Harmful Algal Blooms

Sarah Rushforth
Rushforth Phycology
Phycological Research Consortium
sarah@rushforthphycology.com
801 376 3516

What are HABs?

HABs occur when algal colonies increase to the point of causing visible mats that result in harmful effects on aquatic life, people and other mammals or birds.

Why now

- Cyanobacteria have been around for approximately 400 million years. They're not a new phenomena.
- Why only now seeing cyanobacteria blooms?
- Increases in human impact. Higher Nitrogen release from fertilizer, burning fossil fuels. Increase in P from sewage, detergents, etc.
- Increase in frequency/intensity/distribution
- Increase in available nutrients (runoff, wastewater, etc.).
- Global warming: Harmful algae thrive in warm water. Advantage over non-harmful algae

Potential human/animal health impacts

- Response to toxin production:
  - liver /kidney function
  - Neurological symptoms
  - GI symptoms

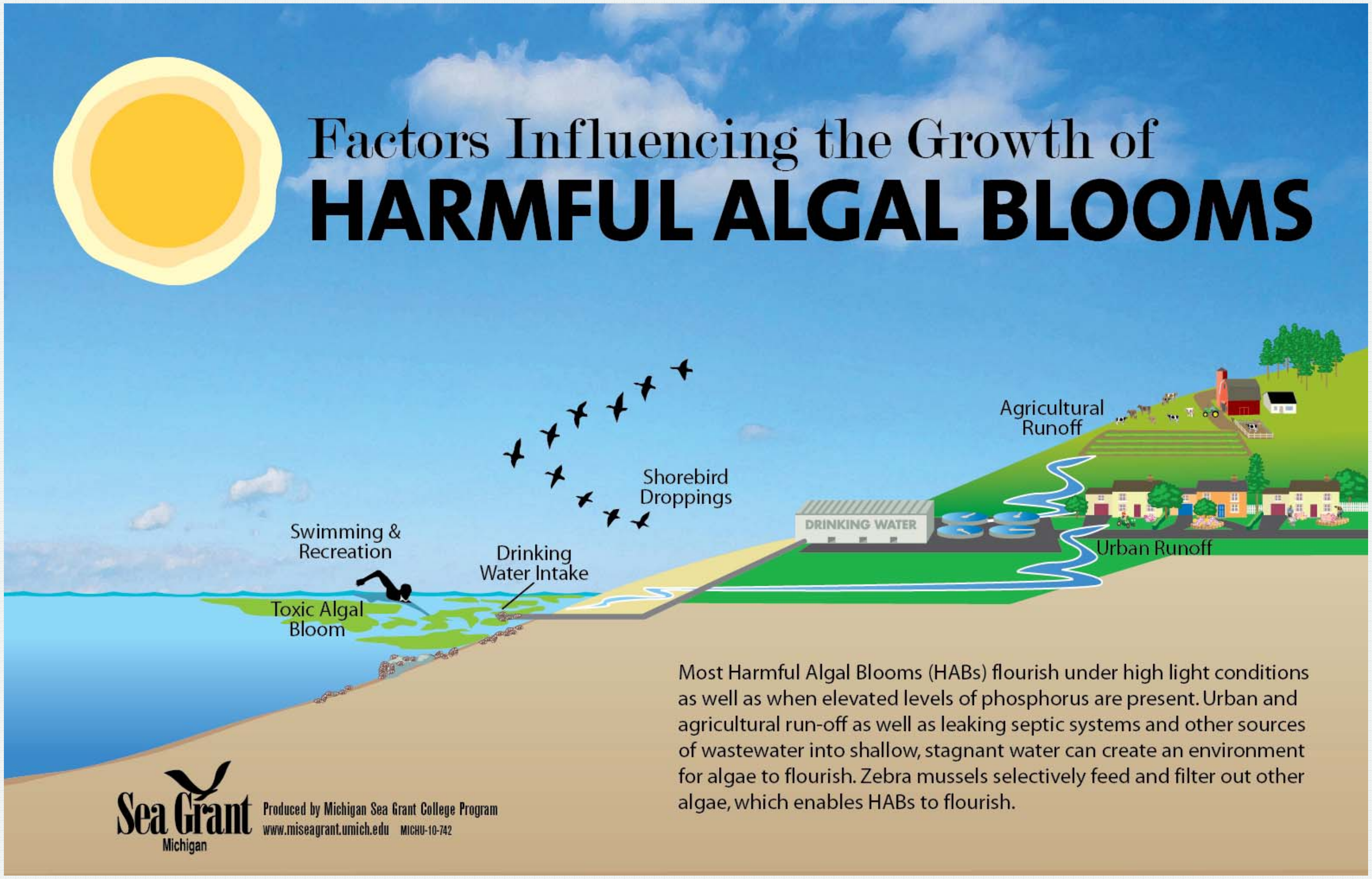
Many unanswered questions about ecology of HABs

Potential ecological impacts

- Anoxic condition
- Light limitation

Assessing bloom composition

- Taxonomy
- Toxicity testing



Why Now?

increase in frequency and intensity is calling attention to algal blooms.

Not a new phenomena.

Population Growth

- Urbanization
- Global warming
- Increased recreational use
- Increased agricultural production
- Increased burning of fossil fuel

Ecological Traits of HABs:
Unanswered Questions Critical for Management

- How might the definition of a bloom vary according to differences in **space** e.g., near shore mat vs. expansive surface film?
- How do we adjust sampling protocols to account for the **volume** of a bloom throughout the water column vs. a surface bloom?
- What drivers determine the **longevity** of a bloom? Is the **composition** of a bloom maintained throughout or does dominance shirt? What drives changes in composition?
- What are the drivers of **diversity** within a blooms? We often think of blooms as monospecific, but more frequently, they are not.
- What factors determine the **abundance** of different taxa that can co-exist under "bloom conditions?"
- How often does bloom **dominance** change between groups?
- What conditions determine composition similarity in blooms across time?
- Does diversity within a bloom **fluctuate** between cyanobacteria dominance vs. diatom vs. dinoflagellate vs. green algae blooms?
- Do toxins have inhibitive or facilitative **interactions**?

