Phytoplankton Monitoring Network (PMN)

Promoting a better understanding of Cyano Harmful Algal Blooms by way of volunteer monitoring.

Basic Cyanobacteria ID

NOAA Charleston Lab

Jen Maucher Fuquay, M.S., CSS contractor
PMN Coordinator

PHYTOPLANKTON MONITORING NETWORK

NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

Science Serving Coastal Communities

To educate the public on harmful algal blooms (HABs) while expanding the knowledge of phytoplankton that exist in coastal waters through research based monitoring.

PMN is a national volunteer organization that monitors for potential Harmful Algal Blooms

Train citizen scientists to:

- *Collect samples from coastal or freshwater environments*
- *Identify potentially harmful algal/cyanobacterial species*
- *Enter information into NOAA database*

NOAA scientists can then:

- *Analyze water samples for HAB toxins*
- *Alert state/local agencies to presence of bloom*
- *Identify temporal and geographic HAB trends*

Why the PMN?

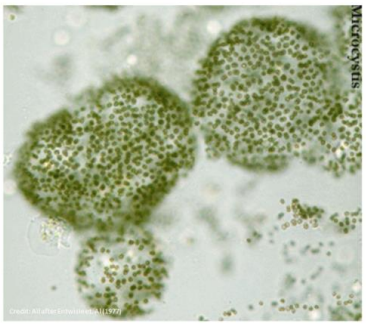
Problem: Very few government or private institutions have the capacity or capability to monitor thousands of lakes (and reservoirs), from the Great Lakes to small residential lakes annually impacted by HABs.

Solution: Engage local citizens in environmental monitoring of potentially harmful cyanobacteria to aid NOAA scientists and others in their research.

Cyanobacterial Harmful Algal Blooms (cyanoHABs)

Cyanobacteria, formerly called blue-green algae, are a type of photosynthetic bacteria.

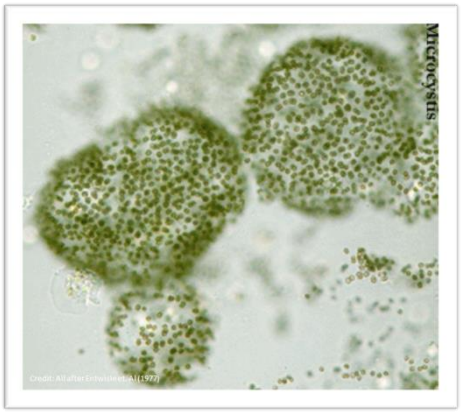
Beneficial in that they can produce oxygen for the water and atmosphere.



Cyanobacterial Harmful Algal Blooms (cyanoHABs)

SOME species, not all, can produce toxins that can impact drinking and recreational waters.

Can affect wildlife, pets and humans



HEALTH EFFECTS OF INGESTION, INHALATION & CONTACT WITH CYANOTOXINS

Every year, Americans fall ill after being exposed to harmful cyanotoxins. This contact can come in many forms, but most results from being in or around water that contains dangerous levels of algae. Below are examples of how cyanotoxins can affect you, based on the route of contact.

INGESTION
- Fever
- Headache
- Drowsiness
- Loss of Coordination

CONTACT
- Eye & Ear Irritation

INGESTION
- Vomiting
- Sore Throat
- Incoherent Speech

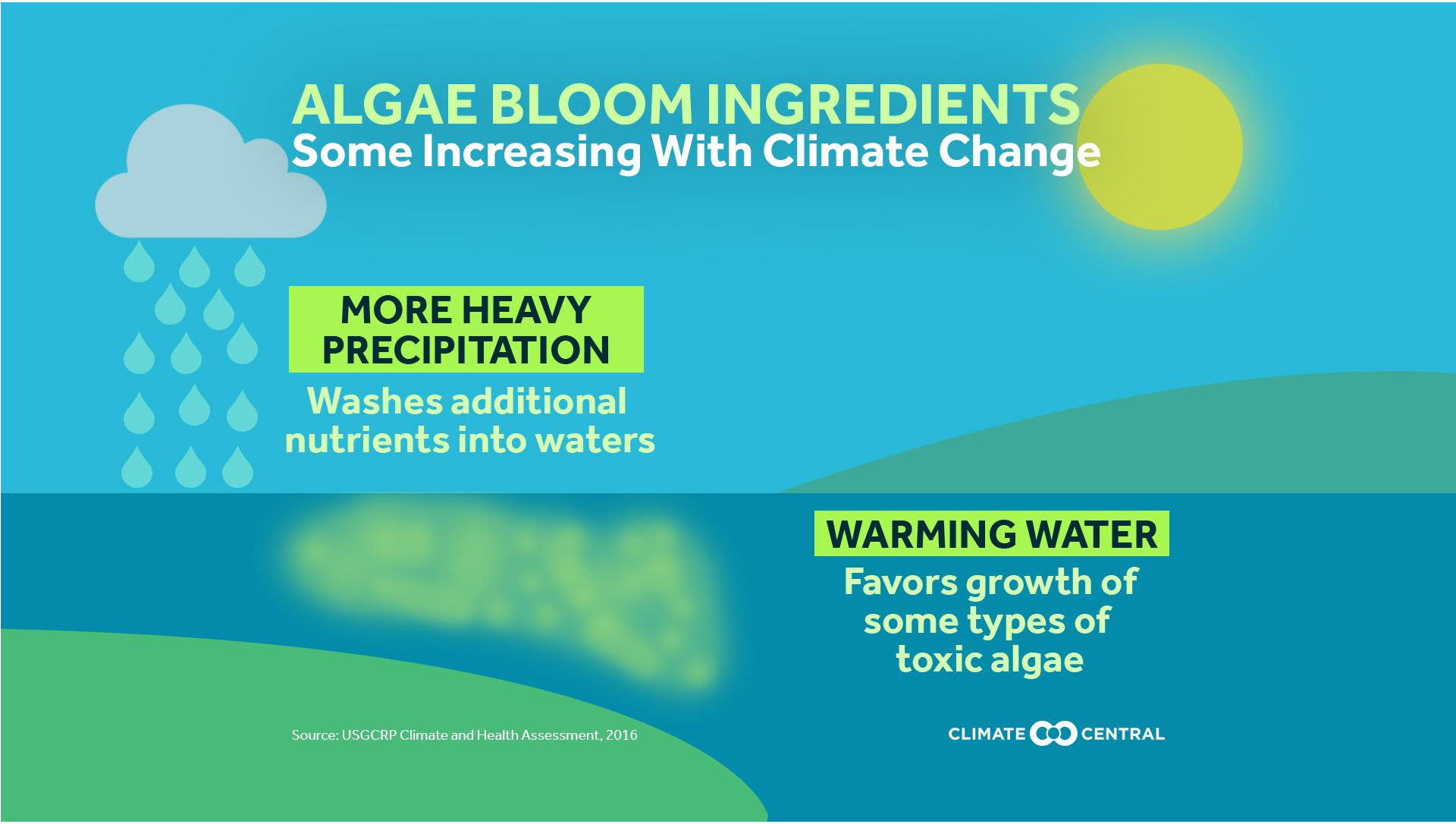
INHALATION
- Coughing
- Wheezing
- Difficulty Breathing

INGESTION
- Tingling
- Burning
- Numbness
- Muscular Twitching

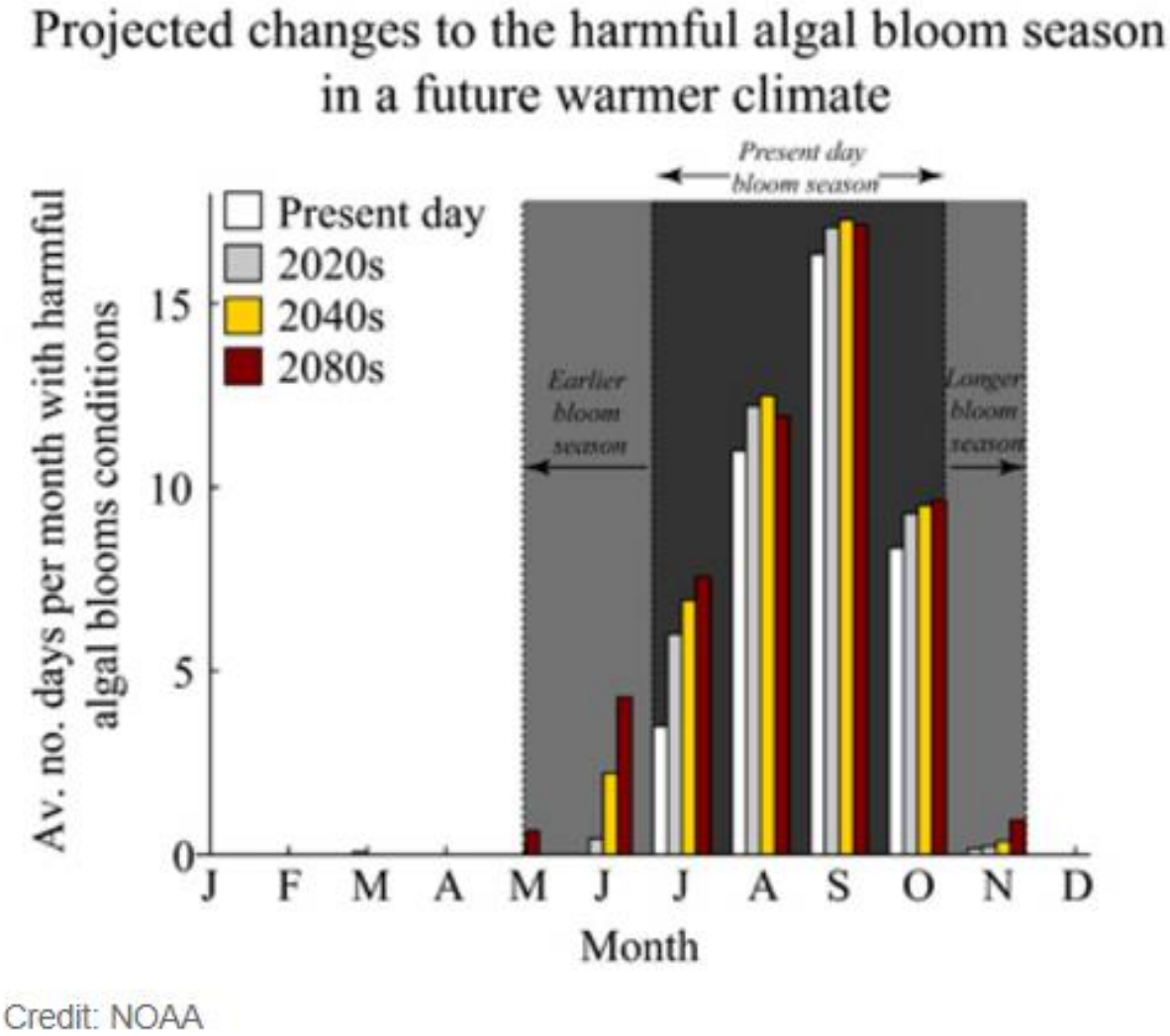
CONTACT
- Skin Irritation
- Rash & Lesions

