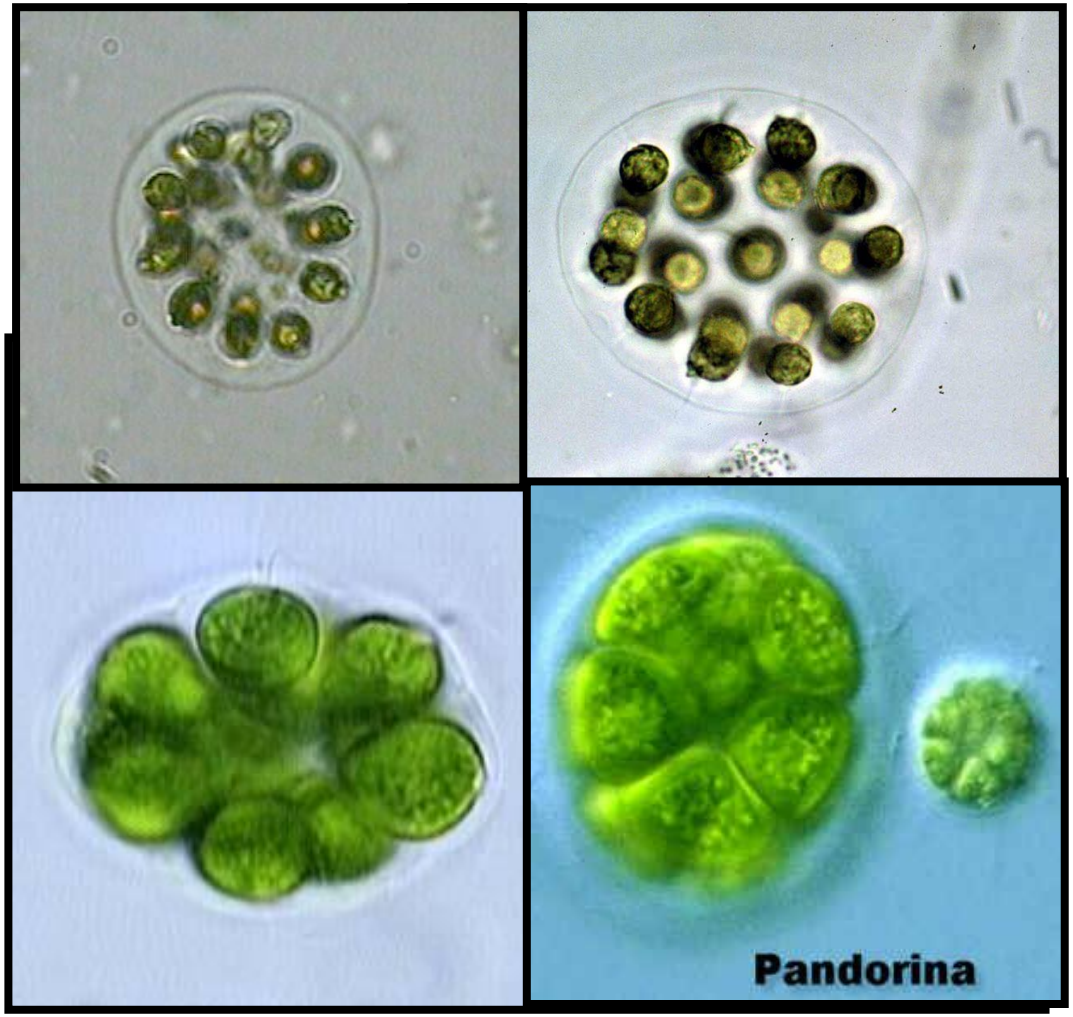

BACILLARIOPHYTA (Diatoms)

- Most important group of algae.
- unicellular and colonial forms.
- Pigments consist of chlorophyll a, c, carotene, and xanthophylls.
- Energy is stored as fat and oil in large globules.
- Cell wall is a silica embedded in pectinaceous matrix and construction consists of overlapping valves, giving a pillbox like.

  e.g. *Asterionella, Cyclotella, Melosira, Fragillaria, Tabellaria, Stephanodiscus, Achnanthes, Synedra, Melosira, Cocconeis, Navicula.*

Eukaryotic algae

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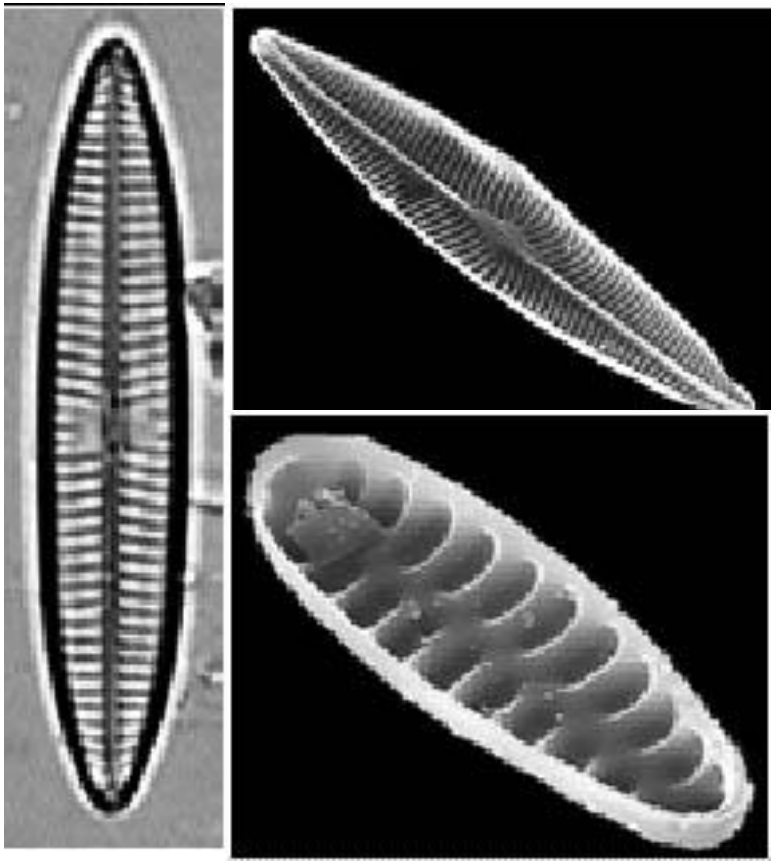