Identifying HABs:
Things to keep in mind:

1. *Not all algal blooms are cyanobacteria*

2. *Cyanobacteria blooms are not always harmful*

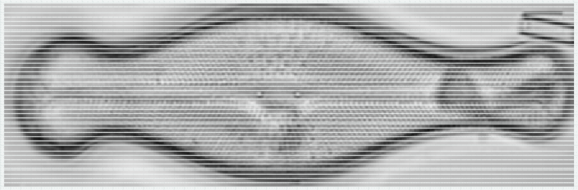
3. *Initial sampling is a screening*

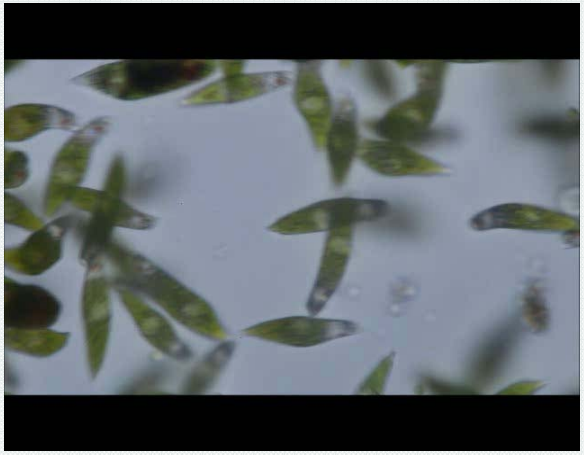
Algal Masses

Spyrogyra sp.

Didymosphenia stalk

Euglena sp



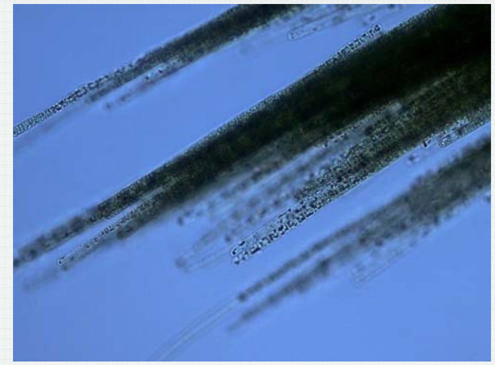


Images: USGS, Sarah Rushforth, Sarah Spaulding

Identifying Harmful Algal Blooms (HABs)

Utah Lake, October 8, 2014

Dolichospermum spiroides



Aphanizomenon flos-aquae

Cyanobacteria (Blue-Green) Bloom

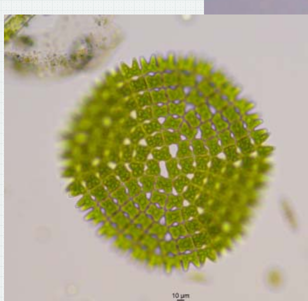
HAB

Chlorophyta (Green Algae)

Very little cyanobacteria present

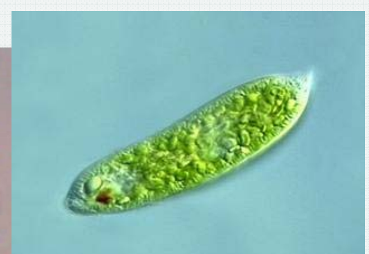
Not HAB

Diatom assemblage



Pediastrum duplex

Oocystis species

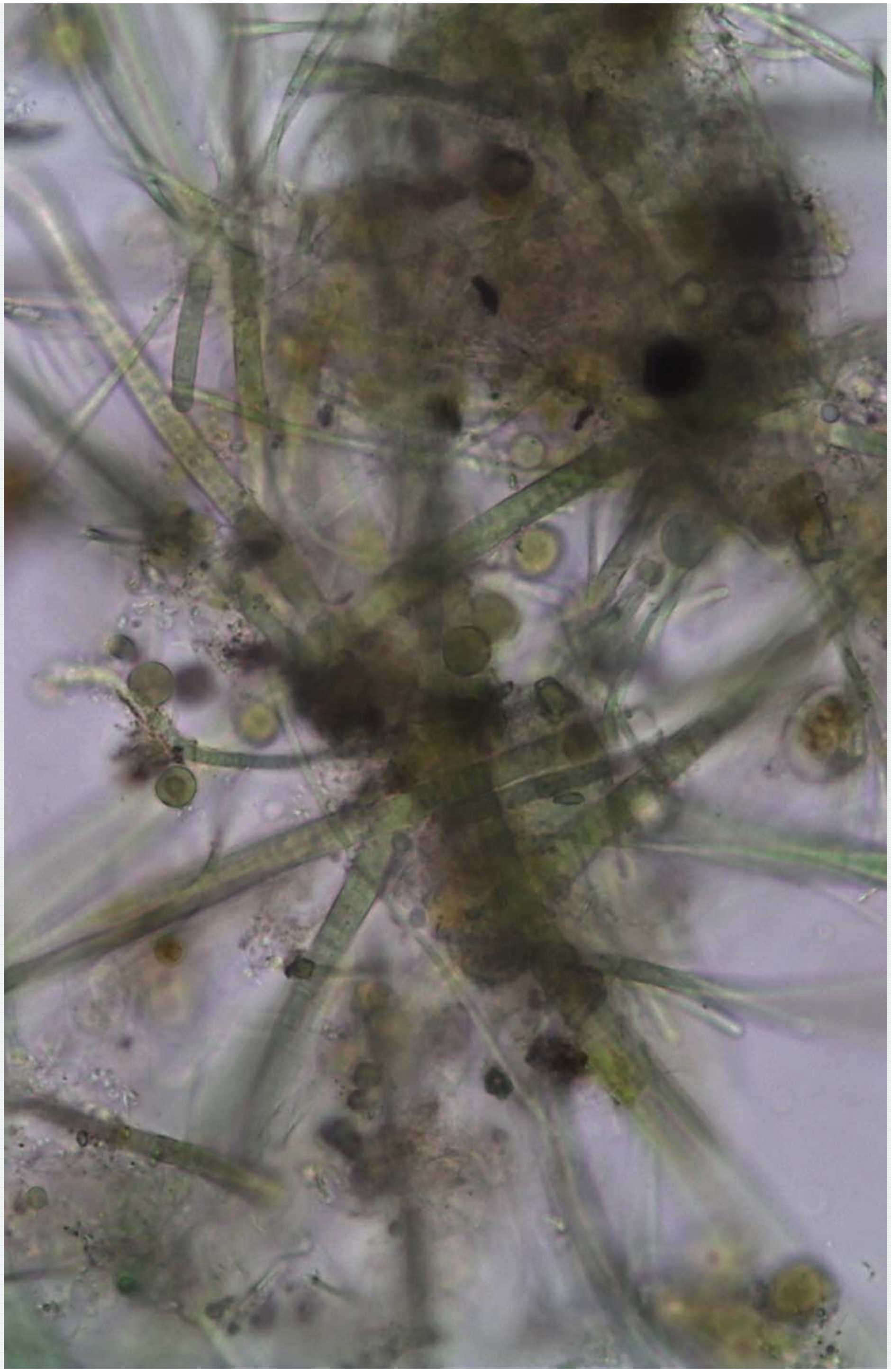


Euglena sp

Utah Lake, August 25, 2015

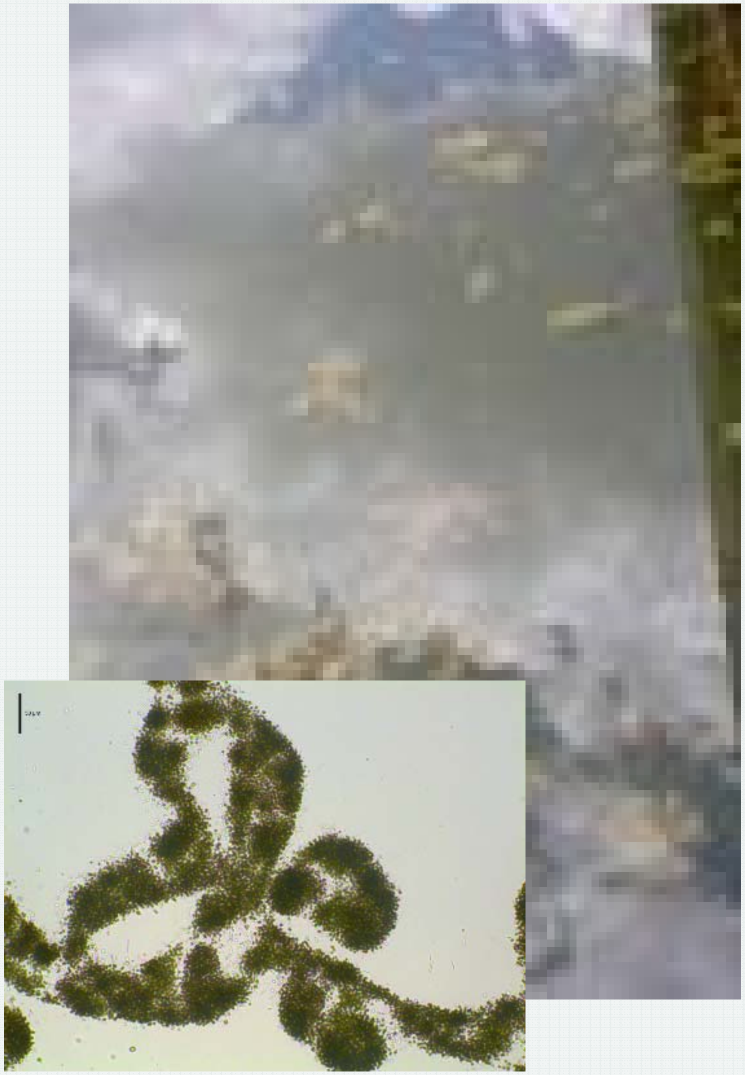
Cyanobacteria

Identification and Enumeration:



Taxonomic Analysis of HABs

1. Taxonomic analysis of a possible HAB starts with **presence/absence of cyanobacteria**
2. HAB confirmation
3. If bloom is an HAB, extent and level of taxonomy needed is determined case by case
4. Early observation of high cell density of a potentially toxic taxa may result in **an immediate recommendation for toxicity testing**
5. Taxonomic identification and enumeration continues and narrows as needed



Microcystis Aeruginosa, bloom and individual colony

Images: Sarah Rushforth

The Taxonomy of HABs

1. Confirmation of cyanobacteria
   (presence/absence)

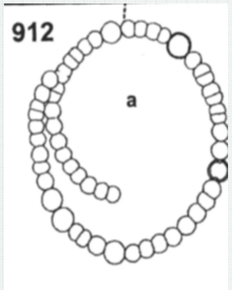
2. Qualitative
   (relative abundance)
   1. to category
   2. to genus
   3. to species

3. Quantitative
   (enumeration)
   1. of categories
   2. of genera
   3. of species

Along with guidelines for toxicity levels, cells per mL can help determine the course of action taken in response to a bloom event.

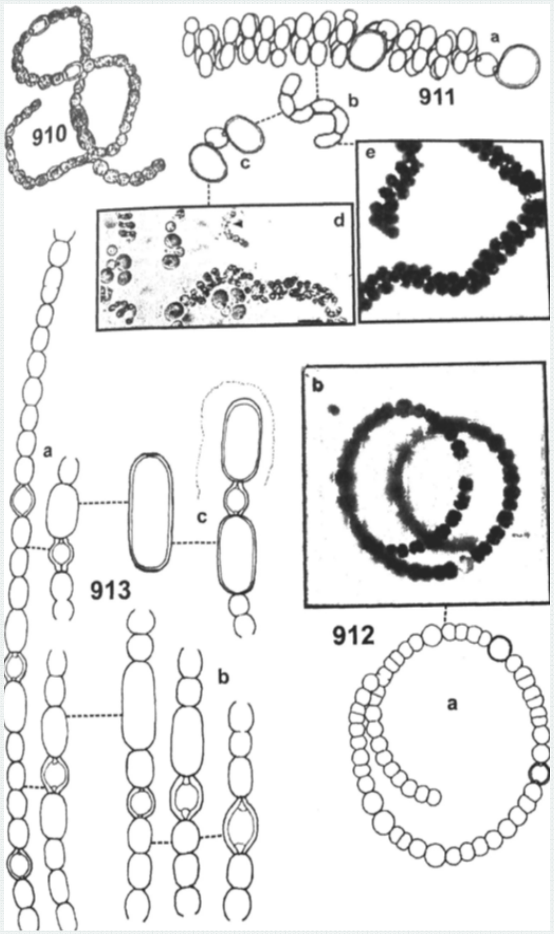
WHO's HAB guidelines include c/mL and states are developing guidelines that follow that criteria.

May save time and money without loss of data if enumeration is conducted to natural counting units p/mL



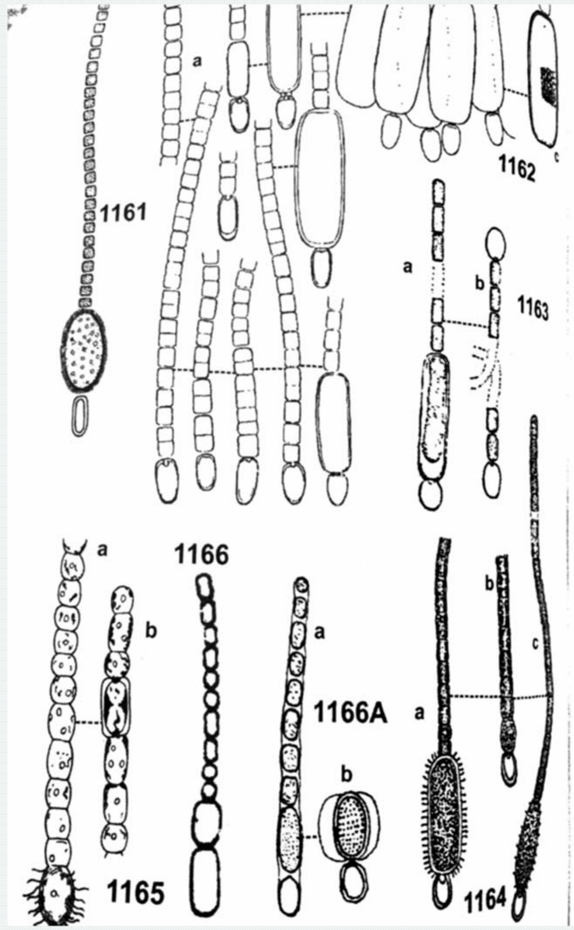
Taxonomy of the Cyanobacteria:

Anabaena



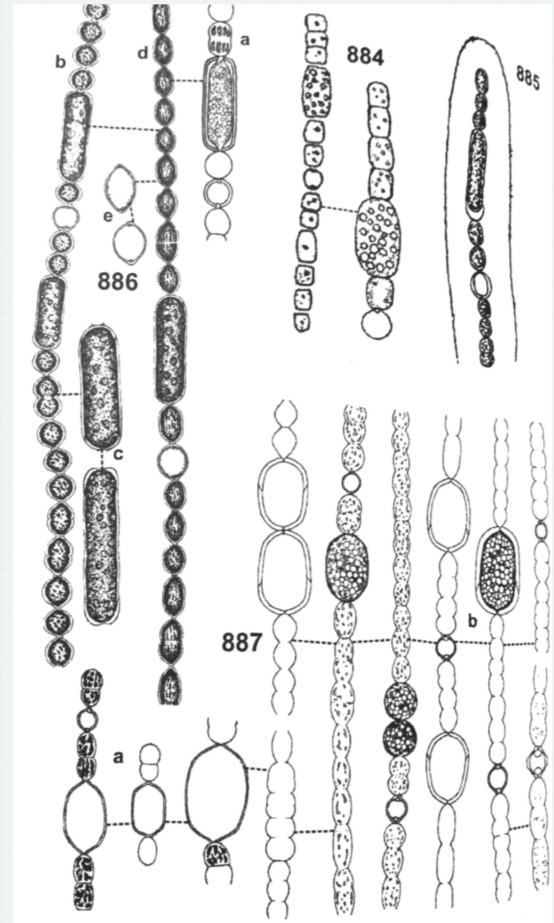
Pictured here:
4 species

Cylindrospermopsum



Pictured here:
7 species

Dolichospermum



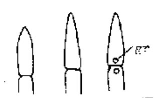
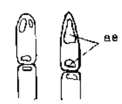
Pictured here:
4 species

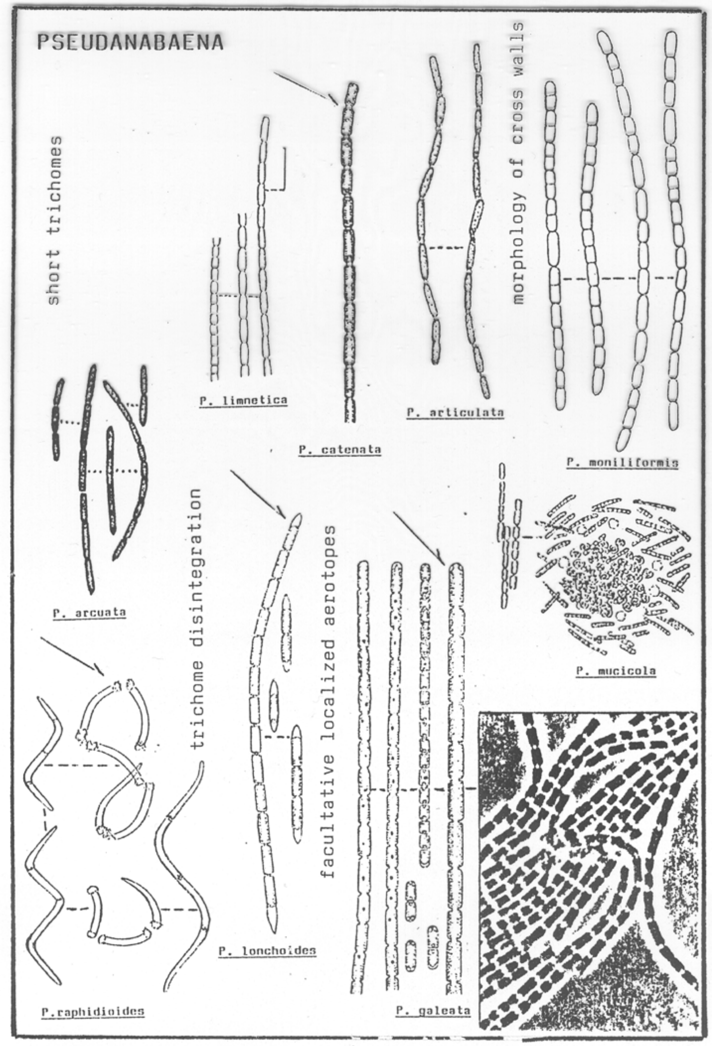
Resistant cyanobacteria from hot spring approximately 105 degrees.
At least 12 genera in this image.

Images: Sarah Rushforth, Mindy Morales, and Kalina Monolov

Common Cyanobacteria Taxa Found in HABs

Pseudanabaena

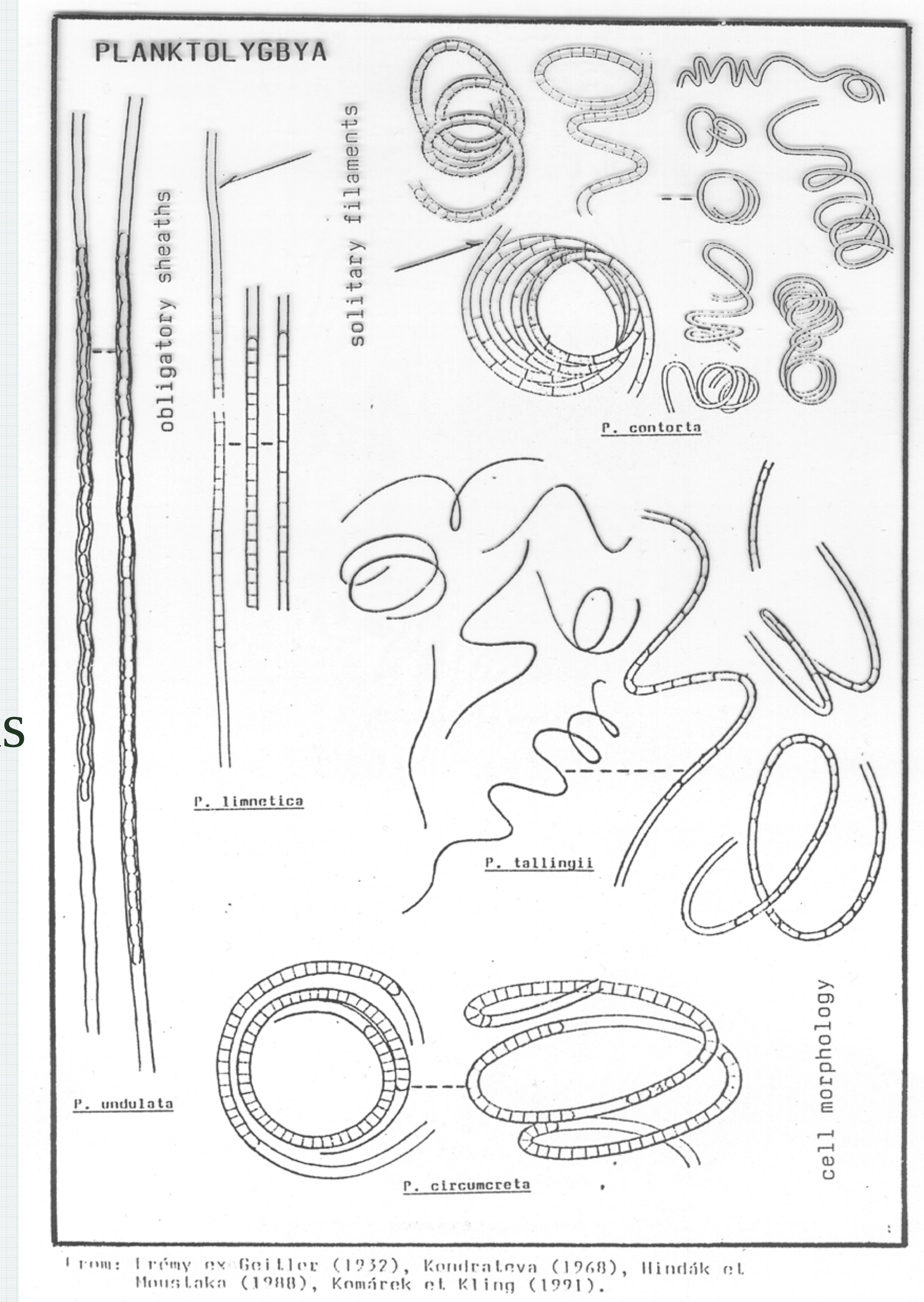
Subgenus	*Pseudanabaena*	*Skujanema*	*Ilyonema*
Cell form	± cylindrical	± cylindrical	± cylindrical
Terminal aerotopes	— or (+)	— or (+)	+
Width of trichomes	0.8—2.5 μm	— 2 μm	— 3 μm
Apical cell			
Type species	*P. catenata* LAUTERB. 1915	*P. arcuata* (SKUJA) c. n.	*P. biceps* BÖCHER 1946
Species	*P. articulata* SKUJA 1948 *P. limnetica* (LEMM.) KOM. 1974 *P. tenuis* KOPPE 1924	*P. acicularis* (NYG.) c. n. *P. franquettii* (BOURR.) BOURR. 1970 *P. mucicola* (NAUM. et HUB.-PEST.) BOURR. 1970 *P. nematodes* (SKUJA) c. n. *P. raphidioides* (GEITL.) c. n.	*P. batrachospermorum* (SKUJA) c. n. *P. galeata* BÖCHER 1949 *P. lonchoides* ANAGN. 1961 *P. papillaterminata* (KISEL.) KUKK 1959 *P. skujae* CLAUS 1962

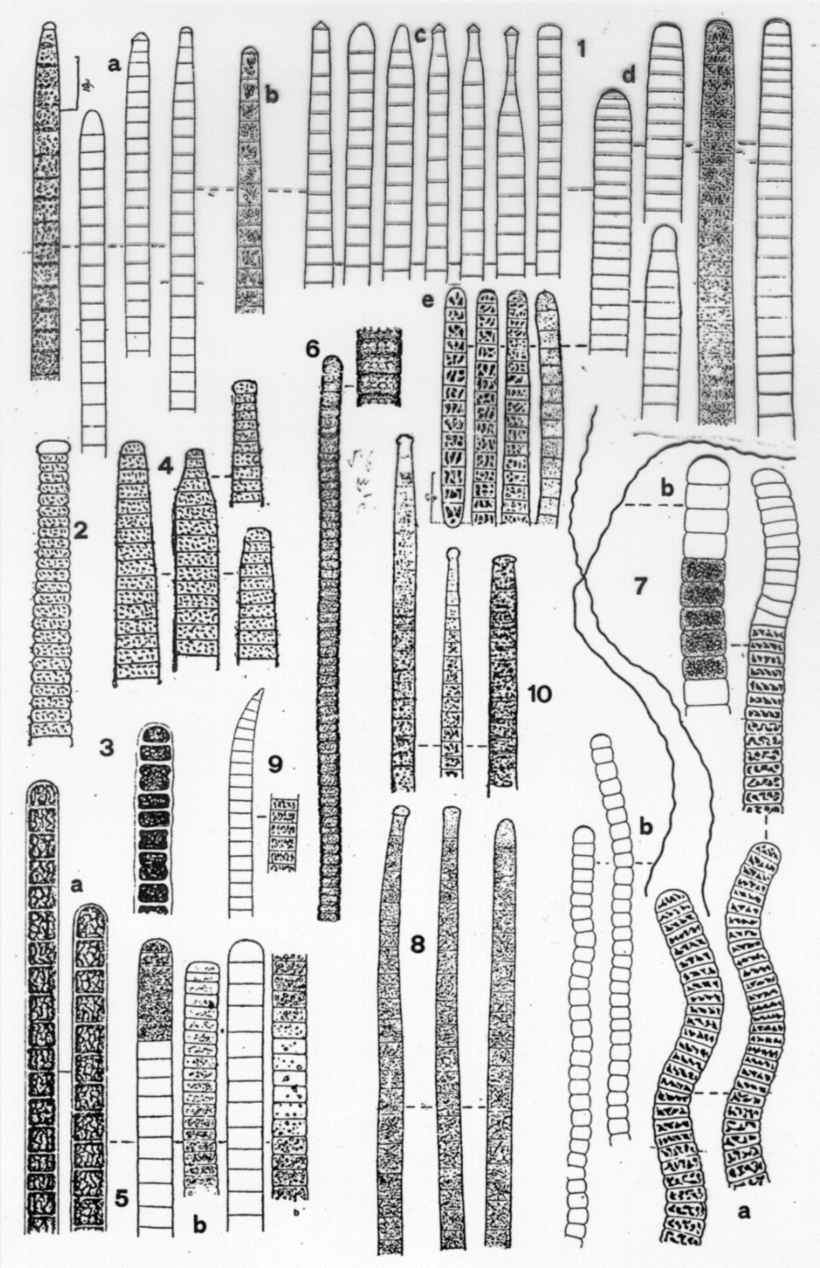


From: Skuja (1948), Skuja ex Geitler (1932) and Starmach (1966), Huber-Pestalozzi (1938), Komárek (1958), Geitler (1959), Anagnostidis (1961), Komárek et Kling (1991).

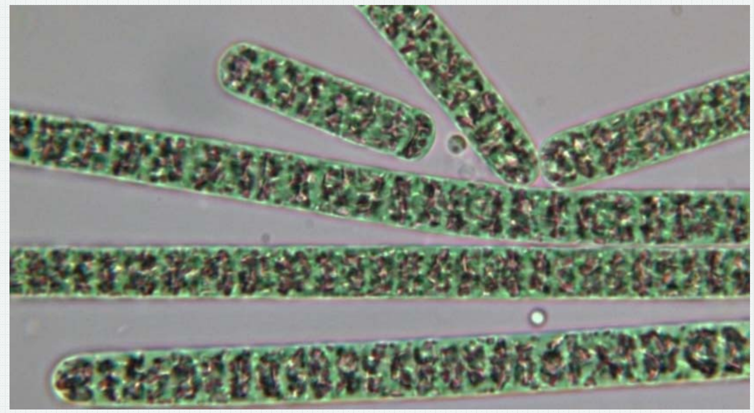
Planktolyngbya

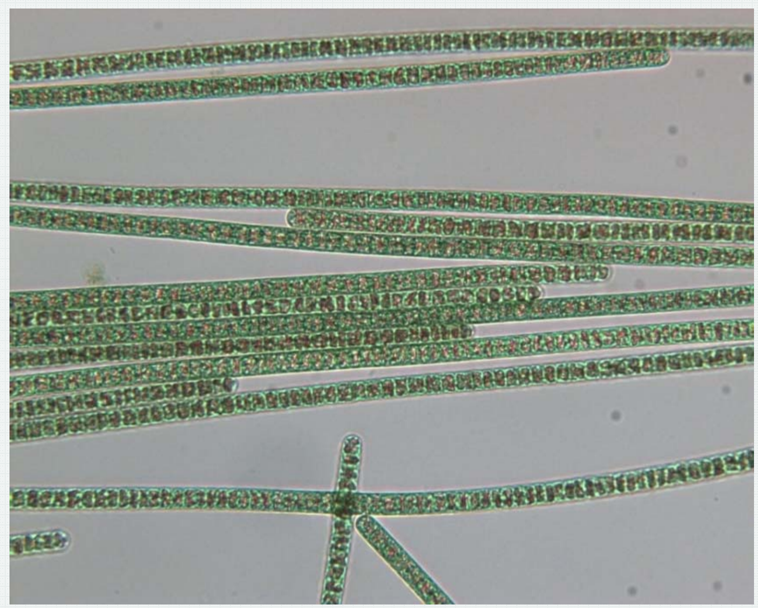
- Solitary trichomes (planktic)
- Max. width 2.8 um
- Presents of obligatory sheaths





Planktothrix



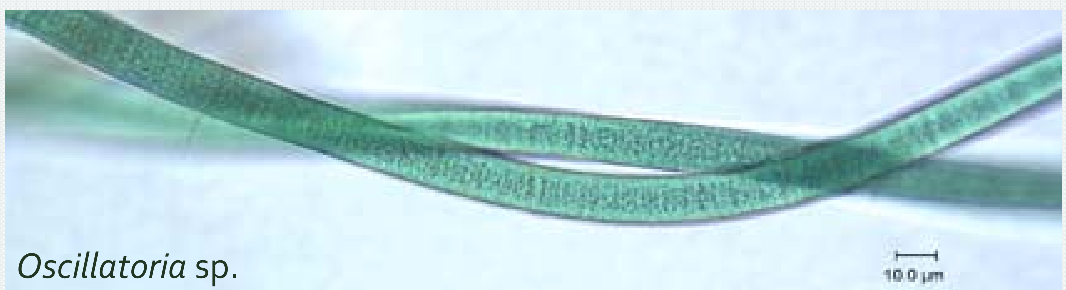


oscillatorialean characters:

1. Filamentous.
2. Absence of heterocytes and akinetes.

Phormidium sp

Psuedanabaena sp



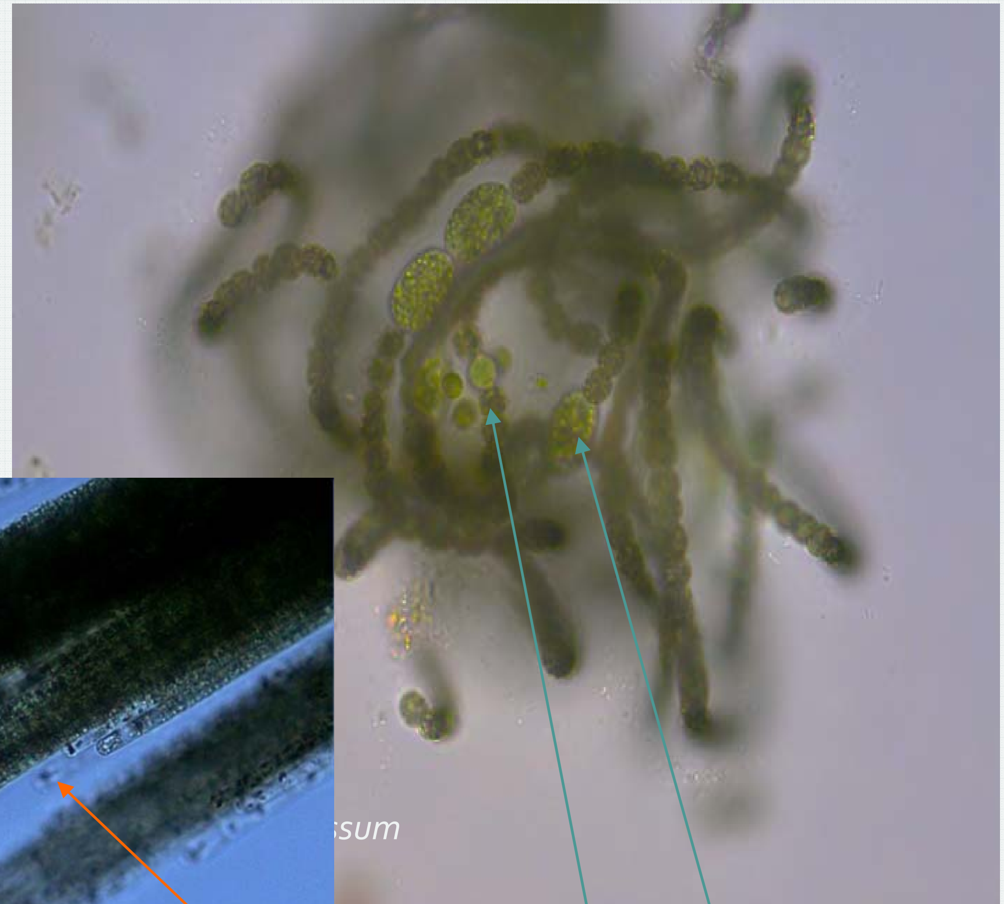
Oscillatoria sp.

Images: Sarah Rushforth, Mindy Morales, and Kalina Monolov

Nostocaceae (filamentous, with heterocyte and akinete)

Anabaena–coiled or straight trichrome, usually solitary, with aero topes
Cylindrospermum–cylindrical trichomes in benthic mats, epiphytic, akinetes always adjacent to terminal heterocytes
Cylindrospermopsis–trichomes planktonic or solitary, akinetes near or next to the heterocytes, attenuated in both ends
Aphanizomenon–trichomes asymmetric, narrowed terminal cells, akinetes intercalary, some form fascicles
Nostoc–trichomes within distinct colonies
Nodularia–cells shorter than wide, planktonic with aerotopes, benthic in mats
Anabaenopsis–planktonic, heterocytes appear terminal

Dolichospermum circinale



Aphanizomenon flos-aquae

Heterocyte

Akinete

Aerotope

Heterocytous characteristics

Dolichospermum circinales

Dolichospermum crassum

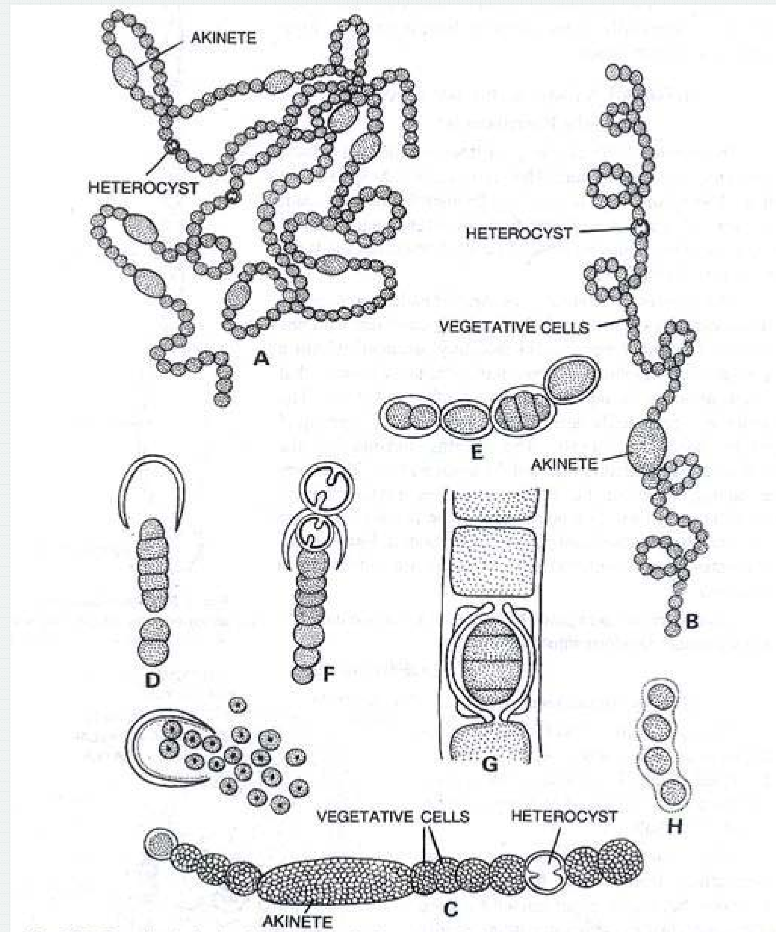
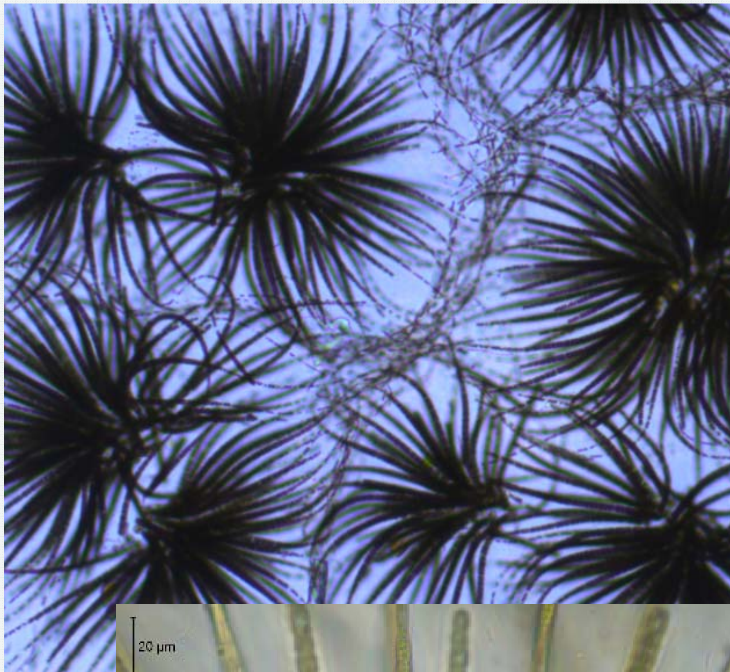
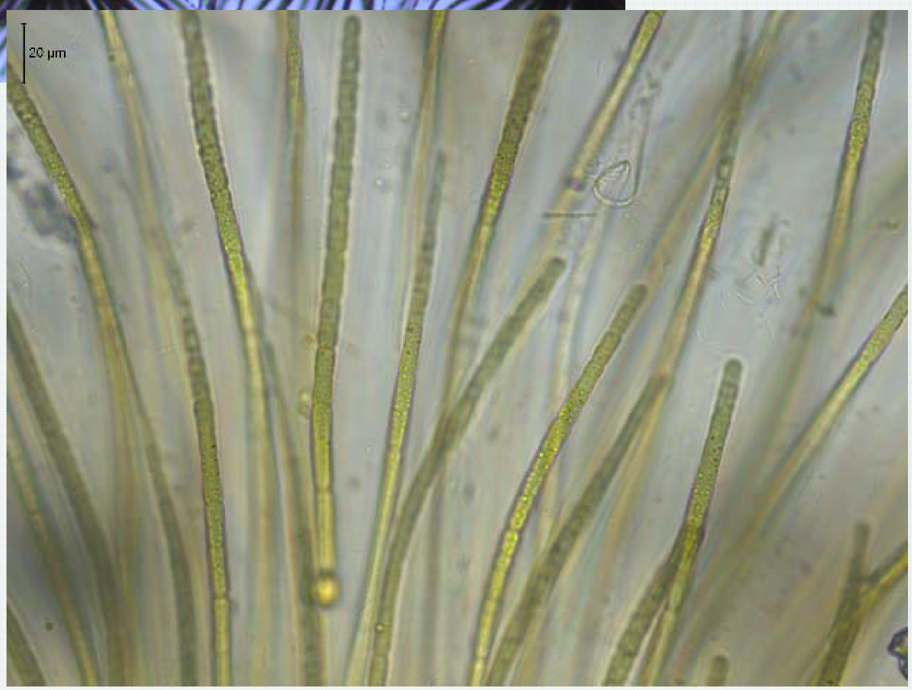


Fig. 2.49. Cyanobacteria. *Anabaena* sp. A, *Anabaena circinalis*; B, *Anabaena spiroides*; C, *Anabaena circinalis* var. *macrospora*; D, germination of akinete in *A. sphaerica*; E-G, germination of heterocyst in *A. hallensis*; H-I, germination of heterocyst in *A. cycadae*.





Gloeotrichia

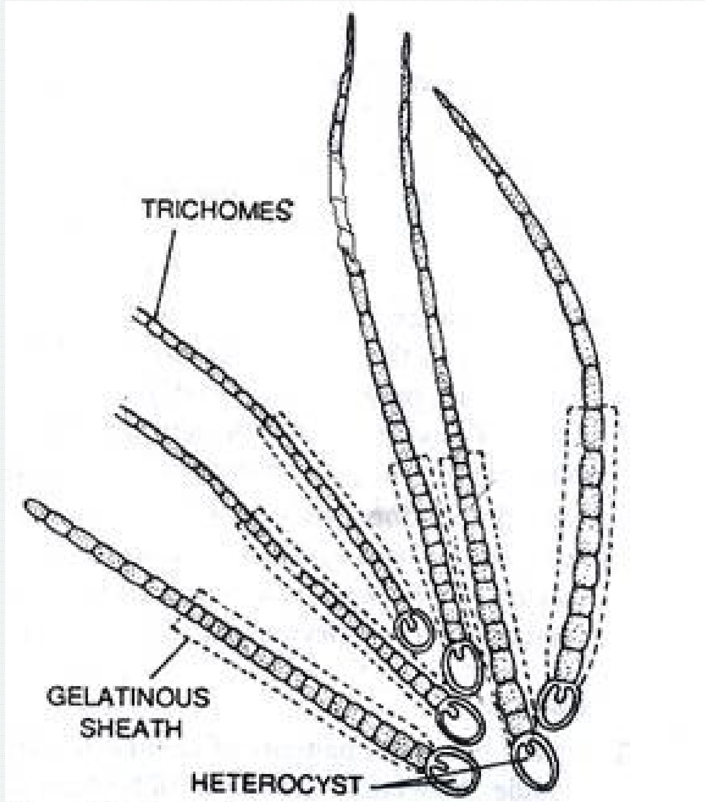


Fig. 2.53. Cyanobacteria. *Gloeotrichia echinulata*. Portion of a sterile colony.

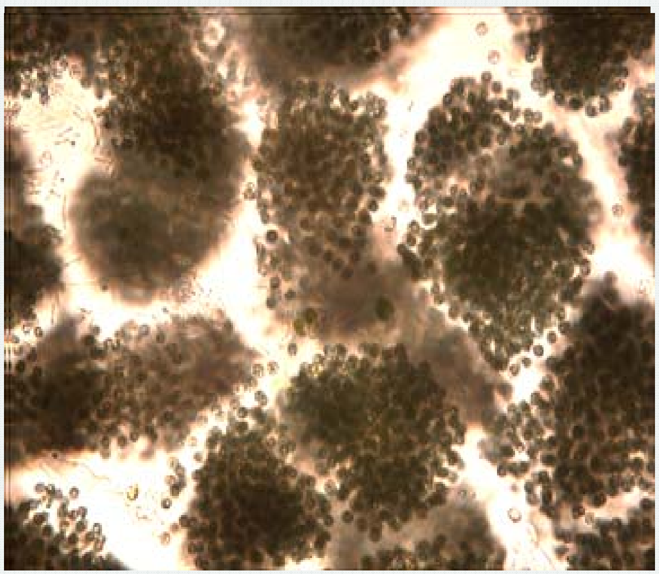
Woronchinia sp.

Woronchinia sp.

Snowella sp.

Microcystis aerugenosa

Aphanothece sp.



Microcystis aerugenosa

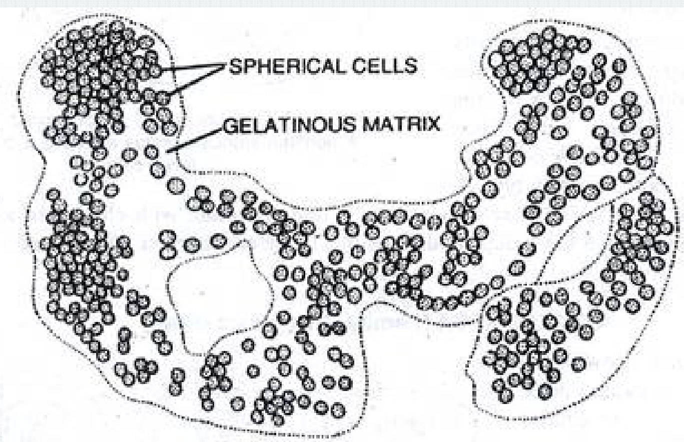


Fig. 2.39. Cyanobacteria *Microcystis.* A colony containing hundreds of cells.

Family-Oscillatorianceae

Chroocococcales
Colonial