What's This Green Goop in My Water?
(Algae/Blue-green Algae)

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Lake Menomin – Dunn Co. K. Schreiber

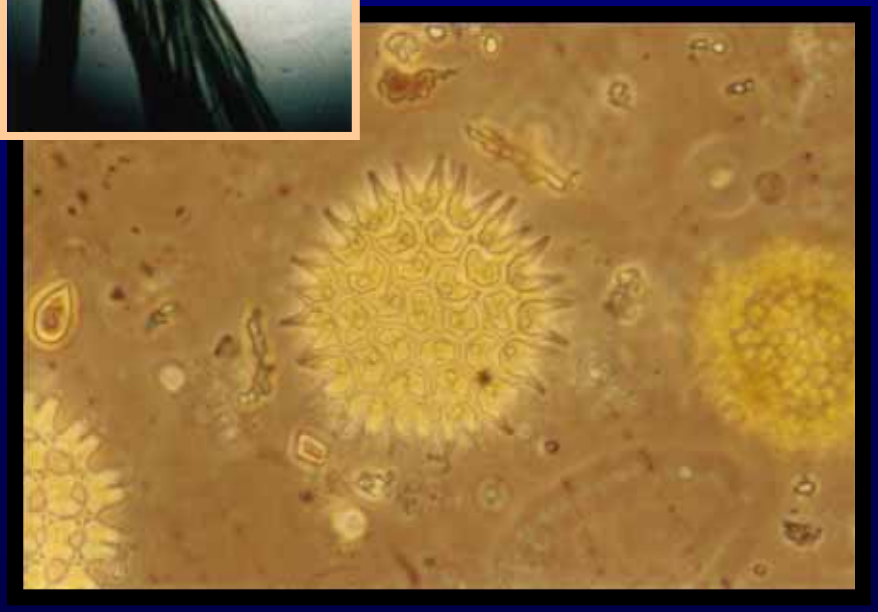
What I Will Cover Today

- Role in the food chain
- Taxonomic groupings/photos
- Cyanobacteria (blue-green algae)
- Nutrient Impacts
- Blue-green algal toxins
- Protection measures
- Summary of blue-green algae toxicity studies in Wisconsin
- Research needs

