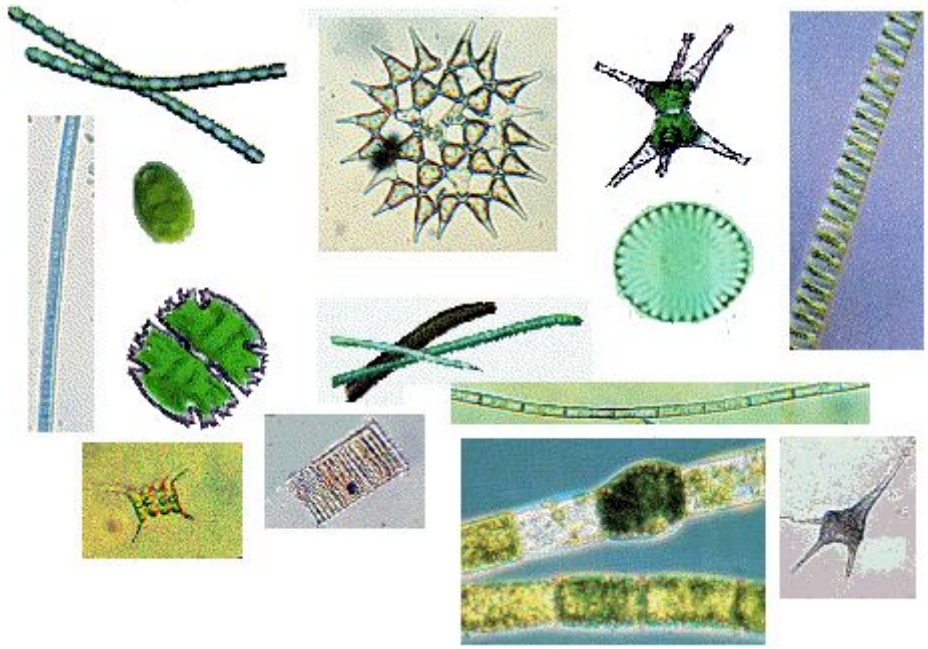
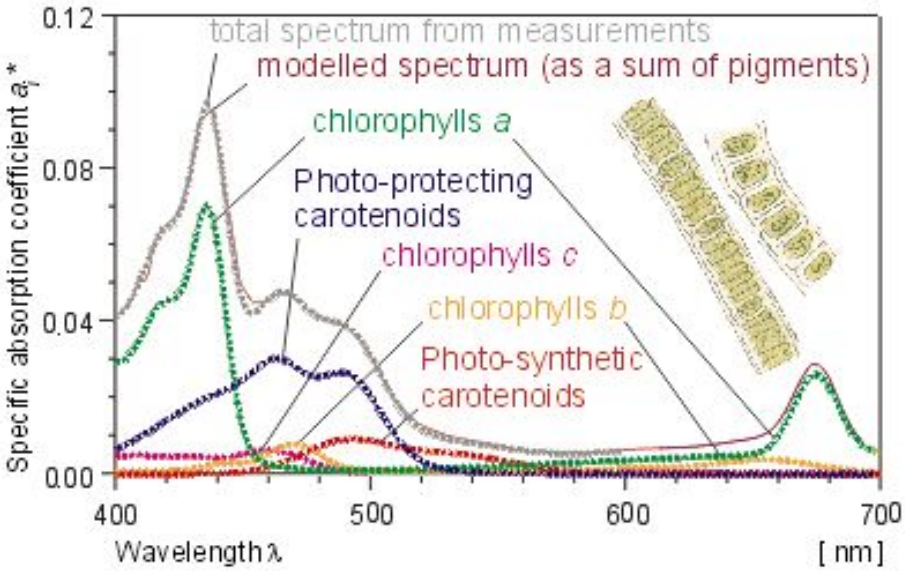
# Biological/Ecological Limnology of Lakes

