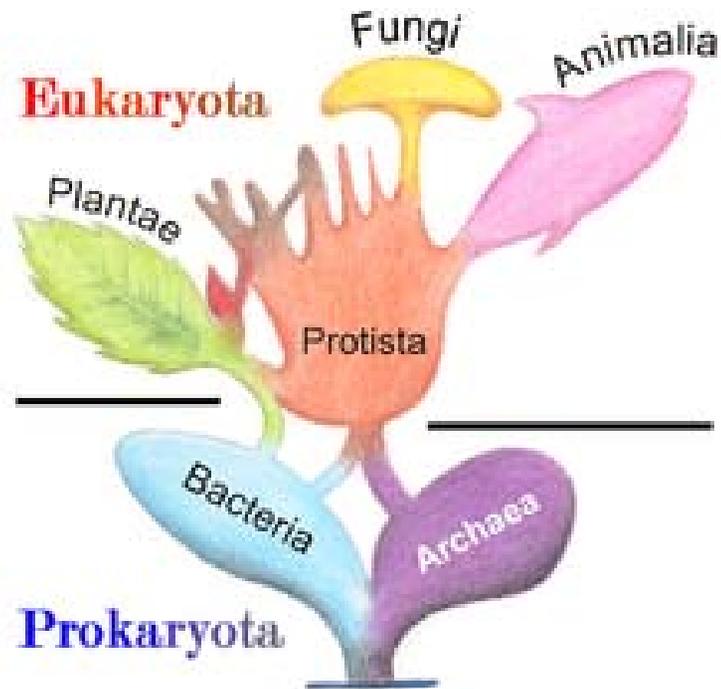


FRESHWATER ALGAL ECOLOGY WITH AN EMPHASIS ON CYANOBACTERIA

Ann St. Amand, Ph.D., CLP
PhycoTech, Inc.

Phylogeny

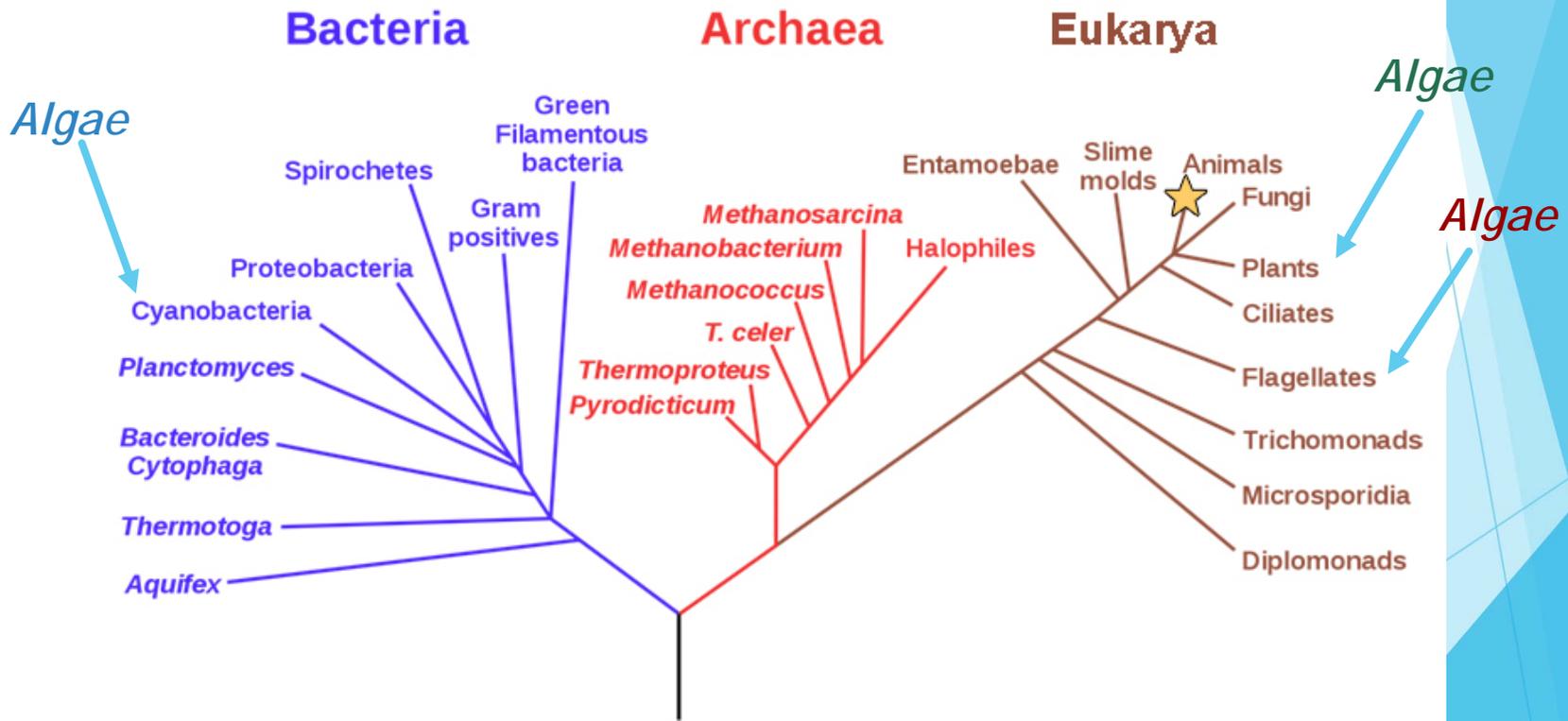
We think in terms of traditional kingdoms



Phylogeny

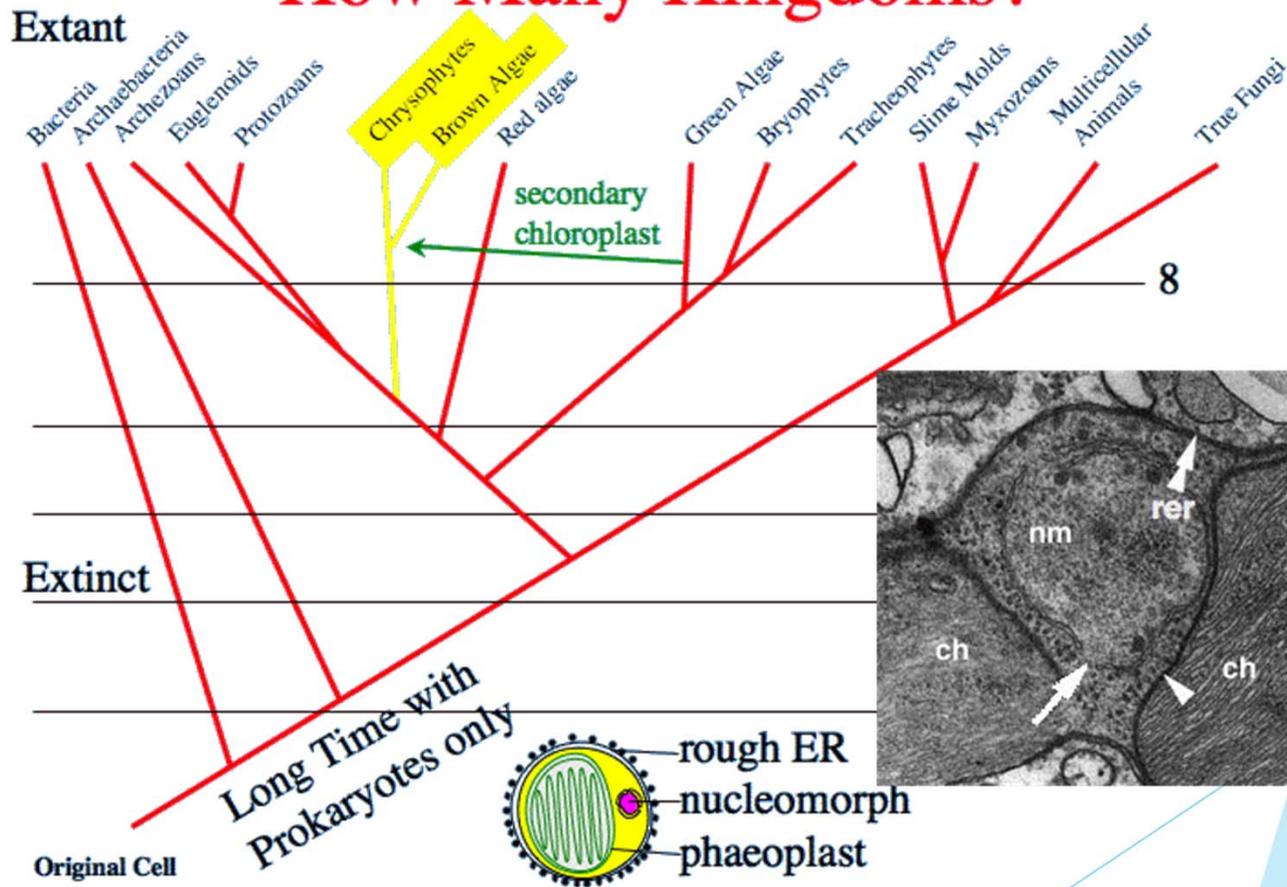
Phylogenetic Tree of Life

★ = You are here



Phylogeny

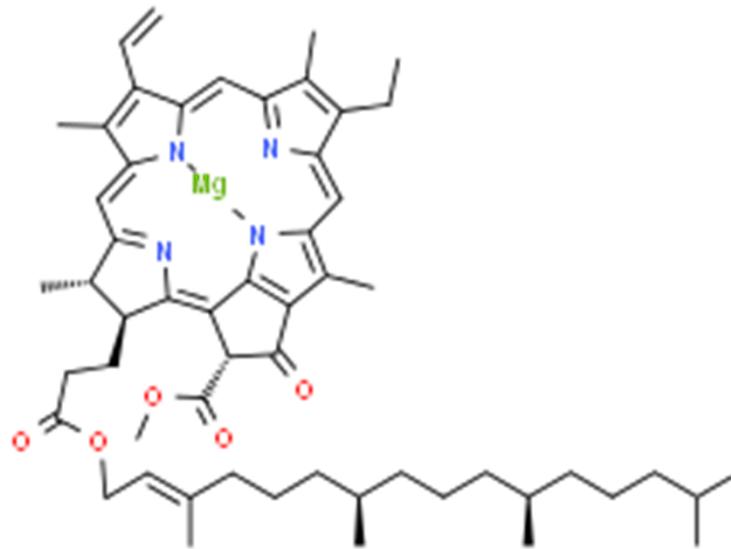
How Many Kingdoms?