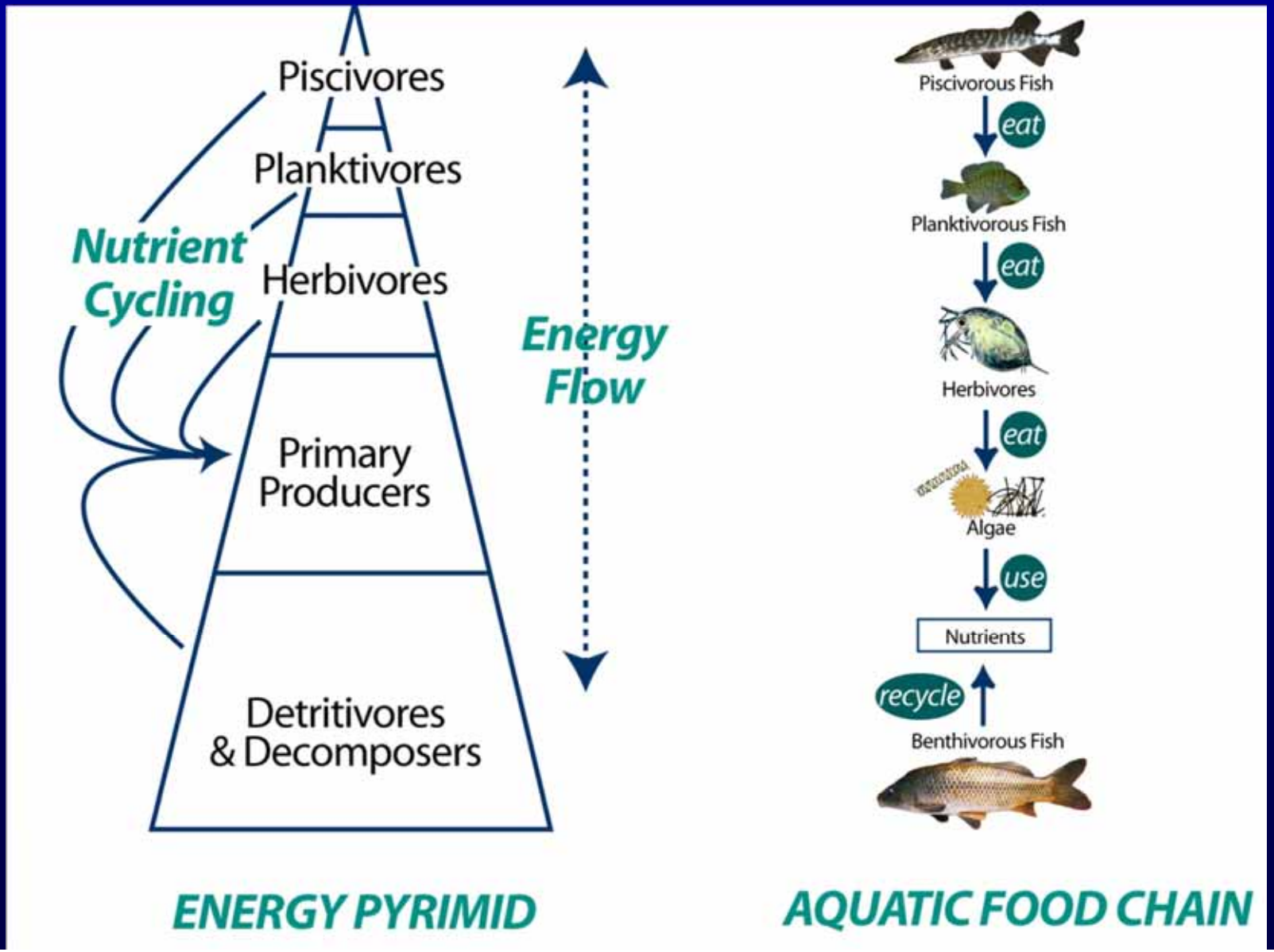
ALGAE

Functions

- Primary Producer
- Oxygen Production
- Major Producer of Organic Carbon



TROPHIC PYRAMID



Attached

Free floating

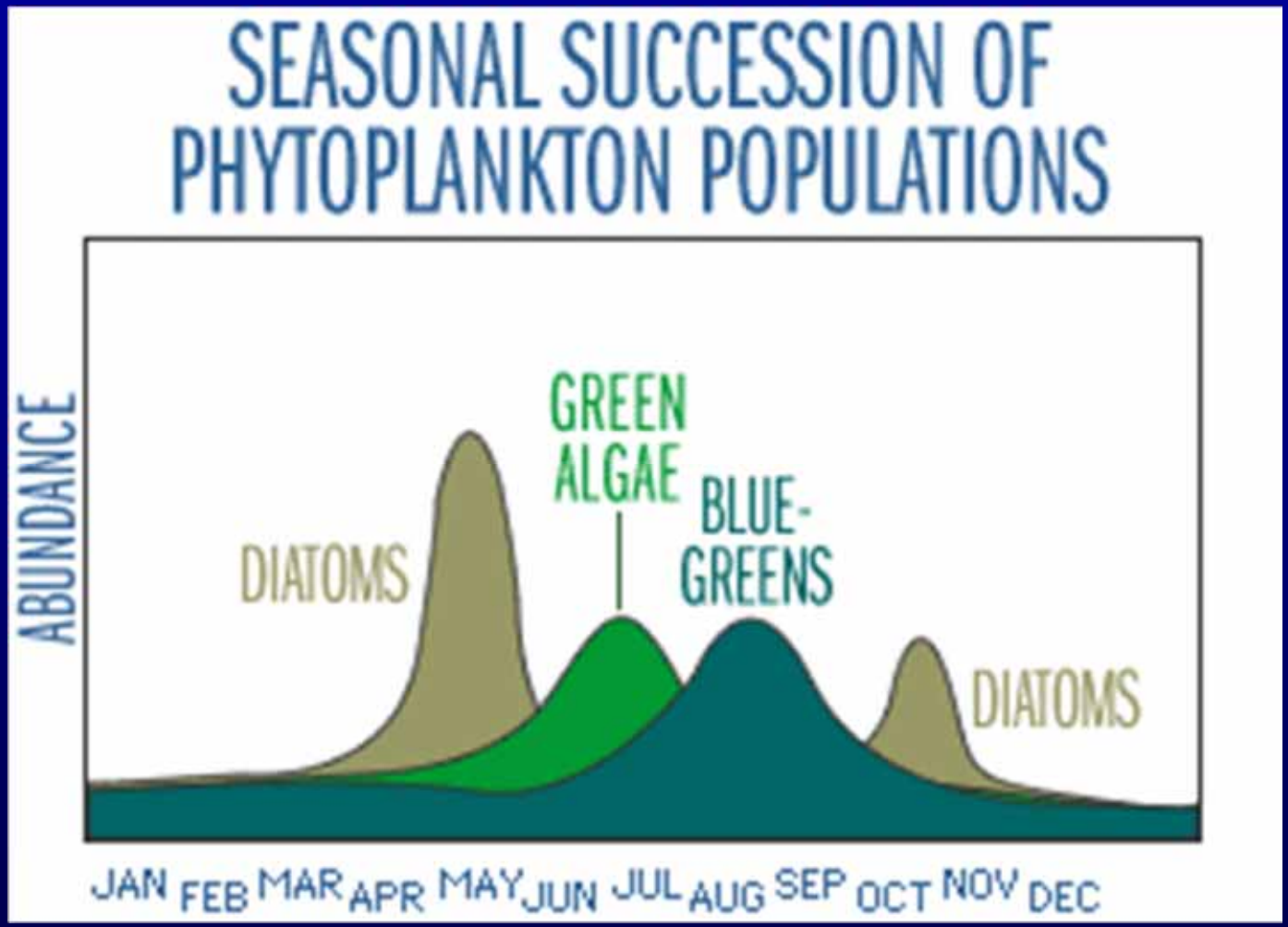
ALGAE

Ten Separate Phyla or Divisions (G.W. Prescott/third edition)

