



LAKE LIFE UNDER THE MICROSCOPE

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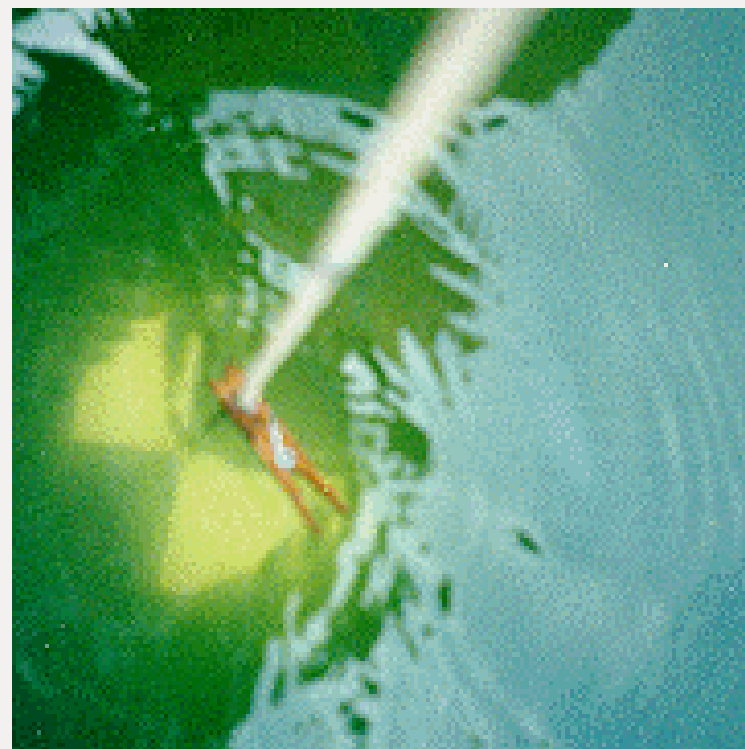


NH
~ 1000
lakes and ponds

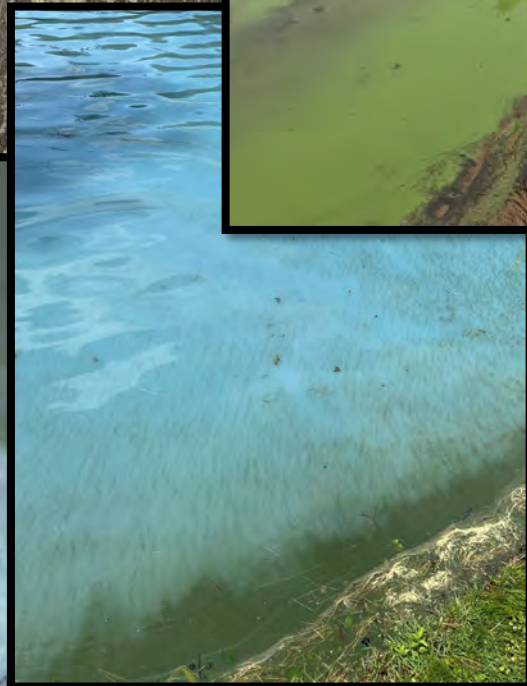


LAKE OR POND?

- A lake is defined as a water body that is not directly connected to a sea or ocean & surrounded by land.
- “Lake” sometimes defined as the area of at least 10 hectares/25 acres or 0.1 square kilometers (120,000 square yards) in size.
- Problem of nomenclature? Definition differs by region.



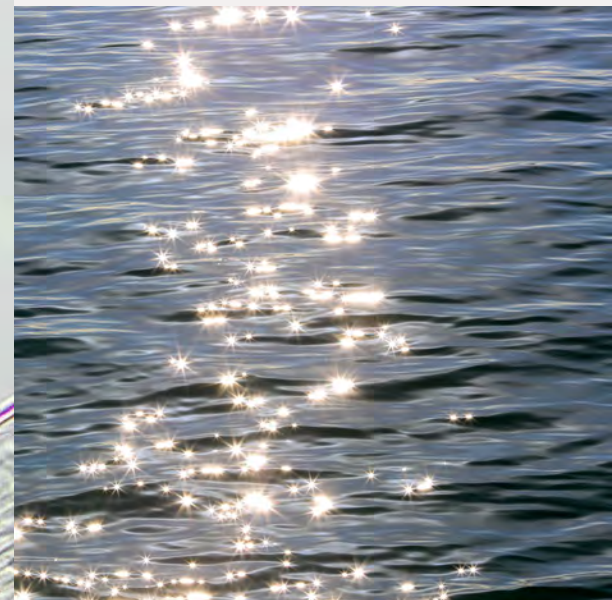
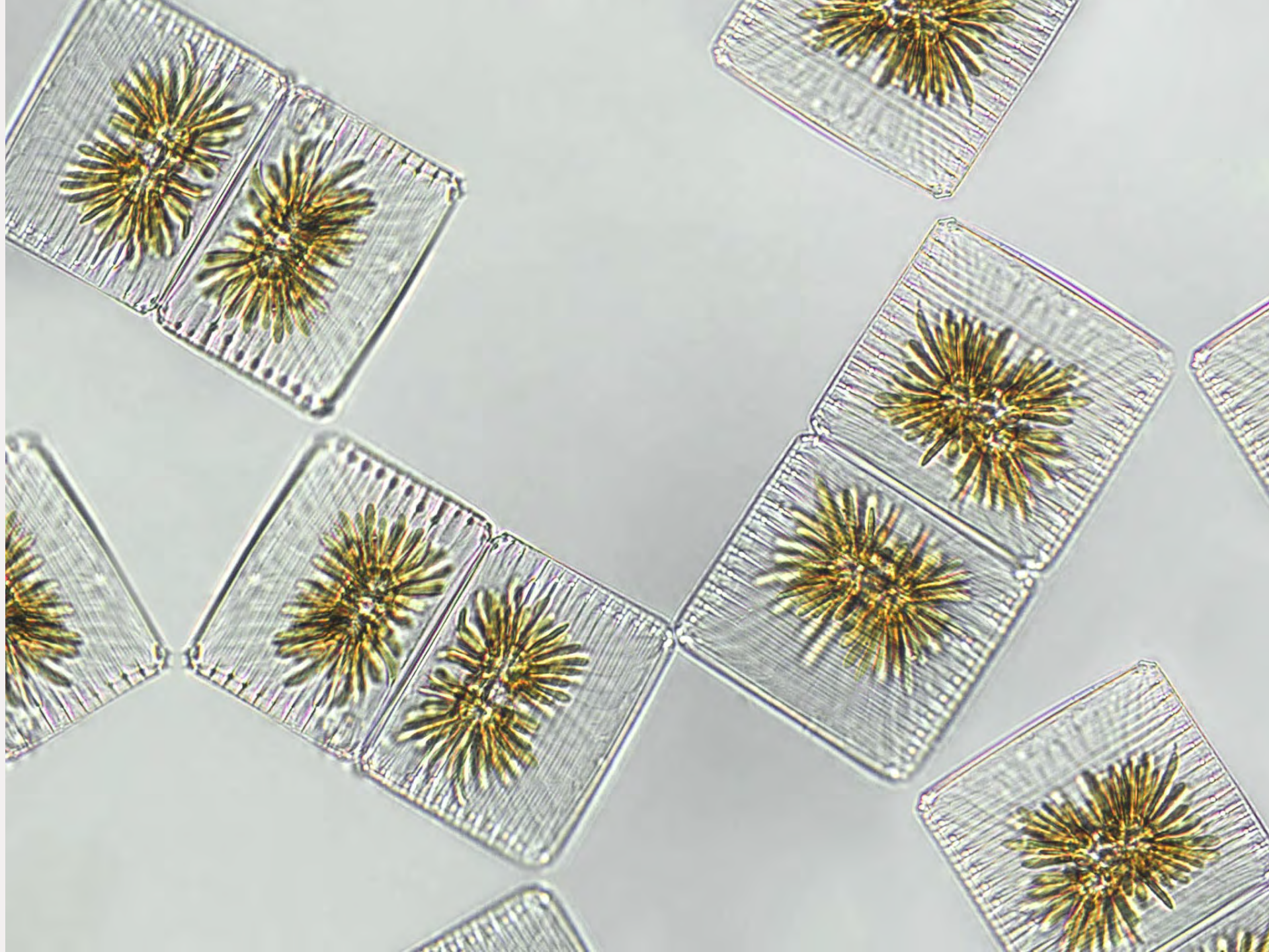




Blooms

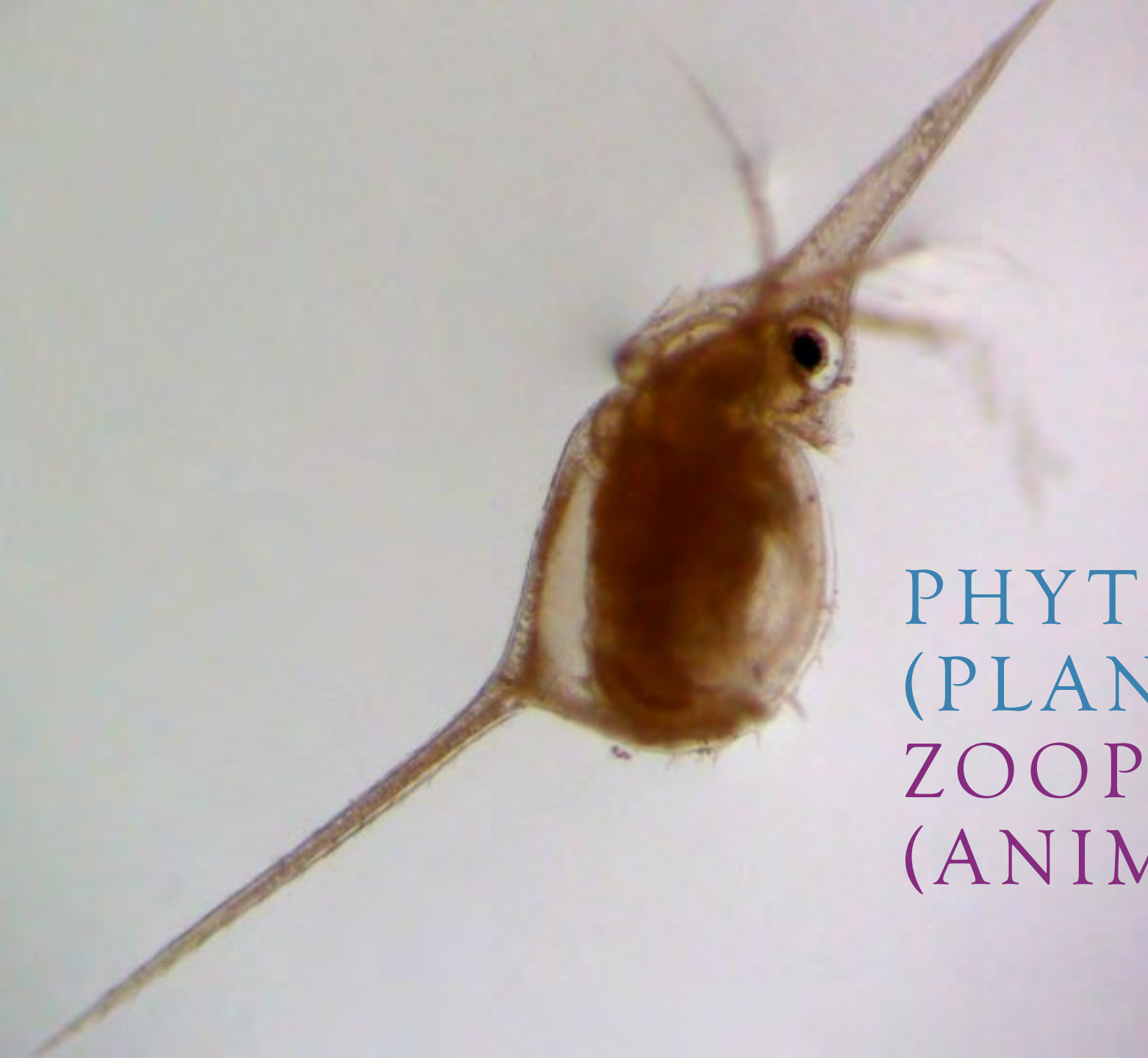
the microscopic world...





A collage of nine microscopic images of various algae species. The images include: a circular diatom with a radial pattern of pores; a green, elongated alga with a central axis and lateral branches; a large, circular, green, star-shaped alga; a brown alga with a central axis and many small, rounded, yellowish-brown structures; a green, elongated alga with a central axis and many small, rounded, green structures; a green, elongated alga with a central axis and many small, rounded, green structures; a green, elongated alga with a central axis and many small, rounded, green structures; a green, elongated alga with a central axis and many small, rounded, green structures; and a green, elongated alga with a central axis and many small, rounded, green structures.





PHYTOPLANKTON
(PLANTS)
ZOOPLANKTON
(ANIMALS)

Succession patterns in plankton communities – the PEG model

Phytoplankton and zooplankton communities in lake systems undergo seasonal succession in relation to **nutrient availability, predation, and competition.** Sommer *et al.* 1986 described these patterns as part of the Plankton Ecology Group (PEG) model.

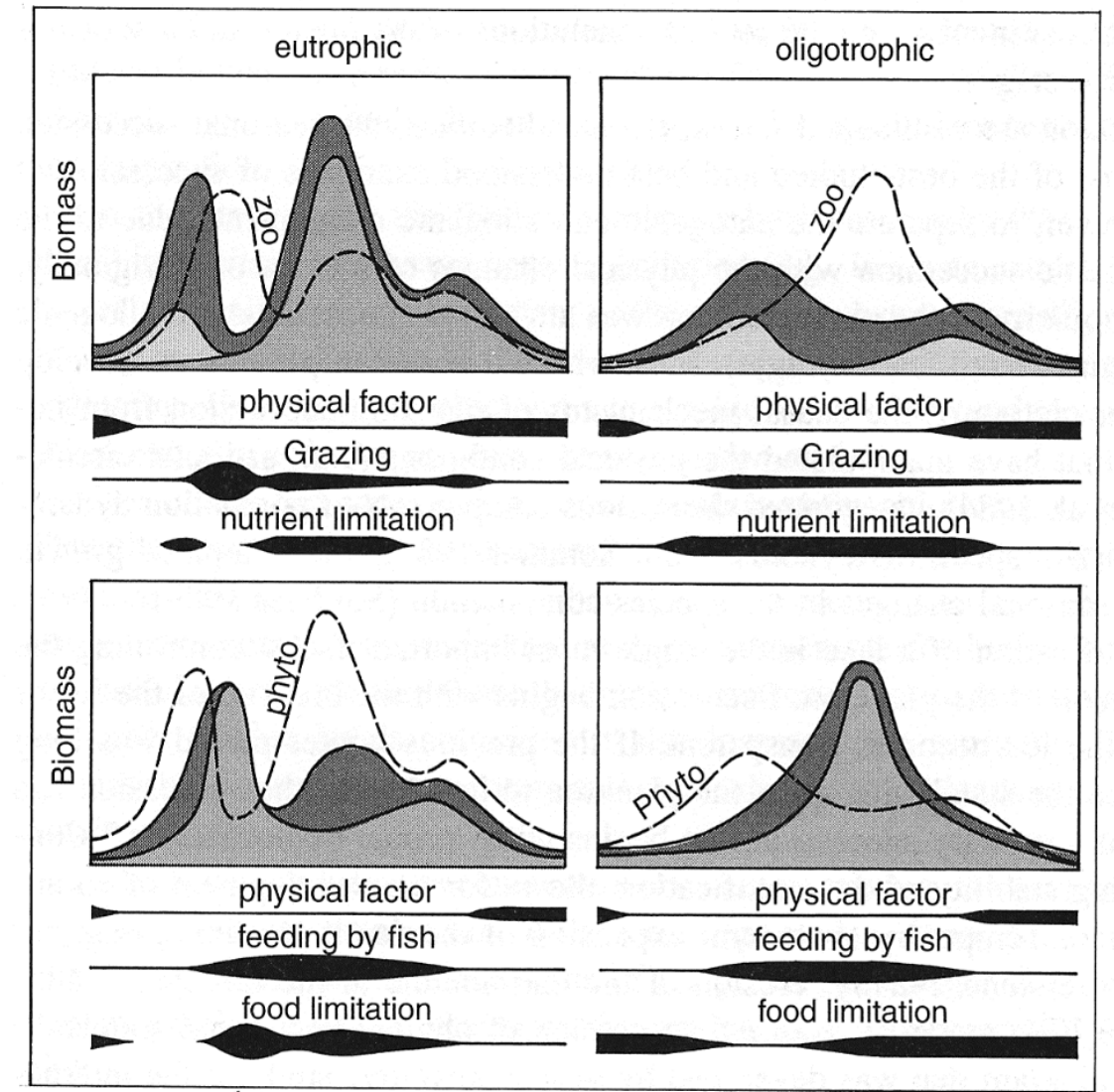


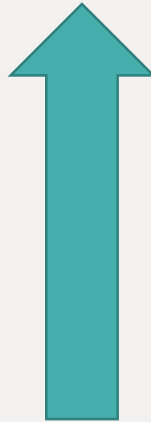
Figure 8.17 Graphic presentation of the PEG model of seasonal succession. Seasonal development of phytoplankton (above) and zooplankton (below) in eutrophic (left) and oligotrophic (right) lakes. Phytoplankton: dark shading, small species; medium shading, large nonsiliceous species; light shading, large diatoms. Zooplankton: dark shading, small species; medium shading, large species. The black horizontal symbols indicate the relative importance of the selection factors (from Sommer *et al.* 1986).

Phytoplankton – microscopic plants, photosynthetic bacteria, etc.

Eutrophic
more phyto

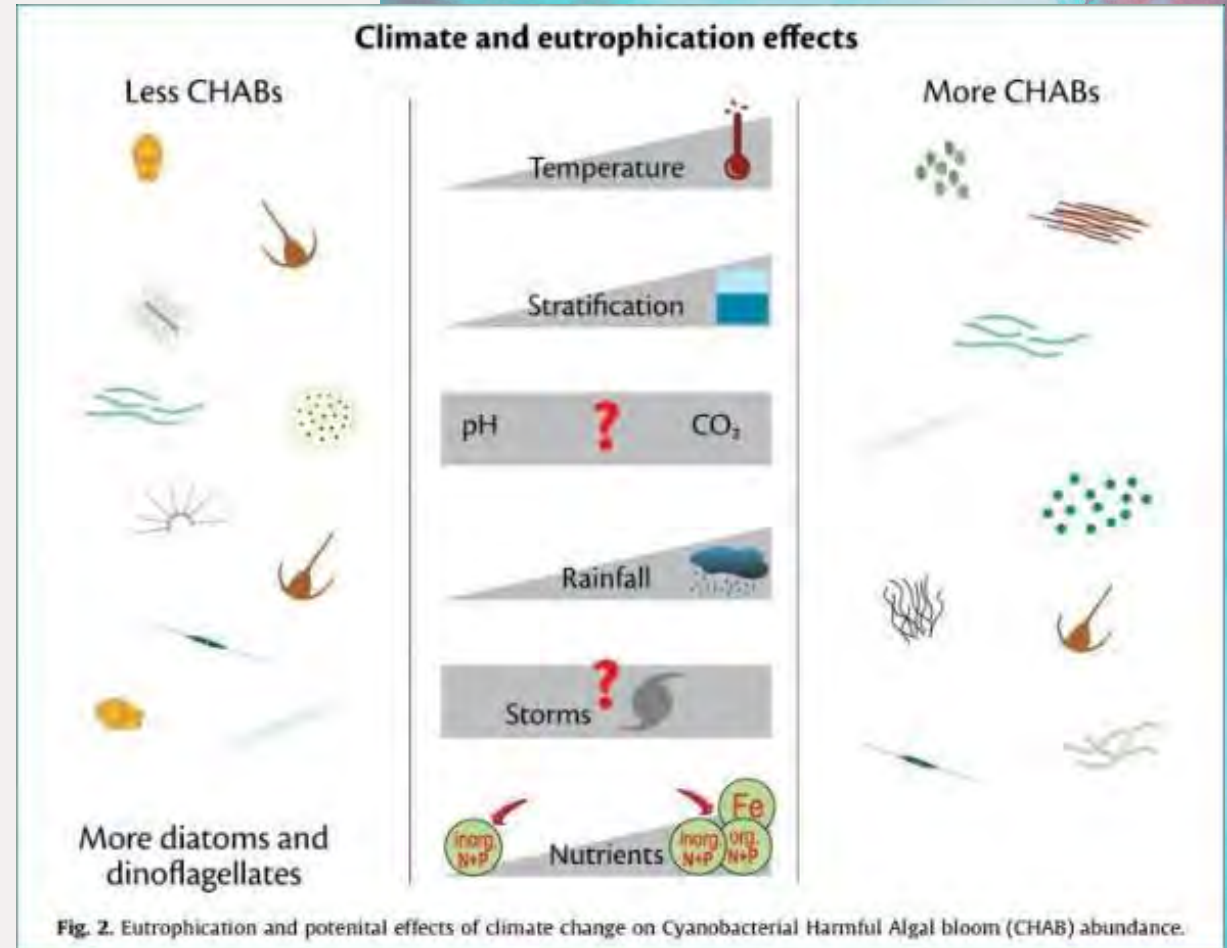
Mesotrophic
moderate phyto

Oligotrophic
few phyto



Phyla/Groups

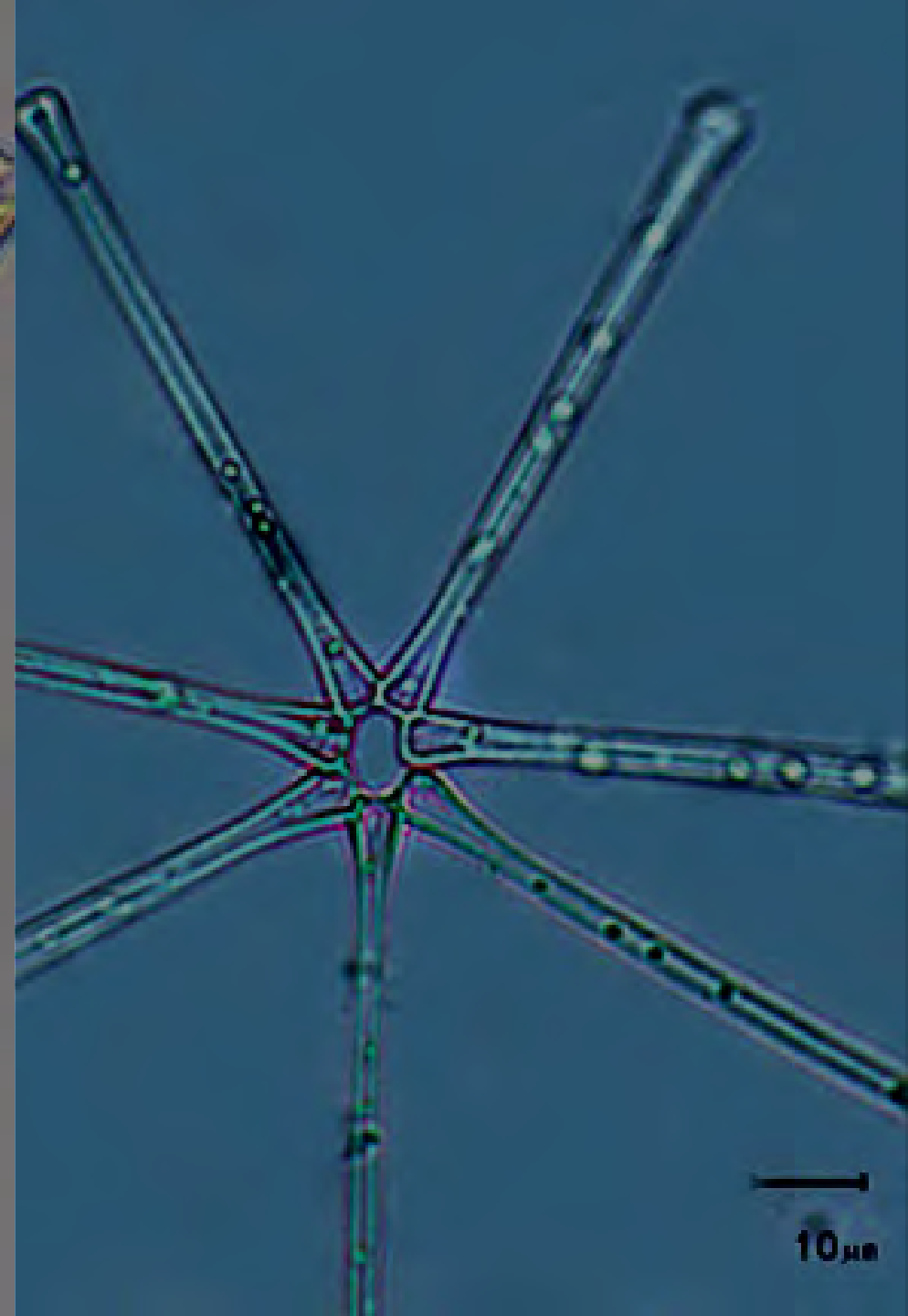
- Diatoms (Bacillariophyta)
- Golden-browns (Chrysophyta)
- Dinoflagellates (Pyrrophyta/Dinophyta)
- Greens (Chlorophyta)
- Cyanobacteria (Cyanophyta)
- Euglenoids (Euglenophyta)
- Yellow-greens (Xanthophyta)





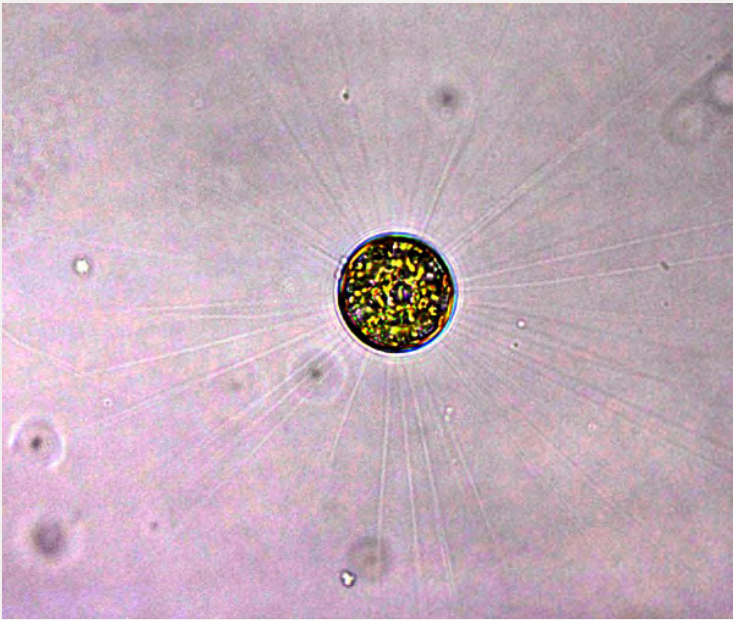
DIATOMS:

TABELLARIA
ASTERIONELLA



Diatoms - Bacillariophyta

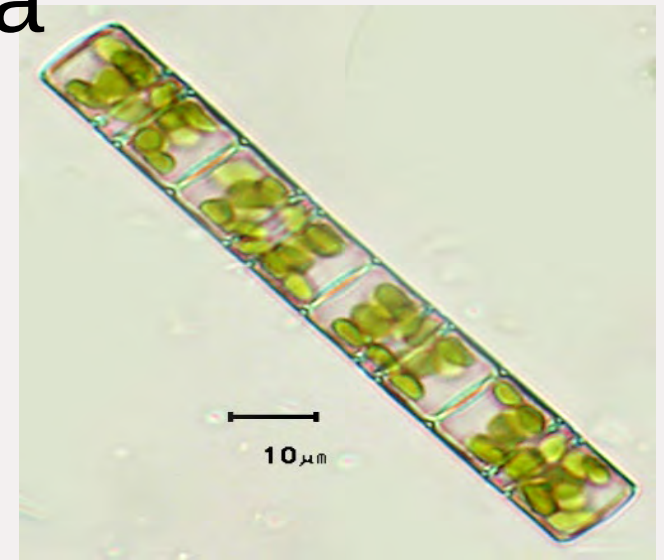
(Silica walls)



Cyclotella unicell



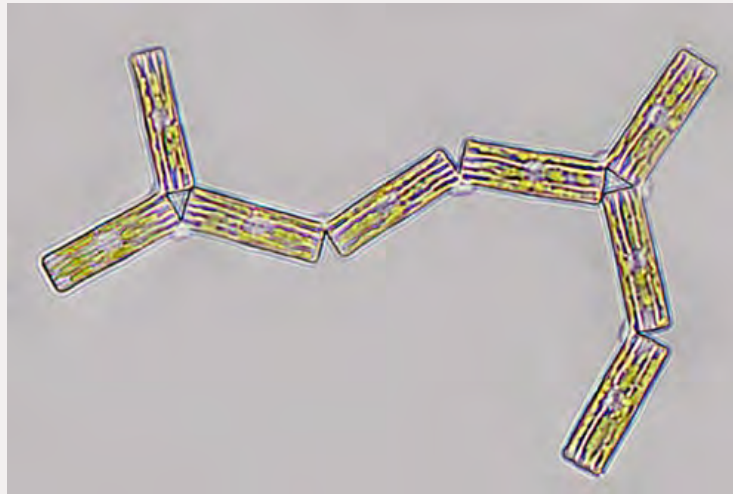
Rhizosolenia unicell



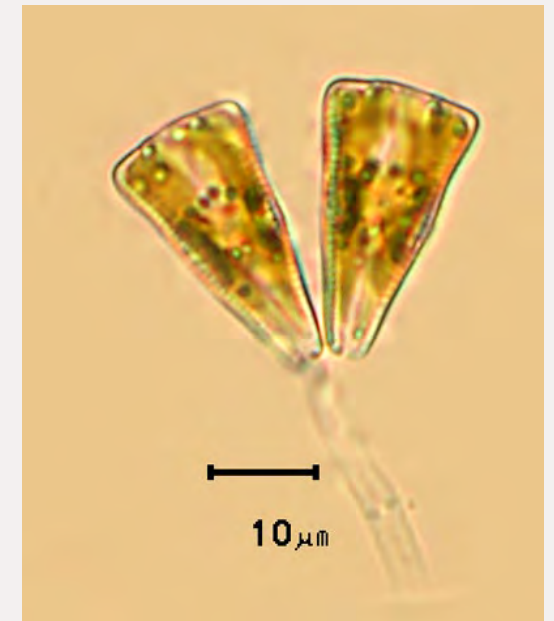
Melosira filament



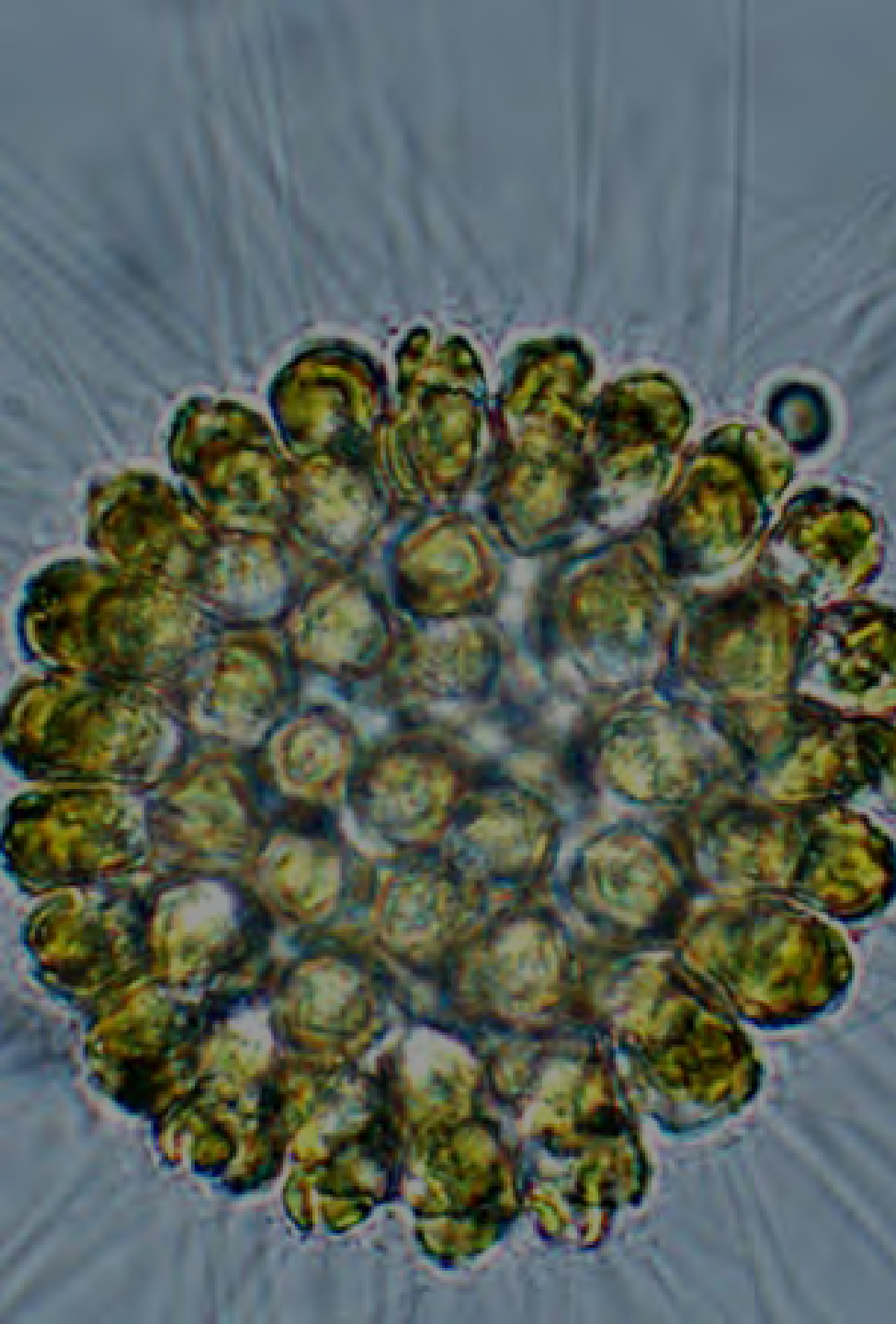
Asterionella colony



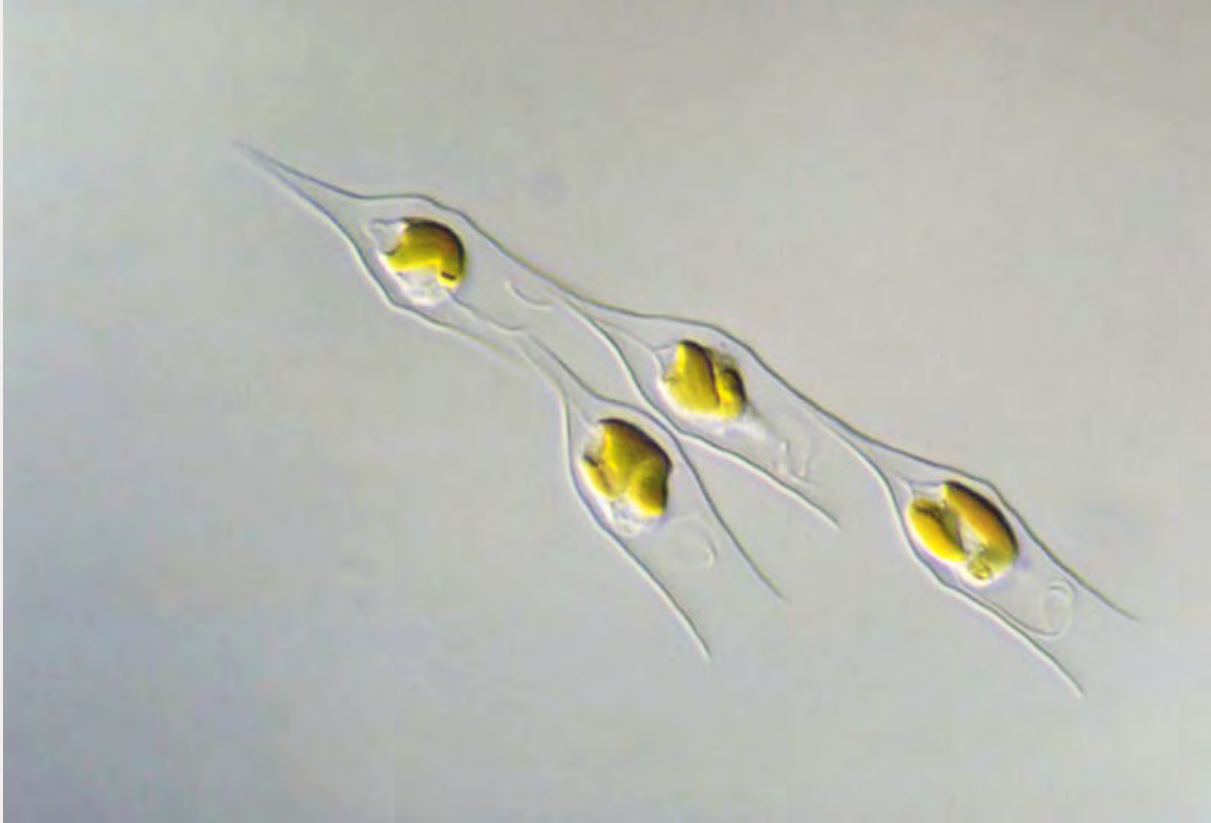
Tabellaria colony



Gomphonema colony



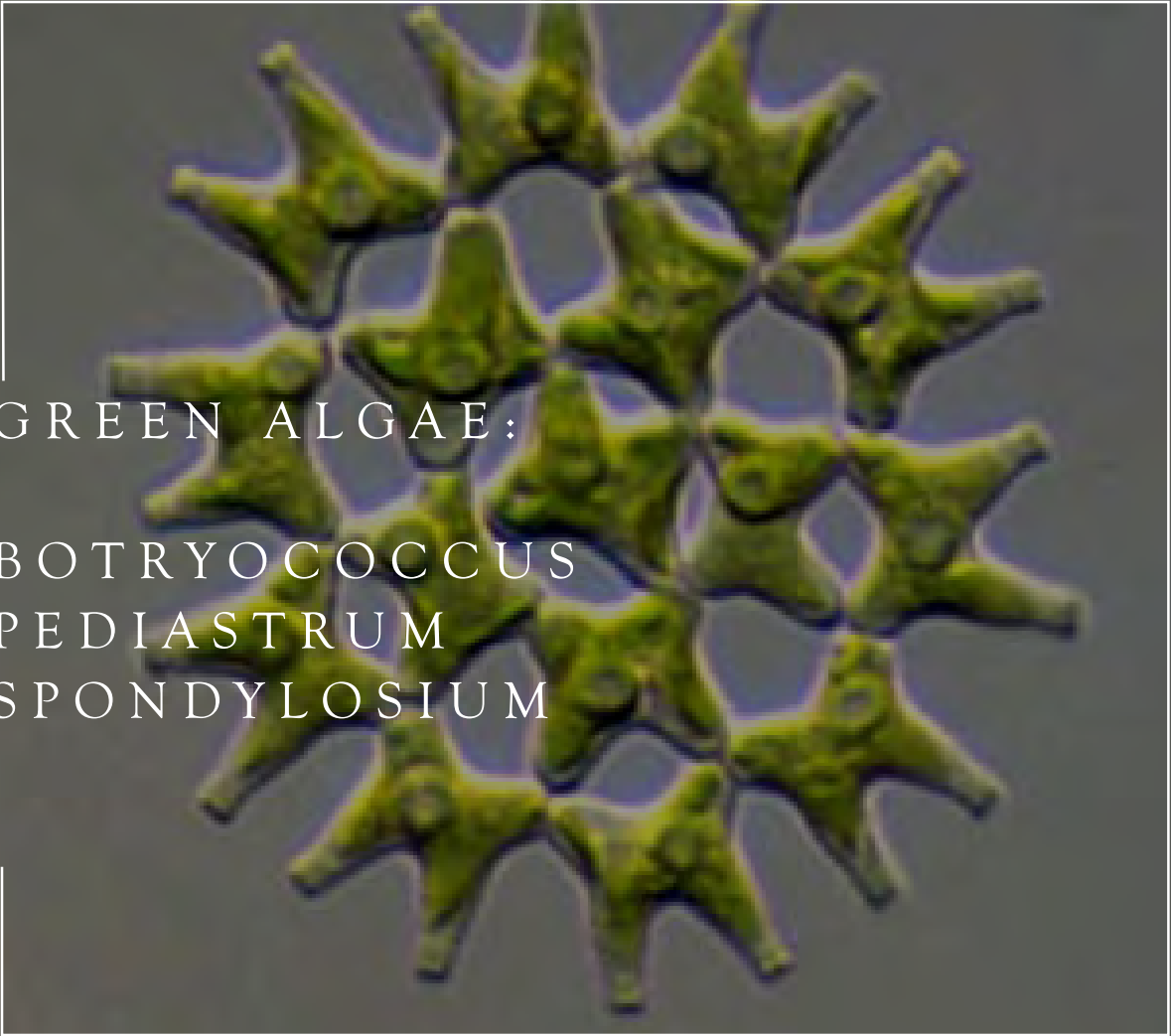
GOLDEN-BROWNS - Chrysophyta



Dinobryon colony
(Polysaccharide lorica)
(Cellulose and Silica)

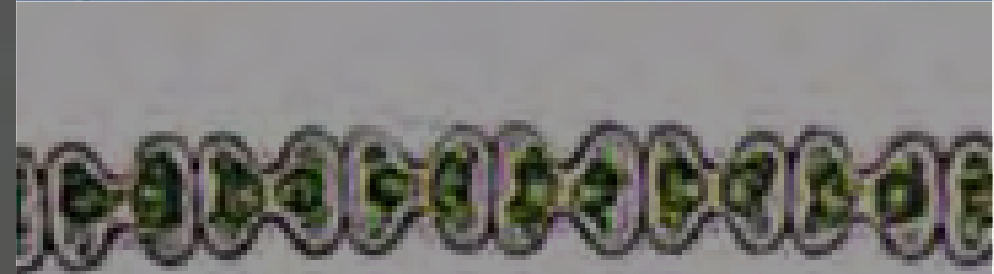
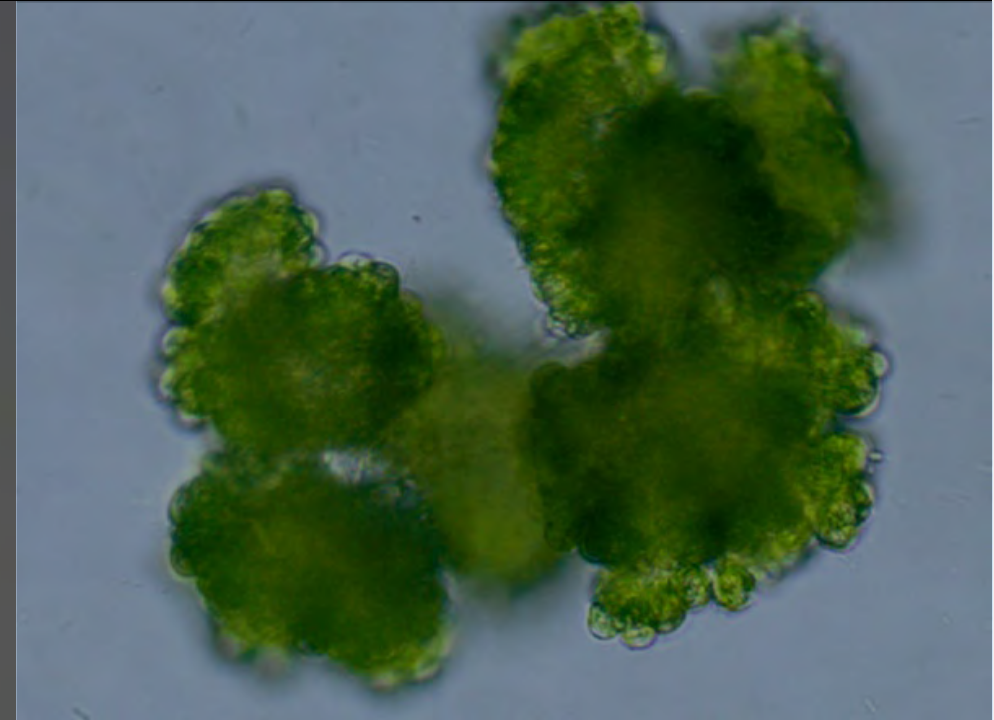


Chrysosphaerella colony
(Silica spines)



GREEN ALGAE:

BOTRYOCOCCUS
PEDIASTRUM
SPONDYLIUM



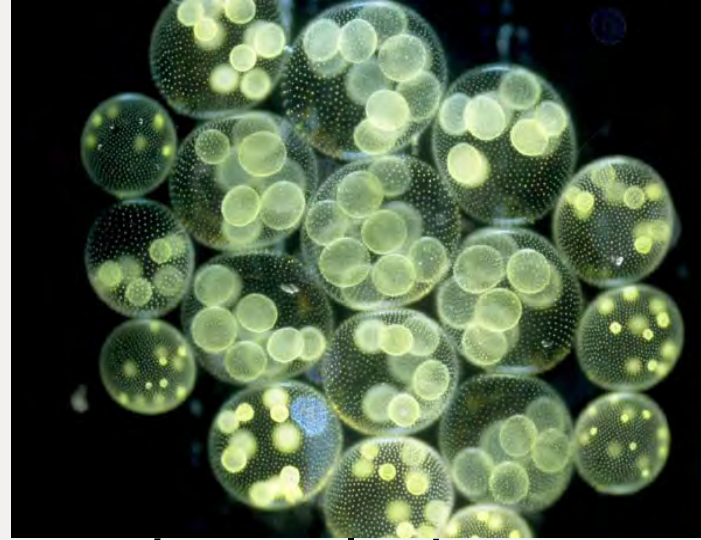
20 μm

Greens- Chlorophyta

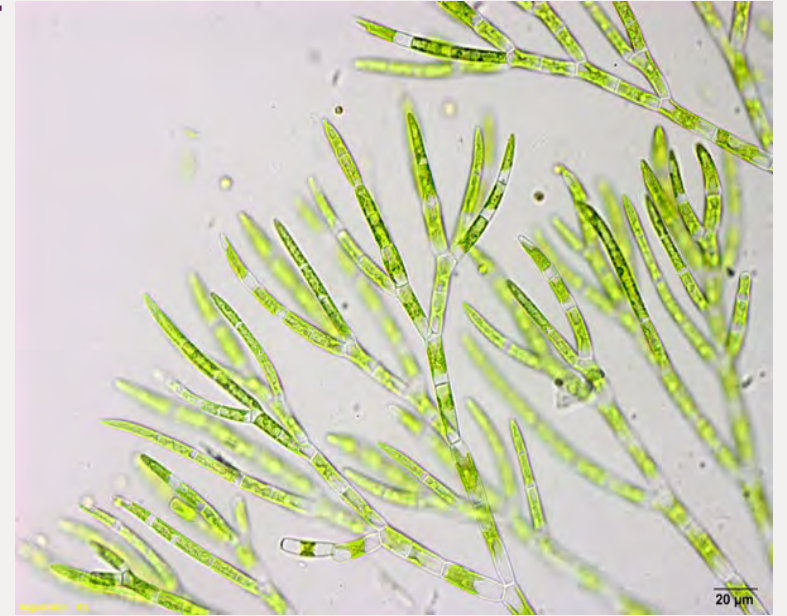
(Cellulose walls)