Eukaryotic algae

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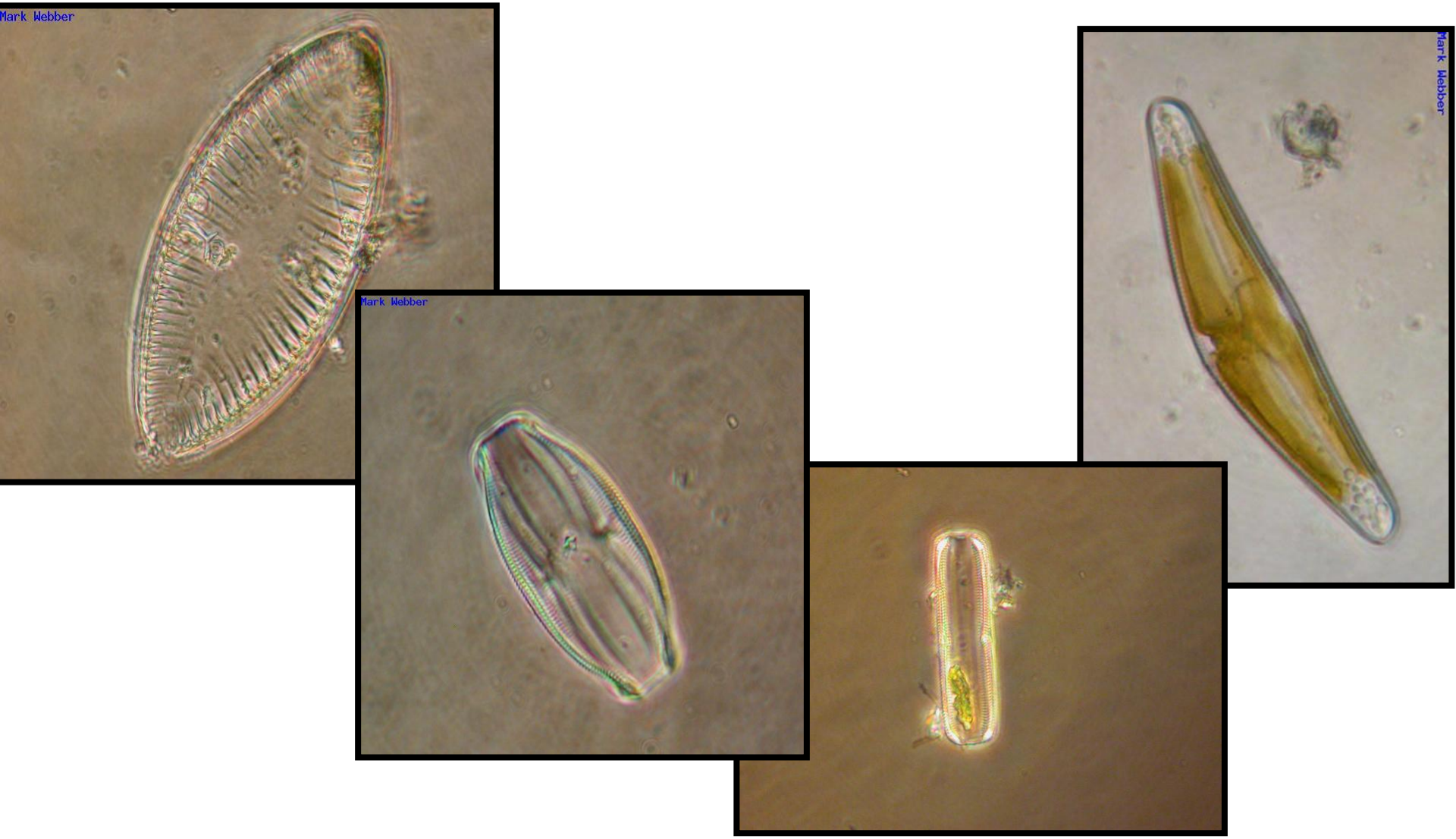

Eukaryotic algae

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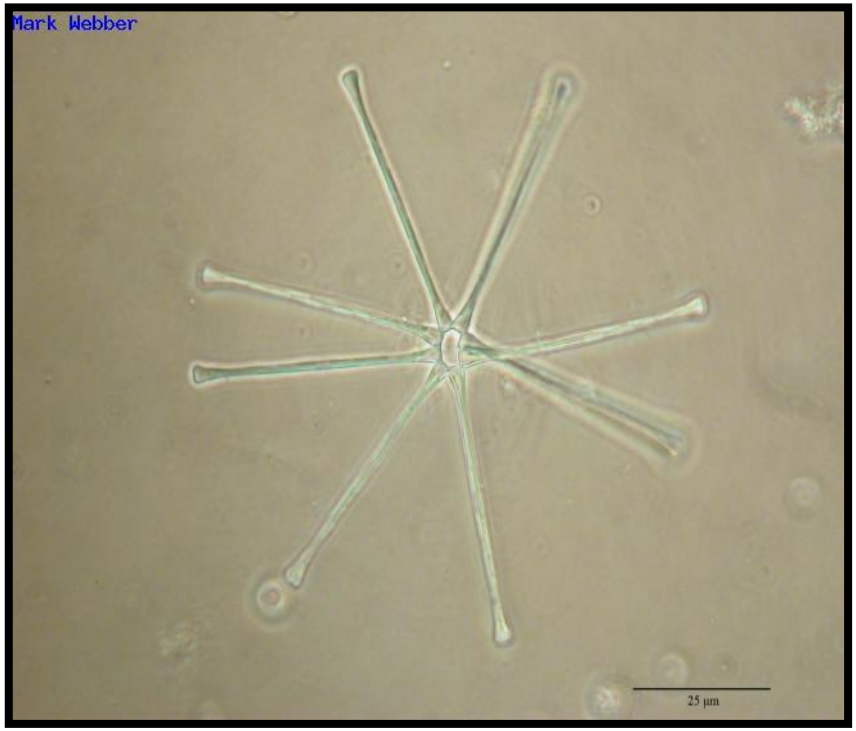

