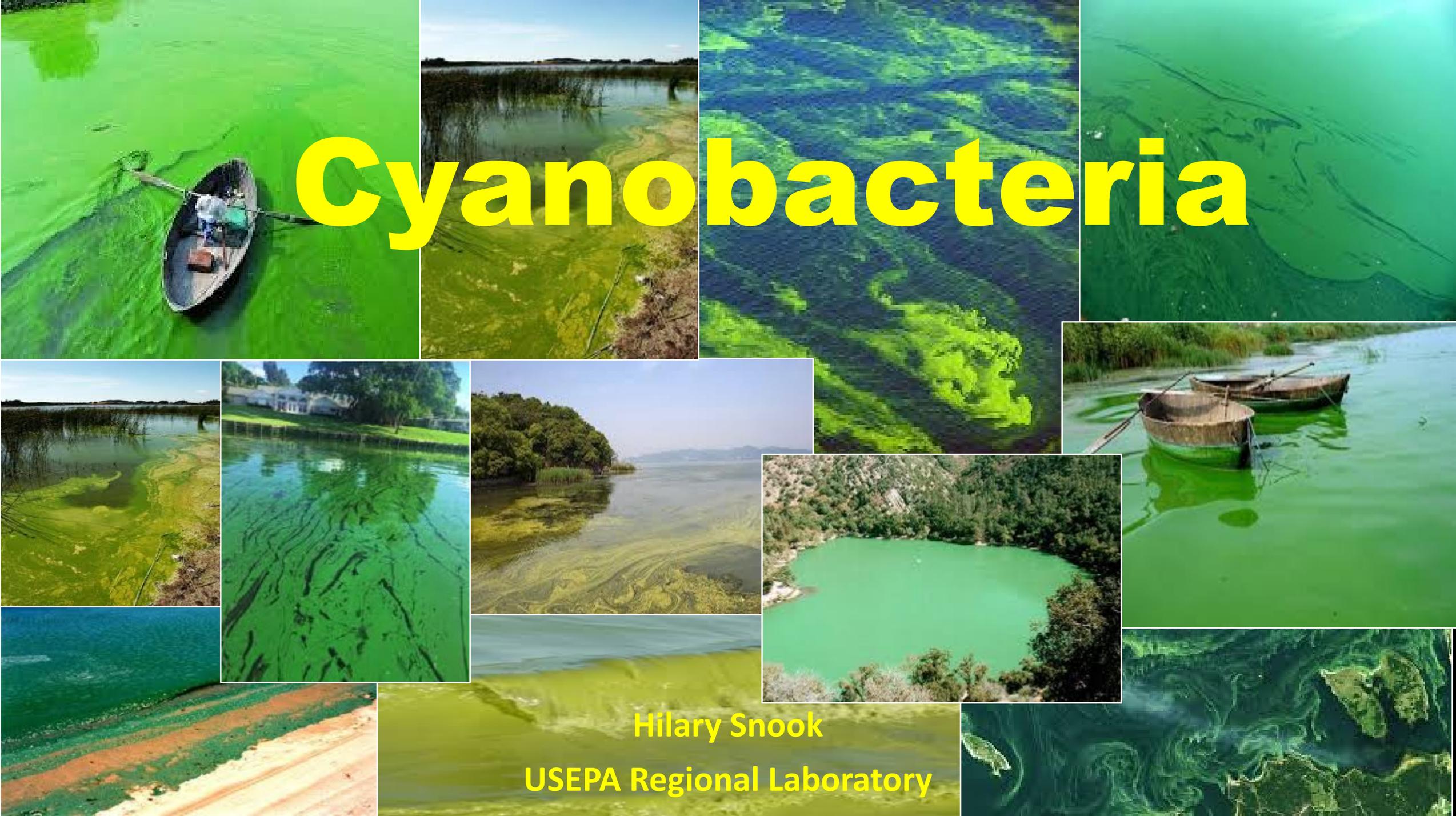


# Cyanobacteria



Hilary Snook

USEPA Regional Laboratory

# Today's Presentation

- **Cyanobacteria primer**
  - where do they come from?
  - What do they look like?
  - How do they behave?
- **Blooms**
  - What causes them?
  - Why do we care?
- **What can we do**
  - Current state of the science

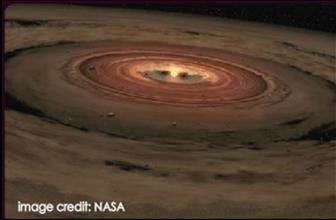


Image credit: NASA

4.5  
BILLIONS

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Image credit: AMNH / wallyg / flickr

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77



Harmful algal blooms may have killed this carnivorous theropod dinosaur, discovered by researchers excavating a series of 70-million-year-old bone beds in northwestern Madagascar.

ANDREW FARKE

## Did tiny algae fell mighty dinosaurs?

By [Carolyn Gramling](#) | Aug. 29, 2017, 3:57 PM

Seventy million years ago, they all came to drink in the rapidly drying river: long-necked sauropods, fierce theropods, crocodiles, lizards, and raven-sized birds. They never left. The giant and the tiny.



Image credit: Cristina Rizk



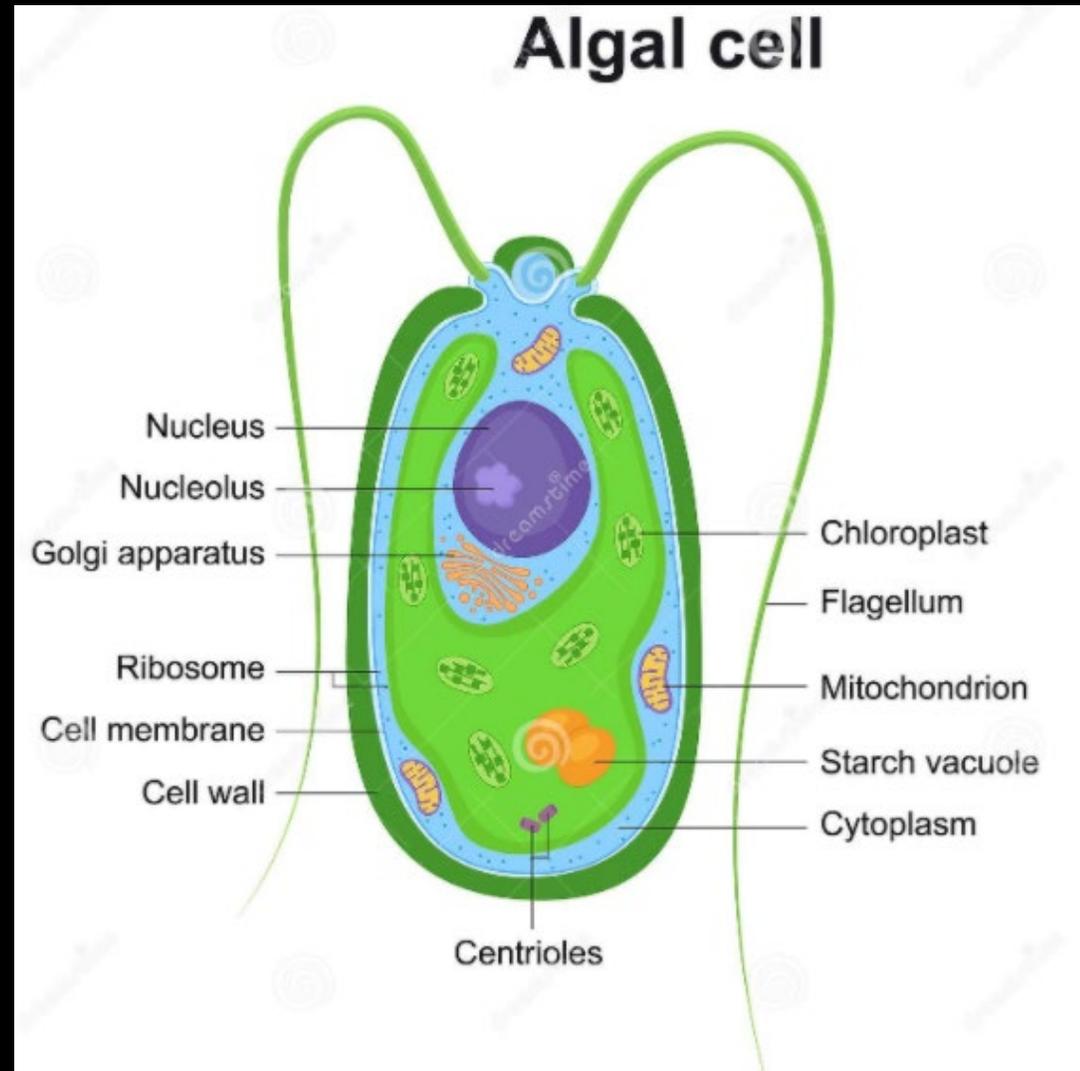
# Where are they found?



ght.com

# Blue-green algae...algae or bacterium?

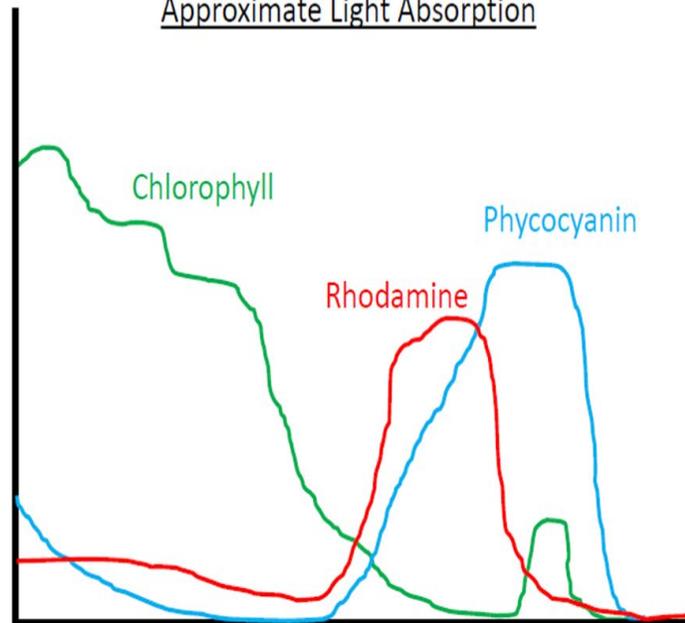
- Structurally like bacteria, functionally like plants
- Lacking a nucleus or membrane bound organelles
- Cyanobacteria photosynthesize their own food