INGESTION
- Nausea
- Cramping
- Diarrhea

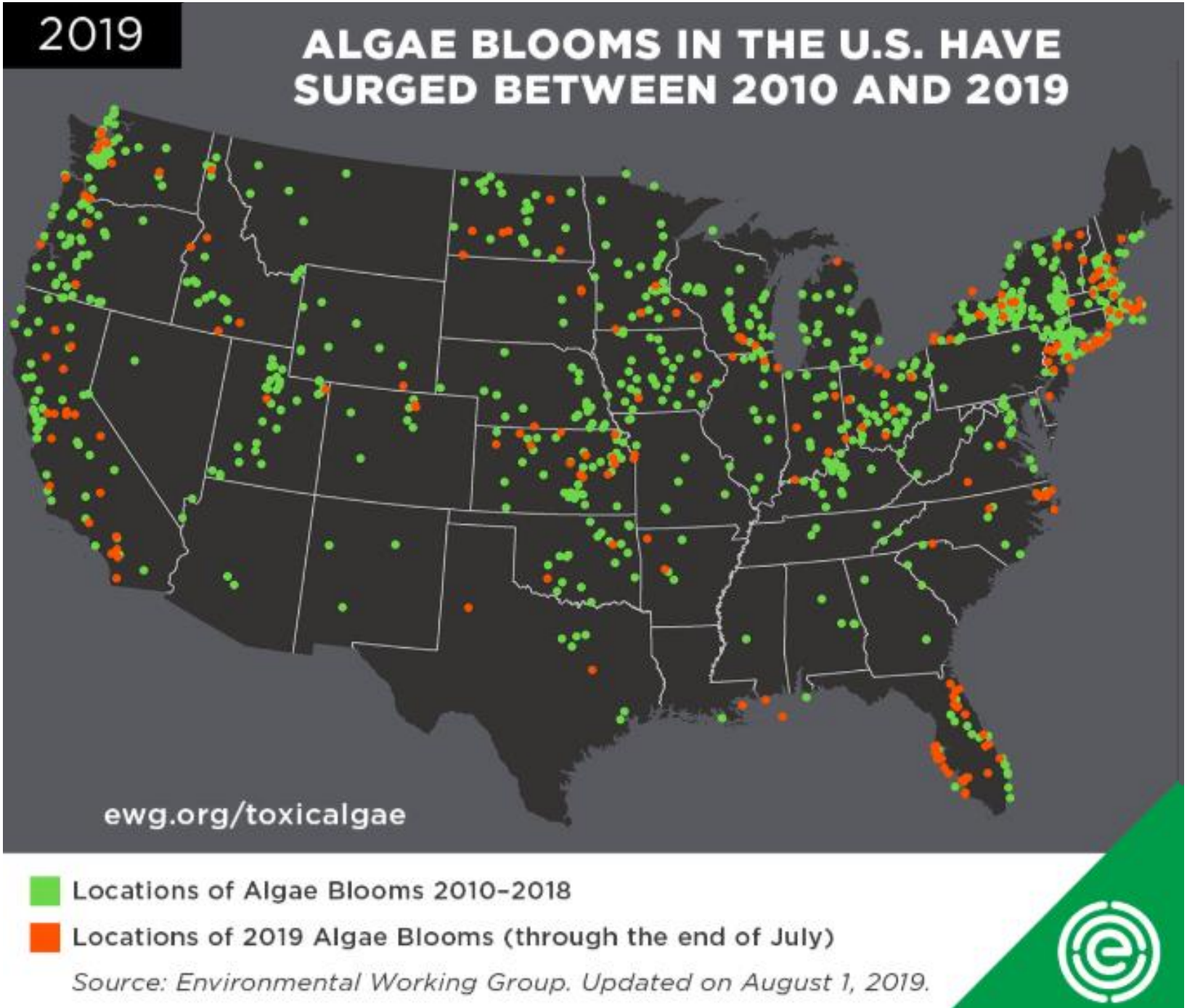
https://www.ewg.org/toxicalgalblooms/



Cyanos like it still, hot and nutrient rich



Each year the desire to live by water and the reliance on large surface waters for recreation and drinking water puts more people and animals at risk for exposure to HABs and the toxins they can produce.


2019
ALGAE BLOOMS IN THE U.S. HAVE SURGED BETWEEN 2010 AND 2019
ewg.org/toxicalgae
Locations of Algae Blooms 2010–2018
Locations of 2019 Algae Blooms (through the end of July)
Source: Environmental Working Group. Updated on August 1, 2019.

All of Mississippi's beaches have been closed for swimming due to toxic algae

UPDATED ON: JULY 7, 2019 / 6:46 PM / CBS NEWS

Clean Water or Green Water?

http://www2.epa.gov/nutrientpollution/harmful-algal-blooms

EPA
United States Environmental Protection Agency

Cannot use taxonomy to predict toxicity

USGS science for a changing world

Slide blatantly stolen from Barry Rosen @USGS

Monitoring Benefits

- **Allows for an 'early warning system'**
  - e.g. Can close shellfish beds/recreational waters and help prevent or reduce exposure and potential illness

- Monitor and maintain an extended survey area along coastal & fresh water bodies throughout the year
- Create a comprehensive list of harmful algal/cyano species inhabiting marine and fresh waters (establish baseline)
- Identify general trends where HABs are more likely to occur
- Promote an increased awareness and education to the public on HABs
- Create a working relationship between volunteers and researchers

PHYTOPLANKTON MONITORING NETWORK

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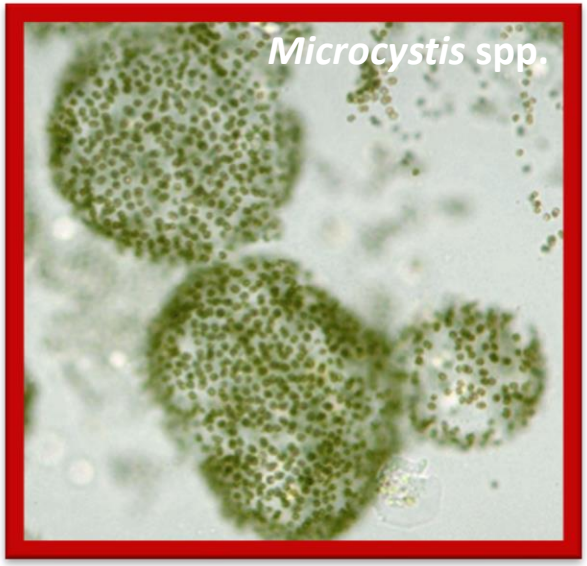
To educate the public on harmful algal blooms (HABs) while expanding the knowledge of phytoplankton that exist in coastal waters through research based monitoring.

Freshwater CyanoHAB monitoring started in 2015 as interagency agreement with EPA Office of Water

- **Modified marine protocols for freshwater**
- **Looking for 5 target organisms**

Target Freshwater Algae

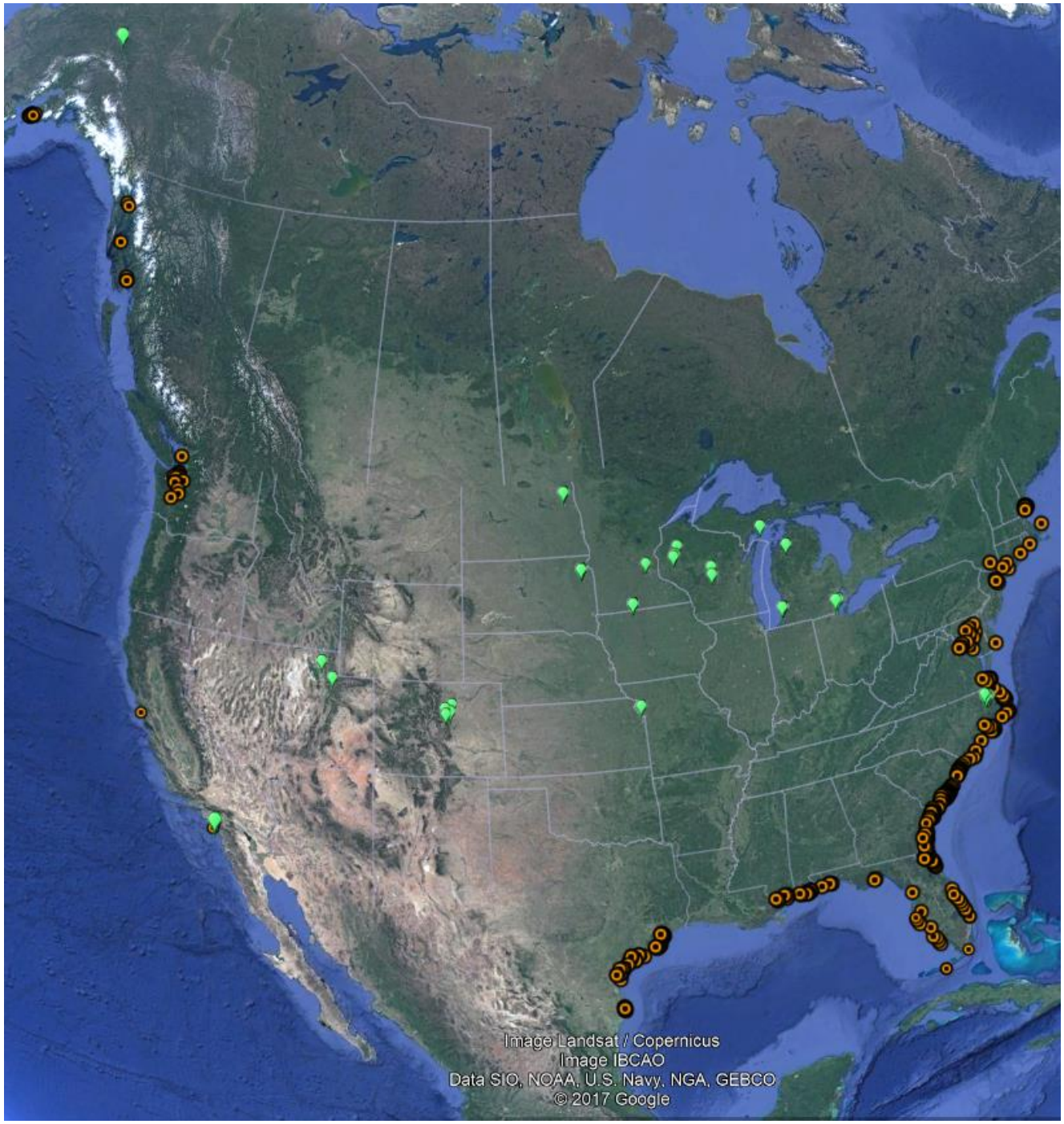


Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring, and management. World Health Organization. 1999

Phytoplankton Monitoring Network

Volunteer Requirements:

1) ***Collect sample*** at least once every two weeks during the sampling season (*1 year/season minimum*)
2) ***Analyze sample*** identifying target algae/cyanos
3) ***Take*** digital pictures to send into the PMN
4) ***Input*** data into the PMN database
5) ***Ship*** sample to PMN as required



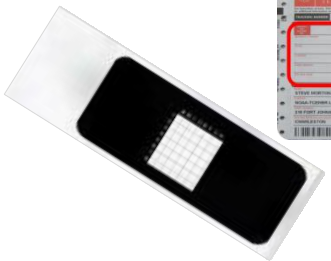
PMN sample sites

Participants include:

- **School groups**
- **Civic groups**
- **Aquariums**
- **Tribal communities**
- **National, State & local gov't entities**
- **Coast Guard Auxiliary**
- **Interested individuals**

Volunteer Equipment

Volunteers are loaned all sampling equipment



- Thermometer
- 5 gridded slides
- Cover slips
- 1L & 125 mL bottles
- 30 mL of Lugol's solution for sample preservation
- Pre-paid overnight shipping label and shipping envelopes

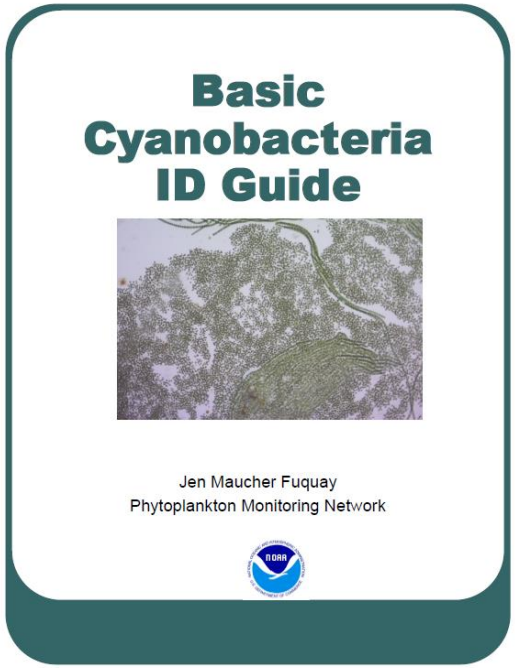
*Identification sheets for target species

Volunteer Equipment (freshwater)

SWIFT M10 T digital microscope

- Provided to Pilot Program participants
- Volunteers take digital pictures of suspected target species and send to PMN
- Allows for rapid confirmation of tentative ID
- Build virtual archive of organisms observed
- WiFi capable- Great for public demonstrations

Training

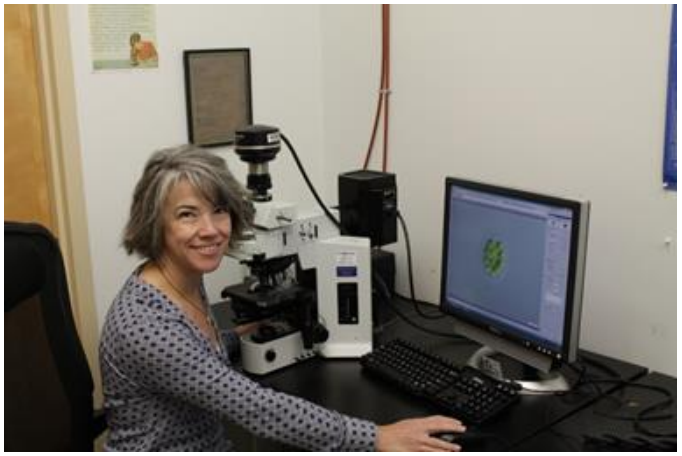


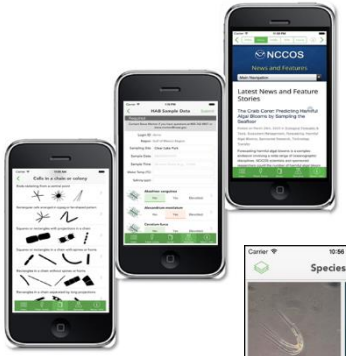
- Usually done remotely
- Background of algae
- What puts the H in HAB?
- Sampling protocols
- How to ID Target species

- Must do practice sampling
- FEEDBACK important!!!
- Data QC'd by PMN

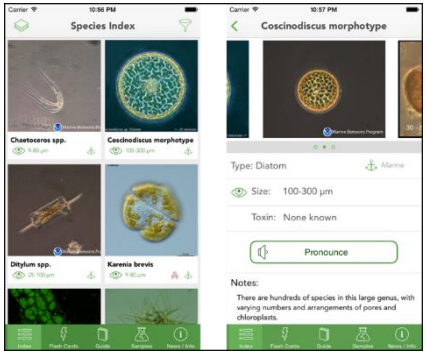
Use of Technology

Rigour: combination of staff experience & use of tools delivers quality results:
Interfacing users with technology





“Phyto “ app



Examples of Data Usage

USGS science for a changing world

Downloaded all estuarine salinity data for tide gauge models

UNIVERSITY OF SOUTH CAROLINA

Uses HAB distribution in Southeast for use in *Vibrio* model

NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM NIDIS Drought.gov U.S. Drought Portal

Downloaded all phytoplankton data to determine ecological changes due to drought

ROFFS™ ROFFER'S OCEAN FISHING FORECASTING SERVICE, INC.

Warns end users to HAB conditions

NOAA FISHERIES SERVICE Northeast Fisheries Science Center NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

PMN data to be included in the FY18 annual State of the Ecosystem report

South Carolina Task Group on Harmful Algae

Freshwater Phytoplankton Monitoring Network (PMN)

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Cyanobacteria

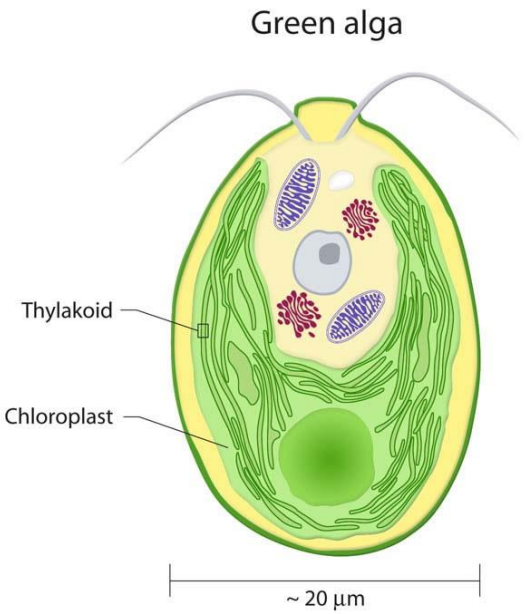
Cyanobacteria Basics

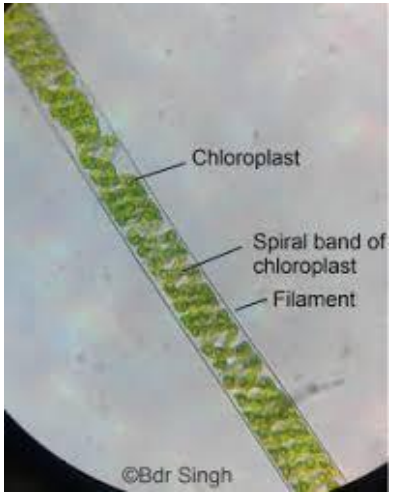
Greek ∞ ***Cyano*** = dark blue ***bacteri*** = bacteria

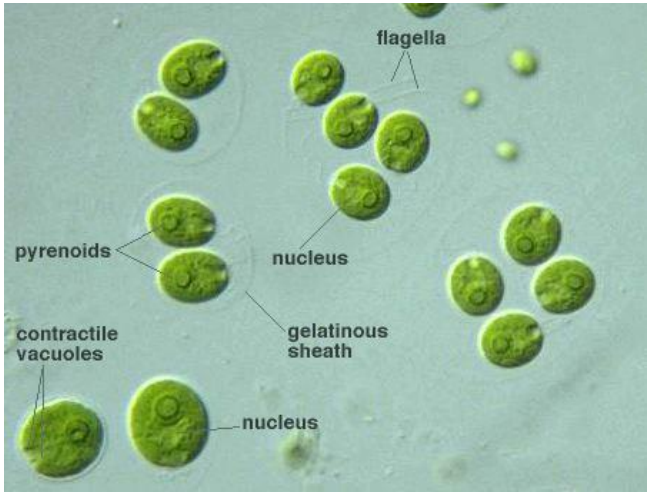
- **Photosynthetic bacteria-**
  prokaryotic cells
- **Not true algae, although we still call them HABs**
  - **CyanoHABs = Cyanobacterial Harmful Algal Bloom**
- **Live in freshwater, brackish, and marine waters**
- **Unicellular to multicellular, some Colonial**

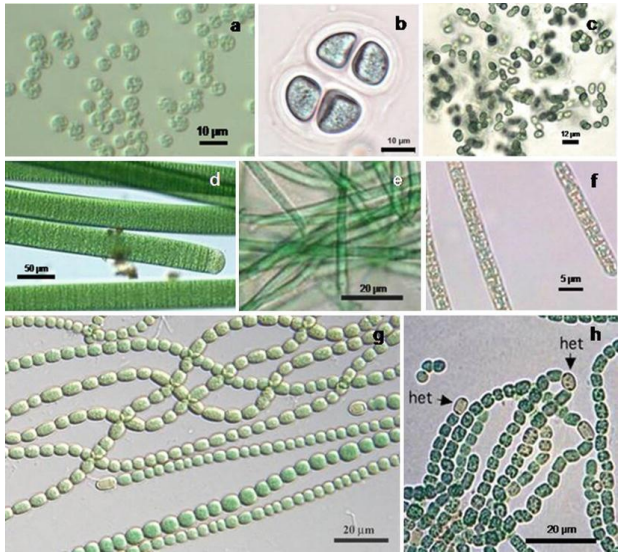
Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring, and management, World Health Organization, 1999

Cyanos vs Algae









Sood et al, 2015)

Phytoplankton Monitoring Network

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Freshwater Morphology

~ 5 Target Species

NOAA Marine Biotoxins Program
Dr. Steve Morton, Principal Investigator

Morphology basics

Aerotopes- gas vesicles

Akinete(s)- thick walled resting spore

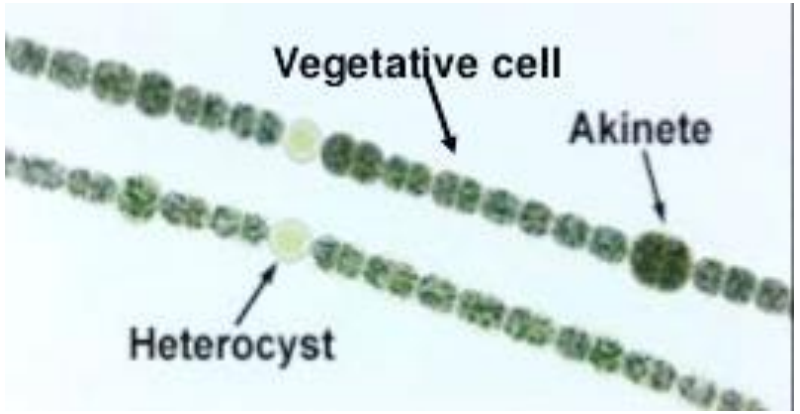
Heterocyte(s)- site of nitrogen fixation; also thick walled but clear

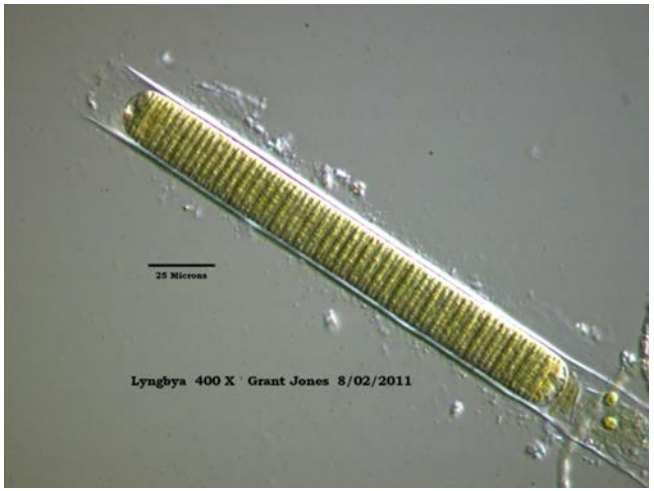
Trichome(s)- a row of cells which are connected

Unbranched- trichome does not have offshoots

Untapered- cells at end of trichome are generally same size as rest of cells

Sheath- outer covering of entire trichome made of polysaccharides



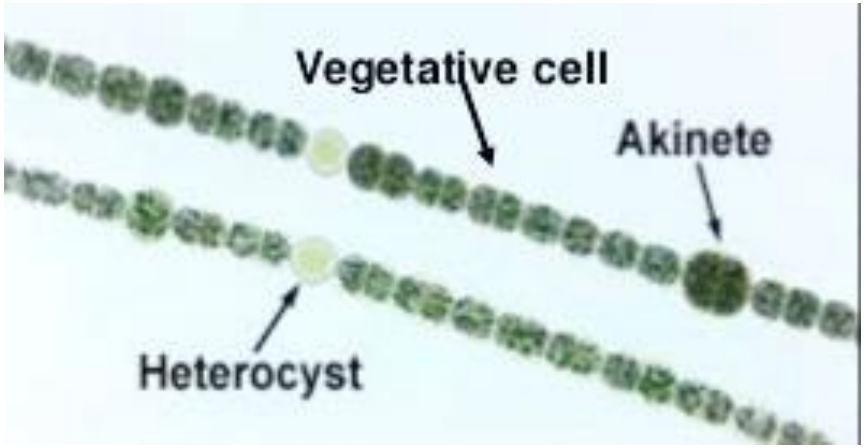


Dolichospermum spp.

N-Fixer

Some *Anabaena* has now been re-classified as *Dolichospermum*

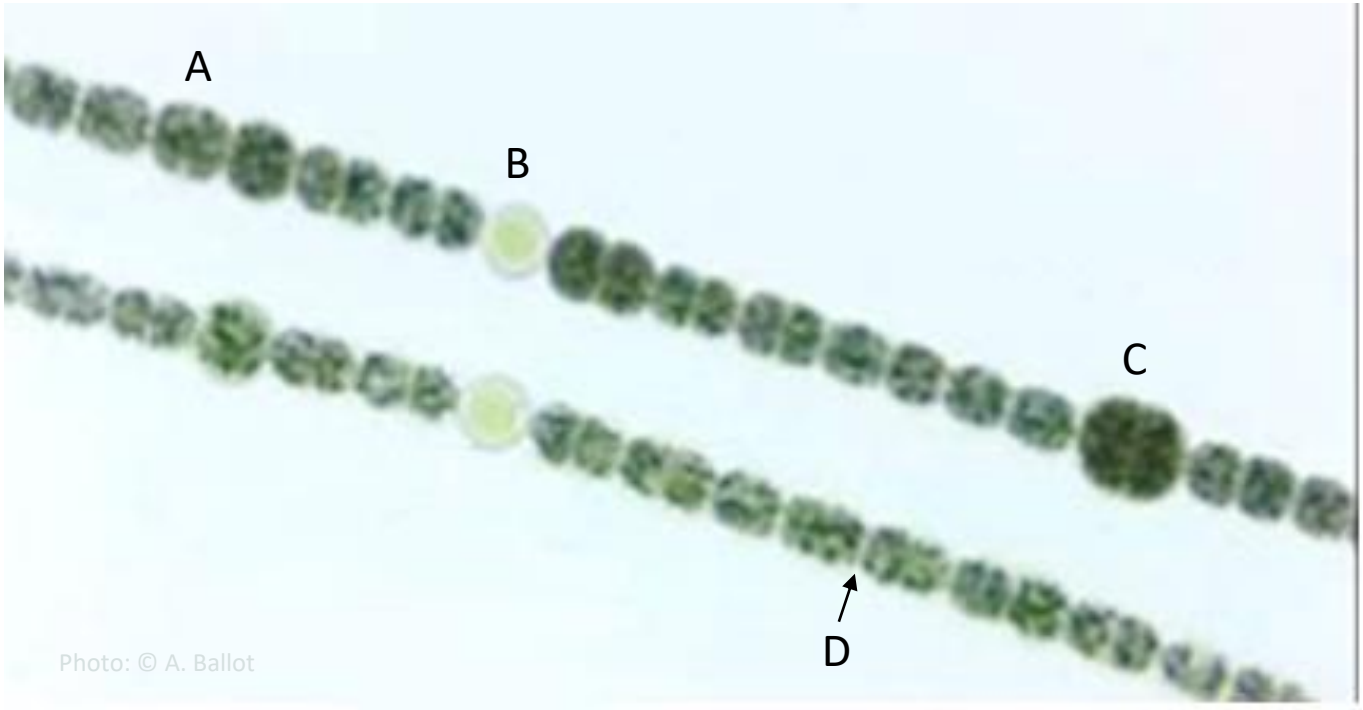
- Filamentous
- Unbranched & untapered
- Trichomes usually solitary
- No sheath*
- Can be straight, curved or spirally coiled



DOLICHOSPERMUM

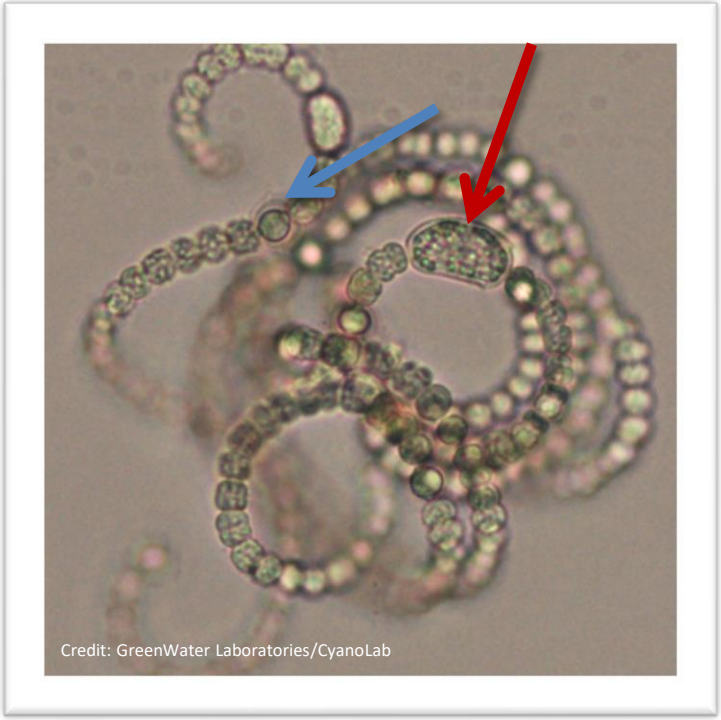
Things to look for:

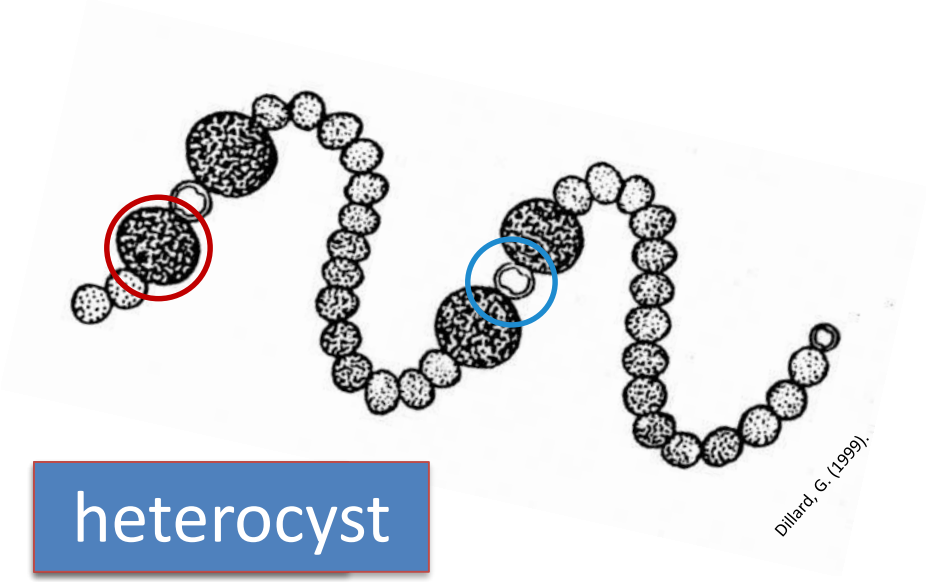
A. Cells rounded or barrel shaped with aerotopes
B. Heterocytes are intercalary
C. Akinetes are intercalary
D. Cells constricted at cross walls



Dolichospermum (Anabaena) spp

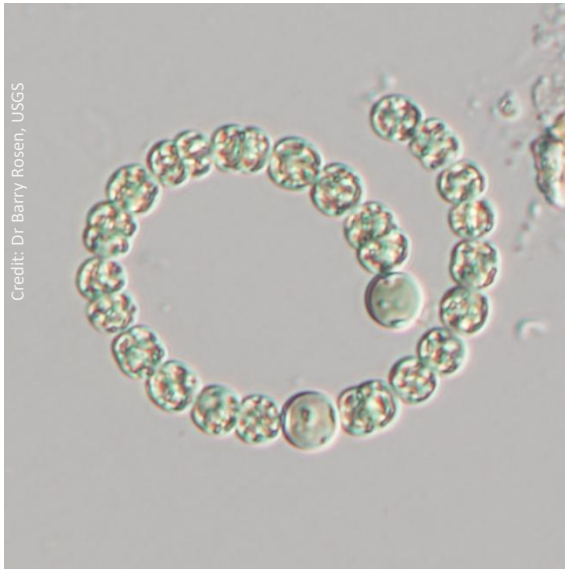
N-Fixer

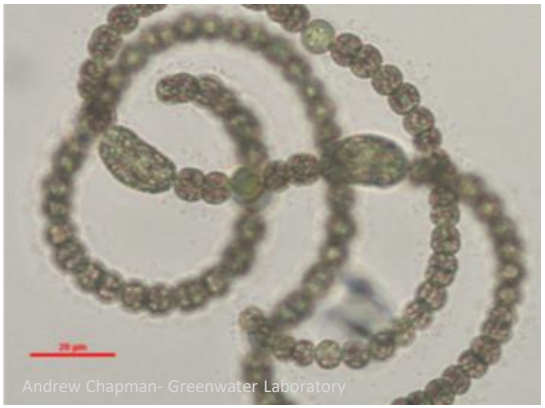




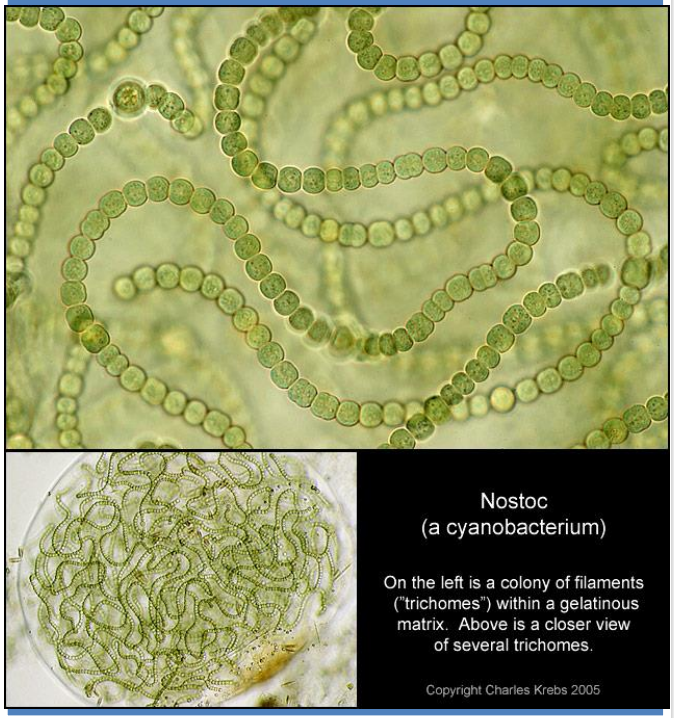
heterocyst

Akinetes known to survive more than 64 years in sediment





Dolichospermum can be confused with Nostoc, but Nostoc trichomes form colonies

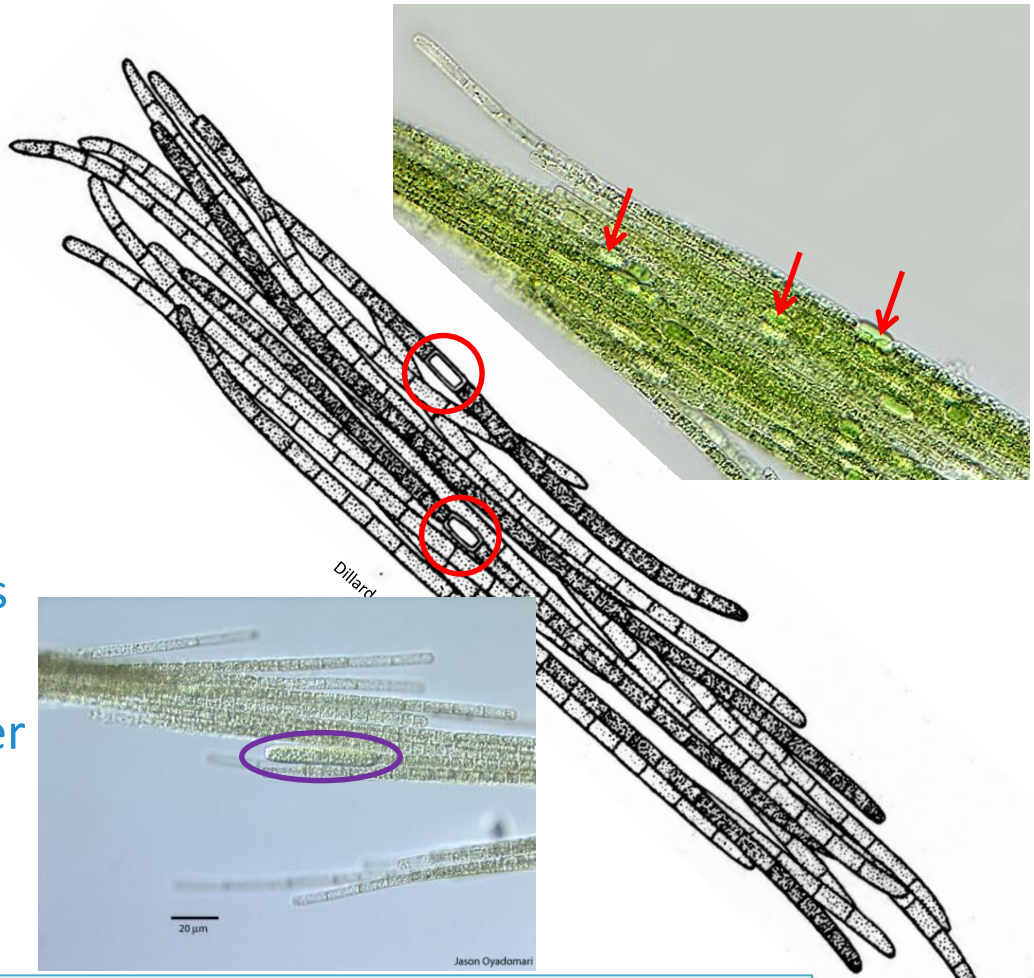


Aphanizomenon spp.

N-Fixer

Approximately 15 known species

- Filamentous, straight, unbranched trichomes
- Tapered at both ends
- No sheath
- Trichomes arranged in parallel layers.
- Has heterocysts and forms akinetes
- Can form winter & summer blooms



Akinetes known to survive more than 18 years in sediment

Aphanizomenon

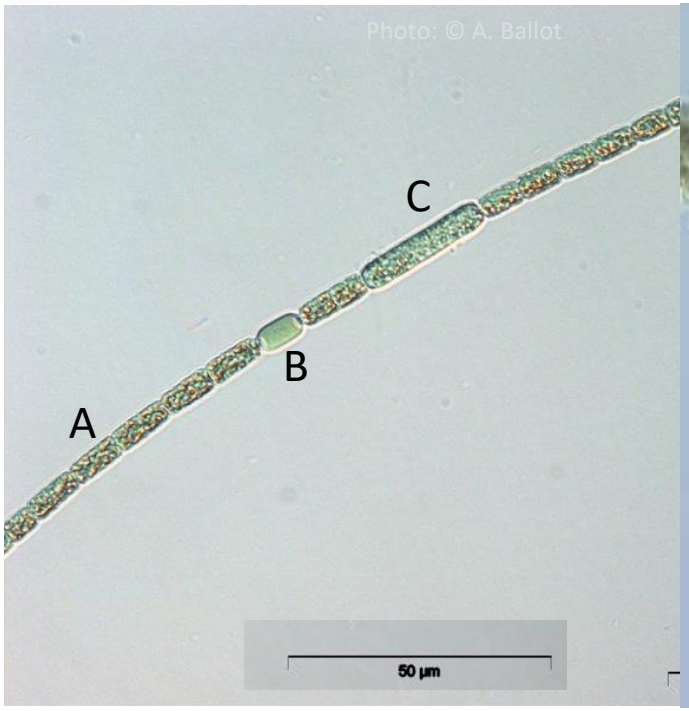
Things to look for:

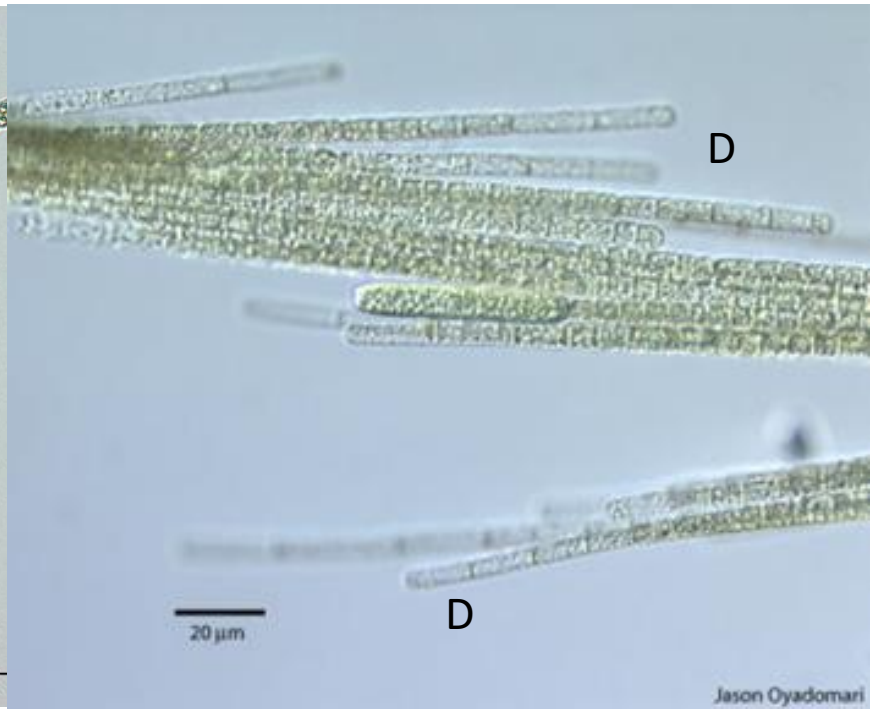
A. Aerotopes (facultative)

B. Heterocytes are intercalary (facultative)

C. Akinetes usually cylindrical and intercalary

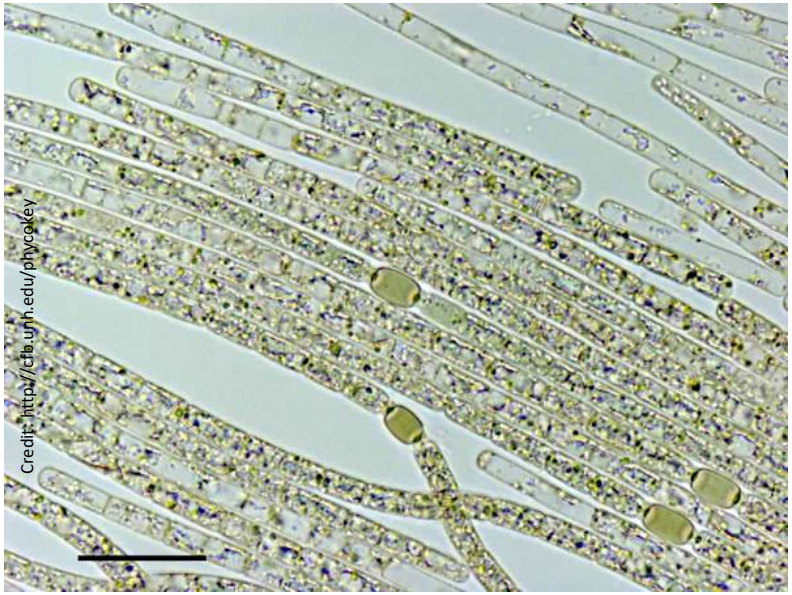
D. Terminal ends are elongated and may be "empty" looking





Aphanizomenon spp

Freshwater Cyanobacteria



Can be confused with :

Anabaena-

Can sometimes be found in bundles but cells are more rounded than *Aphanizomenon*.

Planktothrix-

Can look similar to individual Aphan. trichomes, especially in absence of heterocytes.

Aphanizomenon bloom

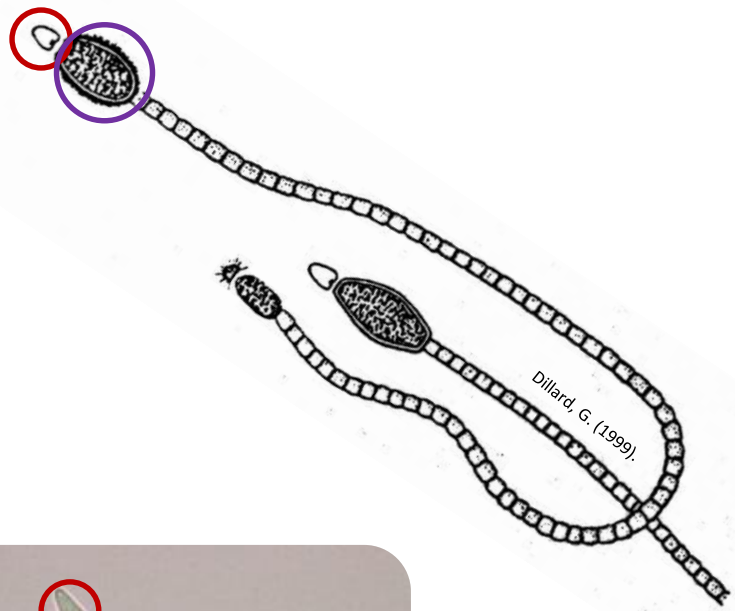
Will be filamentous

Aphanizomenon Flos-Aquae Credit: Klamath Valley Botanicals

Raphidiopsis spp.

N-Fixer

Cylindrospermopsis has now been re-classified as *Raphidiopsis*



- Filamentous, unbranched
- Trichomes are straight, curved or coiled; solitary
- No sheath
- Heterocysts always terminal!
- Akinetes form behind or slightly distant from heterocysts (gives asymmetric appearance)

RAPHIDIOPSIS

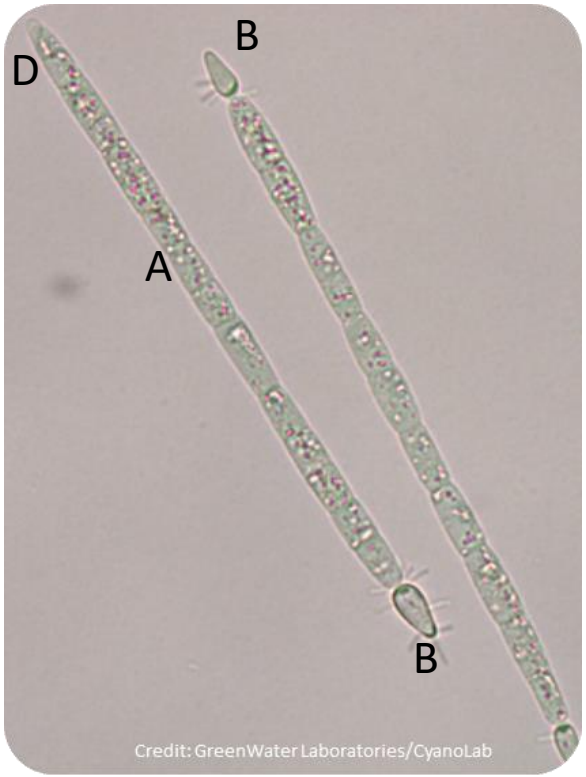
Things to look for:

A. Cells cylindrical with aerotopes

B. Heterocytes (when present) are always terminal at one or both ends

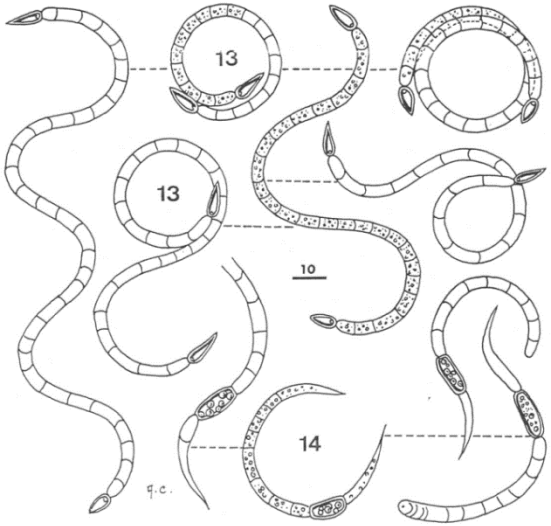
C. Akinetes (when present) usually 1-3 cells back from heterocytes

D. Terminal cells conical or pointy when lacking heterocyte(s).

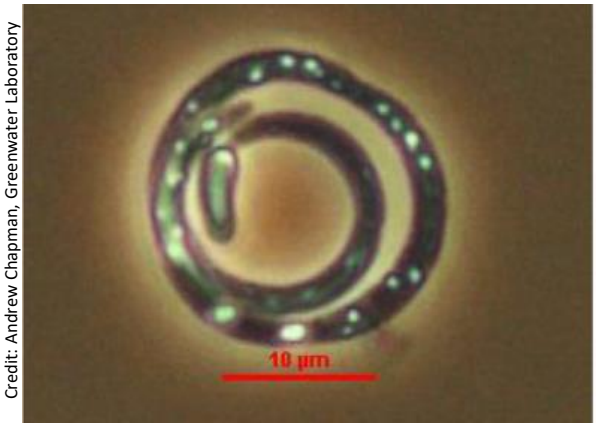


Freshwater Cyanobacteria

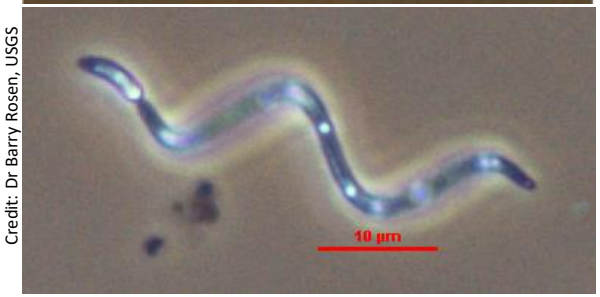
Raphidiopsis spp.