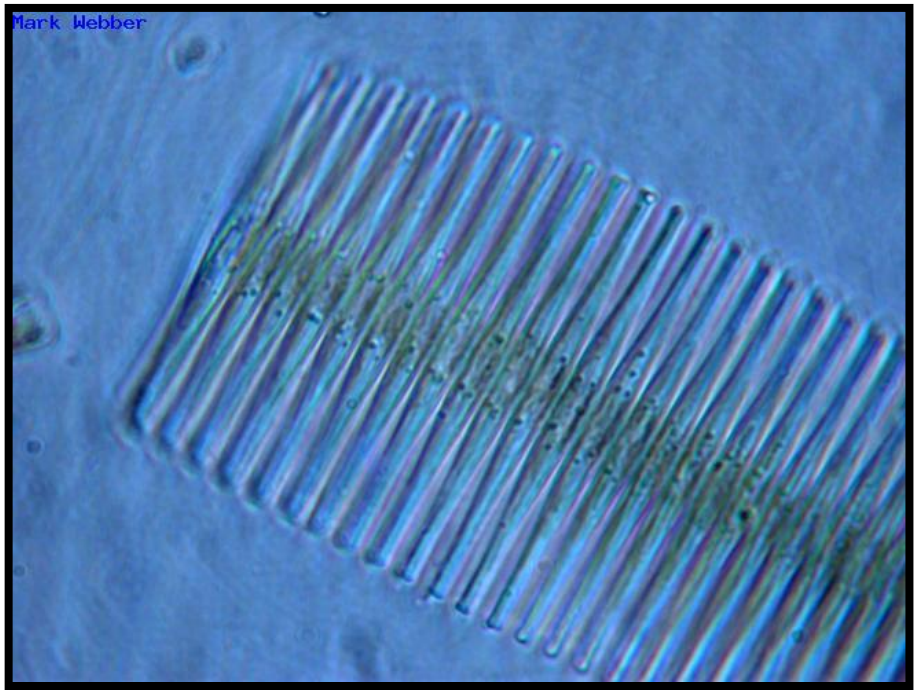

Eukaryotic algae

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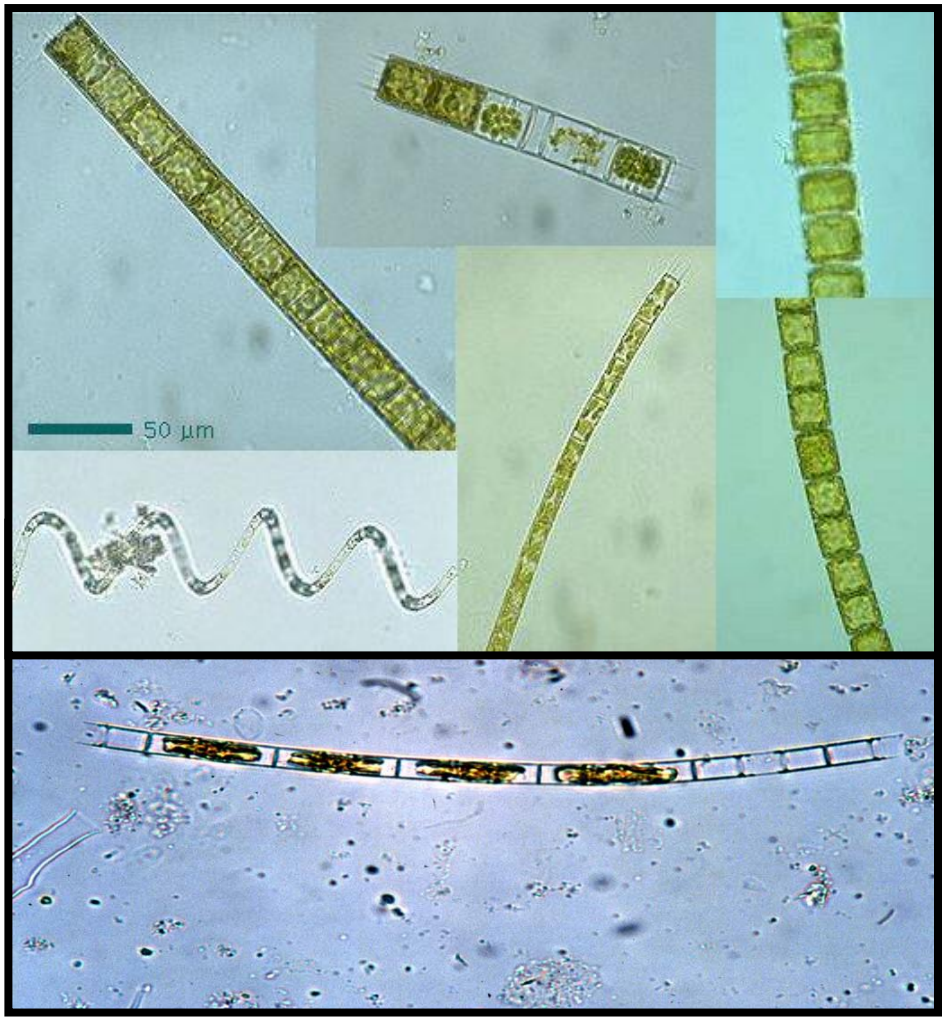

