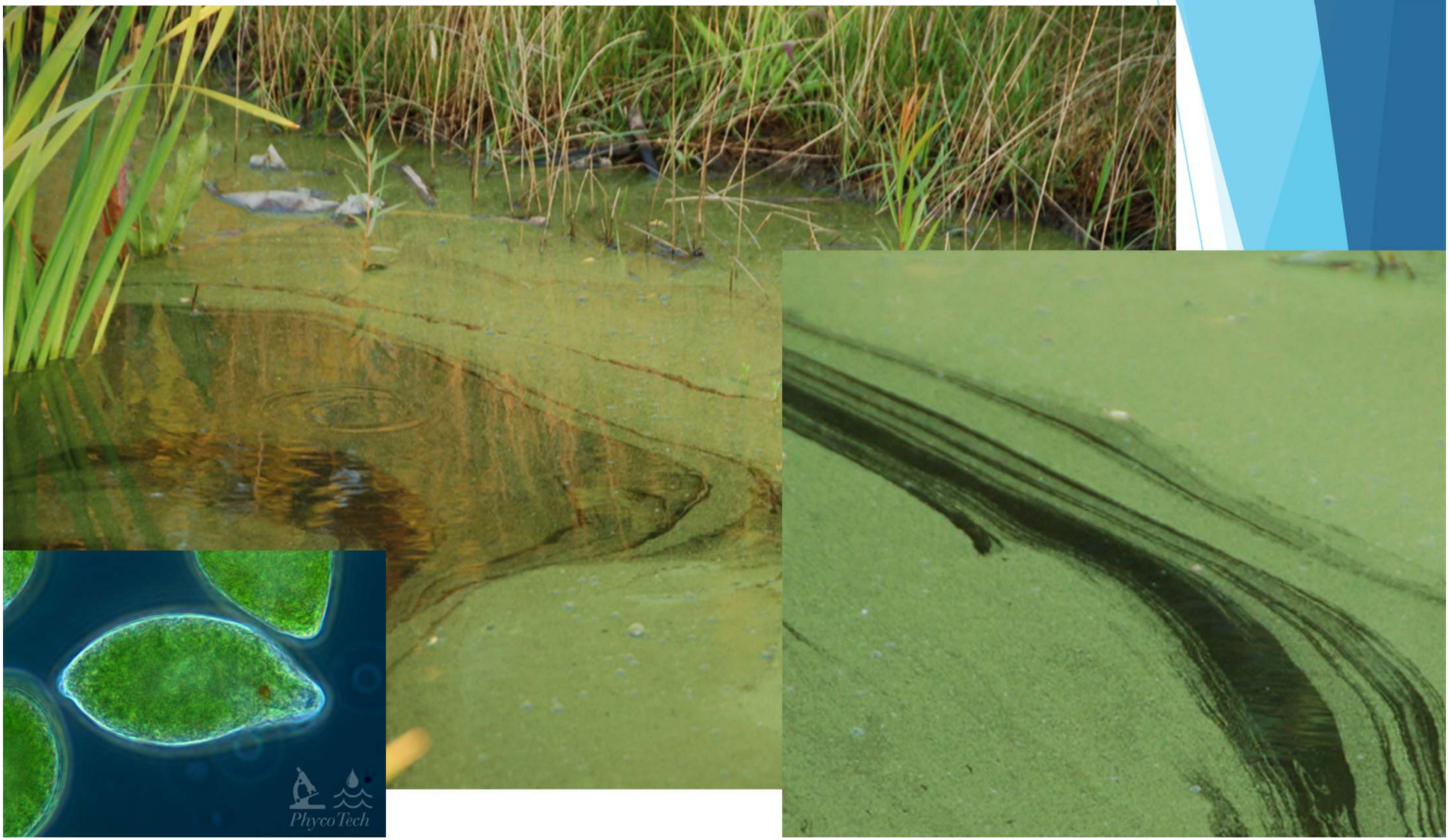
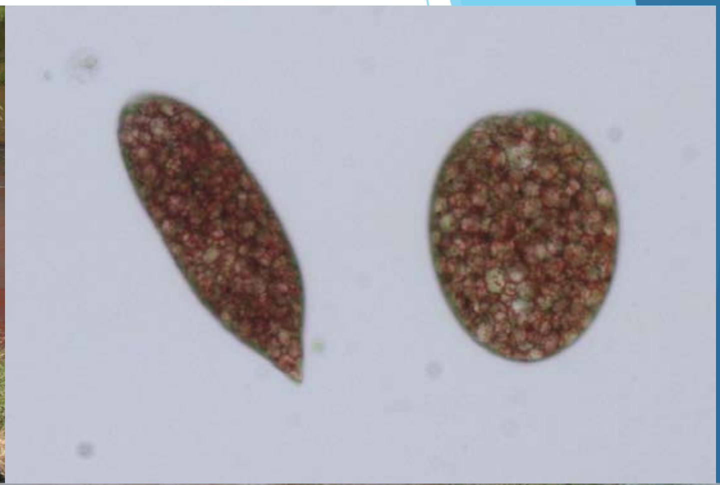
Green and Blue-green Algae

Euglenoid Algae (*Euglena* sp.)



Toxin Producing

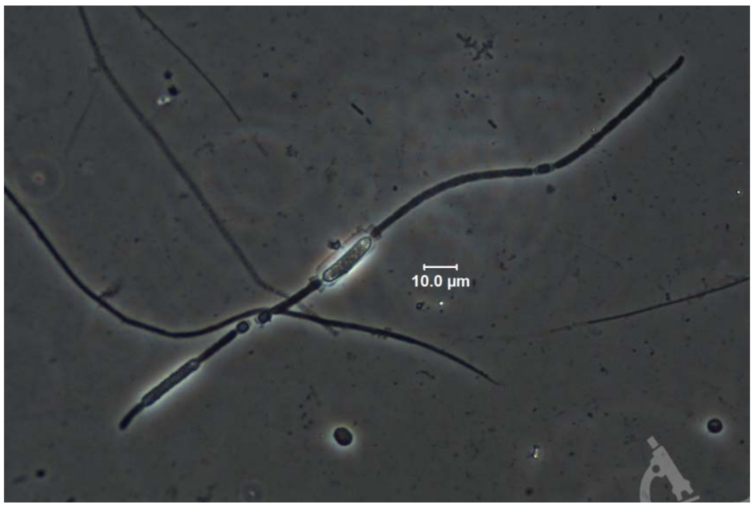
Euglenoid Algae (*Euglena sanguinea*)



Photos: Barry Rosen, USGS

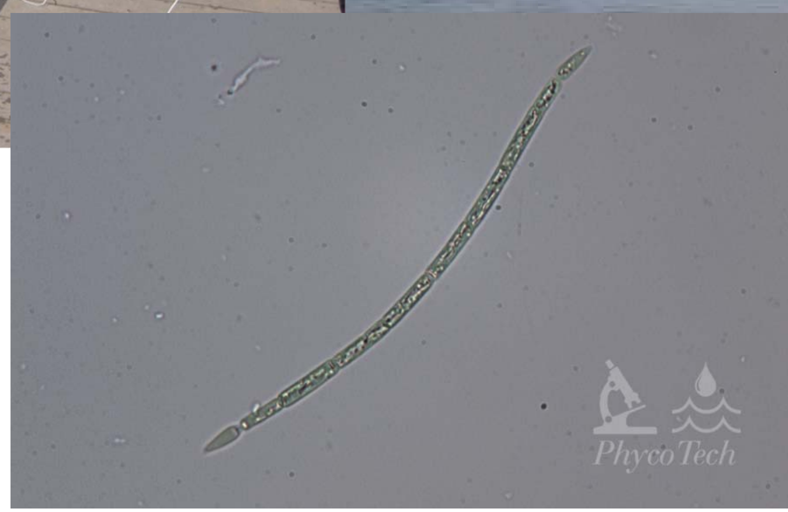
Blue-green Algae-don't do this!

Aphanizomenon gracile

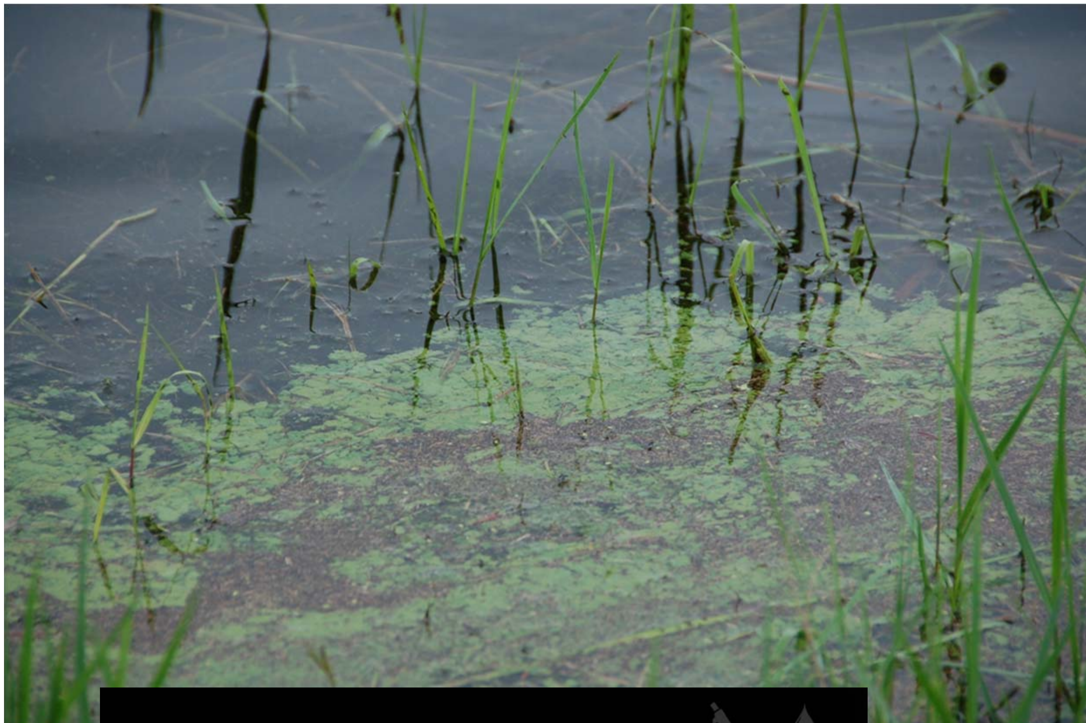


Photos courtesy of Lyn Crighton

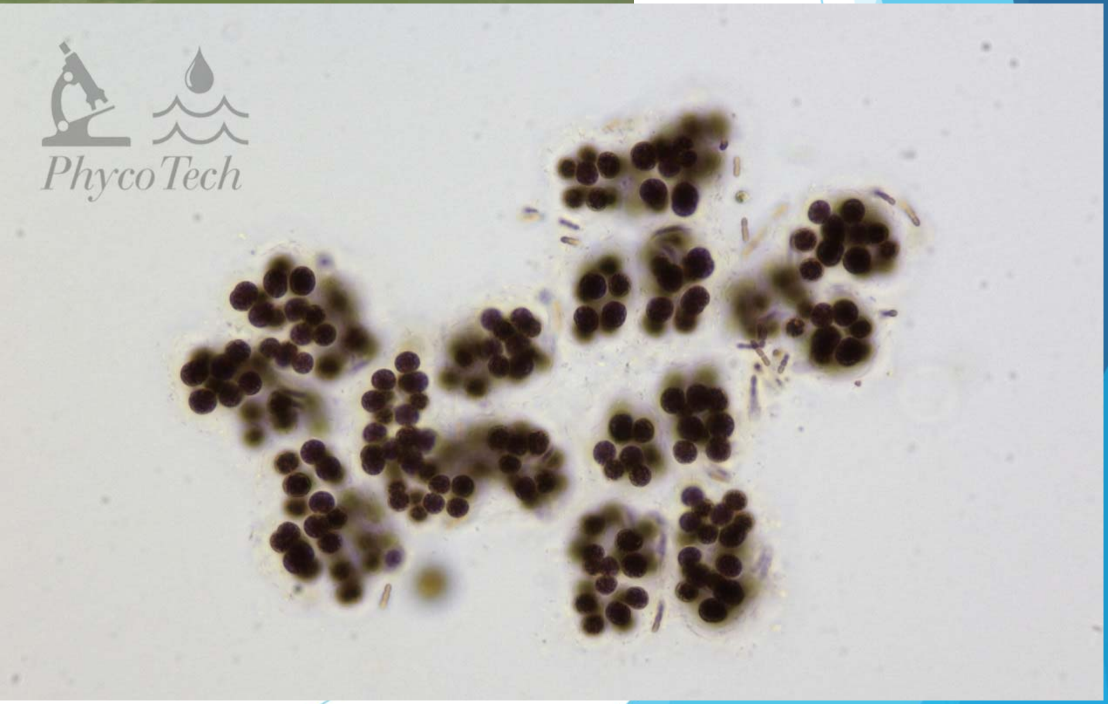
Blue-Green Algae (Raphidiopsis (*Cylindrospermopsis*) *raciborskii*)



Blue-green Algae (*Microcystis aeruginosa*)