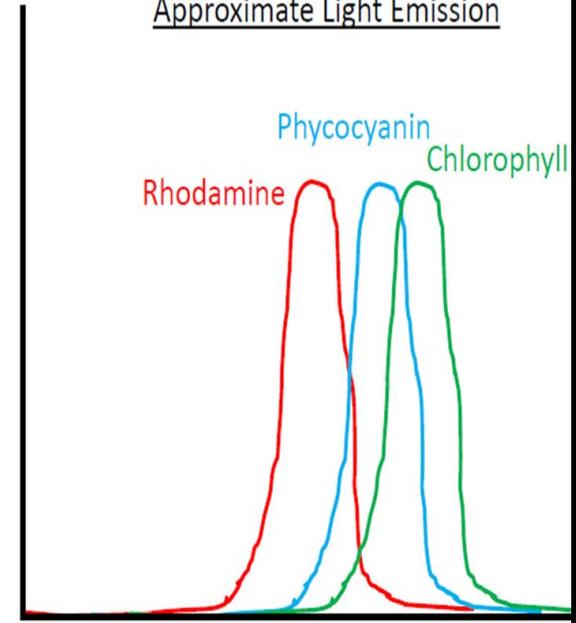
# Handheld 2-Channel Fluorometer



Approximate Light Absorption

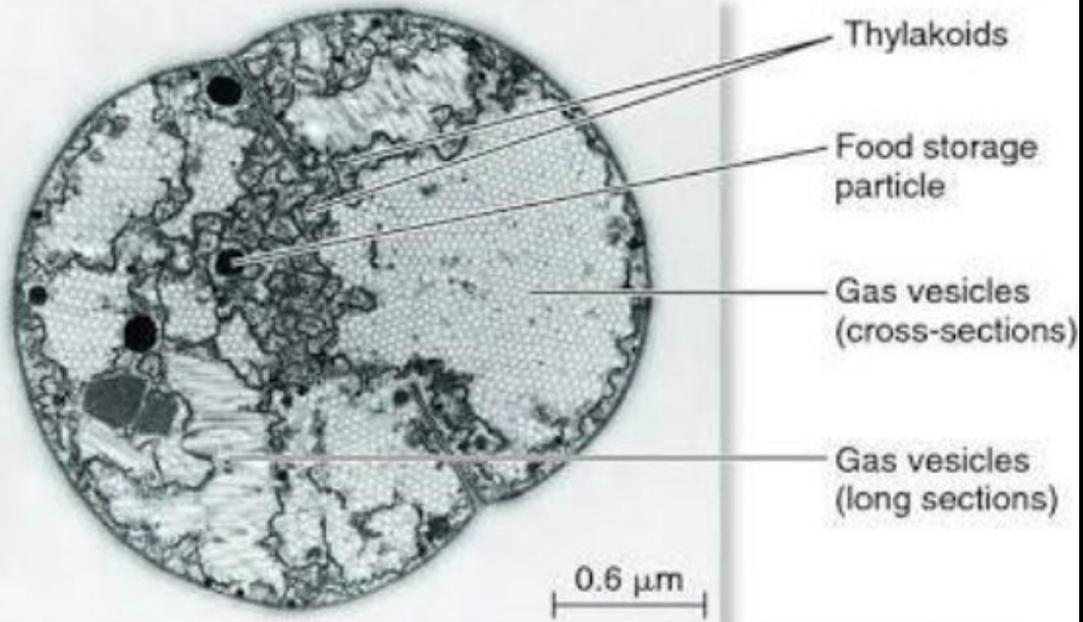


Approximate Light Emission



Likewise, each compound emits its own unique light

Thylakoids provide a greater surface area for chlorophyll and other molecules involved in photosynthesis.



The gas vesicles buoy this photosynthetic organism to the lighted water surface, where it often forms conspicuous scums.



Phycocyanin pigments

# Types of Cyanobacteria

- Forms
  - Unicellular
  - Colonial
  - Multi cellular filamentous
- Can be less than  $2\mu$
- Close to 100 genera
- 2,500 species

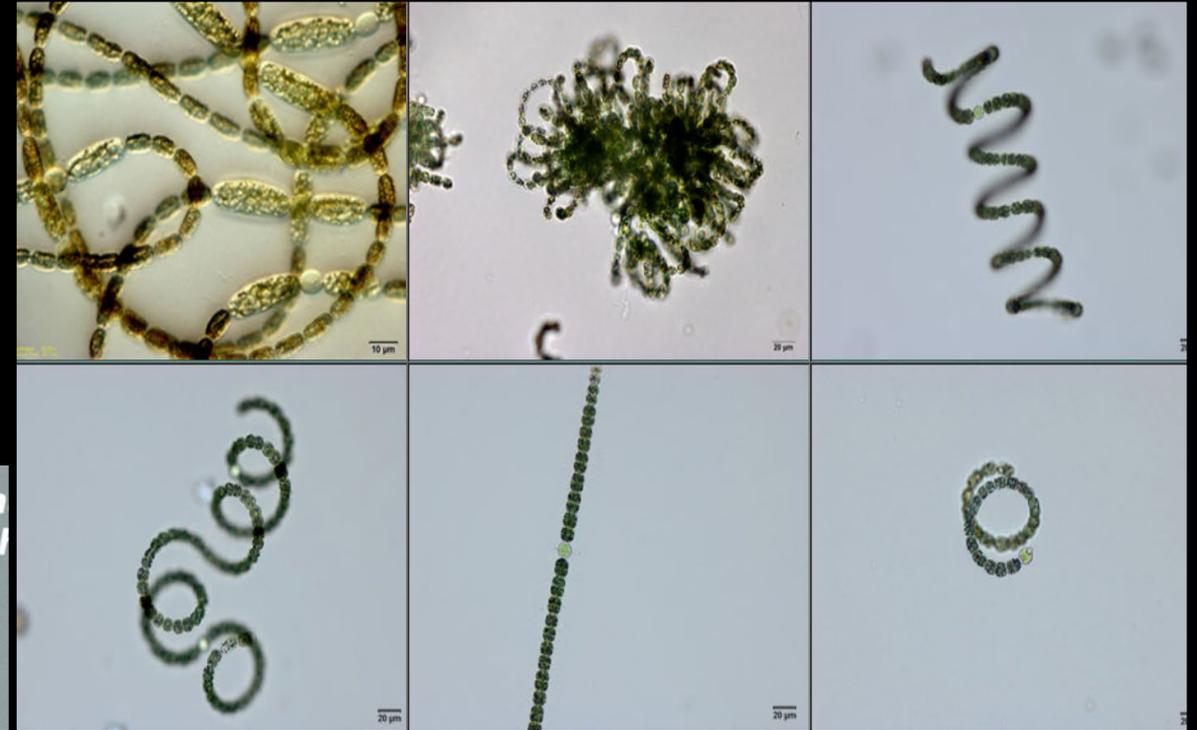
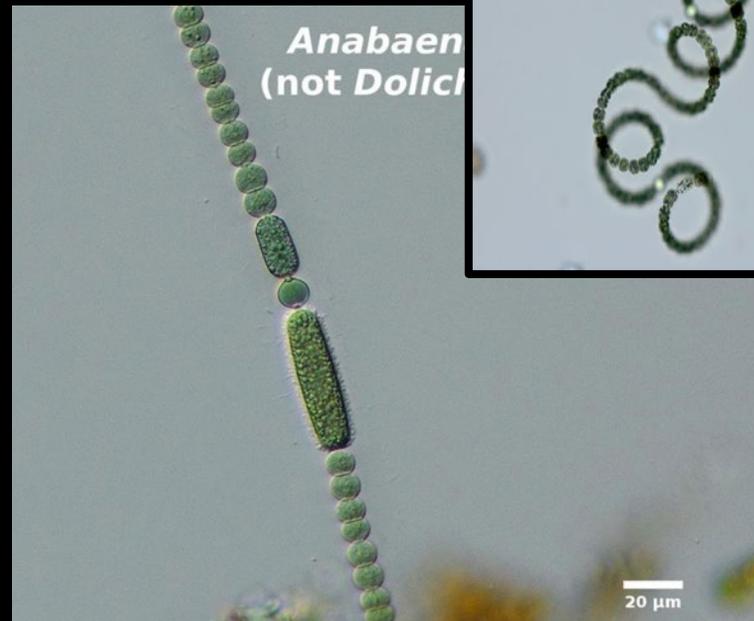


# What Do They Look Like?



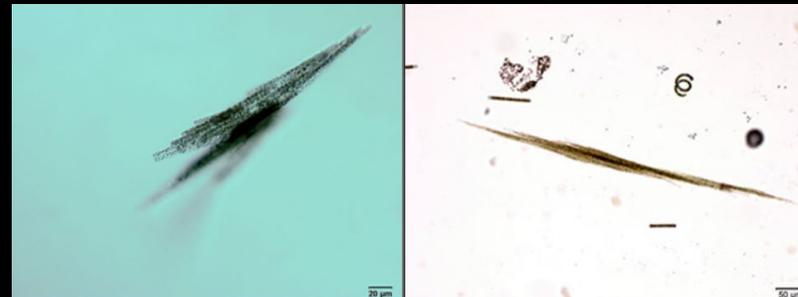
# Anabaena/Dolichospermum

- Filamentous/beadlike 5-20 $\mu$
- Heterocysts
- Akinetes
- Benthic form
- Gas vesicles
  - Dolichospermum
  - Planktonic
  - Toxin forming
- Bloom former
- Taste & Odor