<http://tolweb.org/tree/Tolimages/nucleomorph.jpg>

Phylogeny

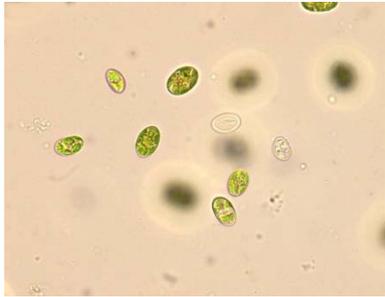
- ▶ The only thing the ALGAE have in common
 - ▶ Chlorophyll *a*.



PhycoTech's Classification Scheme

- ▶ Wehr, J.D., Robert G. Sheath and J. Patrick Kociolek, eds. 2014. *Freshwater Algae of North America*. Academic Press. 2nd Edition. New York, New York.
 - ▶ Major Divisions
 - ▶ Chlorophyta (Greens)
 - ▶ Charophyta (Stoneworts, shhhh, handling in Greens)
 - ▶ Cyanophyta (Cyanobacteria/Blue-greens)
 - ▶ Cryptophyta (Cryptomonads)
 - ▶ Chrysophyta (Chrysophytes)
 - ▶ Haptophyta (Haptophytes)
 - ▶ Bacillariophyta (Diatoms)
 - ▶ Euglenophyta (Euglenoids)
 - ▶ Pyrrhophyta (Dinoflagellates)
 - ▶ Phaeophyta (Browns)
 - ▶ Rhodophyta (Reds)
 - ▶ Raphidophyta (Gonyostomum)

Division Comparison - Basic



Chlorophyte



Chrysophyte



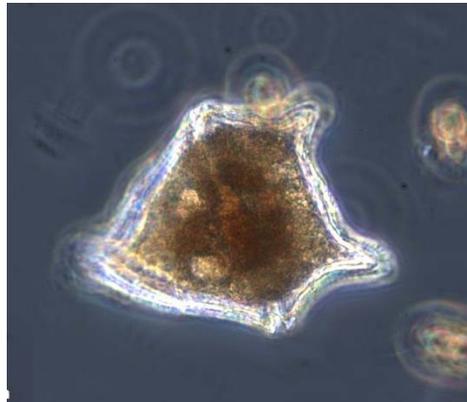
Cryptophyte



Euglenophyte



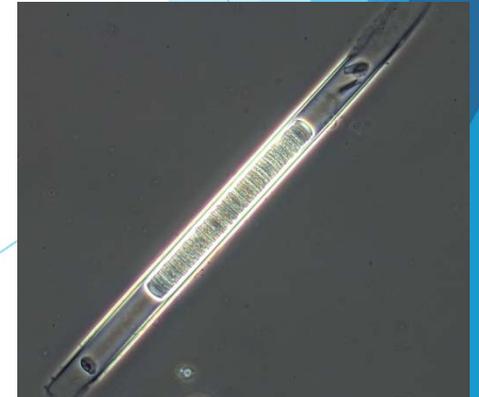
Haptophyte



Pyrrhophyte-thecate



Charophyte



Cyanophyte

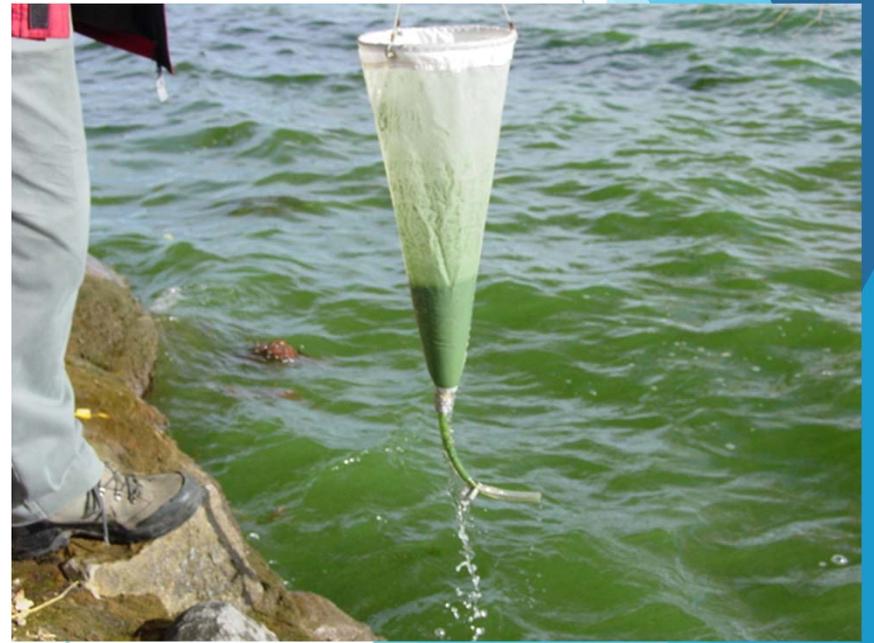
THE PROBLEMS



ALGAL PROBLEMS

Algal problems include:

- ▶ Ecological imbalances
- ▶ Physical impacts on the aquatic system
- ▶ Water quality alteration
- ▶ *Aesthetic impairment*
- ▶ *Taste and odor*
- ▶ *Toxicity*



Algal Problems

An Algae Bloom is *loosely* defined as visible color to the water.



A Harmful Algae Bloom (HAB) adds toxins or *acute ecological disruption* to the definition.

ALGAL PROBLEMS

Taste and Odor

- ▶ At sufficient density, all algae can produce taste and odor by virtue of organic content and decay
- ▶ Some algae produce specific taste and odor compounds that are released into the water
- ▶ Geosmin and Methylisoborneol (MIB) are the two most common T&O compounds; these can induce T&O at very low concentrations

ALGAL PROBLEMS

Taste and Odor

T&O by blue-greens

- ▶ *Anabaena (Dolichospermum), Aphanizomenon, Microcystis, and Oscillatoria (Planktothrix, Pseudanabaena)* are most common T&O producers, but many other genera produce T&O as well
- ▶ Geosmin and MIB often produced
- ▶ Odors usually include musty, grassy, and septic
- ▶ May be produced by planktonic or benthic growths

ALGAL PROBLEMS

Taste and Odor

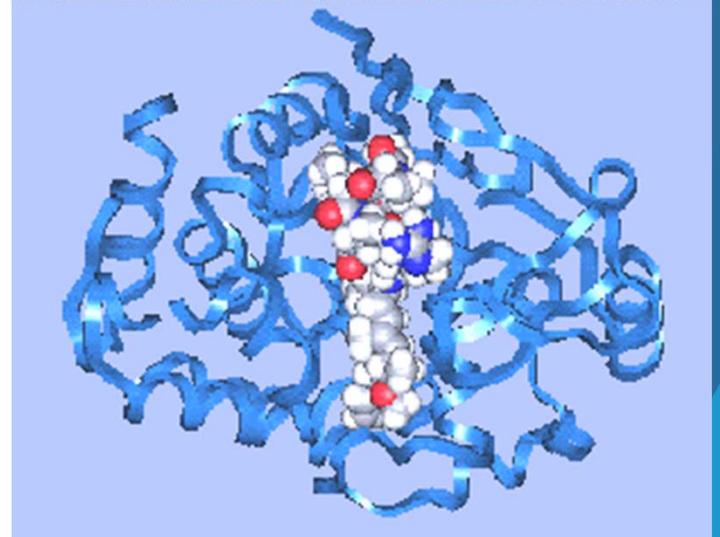
T&O by diatoms

- *Melosira/Aulacoseira, Stephanodiscus, Cyclotella, Asterionella, Fragilaria/Synedra, and Tabellaria* are primary diatoms causing T&O, usually only at high density
- Main odors are geranium, spicy and fishy, with occasional musty or grassy scent
- Not as severe as with blue-greens unless diatom density is very high

ALGAL PROBLEMS

Toxicity-Cyanotoxins

- ▶ Hepatotoxins
 - ▶ disrupt proteins that keep the liver functioning, may act slowly (days to weeks)
- ▶ Neurotoxins
 - ▶ cause rapid paralysis of skeletal and respiratory muscles (minutes)
- ▶ Dermatotoxins
 - ▶ produce rashes and other skin reactions, usually within a day (hours)



PPI-microcystin
LR complex

ALGAL PROBLEMS

Toxicity-Cyanotoxins

Toxin effects

- ▶ Documented deaths of fish, resulting from direct contact and/or interaction with gills
- ▶ Human skin rashes and gastroenteritis common and often linked to algal toxins
- ▶ Documented deaths of dogs and cattle, resulting from high intake of contaminated water, usually directly from lake or stream
- ▶ Rare documented deaths of humans, usually linked to water intake from a contaminated source
- ▶ Influence of extended low level exposure unknown; synergistic effects may exacerbate other illnesses, such as ALS or parkinsons

ALGAL PROBLEMS

Toxicity-Which Genera Produce Toxin?