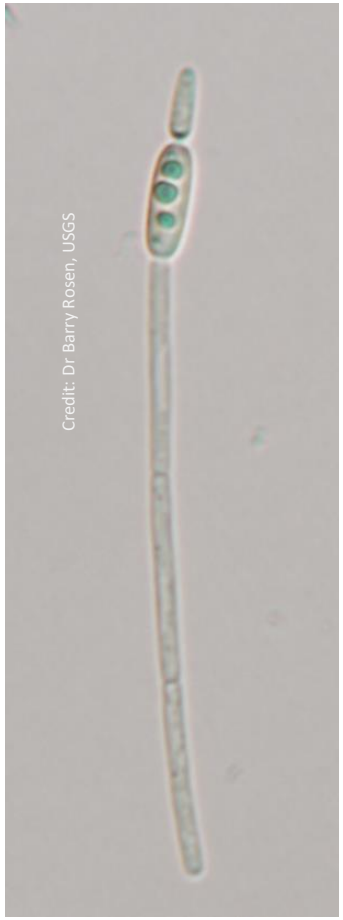
Coute & Bouvy (2004)



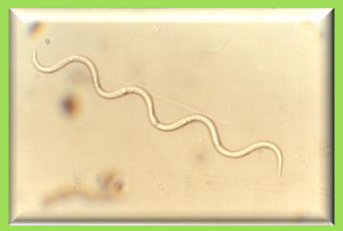
Credit: Andrew Chapman, Greenwater Laboratory



Credit: Dr Barry Rosen, USGS


Credit: Dr Barry Rosen, USGS

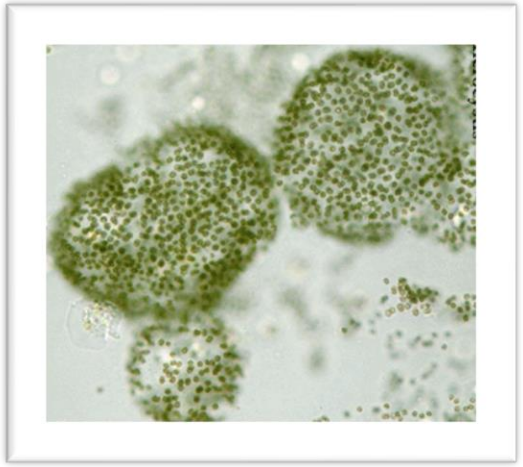
Used to be confused with but now related to:



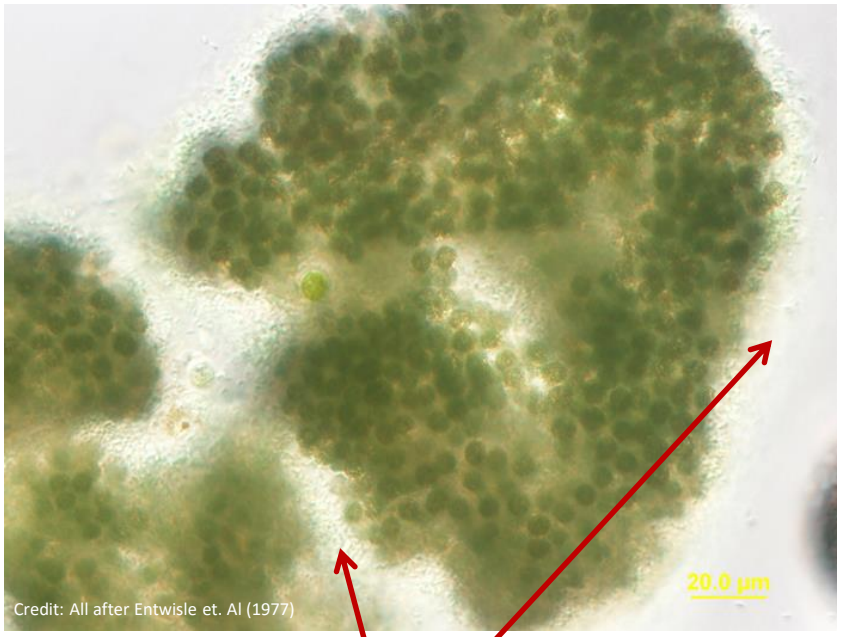
Raphidiopsis curvata- has tapered terminal cells, NO heterocysts, and any akinetes will always be near middle of chain, never at end

Microcystis spp.

Approximately 25 known species



- Colonial
- Unicellular but held together by snotty sheath
- Colonies are irregular, cloud-like (3D) with hollow spaces
- Buoyant due to gas vesicles
- Smells bad!
- Zebra mussels selectively reject Microcystis cells



Microcystis

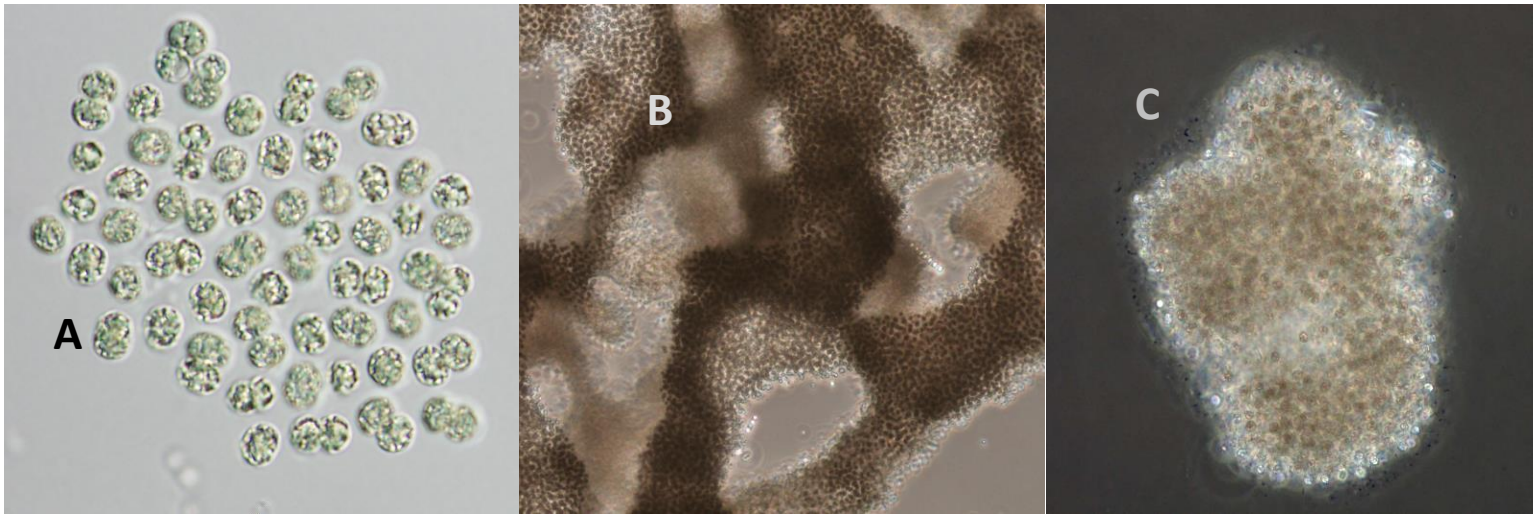
Things to look for:

A. Rounded cells with aerotopes

Cells in colony may be

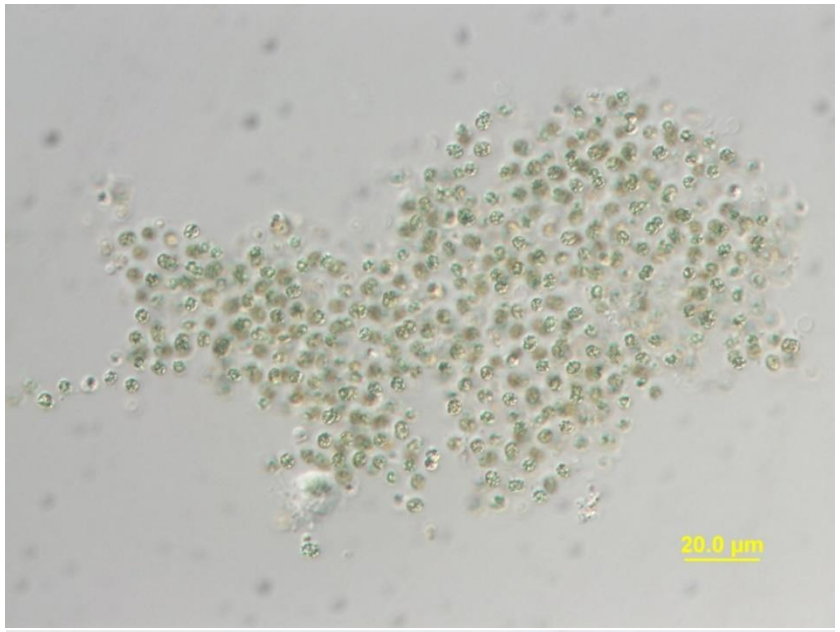
- A. loosely associated
- B. clathrate
- C. densely packed

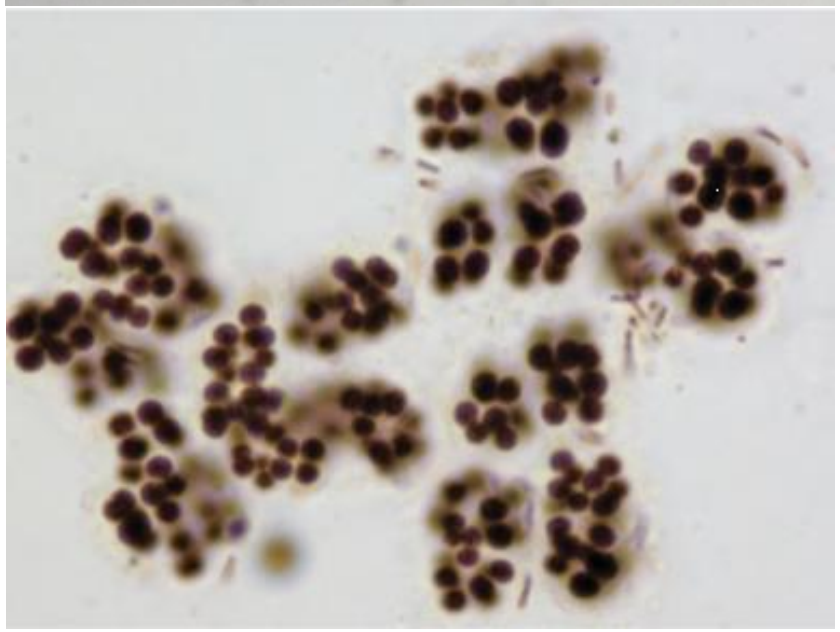
Mucilage can vary in thickness



Microcystis spp.