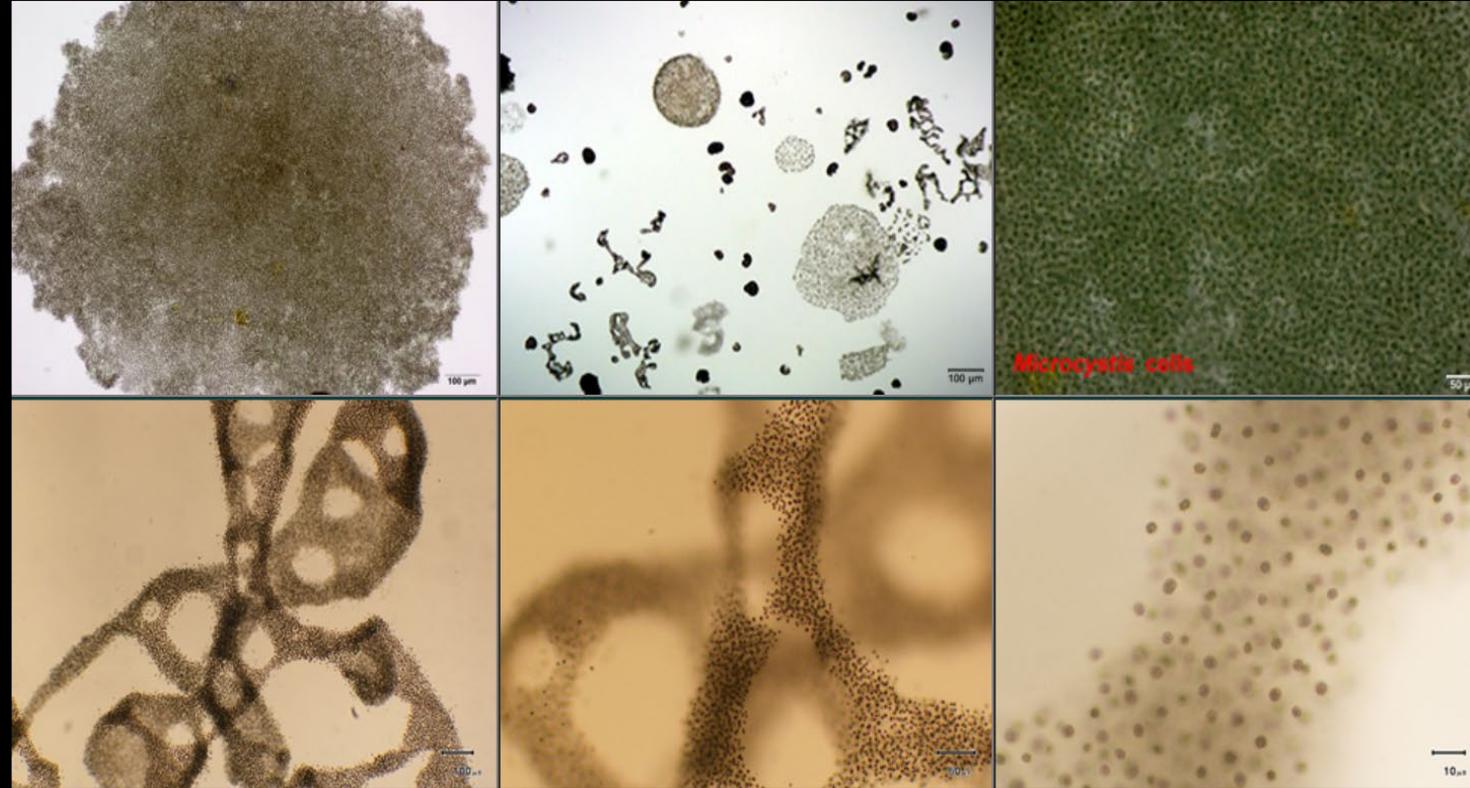
# Aphanizomenon

- Filamentous 3-8 $\mu$
- Cells joined end to end
  - cylindrical
- Heterocysts and akinetes
- Bloom former (nutrient rich)
  - Usually with others
- Gas vesicles
- High temp/light promotes blooms
- Taste & Odor



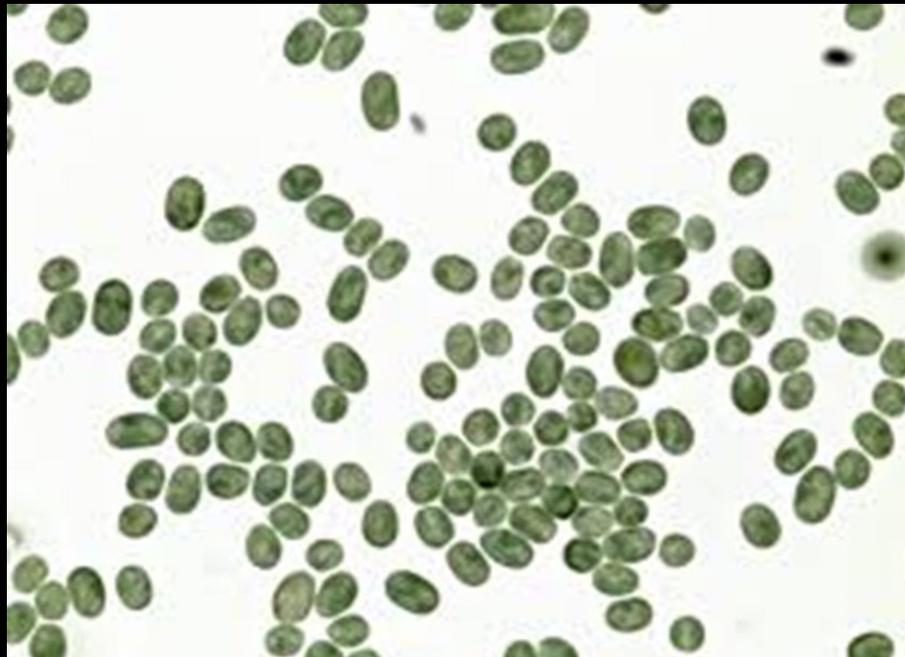
# Microcystis

- Colonial form, cells 2-5 $\mu$
- Often found with others
- Gas vesicles
- Mucilage
- Nutrients
- Warm & calm promotes blooms
  - Can be dense
  - Can be many species in same bloom



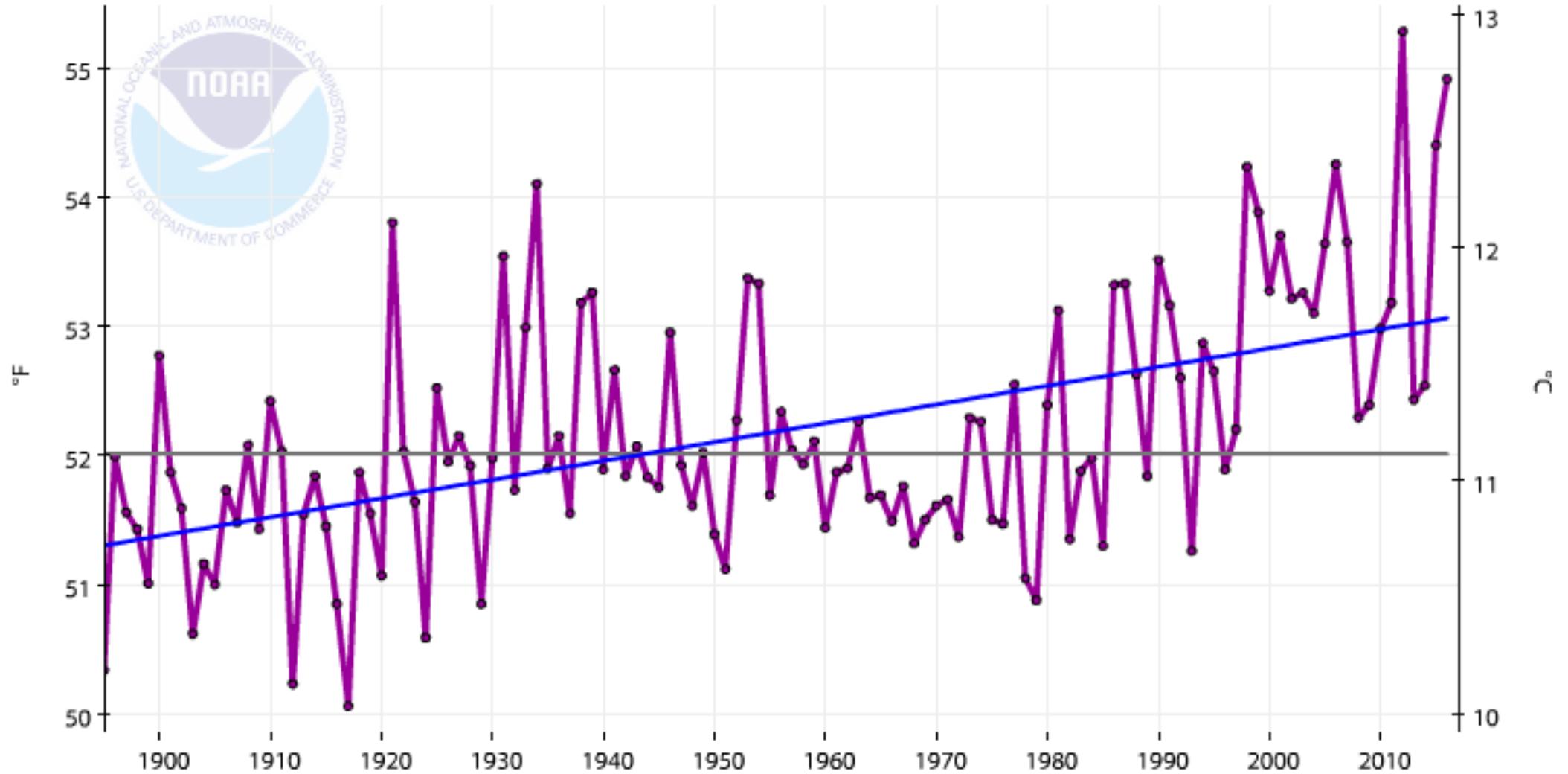
# Types/forms of Cyanobacteria

## “Annie (Dolly), Fannie, and Mike”



# Contiguous U.S., Average Temperature, January-December

— 1895-2016 Trend +1.45°F/Century    — 1901-2000 Mean: 52.02°F    ● Avg Temperature

