What Can We Do About Cyanobacteria ("blue-green algae")

Edwin Wong, Ph.D
Department of Biological & Environmental Sciences
Western Connecticut State University
Danbury CT

Blue-Green Algae Outbreak Kills 32 Cattle in Oregon

KATU News, 2017

Blue-Green Algae Warning Won't Stop Drag Boat Races At Lake El Reno

News on 6, 2019

Blue-green algae blamed for death
thousands of fish at Lake El Reno

KOCO News, 2016

WECT August 9, 2019
Lubbock Avalanche-Journal
August 9, 2019


Huge toxic algae bloom sickens more than 100 in Utah amid heatwave
The Guardian, 2016

Vox, 2014; NASA, 2017

Toxic Algae Bloom Closes 25 Beaches On Mississippi's Coast, Fed By Fresh Floodwaters

July 9, 2019 · 1:43 PM ET

NPR, 2019

Harmful Algal Blooms shut down New Jersey's biggest lake to swimming for most of summer

CGTN America Sep 16, 2019
Morristown Daily Record July 2, 2019

Human intoxication by microcystins during renal dialysis treatment in Caruaru—Brazil

In February 1996, an outbreak of illness occurred at a hemodialysis clinic in Caruaru, Pernambuco State—Brazil. At this clinic 1 [illegible] patients experienced visual liver failure. As of Decem[illegible] syndrome [illegible] ton counts [illegible] voir since 1990. Analyses of [illegible] nt system plus serum and liver

100 suffered liver failure

52 died

Toxicology (2002) 181:441-446

A Cluster of Amyotrophic Lateral Sclerosis in New Hampshire: A Possible Role for Toxic Cyanobacteria Blooms

Scientists Find Cyanobacterial Neurotoxin and Amyloid Plaques in Brains of Stranded Dolphins

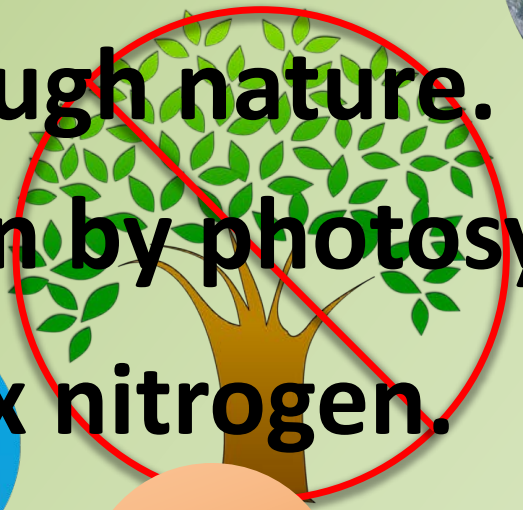
High levels of BMAA (β-methylamino-L-alanine), a neurotoxin produced by cyanobacterial blooms, and beta-amyloid plaques, a hallmark in human beings of Alzheimer's disease, have been detected in the brain tissues from dolphins stranded on the beaches of Florida and Massachusetts.

Various news sources, 2009, 2019

What are Cyanobacteria ("blue-green algae")?

Bacteria, not Algae (plants).

Ubiquitous through nature.



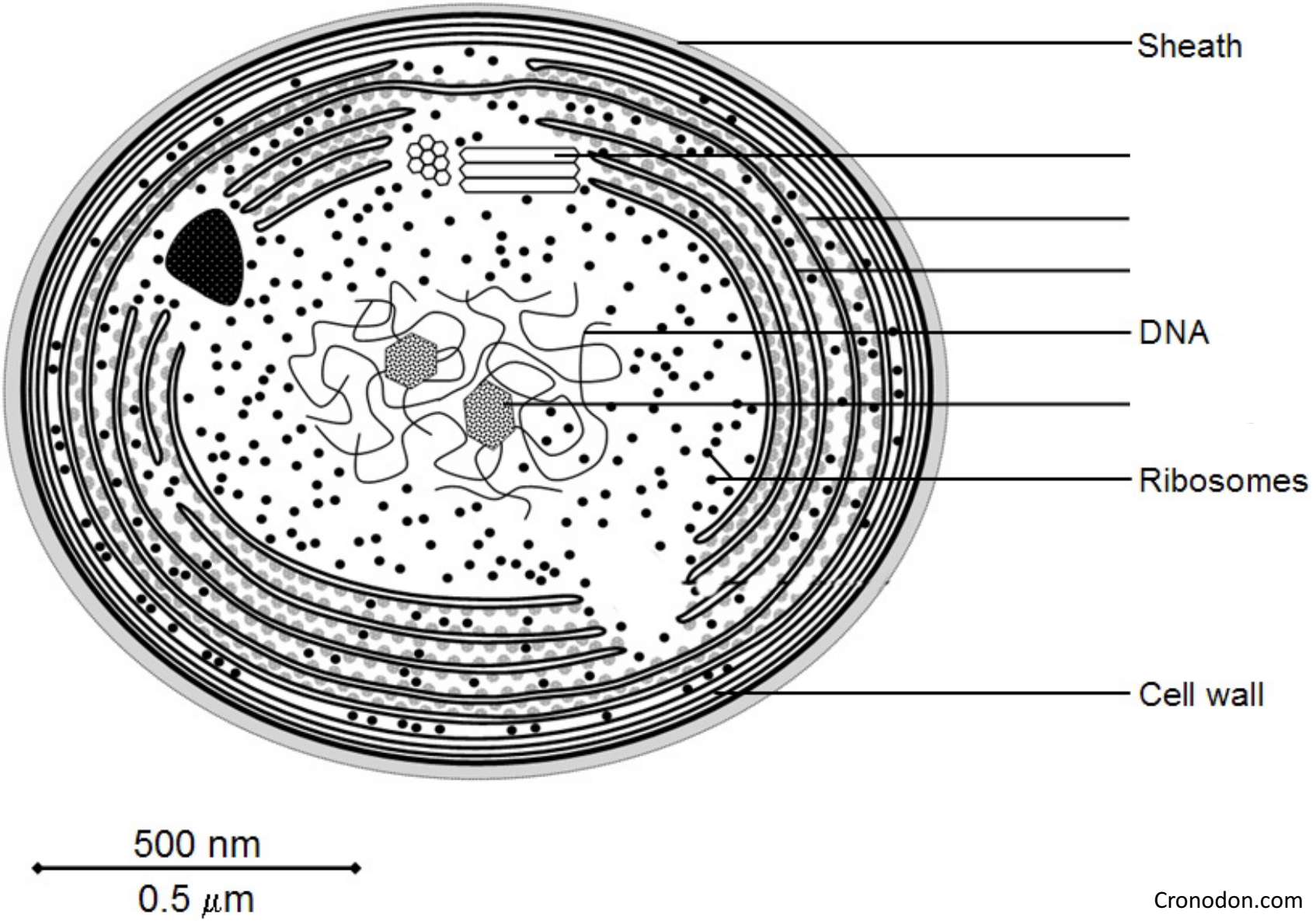
Make oxygen by photosynthesis.