Blue-Green Algae	Microcystin	Anabaena -peptin	Nodularin	Cylindro- spermopsin	Anatoxin	Saxitoxin	Dermato- toxin
Dolichospermum (Anabaena)	X	X	X		X	X	
Anabaenopsis	X						
<i>Aphanizomenon</i> (changes)	X			X	X	X	
Coelosphaerium Woronichinia	X						
Raphidiopsis				X			
Cylindrospermum					X	X	
Gloeotrichia	X						
Hapalosiphon	X						
Lyngbya (Plectonema)						X	X
Microcystis	X	X	X				
Nodularia	X	X	X				
Nostoc	X						
Oscillatoria (Planktothrix)	X	X			X		X
Schizothrix							X
Umezakia				X			

More forms found each year – methods or actual increase?

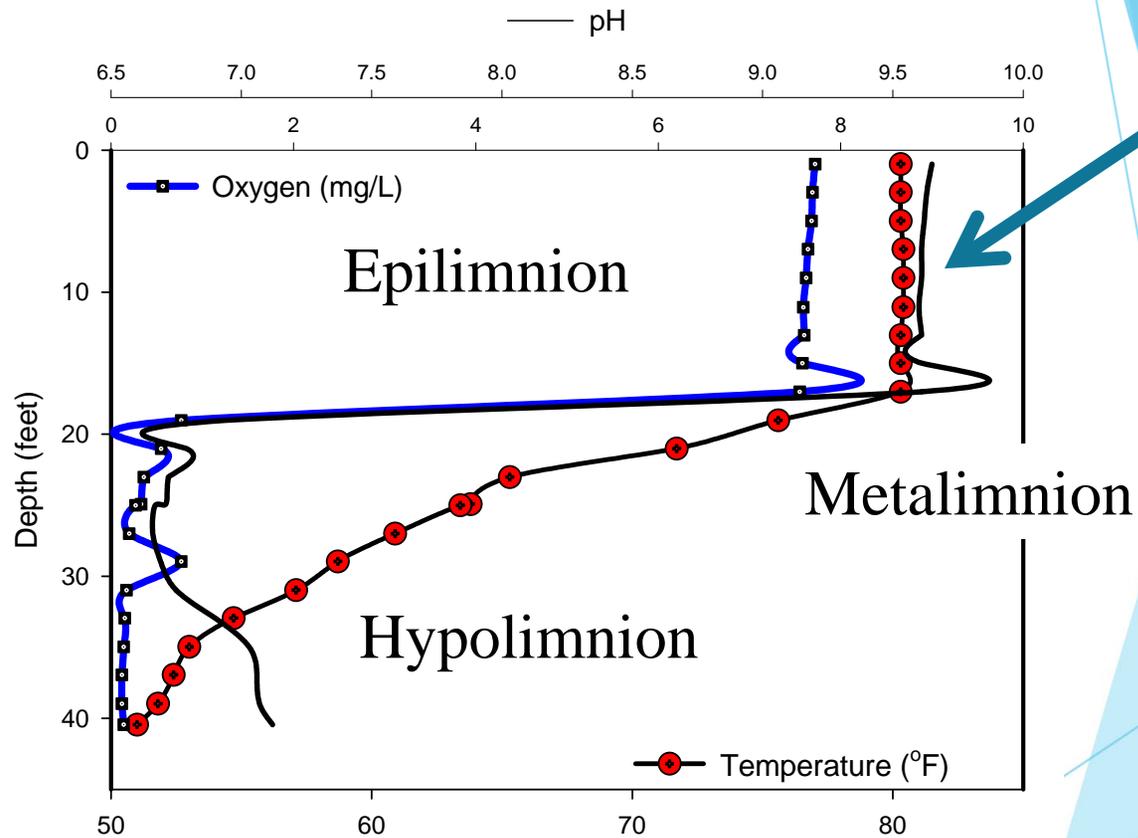
ALGAL PROBLEMS

Recommended Toxicity Precautions

- ▶ Monitor algal quantity and quality
- ▶ If potential toxin producers are detected, increase monitoring and test for toxins
- ▶ For recreational lakes, be prepared to warn users and/or limit contact recreation. US EPA Health Advisory:
 - ▶ Microcystin: 8 ug/L
 - ▶ Cylindrospermopsin: 15 ug

Algal Methodology

Typical Stratification Curve- August 8, 2002

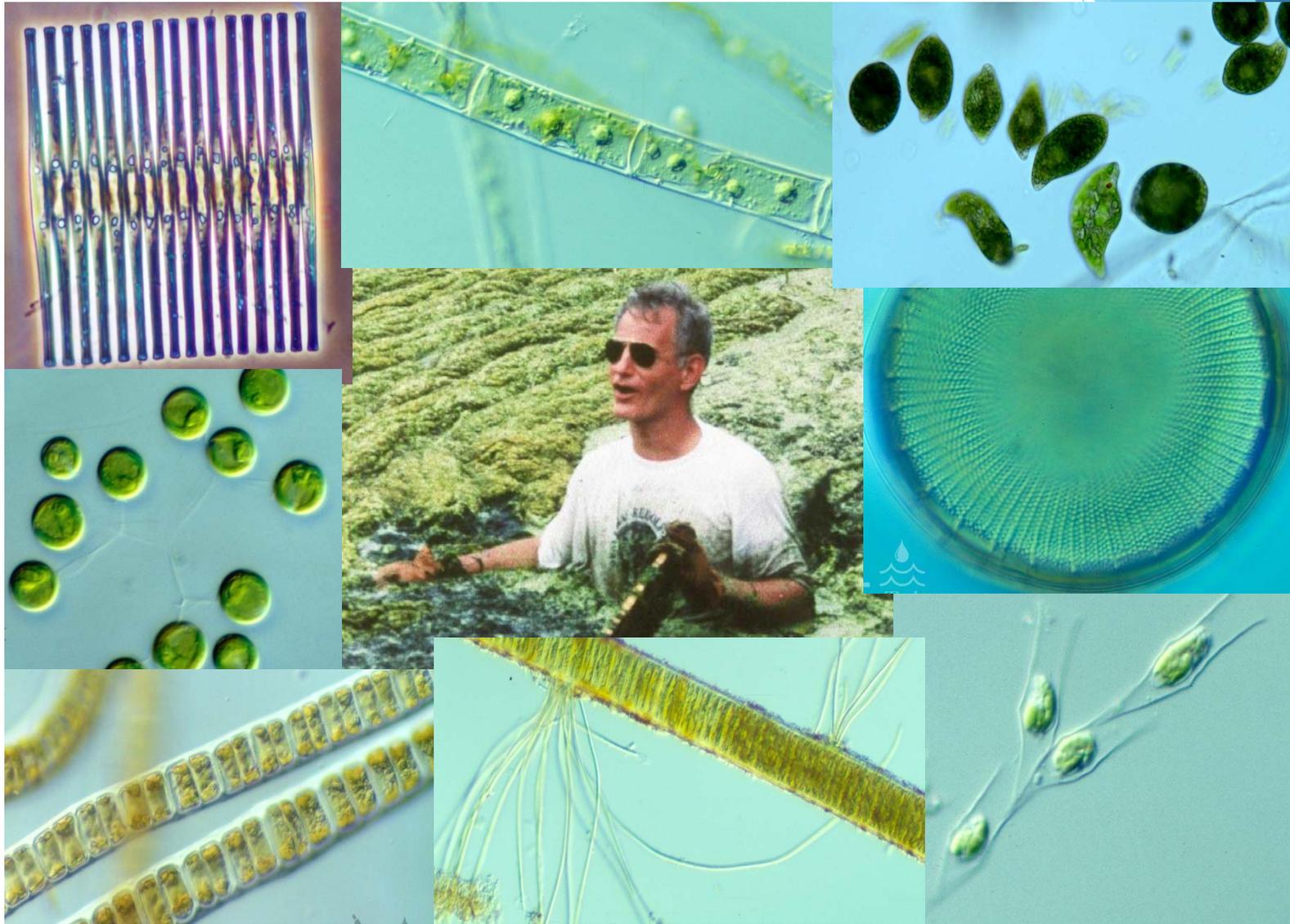


Algal Methodology

- ▶ Lakes are NOT homogeneous water columns
 - ▶ Microstratification locally
 - ▶ Wind rows, Ekman spirals and seiches
 - ▶ Migrating algae and zooplankton
 - ▶ Passive
 - ▶ Active
 - ▶ Pelagic vs. littoral zone