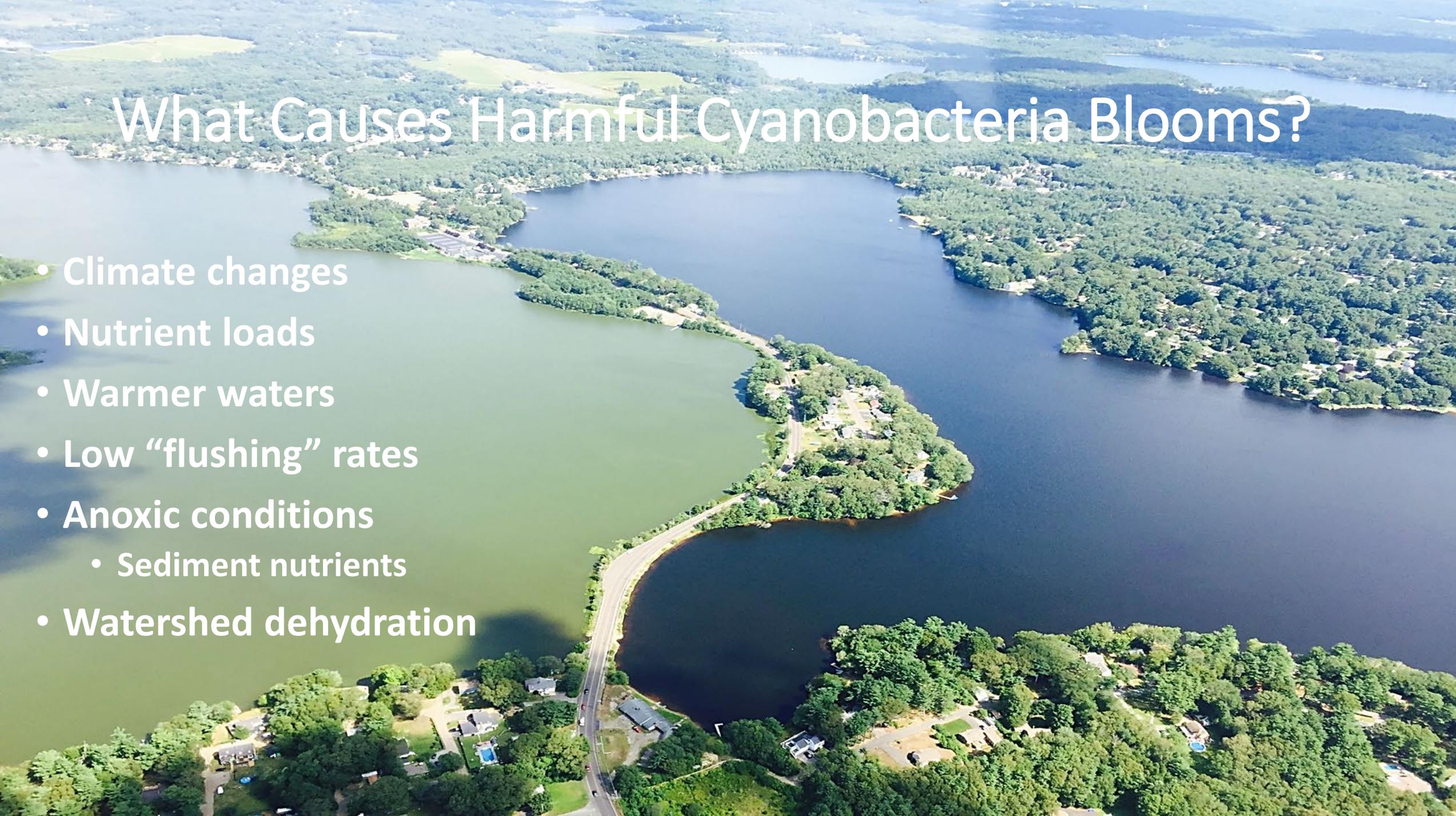




Indian Lake

# What Causes Harmful Cyanobacteria Blooms?

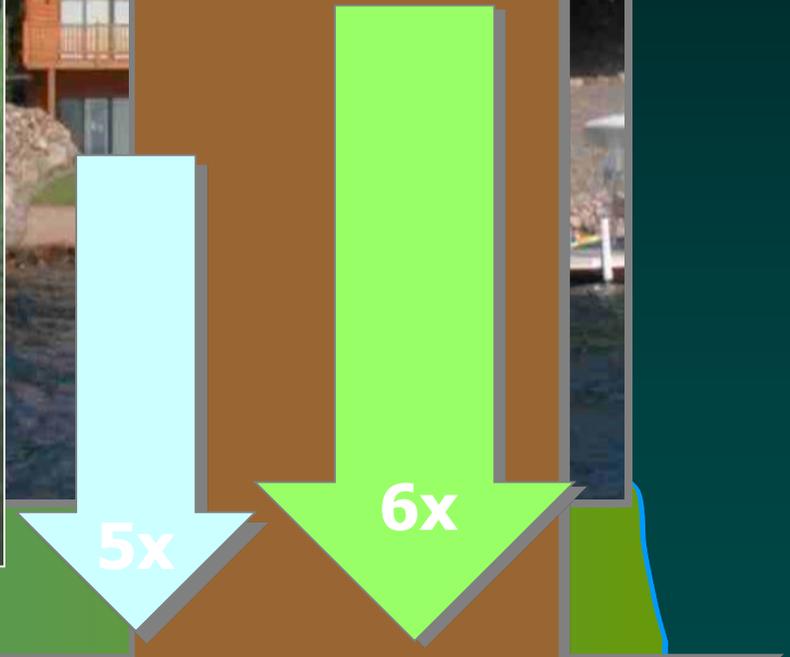
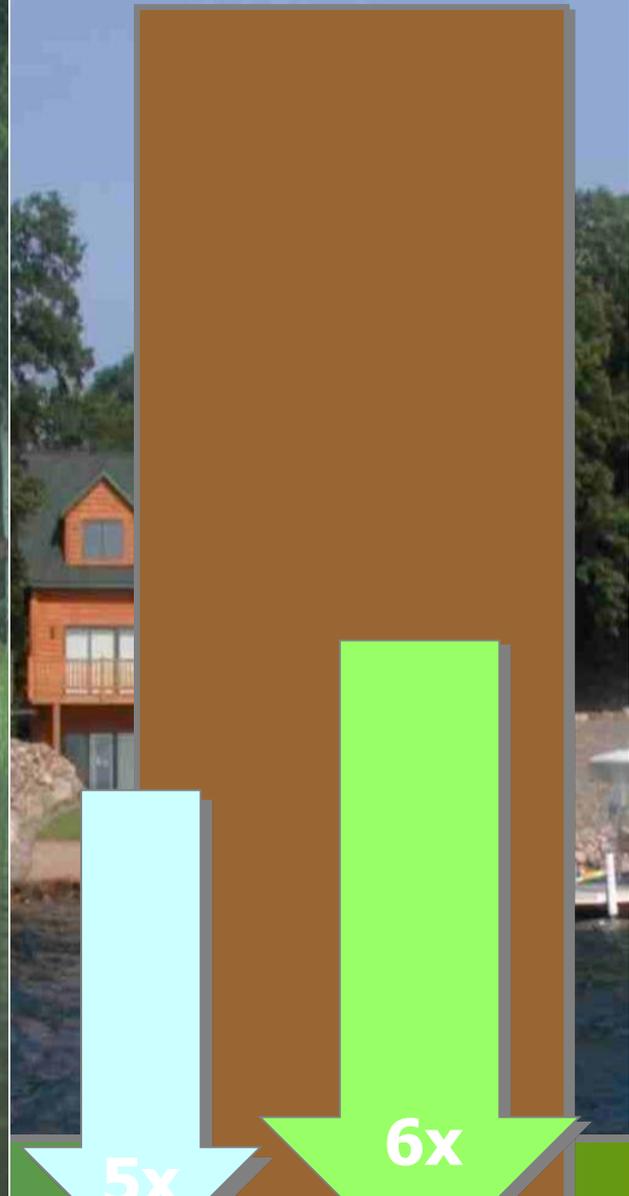
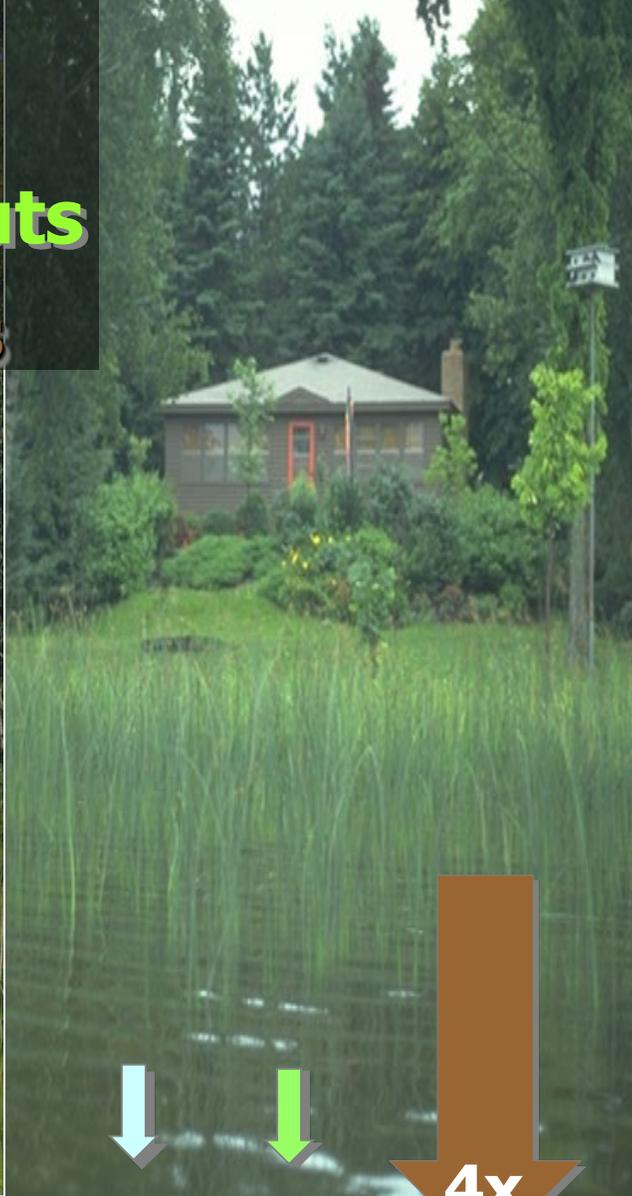
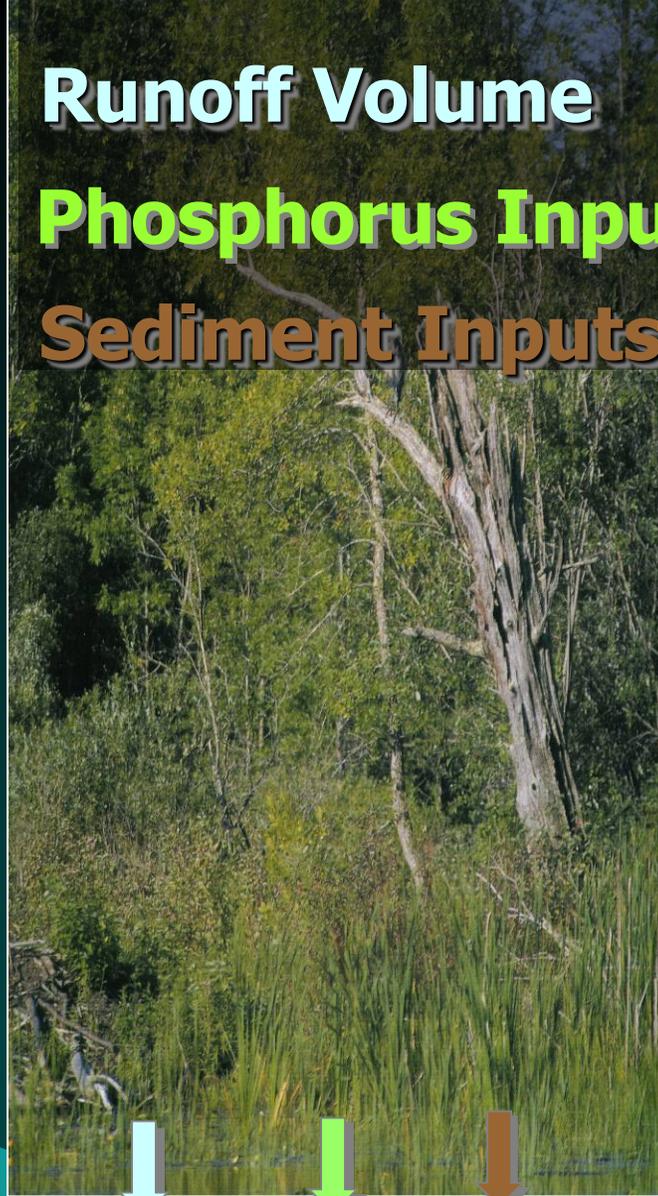
- Climate changes
- Nutrient loads
- Warmer waters
- Low “flushing” rates
- Anoxic conditions
  - Sediment nutrients
- Watershed dehydration



**Runoff Volume**

**Phosphorus Inputs**

**Sediment Inputs**



Adapted From: Wisconsin DNR

**18x**

# What exactly is a “Bloom?”

“You know it when you see it”

- Increase of cyanobacterial biomass
- Couple days to a couple weeks
- Single, or few species
- Visible

Algae blooms are different....and not potentially toxic!

Non-bloom formers – Pico cyanobacteria

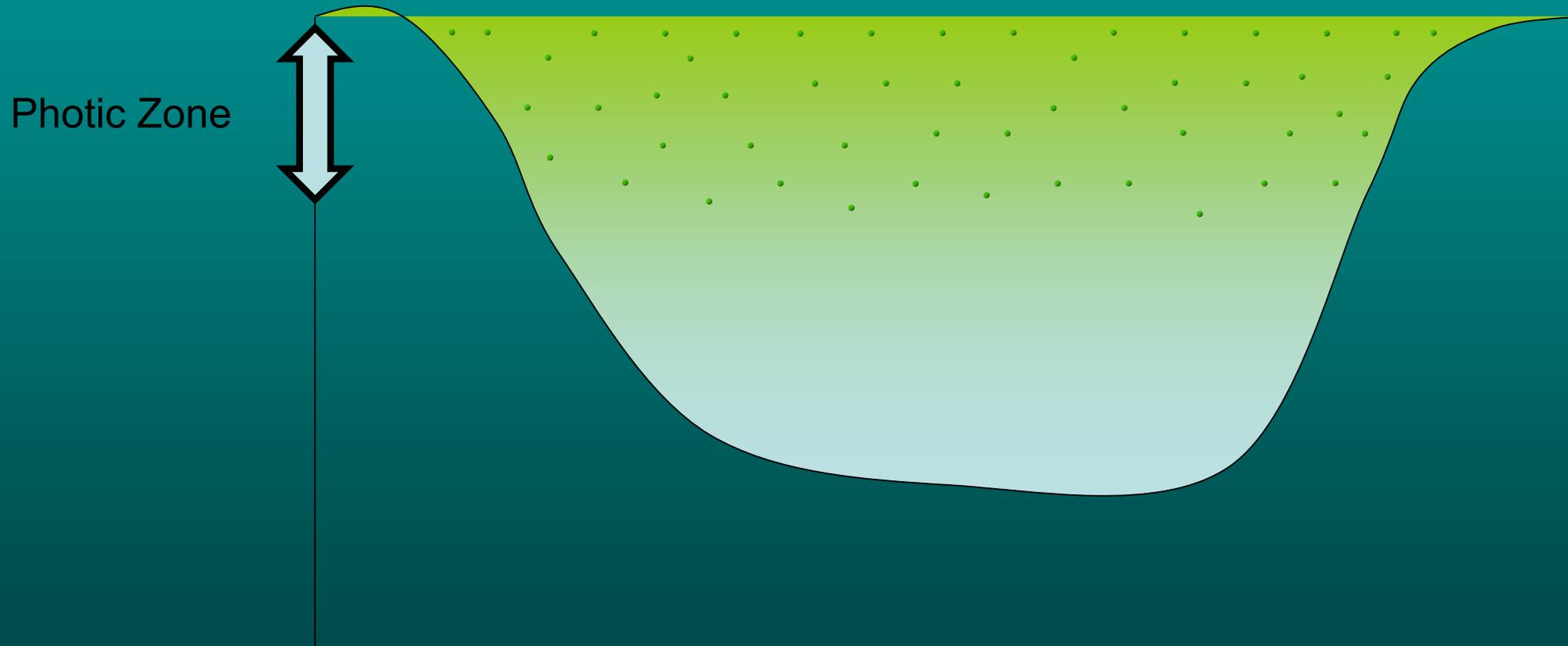
Less than 2 $\mu$ m

Often widely dispersed

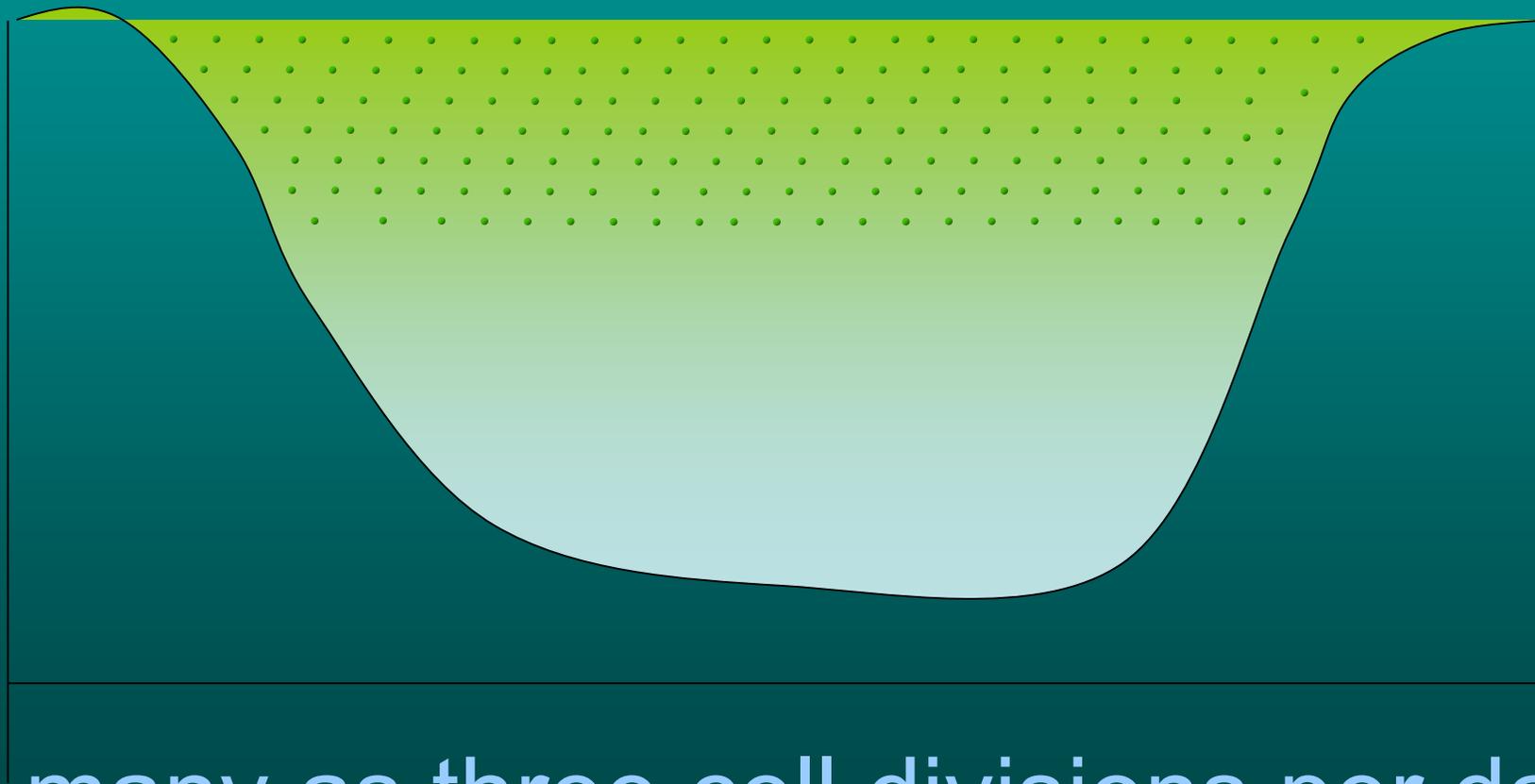
Easily aerosolized/volatilized



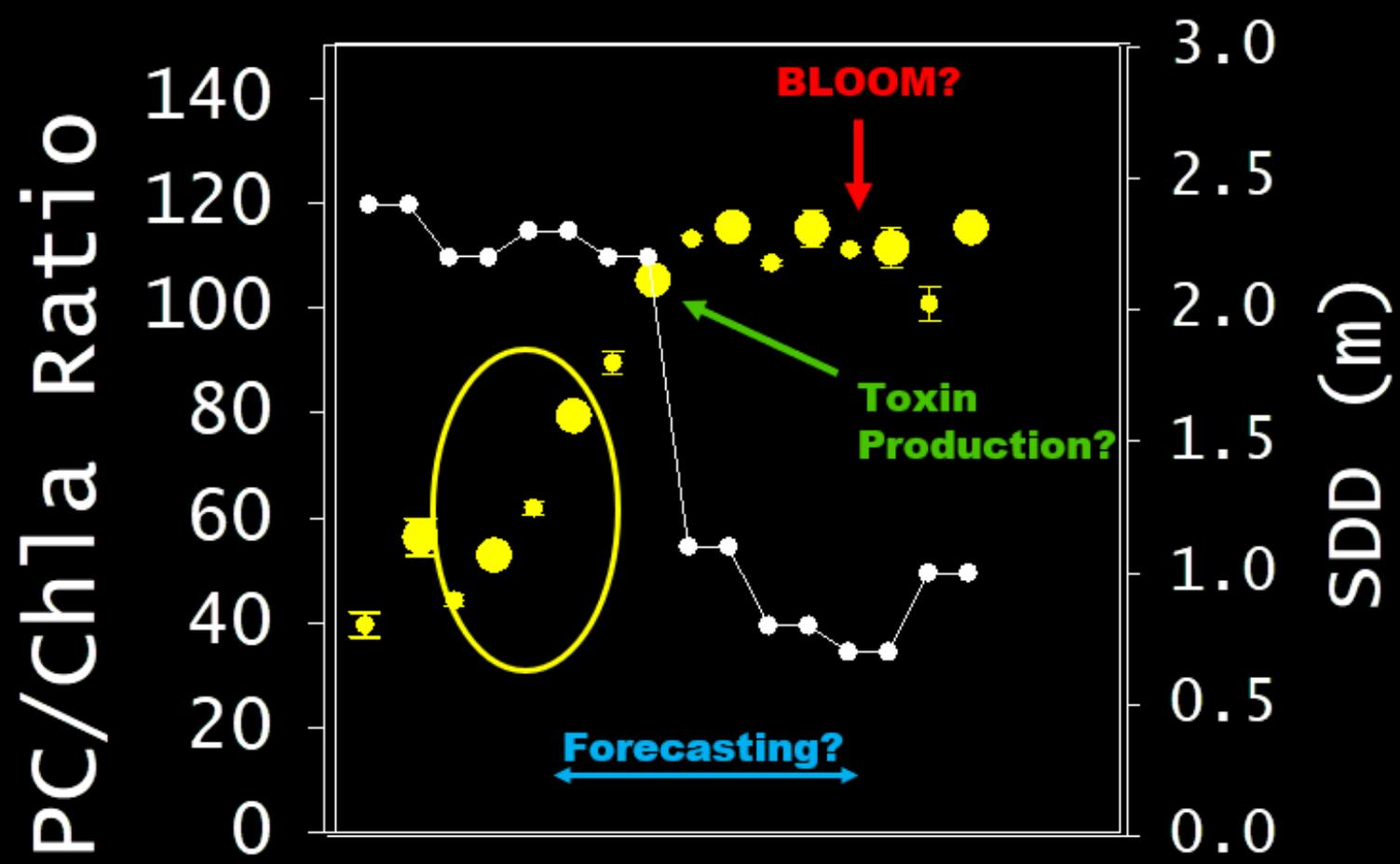