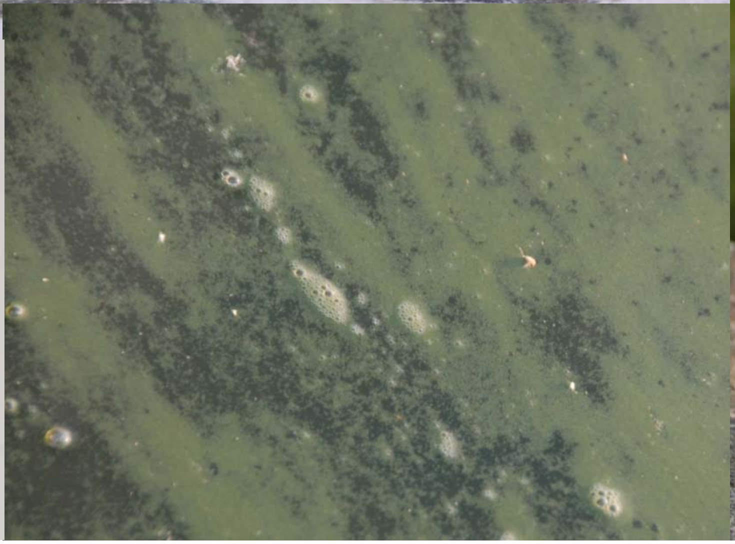


Blue-green Algae
(*Microcystis viridis*)

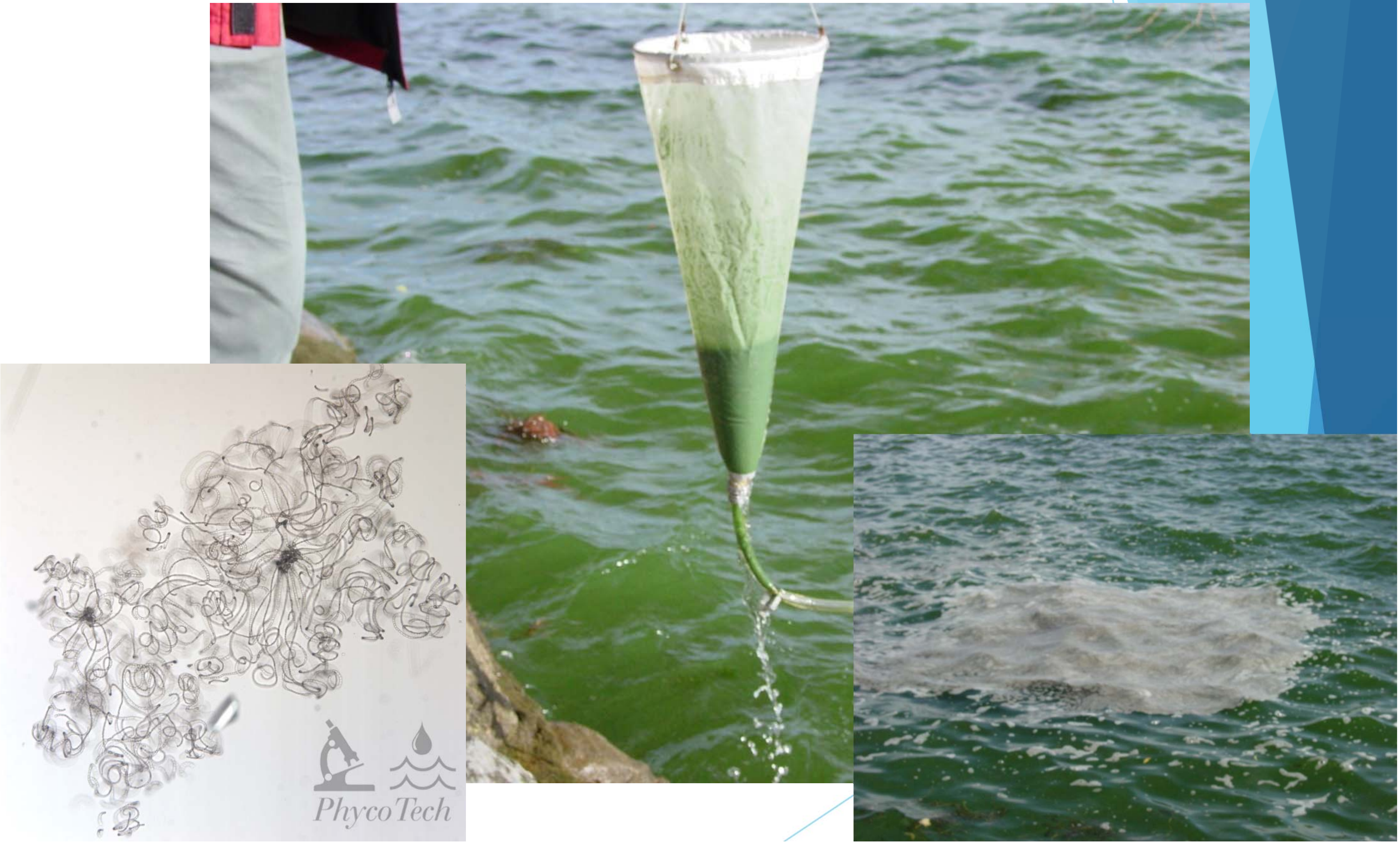


Blue-green Algae
(*Dolichospermum (Anabaena) lemmermannii*)

Blue-green Algae (*Dolichospermum (Anabaena) lemmermannii*)

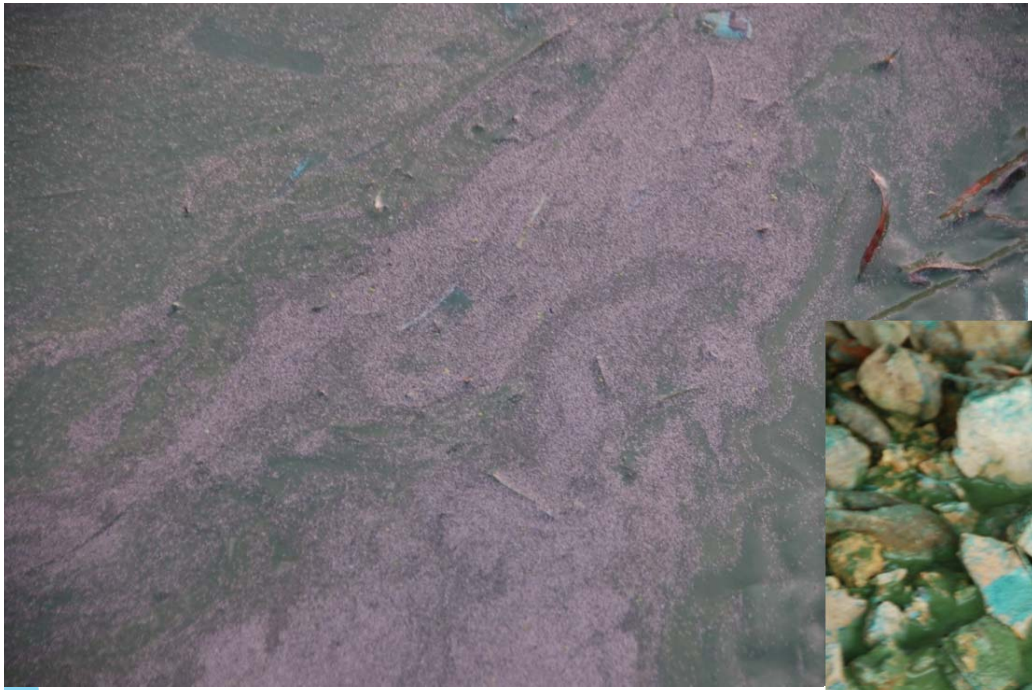


Blue-green Algae (*Dolichospermum (Anabaena) mendotae*)

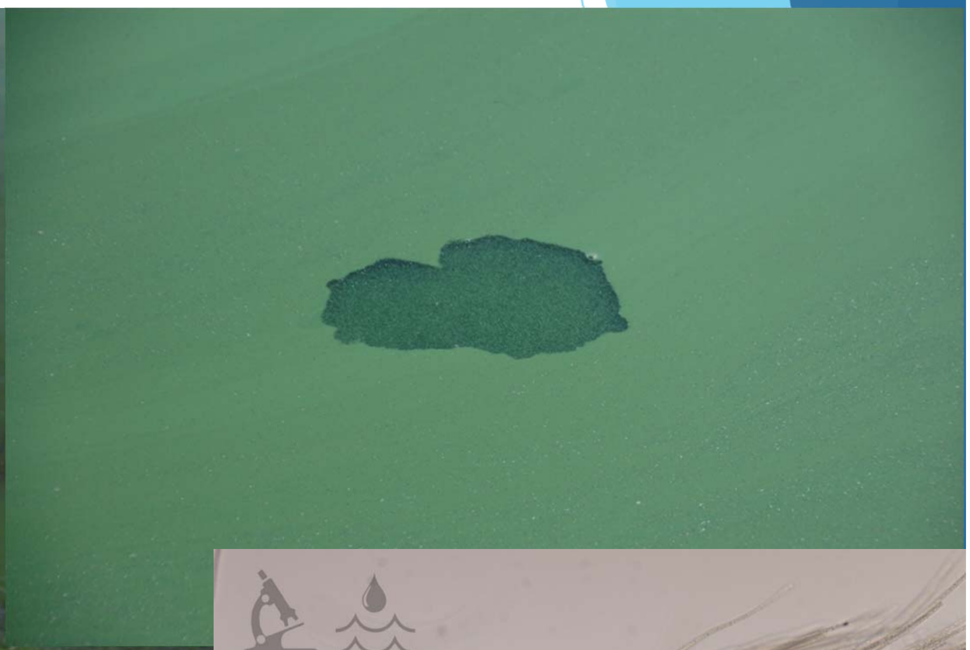


Blue-green Algae (*Dolichospermum (Anabaena) mendotae*)

Blue-green Algae (*Dolichospermum (Anabaena) mendotae*)



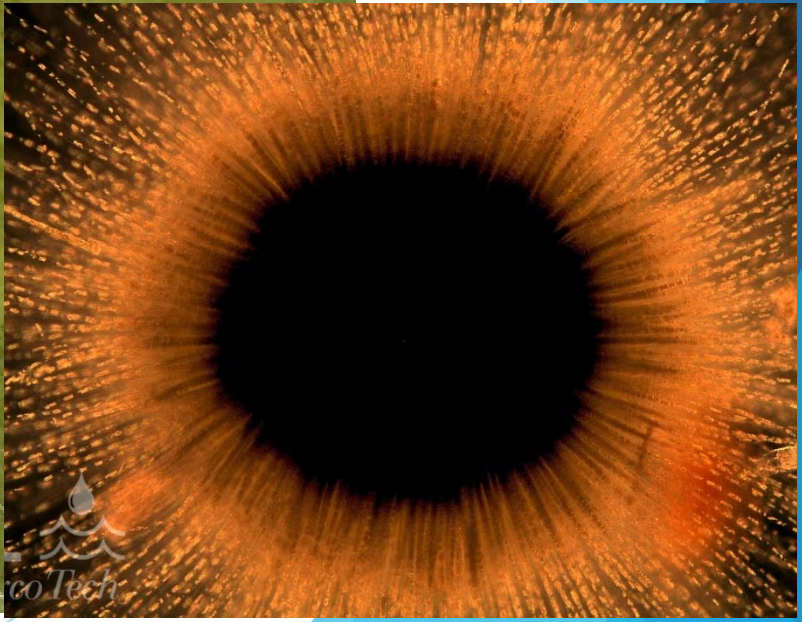
Blue-green Algae
(*Aphanizomenon flos-aquae*)



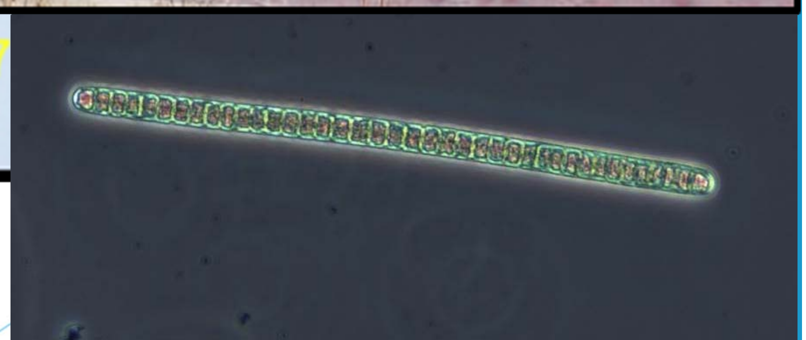
Blue-green Algae
(*Woronichinia naegeliana*)

Blue-green Algae
(*Gloeotrichia echinulata*)