## Phytoplankton

~1 - 50 ⊕m

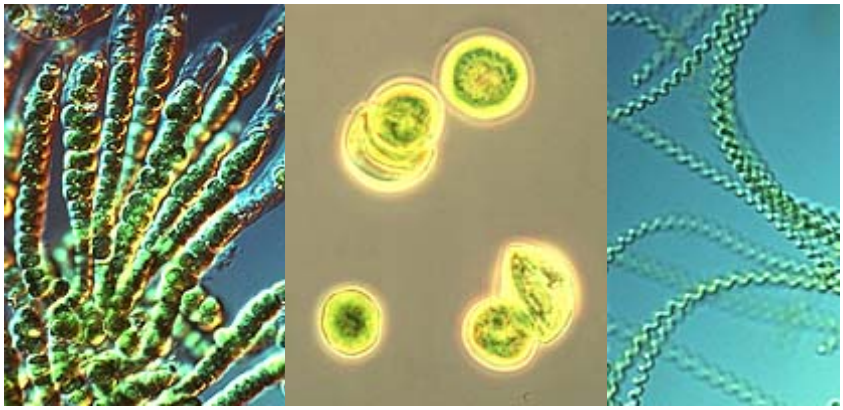





**Some major groups of algae that occur as freshwater phytoplankton:**

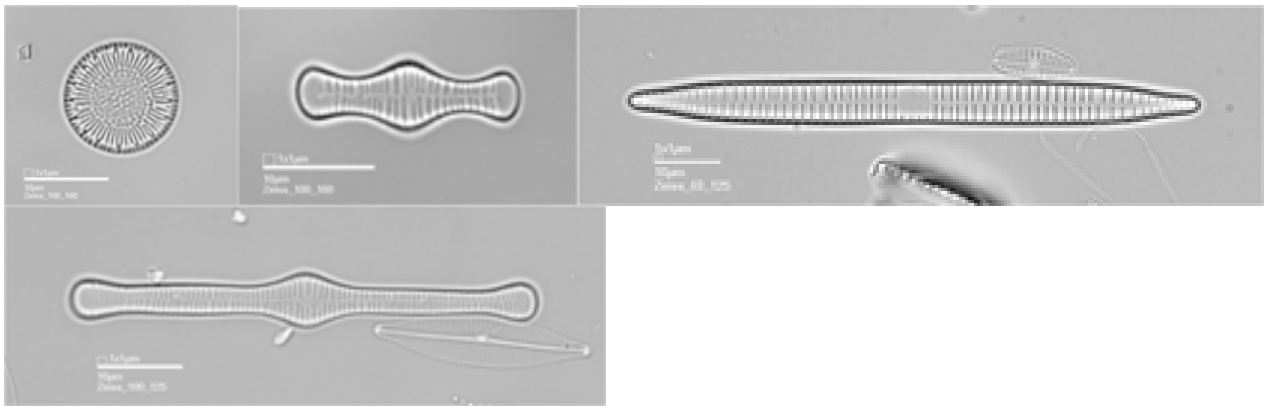
- **Cyanobacteria** (Blue-green 'algae') (note that other non-phytosynthetic bacteria are extremely abundant in freshwater; some are involved in nutrient transformation and cycling, many are important decomposers, and in contaminated waters some are agents of disease)

- procaryote
- slow growth, but need only low nutrient concentrations *What time of year should they be favored?*
- include nitrogen fixers
- Many species produce toxins
- Many species dominate highly eutrophic waters - ordorous and not prefered by most fish

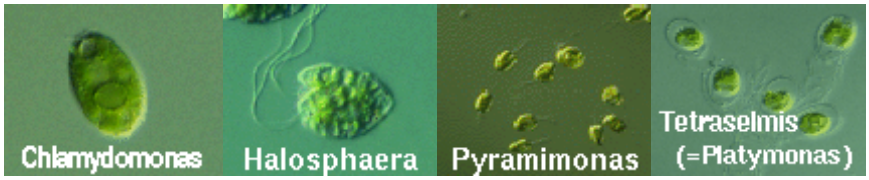


http://phylogeny.arizona.edu/tree/eubacteria/cyanobacteria/cyanobacteria.html

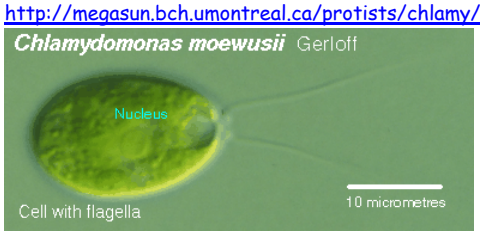
- **Diatoms** - covered by silicon dioxide frustules
  - rapid growth, but require high nutrient concentrations *What time of year should they be favored?*



- **Flagellated greens** - flagellated, chloroplast with chlorophyll a and b
  - slow growth, but need only low nutrient concentrations. *What time of year should they be favored?*



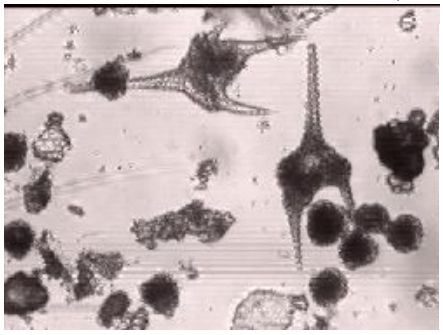

http://megasun.bch.umontreal.ca/protists/chlamy/appearance.html

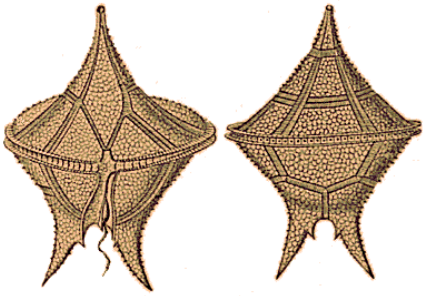



- **Cryptomonads** - typically two flagella at edge of anterior pocket associated with ejectisomes.
  - often occur in nutrient poor lakes, typically in relatively low numbers.


http://megasun.bch.umontreal.ca/protists/crypt/appearance.html

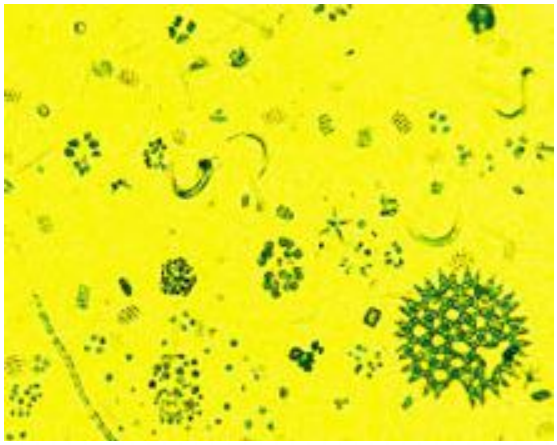
- **Dinoflagellates** - armored with groove circumscribing cell.
  - often minor in freshwater, though relatively large in body size