O_2

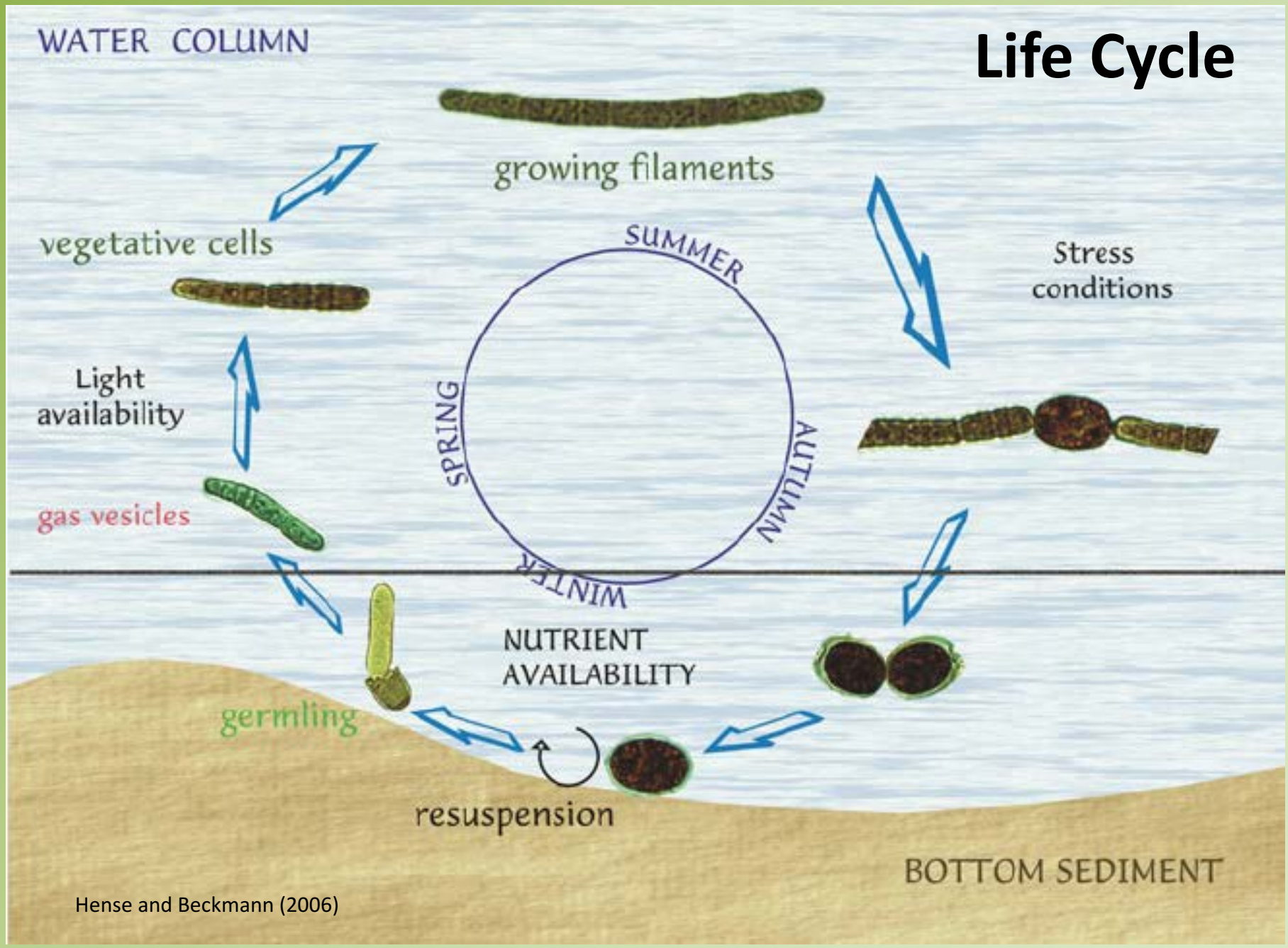
Fix nitrogen.

N_2 → NH_3

Domain: Bacteria Phylum: Cyanobacteria



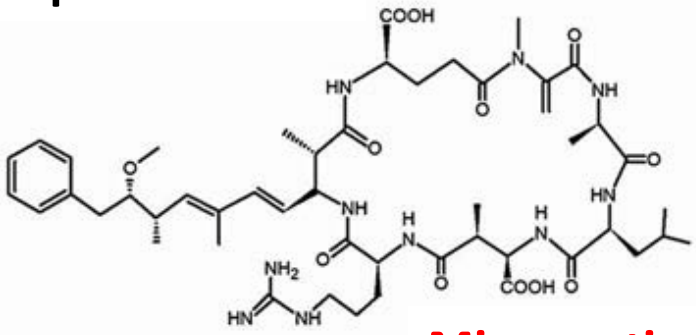
Life Cycle



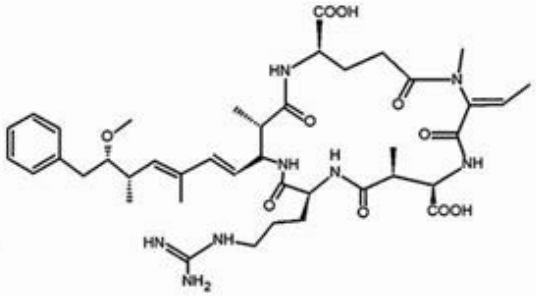
Hense and Beckmann (2006)

Major Cyanotoxins

Hepatotoxins

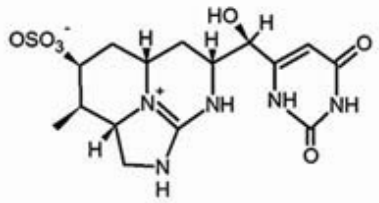


Microcystin



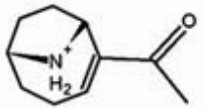
Nodularin

Cytotoxin

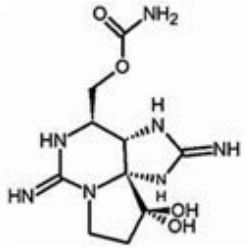


Cylindrospermopsin

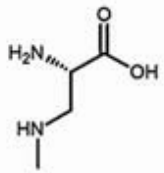
Neurotoxins



Anatoxin

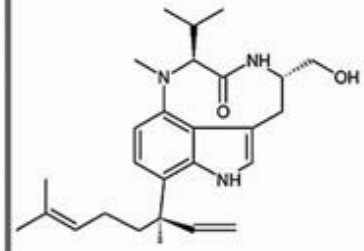


Saxitoxin

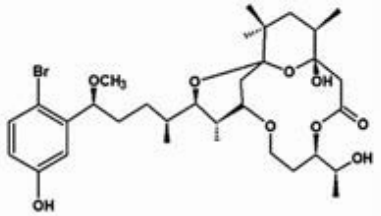


BMAA

Dermatoxins



Lyngbyatoxin A



Aplysiatoxin

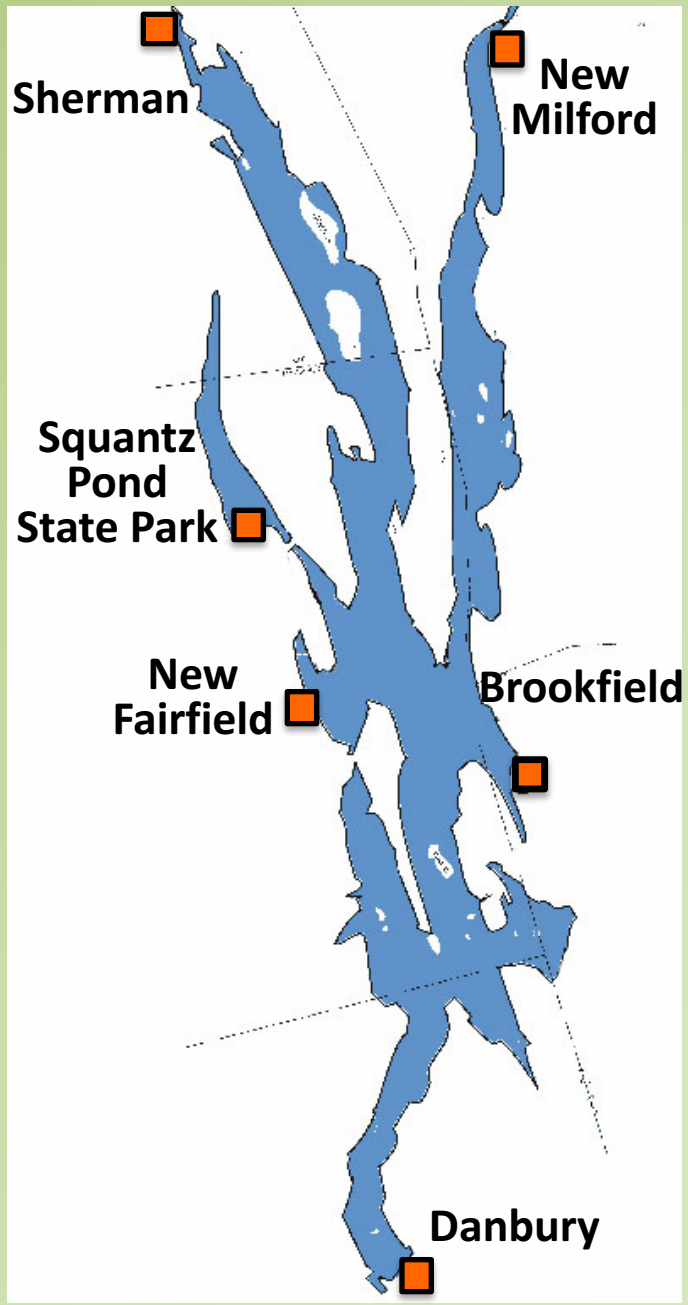
Dittmann, et al. (2013) FEMS Microbiology Review 37:23–43


MASSACHUSETTS
NEW YORK
NEW YORK
RI
Long Island Sound
Bantam Lake
Beseck Lake
Candlewood Lake
Lake Zoar
Colebrook River Lake
Barkhamsted Reservoir
Nepaug Res
Housatonic River
Farmington River
Scantic River
Bolton Lake
Willimantic River
Mansfield Hollow Lake
Quaddick Reservoir
Connecticut River
Lake Waramaug
Shepaug R
Lake Candlewood
Naugatuck R
Housatonic River
Quinnipiac River
Lake Gaillard
Moodus Reservoir
Sheltucket River
Quinebaug River
Pachaug Pond
Gardner Lake
Thames R
Saugatuck Reservoir
Easton Res

Candlewood Lake

- Beaches

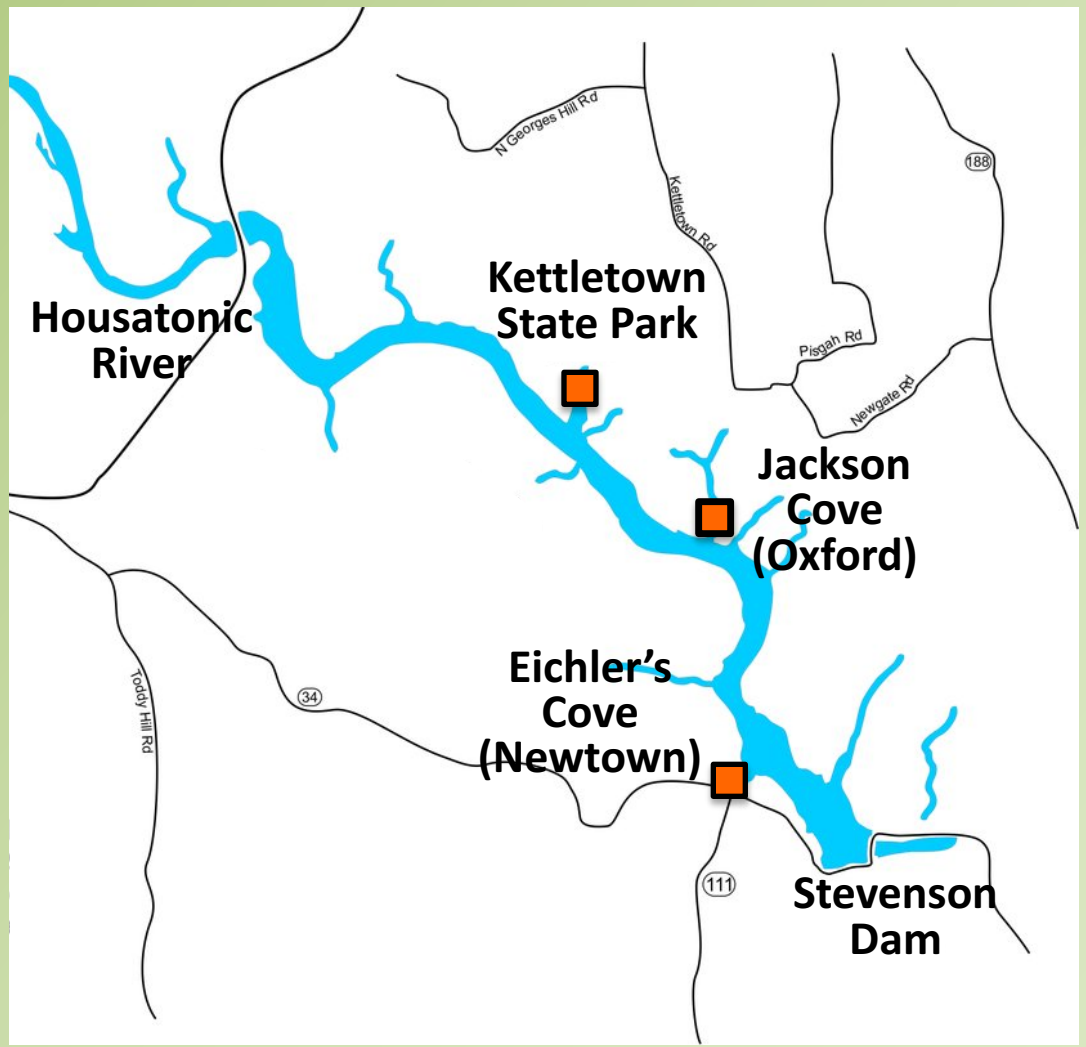
Photo Credit: Samantha Wong

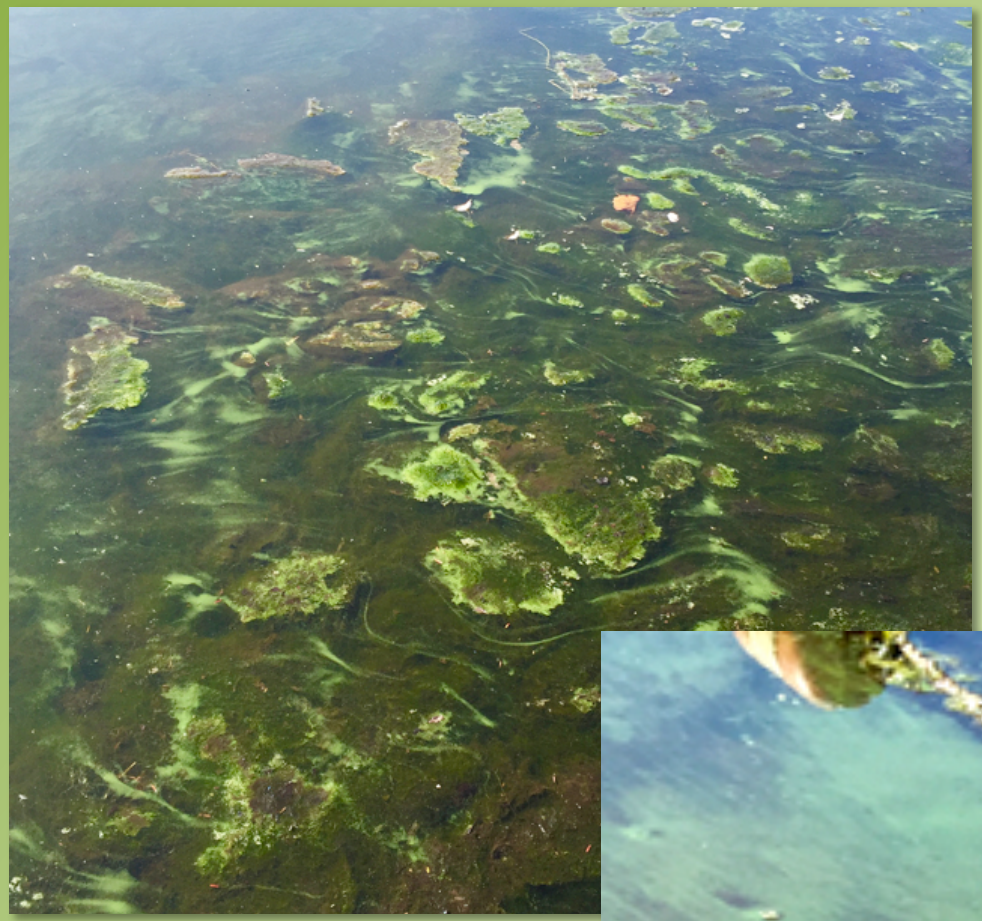


Lake Zoar

- Beaches

Photo Credit: Samantha Wong





Kettletown State Park, Southbury 2017

Photo Credit: E. Wong

Photo Credit: E. Wong

Beseck Lake

- Beach

Beseck Lake, Middlefield 2019

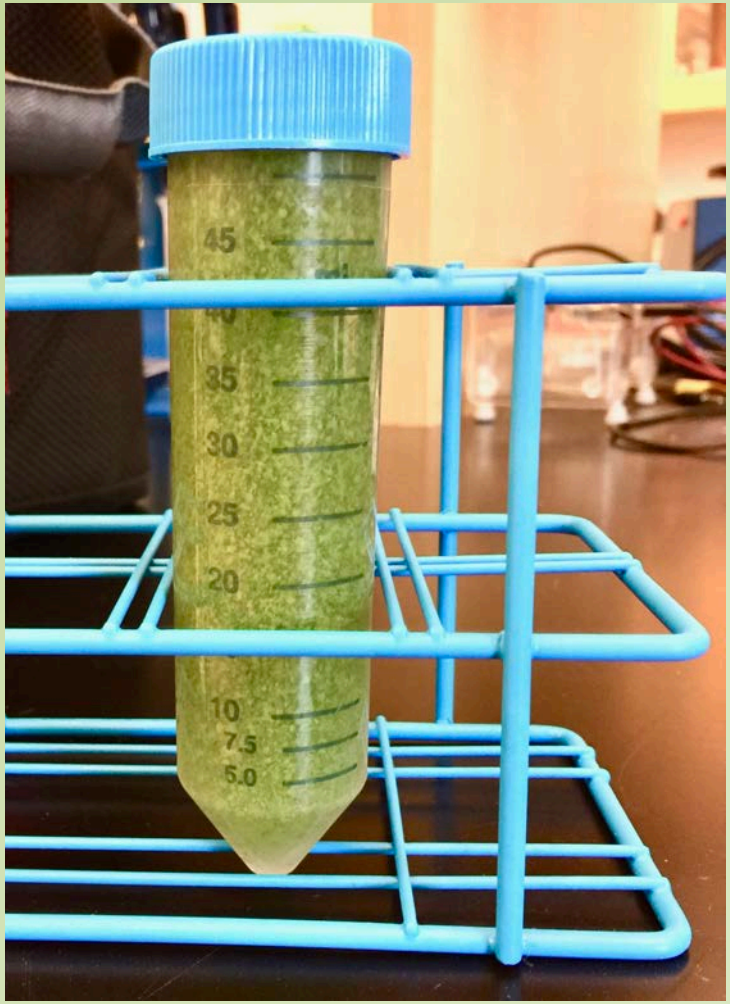
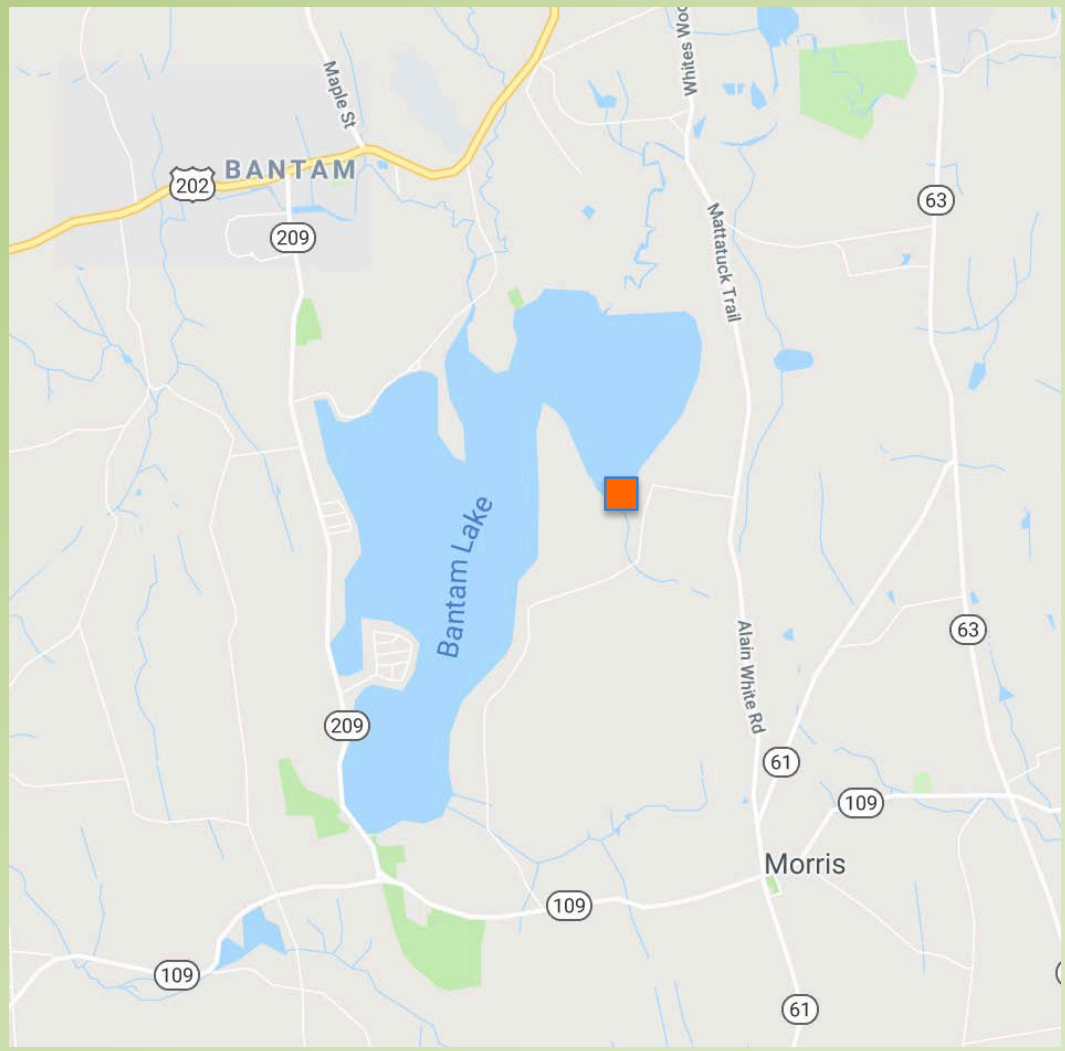


Photo Credit: E. Wong

Bantam Lake

- Beach



How do we monitor cyanobacteria?

- Microscopic identification of cyanobacteria.
- Measurement of cyanotoxin concentration.
- Detection of cyanotoxin synthesis genes.

CLASSIFICATION BY MICROSCOPY

water sample
0.5 m below surface
or from surface bloom

↓

photomicroscopy

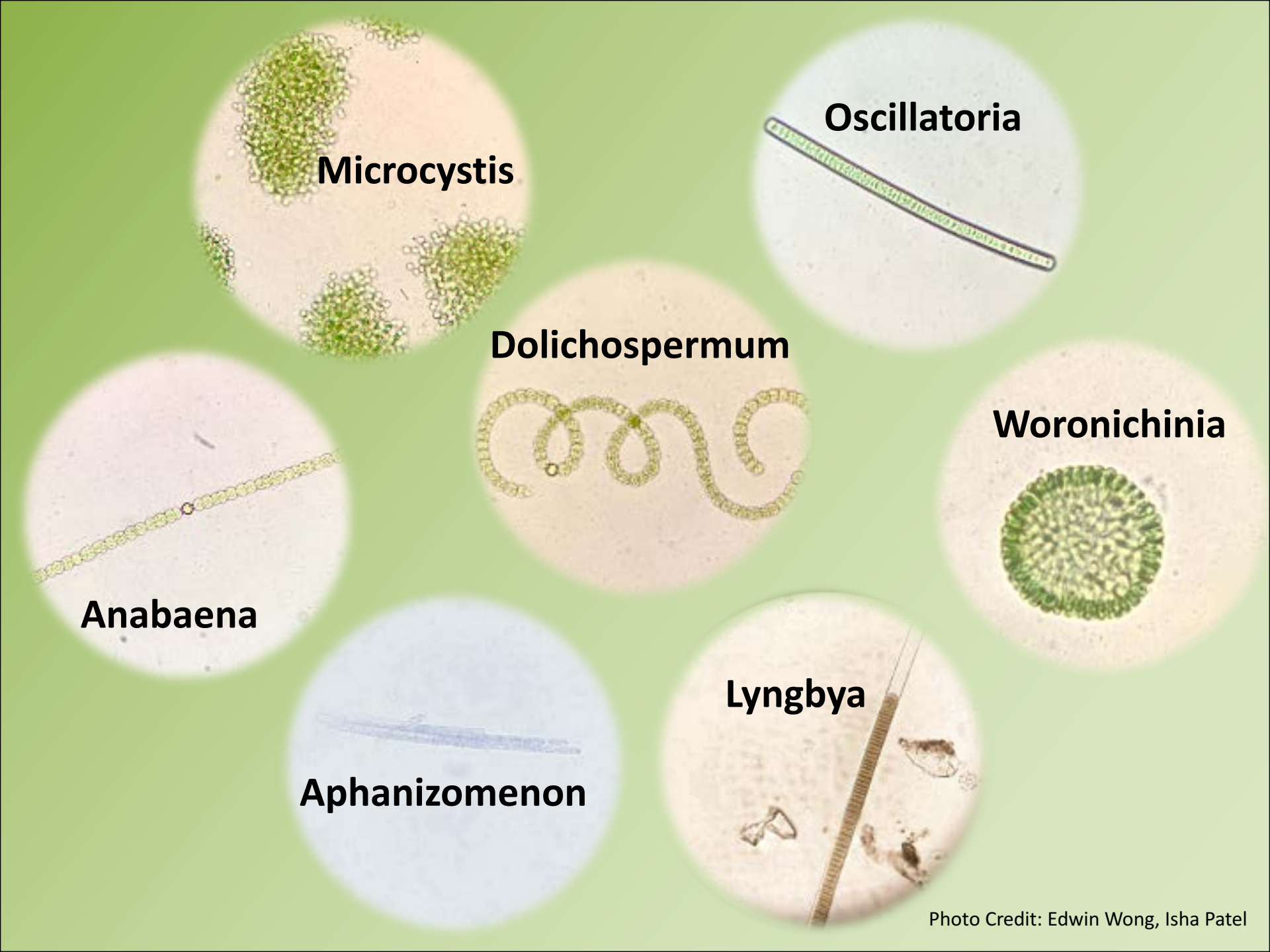
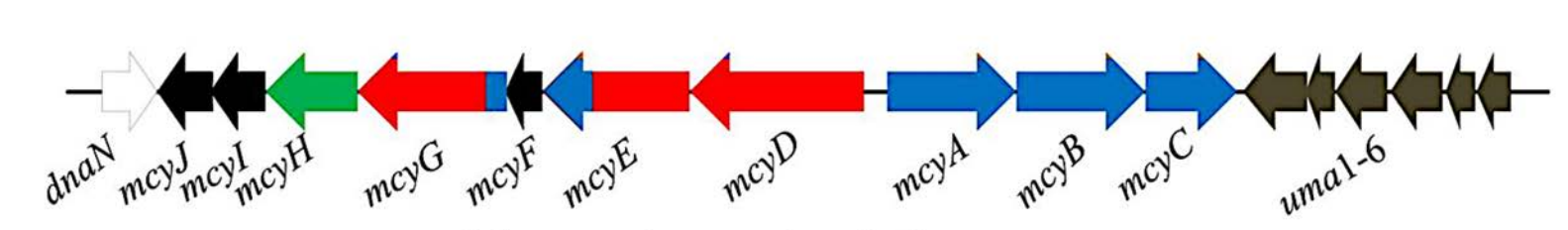


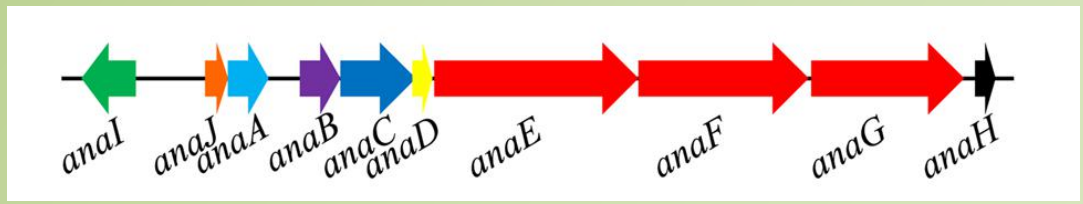
Photo Credit: Edwin Wong, Isha Patel

Toxin Biosynthesis Operons



Microcystin (*Mcy)* gene cluster

Saxitoxin (*sxt)* gene cluster



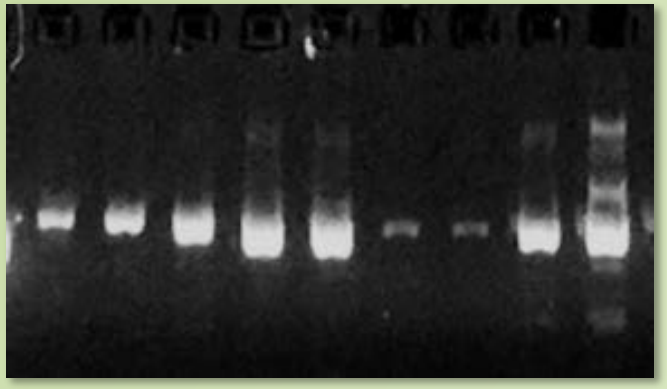
Anatoxin (*ana)* gene cluster

Rastogi, et al. (2015) Front. Microbiol. 6:1–22

DETECTION OF TOXIN GENES

water sample
0.5 m below surface
or from surface bloom

PCR



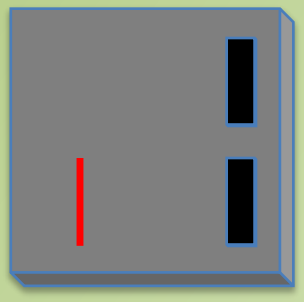
Gel Electrophoresis

Detecting toxin genes by PCR or qPCR

Collect cyanobacteria

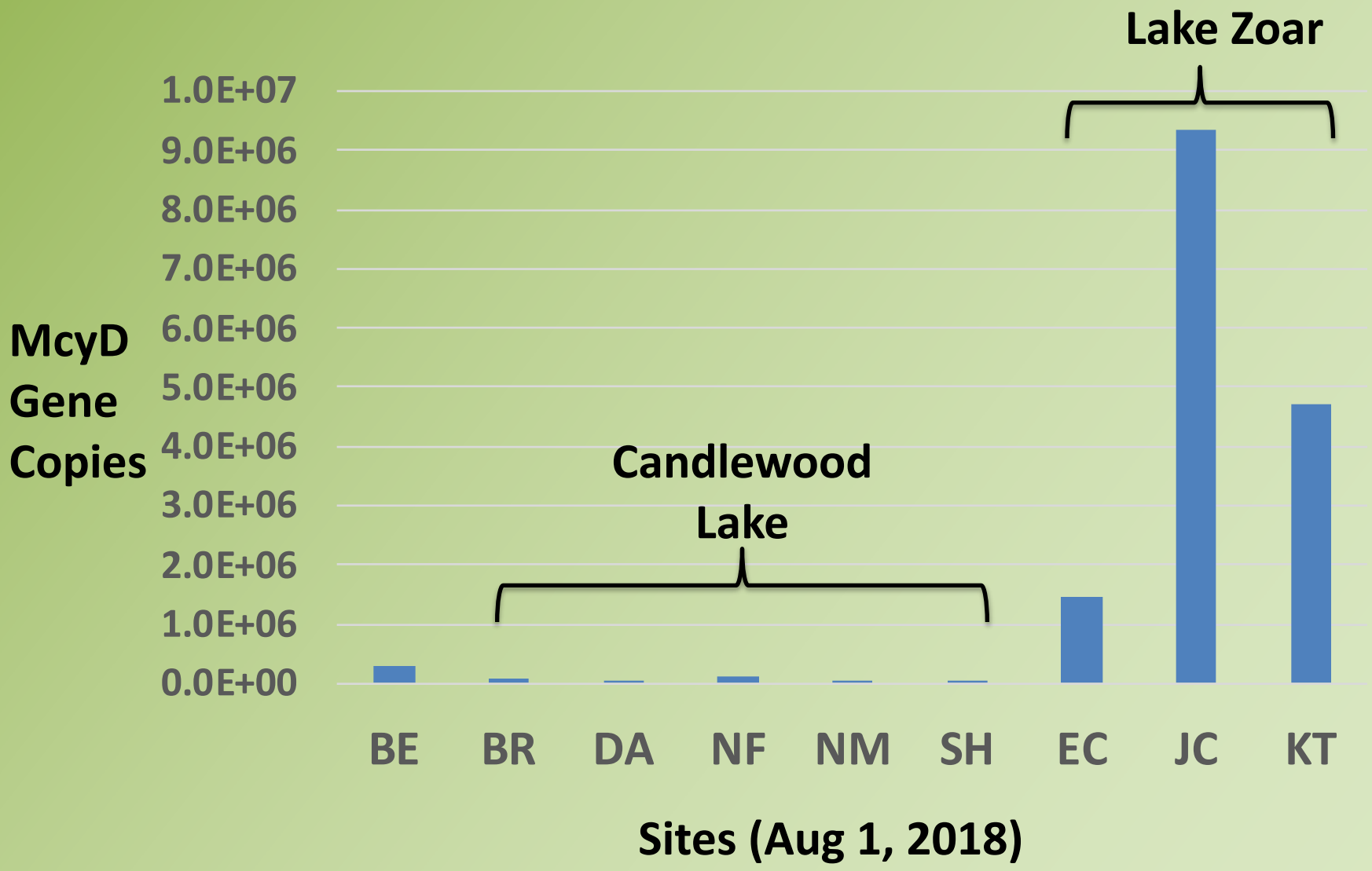
Isolate total genomic DNA

Amplify toxin gene-specific DNA sequences by PCR



Visualize products by gel electrophoresis or quantify by fluorescence

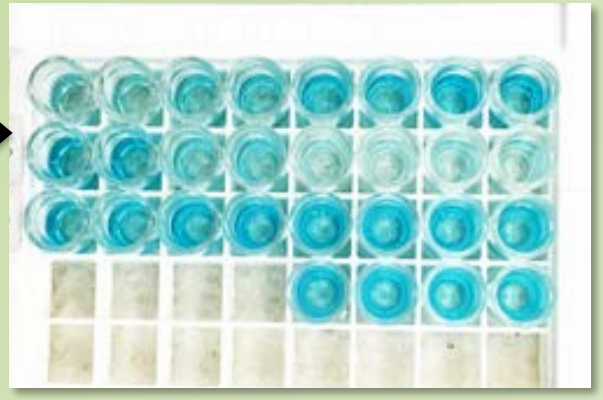
McyD Gene Copy Number



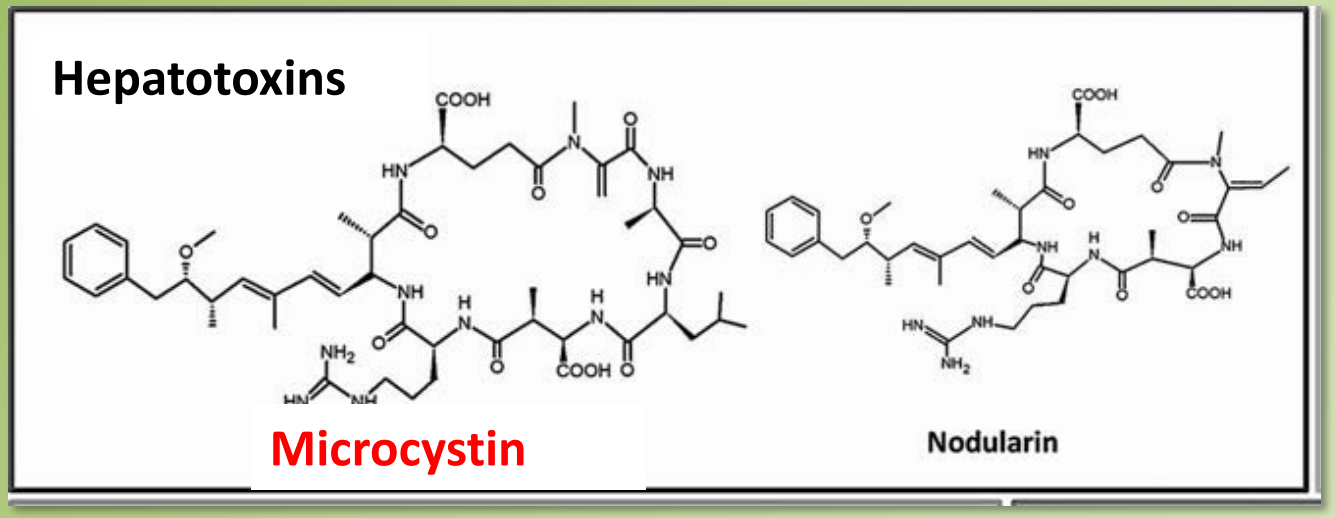
MEASURING TOXIN CONCENTRATIONS

water sample
0.5 m below surface
or from surface bloom

ELISA assay



Microcystin



U. S. Environmental Protection Agency (EPA)
2016 draft water quality criteria for Microcystin

Avoid use of recreational water: 4 µg/L (ppb)

2019 criteria: 8 µg/L (ppb)

Dittmann, et al. (2013) FEMS Microbiology Review 37:23–43

Microcystin Concentrations (ppb) in Candlewood and Zoar Lakes Summer 2016 (6/24 – 9/9)