PART 3: ALGAL FORMS



Algal Forms

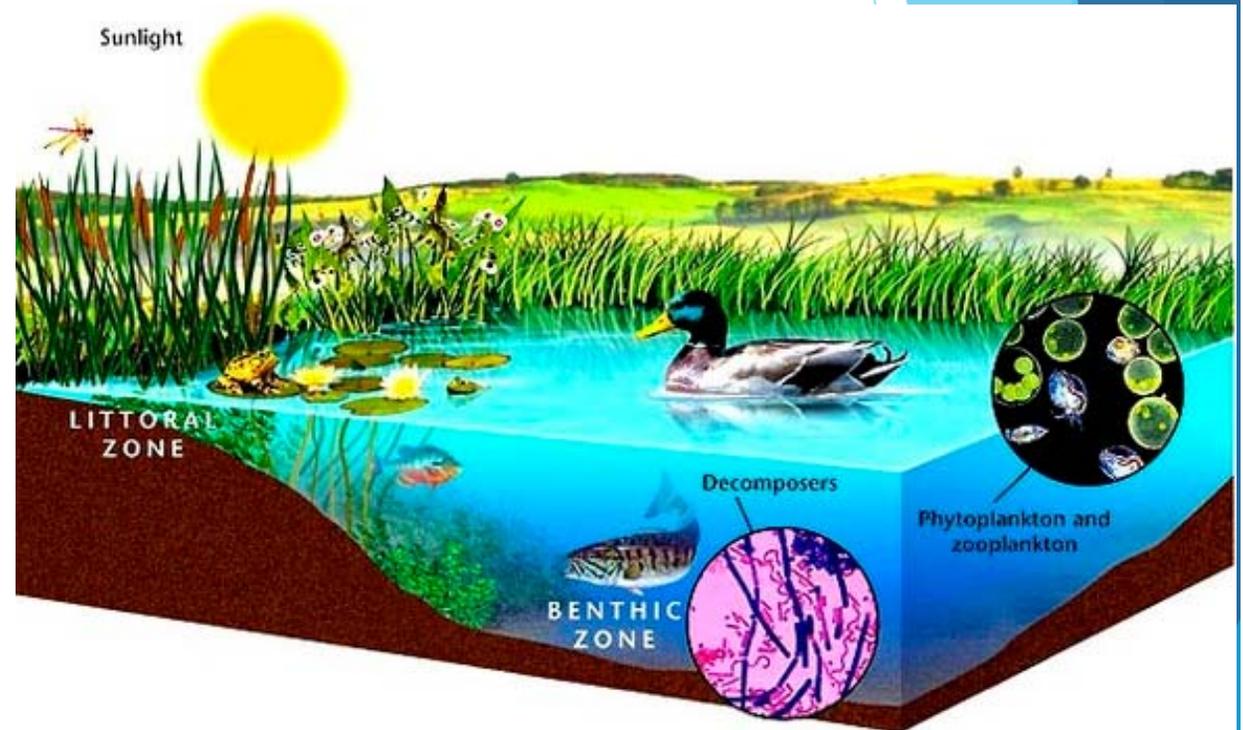


Algal Mats

- ◆ Can be bottom or surface mats - surface mats often start on the bottom
- ◆ Usually green or blue-green algae
- ◆ Possible taste and odor sources
- ◆ Potentially severe use impairment

Algal Forms

- ▶ Planktonic - suspended in the water column
- ▶ Benthic - growing on the lake or stream bottom



Algal Types: Planktonic Blue-greens

Days of Annie, Fannie and Mike are sadly gone...

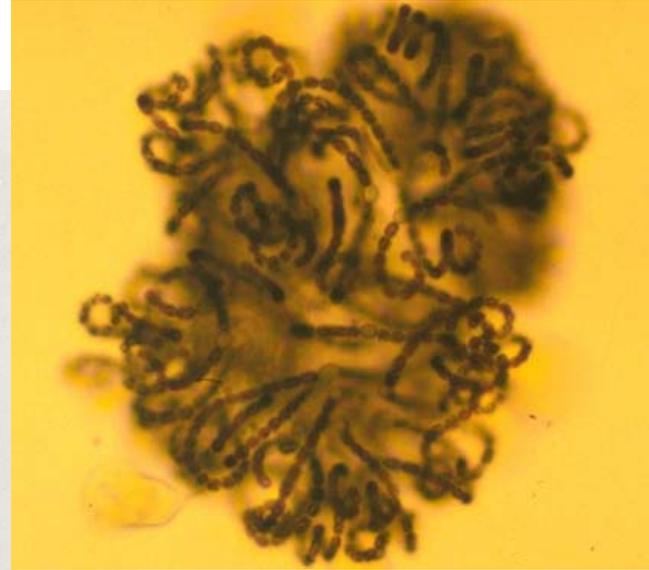
It's now Dolichospermum,
Aphanizomenon, Cuspidothrix,
Sphaerospermopsis, and for now,
Microcystis

CYANOPHYTA - BLUE-GREENS - CYANOBACTERIA

Important Players - HABs



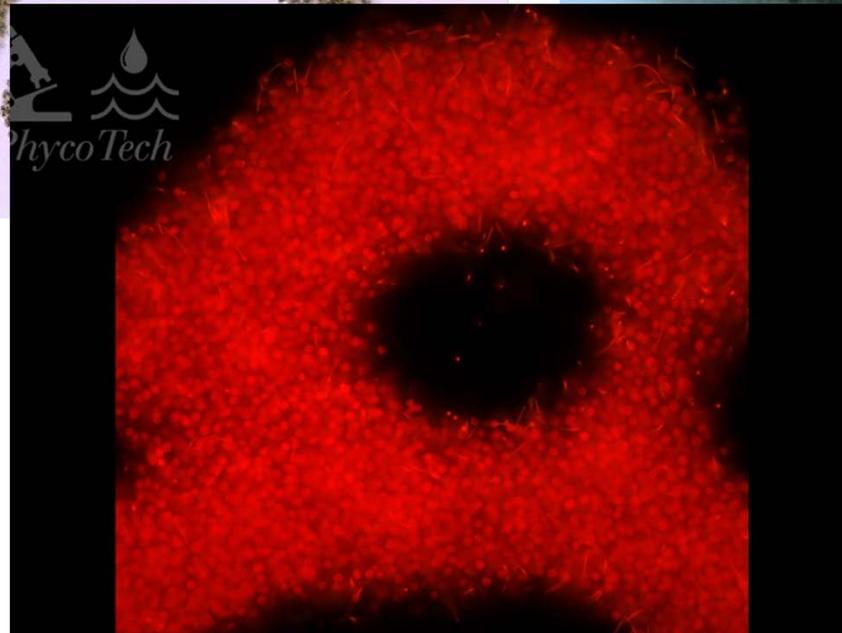
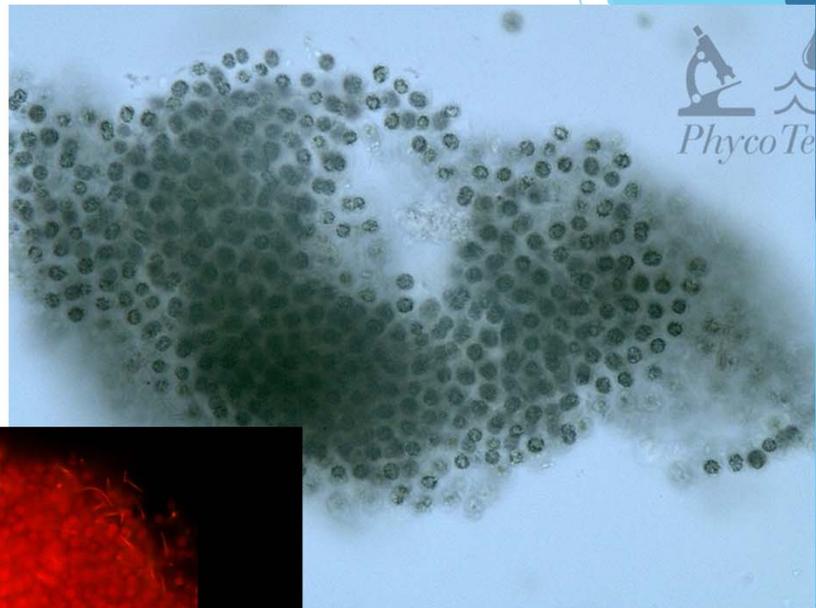
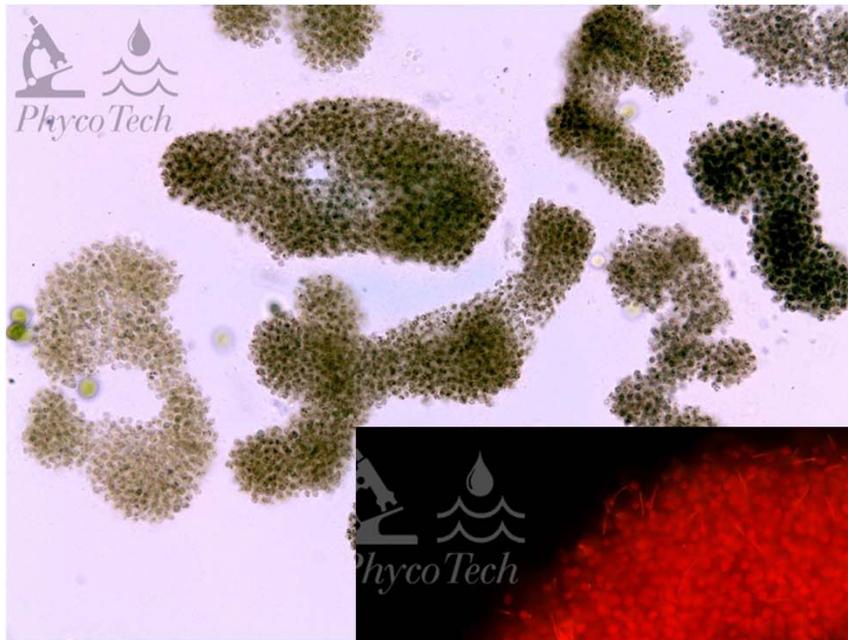
CYANOPHYTA - BLUE-GREENS - CYANOBACTERIA