- Chlorophyta (Green Algae)(319 Genera)
- Chrysophyta (Yellow Brown Algae)(107 Genera)
- Euglenophyta (Euglenoids)(25 Genera)
- Cryptophyta (Cryptomonads)(10 Genera)
- Bacillariophyta (Diatoms) (100 Genera)
- Pyrrhophyta (Dinoflagellates)(18 Genera)
- Rhodophyta (Red Algae)(17 Genera)**
- Phaeophyta (Brown Algae)(3 Genera)**
- Chloromonadophyta (Chloromonads)(4 Genera)
- Cyanophyta/Cyanobacteria (Blue-green Algae) (74 Genera)

~677 Genera (not including species)
**not represented in Wisconsin?

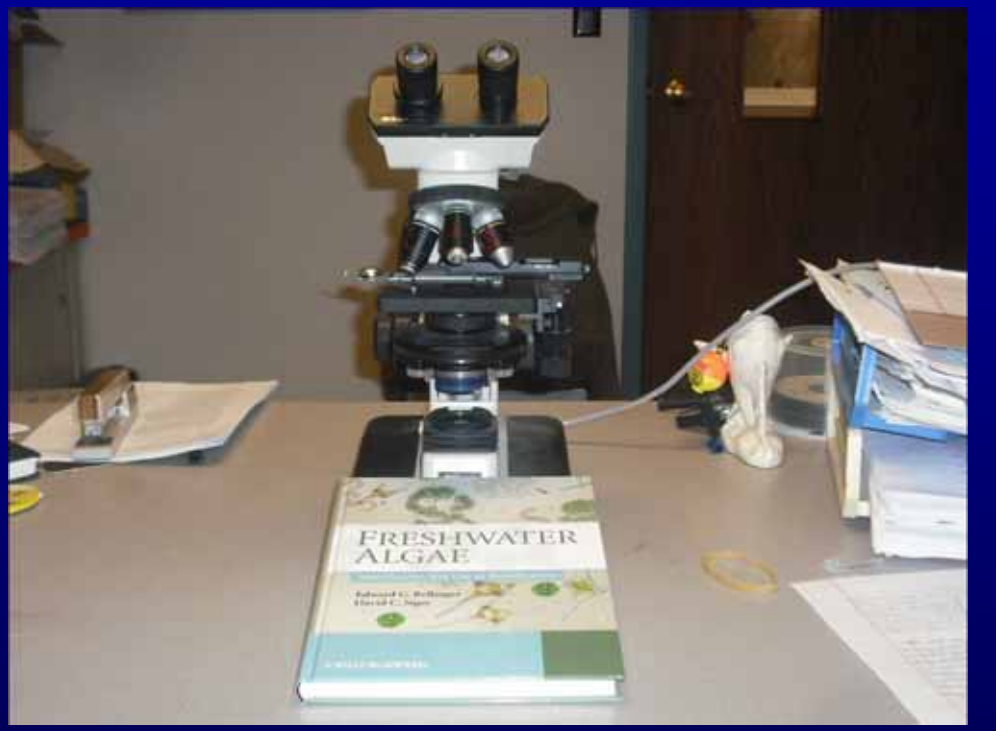
Bear Lake, Forest County



Can also be bioindicators

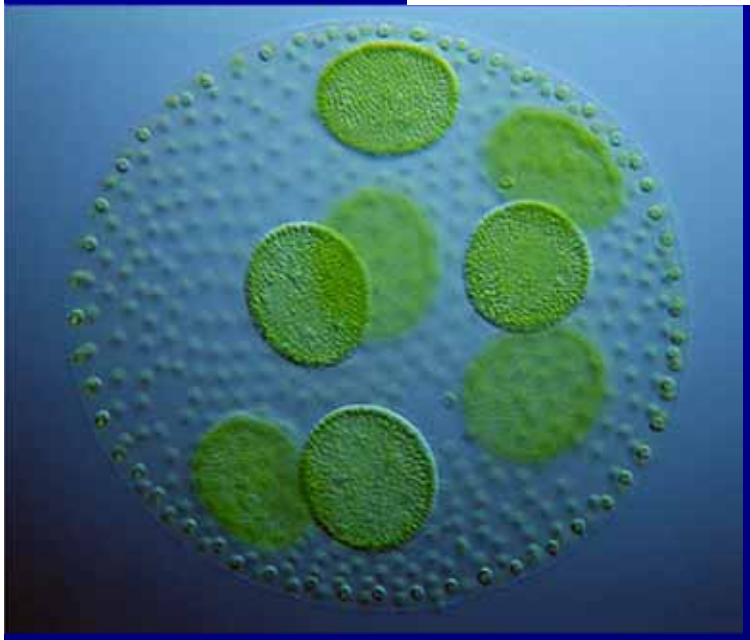
IDENTIFICATION

- Must use a light microscope (100x-1000x)
- Identification is based on
  1. Shape
  2. