Utilizing the ecology of cyanobacteria to address problems of cyanotoxins in lakes:

Applications through Citizen Science

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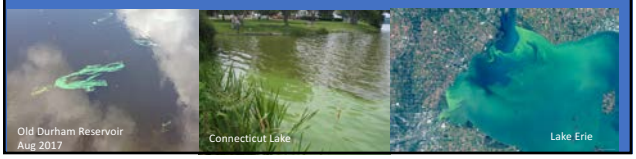
CYANOBACTERIA

"*Nothing* in Biology *Makes Sense* Except in the Light of *Evolution*" Dobzhansky (1973)
"Ecology is evolution in action" W. Lampert (2006)

Keep in mind:

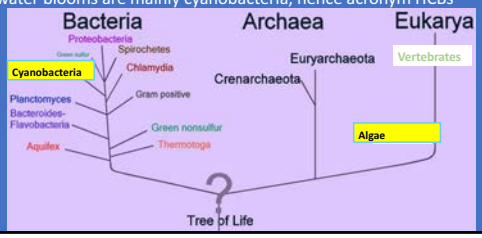
1. **Cyanobacteria were the first (photosynthetic) organisms (3.5 billion ybp)**
2. **Cyanobacteria are an integral part of our natural ecosystems**
3. **To co-exist with them and "manage" them, we must understand their evolutionary adaptations and their ecology**



How much do we need to know to "manage" cyanobacteria?

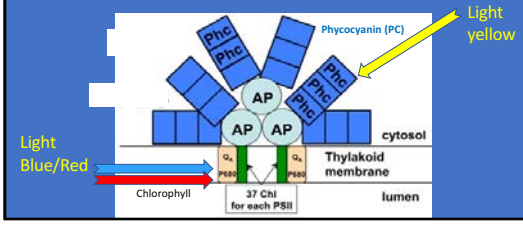
What are cyanobacteria?

- **Formerly (ca. 1970)** known as "blue-green algae" Incorrect as algae are Eucaryotes, whereas cyanobacteria are true bacteria (Procaryotes)
- Confusing since algae bloom in marine systems, hence acronym HABs
- Freshwater blooms are mainly cyanobacteria, hence acronym HCBs



Chlorophyll a: all phytoplankton
Phycocyanin: characteristic of cyanobacteria

- Accessory light-gathering pigments in cyanobacteria



Cyanobacteria Toxins: Examples

Hepato-Toxins

Microcystins (protein phosphatase blockers)
- most cyanobacteria species
- Most widespread
- Over 100 analogs (hence plural)

Cylindrospermopsin
liver and kidneys; tropical/subtropical

Nodularins
- *Nodularia*: brackish water species
- Close analog of microcystins

Neuro-Toxins

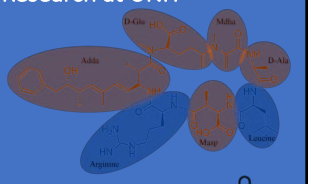
Anatoxins
- *Anabaena*

Neosaxitoxins (saxitoxin=marine red tide)
- *Aphanizomenon*

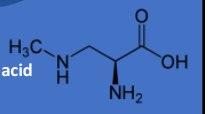
BMAA (beta-methylamino-L-alanine)
- Produced by most cyanobacteria groups
- possible link to neurological disorders (ALS, Alzheimer's)

Focus of Cyanotoxin Research at UNH

Microcystins:
- Cyclic **heptapepides**
- >100 variants
- Hepatotoxin

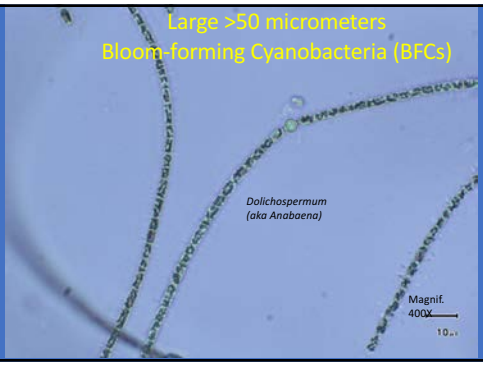


BMAA (β-Methylamino-L-alanine)
- Very tiny **non-protein-building amino acid**
- Neurotoxin



Public and scientific interest has focused on surface blooms

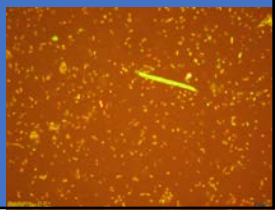
Surface bloom in China: Hans Paerl



Phytoplankton (from zooplankton grazer perspective)

BFC Phytoplankton (>50 µm) "inedibles"

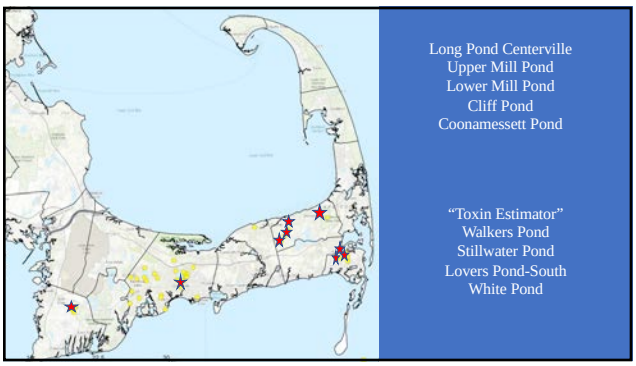
Nano+ Pico 50-0.2 µm "edibles"

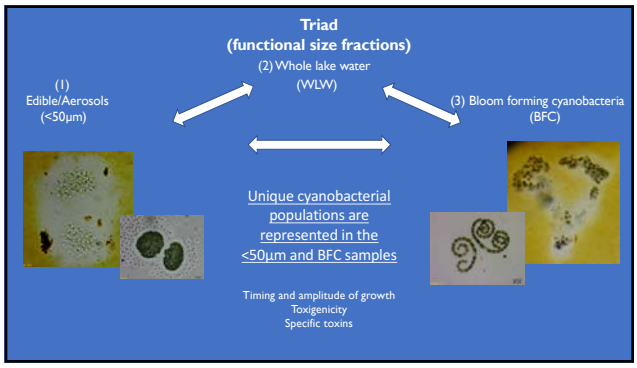


LAKE CYANOTOXIN PROBLEMS

- The Obvious Problem: Surface "blooms"
- The invisible problems:
  - Bioaccumulation in Food webs
  - Toxic aerosols

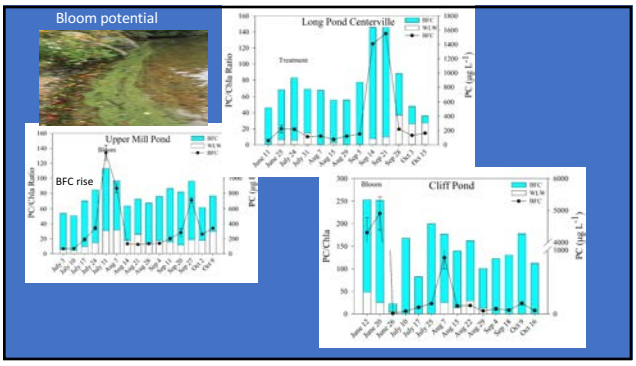

Non-Wind Generated Aerosols
cells
toxins
CLAM V1
Baboosic Lake sunrise

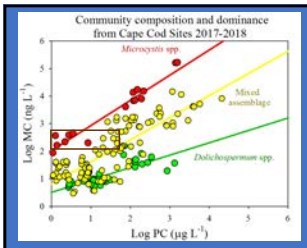

Long Pond Centerville
Upper Mill Pond
Lower Mill Pond
Cliff Pond
Coonamessett Pond
"Toxin Estimator"
Walkers Pond
Stillwater Pond
Lovers Pond-South
White Pond


Triad
(functional size fractions)
(1) Edible/Aerosols (<50μm)
(2) Whole lake water (WLW)
(3) Bloom forming cyanobacteria (BFC)
Unique cyanobacterial populations are represented in the <50μm and BFC samples
Timing and amplitude of growth
Toxigenicity
Specific toxins


Citizen Scientists
CITIZEN SCIENCE PARTNERSHIP
Researchers
Municipal officials
Advocates
Equipment:
WLW
BFC isolates
+
50 μm ring net
Methods:
Fluorometry:
Single Freeze-Thaw (SFT)
ELISA analysis:
Speed-vac evaporation (2-20X)


Important Issues:
Bloom potential: Advance Warning
Estimating toxin levels from Pigments
Pet exposure
Aerosols and Bioaccumulation (planned 2019)
Groundwater contamination

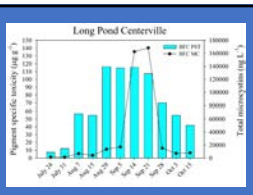

Bloom potential
Long Pond Centerville
Upper Mill Pond
BFC rise
Cliff Pond



Models for Estimating toxin levels

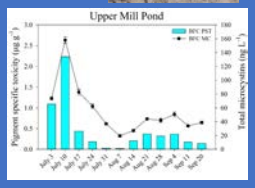
Importance of toxin analysis methods: BFC collection & sample concentration!

Lose 95% of data without BFC's and SpeedVac

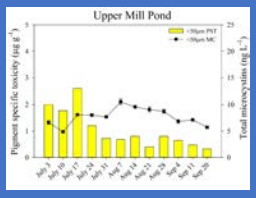


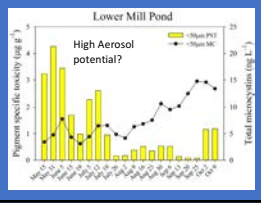
Pet/child exposure

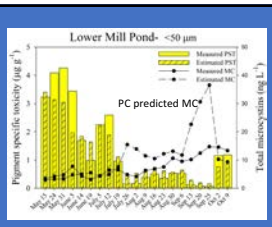
Long Pond Centerville, a *Microcystis* dominated system 50X higher PST and 1000X higher MC than Upper Mill Pond. We don't have any measurements for anatoxins that would be found in a *Dolichospermum* dominated system such as Upper Mill Pond



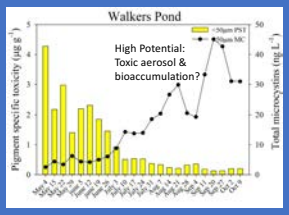
Microcystis PST tends to increase prior to the observed MC levels so poses a salient risk



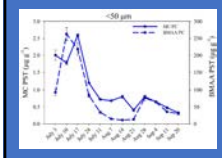


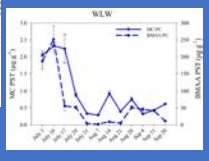


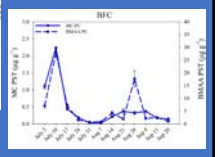
Estimating microcystin levels and exposure potential using fluorometry using <50 µm samples



Dolichospermum spp. from Upper Mill Pond
Microcystin and BMAA pigment specific toxicity







For *Dolichospermum*, production cycles are simultaneous with the same toxigenic "switch " ????