Chlamydomonas unicell



Volvox colonies

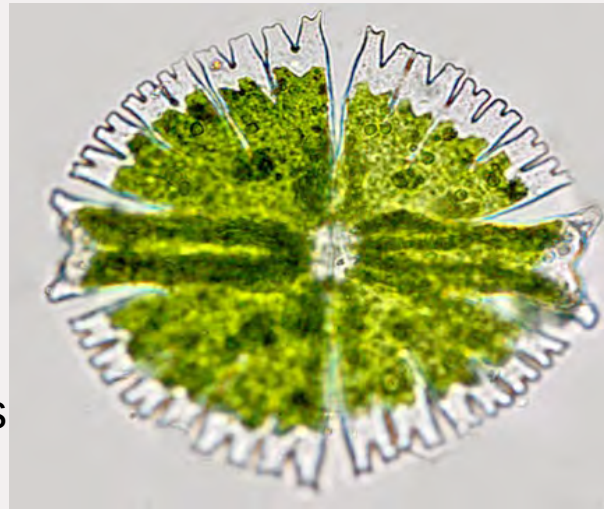


Chaetophora filaments



Xanthidium unicell

Desmids



Micrasterias unicell



Chara filaments

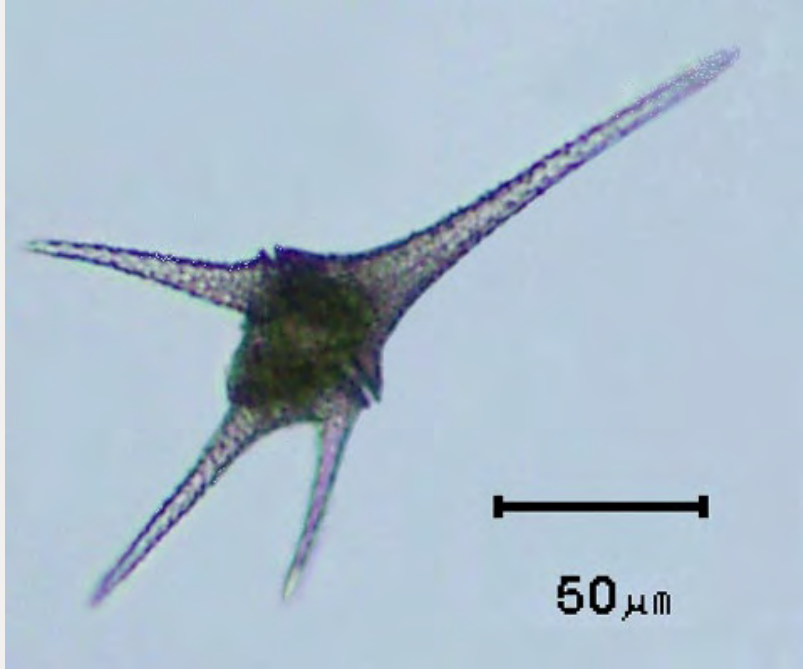
A microscopic image showing several large, oval-shaped cells of Gymnodinium. The cells have a granular, brownish-yellow interior and a distinct, lighter-colored outer boundary. They are set against a dark, textured background.

DINOFLAGELATES:

GYMNODINIUM
CERATIUM



Dinoflagellates – Dinophyta - Pyrrophyta



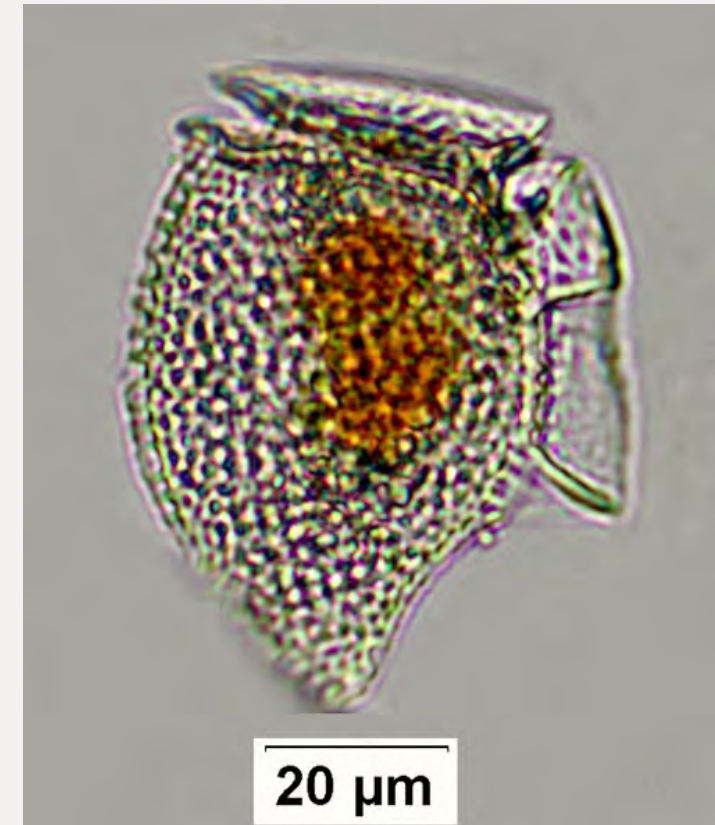
Ceratium (unicell)



Peridinium (unicell)

(Thick cellulose wall plates with whip-like flagella)

Dinophysis – marine HAB



PhycoKey

Contact: [A.L. Baker](#), University of New Hampshire

To enlarge pages use CTRL+

[CFB / Phytoplankton key home page](#) Hover, then Click

Home	Instructions	History	References	Genera
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An Image-Based Key:

**Algae (PS Protista),
Cyanobacteria,
and other aquatic
objects**





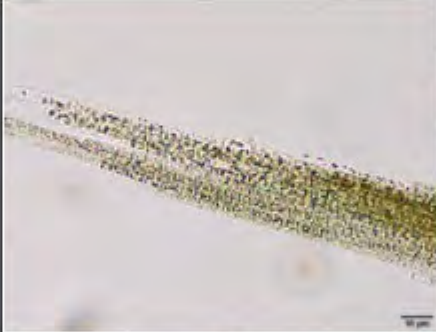
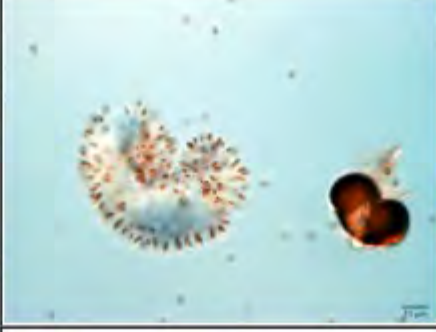
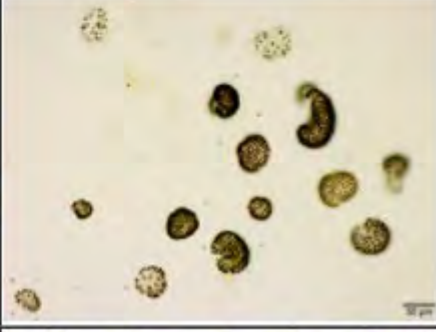
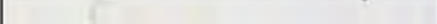
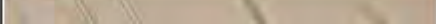
[PhycoKey - Home page \(unh.edu\)](#)

[Cyanobacteria of New England \(unh.edu\)](#)

[cfb.unh.edu](#)

Toxic Cyanobacteria of New England

“The Dirty Dozen”

<i>Purpose & Background</i>		<i>Genus List</i>
		
		
		

Planktothrix/oscillatoria



Anabaena

Woronichinia



Woronichinia



Cyanobacteria

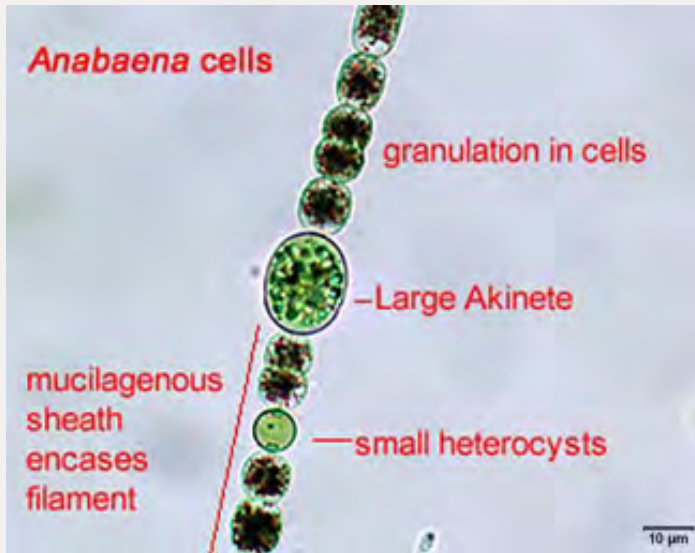
Anabaena cells

granulation in cells

—Large Akinete

mucilagenous
sheath
encases
filament

—small heterocysts



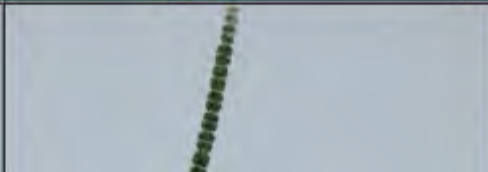
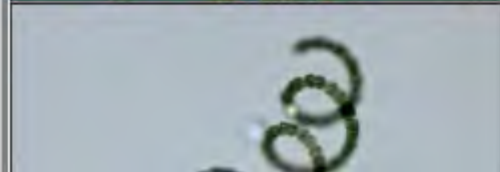
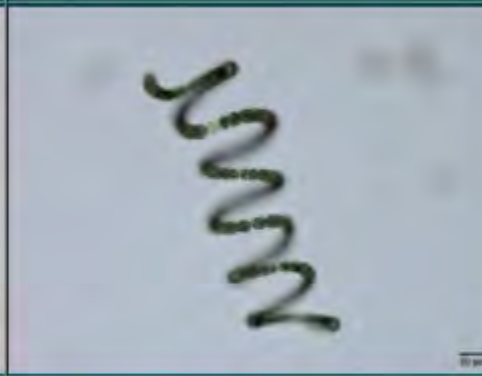
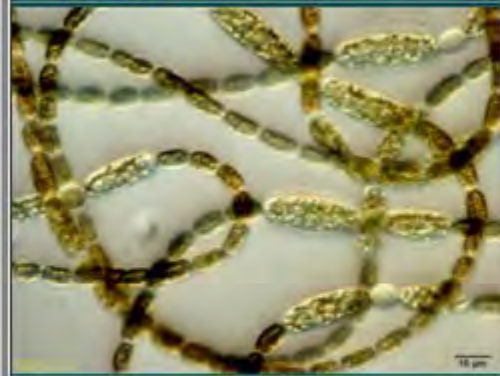
Cyano quick list: <http://cfb.unh.edu/CyanoKey/QuickList.html>

Dolichospermum/Anabaena

Anabaena (unh.edu)

General Description

- *Anabaena* cells are usually arranged in filaments or chains and can be straight, spiralled, coiled or spring-like and often described as "beaded"
- Filaments also have specialized cells called heterocysts and akinetes, used for fixing nitrogen and regenerating cells for future colonies
- A mucilaginous sheath encases the cells of the filament



Typical form

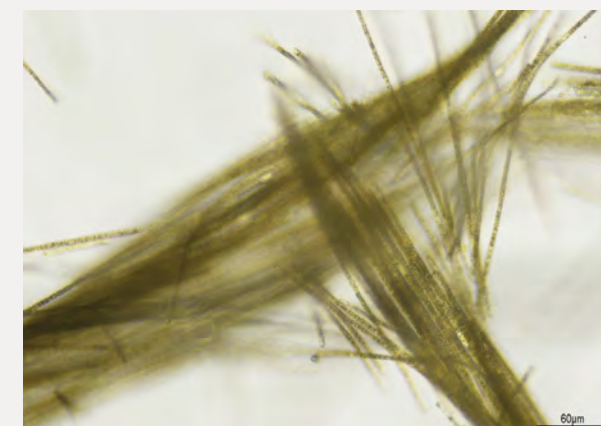
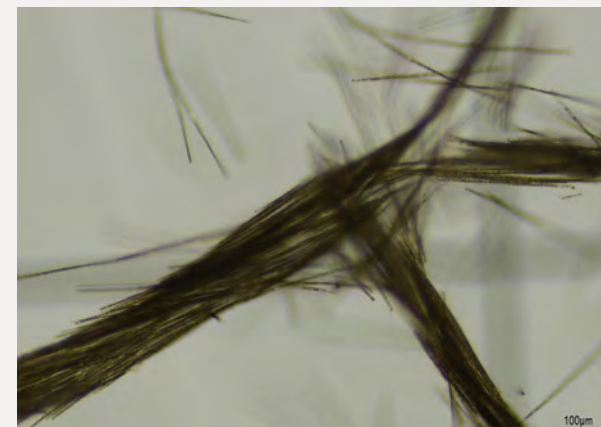


Aphanizomenon (unh.edu)

Aphanizomenon

General Description

- *Aphanizomenon* are small filaments with cells arranged parallel or rafted to each other
- The length of cells are equal or greater than the width
- Heterocysts and akinetes may or may not be present depending on the species
- Individual filaments of *Aphanizomenon* are much smaller than *Anabaena*, but rafted together create a larger cyanobacteria colony

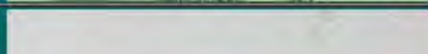
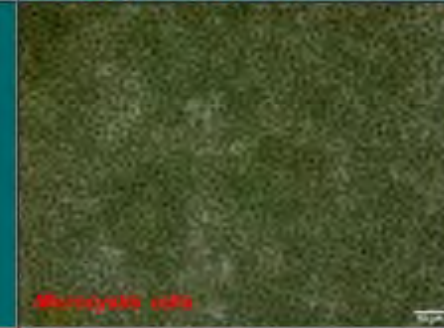
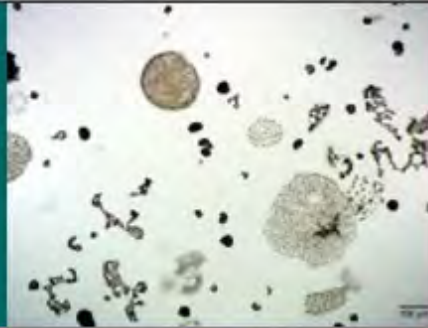
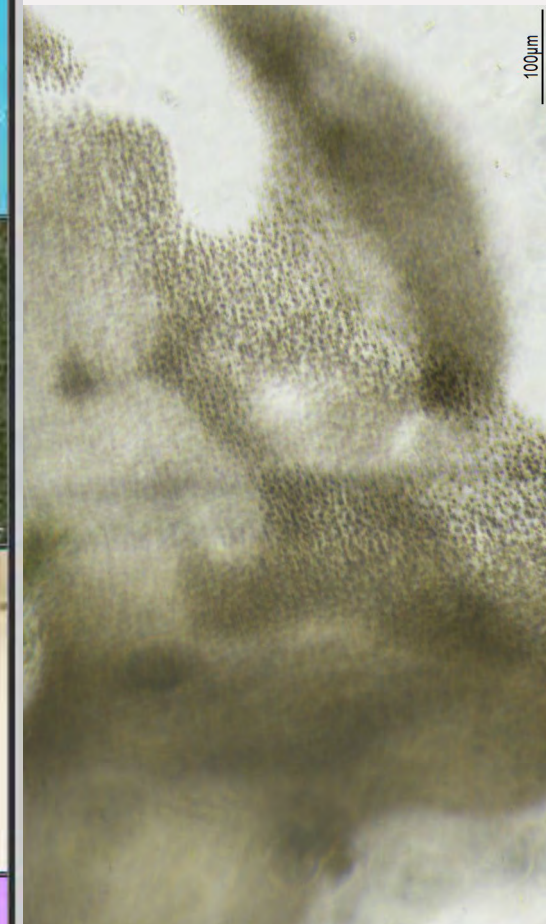
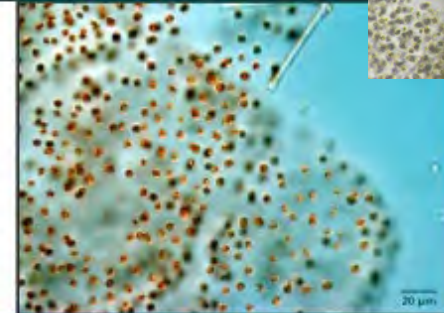
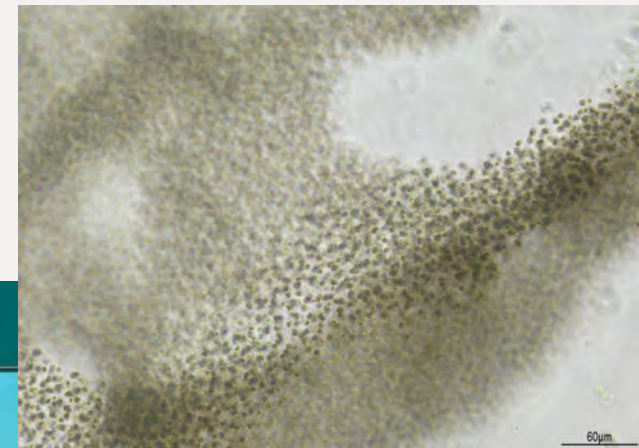


Microcystis (unh.edu)

Microcystis

General Description

- *Microcystis* is one of the most common and diverse of the cyanobacteria, known for its production of hepatotoxic, microcystins
- Cells are granular and sometimes released from the colony and mucilagenous sheath
- Cell-size and colony-shape vary by species, typically cells are about 4-5 micrometers





Wolffia

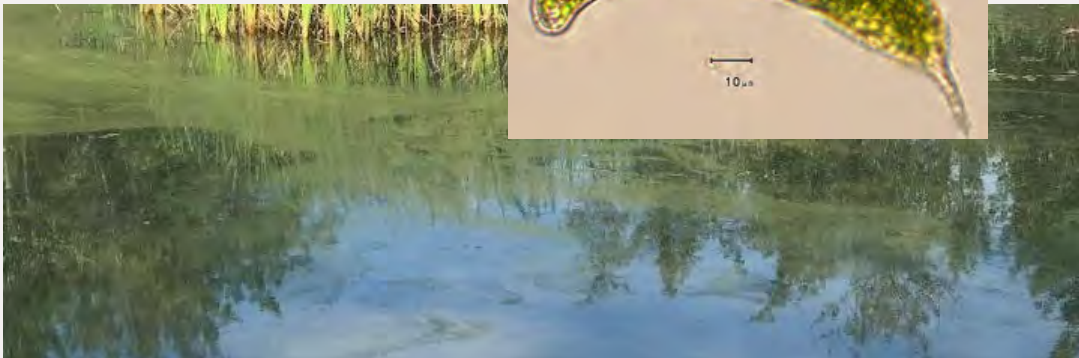
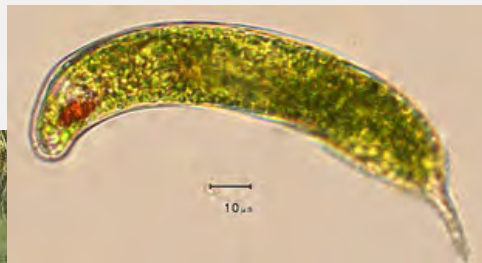
“Scums” that
are not
cyanobacteri
a...

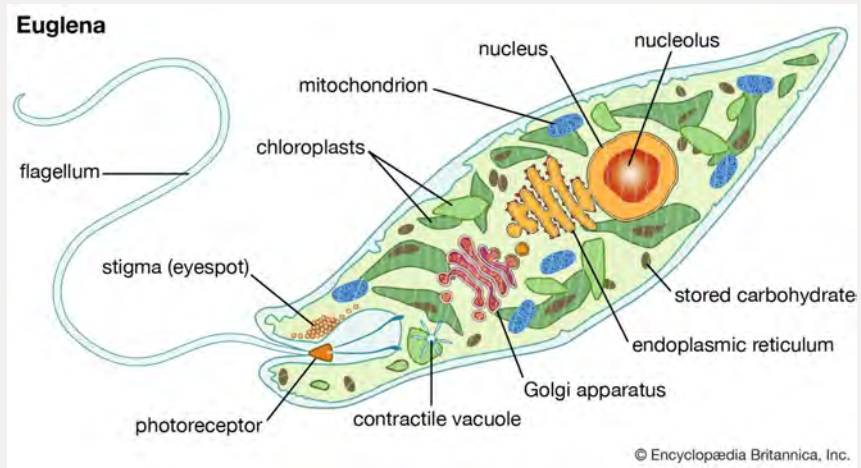


Green Filamentous Algae



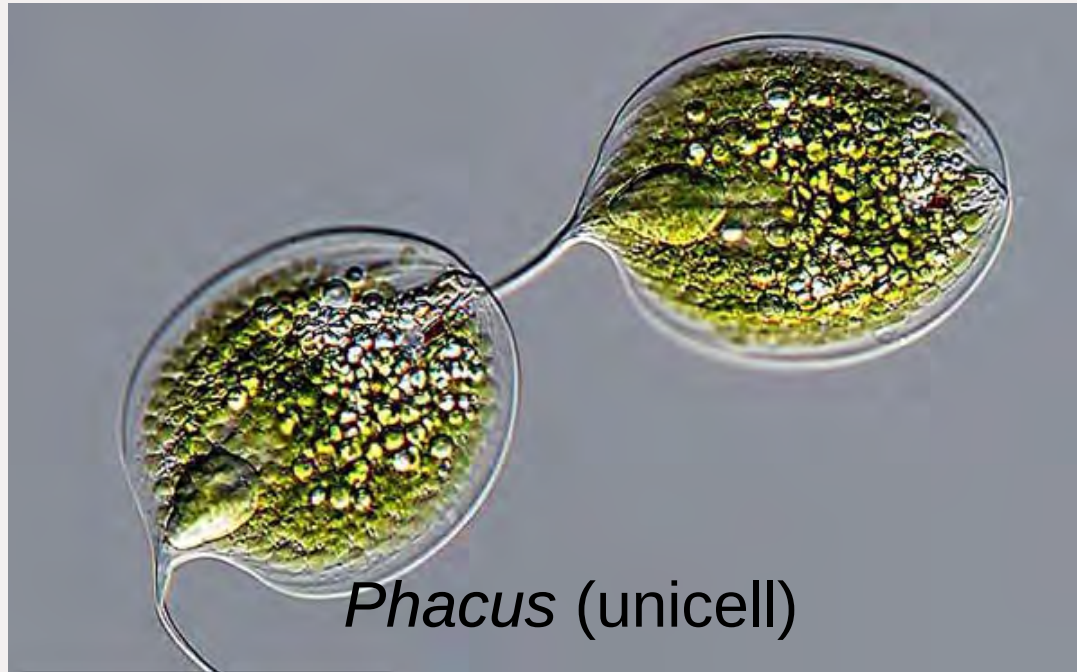
Euglena





Model Organisms

Single- celled
eukaryote
Chloroplasts with 3
membranes

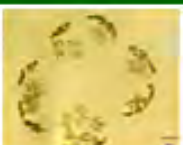
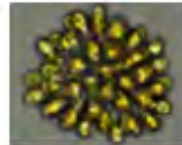


Euglena

Euglenoids - Euglenophyta

[Home](#)[Instructions](#)[History](#)[References](#)[Genera](#)

An Image-Based Key:

**Algae (PS Protista),
Cyanobacteria,
and other aquatic
objects**

Phytoplankton – microscopic plants, photosynthetic bacteria, etc.