Dolichospermum

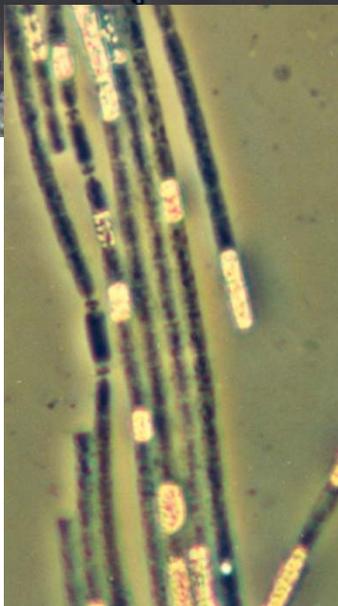
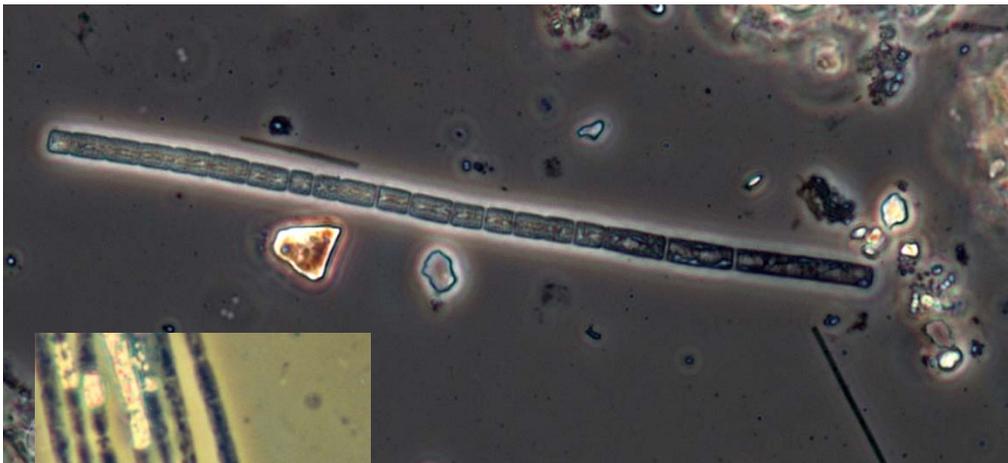
CYANOPHYTA - BLUE-GREENS - CYANOBACTERIA

Microcystis



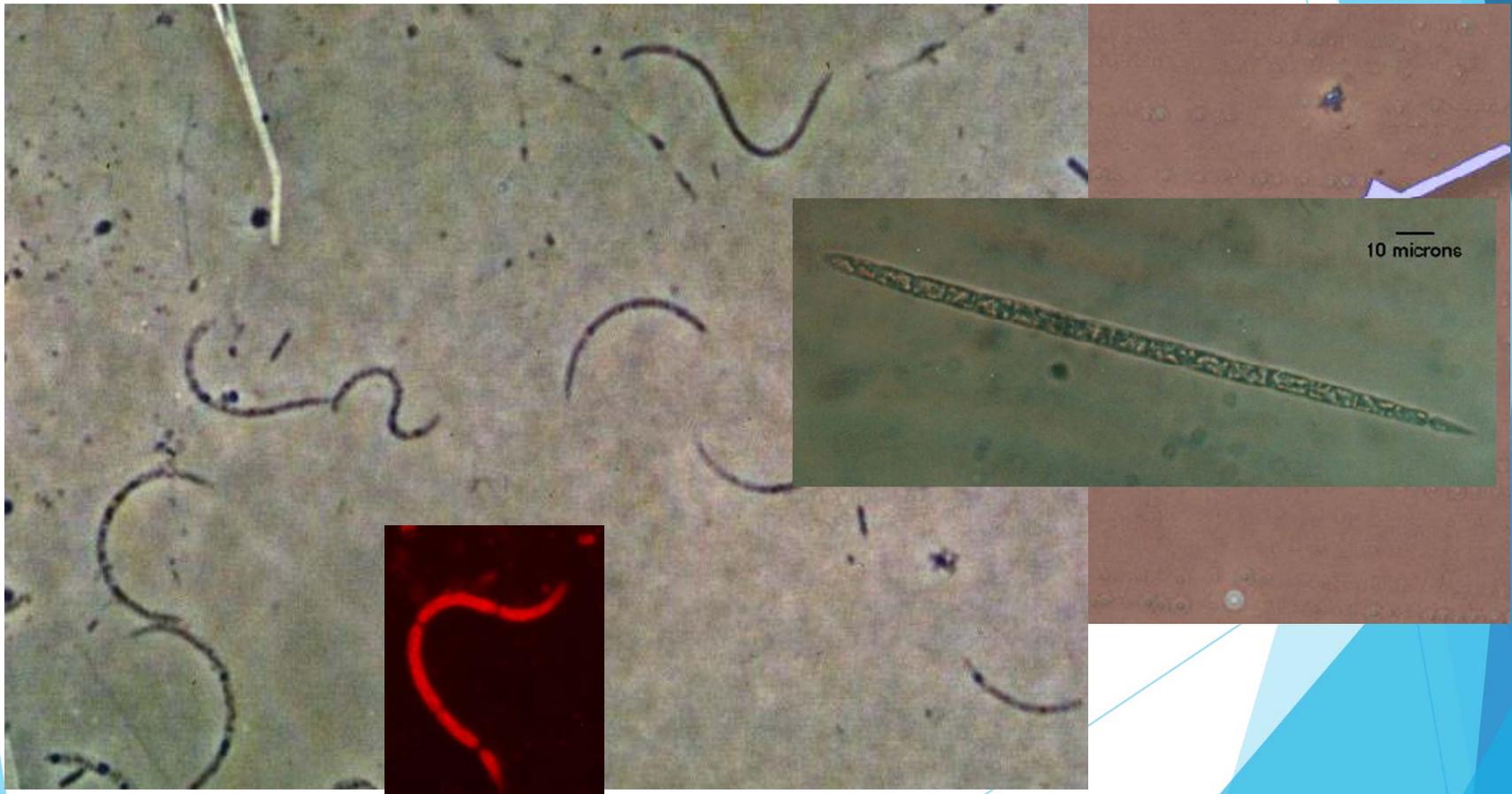
CYANOPHYTA - BLUE-GREENS - CYANOBACTERIA

Aphanizomenon



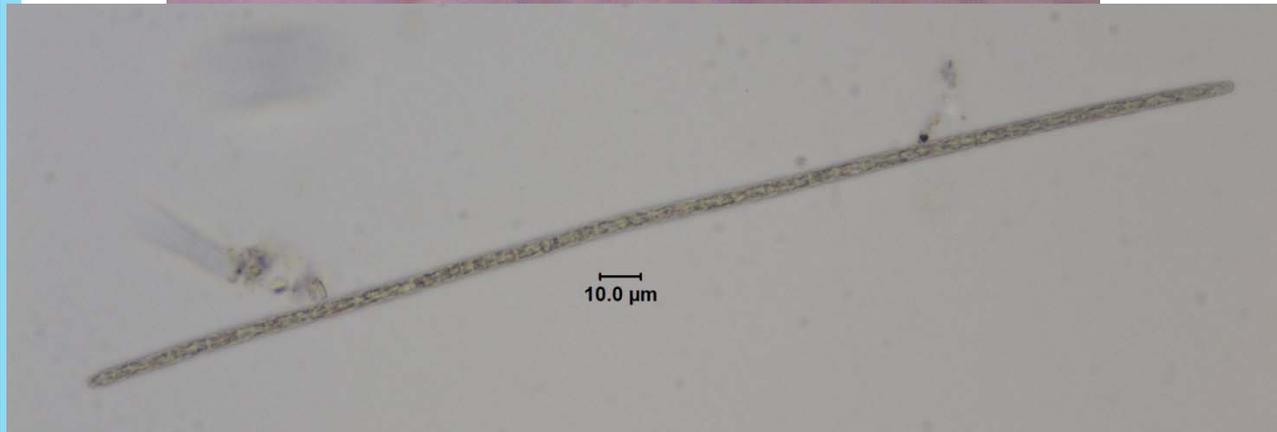
CYANOPHYTA - BLUE-GREENS - CYANOBACTERIA

Raphidiopsis



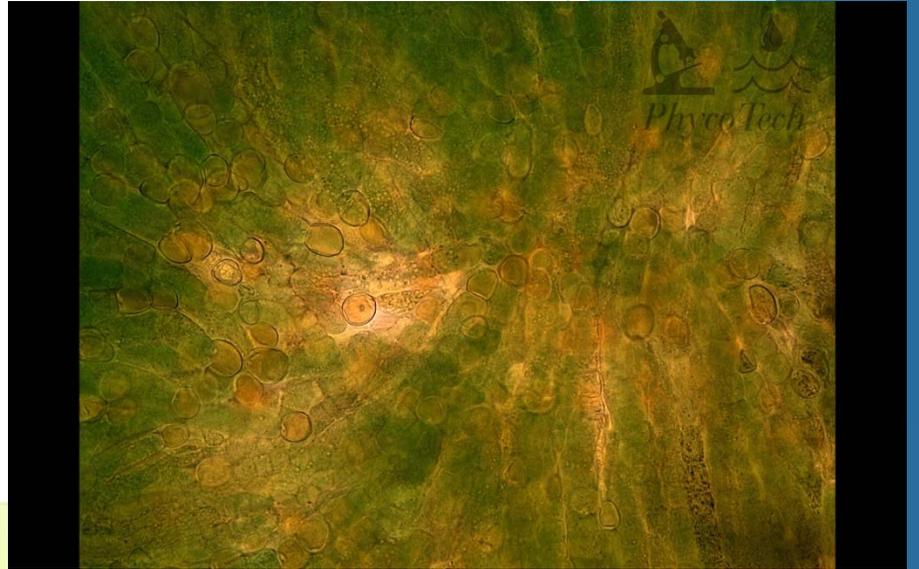
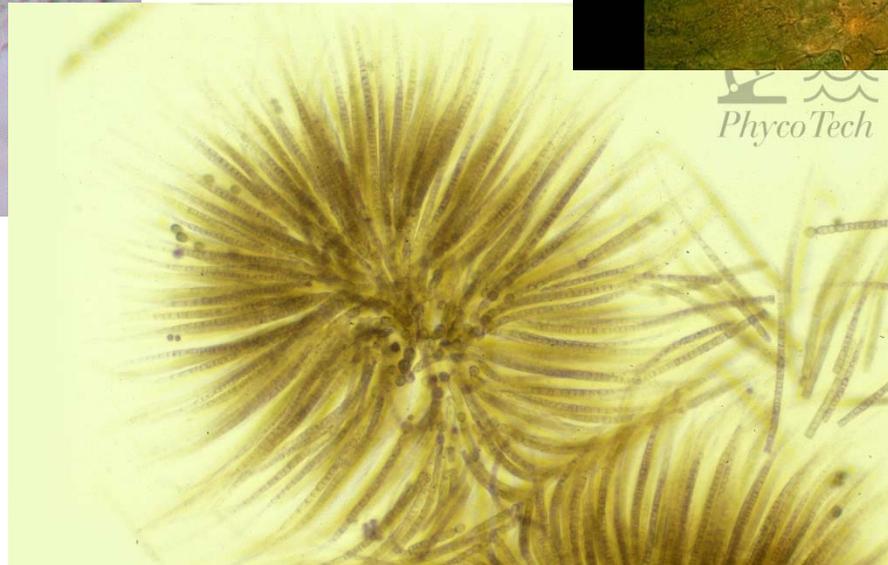
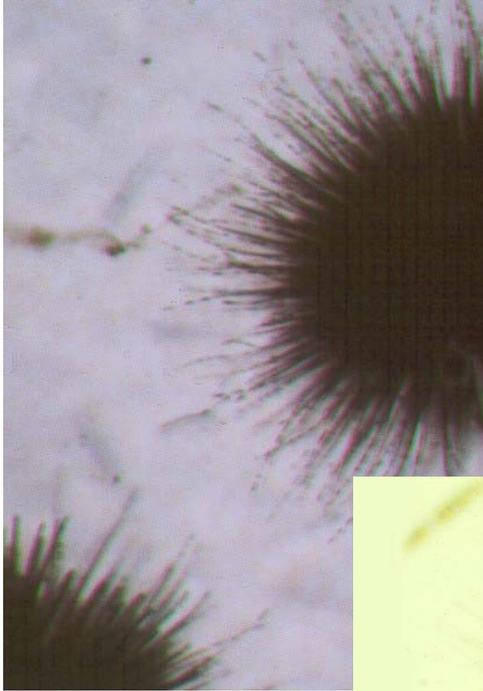
CYANOPHYTA - BLUE-GREENS - CYANOBACTERIA

Planktothrix



Algal Types: Planktonic Blue-greens

Gloeotrichia



CHLOROPHYTA - GREENS

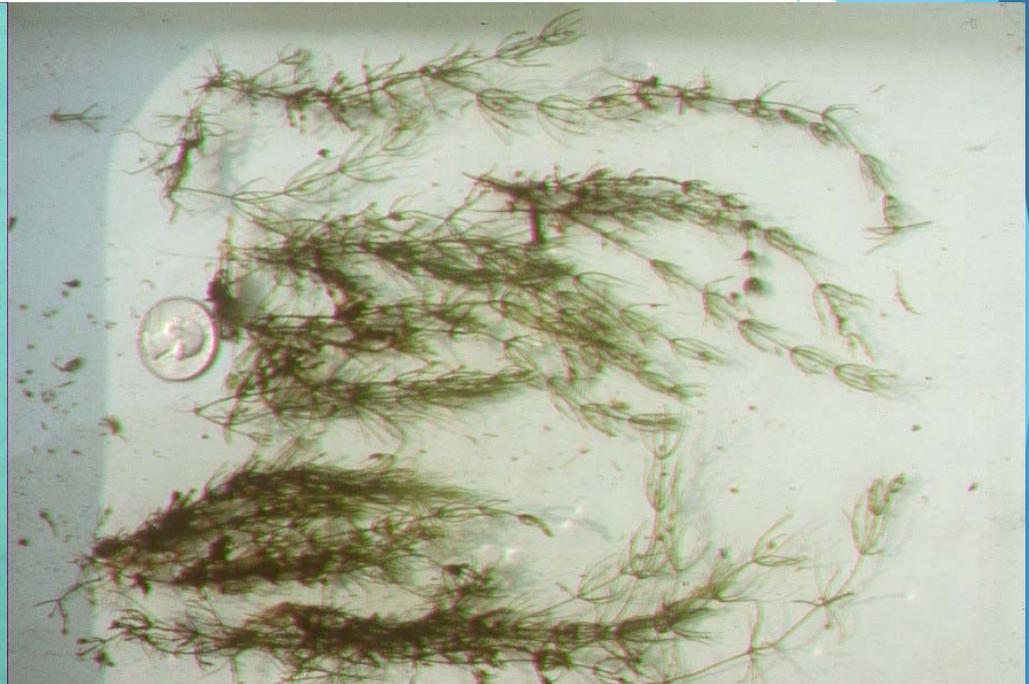
Important Players



ALGAL CLASSIFICATION

CHAROPHYTA

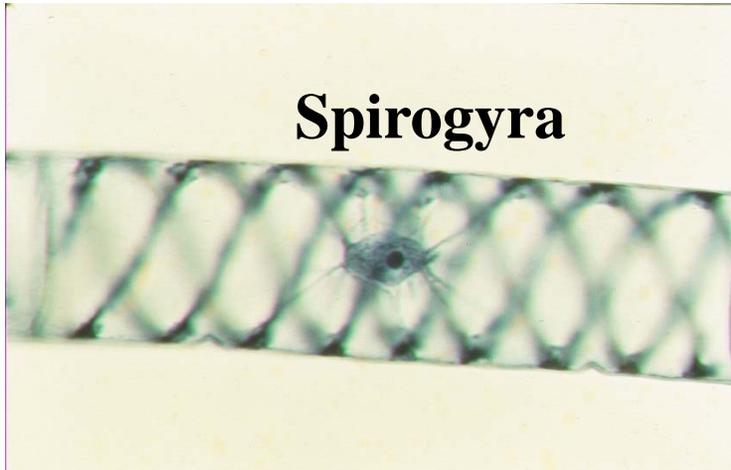
Charophyceae - stonewort



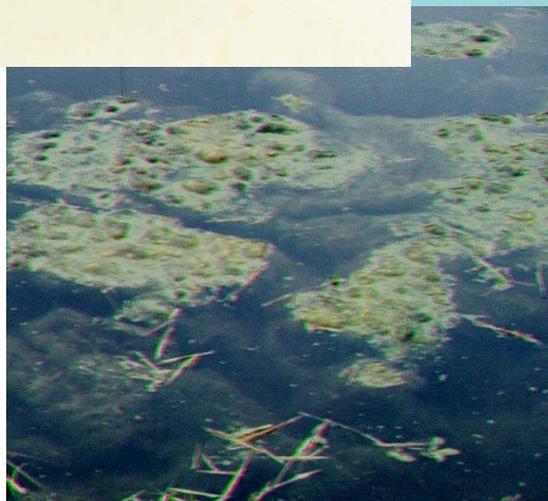
Chara

Algal Types: Mat Forming Greens

Zygnematales - Unbranched filaments, highly gelatinous, *feel "slimy"*



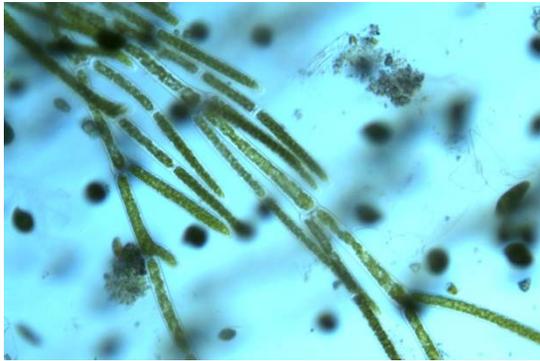
Mats trap gases and may float to surface



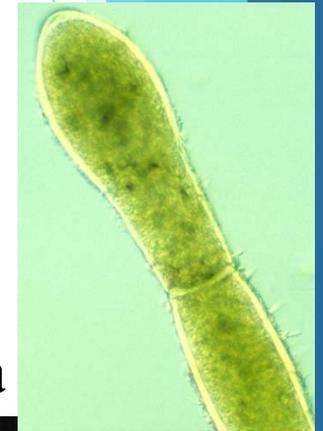
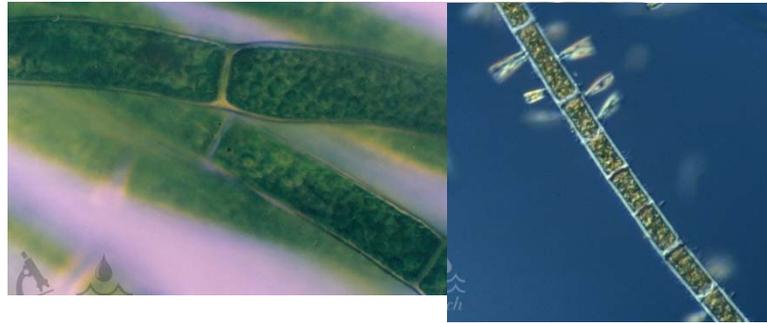
Algal Types: Mat Forming Greens

Cladophorales - Large, branched or unbranched filamentous forms, *feel "rough or brillo-y"*

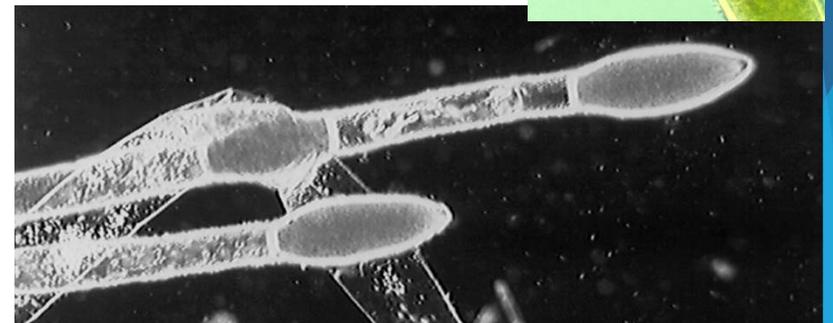
Cladophora



Rhizoclonium

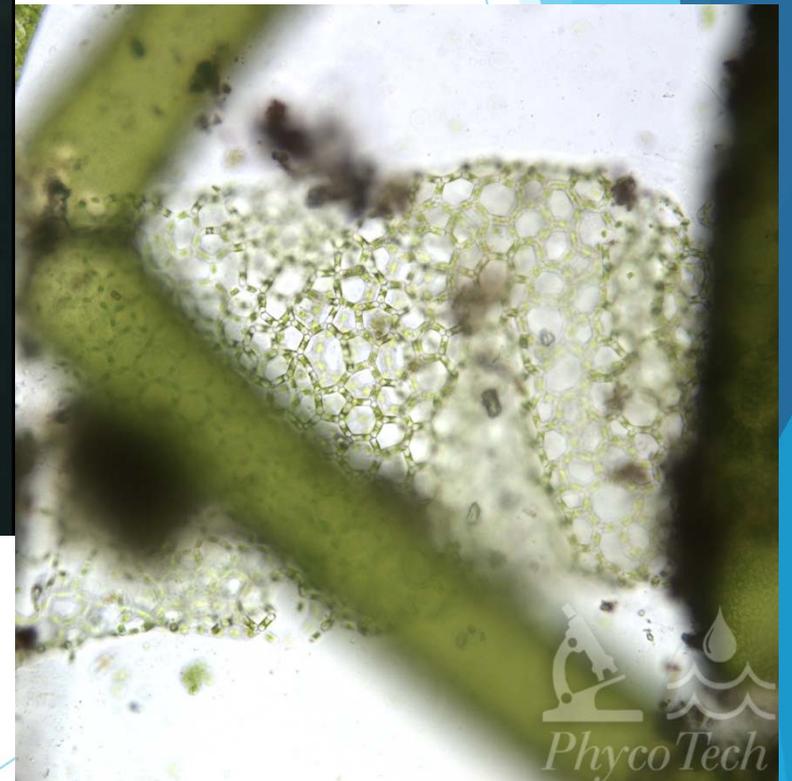
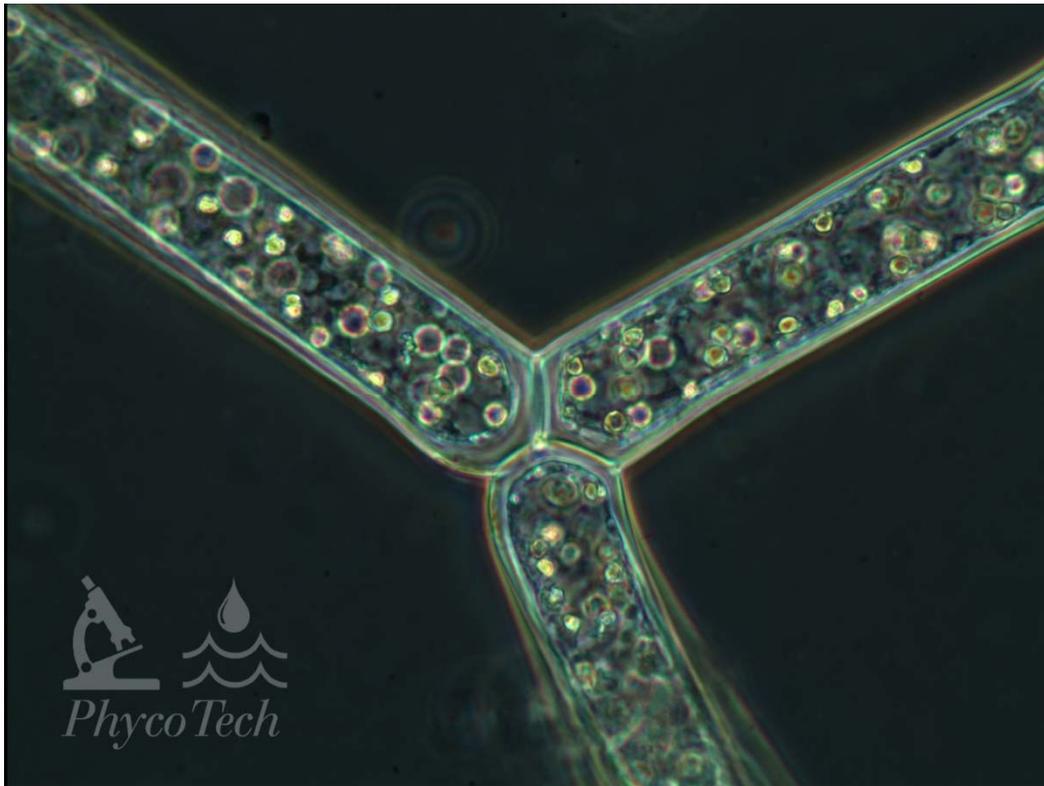


Pithophora



Algal Types: Mat Forming Greens

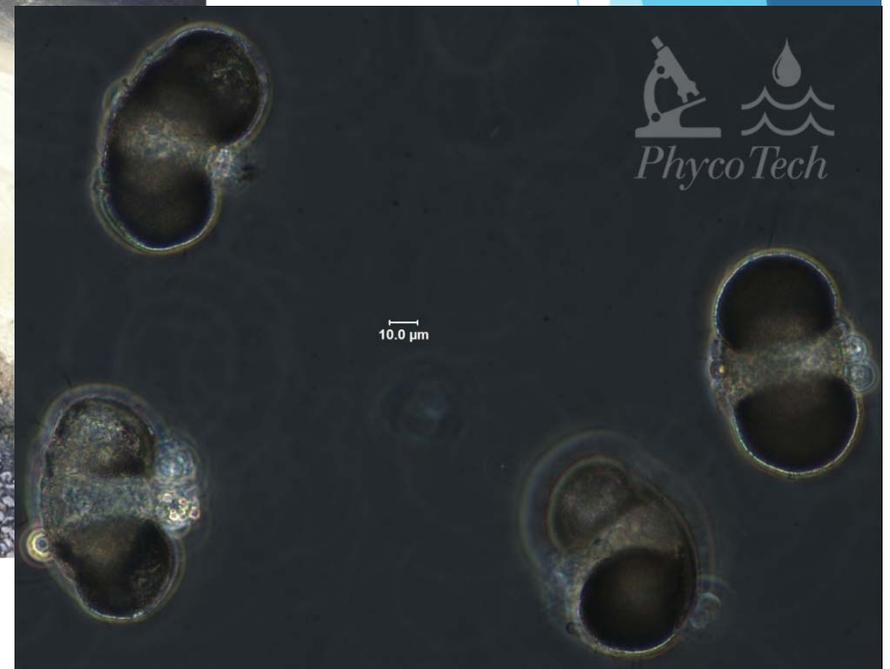
Hydrodictyon



Pollen, Barber Pond



Photo provided by Linda Green

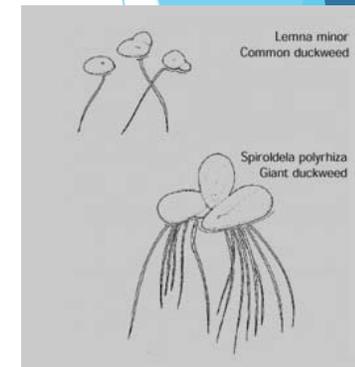


Watermeal (*Wolffia columbiana*)



Inset Photo provided by Linda Green

Duckweed (*Lemna gibba*)



Photos provided by Linda Green

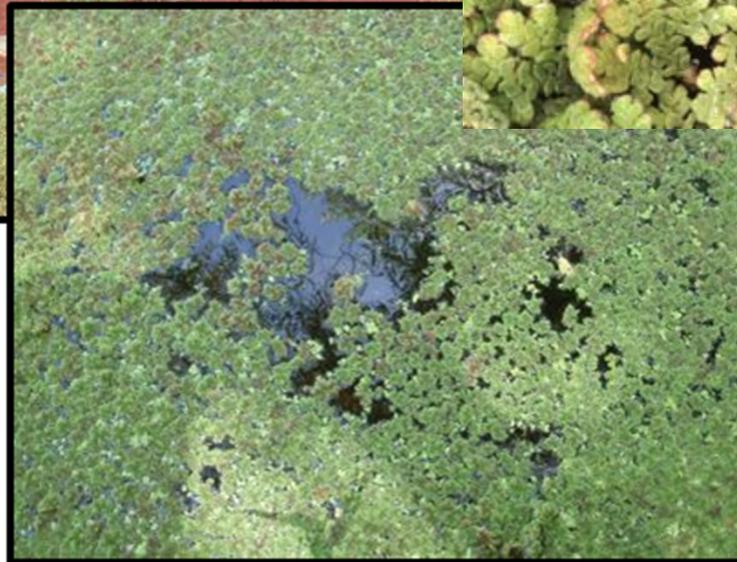
Duckweed - Lake Michigan August 2019



Water Fern (*Azolla* sp.)



Upper Left Photo:
Jennifer Graham



Upper Right and Center
Photos: Missouri
Department of
Conservation

Water Fern (*Azolla caroliniana*)



Photo: Bob Kirschner

Rooted Macrophytes-Pond Weeds



Green Algae (*Enteromorpha prolifera*)



Qingdao, Shandong, China, 2011

http://www.huffingtonpost.com/2011/07/18/algae-bloom-qingdao-china-beach_n_901555.html#s310618

Green Algae (*Cladophora/Oedogonium*)

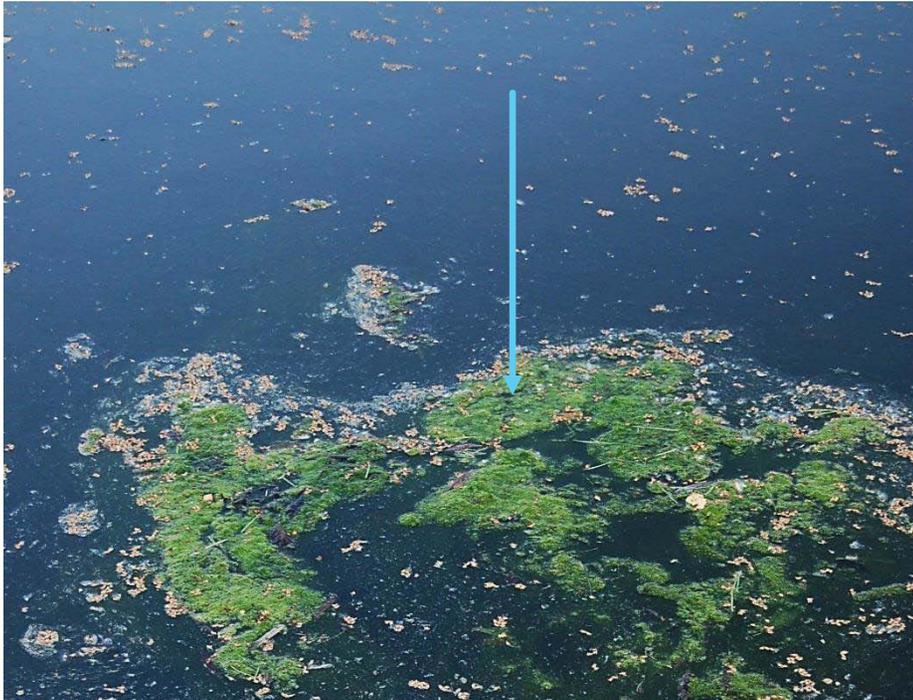
Photo below provided by
Jennifer Graham



Photo above provided by
Nico Clercin



Green Algae (*Cladophora* sp.)



Green Algae (*Mougeotia* sp.)



Photos: Steve Heiskary, MNPCB

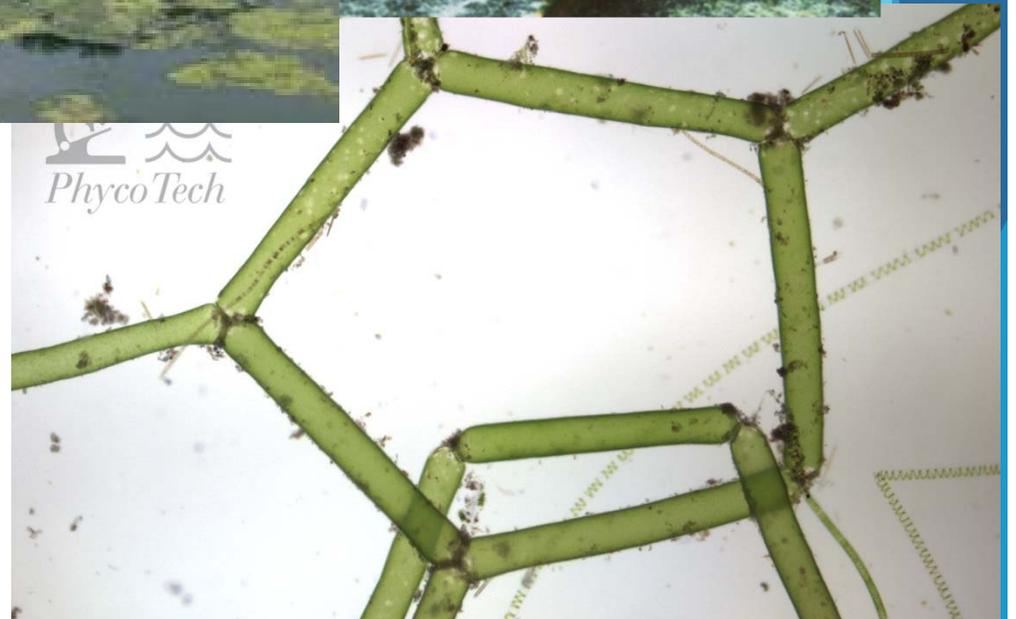
Green Algae (*Hydrodictyon sp.*)



Above Photo:

http://marple.eeb.uconn.edu/g/ratolwww/?page_id=114

Upper Right Photo: Ken Wagner



Green Algae (*Helicodictyon planctonicum*)



Dinoflagellate Algae (*Durinskia/Ceratium*)



Photo: Cody Danielson

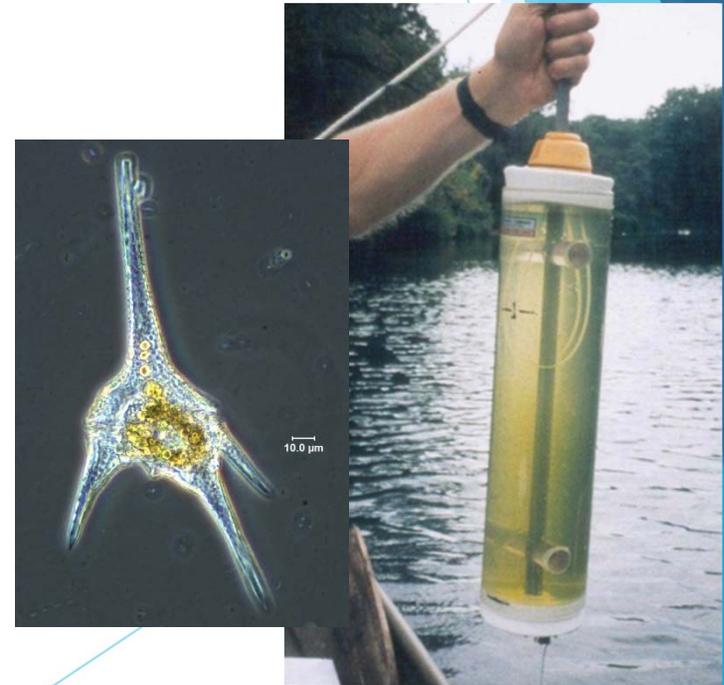


Photo: Ken Wagner

Diatom Algae - (*Nitzschia/Navicula*)

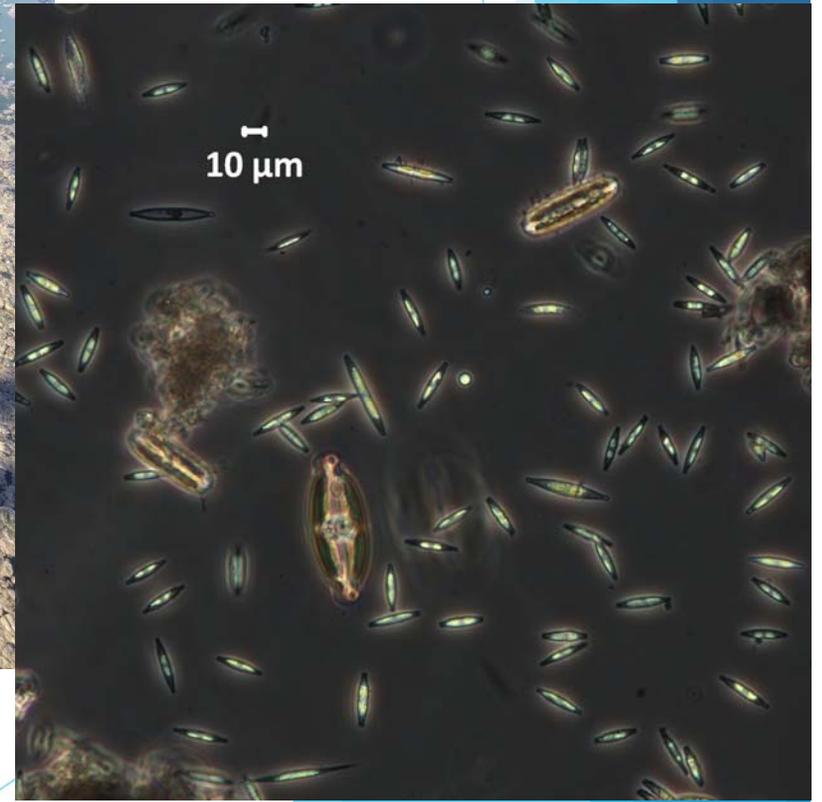


Photo at right:
Joe Rush

Purple Sulfur Bacteria (*Thiopedia*)