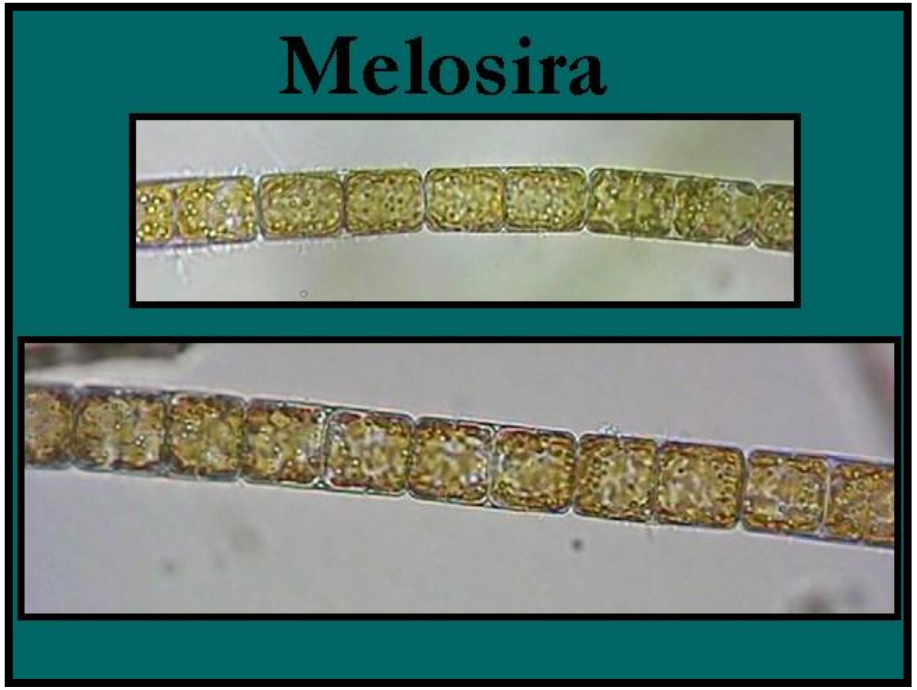

Eukaryotic algae

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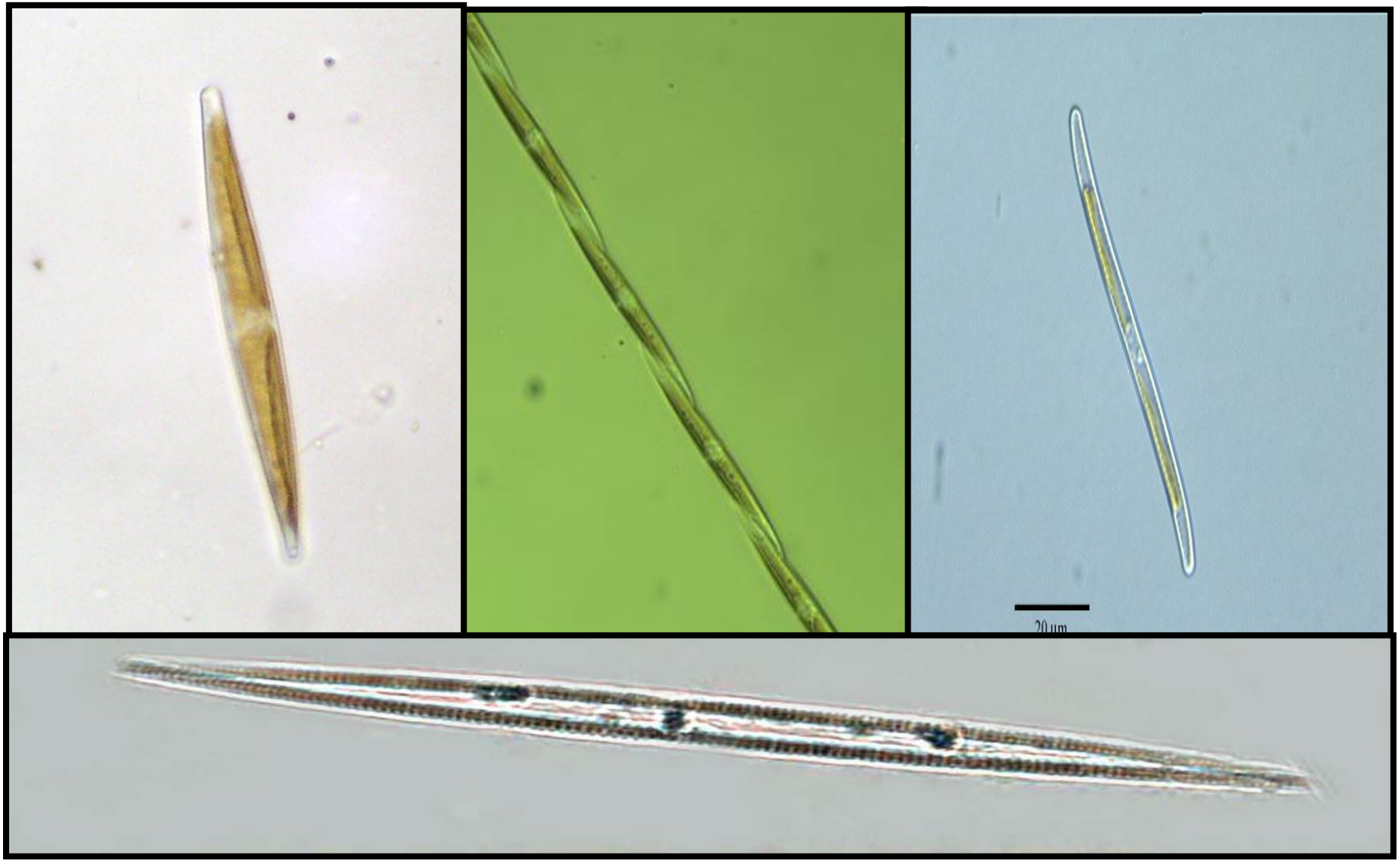

Eukaryotic algae

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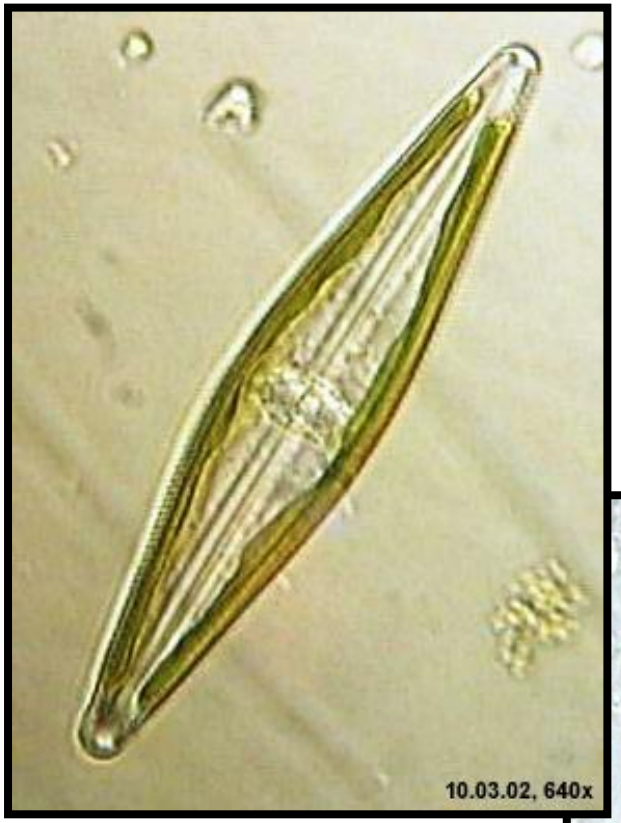


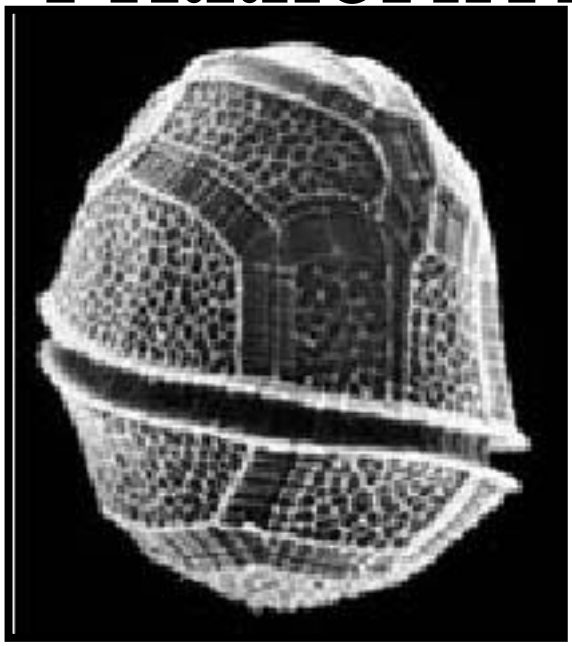
PYRRHOPHYTA (Dinoflagellates)

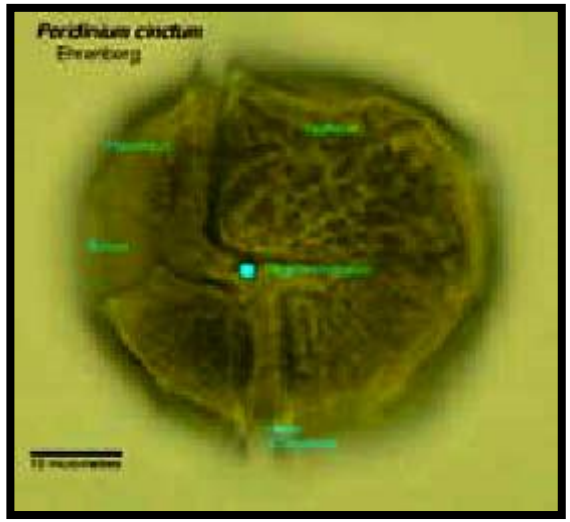
- Unicellular flagellated algae, many of which are motile.
- Most have conspicuous cell wall elaborated with sculptured patterns and formation of large spines and cell wall processes.
- Transverse and longitudinal furrows in cell surface connect and contain flagella which allow weak movement.
- Most species are specific to particular range of Ca, pH, DOM and temperature.

e.g. *Ceratium, Gymnodinium, Peridiniu*m

Eukaryotic algae

PYRRHOPHYTA (Dinoflagellates)