Photo: Midge Eliassen, New Hampshire

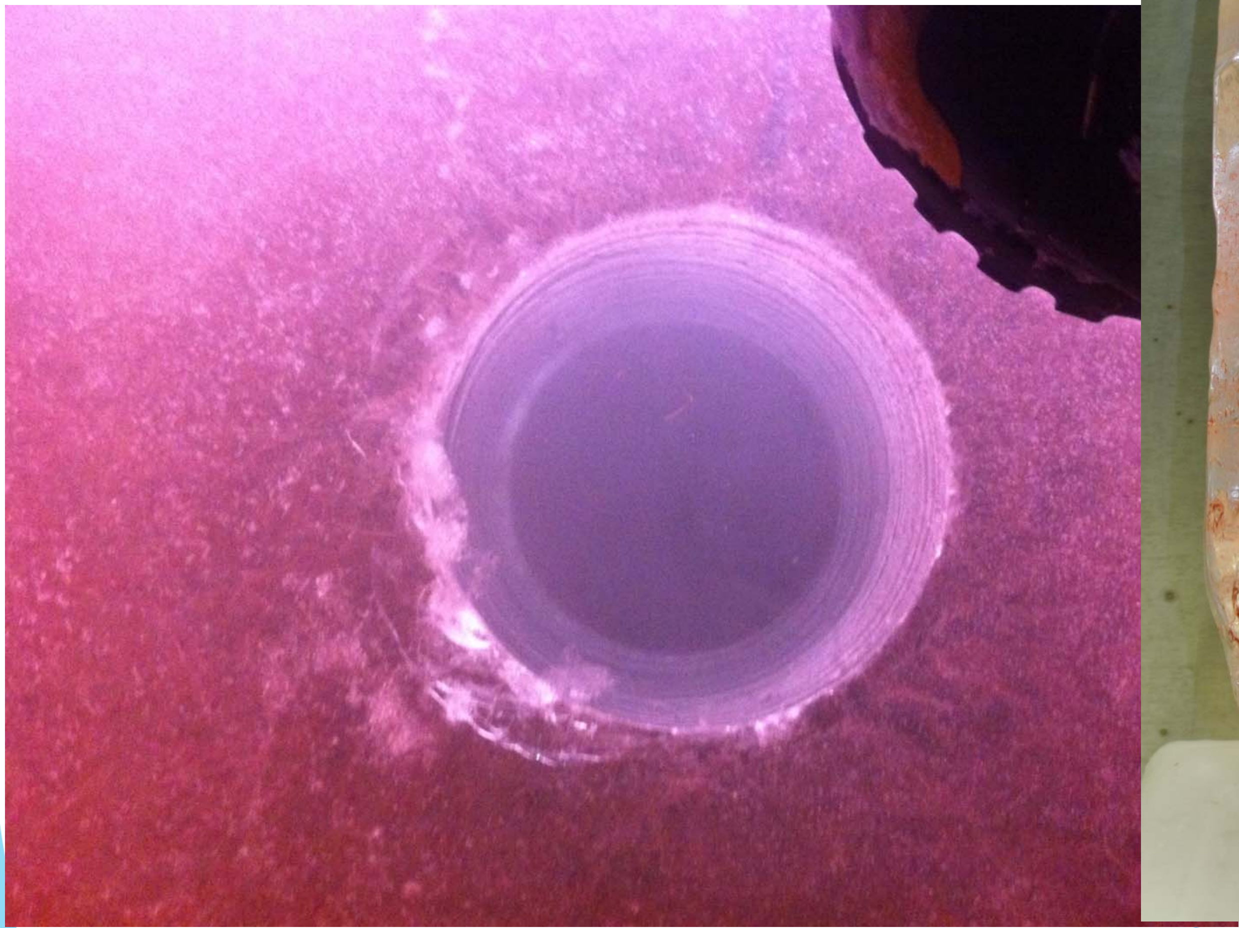


Blue-green Algae (*Planktothrix cf prolifica*)



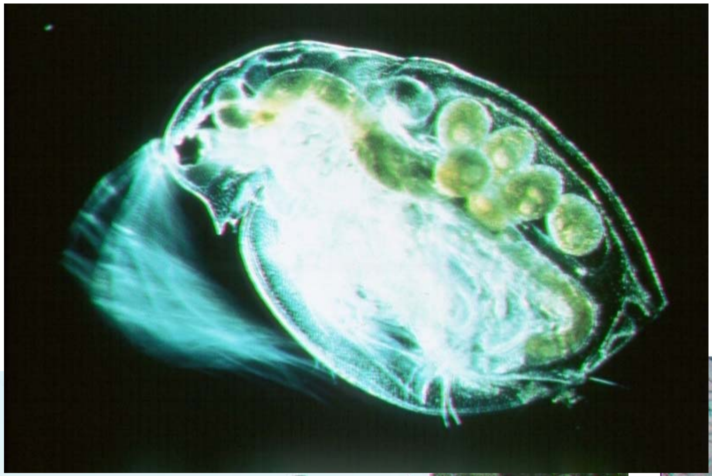
Photos courtesy of: Jennifer Graham

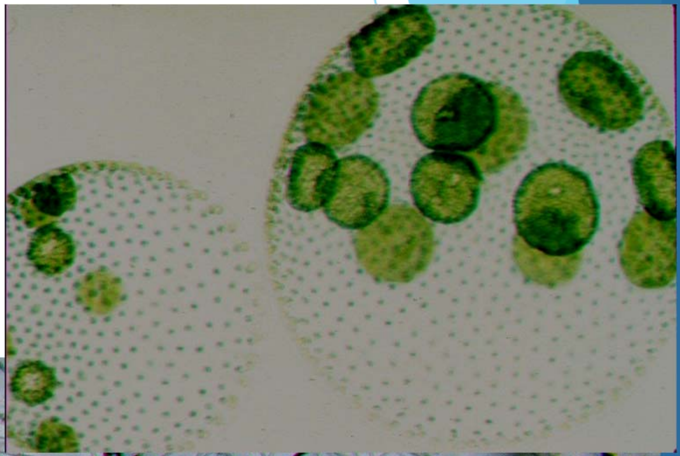
Blue-green Algae (*Planktothrix cf prolifica*)

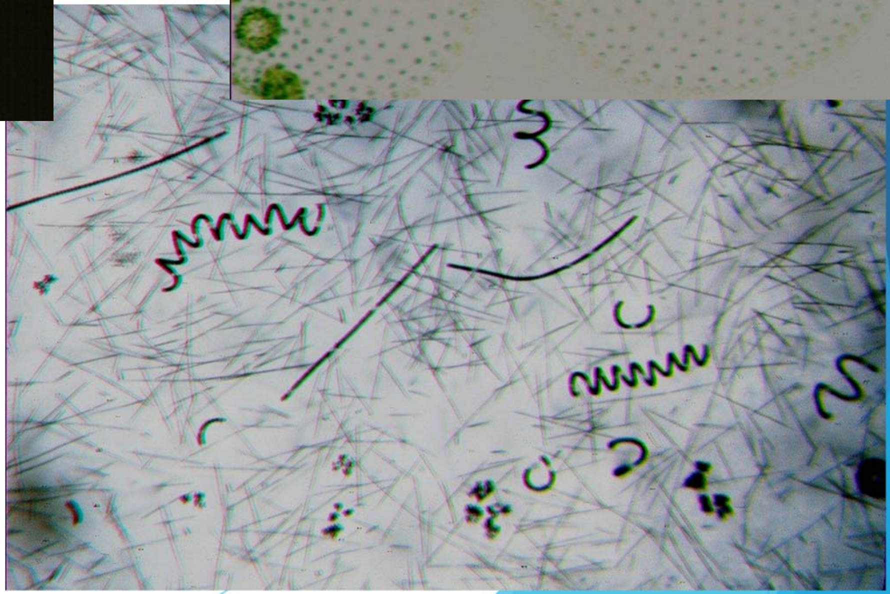


Photos: Ron Zurawell

PART 4: THE ECOLOGICAL BASIS FOR ALGAL CONTROL

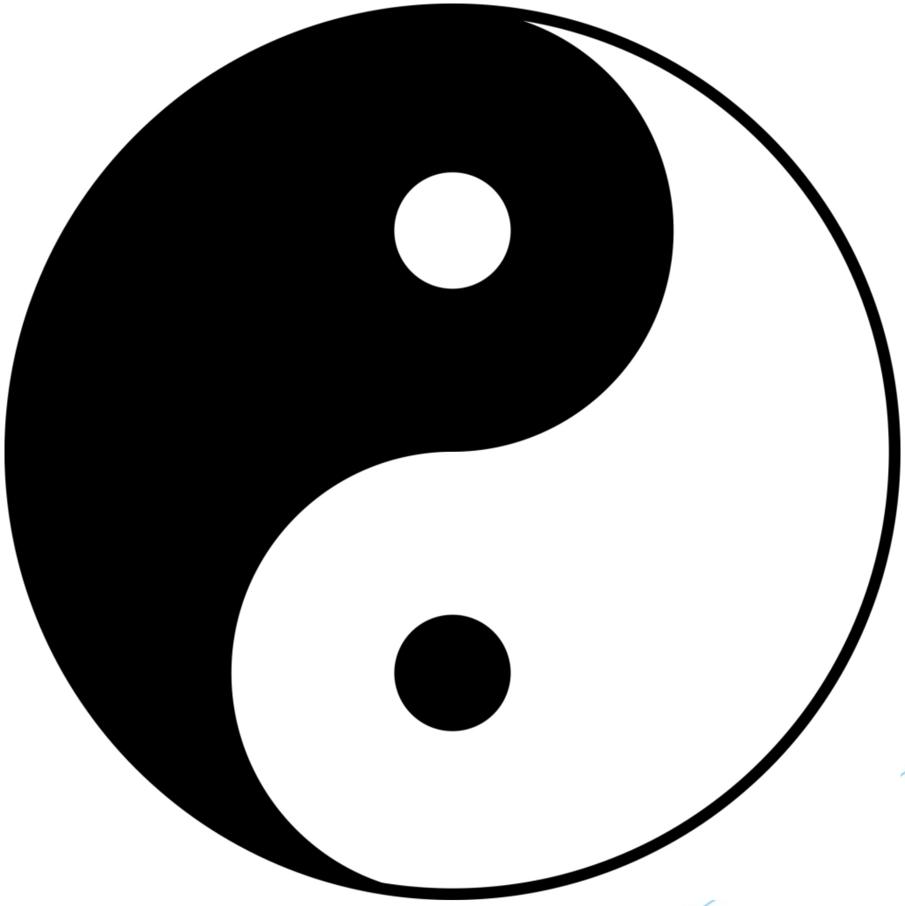






ALGAL ECOLOGY

Always a dance between growth and loss

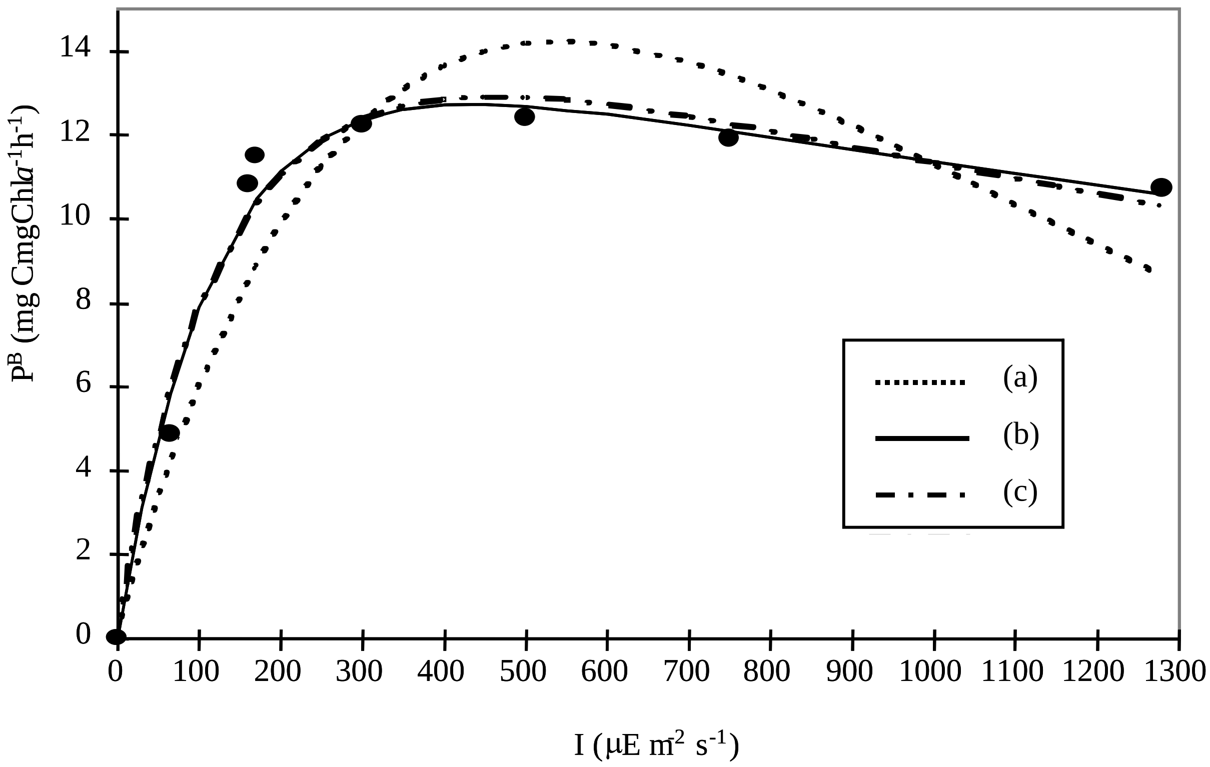


ALGAL ECOLOGY
Key Processes Affecting Growth

Growth Processes

- **Primary production** – controlled by light and nutrients, algal physiology
- **Heterotrophy** – augments primary production, dependent upon physiology and environmental conditions
- **Grazing** – complex algae-grazer interactions
- **Release from sediment** – recruitment from resting stages, related to turbulence, life strategies