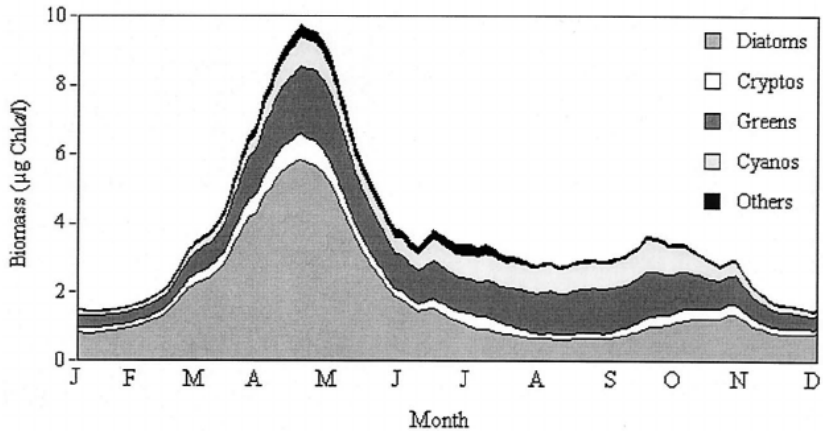




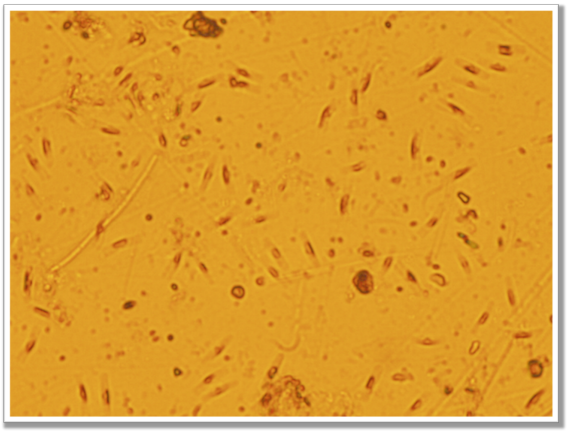
- **Other groups: Euglenoids, Golden-brown Algae ...**

*If all phytoplankton species require essentially the same resources, how can so many species co-exist within the same lake?* ("Paradox of the Plankton").






However, environmental change may not always lead to more biologically diverse systems when the nature of change is less predictable ("Paradox of the Paradox of the Plankton").



*What keeps phytoplankton from settling out?*

*Why are phytoplankton common in lentic systems but not lotic systems?*

*What determines the amount of biomass phytoplankton in a given lake?*

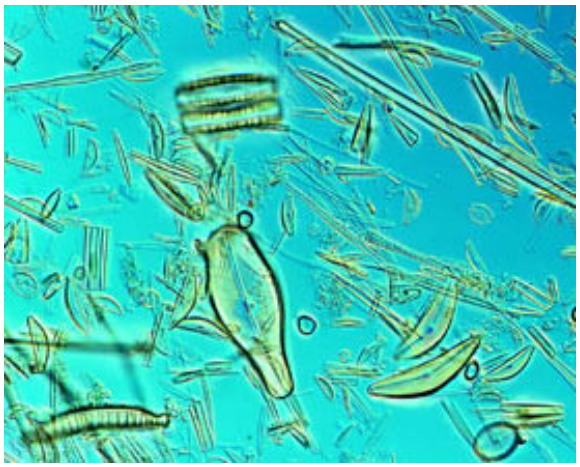
## Other primary producers in freshwater

- **Macrophytes**

*In what aquatic habitats would this group of primary producers dominate?*

*How would these organism differ in their response to take up nutrients and releasing nutrients?*

- **Benthic algae**



*In what aquatic habitats would this group dominate?*

# Primary Productivity - the amount of organic carbon fixed per unit time

photosynthesis:

**carbon dioxide + water ---light---> organic carbon + oxygen + water**

## Measuring Production and Productivity

*Why is this an important measurement?*

Estimates of standing crop (biomass):

- cell counts - volume estimates
- chlorophyll: spectrophotometric and fluorescence
- (Organic carbon and dry weight)

*Does high standing crop indicate high productivity?*

*Can you tell from these snapshots, which roads is transporting more vehicles per minute?*

*What conditions might result in lower than expected phytoplankton biomass despite high rates of primary productivity?*

Estimates of productivity (rate of production):

- Changes in oxygen with light and dark bottles:

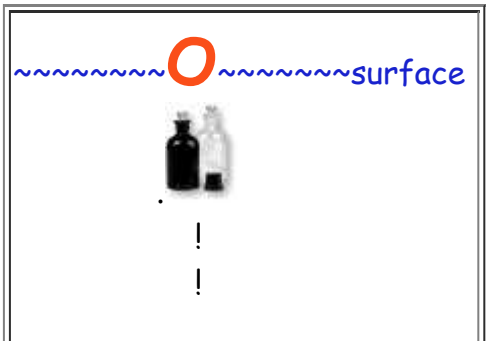
  *How does one measure the effects of photosynthesis on oxygen without the measuring the effects of respiration and atmospheric diffusion? Can one prevent respiration from occurring? Can one prevent photosynthesis from occurring?*