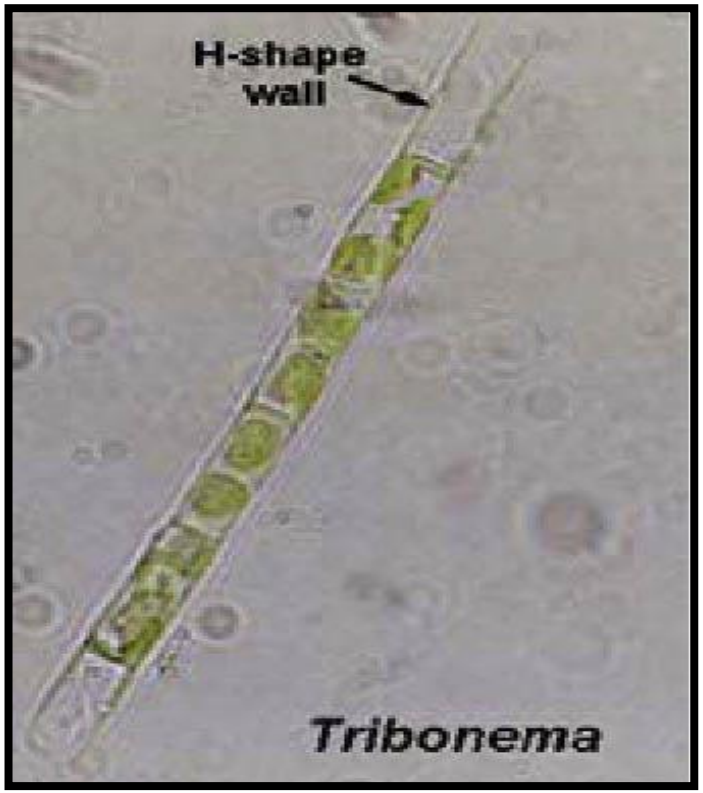


CHRYSOPHYTA (Golden-brown Algae)

- color is due to dominance of β-carotene and some xanthophyll carotenoids in addition to chlorophyll a.
- Unicellular - few are colonial.
- Many lack cell walls and are bound only by cytoplasmic membranes.
- Some colonial forms such as *Synura, Uroglen*a, and *Dinobryon* are widely distributed and often major components of phytoplankton, especially when [P] is low.
- *Dinobryon* and *Uroglena* have obligate nutritional requirements for low [P].

Eukaryotic algae

CHRYSOPHYTA (Golden-brown Algae)



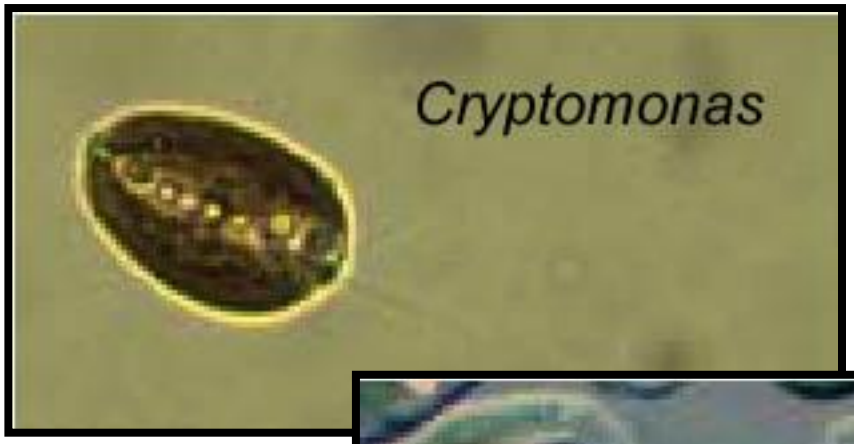
CRYPTOPHYTA (Cryptomonads)

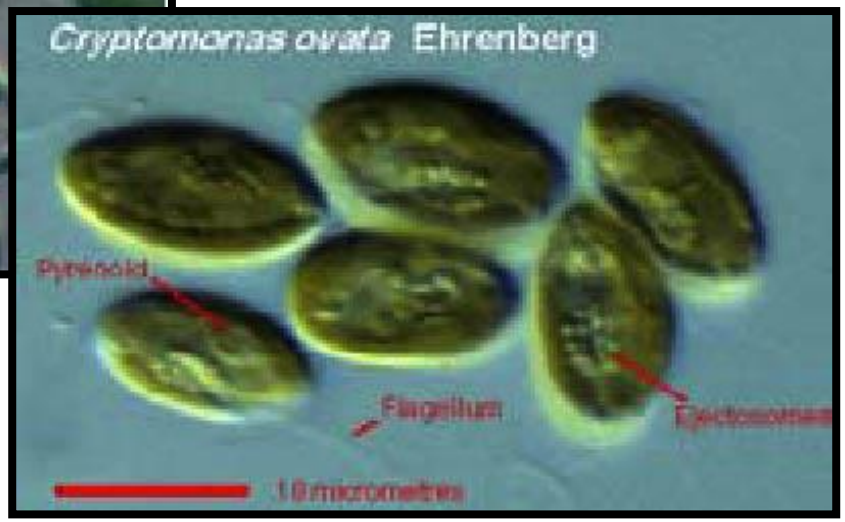
- Most species are naked, unicellular, and motile.
- Usually flattened dorso-ventrally, with anterior invagination with 2 equal length flagella.
- Reproduction is due to longitudinal division.
- Sexual reproduction is unknown as are many facets of life cycle.

e.g. *Cryptomonas, Rhodomonas, Chroomonas*.

Eukaryotic algae

CRYPTOPHYTA (Cryptomonads)





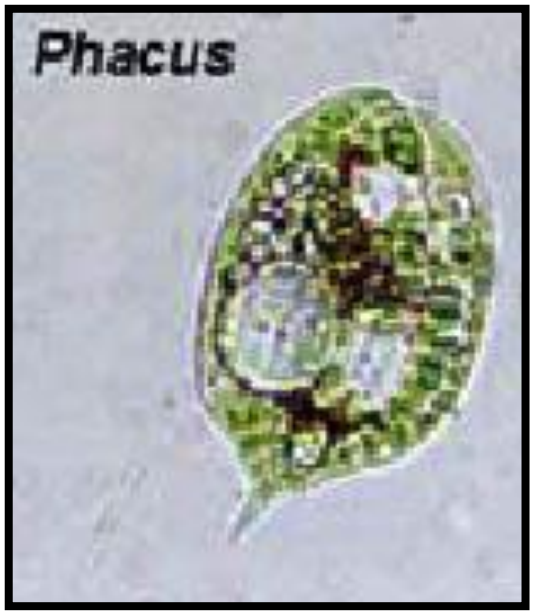
EUGLENOPHYTA (Euglenoids)

- Relatively large and diverse group but few species are truly planktonic.
- Most are unicellular but lack a cell wall and possess 1-3 flagella arising from an invagination of the external membrane.
- Most are P/S and facultative heterotrophs.
- Nutrition is supplemented by the uptake of ammonia and DON.
- Euglenoids are found most often in seasons, depth strata, or lake systems in which ammonia and especially [DON] are high.

e.g. *Euglena, Phacus*

Eukaryotic algae

EUGLENOPHYTA (Euglenoids)



Eukaryotic algae

Rhodophyta

Class Rhodophyceae - red algae

Example: Batrachospermum

Growth Characteristics of Algae

Factors Affecting The Growth Rate of Algae

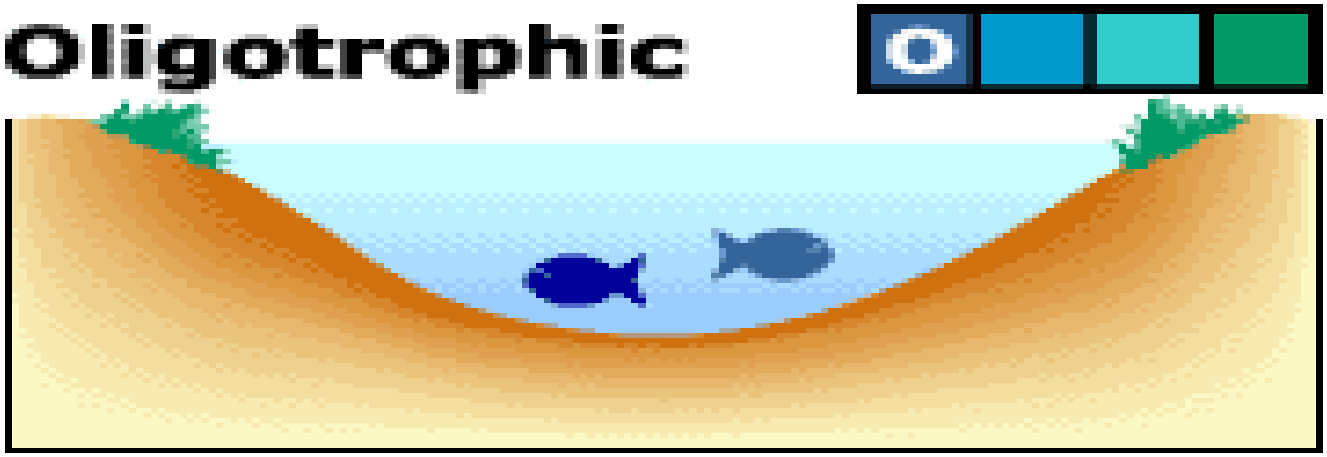
- Light
- Temperature
- Inorganic nutrients: especially
  - Phosphorus
  - Nitrogen
- Organic and inorganic micronutrients
- Biological factors that regulate algae
  - Factors that affect the availability of nutrients
  - Herbivory and parasitism

Increasing attention has been focused on algae that impact the aesthetic quality of drinking water.

Problems created by algae

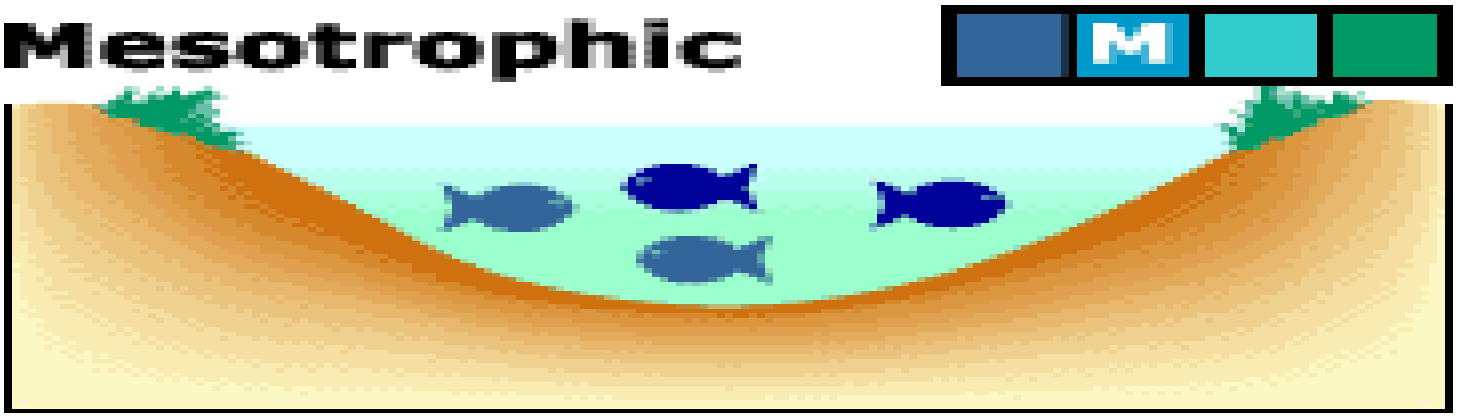
- Problems in water systems.
- Problems in water treatment plants.
- Problems in distribution systems.

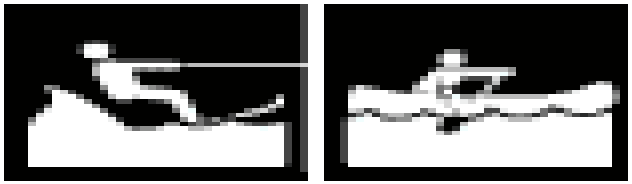
Oligotrophic



Chlorophyll	<3 µg/L
Phosphorus	<15 µg/L
Nitrogen	<400 µg/L
Clarity	>13 feet

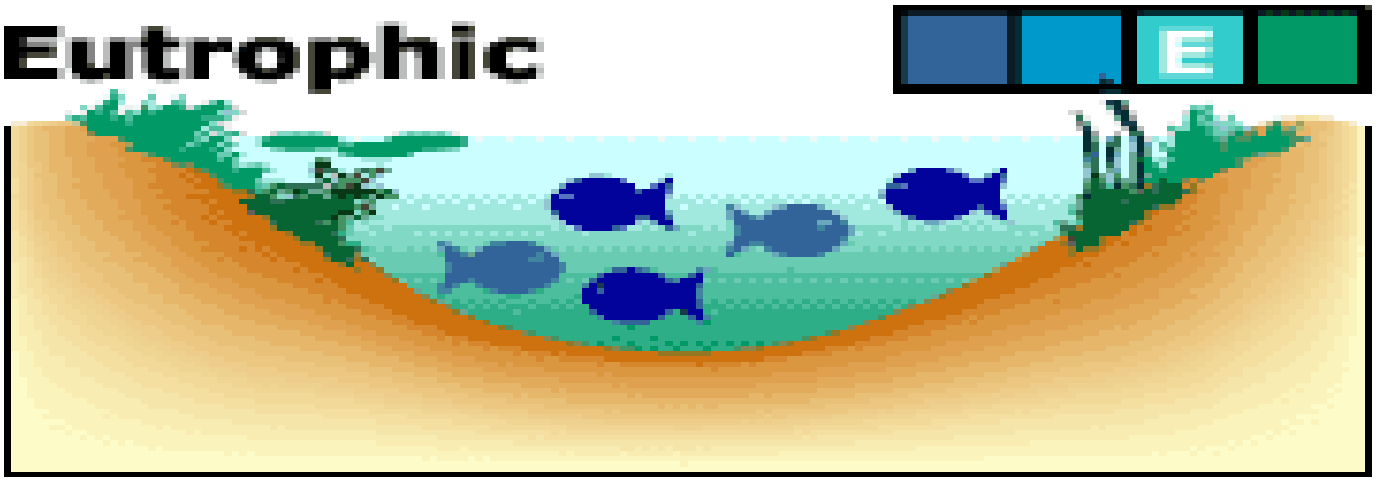
Mesotrophic

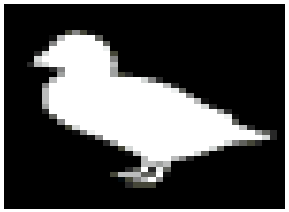


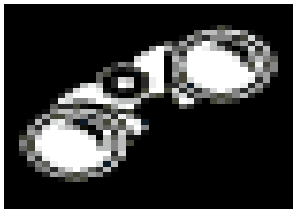


Chlorophyll	3-7 µg/L
Phosphorus	15-25 µg/L
Nitrogen	400-600 µg/L
Clarity	8-13 feet

Eutrophic

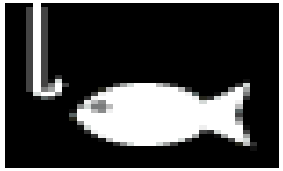


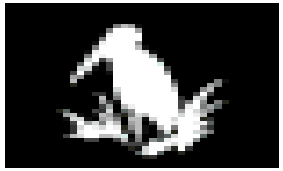




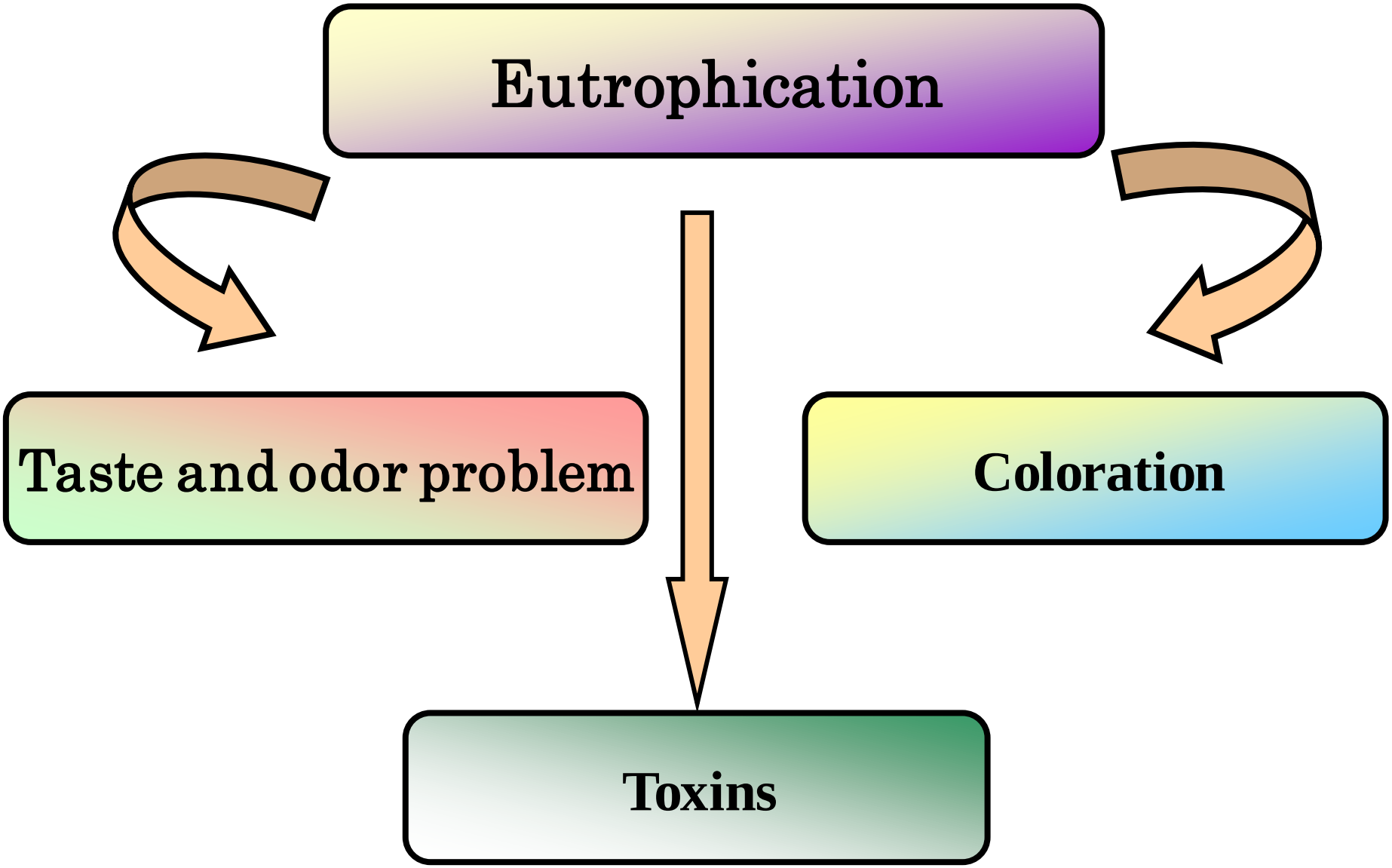
Chlorophyll	7-40 µg/L
Phosphorus	25-100 µg/L
Nitrogen	600-1500 µg/L
Clarity	3-8 feet