Date	Danbury	Brookfield	Candlewood Lake Club	Candlewood Point	Eichler Cove	Jackson Cove	Kettletown	Lynn Deming	New Fairfield	Sherman	Squantz
24-Jun	0.0525	0.041	N/A	N/A	N/A	N/A	N/A	0.0465	0.0275	0.036	0.059
7-Jul	0.22	0.104	N/A	N/A	0.0625	0.076	0.181	0.219	0.275	0.35	0.13
14-Jul	0.166	0.733	N/A	N/A	0.182	0.133	0.124	0.277	0.301	0.216	0.153
21-Jul	0.152	0.261	0.224	0.241	0.215	0.144	0.374	0.338	0.255	0.137	0.135
28-Jul	0.037	0.0485	0.0715	0.1895	0.0165	0.071	0.0525	0.0955	0.0855	0.084	0.007
4-Aug	0.258	0.188	0.232	0.211	0.145	0.281	0.829	0.348	0.227	0.602	0.286
11-Aug	0.14	0.063	0.123	0.114	0.076	0.573	0.232	0.231	0.192	0.486	0.212
18-Aug	0. 141	0. 119	0. 080	0. 090	0. 134	0. 533	0. 486	0. 177	0. 144	0. 077	0.105
25-Aug	0. 128	0. 143	0. 120	0. 127	0. 117	0. 312	0. 135	0.159	0. 160	0. 245	0.13
1-Sep	0. 118	0. 122	0.129	0.15	0.107	0. 168	0.478	0.153	0. 136	0.018	0
8-Sep	0.029	0.021	0.005	0.002	0.022	0.039	0.573	0. 026	0.028	0.083	0.026

Lake Zoar

Conclusion: all samples << 1 ppb

Microcystin Concentrations (ppb) in Candlewood and Zoar Lakes Summer 2017 (6/29 – 9/8)

Date	Danbury	Brookfield	CandleWood Lake Club	Candlewood point	Eichler's Cove	Jackson Cove	Kettletown	Lynn Deming	New Fairfield	Sherman	Sherm. bloom	Squantz
29-Jun	0.526	0.34	0.337	0.2	0.373	0.3515	0.283	0.416	0.398	0.322	4.69	0.2155
6-Jul	0.442	0.697	0.29	0.591	0.657	0.241	0.519	0.367	0.3	0.457	N/A	0.423
13-Jul	0.122	0.345	0.24	0.361	1.101	0.305	0.419	0.227	0.354	0.442	N/A	0.172
20-Jul	0.39	0.461	0.464	0.269	0.304	0.494	0.573	0.434	0.433	0.605	N/A	0.176
27-Jul	0.181	0.369	0.721	0.457	0.425	0.431	1.965	0.596	0.643	0.515	N/A	0.522
3-Aug	0.884	0.667	0.759	0.715	1.405	2.959	>5.25	0.753	0.645	0.487	N/A	0.641
10-Aug	0.416	0.376	0.304	0.328	>5.25	>5.25	>5.25	0.515	0.36	0.338	N/A	0.163
17-Aug	0.800	0.613	0.525	0.433	13.8	22.9	18.73	0.597	0.709	0.764	N/A	0.183
24-Aug	0.42	0.315	0.582	0.367	4.40	5.0	8.15	0.433	0.339	0.605	N/A	0.381
31-Aug	0.325	0.232	0.4	0.345	>5.25	>5.25	>5.25	0.268	0.345	0.293	N/A	0.566
7-Sep	0.334	1.554	0.814	0.555	>5.25	4.084	>5.25	0.48	0.489	0.578	N/A	0.41

Lake Zoar (> 4 ppb)

Microcystin Concentrations (ppb) in Candlewood, Zoar, & Beseck Lakes Summer 2018 (6/27 – 8/29)

Date	Beseck	Brookfield	Danbury	Eichler Cove	Jackon Cove	Kettletown	New Milford	New Fairfield	Sherman	Squantz
27-Jun	0.511	0.715	0.724	0.947	0.615	0.618	0.896	0.332	0.597	0.944
4-Jul	1.064	0.440	0.474	0.661	0.658	0.755	0.730	0.722	0.534	0.435
11-Jul	0.820	0.979	0.802	0.928	0.601	0.744	0.937	0.724	0.332	0.943
18-Jul	0.827	0.937	1.285	1.632	0.978	0.886	1.235	0.716	0.773	0.739
25-Jul	0.496	0.529	0.724	0.833	0.432	0.923	0.520	0.481	0.555	0.545
1-Aug	0.385	0.565	0.556	0.881	5.38	8.10	0.328	0.491	0.344	0.470
8-Aug	0.856	0.484	0.498	5.41	6.46	5.29	0.301	0.455	0.220	0.381
15-Aug	1.680	0.821	0.826	3.797 >100	2.086 >36.92	>5.25 >100	0.680	0.380	0.436	0.528
22-Aug	0.748	0.510	0.610	1.612 2.95	1.066 5.25	3.55 >200	0.446	0.427	0.778	1.044
29-Aug	0.464	0.656	0.575	10.68 >200	2.859 >200	1.737 >5.25	0.696	0.715	0.724	0.672

Zoar

Green values = surface bloom samples

Microcystin Concentrations (ppb) in Candlewood, Zoar, & Beseck lakes Summer 2019 (6/26 – 8/28)

Date	Beseck	Danbury	Brookfield	Jackson Cove	New Milford	New Fairfield	Sherman
26-Jun	1.029	0.789	1.226	1.279	1.53	1.124	0.993
2-Jul	0.22	0.204	0.058	0.143	0.115	0.146	0.099
10-Jul	0.115	0.157	0.248	0.109	0.446	0.084	0.23
17-Jul	0.07	0.137	0.129	0.036	0.134	0.031	0.198
24-Jul	0.178	0.106	0.132	0.092	0.089	0.077	0.084
31-Jul	0.328	0.119	0.082	0.102	0.123	0.06	0.116
6-Aug	0.251	0.123	0.161	0.113	0.078	0.092	0.084
14-Aug	0.234	0.111	0.06	0.114	0.065	0.08	0.076
20-Aug	0. 360	0.093	0.111	0.132	0.129	0.11	0.154
28-Aug	>5.25	0.05	0.044	0.545	0.191	0.088	0.123

Beseck

Zoar

What can we do about Cyanobacteria?

Brainstorm ideas

Control Existing Toxic Populations

Prevent Future Toxic Populations

What do they need for growth?

What can safely kill them?

How to control Cyanobacteria?

Algacides?

The effects of three chemical algaecides on cell numbers and toxin content of the cyanobacteria Microcystis aeruginosa and Anabaenopsis sp.

How to control Cyanobacteria?

Nitrogen fertilizers

Nutrient runoff

How to control Cyanobacteria?

Phosphate products

How to control Cyanobacteria?

Sewage discharge


IS THIS OUR FUTURE ?

Acknowledgments

Wong Lab (WCSU): Ghada Salah Hafez, Robert McArthur, Kayla Zhang, Joshua Sproule, Kim Lockwood, Ashley Horton, Chris Marji, Jacob Markowsky, Isha Patel

Larry Marsicano

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Dean of the Macricostas School of Arts & Sciences and the Office of University Relations, WCSU

Connecticut State Universities branch of the American Association of University Professors