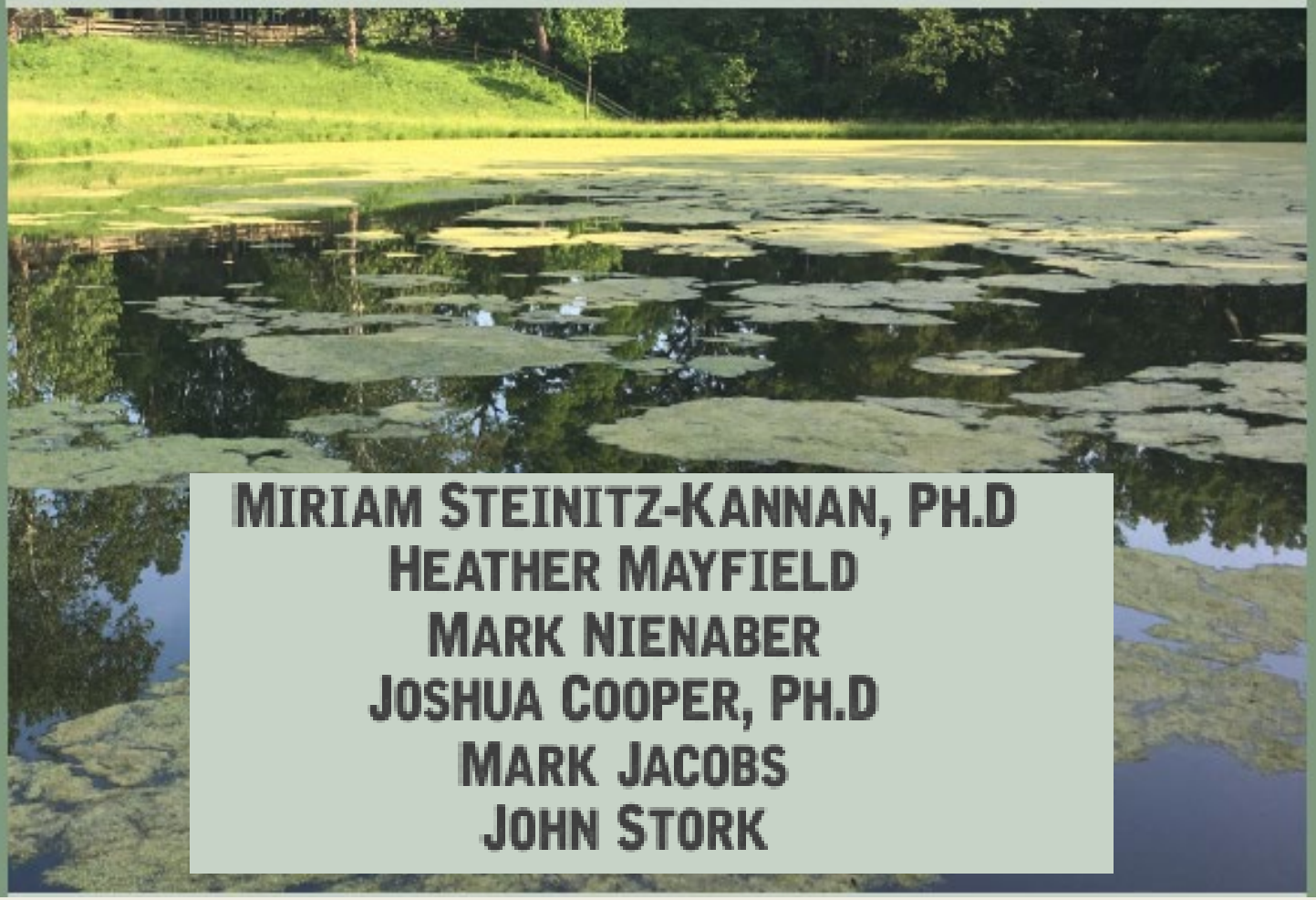
THE GOOD, THE BAD & THE MANAGED:

How to Identify and Manage Algae Scums In Agricultural and Residential Ponds.



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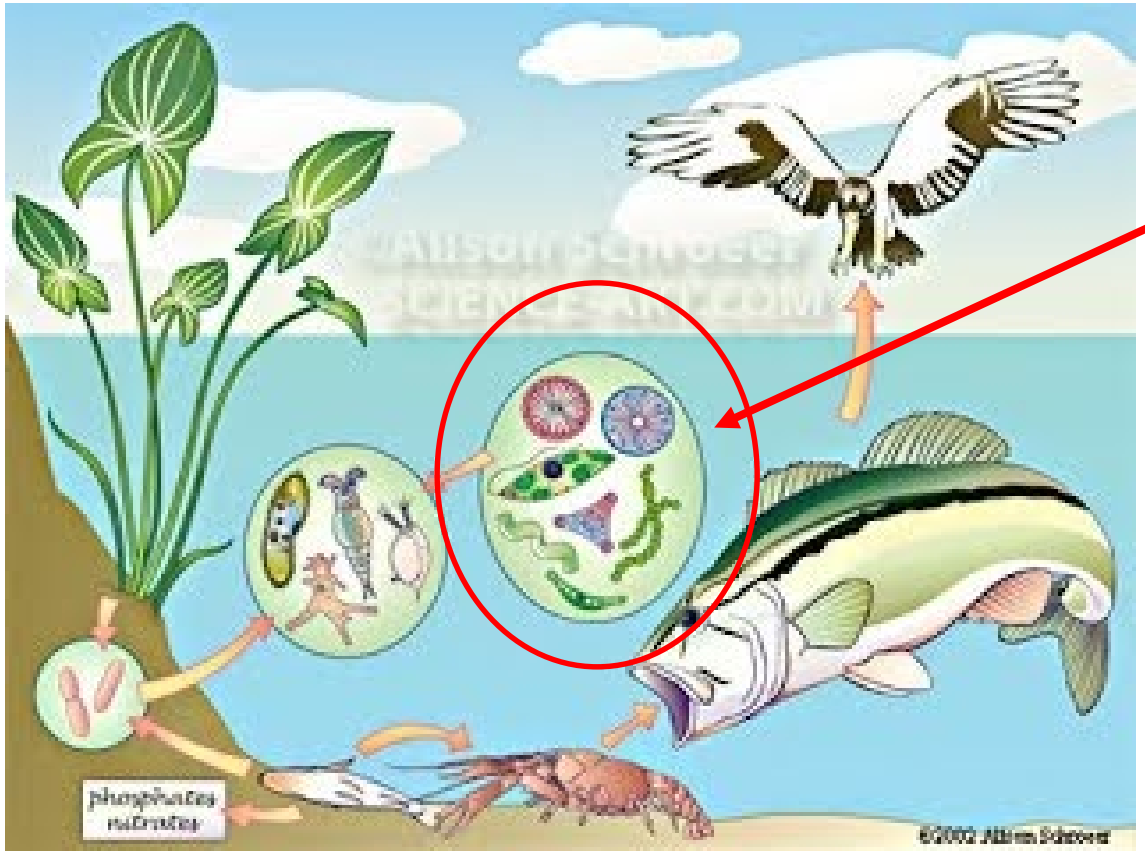
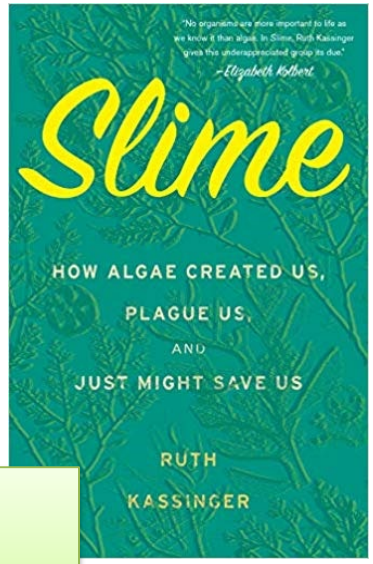
Purpose of Workshop

- Learn to Identify common algal scums that appear in farm and urban ponds.
- Provide you with a field guide and simple training to distinguish potentially toxic blooms (HABs) from harmless algae.
- Provide you with a guide to Best Management Practices to prevent and control algae problems.

What are Algae ?



- The basis of aquatic food webs
- Capture CO_2 and release Oxygen through photosynthesis



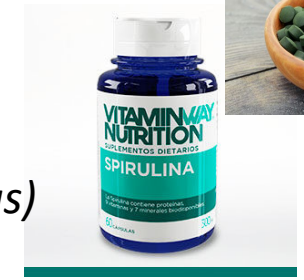
"No organisms are more important to life as we know it than algae.—Elizabeth Kolbert

The Good about algae

- Basis of all aquatic food webs
- Agriculture:
  - Biofertilizers
  - Fix Nitrogen
  - Nutrient cycling
- Human Food:
  - Supplements and Additives
  - Aquaculture
- Environment
  - Biofuels
  - Bioremediation
  - Bioindicators

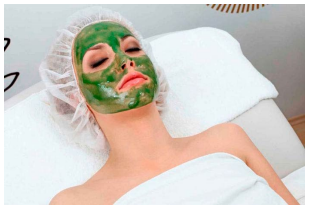
Spirulina (Arthrospira)

Astaxanthin *(Hematococcus)*

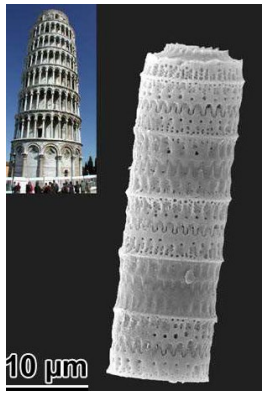


Betacarotene *(Dunaliella)*

Omega 3 Fatty acids (diatoms)

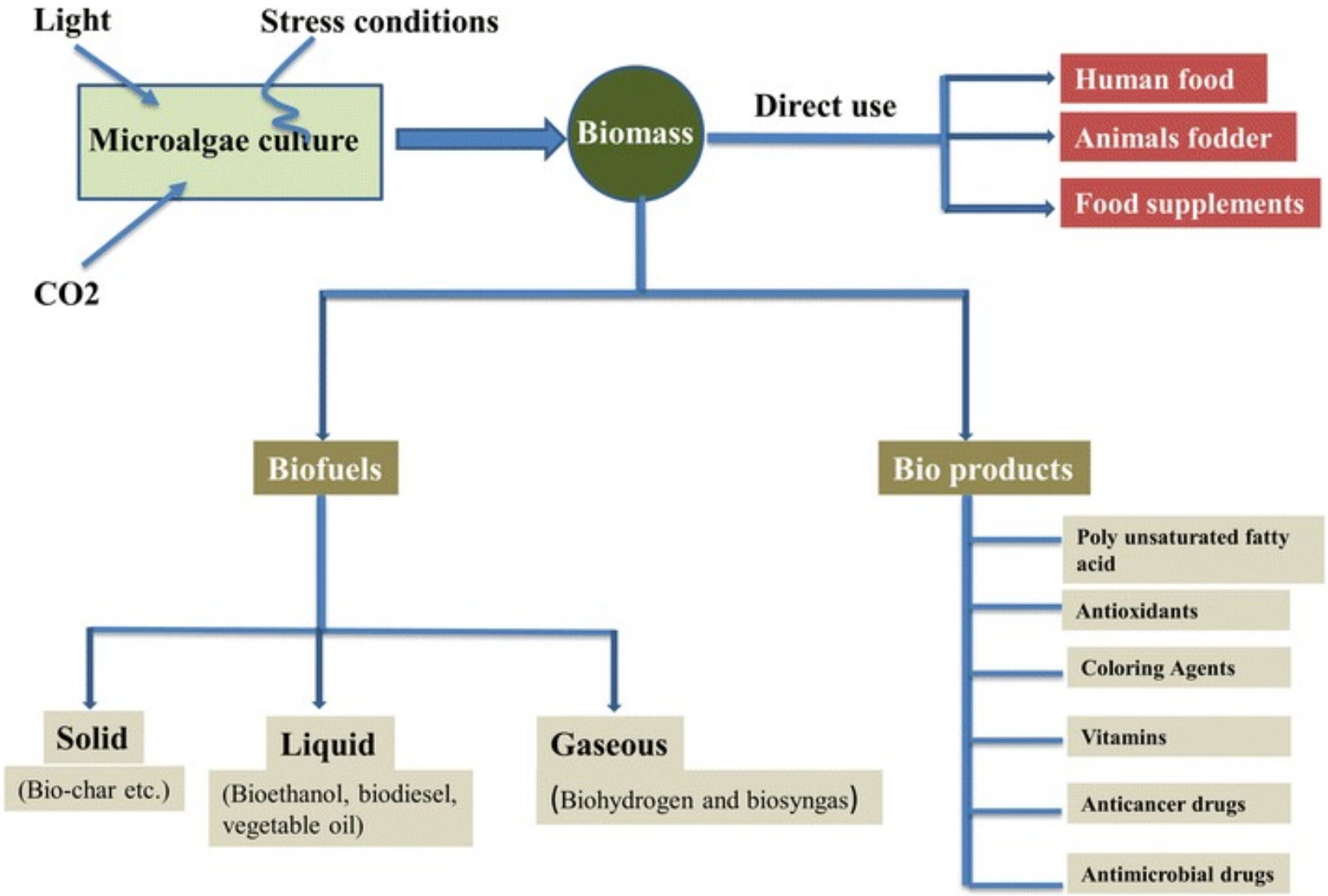


Cosmetics



Nannotechnology

Industrial uses of algae



The Bad about algae

Toxins
HABs

Too much algae can cause Oxygen deficits as the bloom dies = Fish kills

Health Impacts of Cyanotoxins

CLEAN WATER ACTION
CLEAN WATER FUND

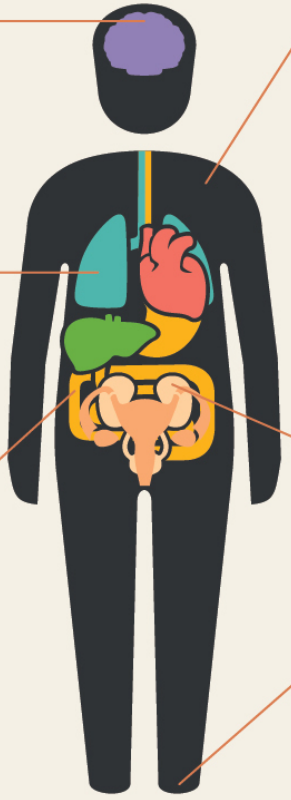
Note: *Not all cyanotoxins lead to all of these health impacts. These listed impacts are caused by microcystins or cylindrospermopsin, the two cyanotoxins that EPA has issued Health Advisories for.*

IN HUMANS

Brain
Source: Ingestion
Symptoms:
- Headache
- Incoherent speech
- Drowsiness
- Loss of coordination

Respiratory System
Source: Inhalation
Symptoms:
- Dry cough
- Pneumonia
- Sore throat
- Shortness of breath
- Loss of coordination

Digestive System
Source: Ingestion, drinking contaminated water, or eating contaminated fish
Symptoms:
- Abdominal pain
- Nausea
- Vomiting
- Diarrhea
- Stomach cramps



Body
Source: Contact, e.g. swimming
Symptoms:
- Irritation in eyes, nose, and throat
- Blistering around the mouth
- Skin rash, including tingling, burning and numbness
- Fever
- Muscle aches (from ingestion)
- Weakness (from ingestion)

Organs
Source: Ingestion
Symptoms:
- Kidney damage
- Abnormal kidney function
- Liver inflammation

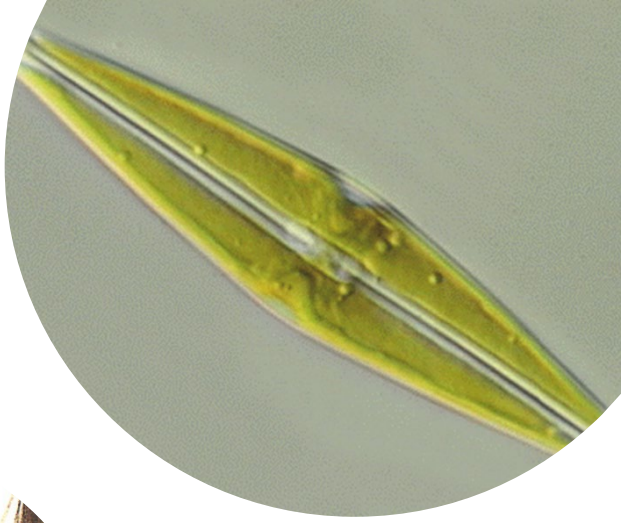
Nervous System
Source: Ingestion
Symptoms:
- Tingling
- Burning
- Numbness

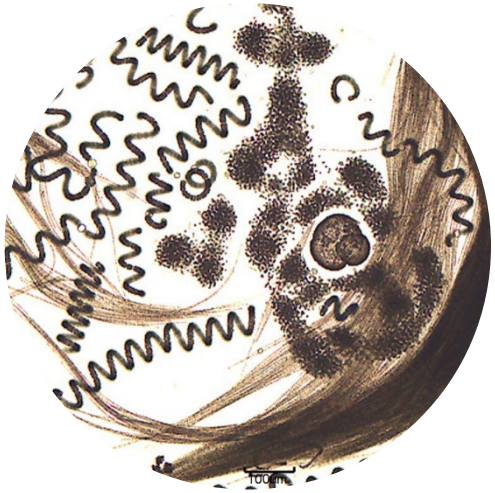
IN PETS

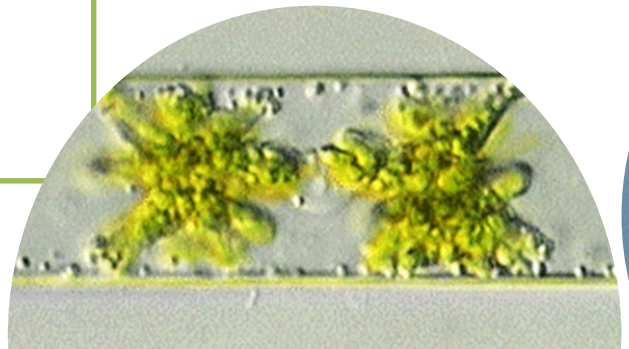
Symptoms:
Vomiting
Fatigue
Shortness of breath
Difficulty breathing
Coughing
Convulsions
Liver failure
Respiratory paralysis leading to death

The Diversity of algae

- There is a great diversity of species in nature
- Balanced pond ecosystems Will have more Good algae, and few of the “bad” algae.
  - **The GOOD:** Diatoms, most green algae
  - **The BAD:** Many Cyanobacteria and Dinoflagellates that may produce toxins







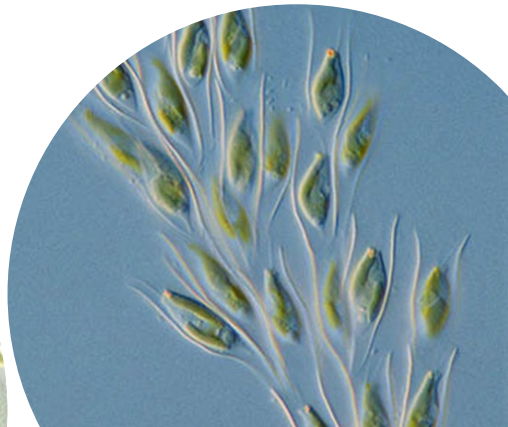
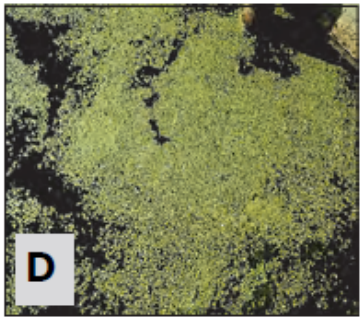


TABLE 1. FRESHWATER ALGAE CLASSIFICATION

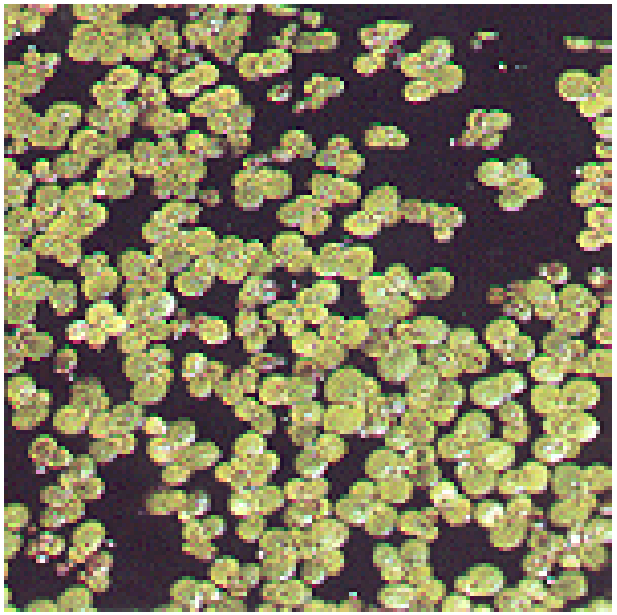
ALGAE GROUP	GOOD	BAD
DOMAIN BACTERIA		
Blue-green Algae (Cyanobacteria)	Produce oxygen for the atmosphere. Some contain bioactive compounds for potential medical use. Some used as biofertilizers. *Spirulina* and *Arthrospira* used as food supplements and antioxidants.	Many genera can produce toxins, including hepatotoxins (liver toxins), neurotoxins, cytotoxins (cell toxins), dermatoxins (skin toxins), respiratory and olfactory irritant toxins. Some cause allergic reactions. Some produce taste/odor compounds that are problematic for drinking water treatment.
DOMAIN EUKARYA		
Euglenas (Euglenophyta)	Some contain anticancer agents. Contain paramylon, a complex carbohydrate used to boost the immune system and treat arthritis.	*Euglena sanguinea* can produce ichthyotoxins (fish toxins). Can be indicators of organic pollution.
Golden Algae (Chrysophyta)	Some used in agriculture as feed supplements.	Some produce taste and odor compounds. *Prymnesium* can produce toxins.
Diatoms (Bacillarophyta)	Most important in aquatic food chain. Produce Omega-3 fatty acids. Used in biofuel production and bioremediation efforts.	Some clog filters during drinking water treatment. *Pseudonitzschia* can produce neurotoxins (in salt/ brackish water only).
Dinoflagellates (Dinophyta or Phyrrophyta)	Produce Omega-3 fatty acids. Some have antifungal compounds.	Some cause "red tides" and produce ichthyotoxins, neurotoxins and dermatoxins.
Green Algae (Chlorophyta)	Found in may food supplements and contain antioxidants. *Chlorella and Haematococcus* are sources of the antioxidant astaxanthin. Most are sensitive to pollution, so they indicate good water quality.	Blooms can still cause problems for healthy pond systems as they decay.

Floating Macroscopic Plants

The "Duckweeds", Watermeal and Water Ferns



Free-floating duckweeds (*Lemna, Spirodella)* and watermeal *(Wolffia)* can attain nuisance levels in ponds (**A**). Duckweeds and watermeal often occur together. Their leaves are disc-like, 2-5 cm long with small roots on their underside. *Lemna* (**B**, **C**) is most common. *Wolffia* (**D**) is the smallest flowering plant in the world. *Spirodella* has a red underside. They require quiet, nutrient-rich water. They reproduce by a very rapid method called "budding", allowing them to cover ponds in a few weeks under summer conditions. Blooms can be reduced by aeration and nutrient reduction.



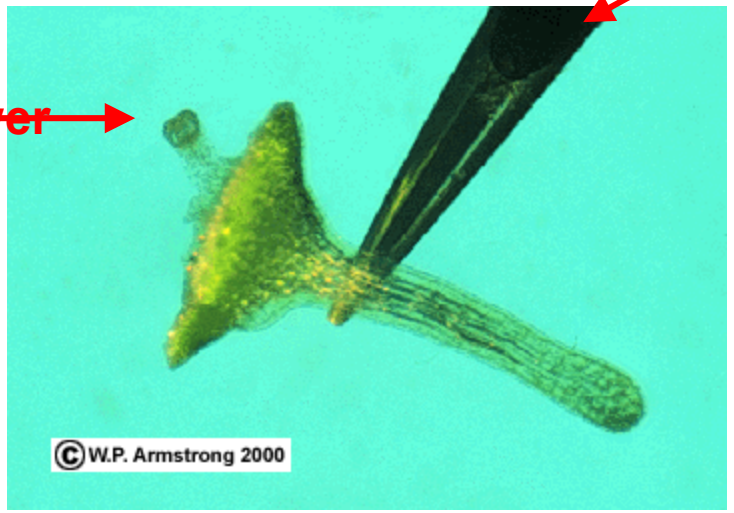
Duckweeds:

***Lemna* and**

Wolffia* = *Watermeal.

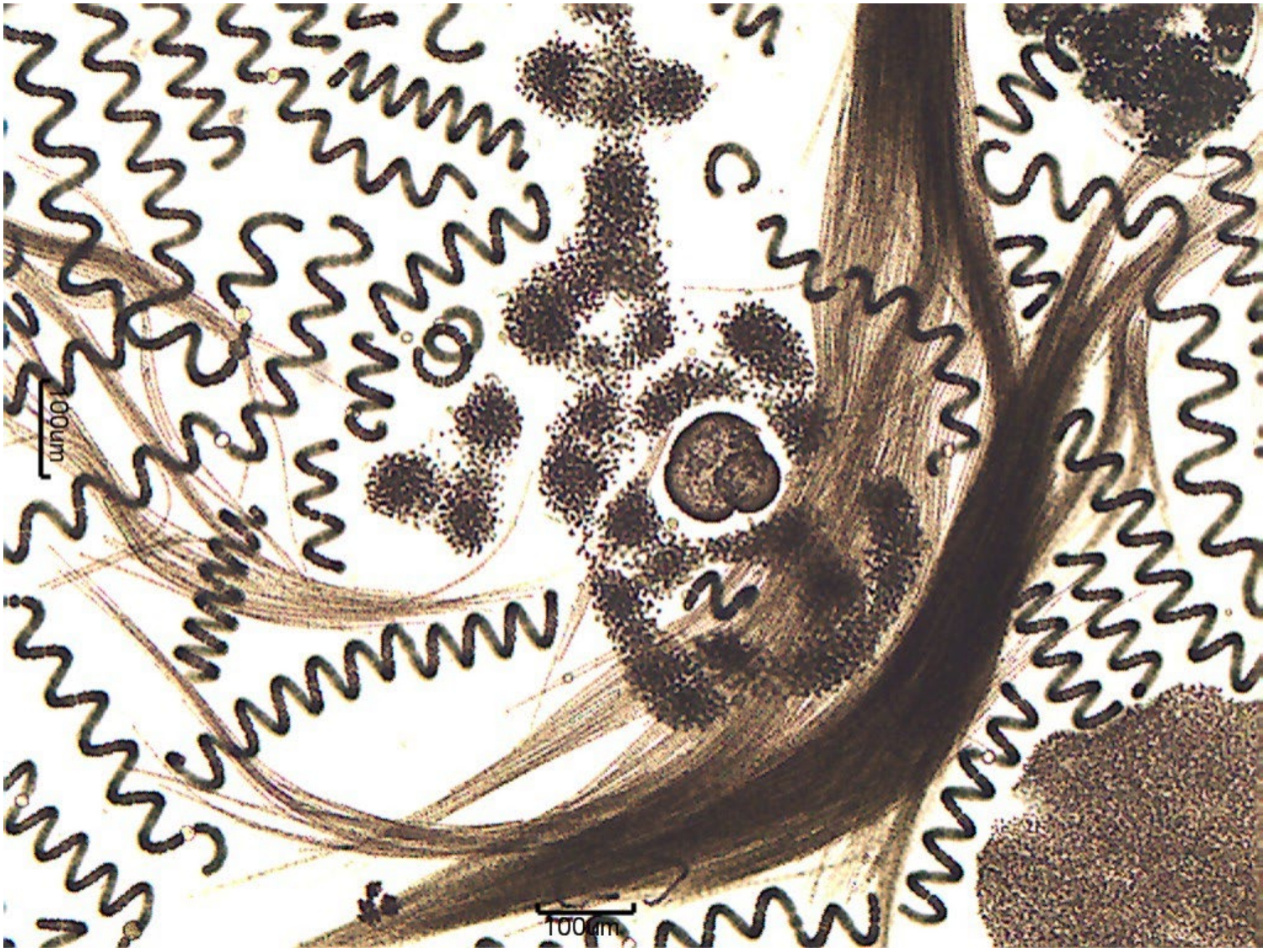
Tip of needle

Flower



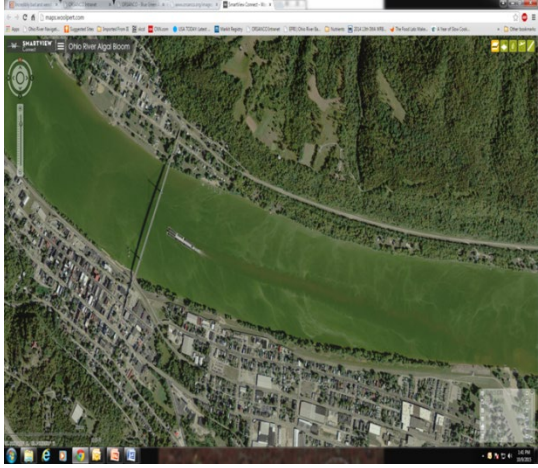
Water ferns *Azolla* (mosquito fern, duckweed fern or fairy moss) can cover farm ponds with their reddish, scale like leaves (**E**, **F**) . Roots hang in the water and have a symbiotic relationship with *Anabaena azollae* that fixes atmospheric Nitrogen. In Asia it is often used as a biofertilizer for rice paddies. It cannot survive freezing temperatures.

Cyanobacterial Blooms



CYANOBACTERIA

Importance



1.) **Some produce HABs**

HABs = 20Kcells/mL

Many toxic genera: Hepatotoxins, neurotoxins, cytotoxins, dermatoxins, respiratory and olfactory irritant toxins, taste/odor, allergy

2.) **Public Health issue**

GCCW - $7500+/day 2015 HAB

3.) **Economic**

US HAB costs = $2.2B annually

[Dodds, et al., 2008]

Identifying Cyanobacteria:

What do they look like?

- A.) Colonies
  - a.) Filamentous
  - b.) Coccoid

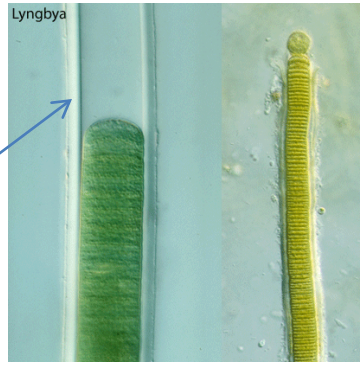
Identifying Cyanobacteria:

Filaments

a.) Sheath – yes/no?

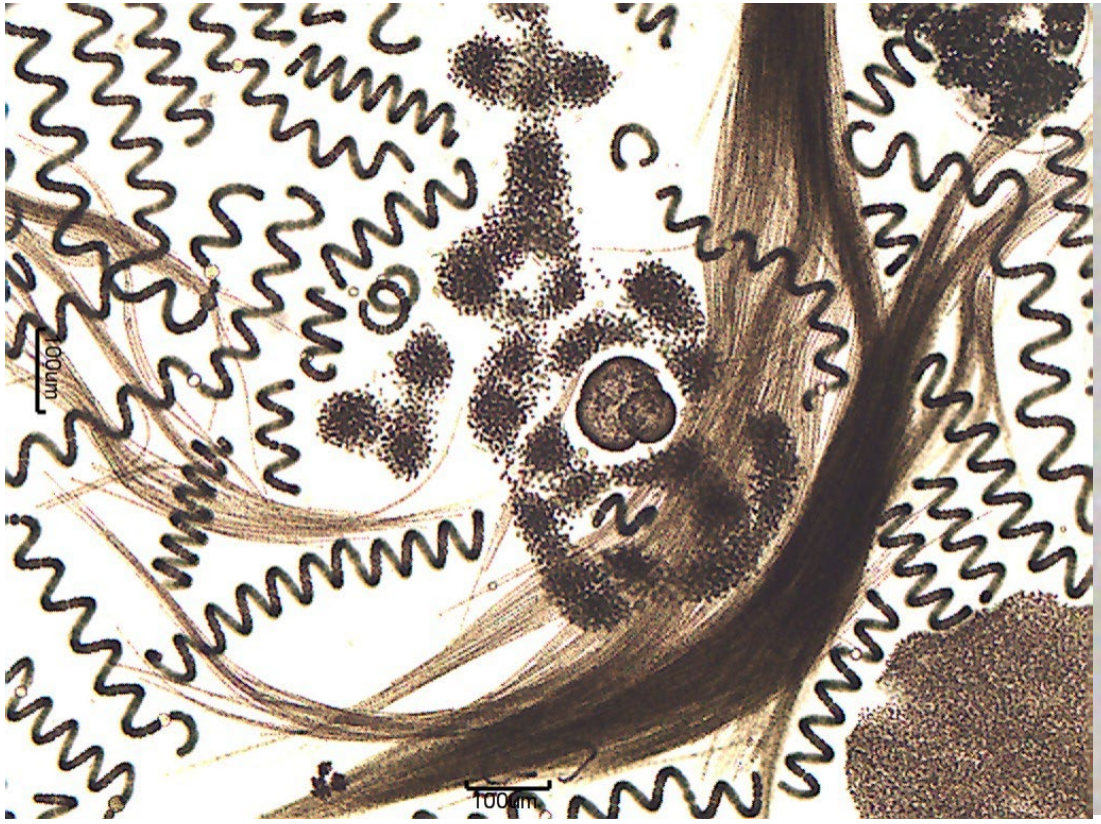
b.) Cell Shape – moniliform?

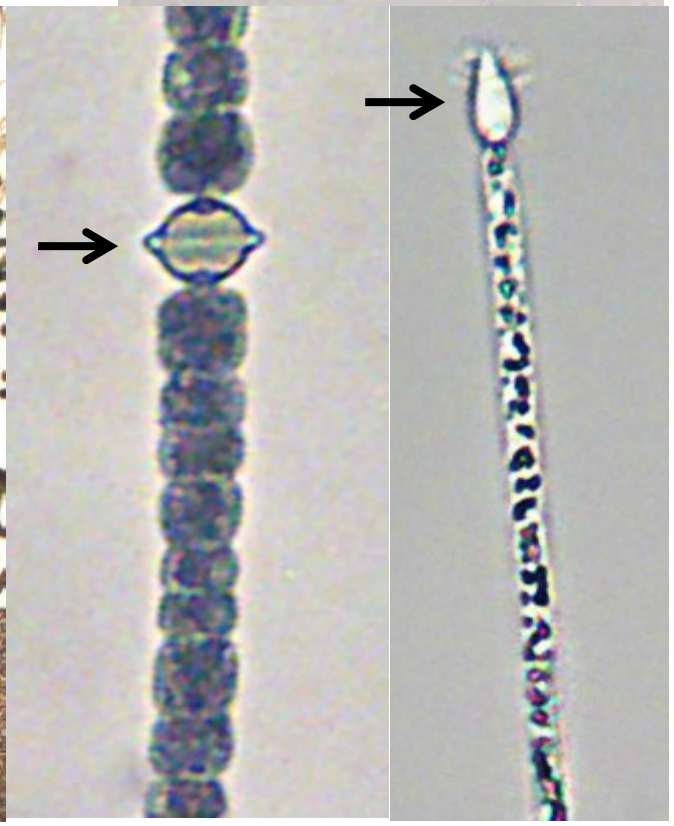
c.) Branched? – yes/no?



Cells

- Aerotopes
- Heterocysts
- Akinets





Where do they live? Habitat

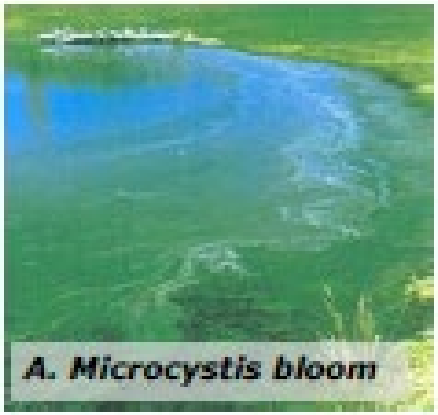
a.) Planktonic

b.) Benthic

c.) Other

FLOATING CYANOBACTERIA (BLUE-GREEN ALGAE)

MICROCYSTIS


A. Microcystis bloom

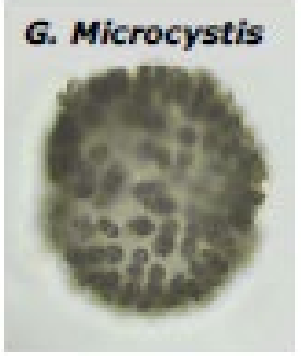

B. Microcystis bloom


C. Microcystis bloom

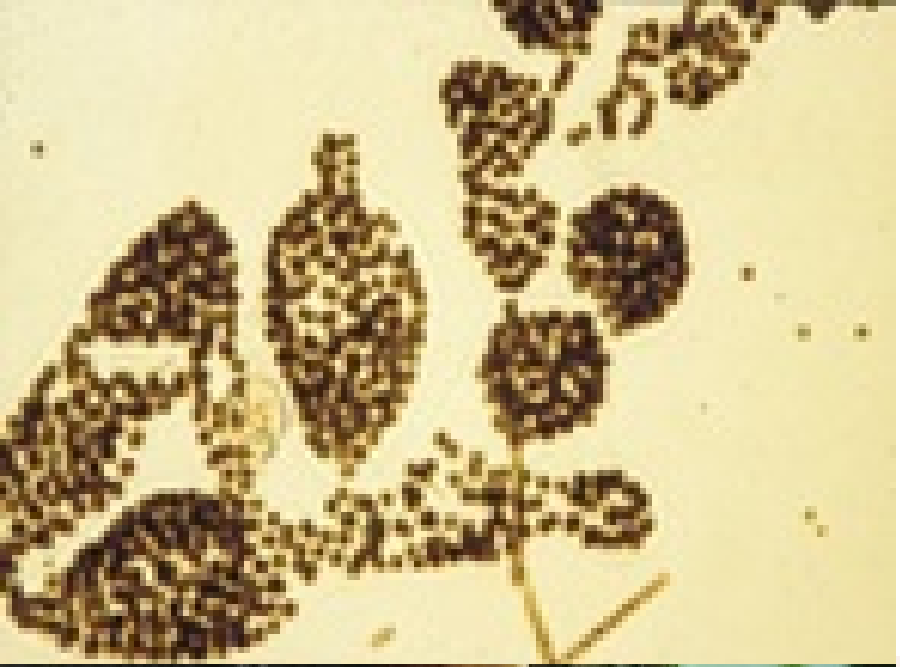

D. Microcystis bloom


E. Microcystis


F. Microcystis


G. Microcystis

Microcystis is the most common cause of HABs in freshwater ecosystems. Blooms often appear like spilled green paint (A,B) or pea soup in the water.

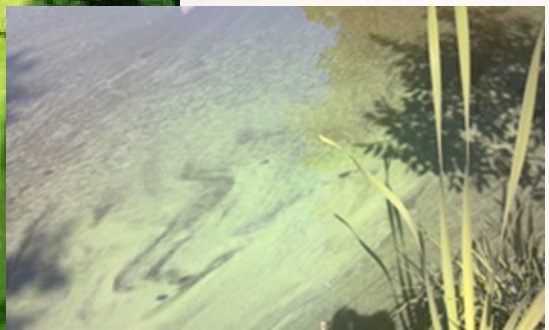


Most common toxic

cyanobacteria

Microcystis

produces hepatotoxins called Microcystins



FLOATING CYANOBACTERIA (BLUE-GREEN ALGAE)

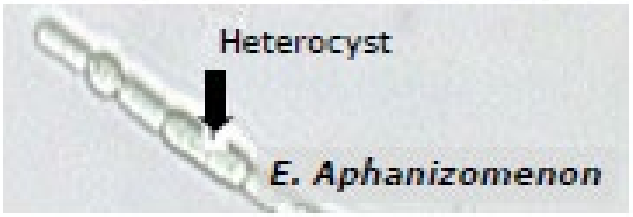
APHANIZOMENON


A. Aphanizomenon bloom


B. Aphanizomenon bloom


C. Aphanizomenon

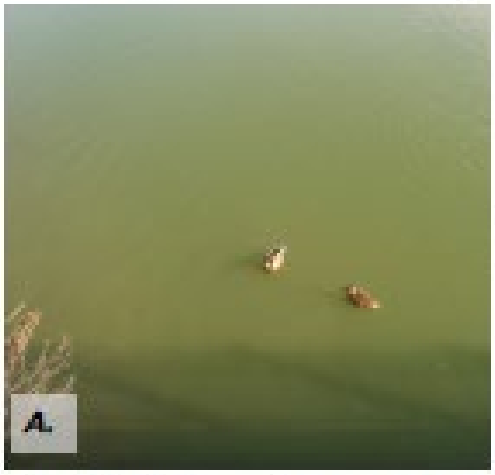

D. Aphanizomenon

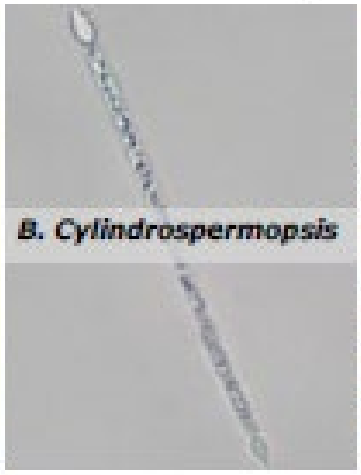


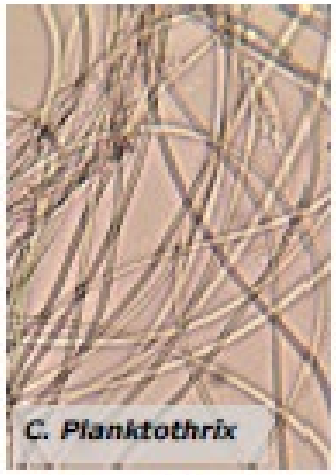
E. Aphanizomenon

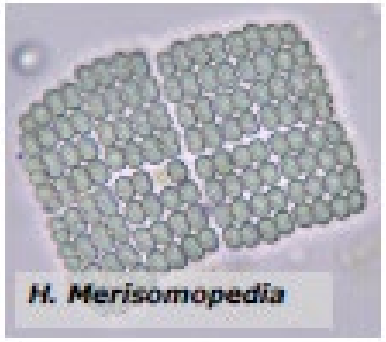
Floating Cyanobacteria (Blue-Green Algae)

Cylindrospermopsis, *Planktothrix*, *Pseudoanabaena*, *Spirulina*, *Arthrospira*, and *Merismopedia*









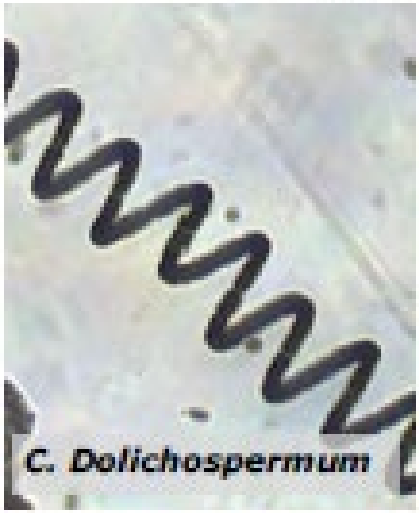
All of these species of blue-green algae color the water brownish-green or dark green when they

FLOATING & ATTACHED CYANOBACTERIA (BLUE-GREEN ALGAE)

DOLICHOSPERMUM AND ANABAENA

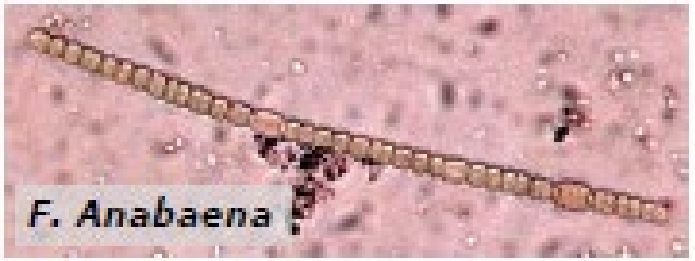

A. Anabaena bloom


B. Dolichospermum bloom


C. Dolichospermum

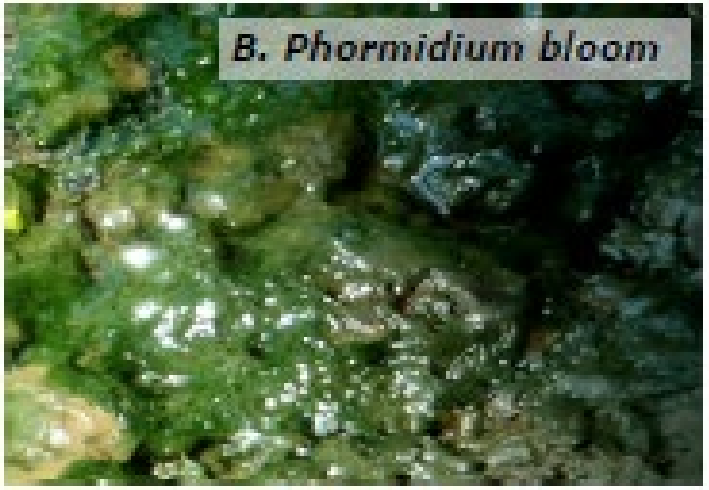

D. Dolichospermum

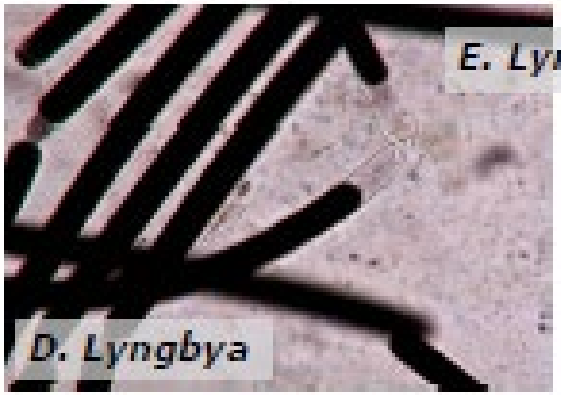

E. Anabaena


F. Anabaena

ATTACHED CYANOBACTERIA (BLUE-GREEN ALGAE)

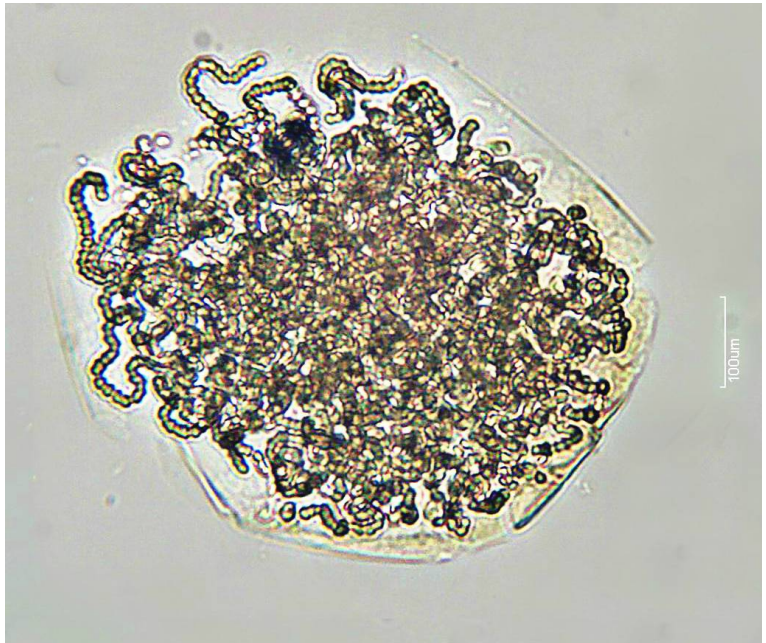
OSCILLATORIA, LYNGBYA, PHORMIDIUM, AND NODULARIA





Attached Cyanobacteria (Blue-Green Algae)

Nostoc



Cyanobacterial Macrocolonies

FLAGELLATED ALGAE

EUGLENA, PHACUS, DINOBRYON, DINOFLAGELLATES, AND PRYMNESIUM

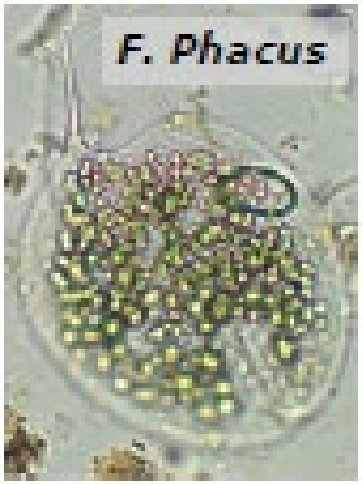

A. Euglena bloom

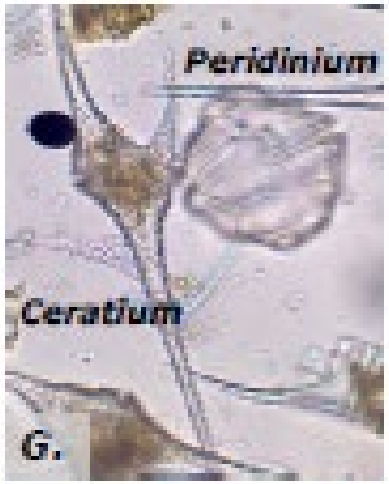

B. Euglena bloom


C. Euglena bloom

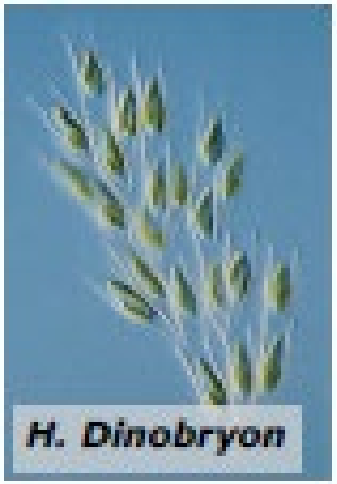

D. Euglena


E. Euglena


F. Phacus



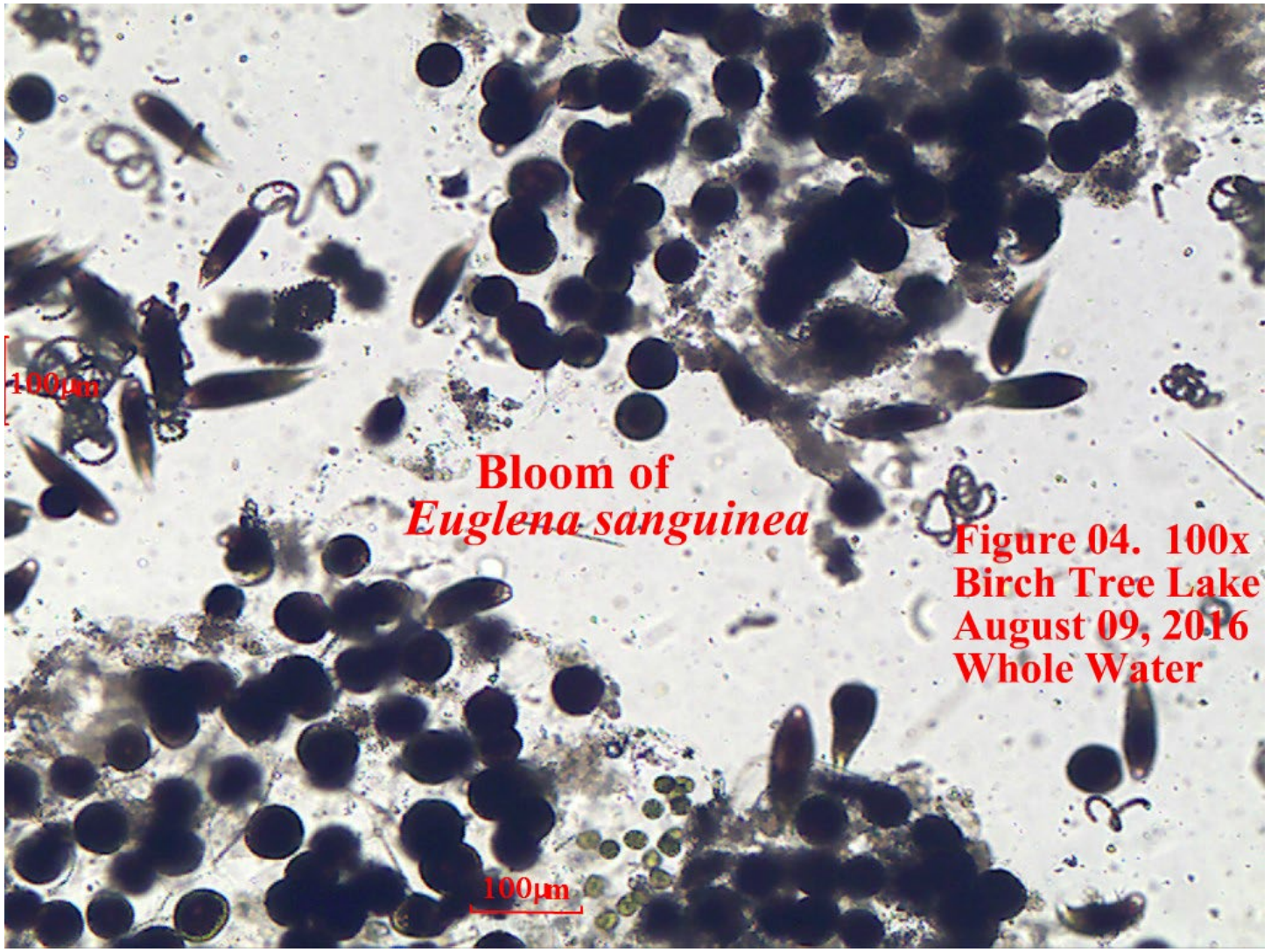
G.


H. Dinobryon


I. Prymnesium*

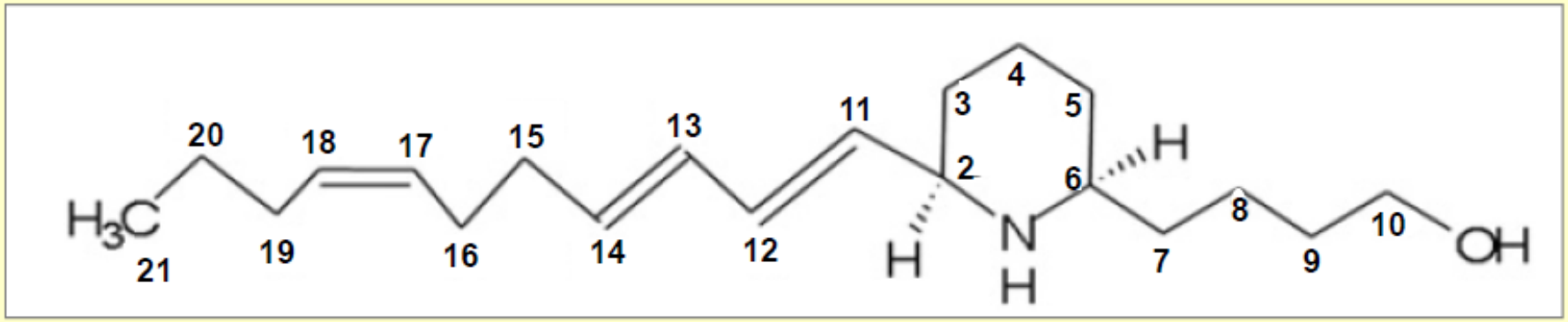
*Photo by Carmelo Tomas, University, North Carolina, Wilmington.

Euglenophyta - *Euglena* Bloom



The toxin euglenophycin –

first discovered from NC *Euglena sanguinea*

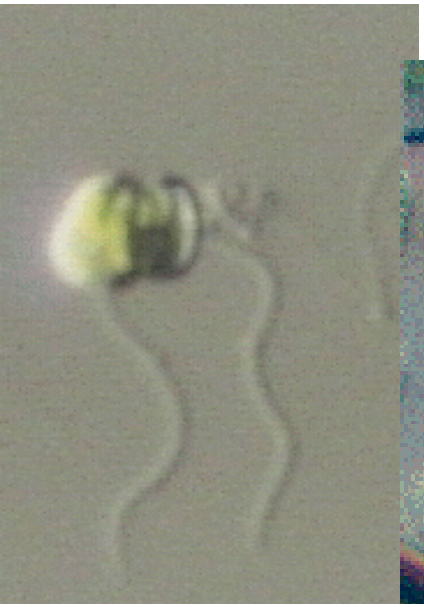


"This compound is an alkaloid similar in structure to fire ant venom. It exhibits ichthyotoxic, herbicidal and anticancer activity at low ppm to ppb dosages." – Zimba et al. (2010)

Fish Toxin

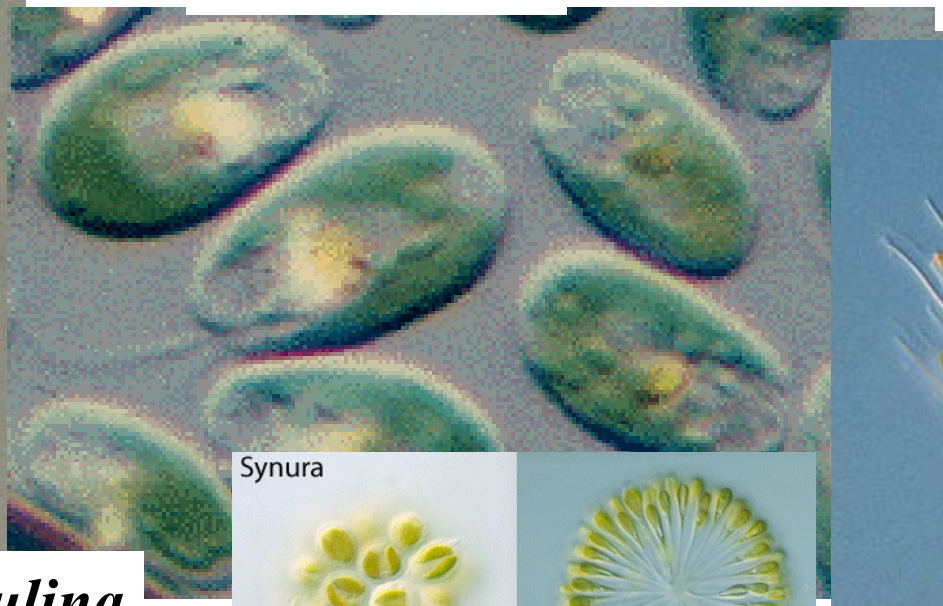
CHRYSOPHYTA—biflagellated, flagella very unequal length.

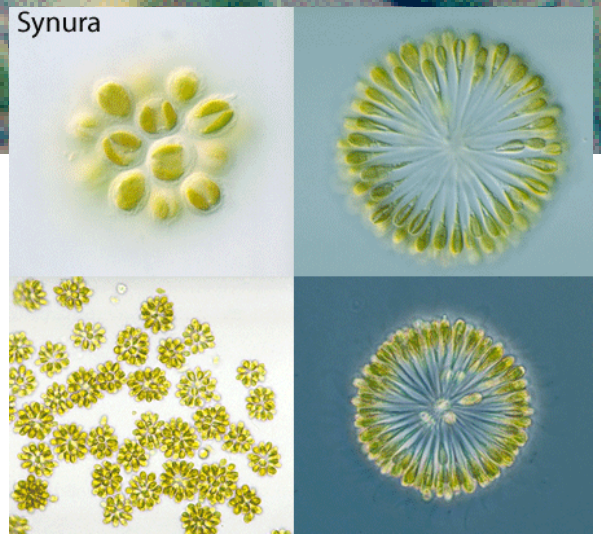
Taste & odor algae… pollution indicators



Chrysochromulina

Chroomonas





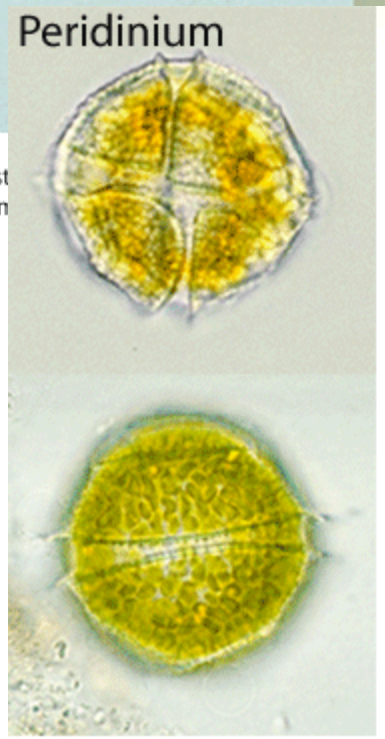
Dinobryon

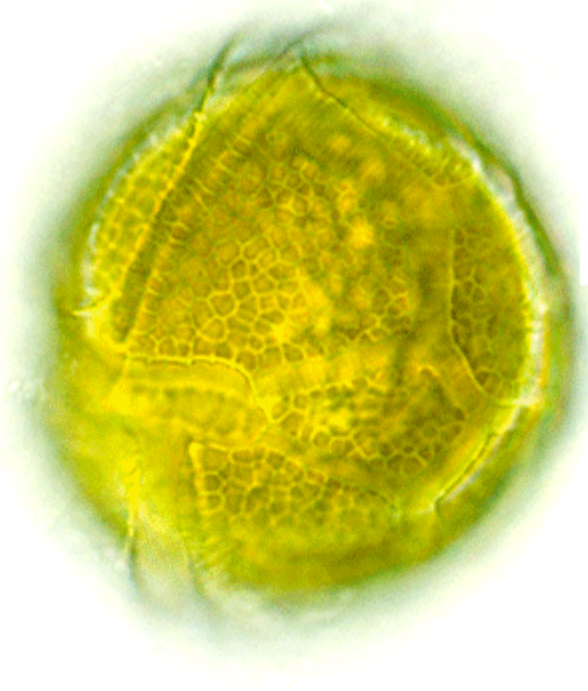
Ceratium

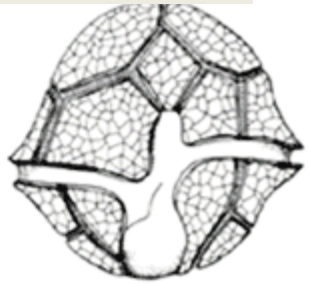
PYRROPHYTA

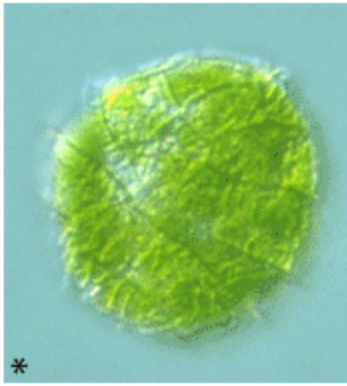
Peridinium

A after Entwisle et al. (1997)
B © N. Sugiyama, see http://protist.i.hosei.ac.jp/Protist
C © K. Mikami, see http://protist.i.hosei.ac.jp/Protist_n







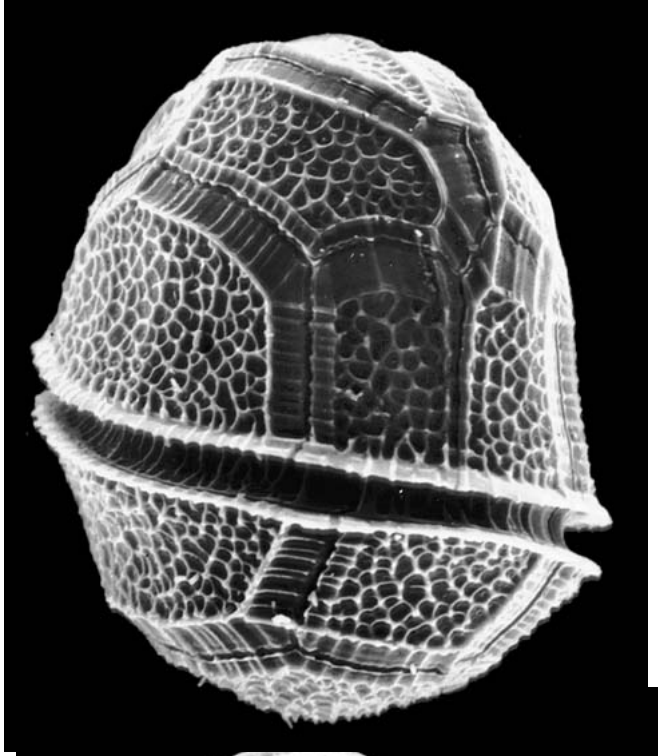


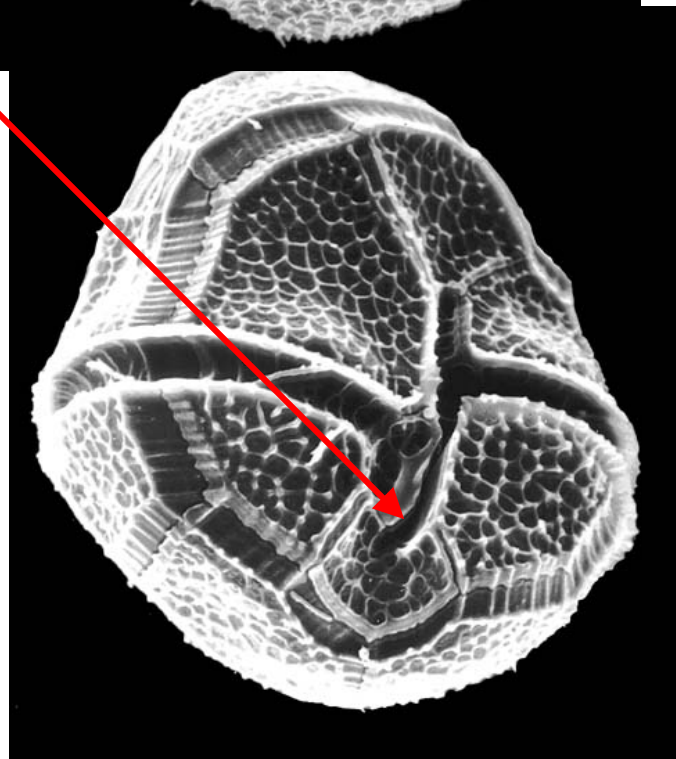
All after Entwisle et al. (1997)
* © Y. Tsukii, see http://protist.i.hosei.ac.jp/Protist_menuE.html

PYRROPHYTA-Dinoflagellates

biflagellated at 90° angles

Peridinium





Many toxic strains! (Red tides)

Gymnodinium

Haptophyte *Prymnesium parvum, the "golden alga"*

- **Complex mix of toxins; some? many? uncharacterized**

- Hemolysins; neurotoxins; fast-acting ichthyotoxins (cyclo amines); cytotoxins, hepatotoxins, reactive oxygen species (ROS) H_2O_2, O_2^-, OH^-; DMSP; toxic fatty acids; other bioactive substances

- Modes of action (many) – act on cell membranes → loss of selective permeability (reversible); disruption of ion regulation in gills

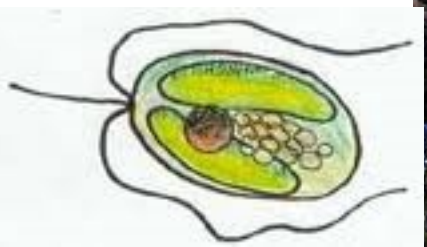
Photo – C. Contraras

Invasive golden algae *Prymnesium parvum* thrives in high conductivity waters & is in OHIO RIVER BASIN.

this alga. States that have reported golden alga include: Alabama, Arizona, Arkansas, Colorado, Florida, Georgia, Maine, Nebraska, New Mexico, North Carolina, Oklahoma, South Carolina, Texas, and Wyoming.

It first showed up in 1985 in the Pecos River in Texas

Now the invasive toxic algae is blamed for contributing to the massive Dunkard Creek fish kill along the Pennsylvania-West Virginia border affected by Marcellus shale drilling.

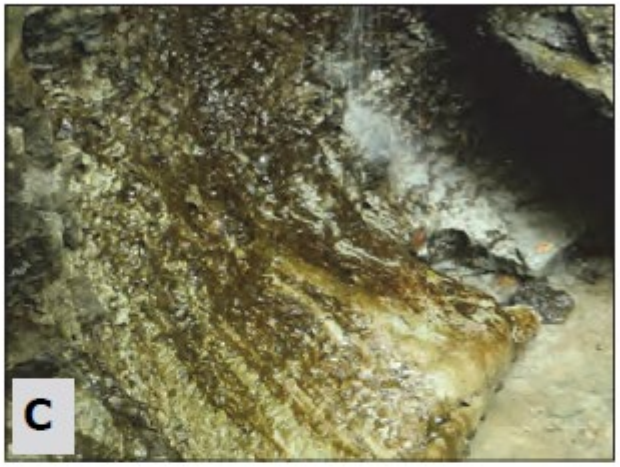


Read more:
http://www.post-gazette.com/pg/09277/1003007-113.stm#ixzz12UKcl9eL

Diatom Blooms


A


B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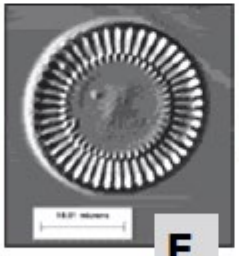
D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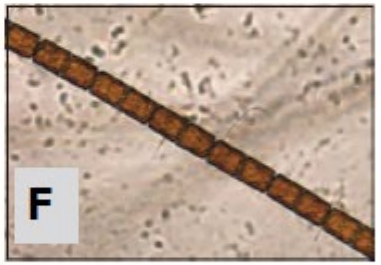
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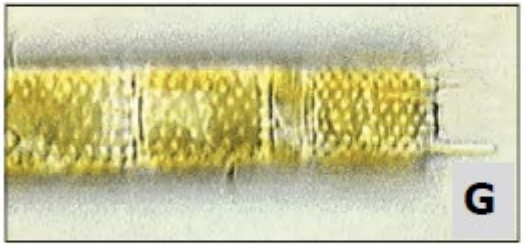
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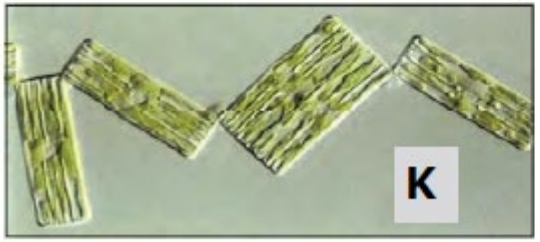
H


J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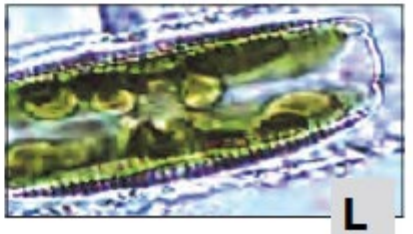
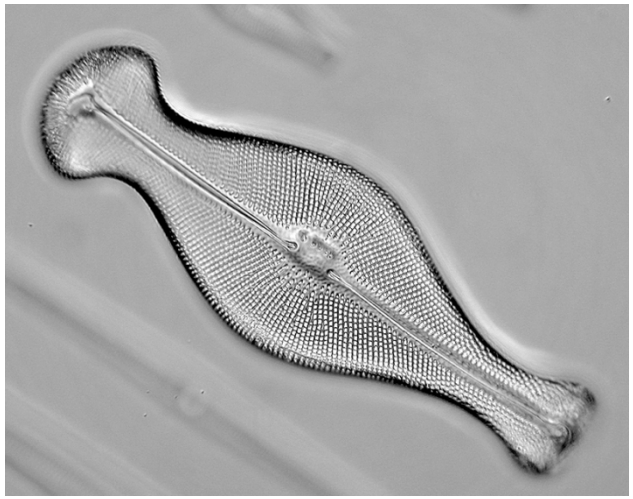
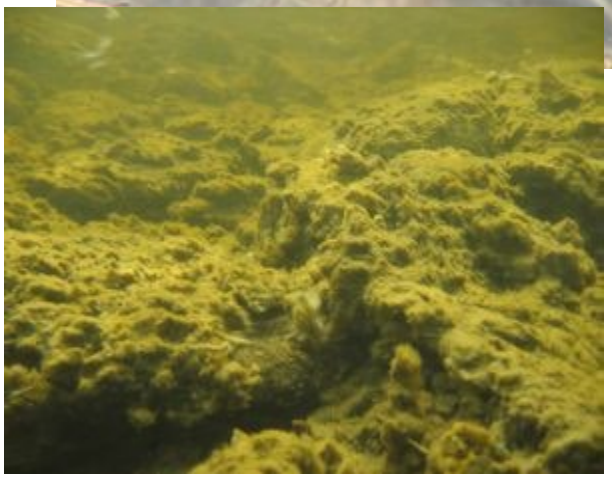
I


L

Didymosphenia geminata, **commonly known as didymo or rock snot, is a species of diatom that in adapting to grow in warm and shallow water. Introduced into NY 2007**

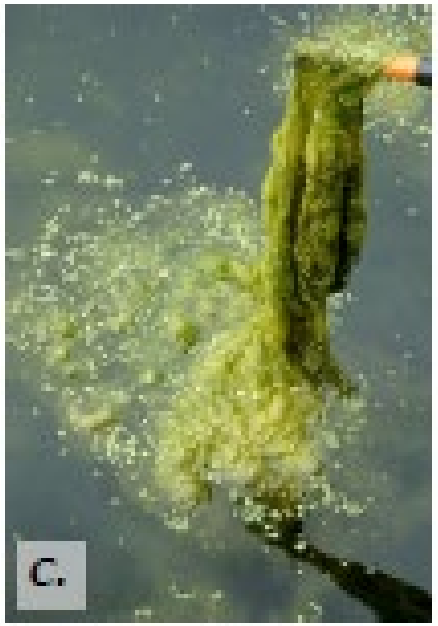


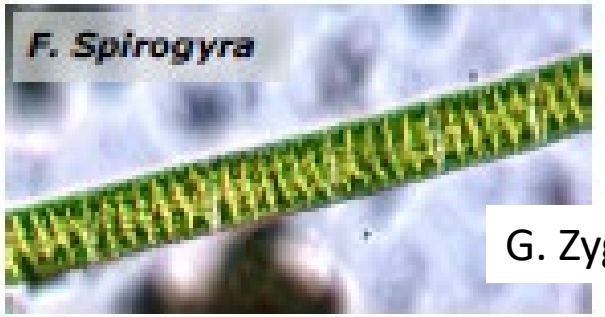


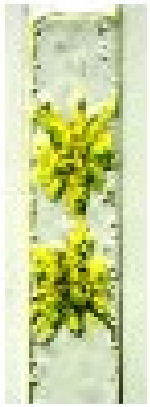
Not yet in this area.