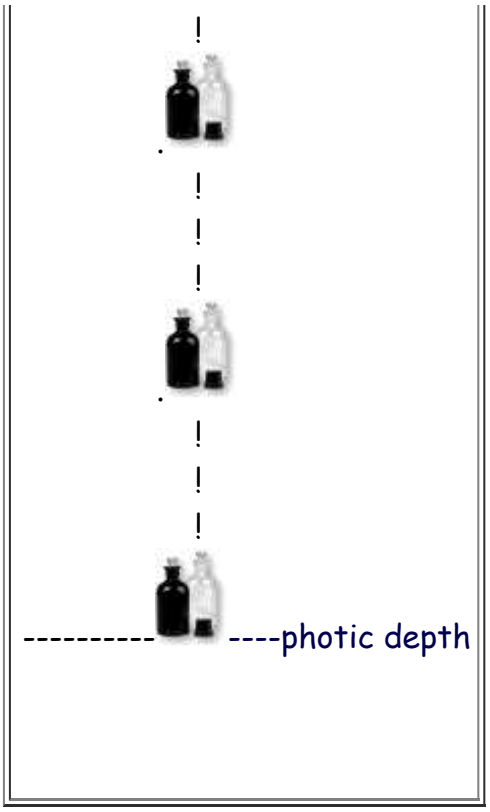
| light bottle | dark bottle | |
|---|---|---|
| photosynthesis and respiration - | respiration | = photosynthesis |
| *net photosynthesis* | *plankton community respiration* | *gross photosynthesis* |

Remember, within a bottle, there are animal and bacterial cells which respire, and phytoplankton that respire and photosynthesize.

Changes in oxygen are then converted to changes in carbon to estimate organic carbon produced over the entire photic zone over a day.

$6\ CO_2 + 12\ H_2O \text{ ----------> } C_6H_{12}O_6 + 6\ H_2O + 6\ O_2$





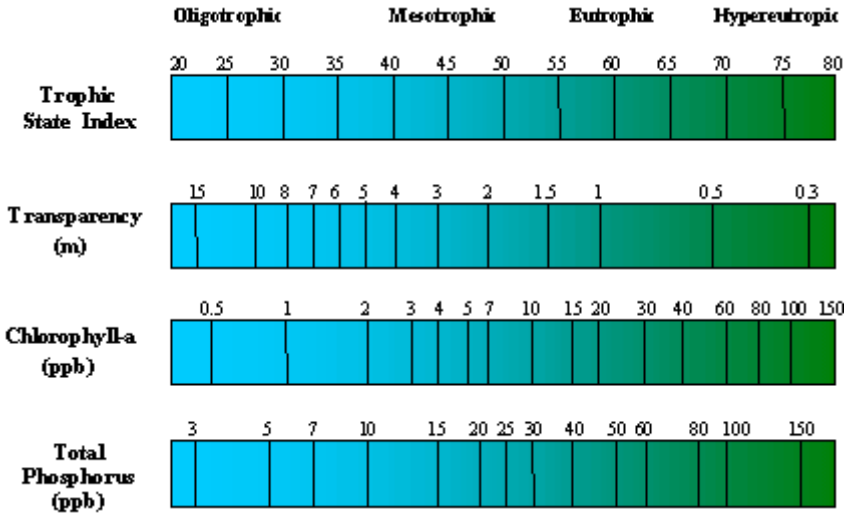

Weight of oxygen produced is converted to weight of carbon fixed by multiplying by 0.375 (based on the atomic weights in the reaction above) and dividing by 1.25 (to correct for conversion of sugar to other organic molecules).

- Changes in carbon 14 isotopes
  Radiactive $C^{14}$ is taken up by phytoplankton and the phytoplankton are then trapped on filters and measured in a scintillation counter.

- Changes in whole lake oxygen over 24 hours or over a season. *How is light 'manipulated'?*

*What are potential problems with these methodologies?*

Estimating rate of primary productivity using the Trophic State Index based on static measurements of water quality using an empirical data model.




*Why is this considered an "indirect" measure of primary productivity?*

-TSI based on chlorophyll

*What conditions might result in lower than expected phytoplankton biomass despite high rates of primary productivity?*

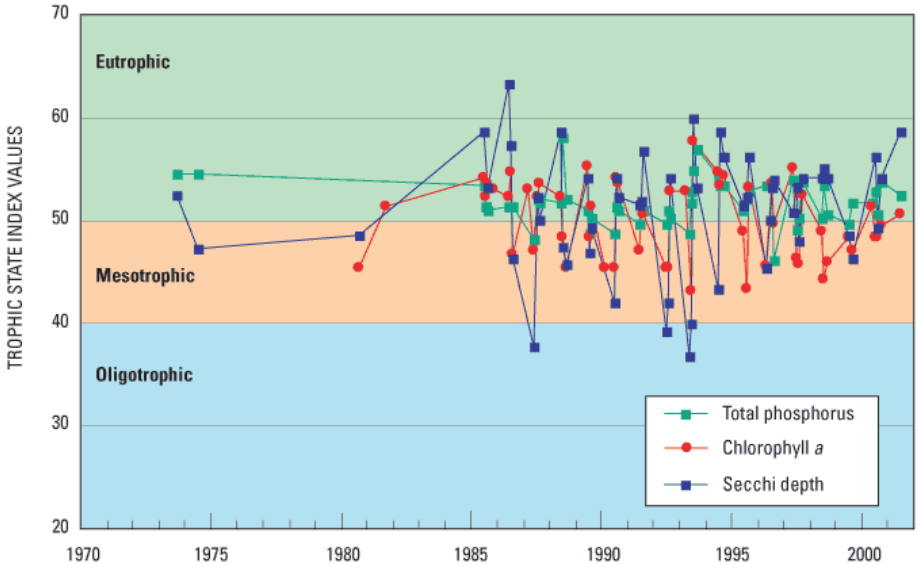
-TSI based on phosphorus concentration

*Why should this be related to the rate of phytoplankton production? What is being assumed about the nature of this nutrient in this estimate of productivity?*

-TSI based on secchi depth

*What is being assumed about the nature of the particles in this estimate of productivity?*

*So, how well does estimating rate of primary productivity from static measurements of water quality work?*



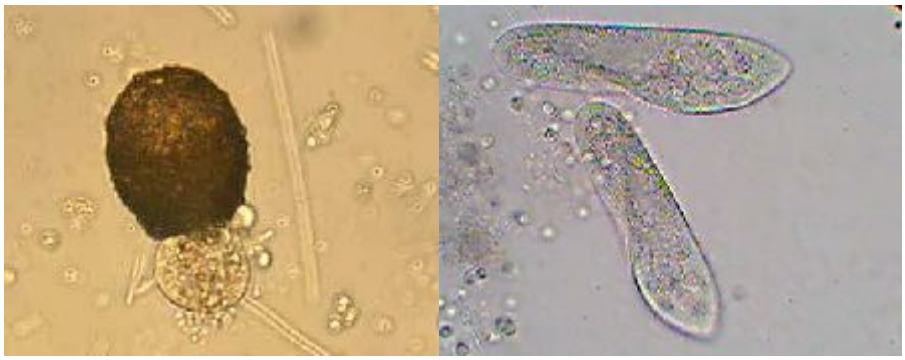

# Zooplankton

## TAXONOMY OF FRESHWATER ZOOPLANKTON

(extensive photo gallery)

*Zooplankton occur primarily in lentic systems. Why?*

- **Protozoans** - little studied because not retained by net (60-200 µm) and ignored by phycologists, though likely an important trophic link between bacterial picoplankton and some zooplankton.



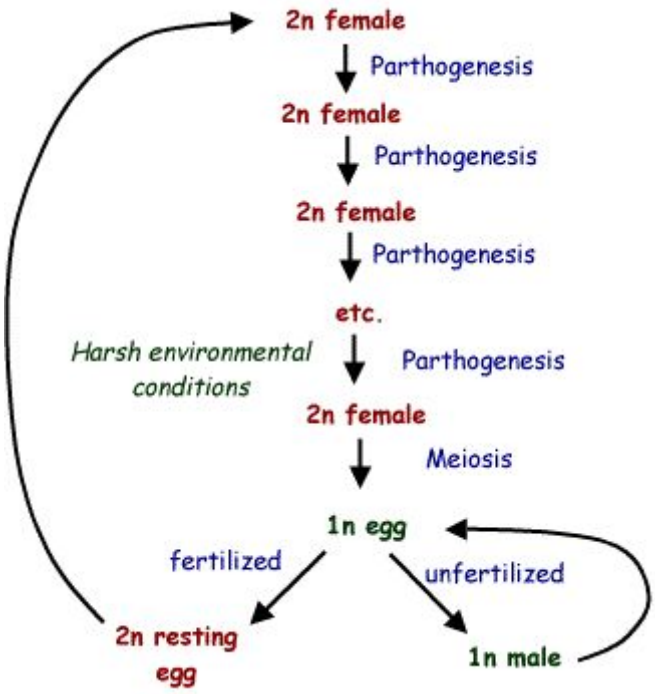
http://www.stetson.edu/~kwork/favorite.htm

- **Rotifers**

~1500 species, size between 0.04 and 2.5 mm

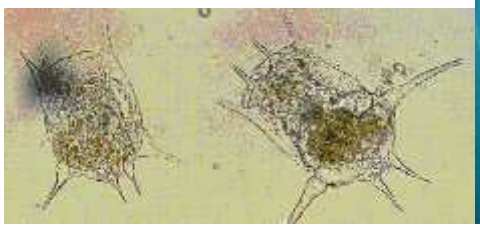
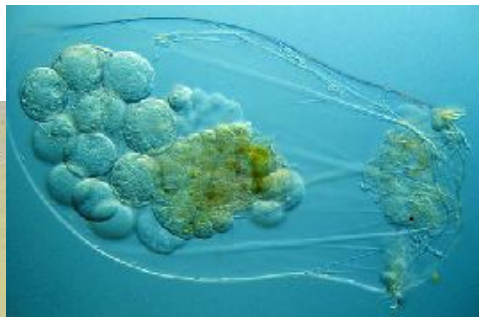
**generation time:** days, several generations per year

**reproduction:** populations mostly female reproducing by parthogenesis, but periodically reproduce sexually producing resting eggs




**feeding:** wheel of cilia (only size selective) filter feeding (with mastix for grinding) on bacteria, small algae, but some predators

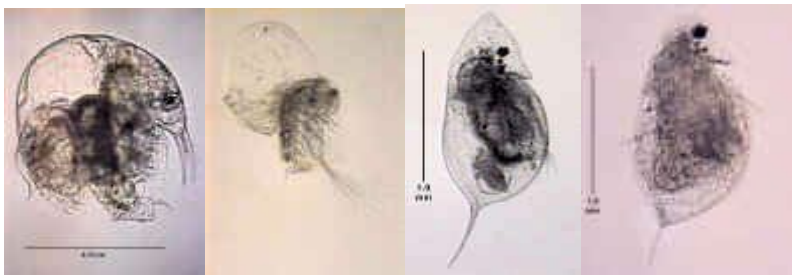
Ecological interactions may be subtle, for example release of molecules (allelopathic substances) may affect morphology.

- **Crustaceans**

~450 species, 0.2 - 6 mm ( though some larger such as *Leptodora kindtii* 18 mm, and ~*Holopedium*)

## Cladocerans



**generation time:** weeks, several generations per year

**reproduction:** parthogenetic so populations mostly female, eggs being incubated under carapace.

*What are the function of antennae and of legs?*

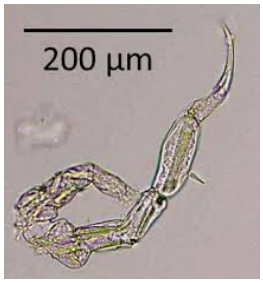
**feeding:** filter feeding on larger algae, but a few predators

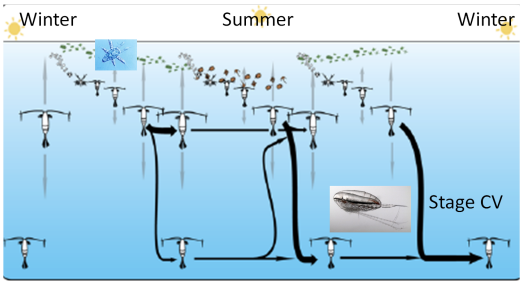
- ## Copepods

Similar size range as cladocerans

**generation time:** usually 1-3 generation per year depending on species, usually life span one year.

**reproduction:** sexual with male tracking female. Molting with 6 nauplier stages, and 5 copepodids. Often with **diapause** stage.



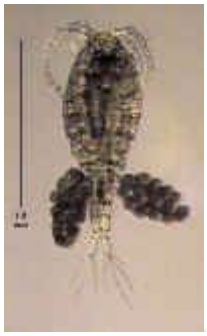



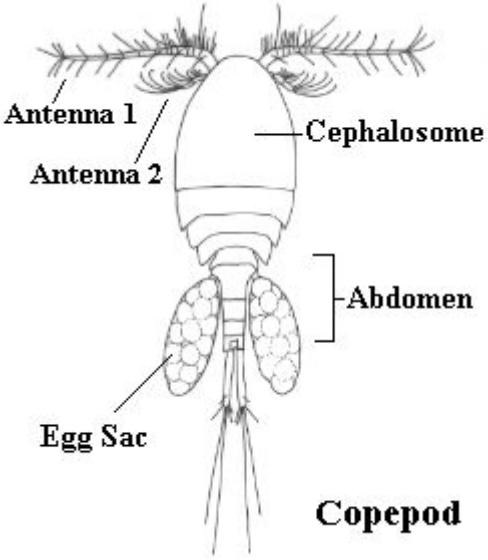

**feeding:** filter feeders (most calanoids) on larger algae, often predators. Typically strong swimmers.

Three main groups of copepoeds:

- **calanoid**

- **cyclopoid**






  - **harpacticoid** (typically benthic)

Species diversity in freshwater zooplankton communities is high for copepods, as is also the case for cladocerans and rotifers.

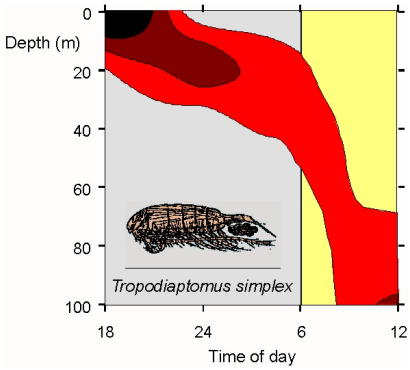
- **Insects - *Chaoborus*** -non-visual predators, **meroplanktonic**


In smaller ponds and wetlands and in marine systems, other taxonomic groups important components of the plankton

## ECOLOGY OF ZOOPLANKTON

- **diel vertical migration**

  *Why migrate? Other factors?*




  *What conditions might favor a reverse migration?*

  *What conditions might favor horizontal migration?*

- **effects on phytoplankton**

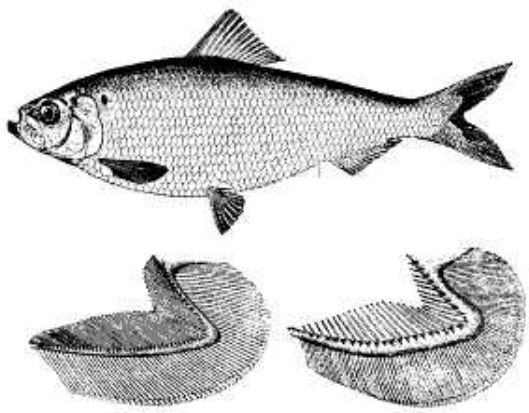
  *Are effects on phytoplankton always negative?*

http://www.cladocera.de/

- **effects of predators**

*How is body size of zooplankton affected?*

Brooks and Dodson 1965



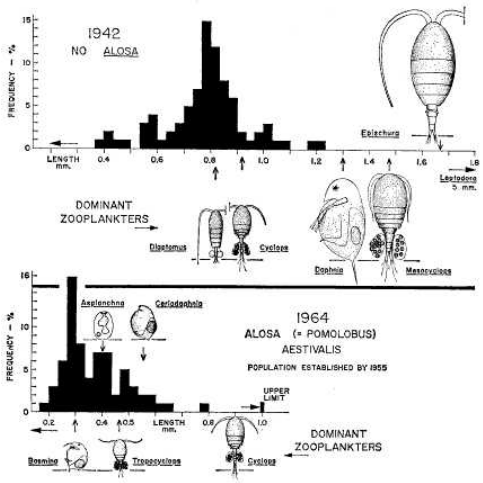



Fig. 4. The composition of the crustacean zooplankton of Crystal Lake (Stafford Springs, Connecticut) before (1942) and after (1964) a population of *Alosa aestivalis* had become well established. Each square of the histogram indicates that 1 percent of the total sample counted was within that size range. The larger zooplankters are not represented in the histograms because of the relative scarcity of mature specimens. The specimens depicted represent the mean size (length from posterior base lines to the anterior end) of the smallest mature instar. The arrows indicate the position of the smallest mature instar of each dominant species in relation to the histograms. The predaceous rotifer, *Asplanchna priodonta*, is the only noncrustacean species included; other rotifers were present but not included in this study.

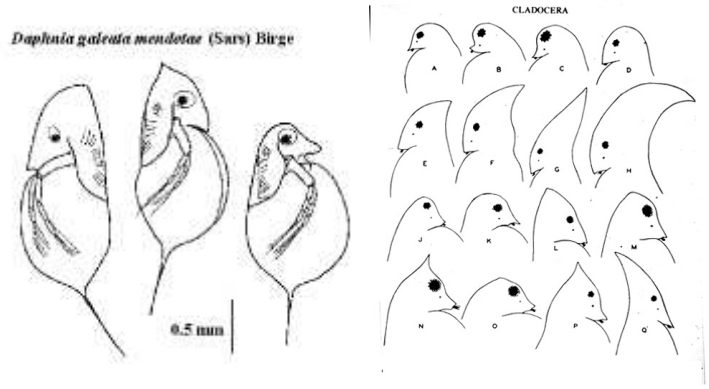
*Why are large bodied zooplankton favored where predation intensity is low?*

Most invertebrate preadators (e.g. *Chaoborus*) are tactile rather than visual predators. *Would body size of zooplankton affected differently if the predators are invertebrates?*

*How is species diversity of the zooplankton community affected?* Keystone predators and the complimentary niche hypothesis

Cyclomorphosis

*What is the advantage of longer spines and helmets? Why not just increase overall body size?*




# Vertebrate Nekton

mostly fish, but may also include amphibians

Various consumer trophic levels and feeding strategies depending on species. Includes:

- **planktivores**
  - particulate feeding - dependent on light to seek out individual prey.

    *What type of zooplankton might be selected by this type of predator?*

    As turbidity increases, predator ability to dectect prey decreases faster than ability of prey to detect and respond to predators.

  - filter feeding - indiscriminate movement of water over gill rakers, not dependent on light.

    *What type of zooplankton might be selected by this type of predator?*

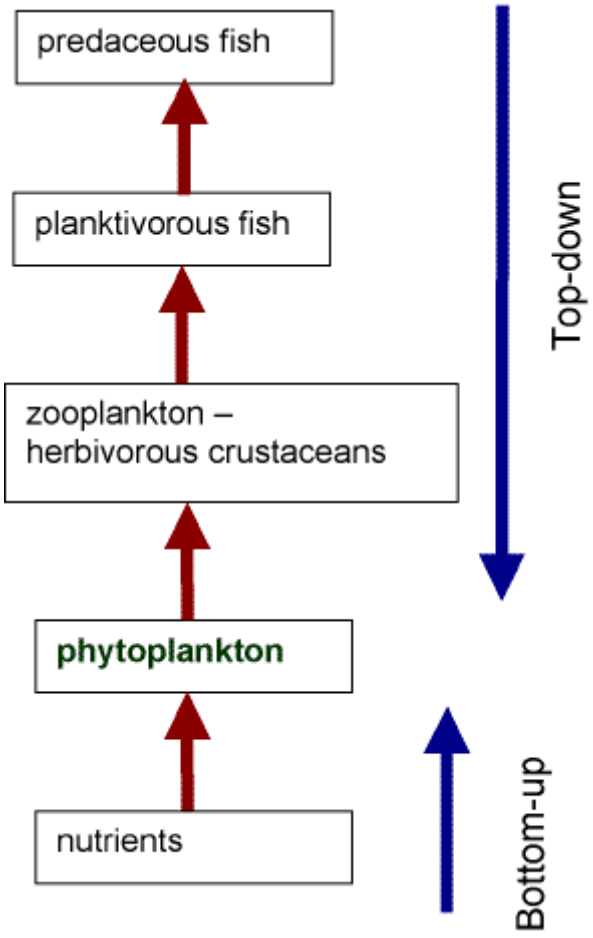

*How might fisheries differ in natural lakes versus reservoirs?*

Intermediate between these modes of feeding would be **buccal gulping** of dense groups of prey (also light dependent)

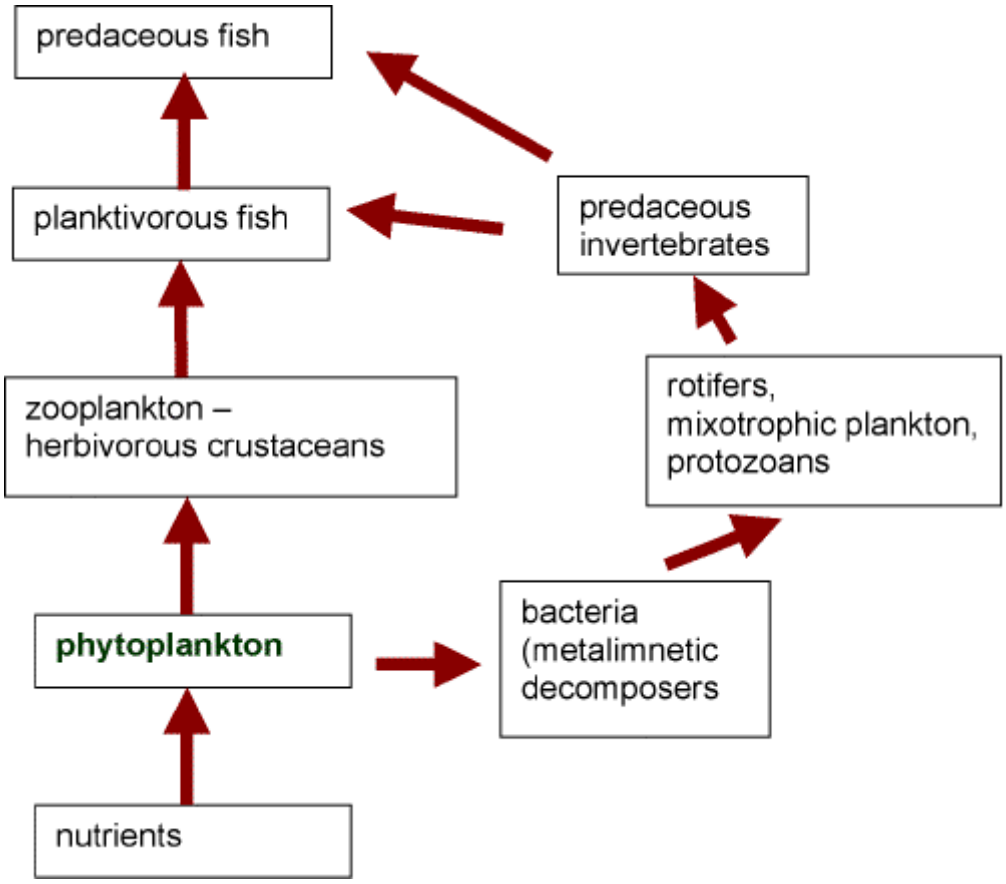
- **piscivores**

**Trophic cascade (top-down management)**

If the abundance of one trophic level changes, what would happen to the trophic level below (e.g.)?




But food webs in lakes, particularly in the southeast USA, are more complex with significant energy moving through the "detrital loop" (microbial loop):




*What are the effects of invertebrate predators?*

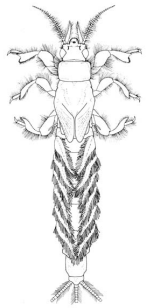
*How might turbidity affect plankton community?*

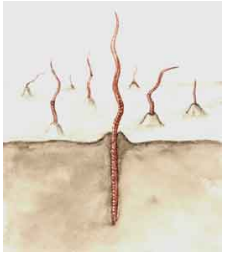
## Benthos

Macroscopic benthos are generally insect larvae, mollusks, annelids, crustaceans...

*In lakes, what would be a primary factor in explaining the distribution of benthic animals? Why?*

*How might distribution change as a lake becomes more eutrophic?*





*How might distribution and abundance differ in a reservoir used for flood control?*

*Quantitative sampling of benthos can be difficult,*



*But lake benthic communities may be useful as biological indicators to assess overall ecosystem health.*

***Other Generalities concerning benthic communities in lakes:***

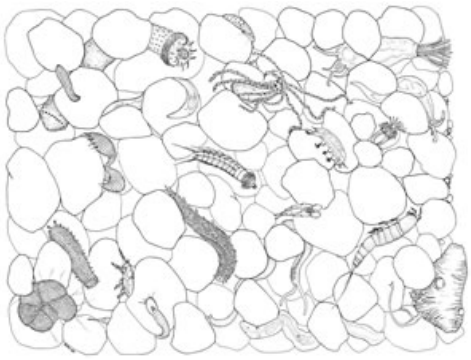
Predation can effect body size of lake benthos as well.

Benthic organism have effects plankton communities. *How?*


Introduction of zebra and quagga mussels has coincided with declines in native mussels, and significantly change water quality in lakes.

*In what kind of aquatic systems might benthos be ecologically more important and diverse? Why?*

**Meiofauna (or psammon)** are the microscopic community of animals living between grains of sediment, differing taxonomically from the macrobenthos.



## Neuston

**Neuston** refer to those organisms suspended on the top of the water's surface or inhabiting the area immediately below the surface.
Includes bacteria, alga cells (some specially adapted), microcrustaceans, and even larger organisms including snails, hydras, flatworms, mosquito larvae, and insects.

epineustonic

hyponeustonic

*What wind conditions might favor this community?*

Several organisms take advantage of surface tension

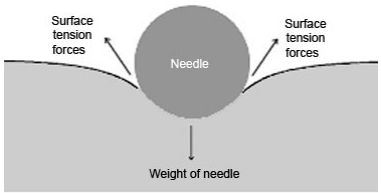



Fig 2. Forces enabling a needle to float on water

But surface tension may not be an advantage to all organisms, which in turn may be a benefit to others.