# How Harmful Algal Blooms (HAB's) Form



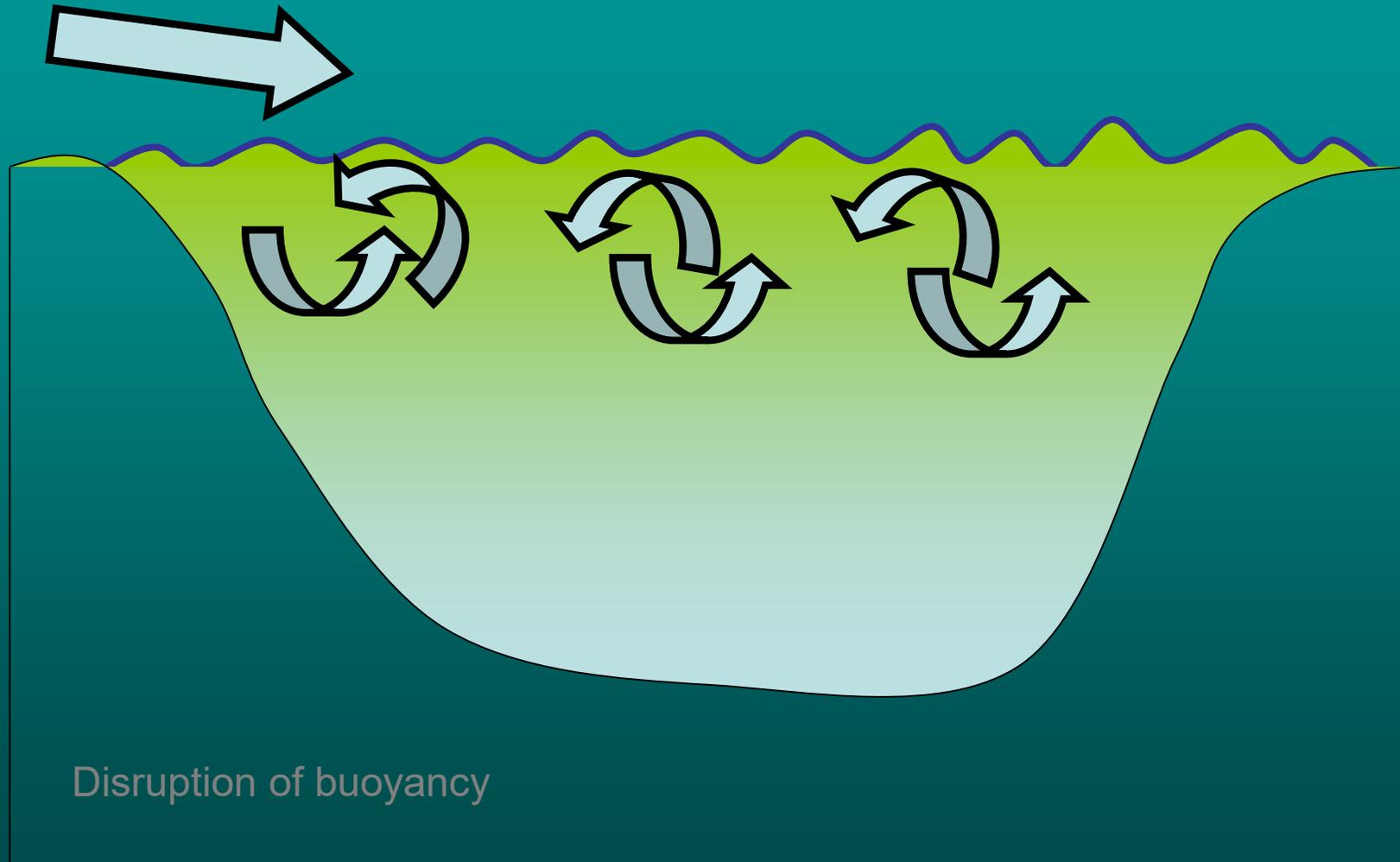
- Warming
  - Algae-  $<59^{\circ}\text{F}$
  - Cyano-  $>79^{\circ}\text{F}$
- Stratification
- Anoxia/nutrient release