Freshwater Cyanobacteria





Credit: Dr Barry Rosen, USGS

Can be confused with :

Woronichinia sp.

Image by Jason Oyadomari

Woronichinia makes a hollow ball of cells

Microcystis bloom

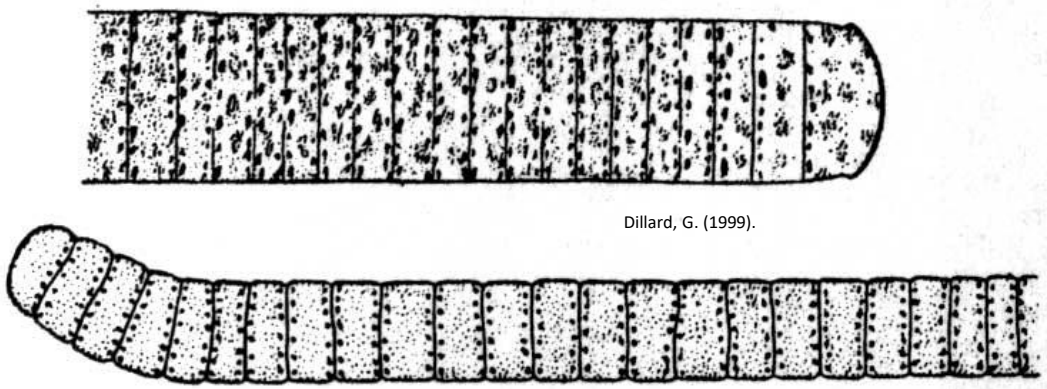
Will NOT be filamentous and will be quite stinky

Planktothrix morphotype

More than 100 known species

Formerly classified as Oscillatoria

- Filamentous, unbranched
- Trichomes cylindrical, straight or slightly wavy
- No sheath
- No heterocysts
- No akinetes
- Motile with gliding oscillations



Dillard, G. (1999).

PLANKTOTHRIX

Things to look for:

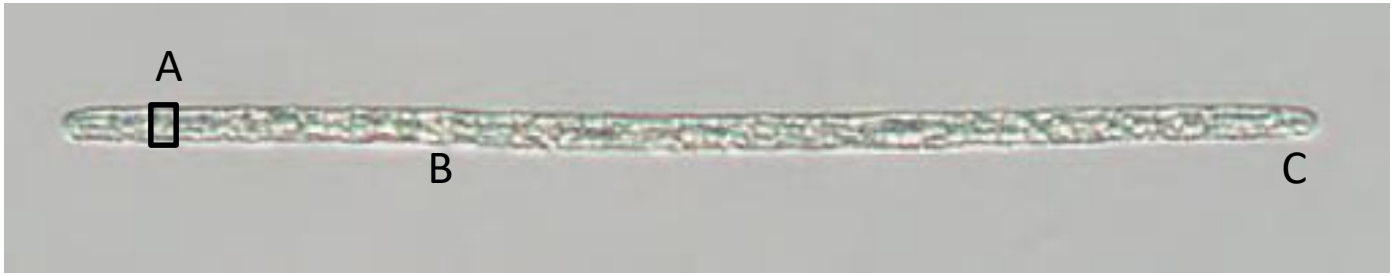
A. Cells cylindrical; mostly wider than long

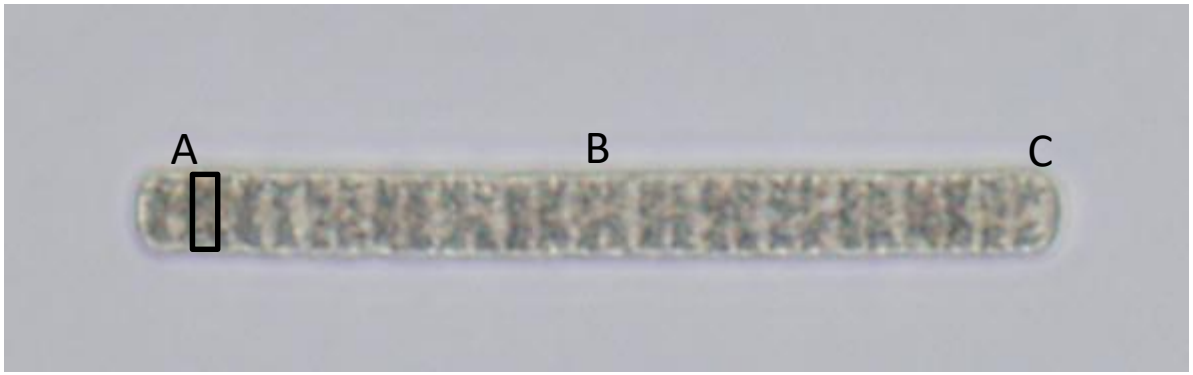
B. LOTS of aerotopes throughout cells

C. Terminal cells rounded

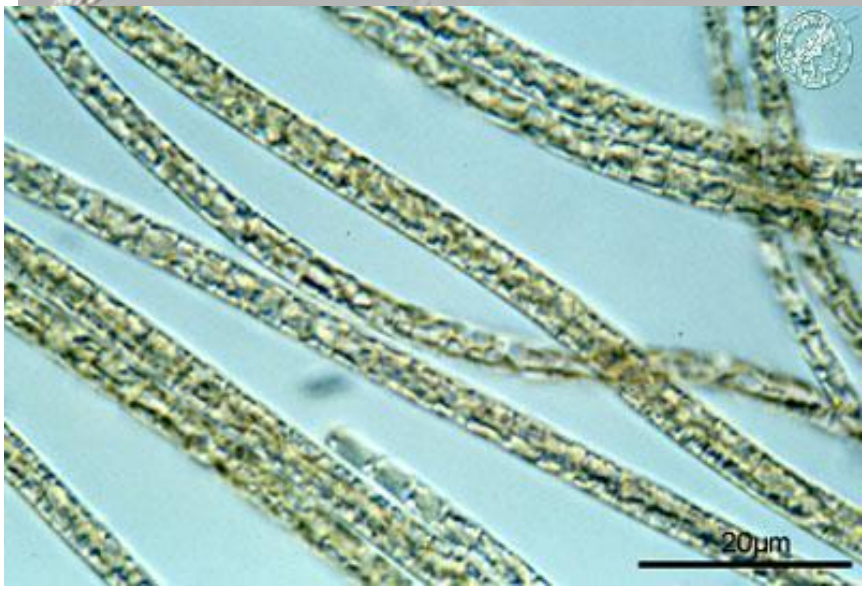
- No heterocytes (not a N_2 fixer)

- No akinetes



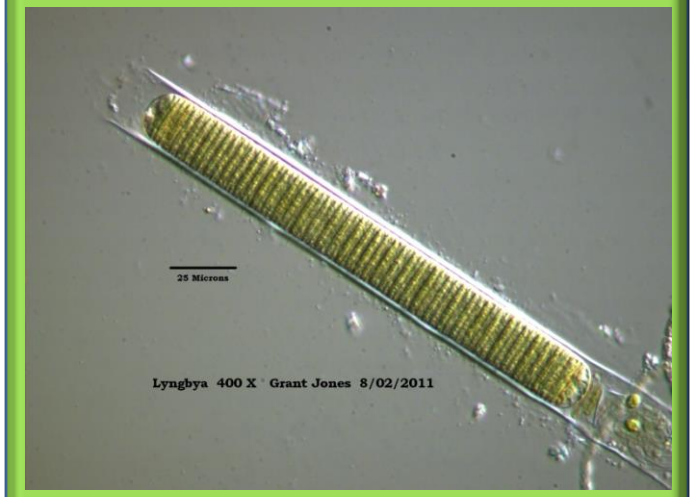


Planktothrix morphotype.



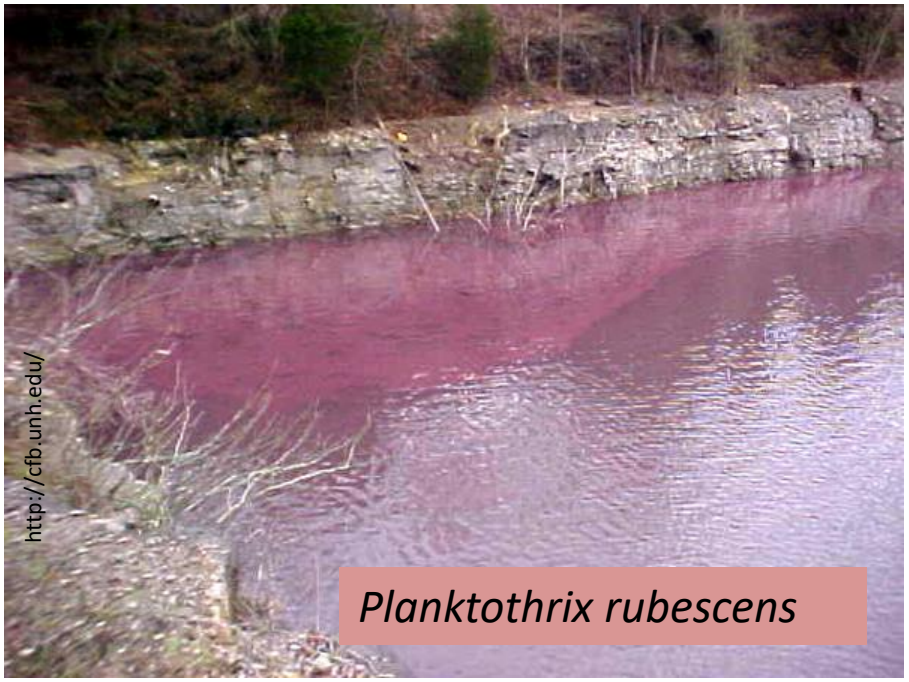
Can be confused with :

Lyngbya-
Has a visible sheath



Planktothrix bloom

Filamentous
Can be red or green depending on species



Planktothrix rubescens

Funding partners

Many thanks to Andrew Chapman at Greenwater Labs for supplying cultures for todays demo

For More Information

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Links:
https://coastalscience.noaa.gov/research/stressor-impacts-mitigation/pmn/- PMN website
http://youtu.be/ItzxoB06De0- Phyto app demo

Identification of Slides

Stations set up for each of the 5 target organisms.

Extra stations have mixed samples to observe and try to ID organisms

Use ID guides by microscopes to try and ID any cyanobacteria present