ALGAL ECOLOGY



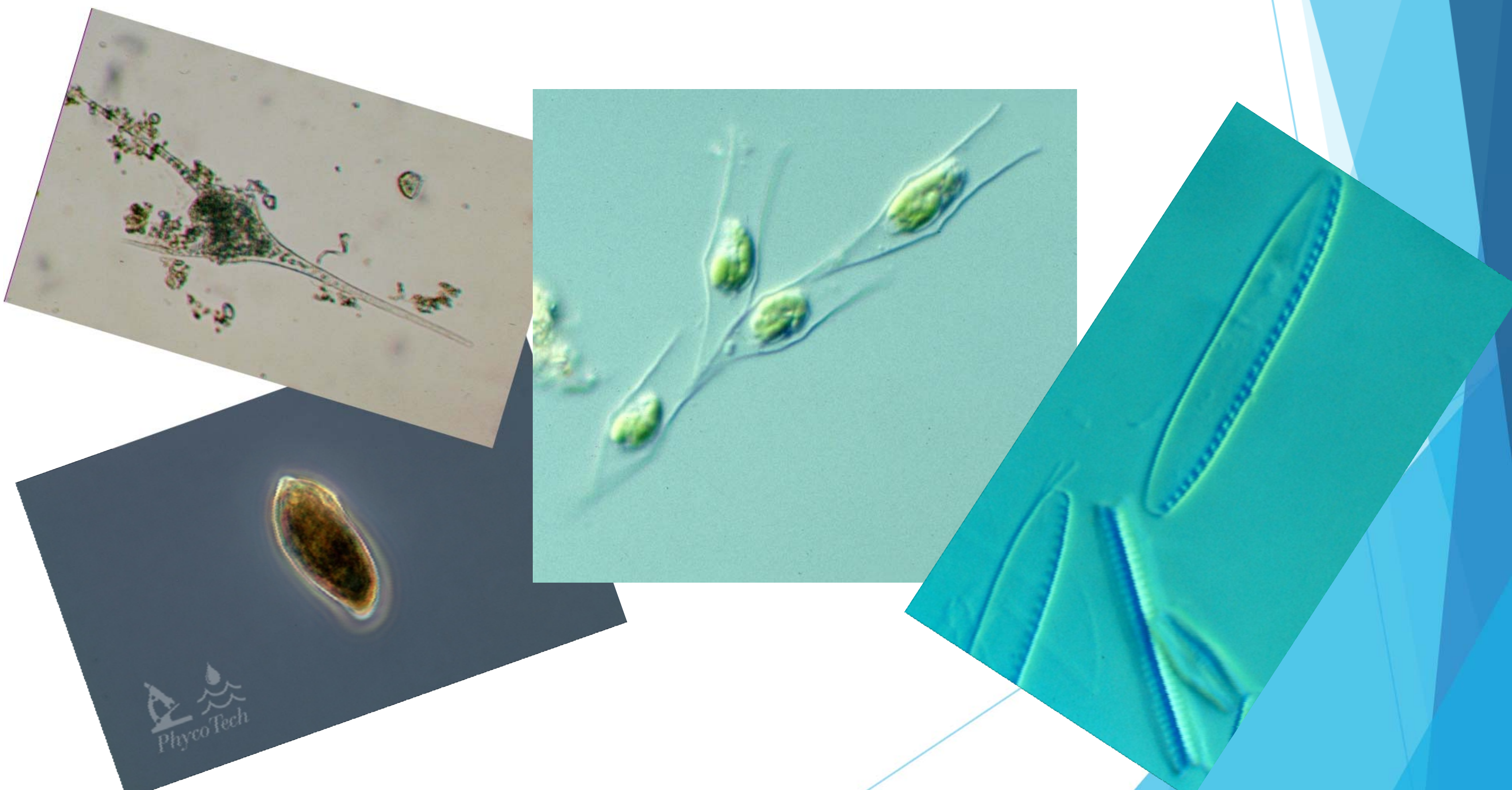
Primary Production-

modified by temperature, light, nutrient availability, physiological health

Photosynthesis versus Irradiance (*P/I*) curves obtained after fitting the data with the Steele (1965) (a), Platt et al. (1980) (b) and Eilers & Peeters (1988) (c) equations. Each point represents the mean value of three replicates obtained from a non-concentrated sample. Taken from: **Macedo, M.F., Ferreira, J.G. and Duarte, P., 1998. Dynamic behaviour of photosynthesis-irradiance curves determined from oxygen production during variable incubation periods. Mar. Ecol. Prog. Series, 165, 31-43.**

ALGAL ECOLOGY

- **Heterotrophy**, either absorbing organic compounds or direct phagotrophy



ALGAL ECOLOGY

Pallium – Feeding Pseudopod

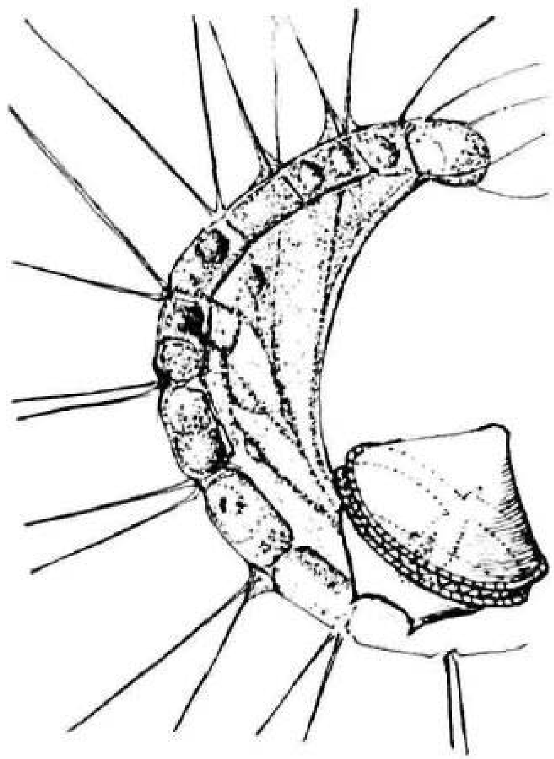
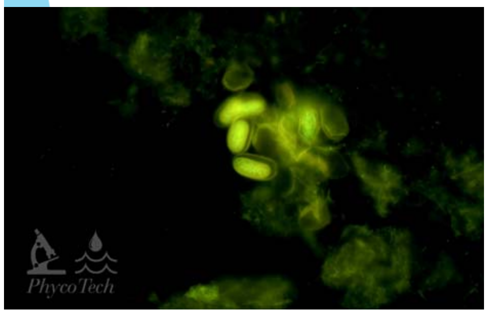


FIG. 23. *Protoperidinium spinulosum* feeding on *Chaetoceros curvetus*, illustrating radial fibrillar structure within web-like pallium. From video recording. Jacobson & Anderson 1986 J Phycol

ALGAL ECOLOGY

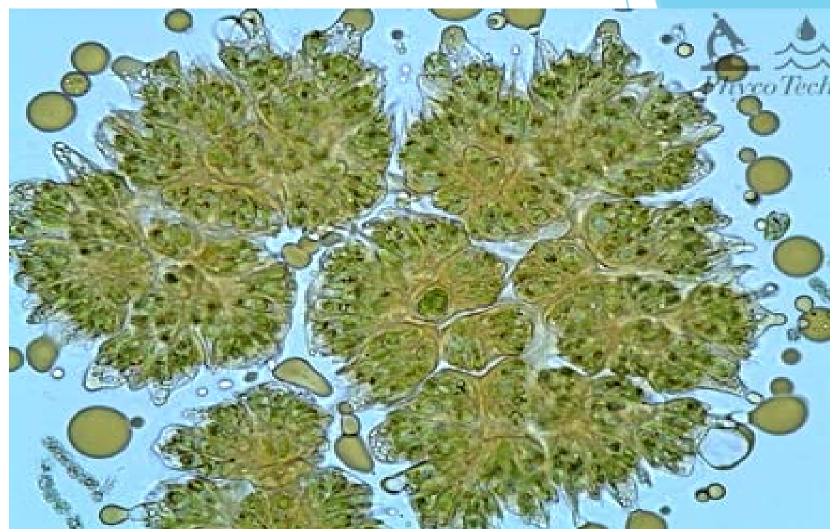
Release from sediment

- **Recruitment from sediment surface due to increasing light and temperature**
  - Cyanophytes - akinetes, hormogonia, and small daughter colony germination/growth
  - Dinoflagellates - cyst germination
  - Chlorophytes/Chrysophytes – oocyst/cyst germination
- **Entrainment from flocculent surface sediments due to turbulence or turnover**

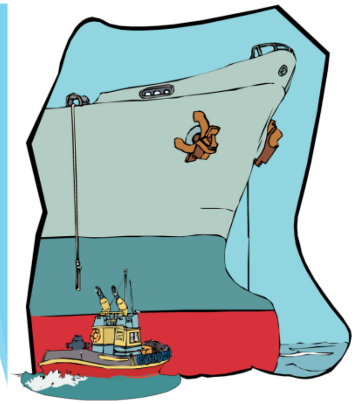


ALGAL ECOLOGY

- **Ability to maintain position in the water column**
  - Form advantageous length to width colonial/cell ratios
  - Produce oils (Diatoms, *Botryococcus*)
  - Produce gas vesicles (Cyanophytes)



ALGAL ECOLOGY



- Colonization (Invasion)
  - Natural
    - Water spray/aerosols
    - Flow from upstream/connected water bodies
    - Floods
    - Wildlife, especially migratory waterfowl
  - Anthropogenic
    - Ship ballast water
    - Water from boat engine manifolds, live wells
    - Manmade canals

ALGAL ECOLOGY
Key Processes Affecting Growth

Loss Processes

- **Physiological mortality** – inevitable but highly variable timing – many influences
- **Grazing** – complex algae-grazer interactions
- **Sedimentation/burial** – function of turbulence, sediment load, algal strategies
- **Hydraulic washout/scouring** – function of flow, velocity, circulation, and algal strategy

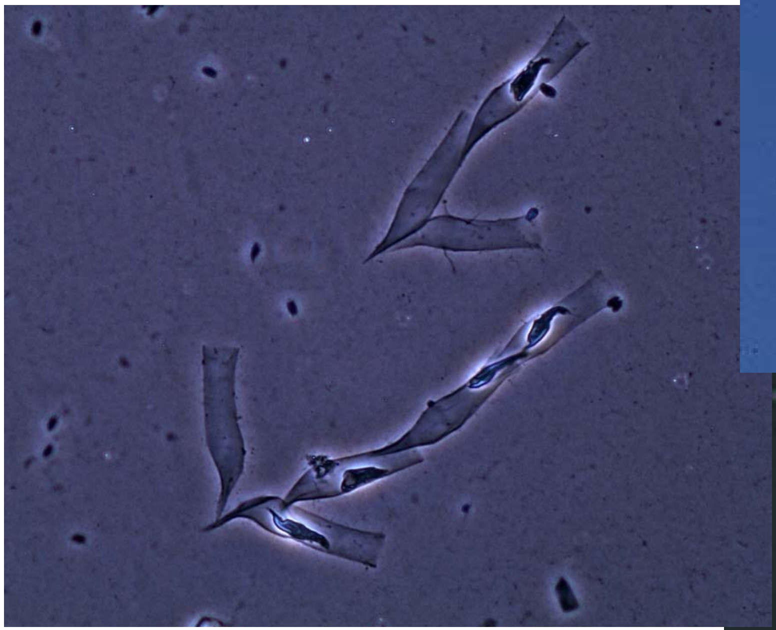
ALGAL ECOLOGY
Key Processes Affecting Growth

Annual variability in growth/loss factors in midwestern lakes

- Winter –
  - Possible ice cover, reverse stratification
  - Under ice circulation is an important factor
  - Low light and temperature affect production
  - Variable but generally moderate nutrient availability
  - Possibly high organic content
  - Grazer density usually low