Filamentous Green Algae

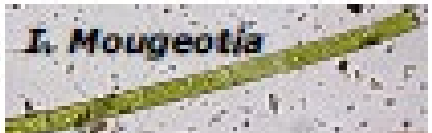
Spirogyra, Mougeotia, and Zygnema





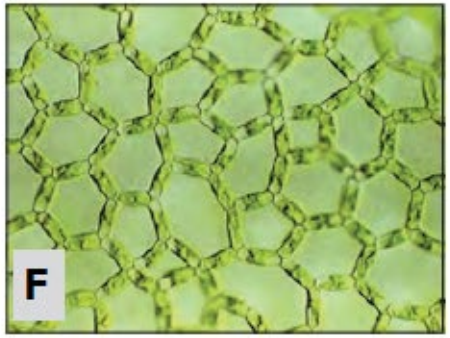


G. Zygnema



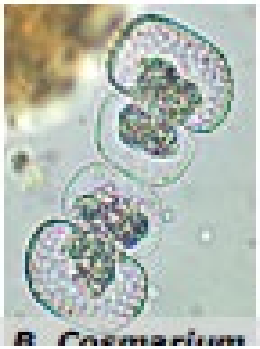
Branched Filamentous Green Algae

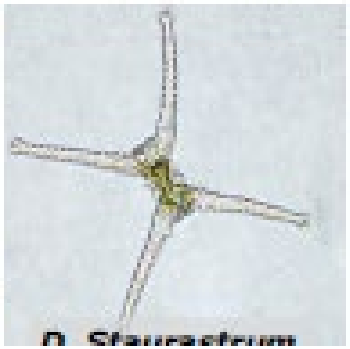
Cladophora and Hydrodictyon

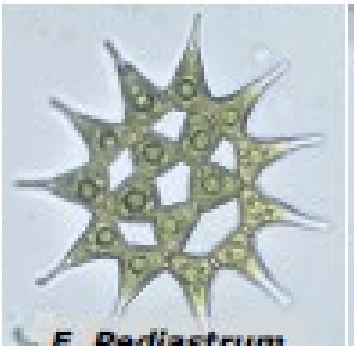


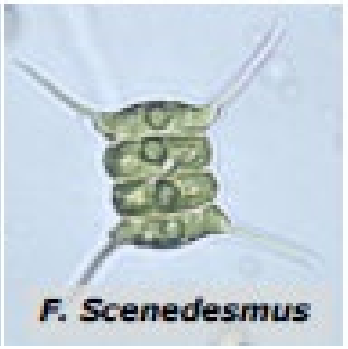
Common Planktonic Algae in Well-Managed Ponds

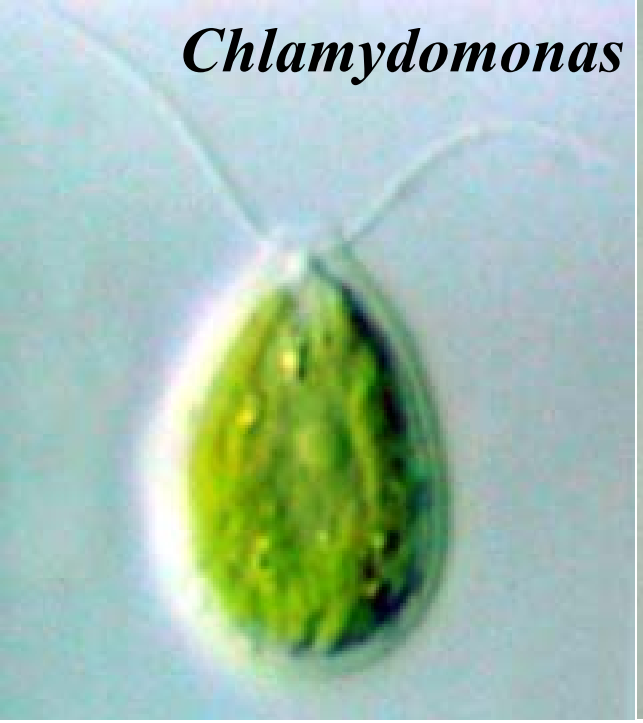
Cosmarium, Closterium, Staurastrum, Pediastrum, Scenedesmus, and Volvox

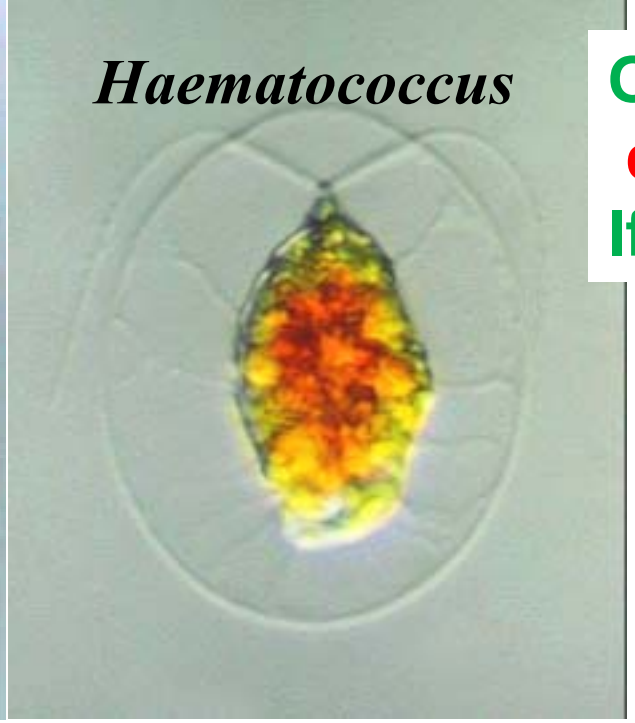






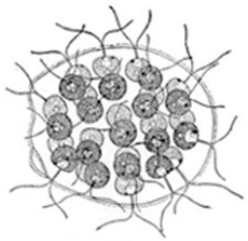


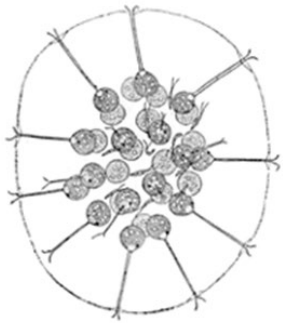




Other green algae
do not form scums
If motile=biflagellated

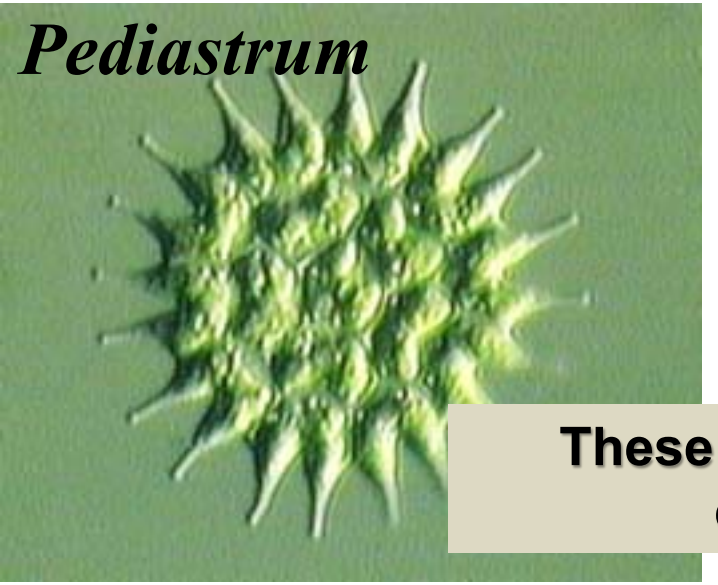
Source of Astaxanthin- pink color in farmed salmon

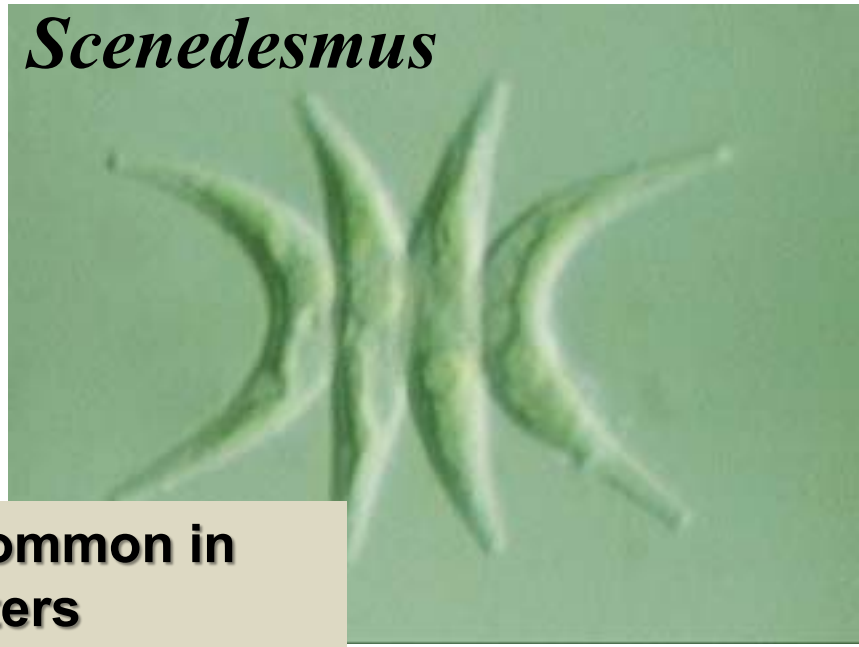




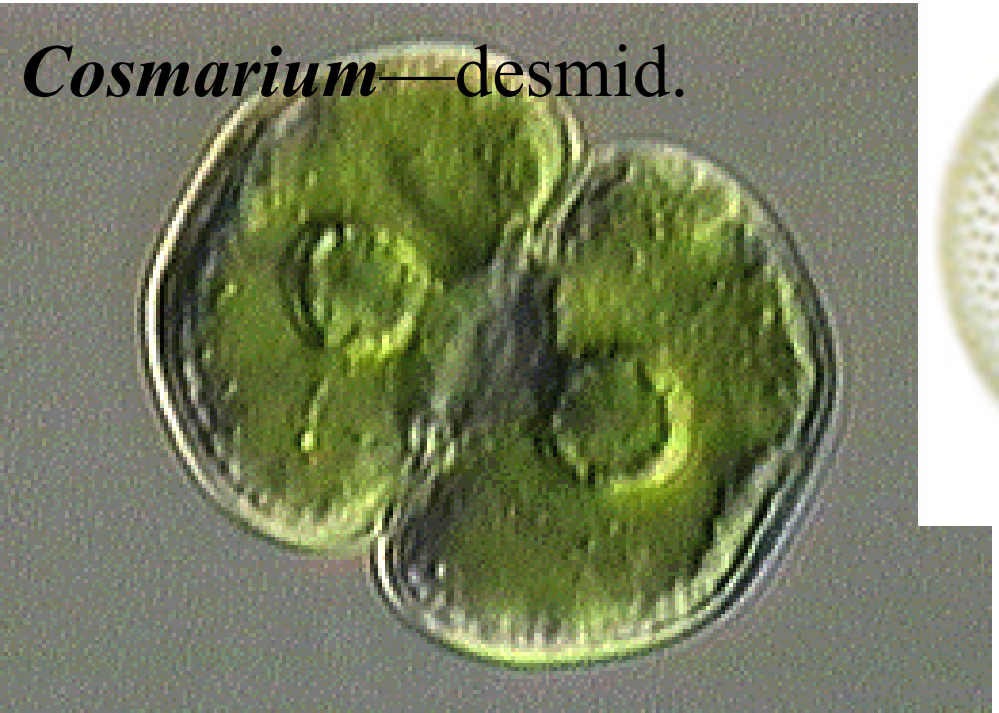
Eudorina

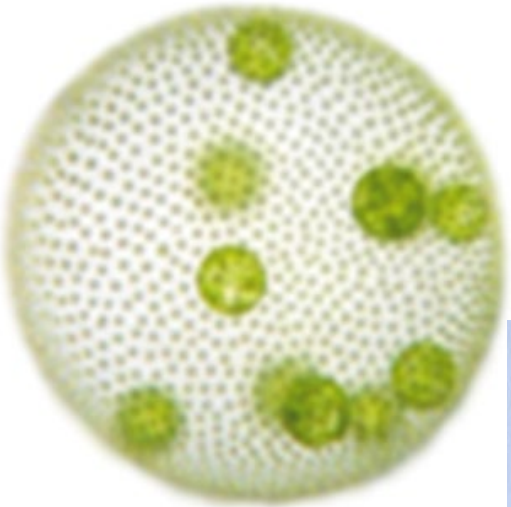
CHLOROPHYTA-Green algae.



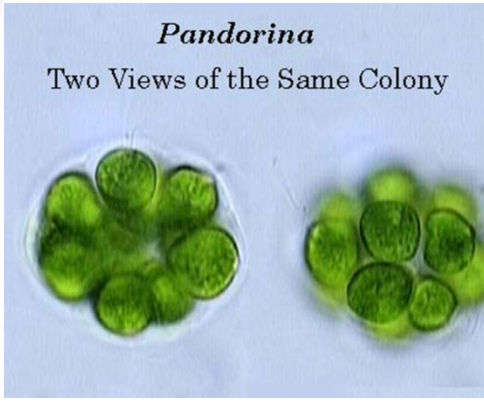


These genera are common in eutrophic waters



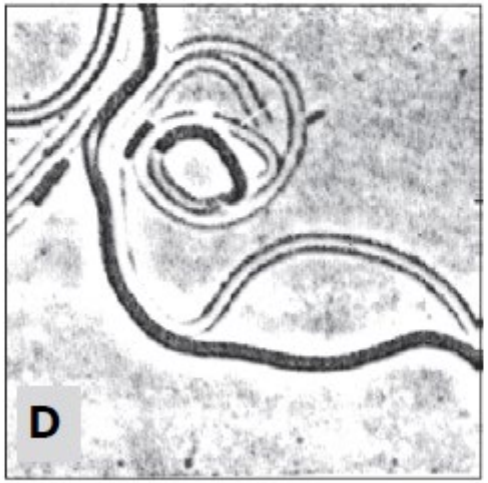


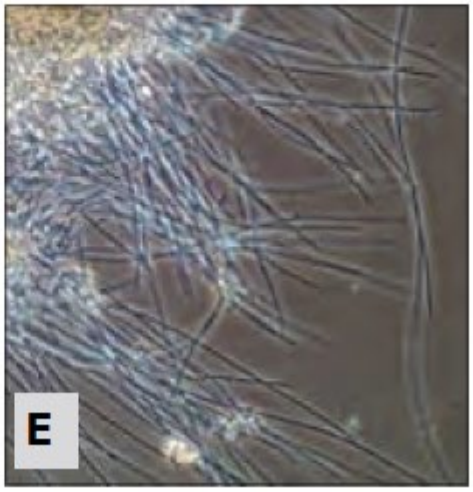
Volvox



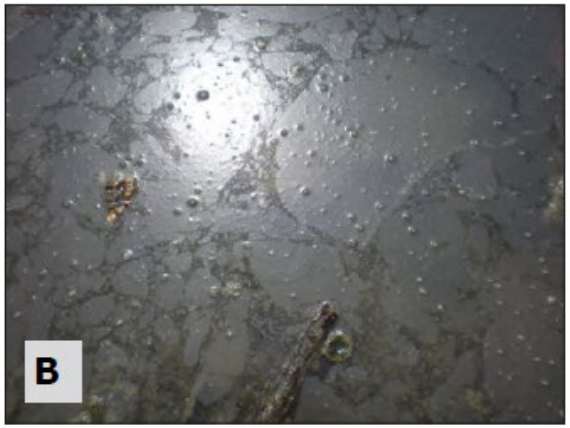
Bacterial Scums

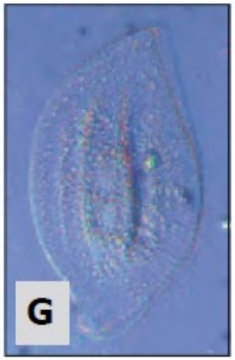
Iron Bacteria -*Sphaerotilus*

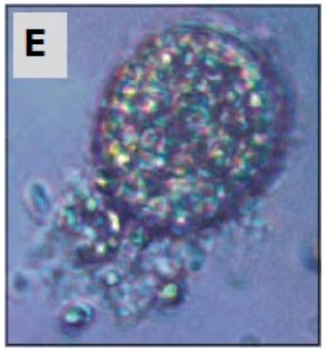


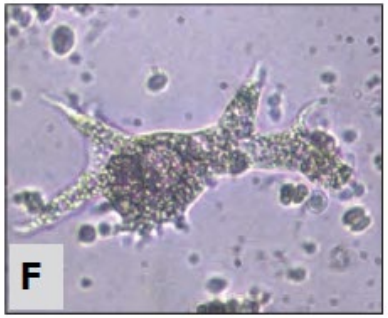


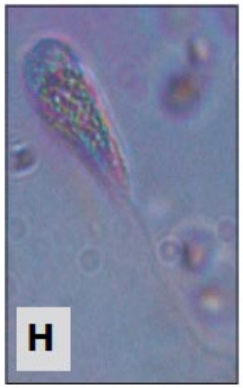
Protozoan Scums





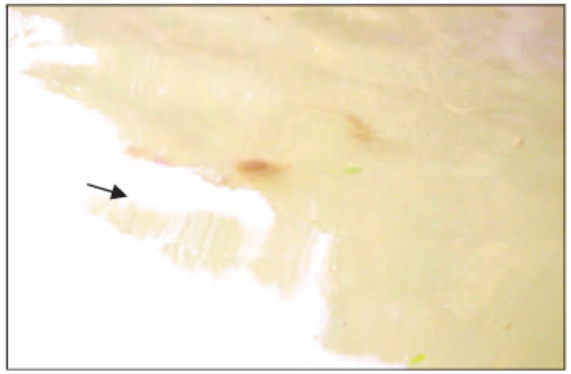




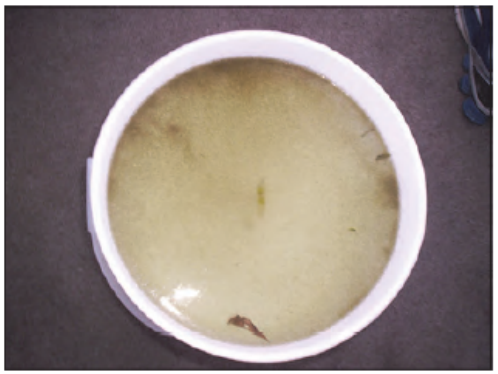


Zooplankton Scums

Daphnia lumholtzi, and sometimes other zooplankton, can "swarm" producing scums that are usually brown. *Daphnia lumholtzi* was found as a swarming brown scum in Lake Cumberland on October 9, 2009.

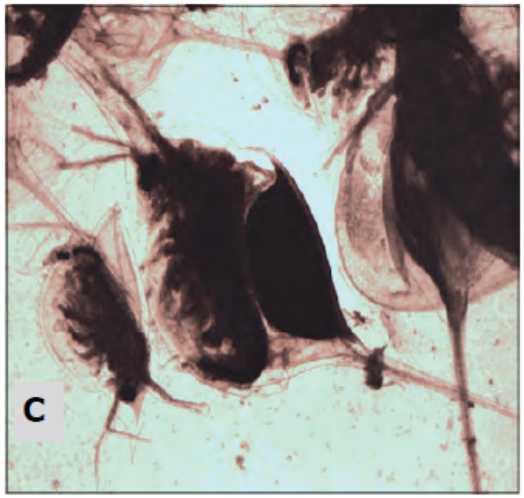


A



B

Brown scum in the water of Lake Cumberland (A) and in the bucket collected from this site (B). Note tendency of the brown organisms to become concentrated in one side of the bucket.

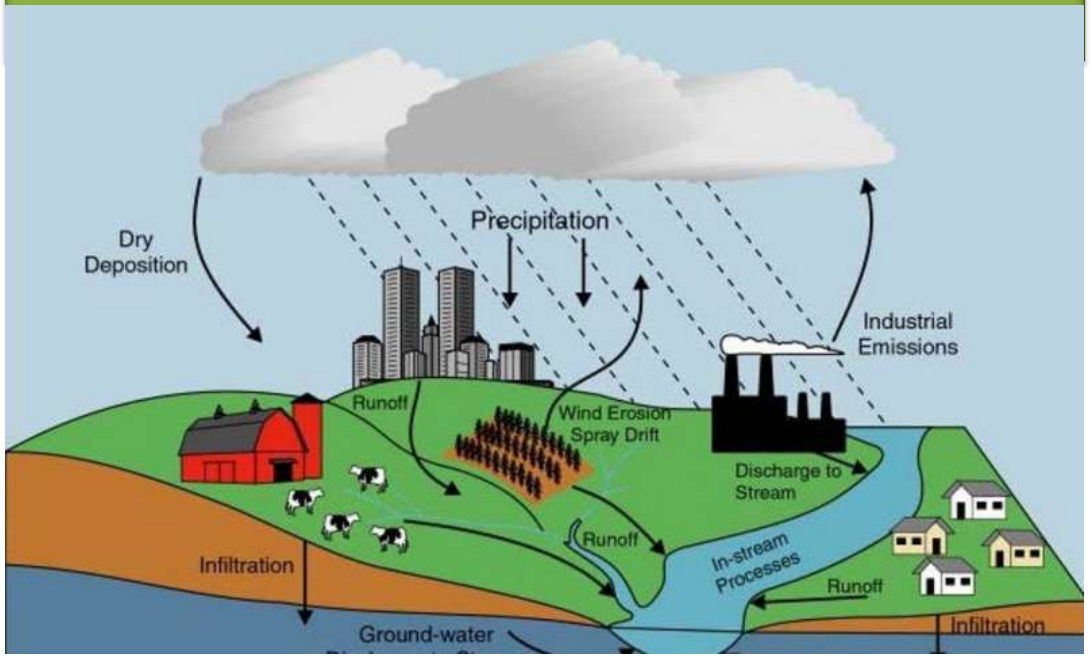


C

In the microscopic view of *Daphnia lumholtzi* (**C**), note the saddle-shaped ephippium (shell that encloses the egg) on th back of the middle specimen. *Daphnia* with ephippia were more common in the scum as compared to those found isolated in the plankton. There were also small males in the scum, seen in the left specimen (**C**). This suggests swarming is an adaptation for sexual reproduction in this species, sinc ephippial (resting) eggs are formed only by sexual reproduction. The long tail spines often cross (bottom right of **C**) contributing to the clumping of individuals so the scur does not separate. Northern Kentucky University students baptized this brown scum full of "crosses" as "holy crap".

MANAGING YOUR POND

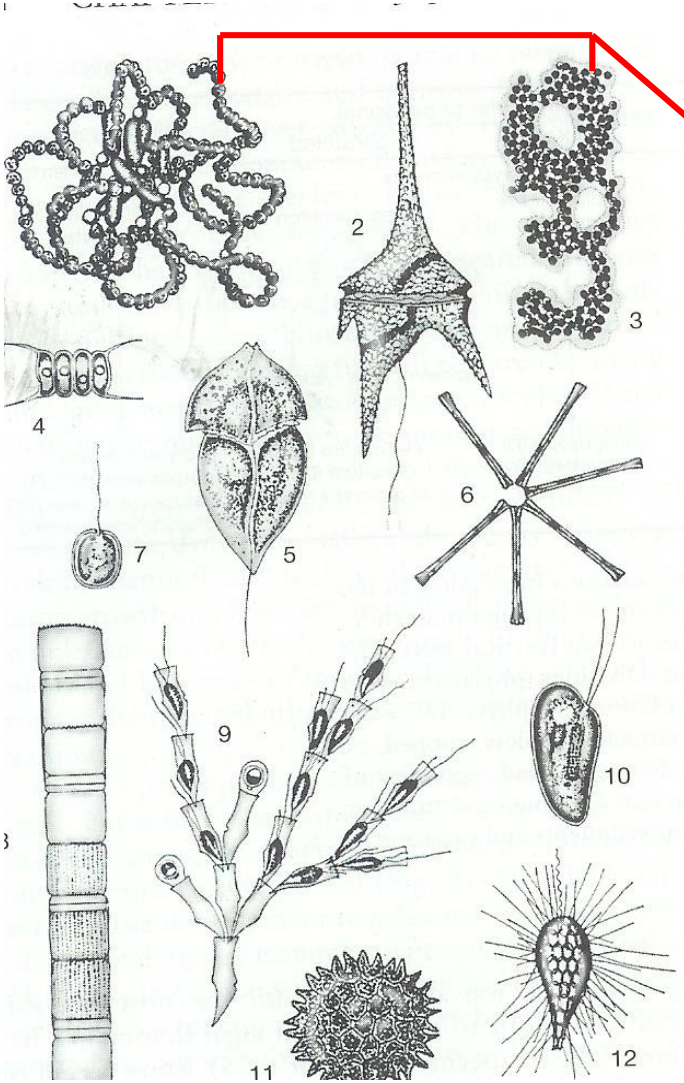
What causes HABs?

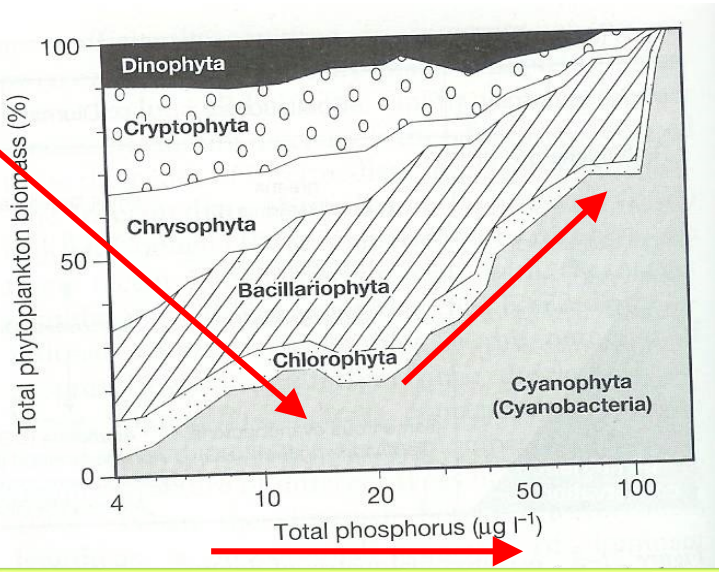


Nutrient pollution: sources include decaying organic material; fertilizers applied to crops, lawns and golf courses; manure from fields or feedlots; atmospheric deposition; groundwater discharge; and municipal wastewater discharge.

Credit: USGS: https://phys.org/news/2018-08-florida-algae-crisis.html#jCp

Algal Types

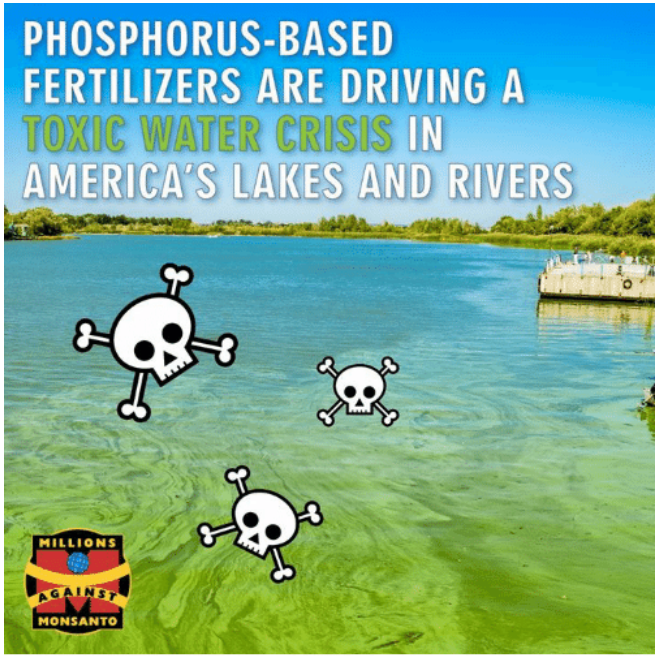




As TP increases, % of Cyanobacteria increases, excluding 'good' species.