As many as three cell divisions per day

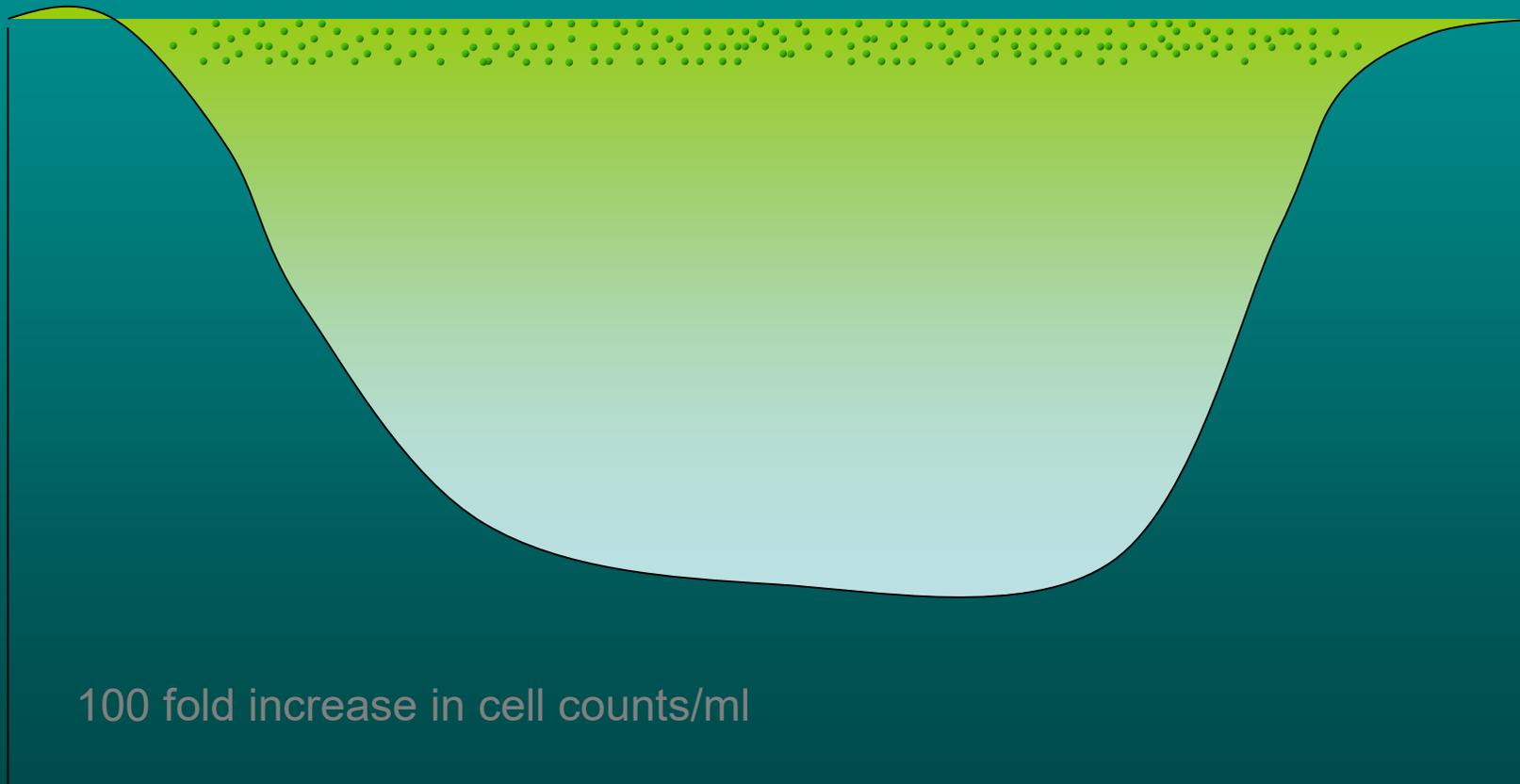


# Wind Action

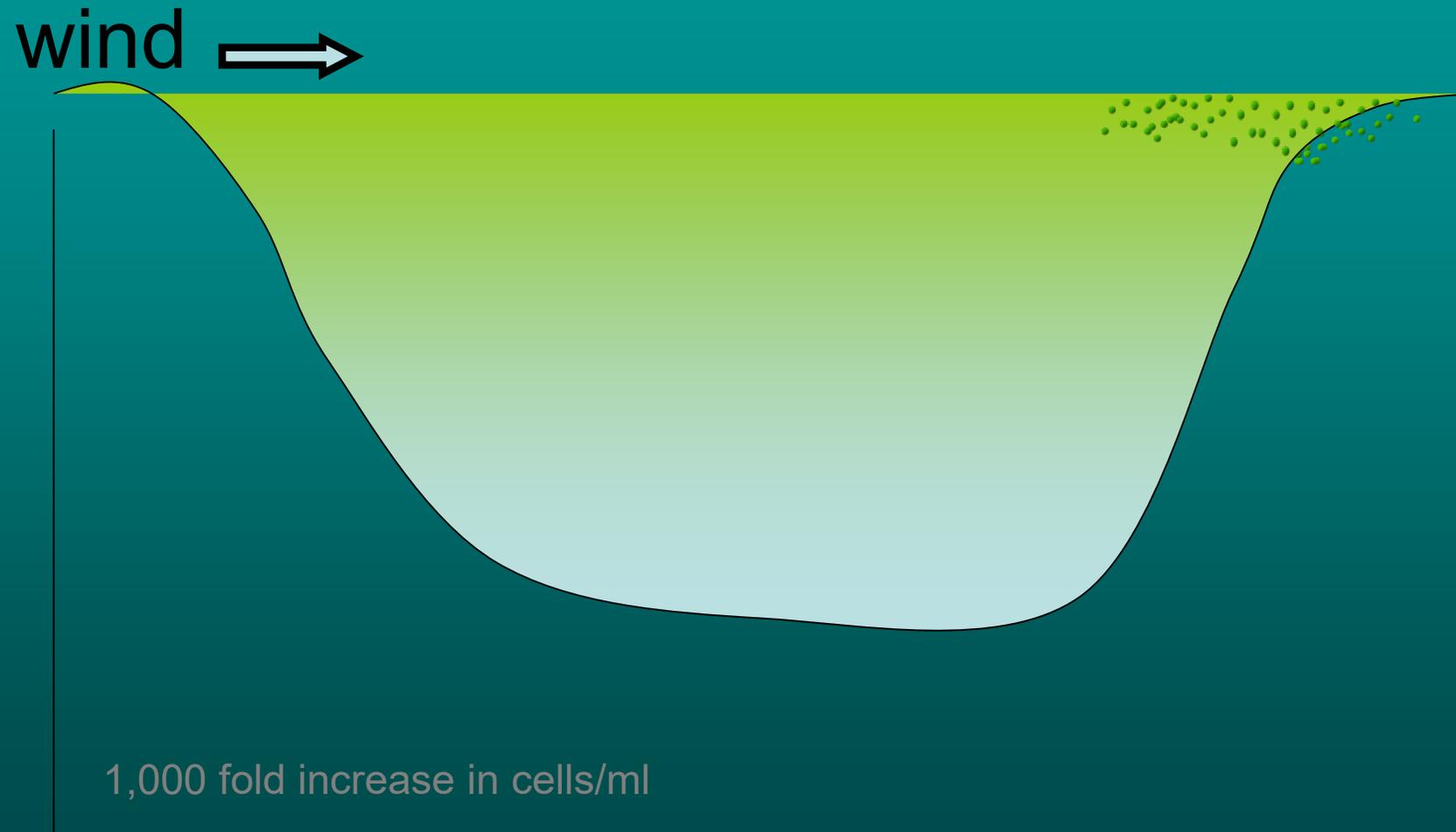


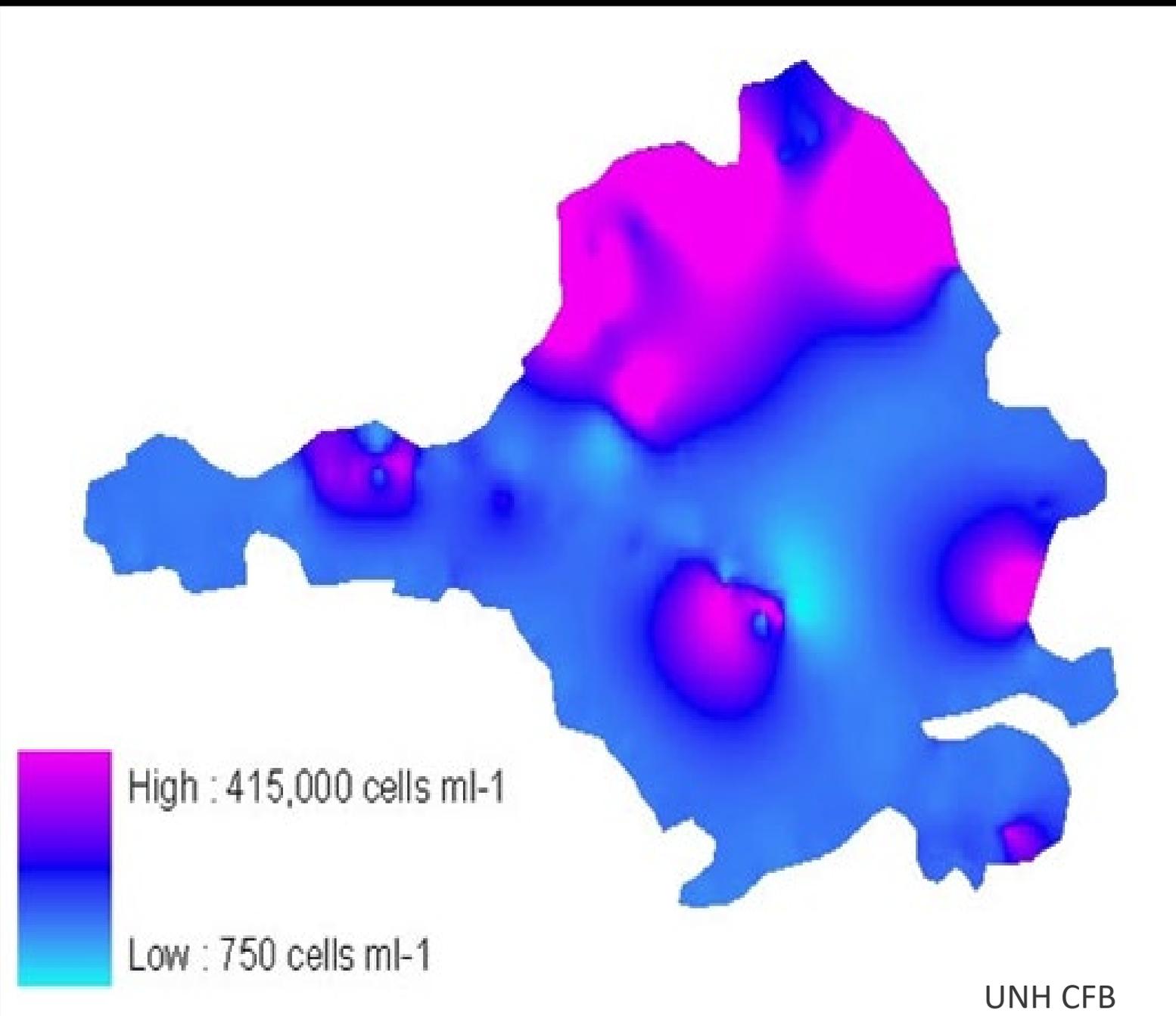
Disruption of buoyancy

# Inability to regulate buoyancy



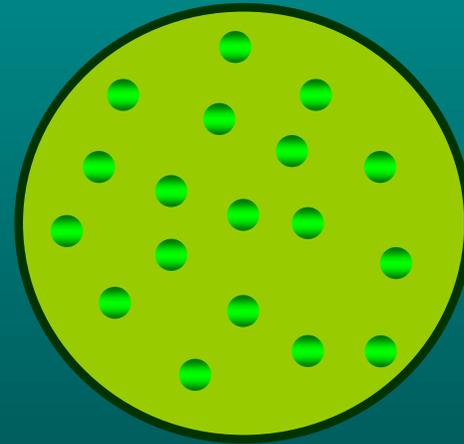
# Super Concentration and Decomposition of bacteria







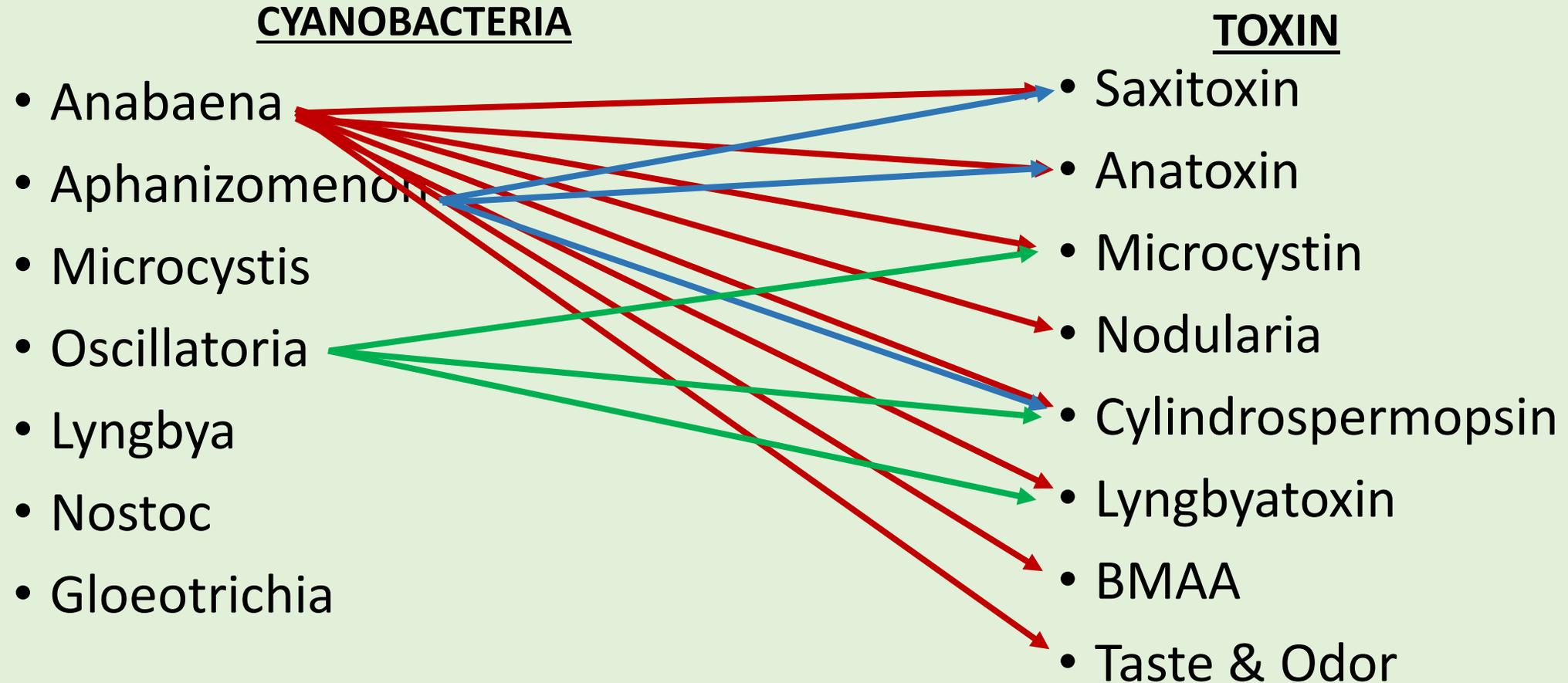
- Toxicity not affected by boiling water
- Cell death releases the toxins
- Cell rupture releases toxins
- Ingestion release toxins



# Jar & Stick Test



# Toxins Associated with Specific Genera



# TOXINS

## Oral LD<sub>50</sub> μg/Kg

- Saxitoxin 9
- Anatoxin (VFDF) 20
- Microcystin-LR 50
- Nodularia 50
- Cylindrospermopsin 200
- Ricin 0.02
- Cobra 20
- Curare 500
- Cyanide 1,500
- Strychnine 2,000

# Cyanotoxin targets

- Saxitoxin Neurotoxin
- Anatoxin Neurotoxin
- Microcystin-LR Hepatotoxin, tumor promoter
- Nodularia Hepatotoxin, tumor promoter, weak carcinogen
- Lyngbyatoxins Dermatoxin
- Cylindrospermopsin Neurotoxin, multiple organs, genotoxic
- BMAA Neurotoxin

# Routes & Types of Exposure

- Dermal – Acute – Lyngbya toxin
  - Itchiness, mild to severe skin rashes (i.e. Lyngbya)
  - Symptoms occur within hours of direct exposure
- Ingestion – Acute – Microcystin toxin common
  - Most common with pets & wildlife (direct consumption, licking fur)