ALGAL ECOLOGY

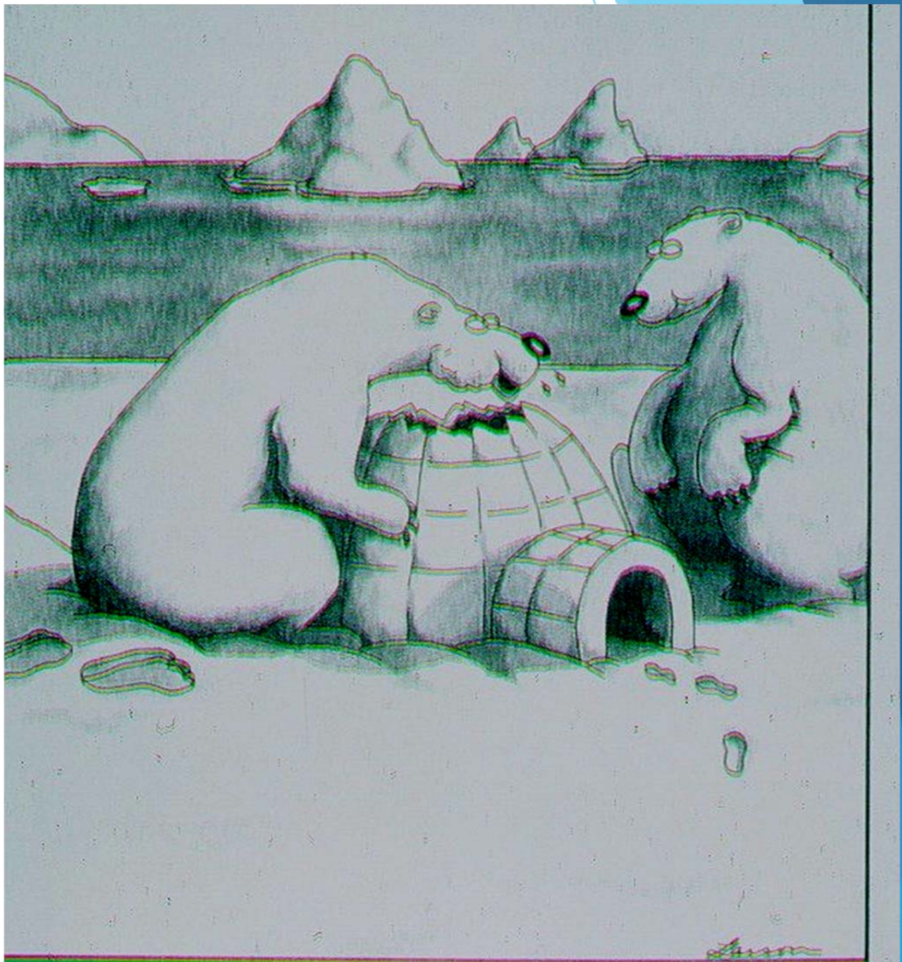
- **Physiological Mortality – loss of cells**



ALGAL ECOLOGY

• The Role of Grazing

- Grazing can be a major force in both algal quantity and quality
- “Top down” control
- Consumption and nutrient regeneration can both be factors



"Oh, hey! I just love these things! . . . Crunchy on the outside and a chewy center!"

ALGAL ECOLOGY

• The Role of Grazing

- Food webs are complicated, even in the simplest of systems
- Top down and bottom up controls are being exercised at the same time

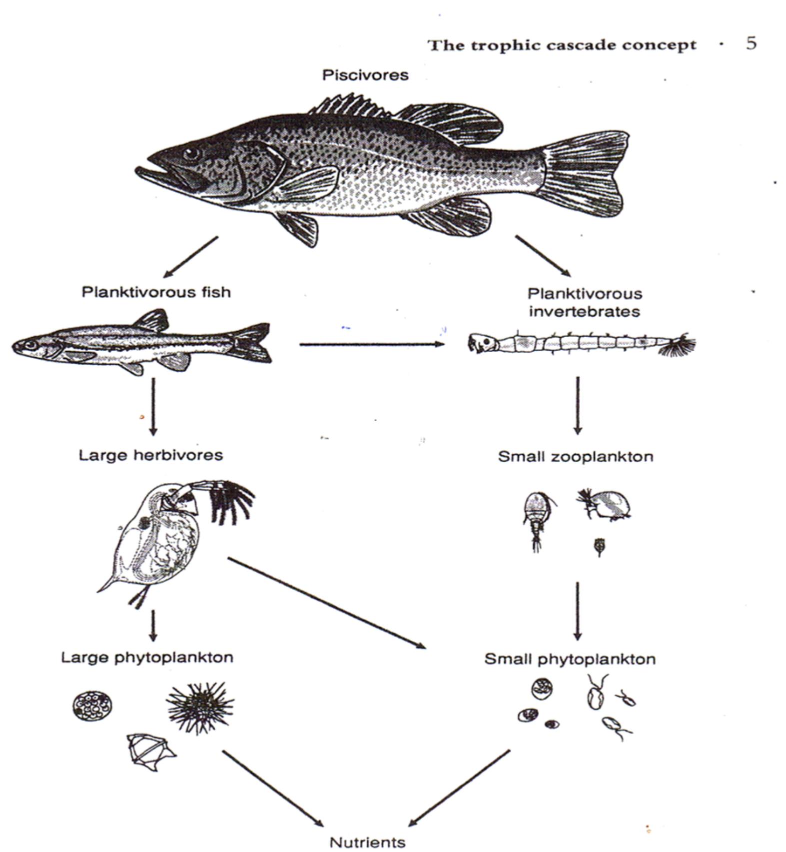
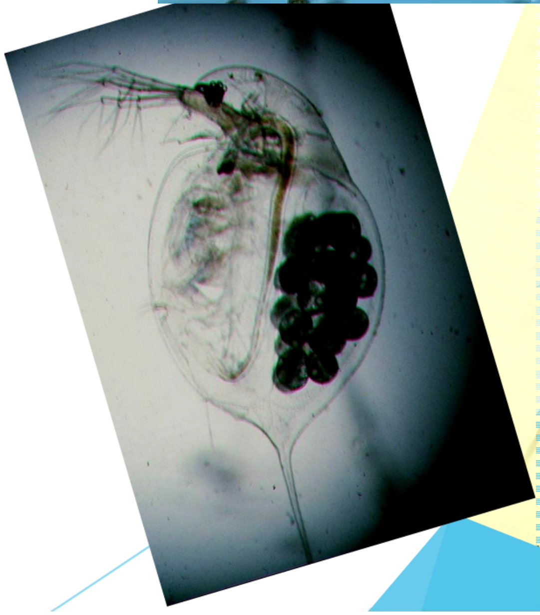


Image from Carpenter and Kitchell 1993

ALGAL ECOLOGY

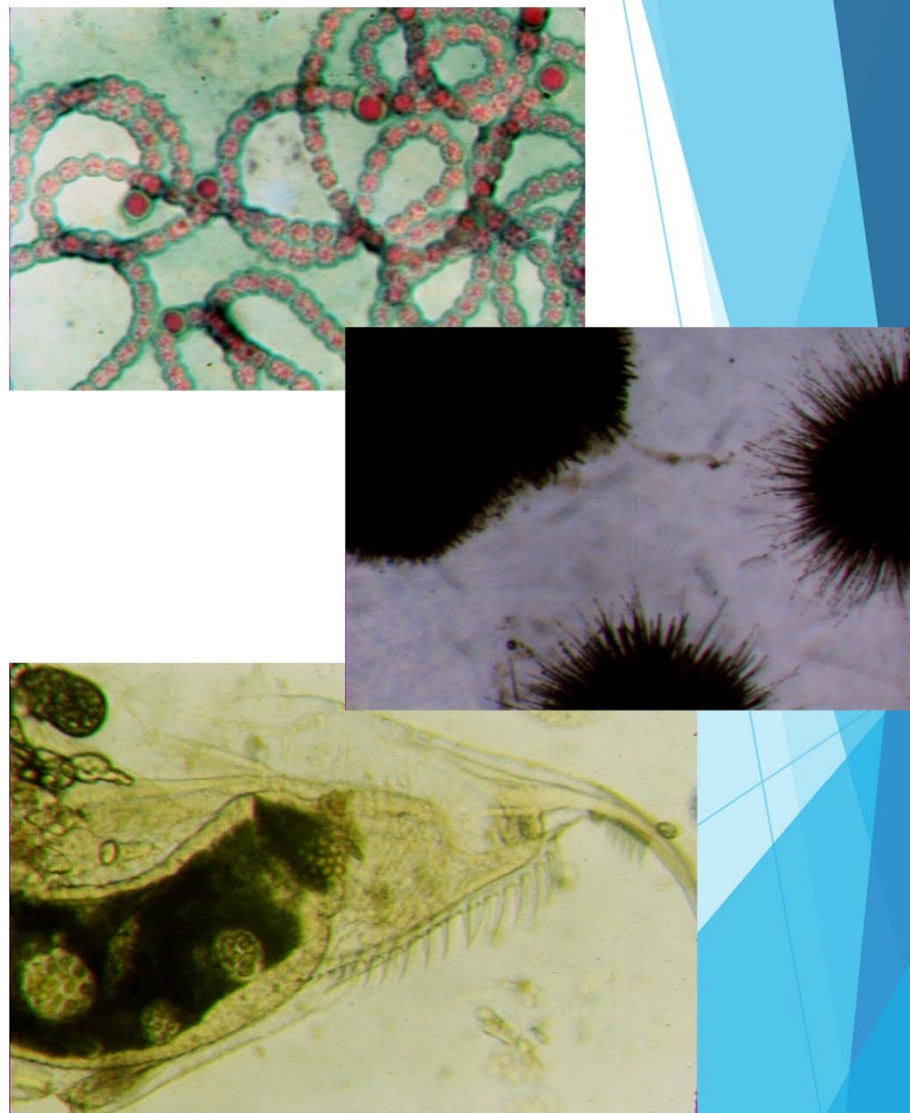
- **The Role of Grazing**

  - Key grazing factors include:
    - Grazer size
    - Grazer selectivity
    - Grazer abundance
    - Grazer specific excretion rates



ALGAL ECOLOGY

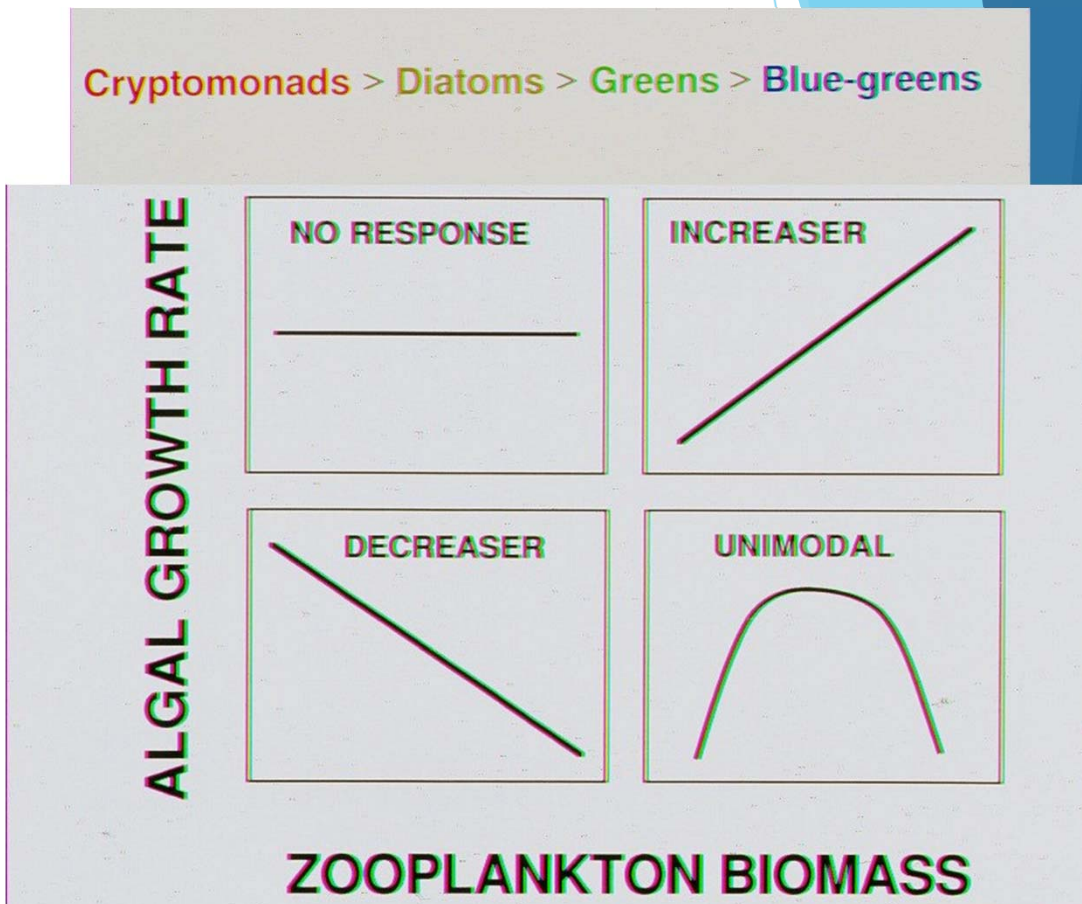
- Key algae features in relation to grazing include:
  - Growth rate
  - Resistance to grazing
    - Physical (size, spines)
    - Chemical (toxins)
  - Ability to migrate



ALGAL ECOLOGY

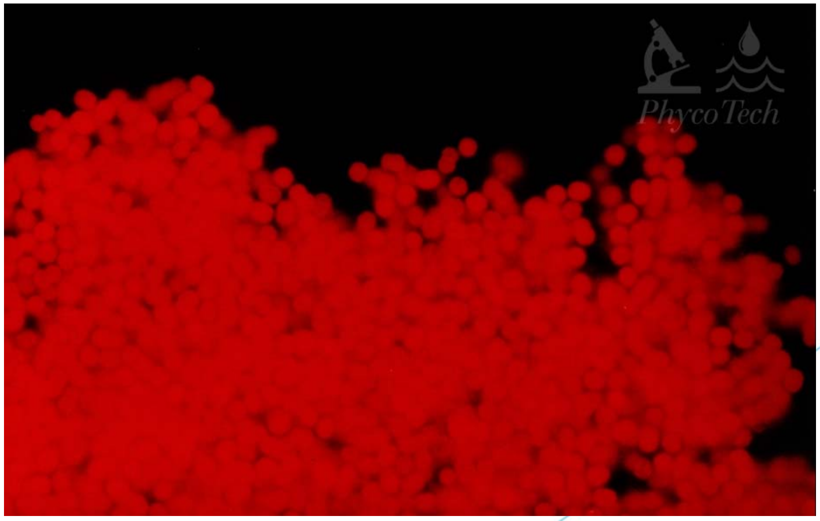
- **The Role of Grazing**

  - Food preferences follow a general trend
  - Response of algae to grazers varies



ALGAL ECOLOGY

- **The Role of Grazing**
  - Toxic *Microcystis aeruginosa* blooms in Lake Erie are exacerbated by differential grazing by zebra/quagga mussels and species-specific excretion rates at the sediment water interface; both favor *Microcystis*!