Diatoms (Bacillariophyta)

Golden-browns (Chrysophyta)

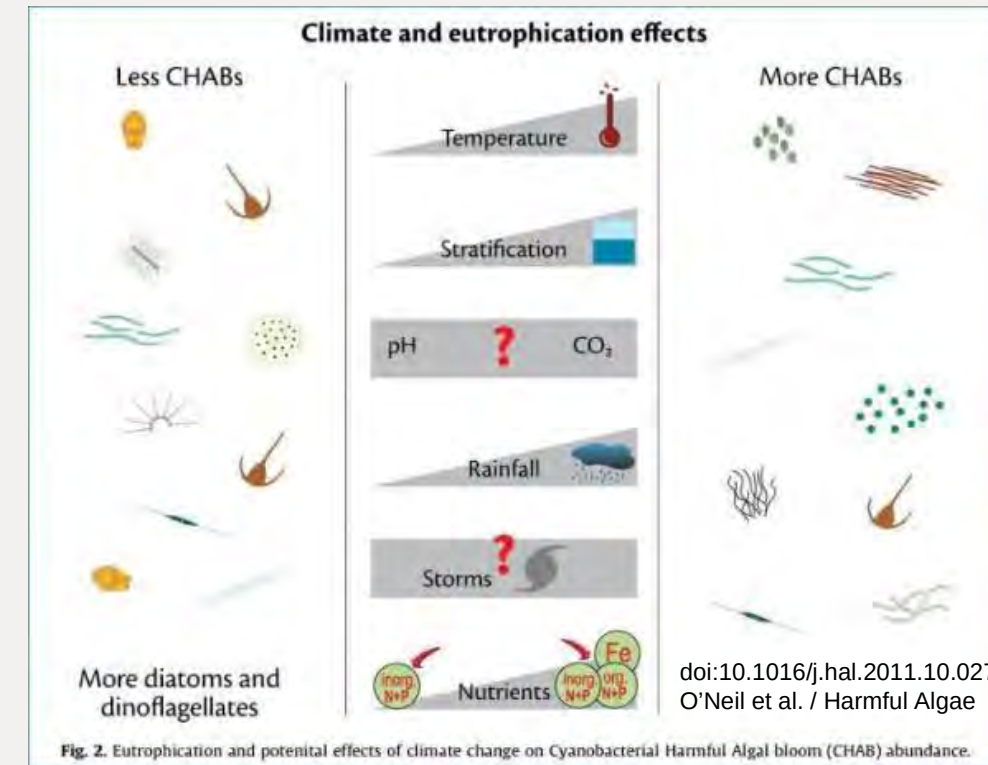
Dinoflagellates (Pyrrophyta/Dinophyta)

Greens (Chlorophyta)

Cyanobacteria (Cyanophyta)

Euglenoids (Euglenophyta)

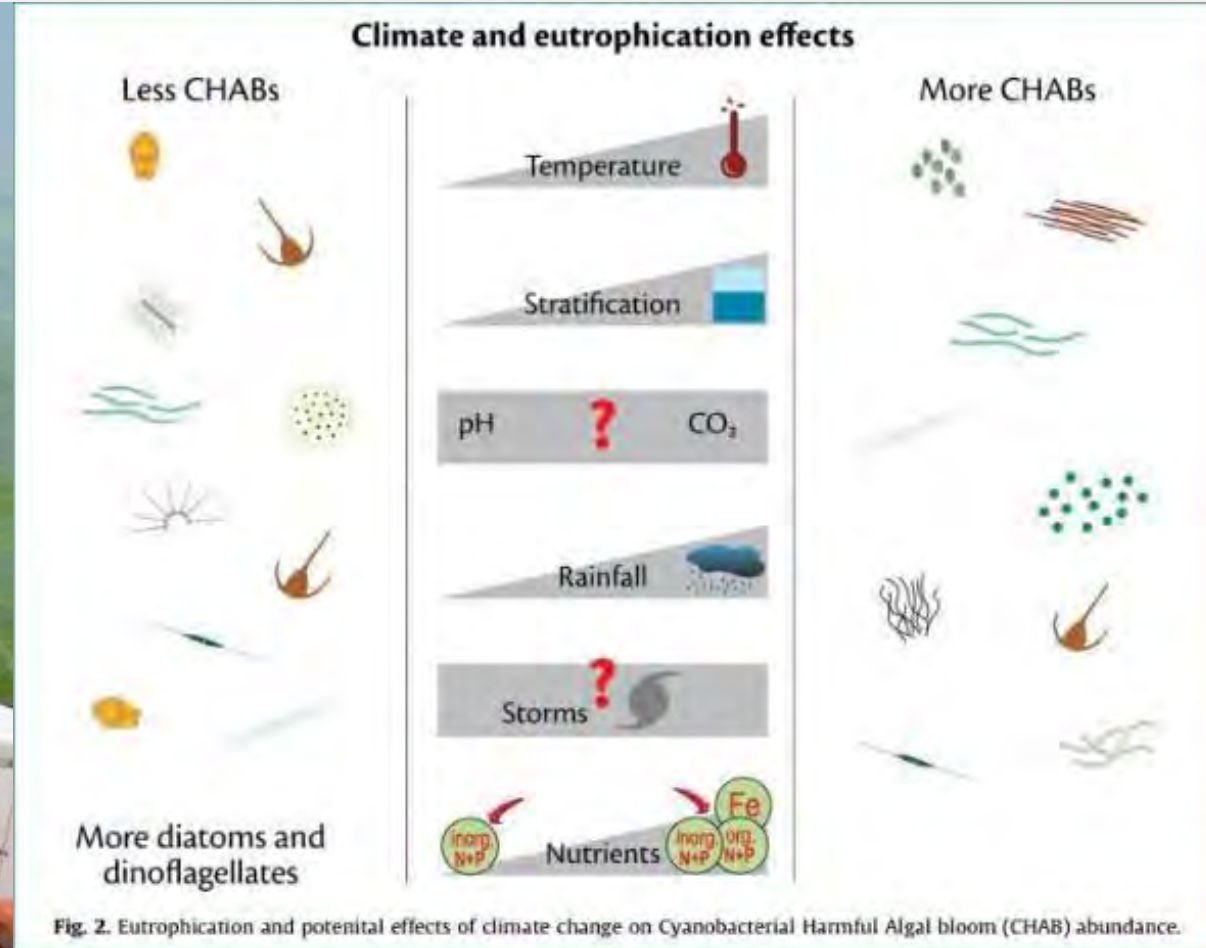
Yellow-greens (Xanthophyta)

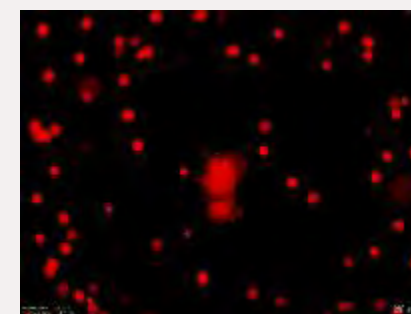
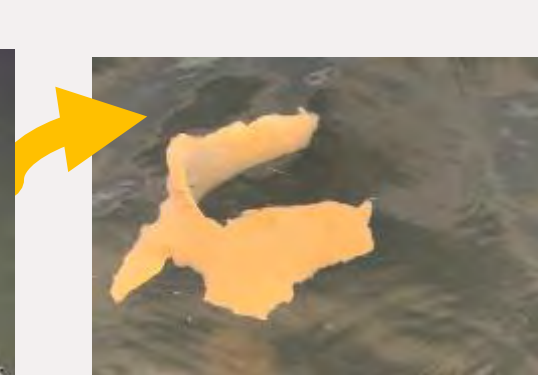
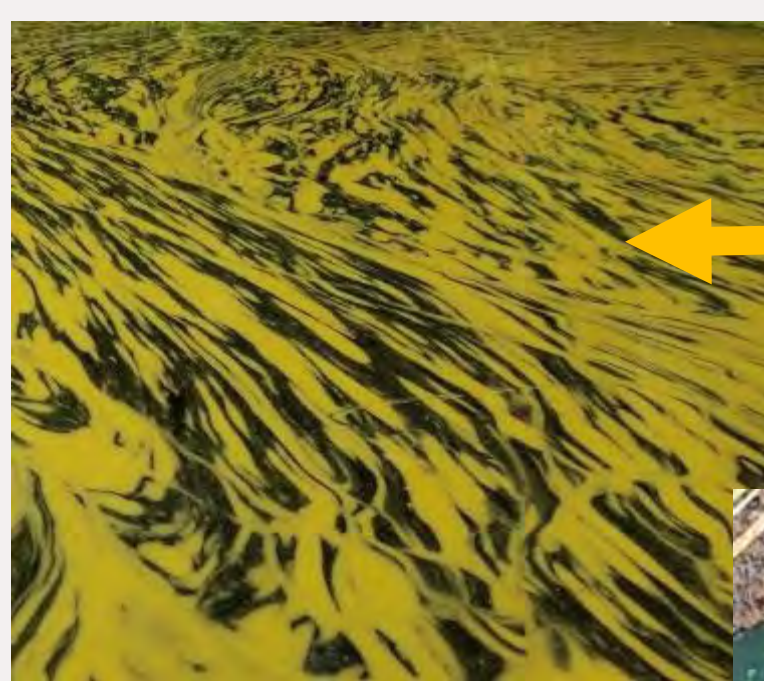
Eutrophic
more phytoMesotrophic
moderate phytoOligotrophic
few phyto

Public and scientific interest has focused on surface blooms



Surface bloom in China: Hans Paerl





surface
accumulations



a food chain story...

Cyanotoxin Exposure

- Recreational
- Drinking water
- Dermal contact
- Inhalation
- Food Webs...

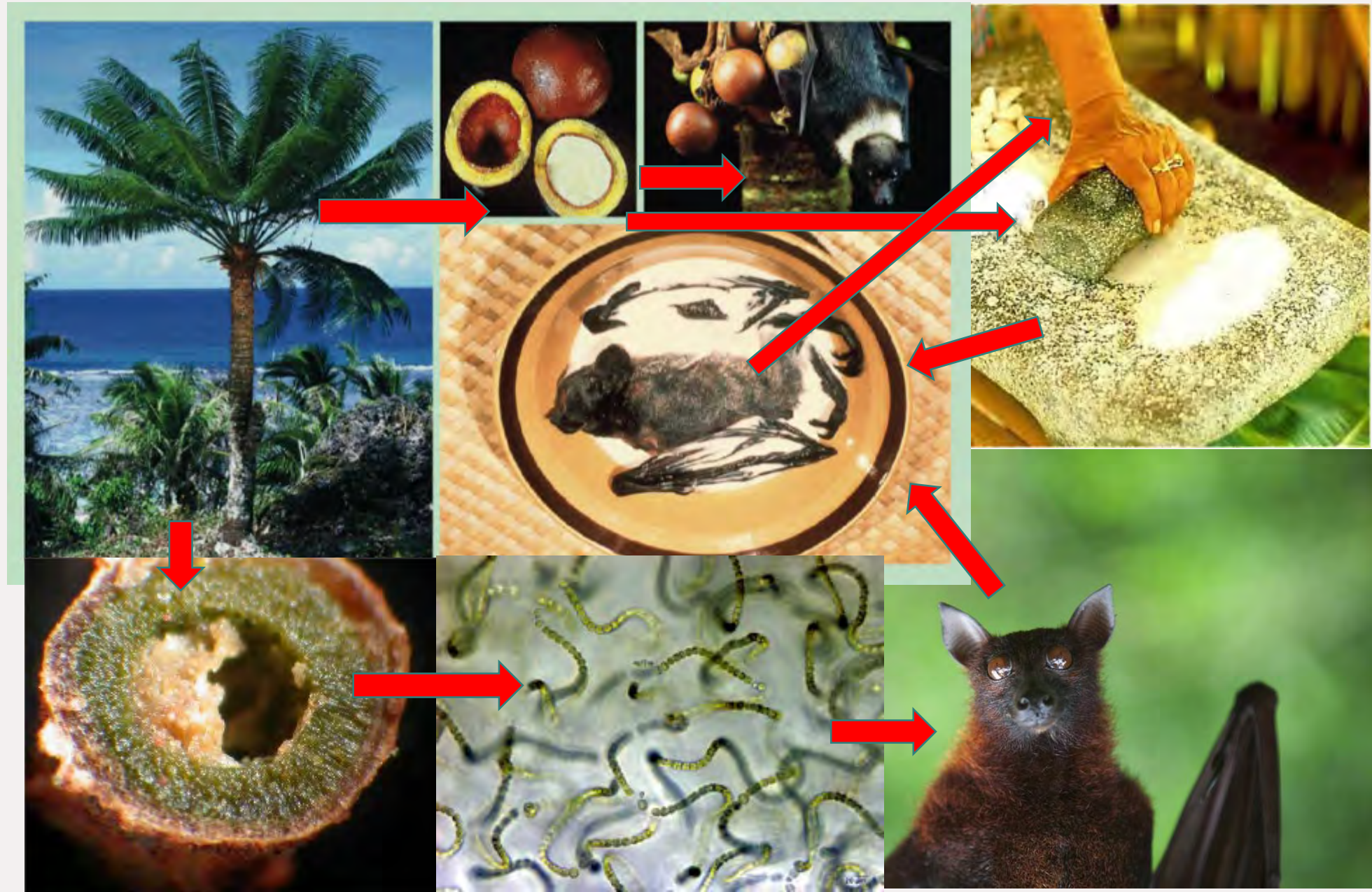
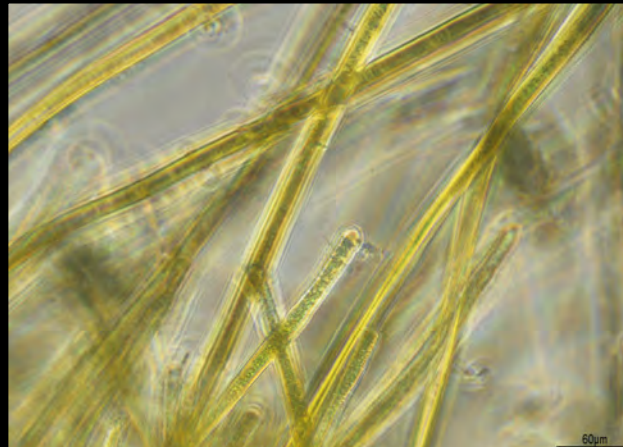
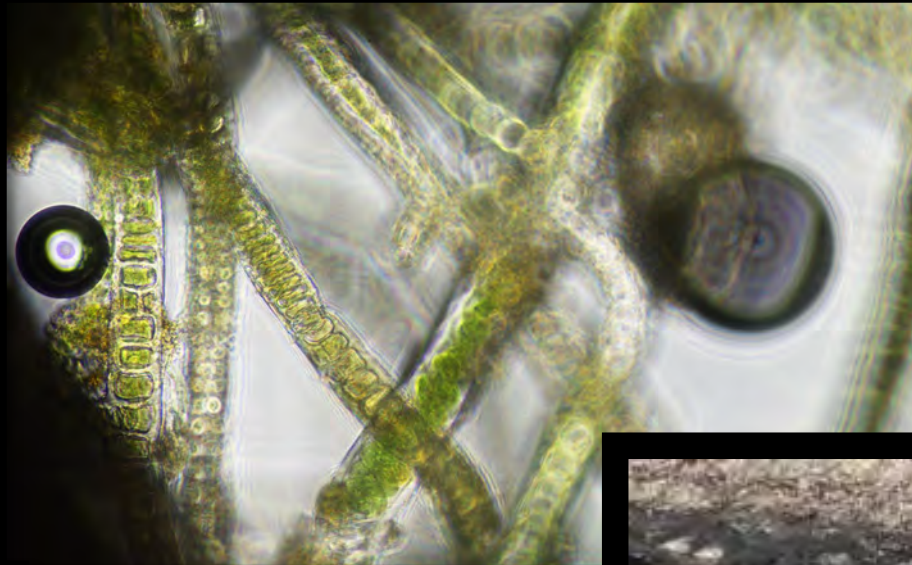
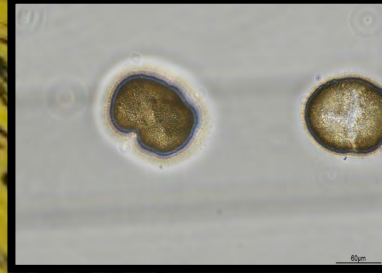


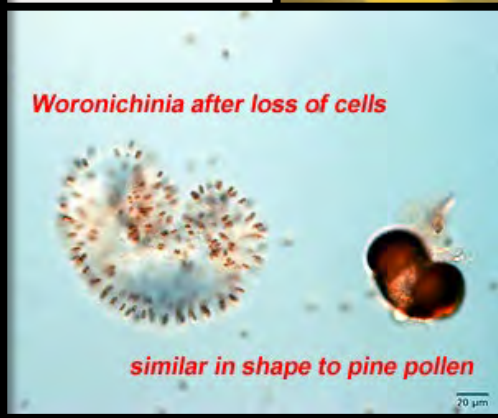
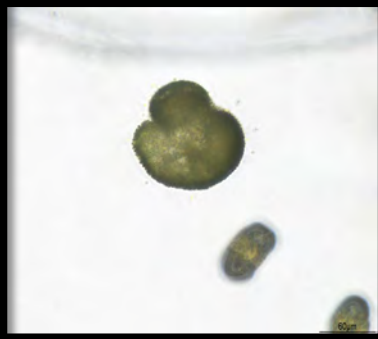
Photo Collage source: JF Haney

Stigonematales and other benthic mats of cyanobacteria





Woronichinia



Toxic Cyanobacteria of New England

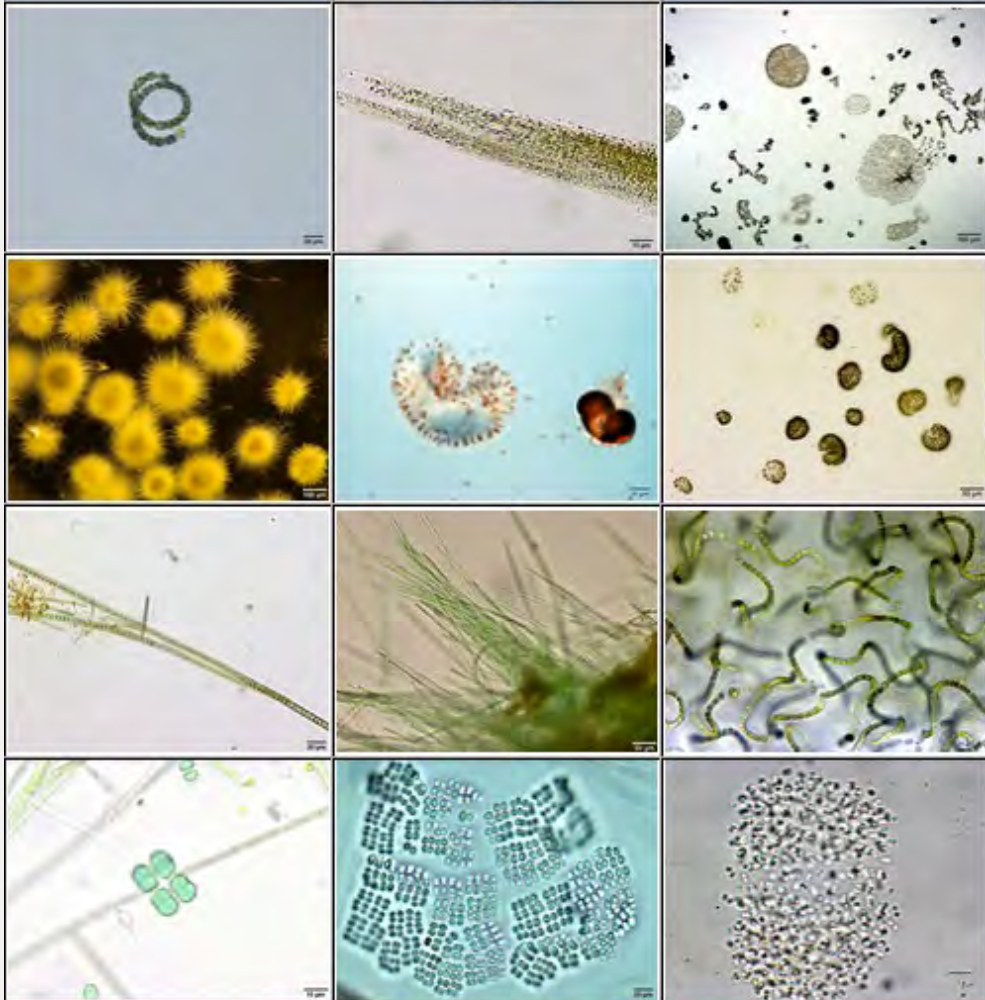
"The Dirty Dozen"