  - Drinking water, cooking, recreation (boiling doesn't help!)
  - Usually hepatic – can be lethal (minutes)
  - Neurotoxin pathway – PSP, BMAA (bioaccumulates/bioconcentrates)
- Inhalation – Chronic – non-bloom forming pico cyanobacteria
  - Compelling evidence with BMAA and ALS
  - Transport at the molecular level

# Toxicity Associated with Cyanobacteria

- We still don't know when toxins are expressed, but
  - Often when waters warm up and “hyper blooms” occur
  - A visual bloom doesn't necessarily mean toxins are present
  - Clear water doesn't guarantee toxins aren't present
  - Much research currently underway
- Toxins are not limited to the large bloom forming cyanos
  - Pico cyanobacteria – low concentration, chronic exposure
  - Blooms can be locally isolated in small areas
  - Blooms can occur at depth

# Treatment Options

- Nutrient reductions
- Flocculants/binders
- Oxygenation/aeration
- Ultrasound/sonication
- Algaecides
- Rooted plants
- Trophic balance
- Dredging
- Flow manipulation



- EPA Approved APP
- iPhone and Android compatible
- New launch very soon
- Intro and training video clips
- Downloadable via APP stores or from [Cyanos.org](http://Cyanos.org)

# CYANOS.ORG

[http://listserv.uri.edu/cgi-bin/wa?SUBED1=CYANO\\_COLLAB](http://listserv.uri.edu/cgi-bin/wa?SUBED1=CYANO_COLLAB)

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