ALGAL ECOLOGY

Sedimentation/burial

- Highly influenced by stratification scheme
- Turbulence
  - Within major strata
  - Micro-stratification
- Sediment load
  - Internal
  - Upstream
- Physiological State
  - Weaker, less healthy cells sink faster
- Motility
  - Diatoms with raphe can reposition themselves if buried
  - Chrysophytes, Cryptophytes, Dinoflagellates, Chlorophytes with flagella can all migrate to some

ALGAL ECOLOGY

Hydraulic Washout/Scour

- Highly influenced by stratification
  - Reservoirs
  - Large rivers
- Flow
  - Rainfall
  - Morphometry
- Velocity
  - Volume
  - Grade
  - Substrate type
  - Time since last disturbance
- Physiological state/algal mat age
  - Older, more complex mats slough easier
- Basal attachments

ALGAL ECOLOGY

Desiccation

- Cyanophytes handle drying the best
- Normal hydrologic cycles
  - Ephemeral streams
  - Lower water levels in summer
  - Dry versus wet seasons
- Geologic Disturbance
  - Earthquakes
  - Volcanos
  - Subsidence of flood waters
  - Natural movements in stream/river beds

ALGAL ECOLOGY
Key Processes Affecting Growth

Annual variability in growth/loss factors in midwestern lakes

- Spring/fall –
  - Isothermal and well-mixed
  - Relatively high nutrient availability
  - Light increases in spring, decreases in fall
  - Temperature low to moderate
  - Stratification setting (spring) or breaking down (fall)
  - Grazer density in transition (low to high in spring, high to low in fall)

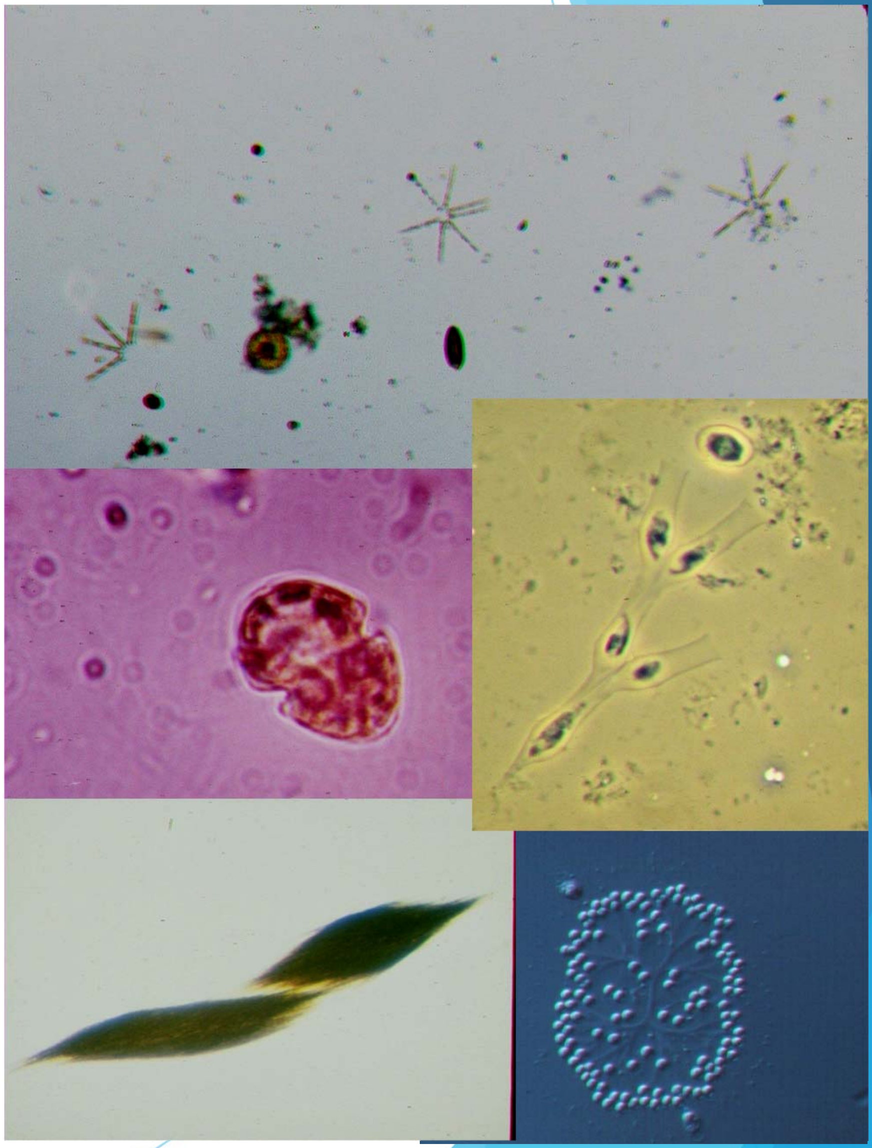
ALGAL ECOLOGY
Key Processes Affecting Growth

Annual variability in growth/loss factors in midwestern lakes

- Summer –
  - Potential stratification, even in shallow lakes
  - Often have low nutrient availability
  - Light limiting only with high algae or sediment levels
  - Temperature vertically variable – highest near surface
  - Vertical gradients of abiotic conditions and algae
  - Grazer densities variable, often high unless fish predation is a major factor

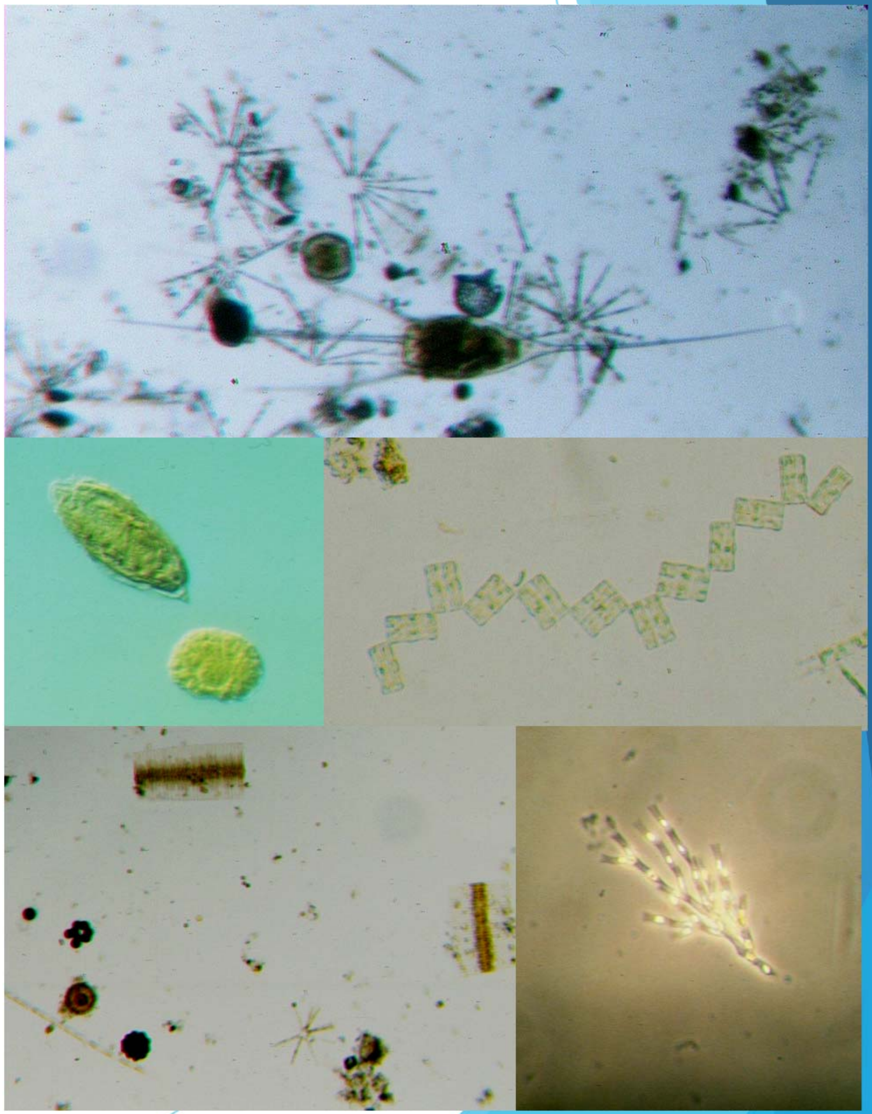
ALGAL ECOLOGY
Phytoplankton Succession - Winter

- Under ice, mainly cryptophytes, chrysophytes, diatoms, naked dinoflagellates
- Some non-nitrogen fixing blue-greens, but also possibly *Aphanizomenon*



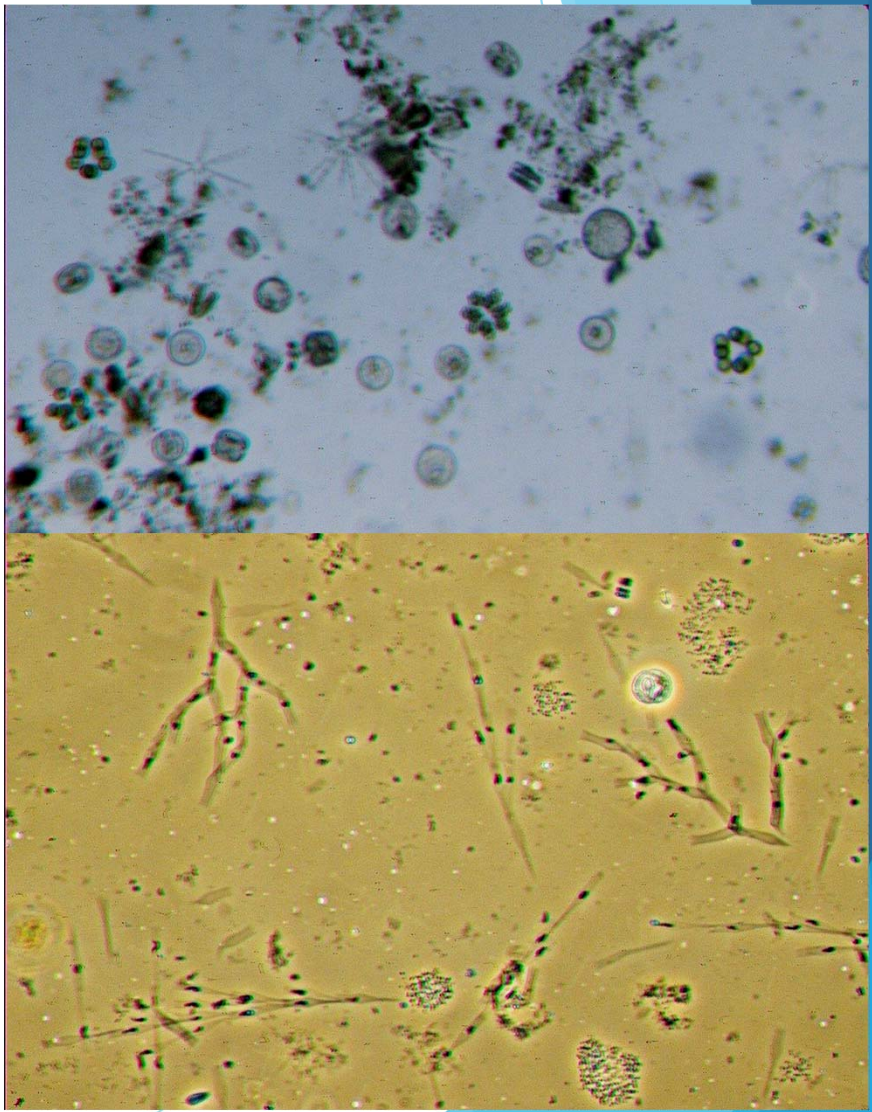
ALGAL ECOLOGY
Phytoplankton Succession – Early Spring

- Most lakes experience rapid increase in algal density
- Diatoms, cryptophytes, and chrysophytes tend to dominate
- Temperature is a primary control factor



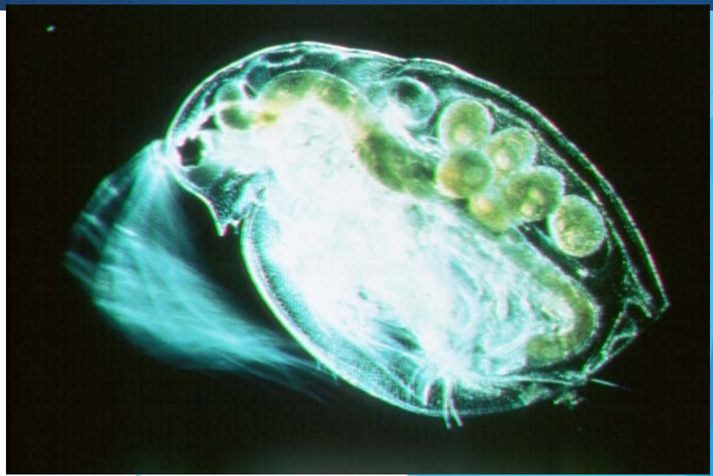
ALGAL ECOLOGY
Phytoplankton Succession – Late Spring

- Diatoms tend to dominate, often with Chlorococcalean greens and cryptophytes
- Chrysophyte blooms possible
- The later the spring maximum, the less likely that diatoms will dominate
- Overwintering benthic colonies may be recruited to the plankton community



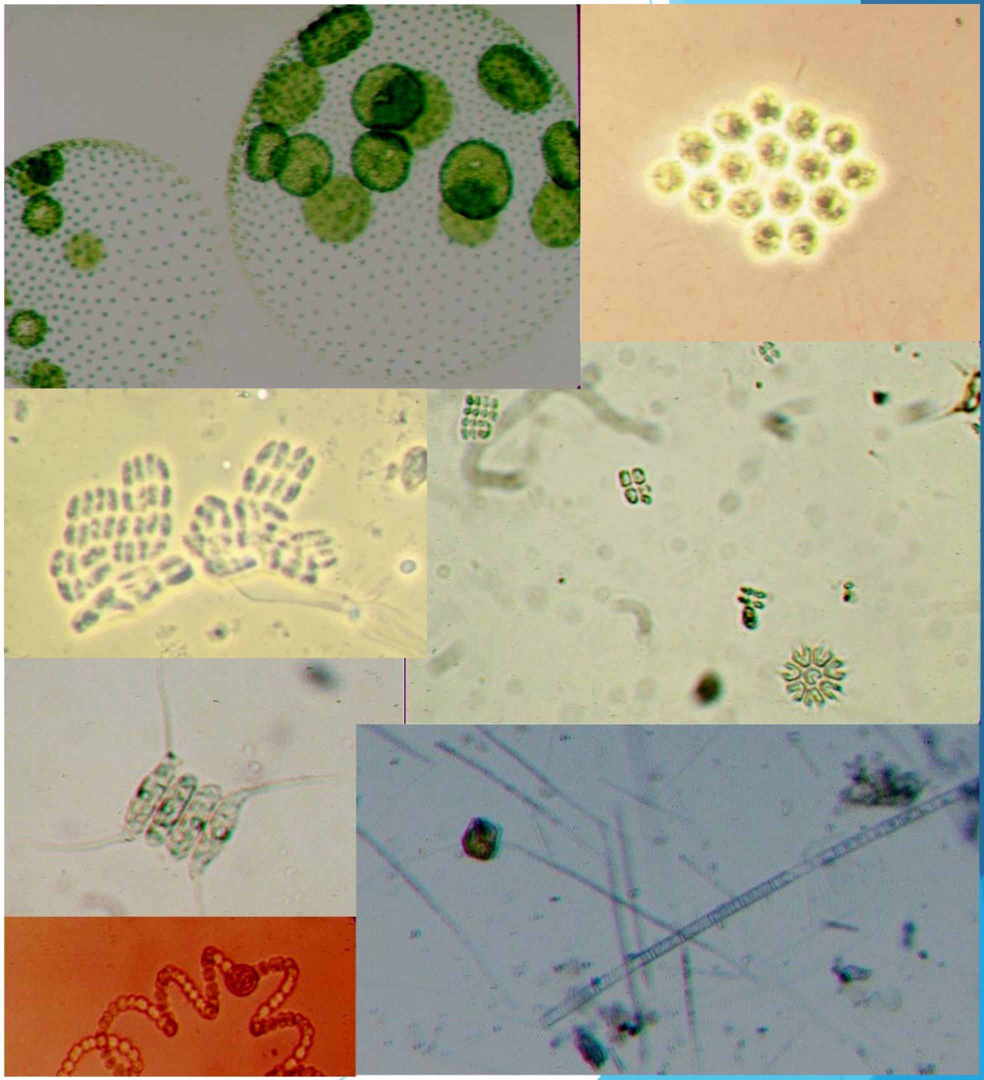
ALGAL ECOLOGY
Phytoplankton Succession – Late Spring

- Increasing light cues spring blooms where nutrients are available
- Grazing and algal settling increases during spring with rising water temperature
- Clear water phase often results from loss processes overshadowing growth in late spring



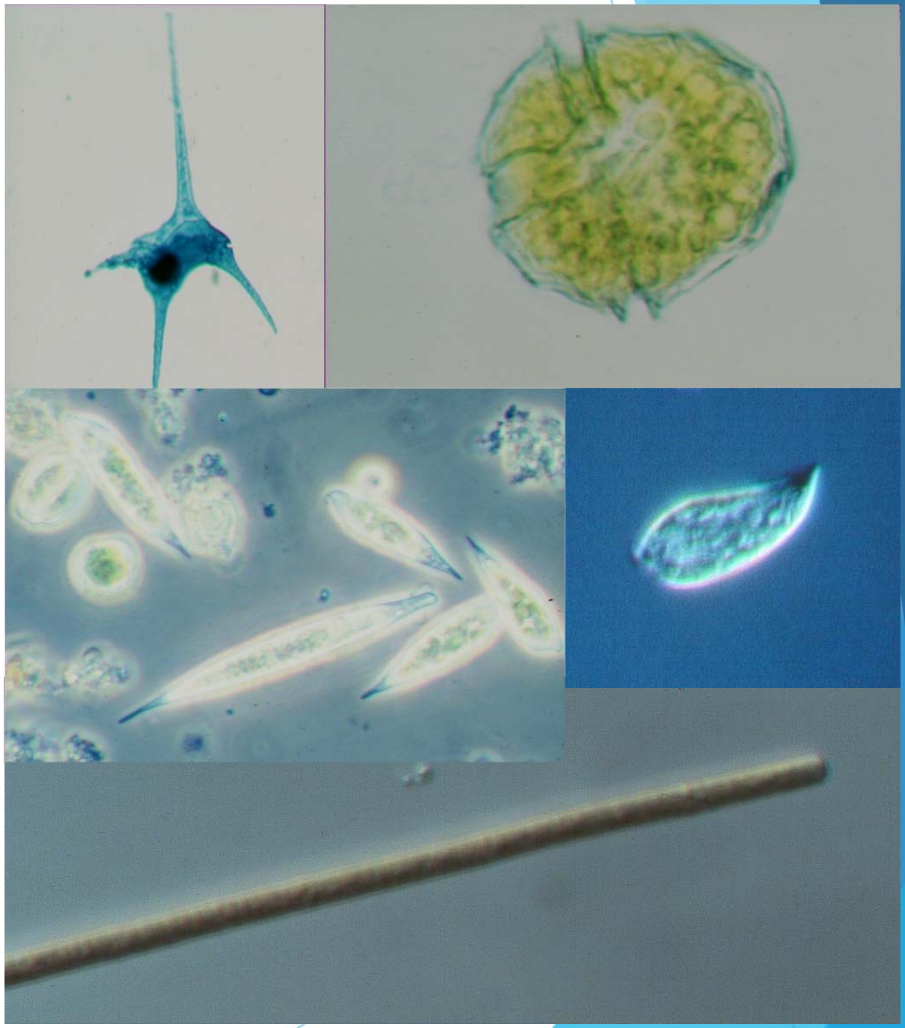
ALGAL ECOLOGY
Phytoplankton Succession – Early Summer

- Greens increase, especially Volvocales and Chlorococcales
- Some blue-greens appear at increased density



ALGAL ECOLOGY
Phytoplankton Succession – Early Summer

- May get metalimnetic blooms of cryptophytes, chrysophytes, dinoflagellates or blue-greens, especially *Oscillatoria*



ALGAL ECOLOGY
Trophic Gradients - Summer

Summary of trends by Watson et al. 1997

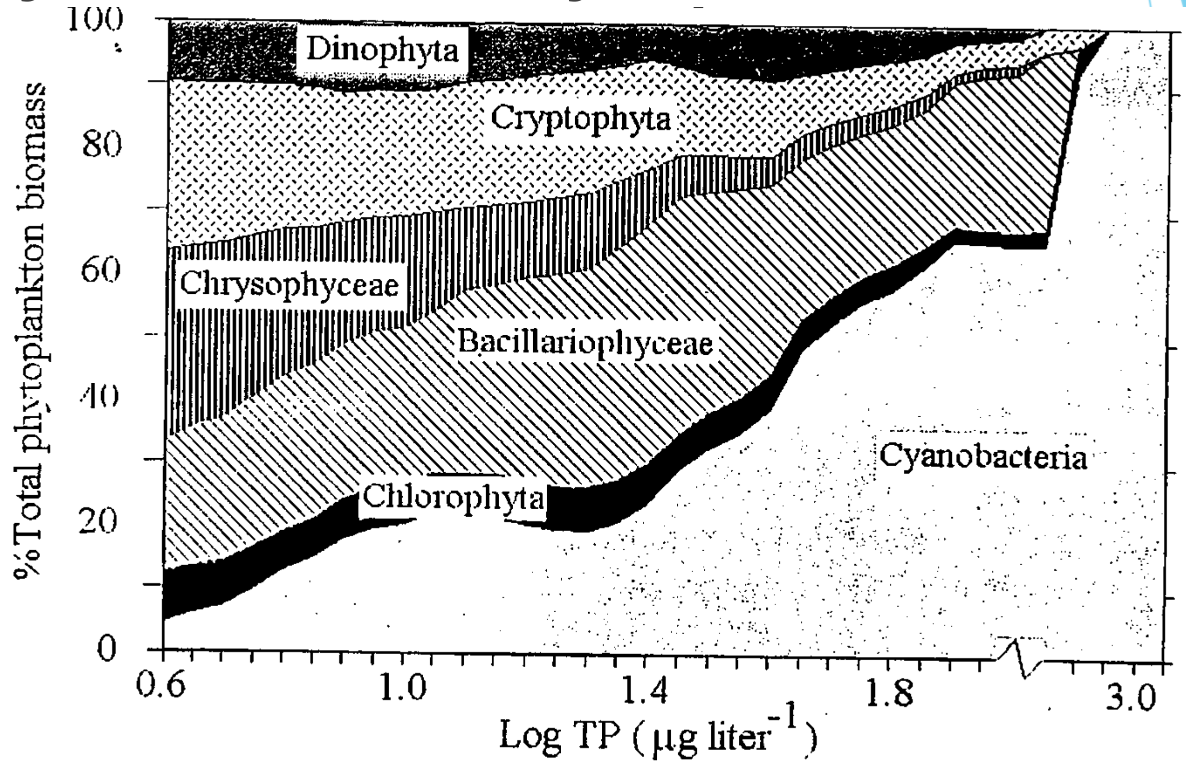
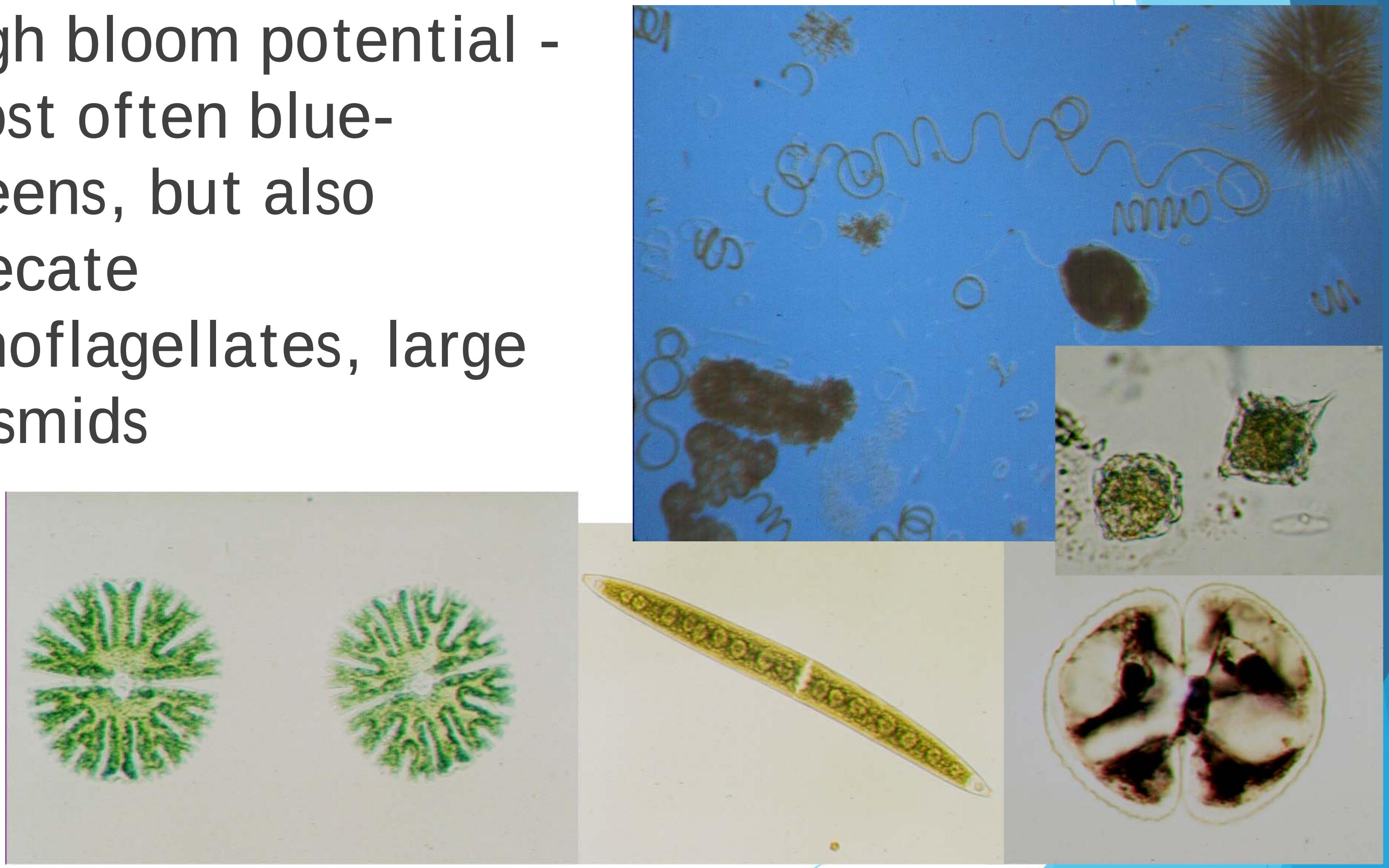


Fig. 4. Area plot of average contribution (%) of individual taxonomic groups to total summer biomass; data fitted with LOWESS smoothing technique.

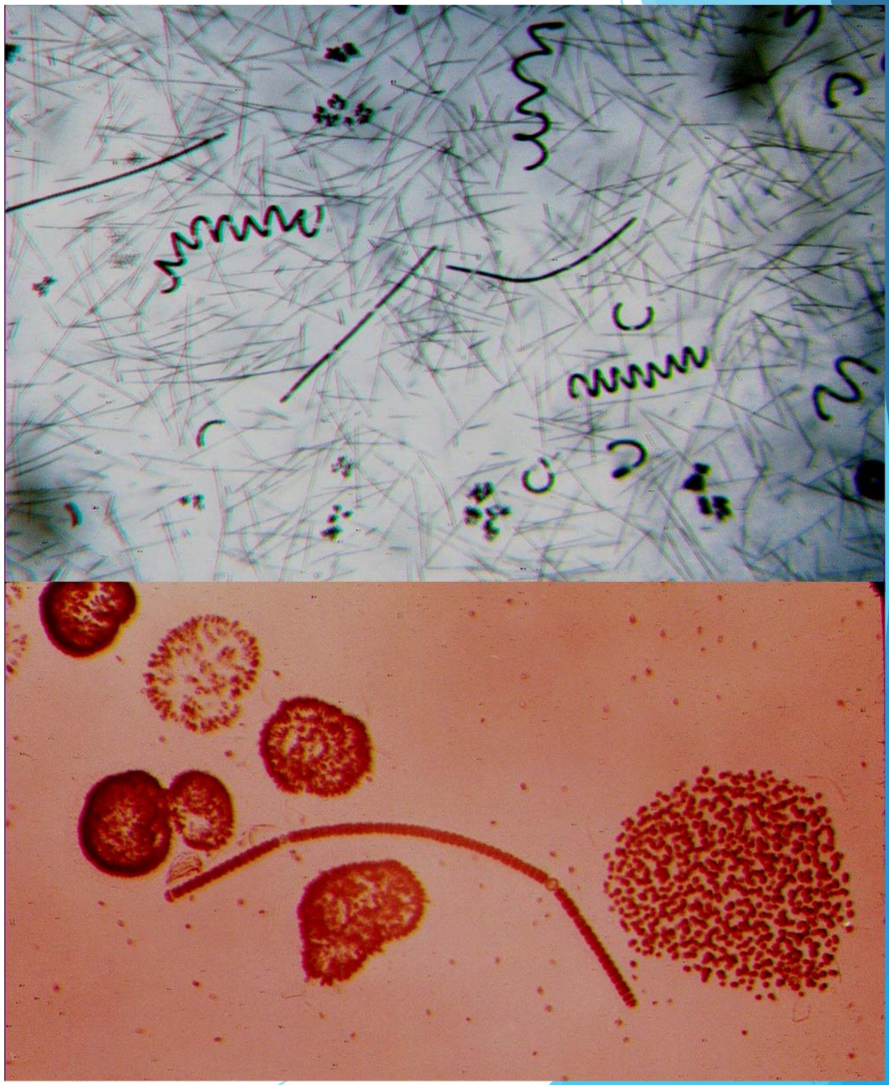
ALGAL ECOLOGY
Phytoplankton Succession – Late Summer

- High bloom potential - most often blue-greens, but also thecate dinoflagellates, large desmids



ALGAL ECOLOGY
Phytoplankton Succession – Late Summer

- Nitrogen-fixing blue-greens especially common bloomers
- May get blooms of non-N fixing blue-greens if N is high
- May get population oscillations between N-fixers and non-N-fixers

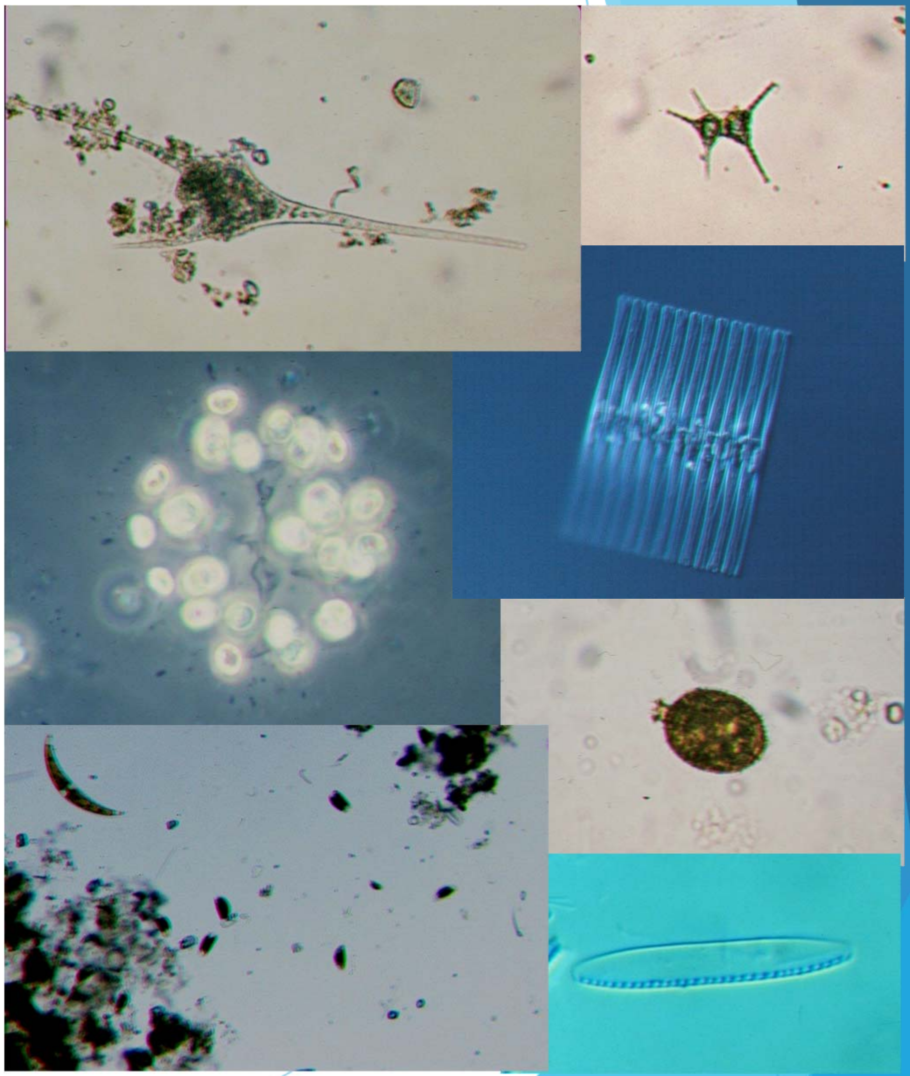


ALGAL ECOLOGY
Phytoplankton Succession – Late Summer

- May also get green or blue-green mats floating to the surface
- Most often Cladophorales or Oscillatoriales
- Mats tend to start on bottom, floating to surface after trapping gases

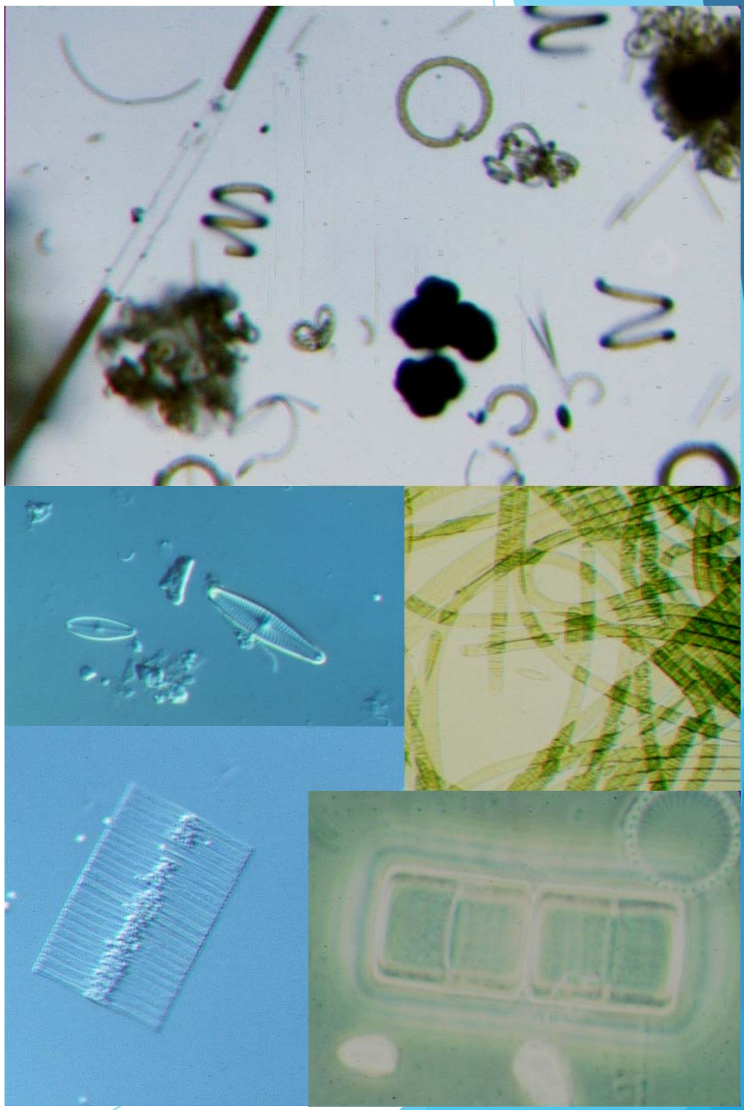
ALGAL ECOLOGY
Phytoplankton Succession – Late Summer

- A variety of other algae may be mixed in, but dominance by one taxon or a few taxa is typical in productive lakes
- Growth often nutrient limited, but dense surface growths may create light limitation below
- Grazing may be high, may be selective



ALGAL ECOLOGY
Phytoplankton Succession - Autumn

- "Leftover" blue-greens may remain abundant well into autumn, exception is *Raphidiopsis* which often blooms late summer into mid-fall
- Metalimnetic growths often reach surface upon mixing
- Diatoms often assume dominance after turnover



ALGAL ECOLOGY
Phytoplankton Succession - Autumn

- Desmids also respond positively to mixing
- As the water cools, the oil-laden *Botryococcus* may become abundant
- Nutrients tend to be abundant after turnover

Questions?

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269-983-3654