cfb.unh.edu

Purpose & Background



Genus List

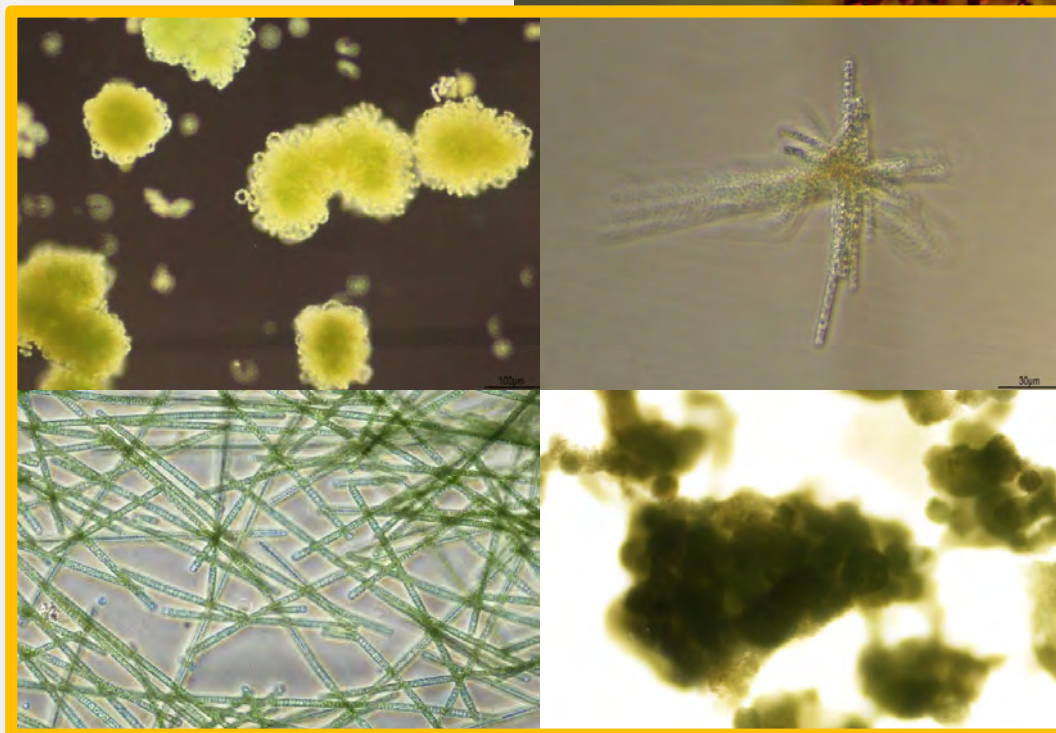


University of New Hampshire, Center for Freshwater Biology; cfb.unh.edu

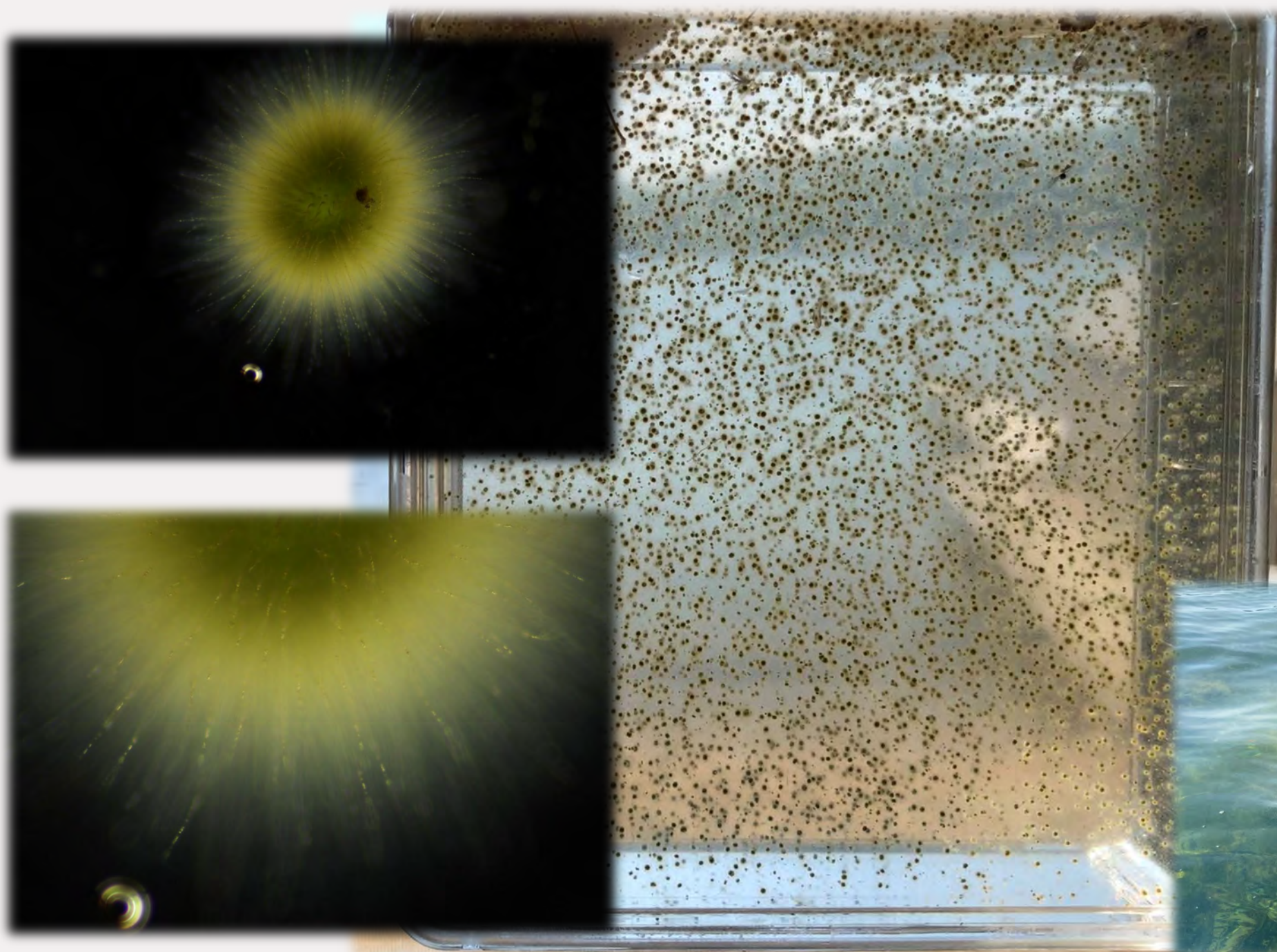
Cyanobacteria
may produce
toxins called
CYANOTOXINS

*Toxins may cause skin
irritations, gastroenteritis,
seizures, chronic illness
and death.*

Cyanobacteria



Not all
cyanobacteri
a are toxic



Gloeotrichia



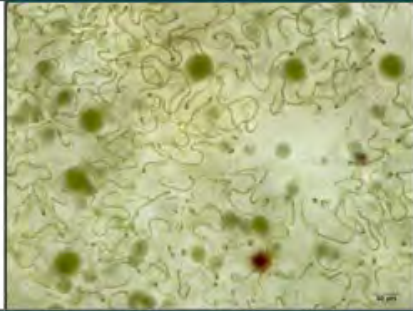


Nostoc

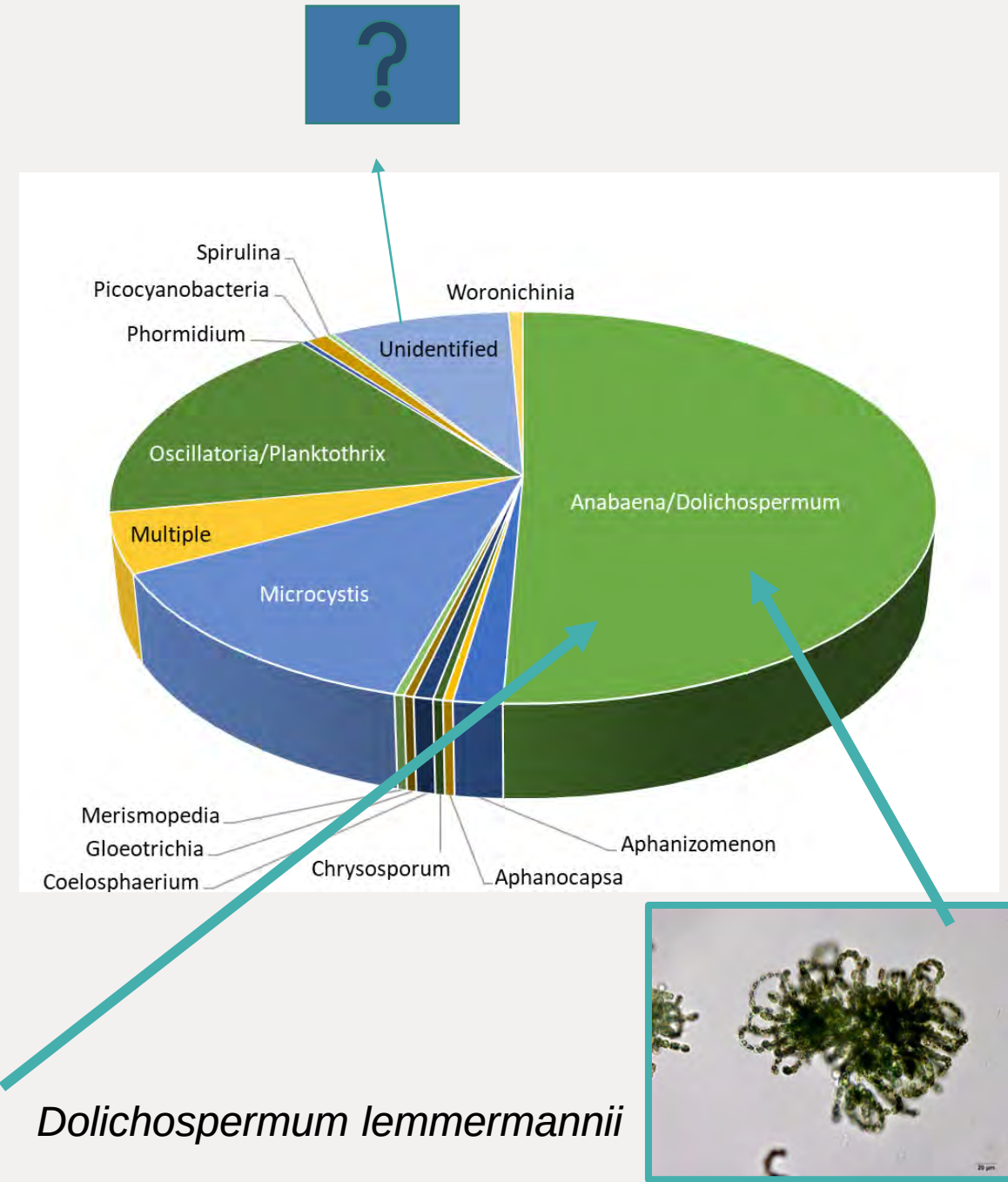
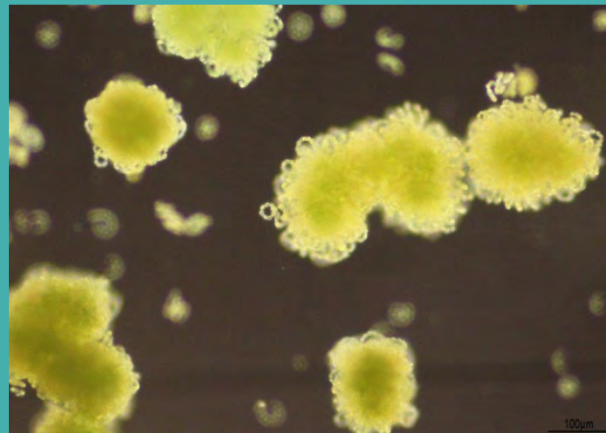
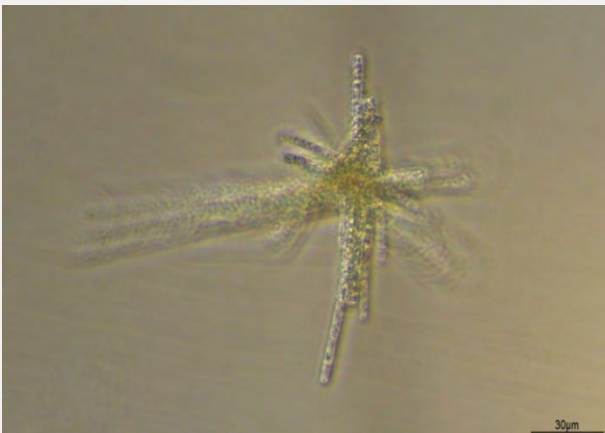
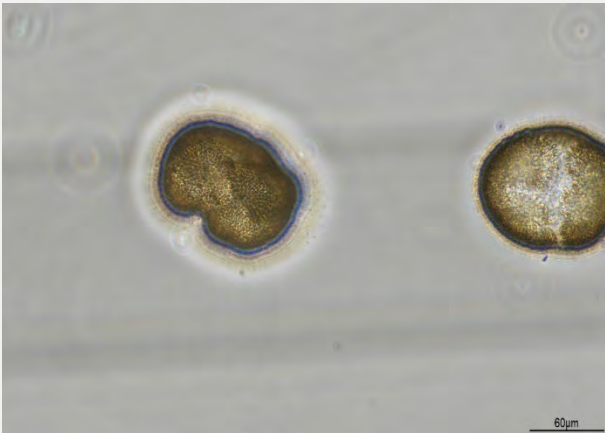
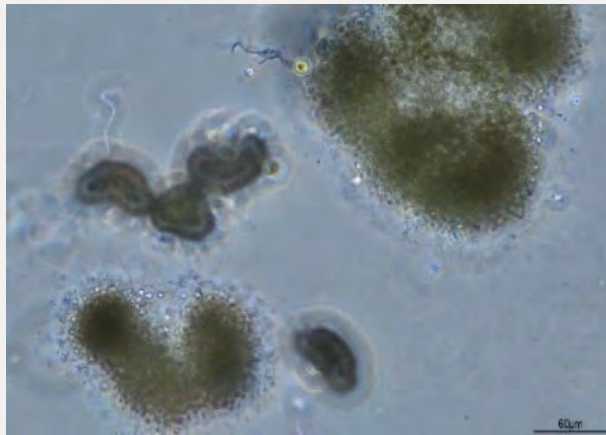
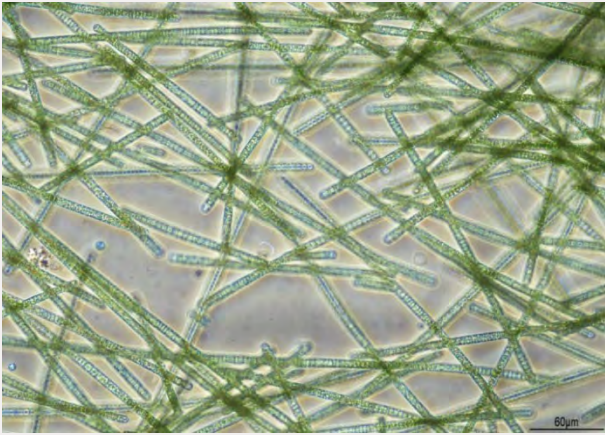
Nostoc

General Description

- *Nostoc* cells are similarly arranged as *Anabaena*, but often found within a thick-mucilaginous ball referred to as "the sea tomato"
- The filaments appear kinked and have heterocysts
- Cells are shorter in length than in width



authentic Nostoc are
sometimes referred to as sea tomatoes

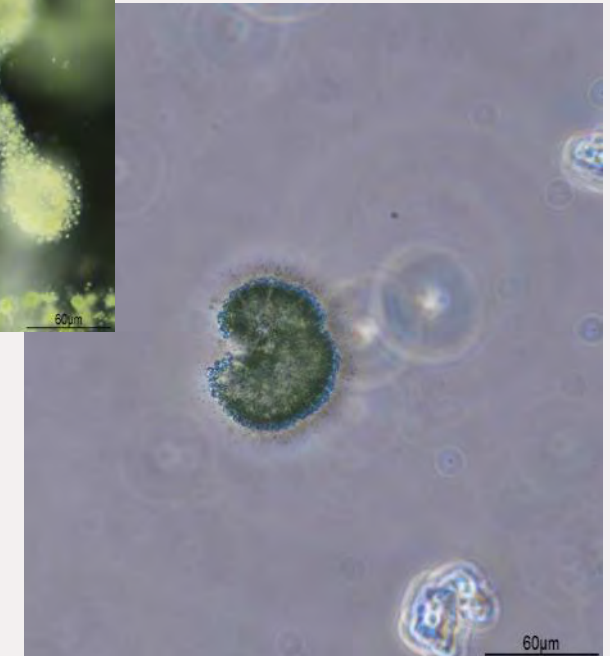
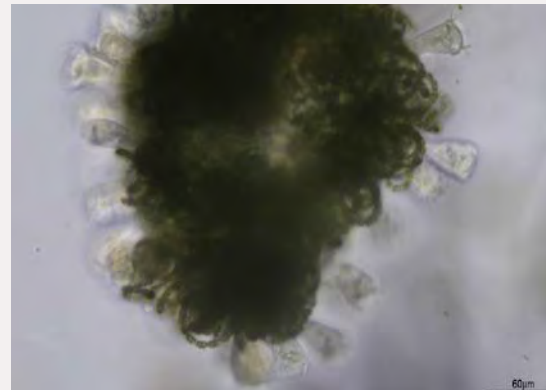
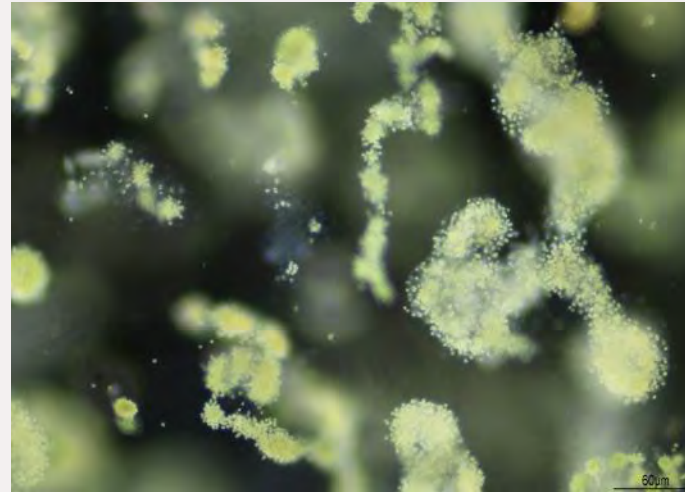


Locke Lake

Barnstead Advisory: August 4 - September 8, 2021

Microcystis, *Woronichinia*, *Dolichospermum*
Over 50 million cells/ml in worst observed

Locke Lake Colony
Recreation and Drinking
(Webster Stream outlet)





exo¹

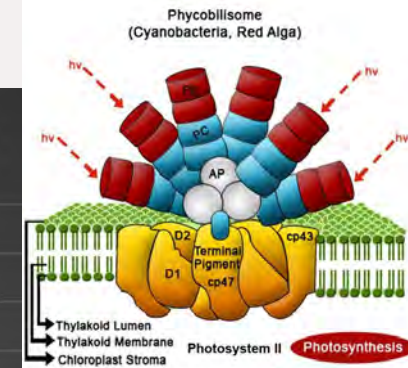
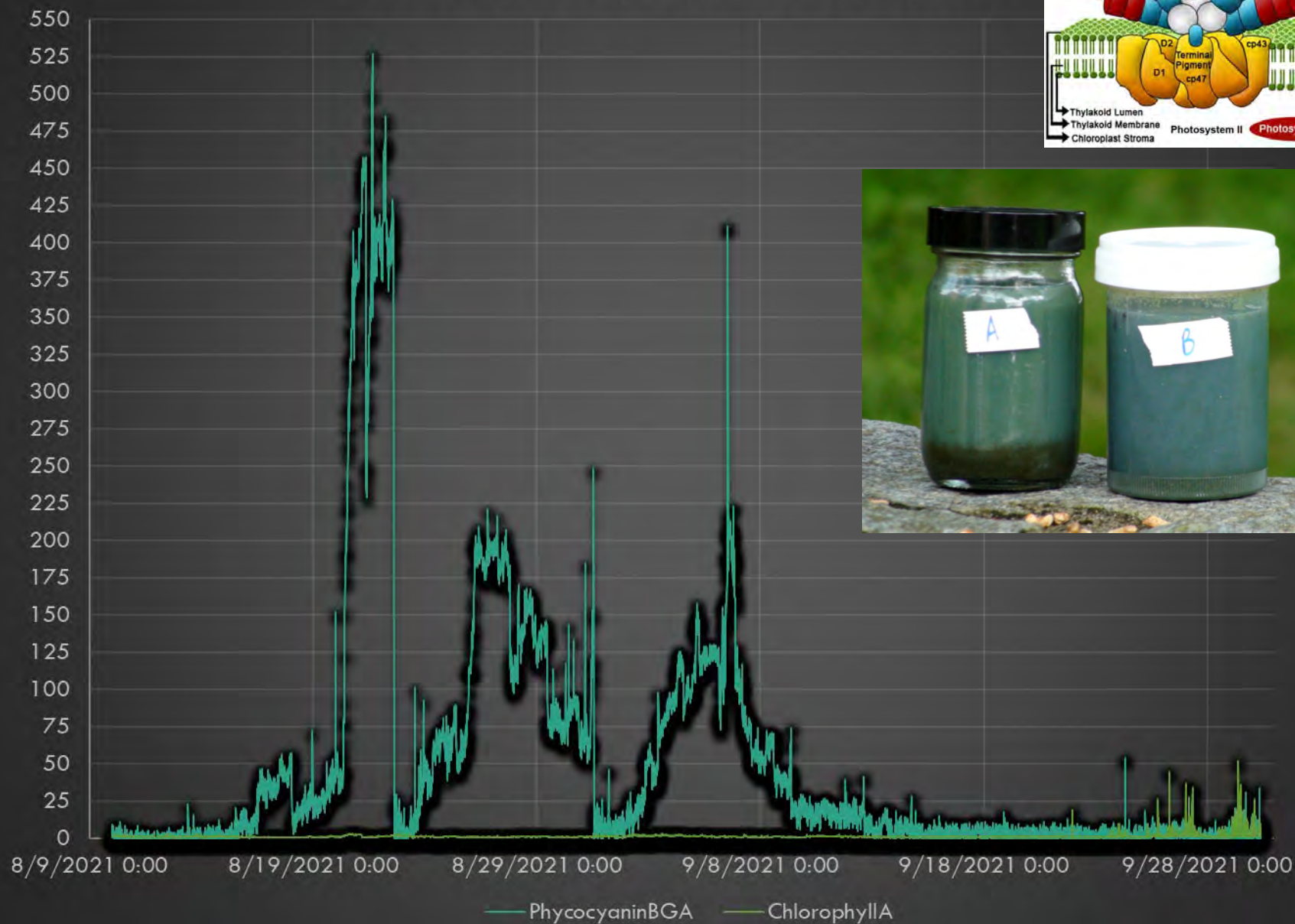
Phycocyanin and
Chlorophyll Fluorescence

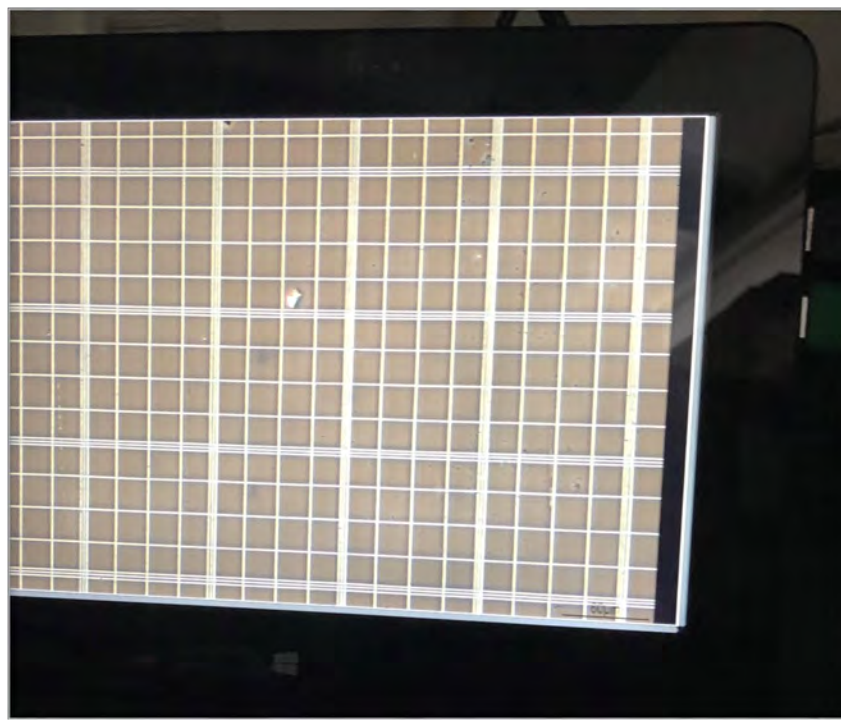
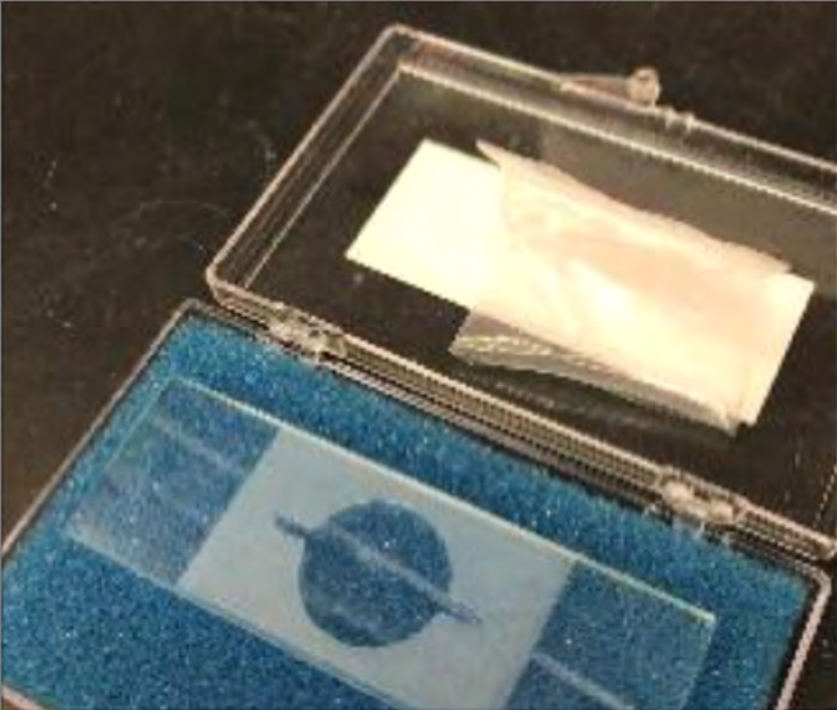
Micrograms/L ($\mu\text{g L}^{-1}$)

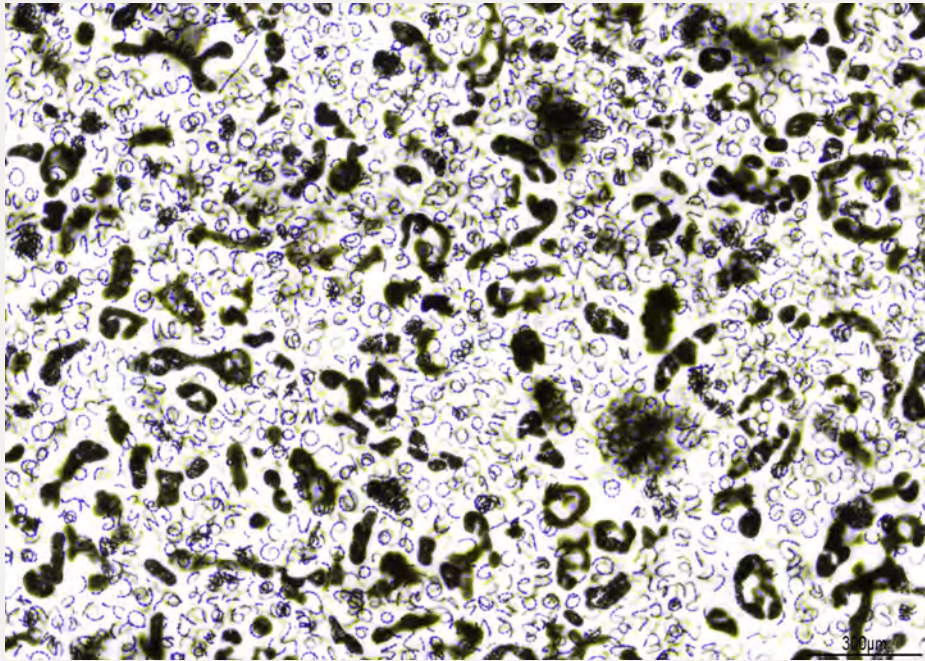
Relative Fluorescent Units
(RFU)

DES/PEU

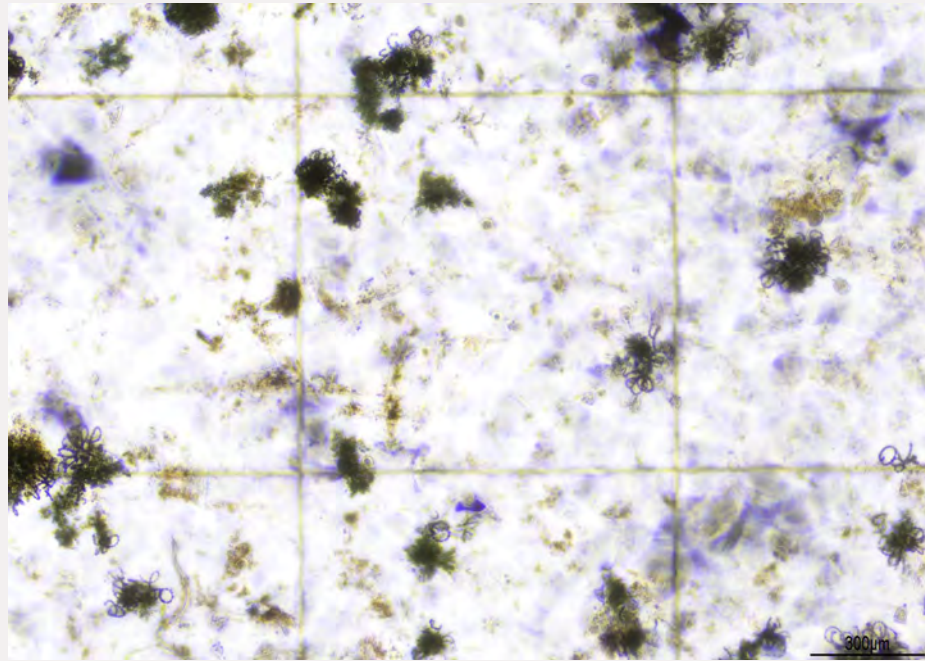
Sonde Data 8/10/2021-9/30/2021





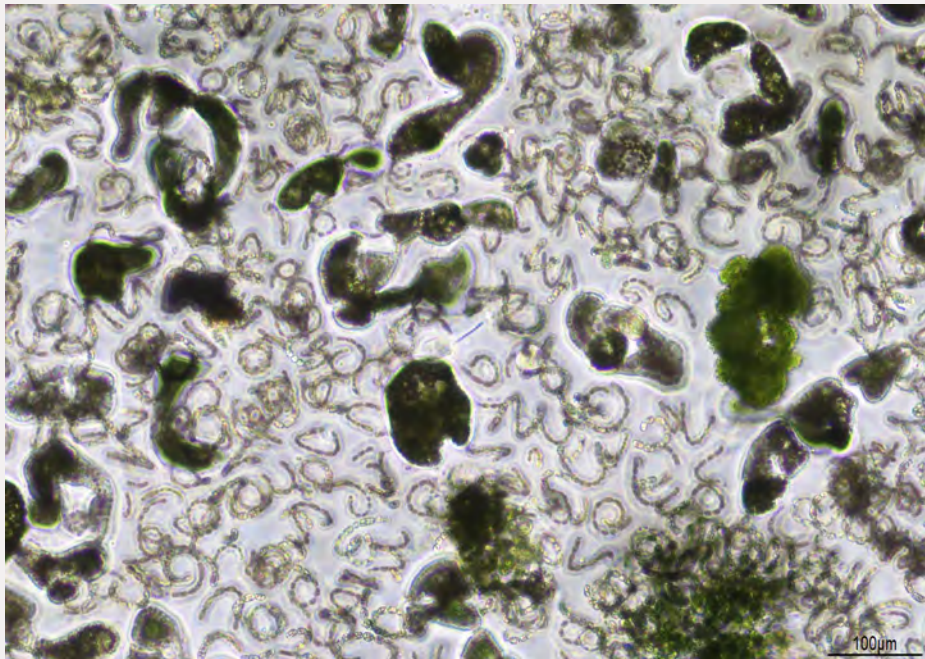


40x

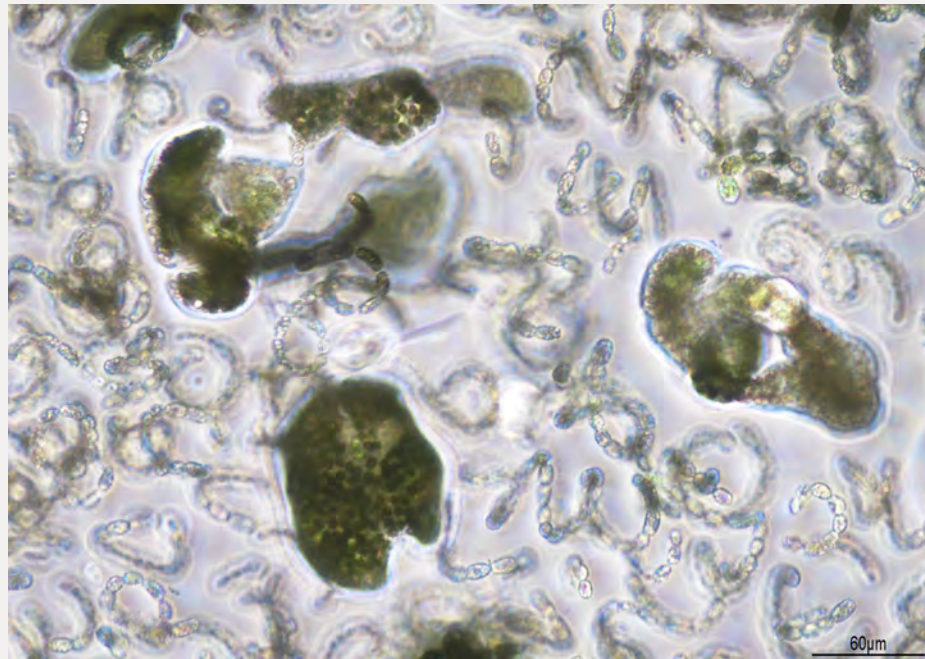


Fine focus on floaters
or sinkers

40x

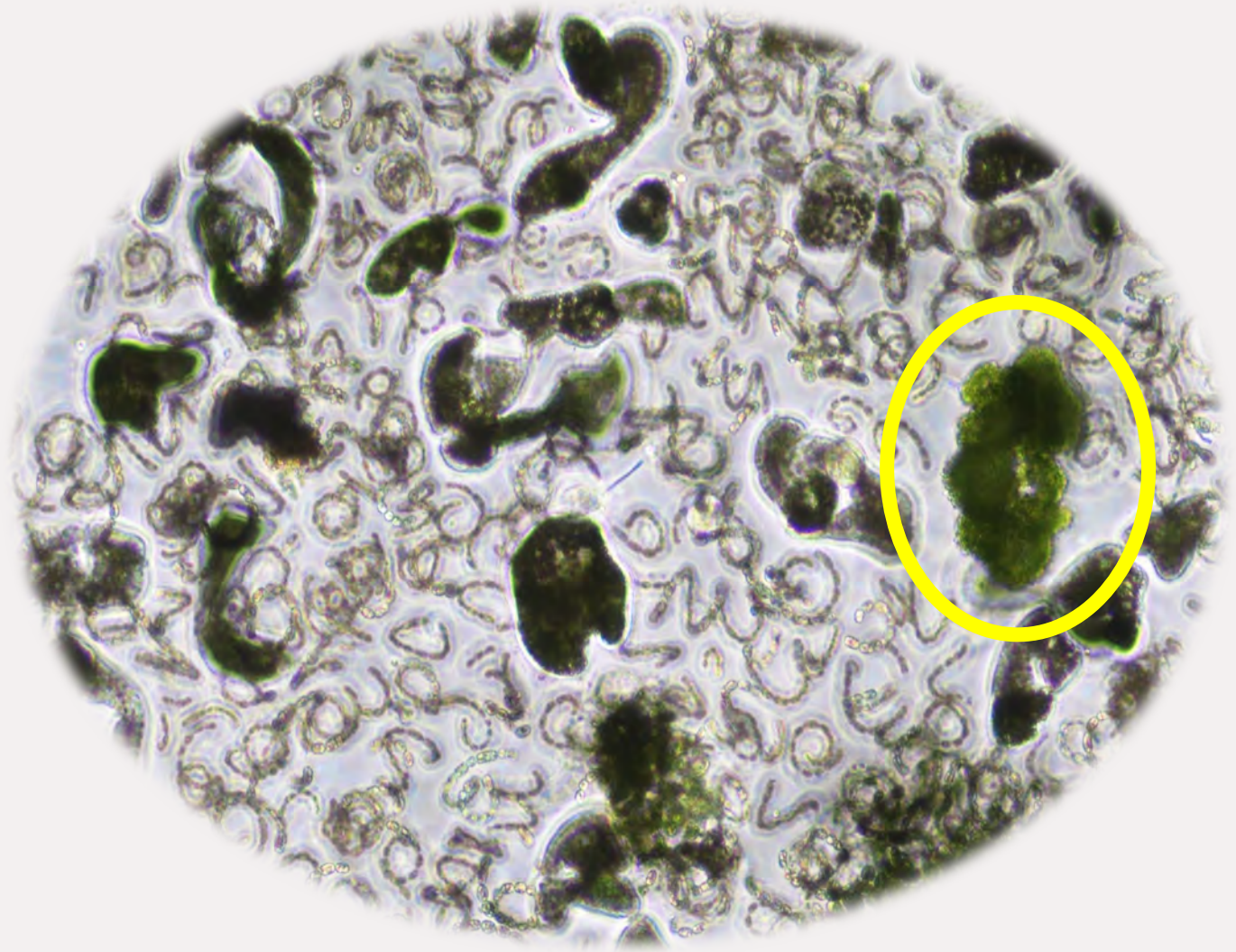


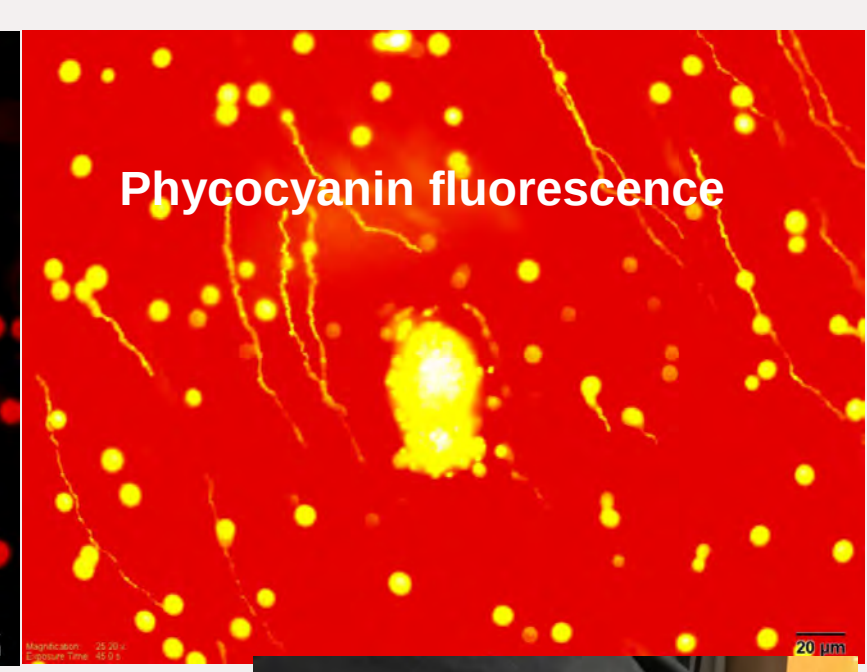
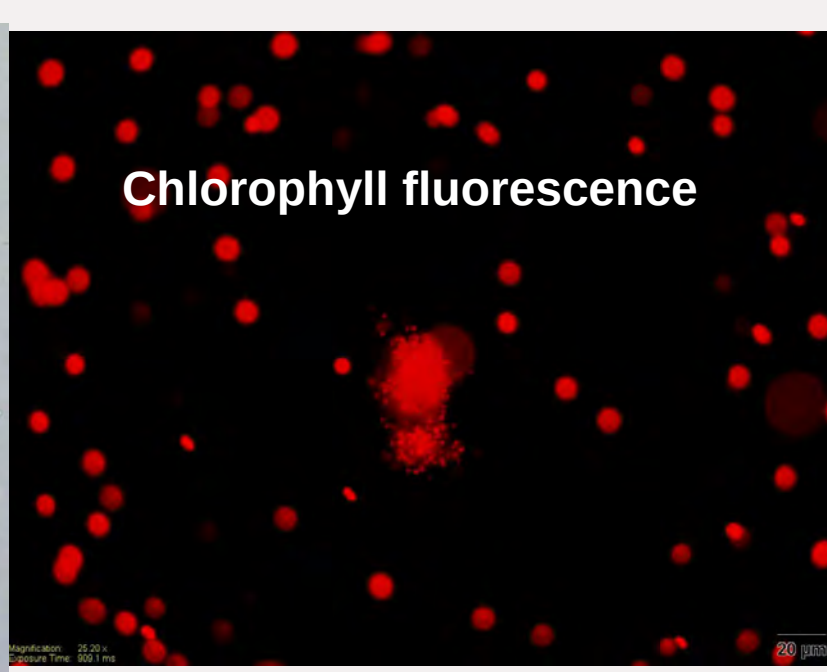
100x



200x

Which colony is
NOT
cyanobacteria?

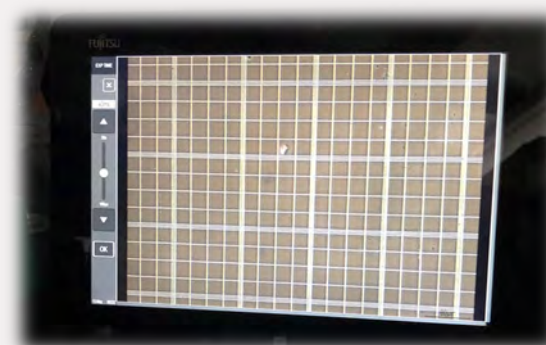




Picocyanobacteria - *Aphanocapsa*

pigment response by epi

Picocyanobacteria can also be detected through pigments responses via fluorometry



Cell can be enumerated with a hemocytometer

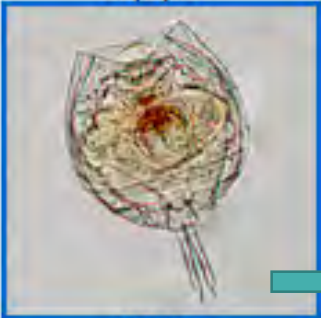




Cladocera



Copepoda



Rotifera



Other Arthropods

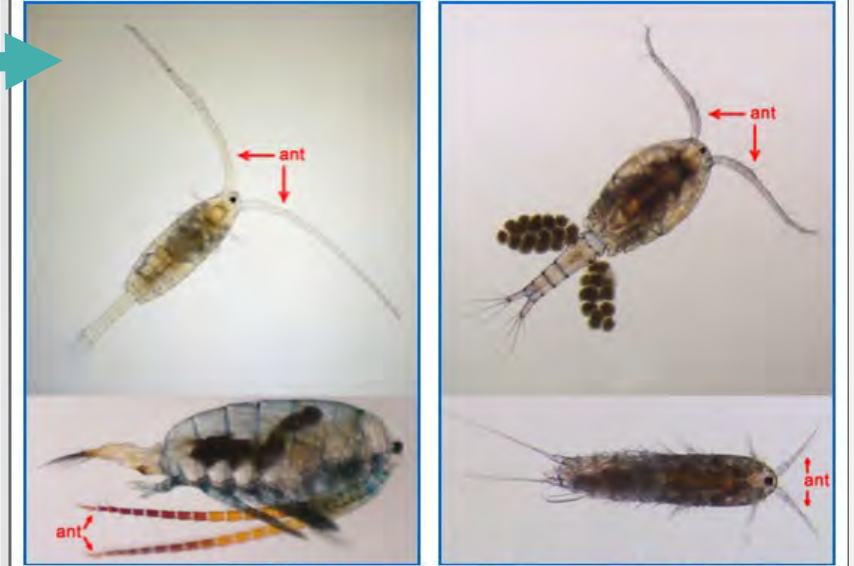
Cladocerans



Rotifers



Copepods



First antennae (ant) long relative to body, with 23 to 25 segments

First antennae (ant) short relative to body, with 18 or less segments

Taxonomy

Phylum	Arthropoda
Subphylum	Crustacea
Class	Maxillopoda
Subclass	Copepoda

Zooplankton
microscopic
animals

Chaoborus



cfb.unh.edu Zooplankton Key

Copepod Types

Calanoids



Predominantly Herbivores

Cyclopoids



Predominantly Predatory Carnivores





Daphnia sp.



Bosmina sp.



Holopedium sp.

Nanoplankton (2-50 μm)

Picoplankton (0.2-2.0 μm)

Net Phytoplankton (>50 μm)



Grazers who are size selective

Daphnia
Zooplankton
Arthropods
Cladocerans

Mesh filters for food particles

Biramous 2nd
Antenna
(With Swimming hairs)

Ocellus

Rostrum

Ventral
Spinules

Post Abdominal
Claws and Pecten

Postabdomen

Eye

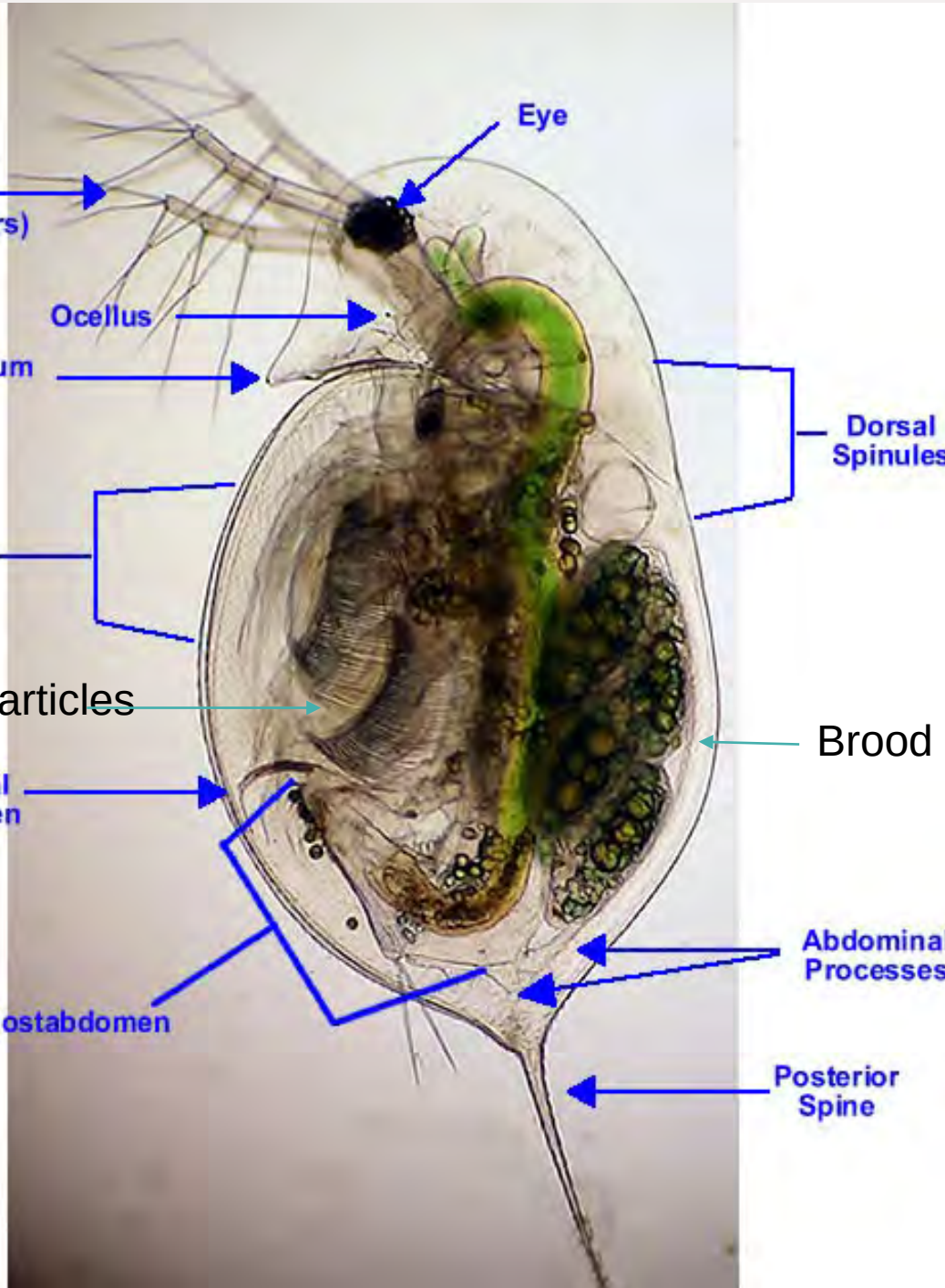
Dorsal
Spinules

Brood chamber with developing eggs

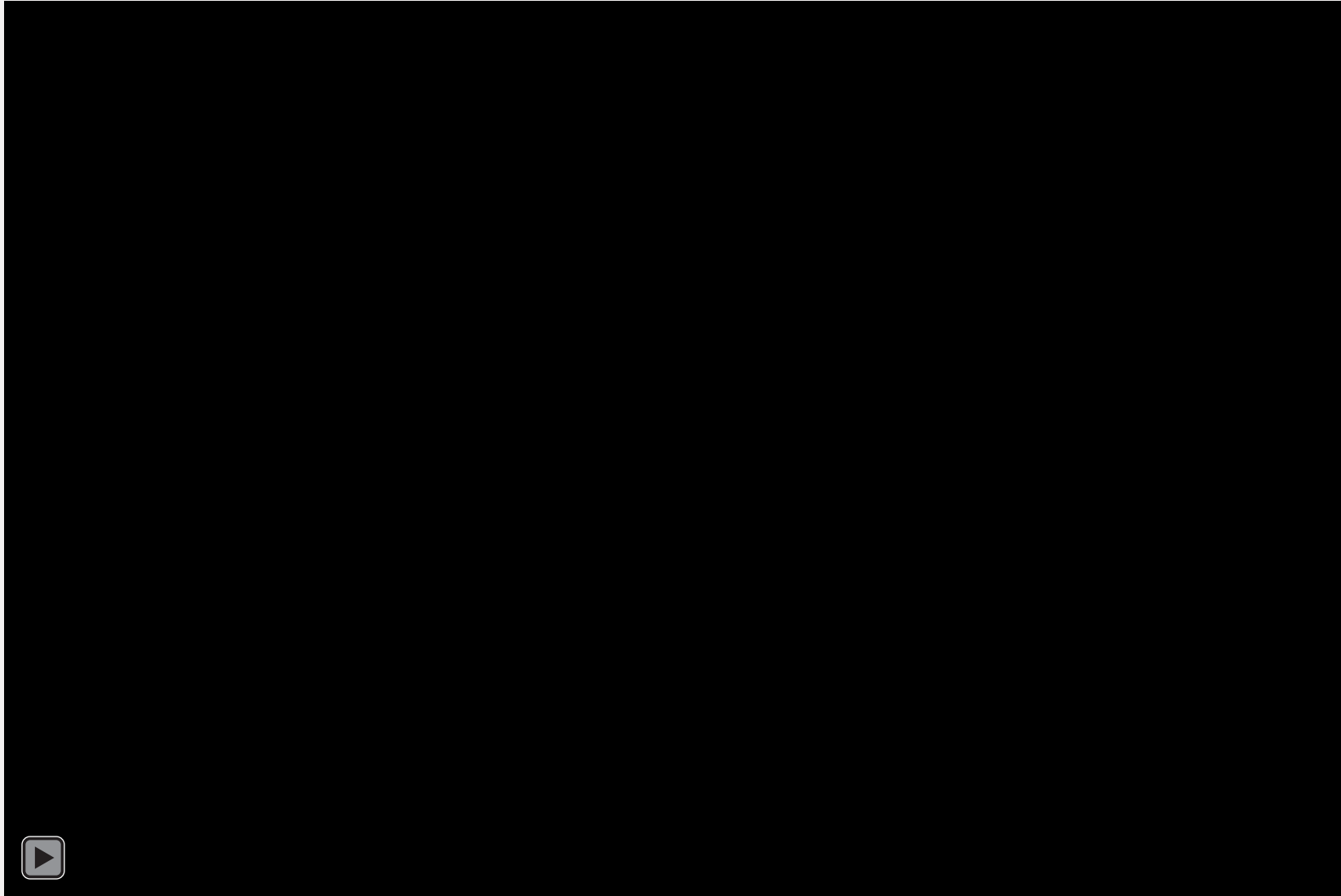
Abdominal
Processes

Posterior
Spine

Parthenogenesis



DAPHNIA MOLTING



DR. JIM HANEY'S
VIDEO OF DAPHNIA
REJECTING CYANOBACTERIA

Post Abdominal Rejections

Picocyanobacteria abundance and toxicity are seasonally variable in NH lakes.

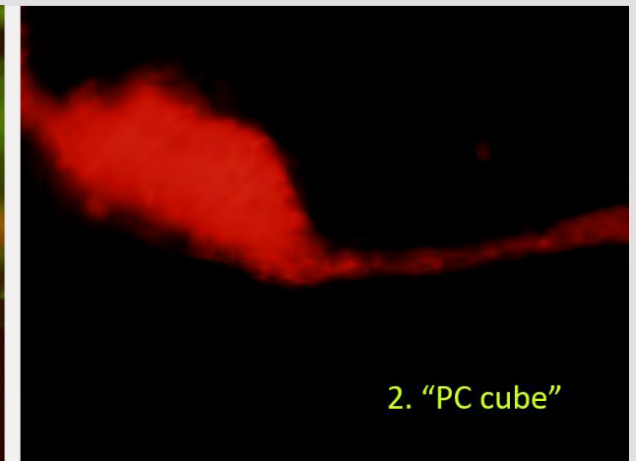
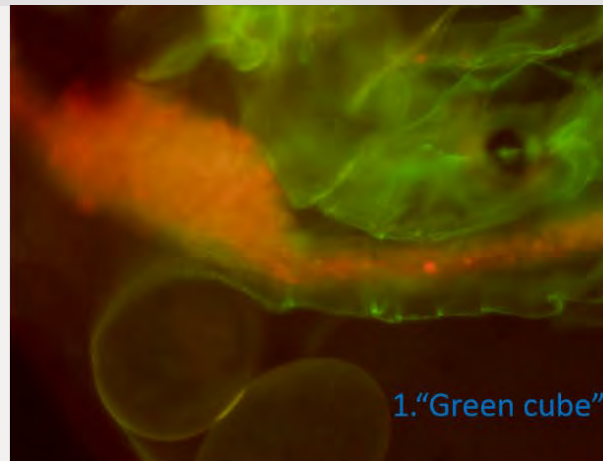
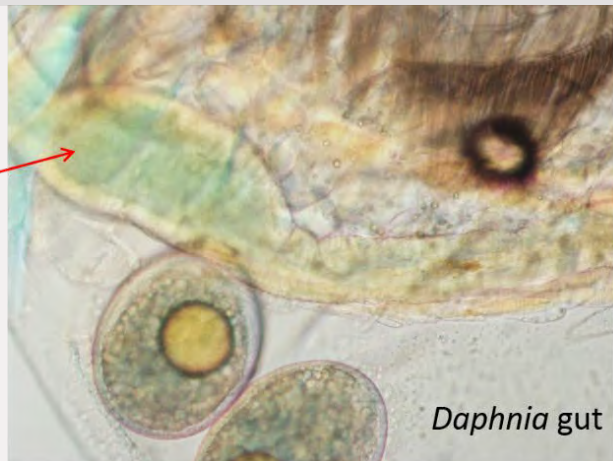




Photo by Kevin Kelly

Resting eggs or “ephippia”
from *Daphnia*

Daphnia with ephippia



Photo by cfb.unh.edu

Daphnia reproduce by parthenogenesis (they clone themselves).

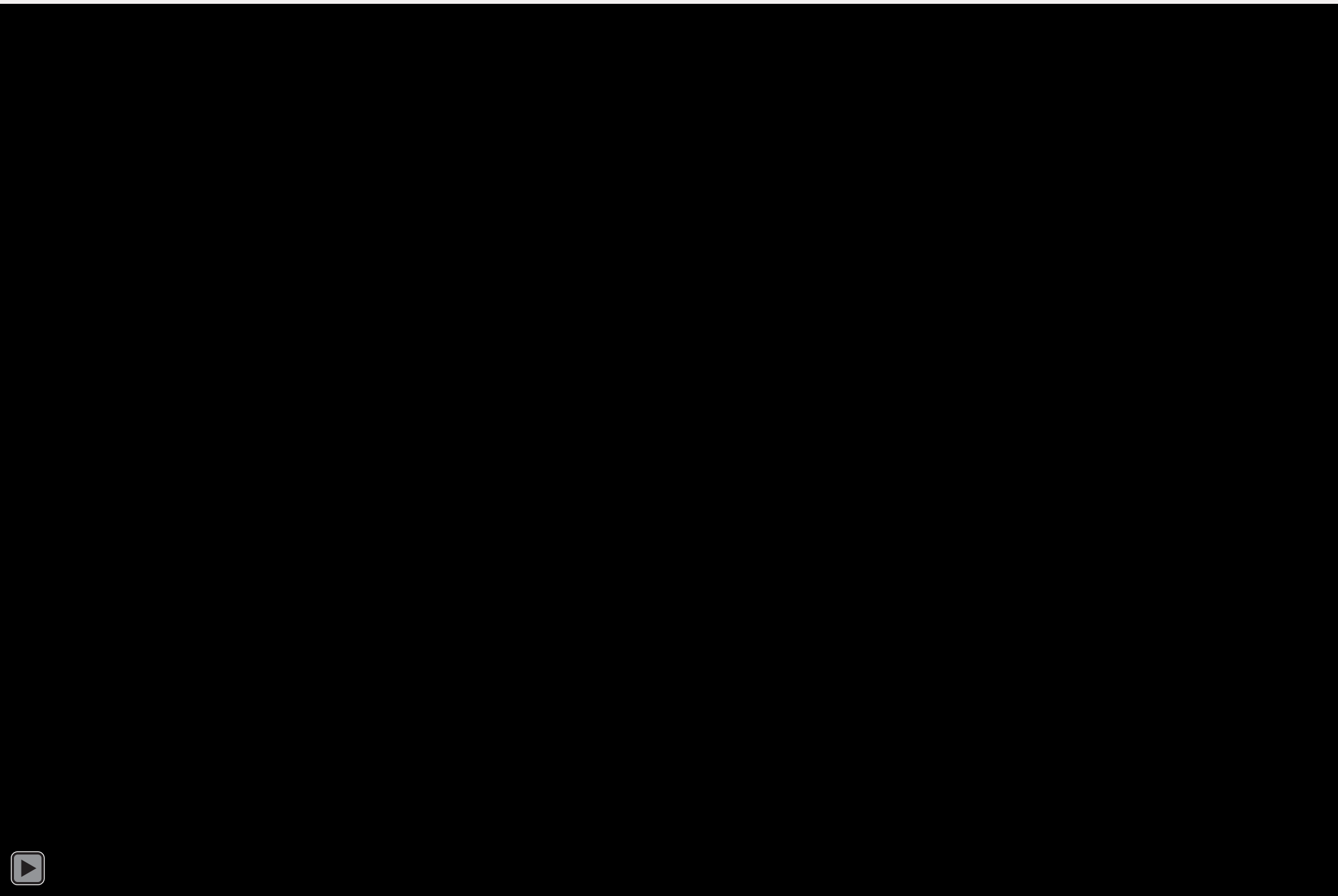
Daphnia may reproduce sexually, resulting in diapause eggs or ephippia.



Photo by Kevin Kelly

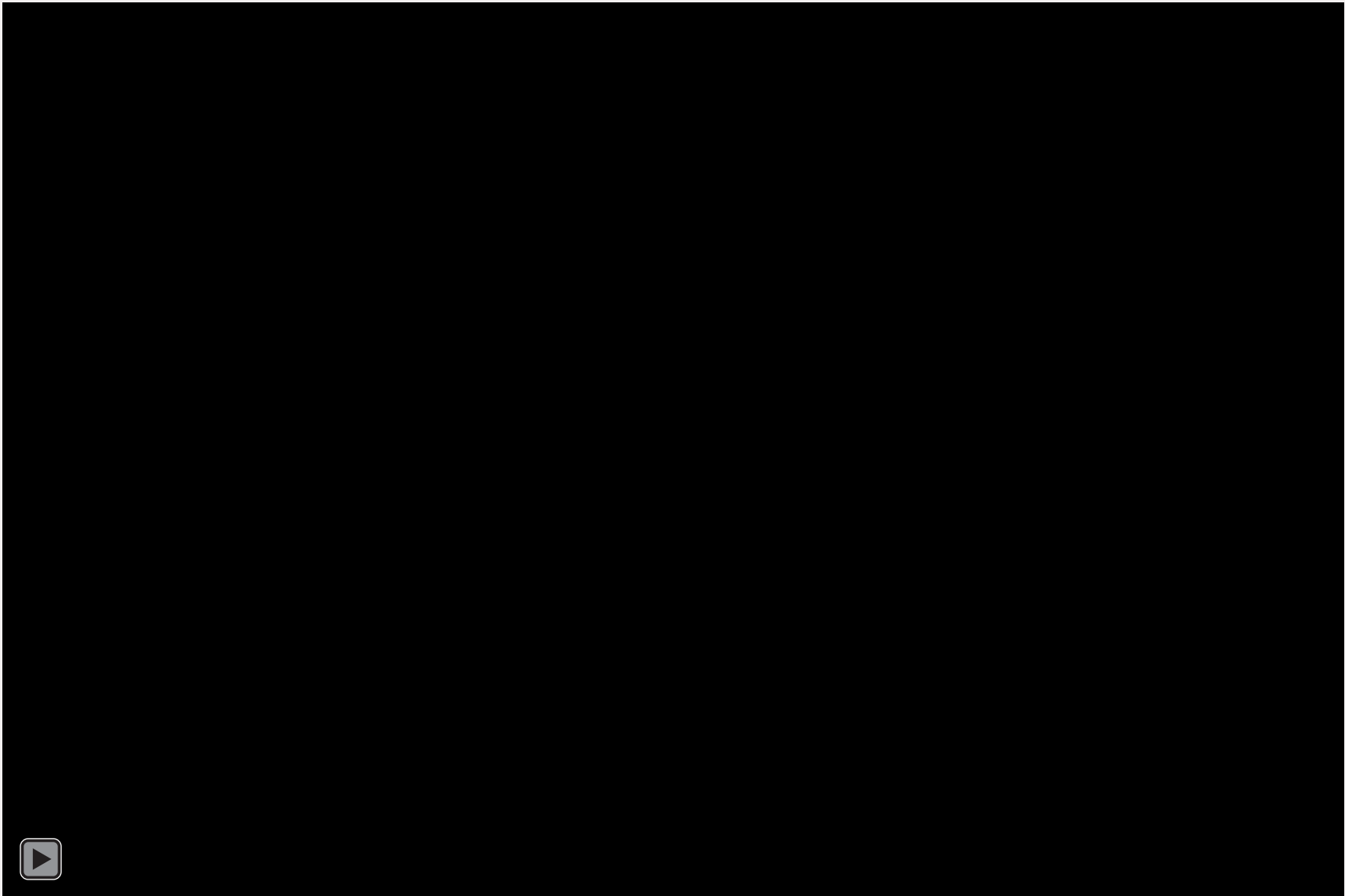
Lake foam (with ephippia)

Lake foam is a product from natural degradation of organic material in waterbodies, lakes, rivers and streams.



Chaoborus: predators on zooplankton

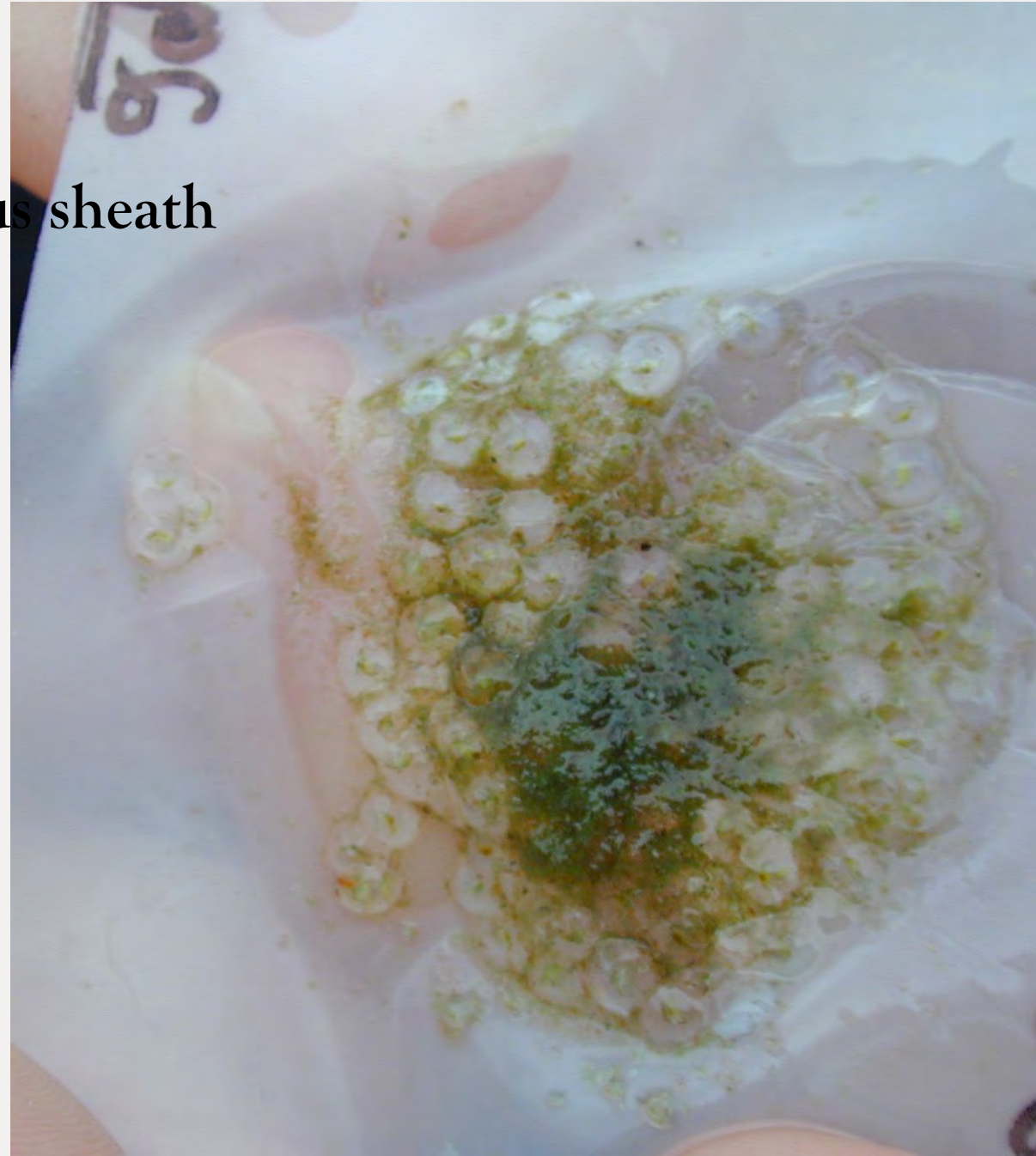
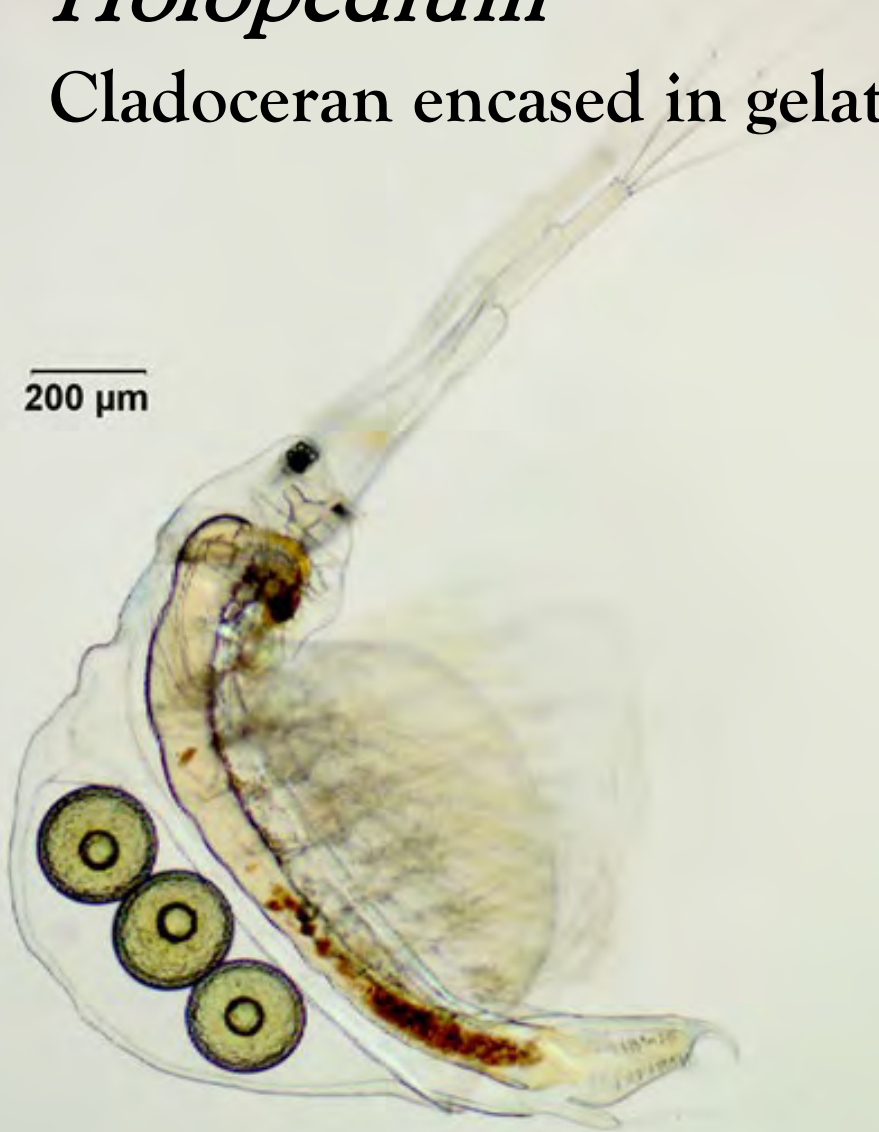


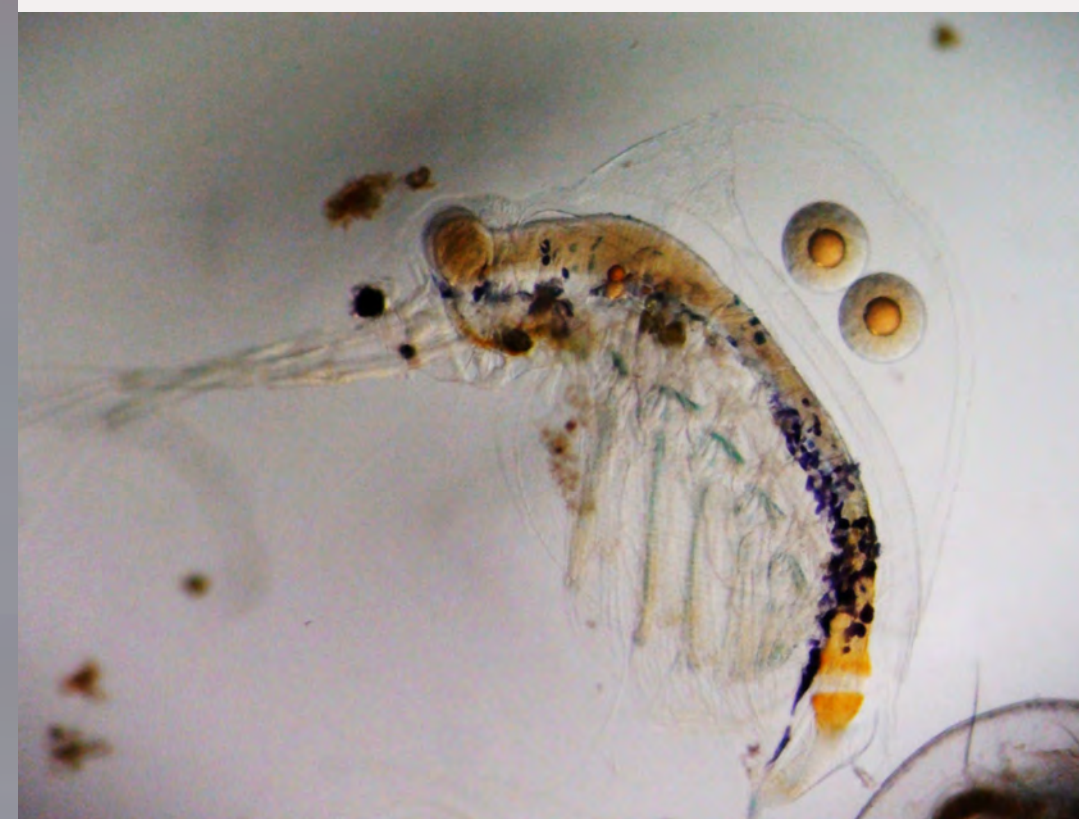


Holopedium

Cladoceran encased in gelatinous sheath

200 μm





“Mysterious goo balls baffle Lake Superior beach-goers”.

Polyphemus pediculus

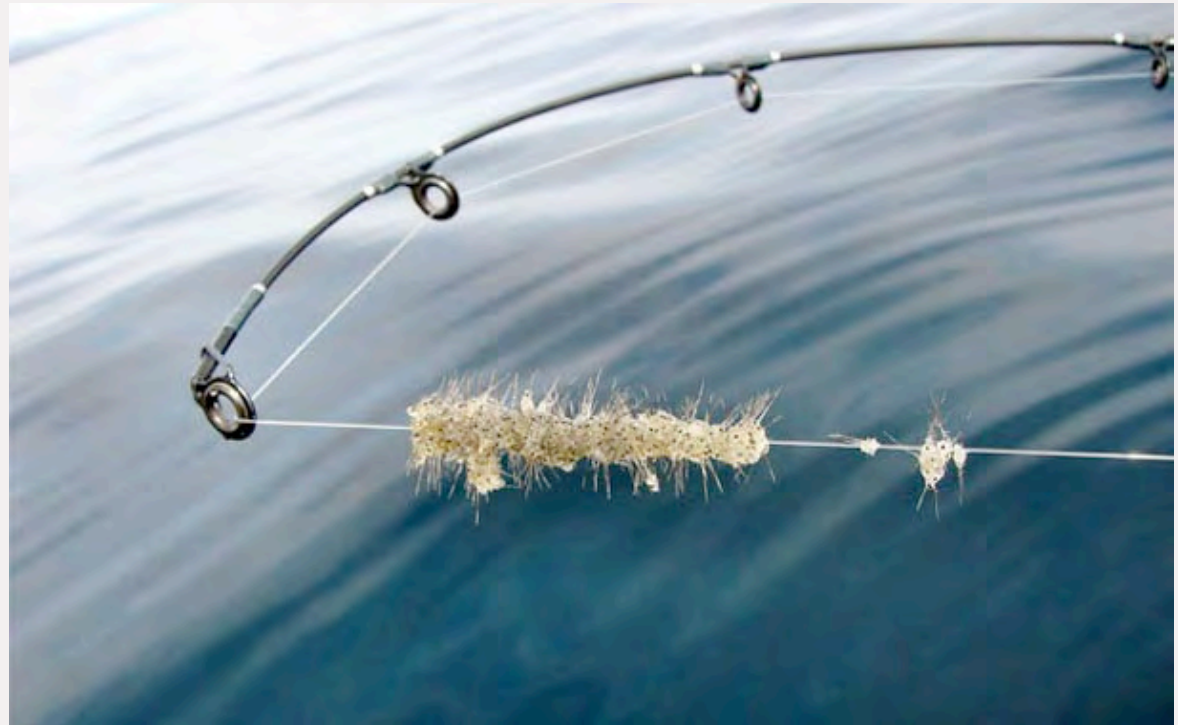
1. **Predatory** cladoceran (1 of 2 species)
2. **Diurnal** daytime active
3. **Visual** predator (most invert predators are tactile)
4. **Rapid** population response: A predator that **reproduces** as **fast** as its prey



***Bythotrephes* (spiny water flea):** Winni- 1st report September 2023



Evolved adaptations to extreme levels of fish predators in Caspian Sea



Invasive spiny water flea found near Lake Champlain
Jun. 29, 2014, 6:17 pm by John Herrick



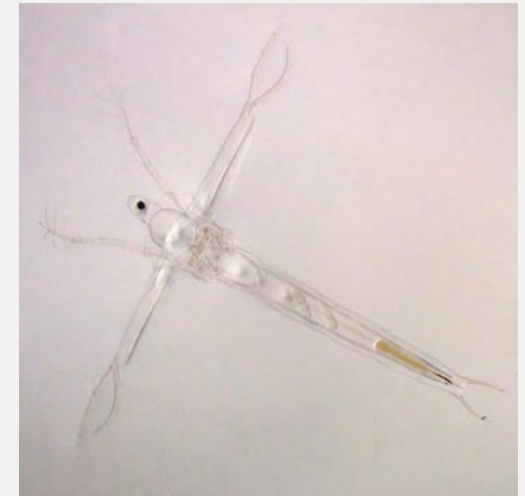
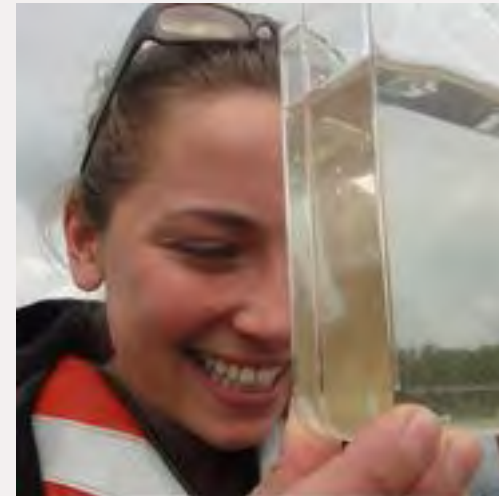
Dr. Amanda McQuaid

Specialist in Lakes, Water Quality & Ecotoxicology

UNH Extension

Amanda.McQuaid@unh.edu

FEEL FREE TO REACH OUT!



ASSOCIATE EXTENSION STATE
SPECIALIST IN ECOTOXICOLOGY
AND WATER QUALITY

EXTENSION PROFESSOR

DIRECTOR OF LAKES LAY
MONITORING PROGRAM

UNIVERSITY OF NEW HAMPSHIRE
COOPERATIVE EXTENSION

JOINT FACULTY IN THE
DEPARTMENT OF BIOLOGICAL
SCIENCES

LAKE STEWARD AND ADVOCATE



Welcome to the
UNH Center for Freshwater Biology



**Taxonomic
Keys:**

["Dirty-Dozen"
Cyanobacteria](#) (beta)

[Aquatic Plants](#)

[Phytoplankton](#)

[Vernal Pool Plankton](#)

[Stream Insects](#)

[Zooplankton](#)



Welcome to the UNH Center for Freshwater Biology



Lakes and streams are among our most valuable and delicate resources. Maintaining the quality of these aquatic ecosystems for present and future generations requires an understanding of the potential problems and their solutions. The Center for Freshwater Biology (CFB) is based at the University of New Hampshire and promotes training, research and outreach activities concerning freshwater systems within the state of New Hampshire, nationally and globally.

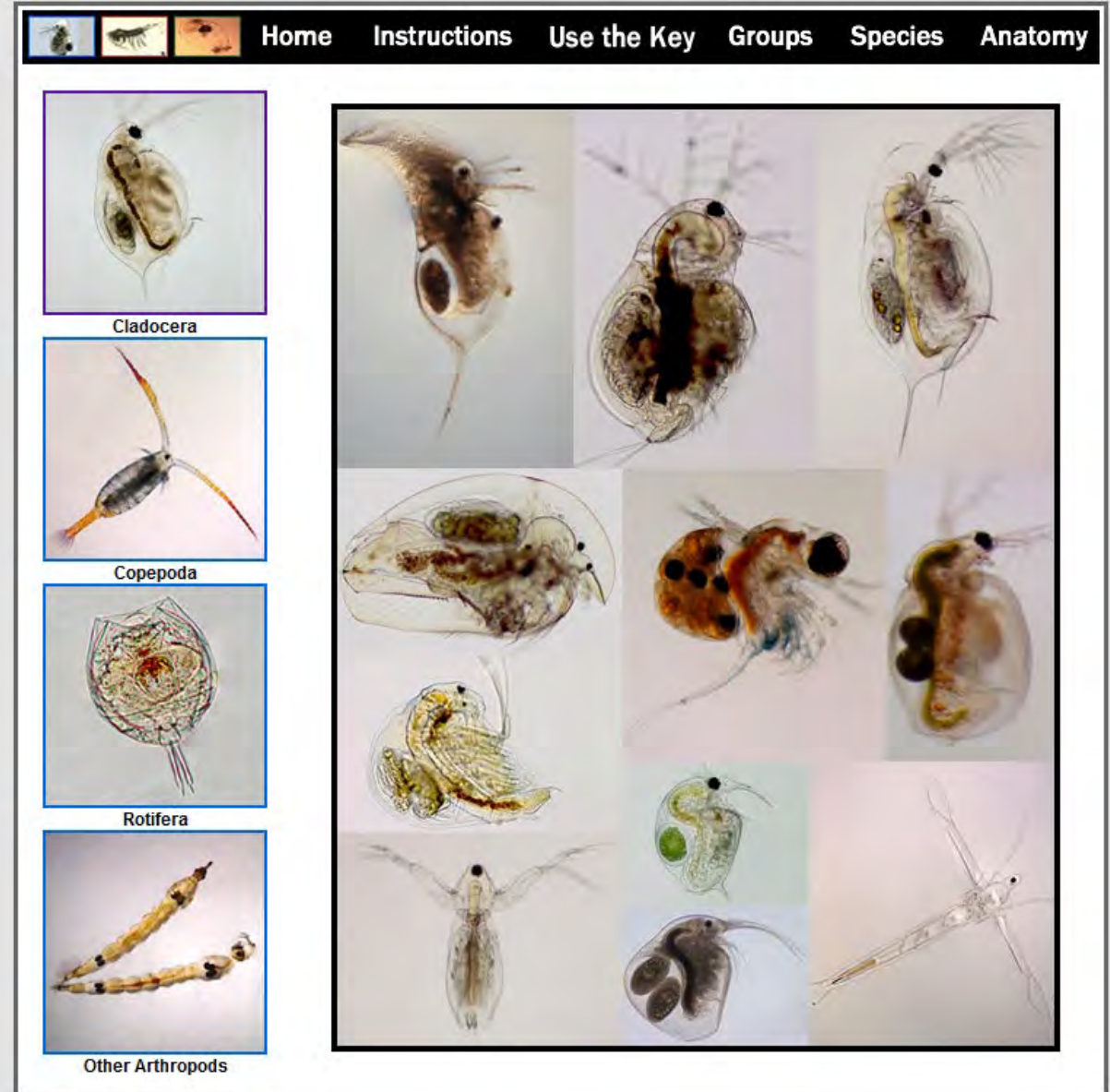
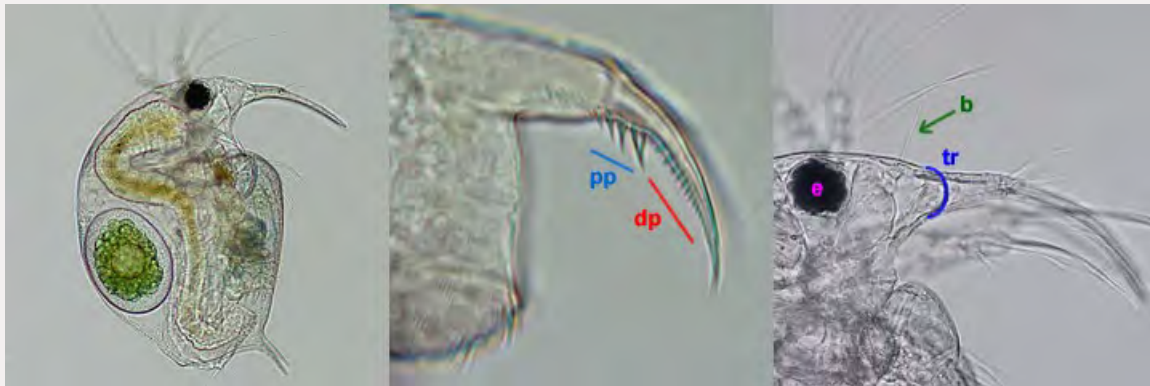
[Contact the CFB](#)

<http://cfb.unh.edu/>

CFB Zooplankton Key

An Image-Based Key To The
Zooplankton Of North America

<http://cfb.unh.edu/cfbkey/html/index.html>



Cyanobacteria Key

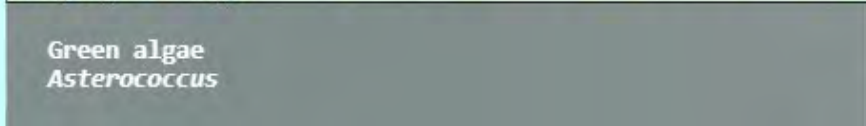
Image size: Normal

Choose the best matching row:

1. **CYANOBACTERIA** - Cyanobacteria cells will not have chloroplasts, flagella, cilia, eyespots, or other visible cell organelles : 3 subgroups



2. **ALGAE WITH CHLOROPLASTS**. Cyanobacteria may look green, blue-green, gray, brown, or even purple, but Cyanobacteria cells do not contain chloroplasts. Here are a few examples of cells with chloroplasts : 0 subgroups: 9 images



[Cyanobacteria key \(snoringcat.net\)](http://snoringcat.net)

Robin Matthews- Northwest, USA



Welcome to the cyanobacteria key
To start, click here!

Version 1.2

Robin Matthews and Geoffrey Matthews

Commonly observed Potentially Toxigenic (PTOX) Cyanobacteria

To guide researchers and other labs, we have put together a list of cyanobacteria that have been shown to produce toxins and made it freely available to the public: [PTOX Cyanobacteria list](#)

At GreenWater Laboratories, we have been developing a list of the suspected and confirmed potentially toxigenic (PTOX) cyanobacteria in order to guide our analysts in toxin analysis recommendations.



front standard v 3.5.1 (usgs.gov)

Field and Laboratory Guide to Freshwater Cyanobacteria Harmful Algal Blooms for Native American and Alaska Native Communities



acteria and their associated cyanotoxins.



PhycoTech, Inc. |
Environmental
Consulting in St.
Joseph, MI



Appendix A. Visual Guide to Common Harmful Cyanobacteria – hcb (itrcweb.org)

Strategies for Preventing and Managing Harmful Cyanobacterial Blooms (HCBs)

Appendix A. Visual Guide to Common Harmful Cyanobacteria

A.1 Introduction

Cyanobacteria, also known as **blue-green algae**, are a group of microorganisms that live in freshwater and marine habitats throughout the world. Several cyanobacteria species have the ability to produce cyanotoxins, which pose a threat to human health—especially for those who directly consume water and fish taken from a water body with a high concentration of cyanobacteria. Please see [Section 3](#) for important information about health concerns associated with exposure to cyanobacteria blooms.

Technically, cyanobacteria are **bacteria**; however, the names **algal bloom** and **harmful algal bloom (HAB)** have persisted for many decades. In this document, we specifically refer to blooms composed of cyanobacteria as **harmful cyanobacterial blooms (HCBs)**. HCBs typically form under specific conditions, such as those with abundant nutrients, a stable water column, ample light, and warm temperatures. Most **planktonic** cyanobacteria also regulate their buoyancy to optimize their position in the water column or float to the surface. Wind can disrupt this process and allow massive accumulations of organisms on the leeward shoreline of a water body.

Warming global temperatures may exacerbate the issue of cyanobacteria blooms. One reason is because these blooms proliferate at very warm water temperatures and are more tolerant of these warmer conditions than their competitors, such as green **algae**. In addition, warming temperatures and less ice cover are creating a longer **growing period**, or the length of time when a water body is above the temperature threshold that favors cyanobacteria. See [Section 3](#) for more information.

Appendix

Appendix A. Visual Guide to Common Harmful Cyanobacteria

Appendix B. North American Lake Management Society survey on HCB notification/outreach

Appendix C. Management Strategy > Fact Sheets

Appendix D. Team Contacts

Cyanosite

25 YEARS • 1994-2019

HOME IMAGES RECIPES TOXINS LINKS CONTACT

USAGE POLICY CREDITS SUBMISSIONS

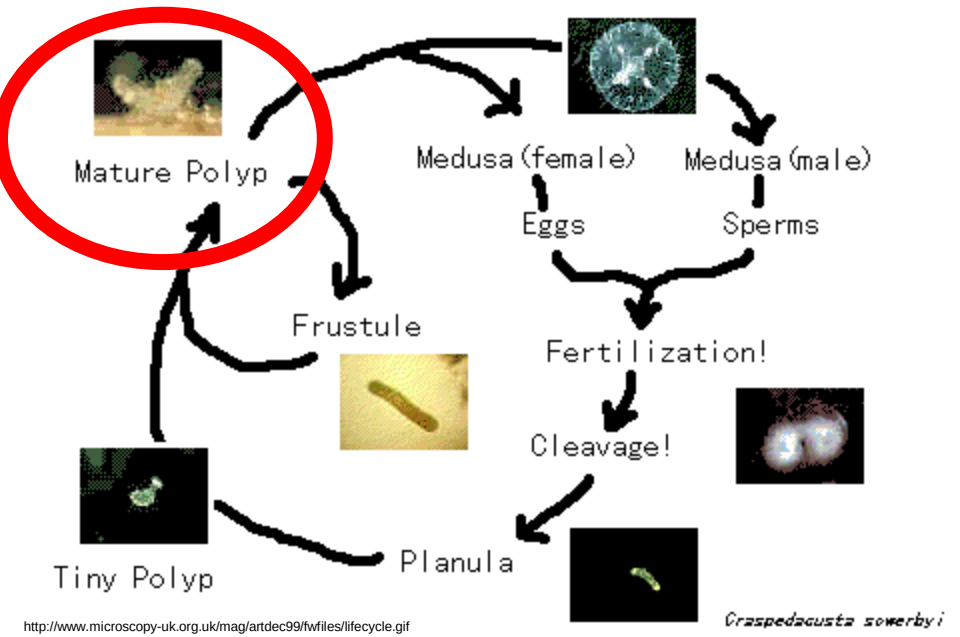
Cyanobacteria Image Gallery

Cyanosite Image Gallery (purdue.edu)

Videos

The Great Escape

Grazing on Cyanos



Jellyfish!

Medusa



https://www.google.com/urn:sa=1&un=https%3A%2F%2Fwww.hrwc.org%2Fflake-monitoring-volunteers-spot-an-elusive-critter-the-freshwater-jellyfish%2F&sig=ACuVaw1_ePLDH7MM5eHQM4kRUE=s

Medusa



https://www.gannett-cdn.com/presto/2018/09/21/PSPR/2db32aea-15ca-48a2-8495-a7e7fc61c582-fresh_water_jellyfish_photo.jpg?crop=2437,1373,x0,y0&width=2437&height=1373&format=pjpg&auto=webp

- The polyp stage (a developmental form) occur on the bottom sediments of lakes with jellyfish, rarely observed
- The medusa (free swimming) is the form we see up in the water column



Various polyp stages attached to sediment

Matthias Jacob Schleiden

Medusa



https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcQy-P6d-4xzXNx4mF-ul_Tlb4mSY6iXflpWAg&usqp=CAU

IRON BACTERIA/IRON PRECIPITATE

- Iron bacteria are microscopic but their stalks can be macroscopic
- The iron floc and slime they cause is macroscopic and very visible
- Can stick to bottom, coat rocks, or be a sludgy mat
- Not harmful, but can be unsightly
- Can even occur in wells!

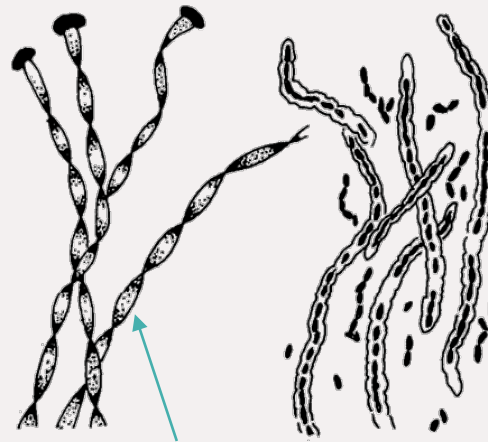


alamy stock photo

CPFBN
www.alamy.com



https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.loe.org%2Fshows%2Fsegment-s.html%3FprogramID%3D14-P13-00023%26segmentID%3D5&psig=AOvVaw19mrvg_17VqG8wbl6a6J&ust=1614697874563000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCMCa38ywj-8CFQAAAAAdAAAAABAP



Some research suggests
That these stalks help attach
The bacterium to the sediment

The touch test: Does it shatter or go right back together? If it shatters, it's iron!



https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.piquenewsmagazine.com%2Fwhistler-news%2Fnaturespeak-is-that-oil-on-the-beach-2507979&psig=AOvVaw19mrvg_17VqG8wbl6a6J&ust=1614697874563000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCMCa38ywj-8CFQAAAAAdAAAAABAP