Hypereutrophic





Chlorophyll	>40 µg/L
Phosphorus	>100 µg/L
Nitrogen	>1500 µg/L
Clarity	<3 feet

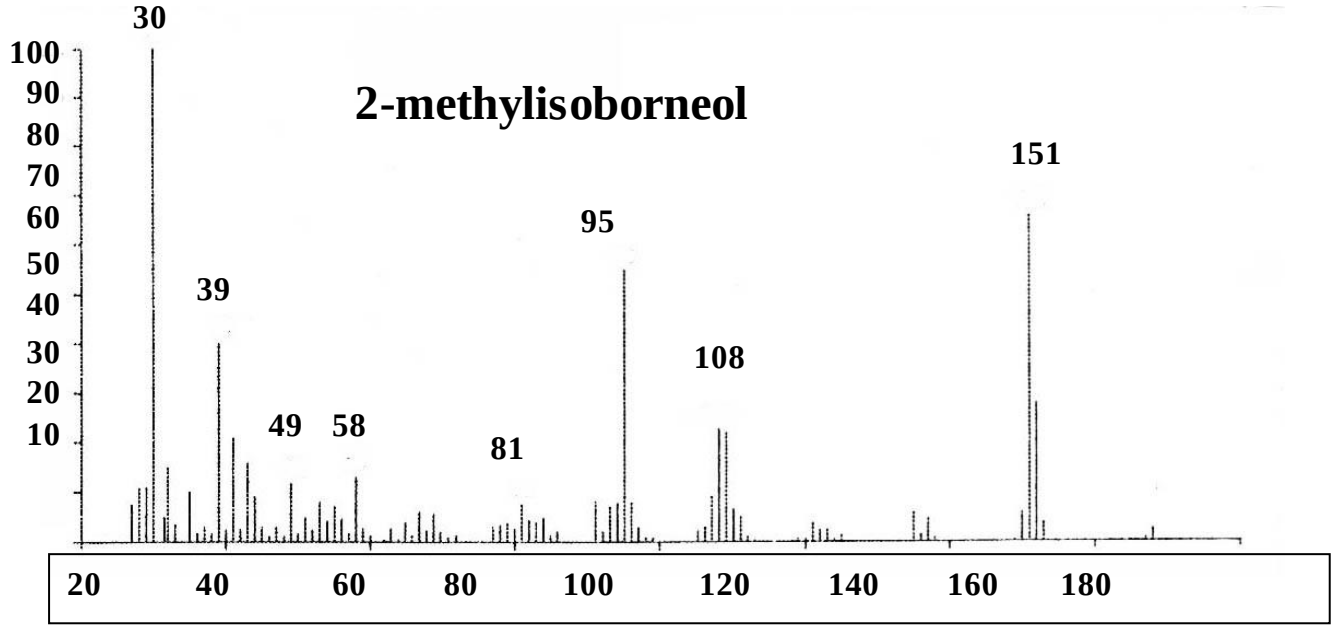

Eutrophication
Taste and odor problem
Coloration
Toxins

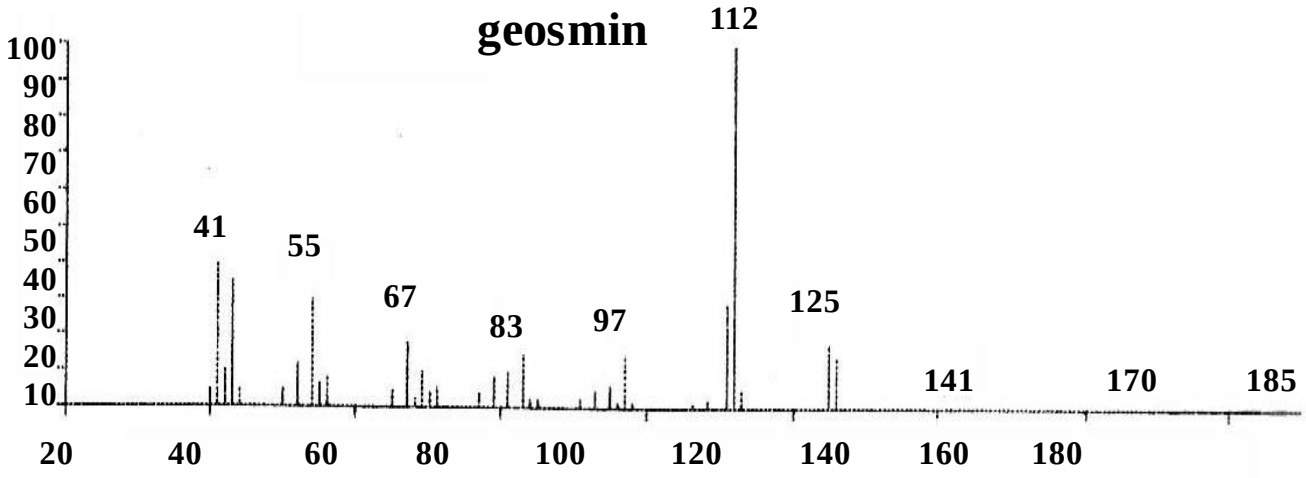
WATER QUALITY IMPACTS ASSOCIATED WITH EUTROPHICATION

- Noxious algae (scums, blue-greens, taste and odor, visual).
- Excessive macrophyte growth (loss of open water).
- **Loss of clarity (secchi depth goes down).**
- **Possible loss of macrophytes (via light limitation by algae and periphyton).**
- **Low dissolved oxygen (loss of habitat for fish and fish food).**
- Excessive organic matter production (smothering eggs and bugs).

- Blue-green algae inedible by some zooplankton (reduced food chain efficiency).
- **Toxic gases (ammonia, H2S) in bottom water (more loss of fish habitat).**
- Possible toxins from some species of blue-green algae.
- **Chemical treatment by lakeshore homeowners or managers may result (copper, diquat, 2,4-D, etc.).**
- Drinking water degradation from treatment disinfection byproducts.
- **Carcinogens, such as chloroform (from increased organic matter reacting with disinfectants like chlorine)**

Taste and odor problem





Toxins

On the basis of their mode of action, toxin can be grouped into:

1) Hepatotoxins: are a group of cyclic heptapeptides difference in amino acids and in the presence or absence of a methyl group in amino acids e.g.
2) Neurotoxins (which affect the nervous system)
3) Toxic alkaloids, causing gastrointestinal symptoms or kidney disease in humans.
4) Lipopolysaccharides

Coloration

Filter and screen clogging problem

In extreme cases the clogging may recur so frequently that the amount of water required to backwash the filter is greater than the volume of filtered water which reaches the distribution system. Thus the presence of algae can slow up the process of water treatment and add materially to its cost.

Both the slow and rapid sand filters may become clogged with algae, but in the former the algae and other aquatic microorganisms may play a useful part in the treatment process. They form a loose, slimy layer over the surface of the sand and act as a filter. The algae in this layer release oxygen during photosynthesis, and the oxygen in turn is utilized by bacteria, fungi, and protozoa which establish themselves in and on the filter.

Asterionella, Fragilaria, Tabellaria, Synedra, Navicula, Cyclotella, Diatoma, Cymbella. The rigid cell wall of diatoms is composed principally of silica and is not subject to decomposition. Therefore, even though the diatoms may die of rapidly on the surface of the filter, their silica walls remain and plug the pores in the sand.

Algae that have passed through slow filters, *Chlamydomonas*. The ease with which the algae penetrate depends upon several factors, the principal ones being the rate of flow, the grade of sand used, and the type of organism.

Slime

Slime-producing algae are important in open reservoirs and in uncovered holding basins of recirculating systems. They can become a serious problem especially in the water supplies for pulp mills and food industries by causing slime spots or masses in the products.

Algal slime commonly is derived from the mucilaginous capsule algae as a group are slime producers. Several diatoms as well as green and red algae and a few flagellates also produce slimy sheaths or capsules.

Corrosion

- **Algae have been reported to cause corrosion in metal tanks or basins open to sunlight. *Oscillatoria* growing in abundance in water in an open steel tank has caused serious pitting of the metal.**

- **Indirectly increases in organic deposits in the pipe, increases in the dissolved oxygen in the water through photosynthesis in changes in the pH, CO2 content, and calcium carbonate content. These changes can, in turn, have a more direct relationship to corrosion.**

Drinking Water Storage Tanks

⏩ Water Quality Degradation Concerns

The use of water reservoirs can lead to significant water quality degradation and increase health risks to consumers.

⏩ Indicators of Pollution

*** Algal growth**
*** Coliform bacteria growth**
*** Heterotrophic plate count (HPC) bacteria growth**
*** Turbidity**
*** Particulates Metals**
*** Taste and odor**
*** Disinfection byproducts such as trihalomethanes (THMS)**
*** Insect larvae**
*** *Giardia* and *Cryptosporidium***
*** Nitrification of chloraminated water**

Your Questions Please