Eutrophication (due to increased nutrients) causes:

- **decline in species diversity**
- **increase in algal biomass**

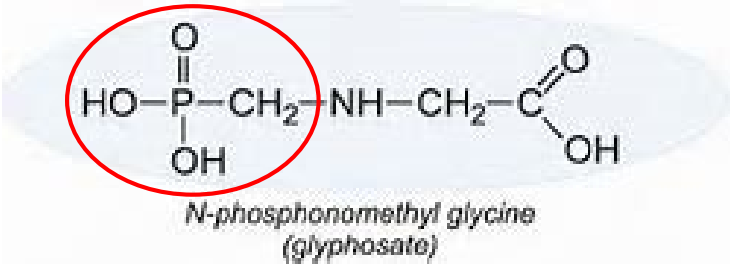


Blue-green algae has existed for millions of years. But crop chemicals such as glyphosate are fueling an explosion of toxic algae blooms across the U.S. Learn more: https://orgcns.org/2ErNHZt

A Herbicide acting as a Fertilizer!

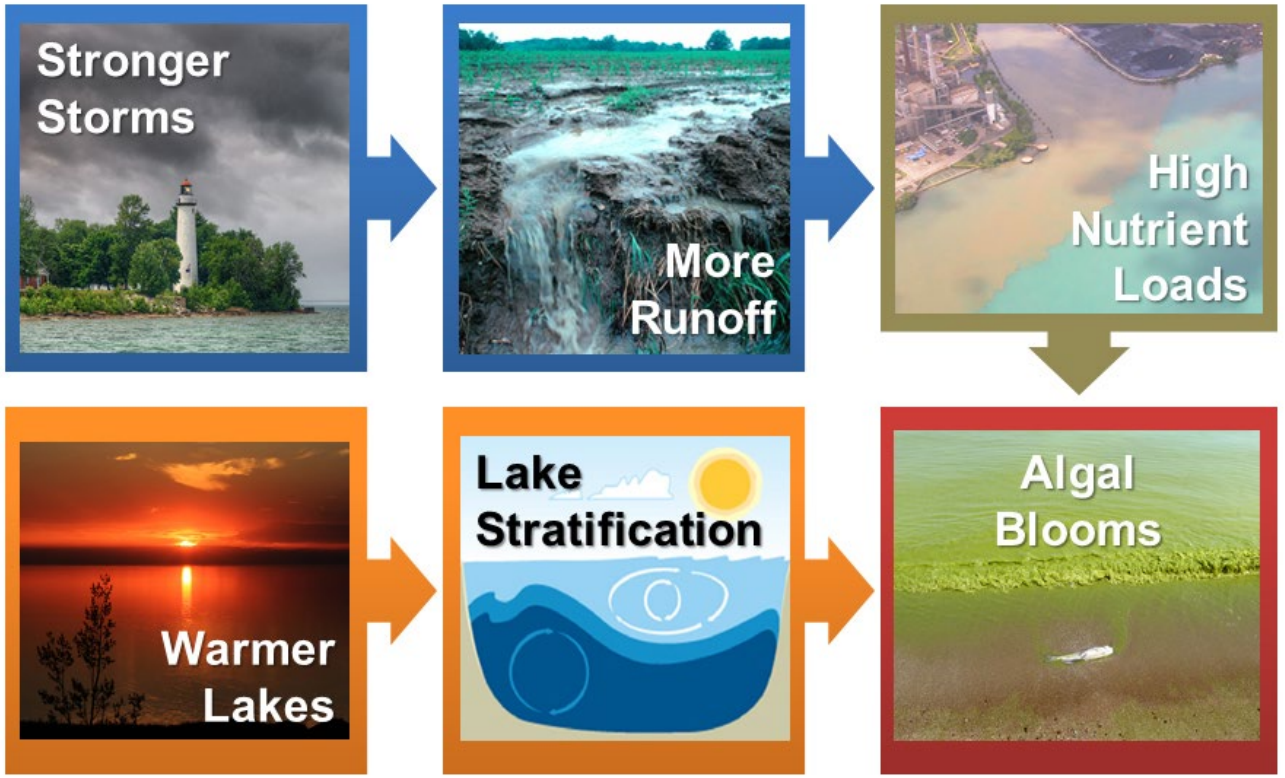
Glyphosate (Roundup, Rodeo)

- Kills "good" algae and aquatic plants
- "Feeds" toxic cyanobacteria!



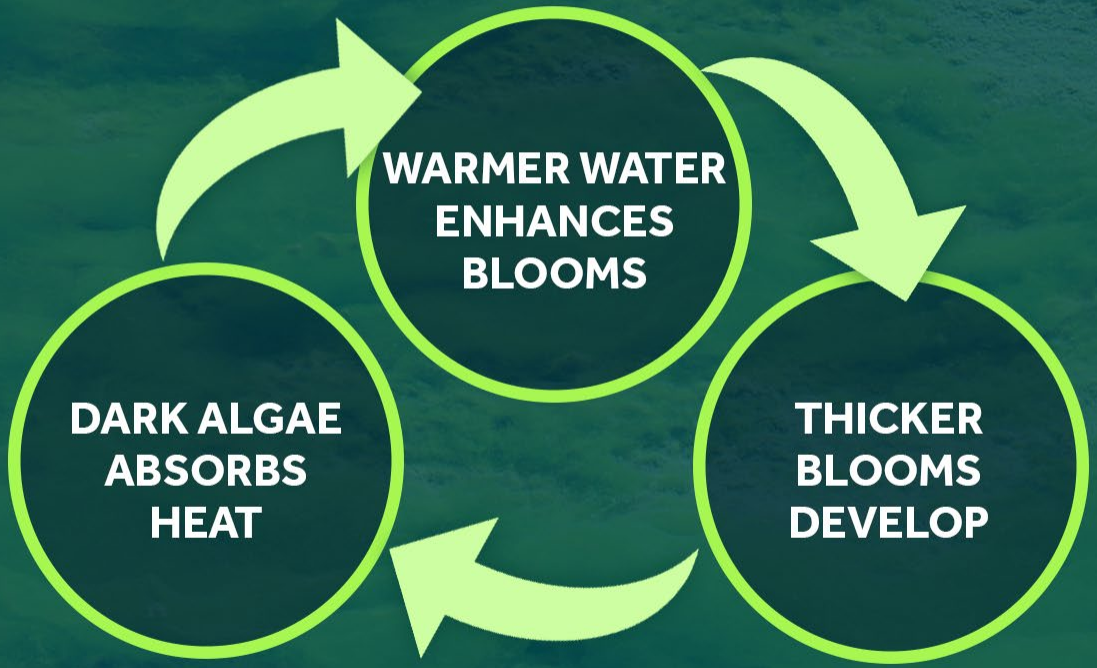
N-phosphonomethyl glycine (glyphosate)

Conspiring Climate Changes and Algal Blooms



ALGAE BLOOM FEEDBACK

An Unhealthy Cycle



Source: EPA

CLIMATE CENTRAL

Types of Toxins

- **Neurotoxins**

Possible symptoms

- Death by respiratory paralysis - Rapid action
- Tingling, numbness, incoherent speech, drowsiness
- Memory loss
- Alzheimer's disease and Amyotrophic lateral sclerosis

Toxins:

- Anatoxin - a.
- Anatoxin - a (s).
- Homoanatoxin-a
- Saxitoxin
- Neosaxitoxin
- Brevetoxins (Neurotoxic Shellfish Poisoning)
- Domoic acid (diatom)

Produce by Cyanobacteria (fresh water)

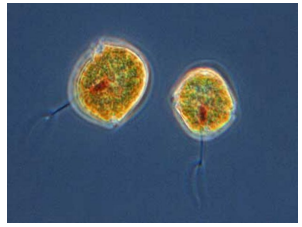
Dolichospermum Microcystis, Anabaena, Aphanizomenon, Oscillatoria, Phormidium, Cylindrospermopsis

Produced by Dinoflagellates (marine)

Karenia,

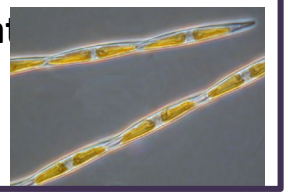
Alexandrium

>60 dinoflagelate species can produce toxins



Produced by Dia

Pseudonitzschia



Types of Toxins

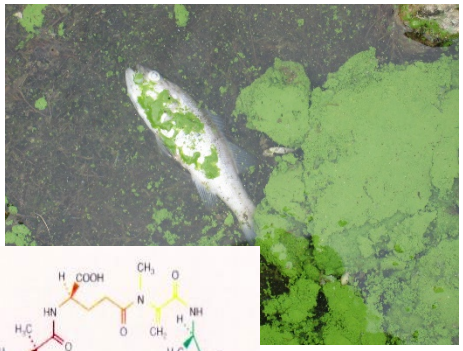
Liver Toxins

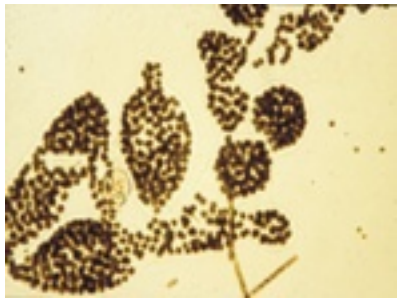
Possible symptoms

- Liver inflammation, hemorrhage
- gastrointestinal problems
- Tumor promoter, liver cancer
- Pneumonia,
- Dermatitis

Produce by Cyanobacteria

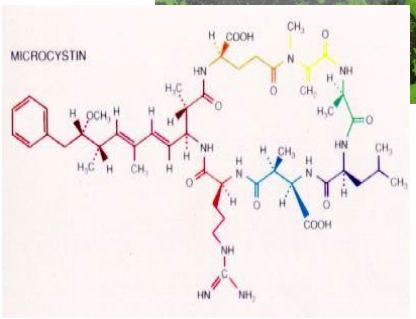
Microcystis, Dolichospermum, Anabaena, Planktothrix, Hapalosyphon, Oscillatoria, Cylindrospermopsis, Nodularia





Toxins:

- Microcystins (many types)
- Nodularins
- Cylindrospermopsins

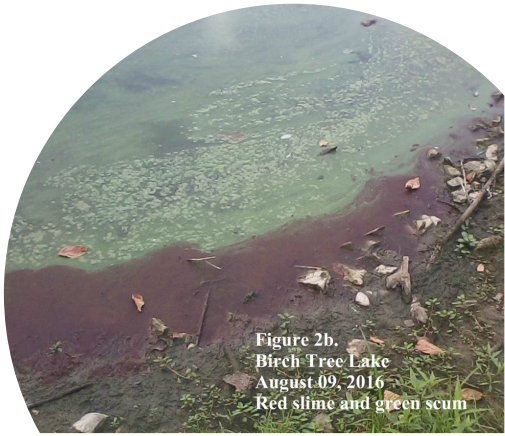


Other Toxins

- Lipopolysaccharides produced by most cyanobacteria

Possible symptoms:
Gastrointestinal problems, dermatitis, respiratory problems

- Euglenophysin produced by *Euglena sanguinea- fish kills*
- *Complex of many toxins Prymnesium parvum* ***– fish kills.***



EPA GUIDELINES AND RECOMMENDATIONS

EPA Cyanotoxin	Drinking Water Provisional Guideline
Microcystin-LR	1 µg/L

Do Not Drink – children under 6 and sensitive populations
Microcystin: 0.3 µg/L
Anatoxin-a: 20 µg/L
Cylindrospermopsin: 0.7 µg/L
Saxitoxin: 0.2 µg/L

RECREATIONAL WATERS

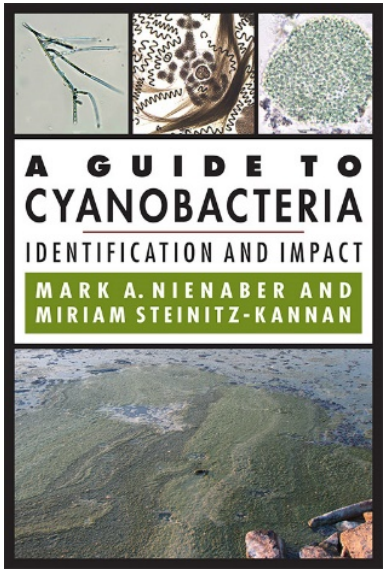
Relative Probability of Acute Health Effects	Cyanobacteria (cells/mL)	Microcystin-LR (µg/L)	Chlorophyll-a (µg/L)
Low	< 20,000	<10	<10
Moderate	20,000-100,000	10-20	10-50
High	100,000-10,000,000	20-2,000	50-5,000
Very High	> 10,000,000	>2,000	>5,000

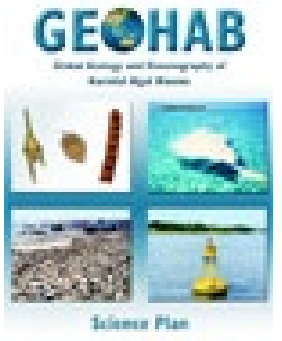
http://www.epa.gov/nutrient-policy-data/guidelines-and-recommendations

Learn more about toxic algae

Article on Glyphosate use:https://esajournals.onlinelibrary.wiley.com/doi/epdf/10.1002/fee.1985

https://eec.ky.gov/Environmental-Protection/Water/Monitor/Pages/HABS.aspx





Wetlands Management Micro-credential

Wetlands are a critical part of our ecosystem, abating flooding and regulating waterways. The Northern Kentucky University *Wetlands Management Micro-credential* will provide professionals, students, and anyone interested the knowledge to identify wetland plants, assess wetlands biodiversity, and learn wetlands delineation and monitoring through investigation of critical areas. These professional short courses will cover criterial and reporting for the Eastern Mountain Piedmont region as well as the Midwest region and be conducted through the *NKU Research and Education Field Station (REFS)*.

Micro-credential Course Criteria:

- Wetland Plant Identification (req)
- Wetland Delineation (req)
- One elective

2019 Courses:

WETLANDS PLANT IDENTIFICATION (micro-credential requirement): (3 days)

Learn species identification from live and preserved specimens of wetland plants. This course provides the knowledge base for accurate plant identifications that are required for vegetative biodiversity assessment, and wetlands mitigation monitoring.

~~**Date: July 15-17, 2019 Location: NKU REFS**~~ **Next Offered Summer 2020**

WETLANDS DELINEATION (micro-credential requirement): (5 days)

Learn field protocols to confidently locate, identify, and map jurisdictional wetlands. Topics covered will focus on wetland hydrology, hydric soil, and wetland vegetation field indicators. Course will cover the 1987 US ACOE Delineation Manual and the Eastern Mountains and Piedmont Regional Supplement, as well as wetlands in the Midwest.

~~**Date: August 5-9, 2019 Location: NKU REFS**~~ **Next Offered Summer 2020**

INVASIVE SPECIES MANAGEMENT AND VEGETATION MONITORING (micro-credential elective): (3 days)

Learn how to field identify non-native invasive plant species and correctly manage them to improve habitats. Course content will include field techniques and protocols of vegetation monitoring for both baseline conditions and monitoring project success.

Date: September 18-20, 2019 Location: NKU REFS - Sign-up Today!

Find out more at:
https://www.nku.edu/refs.html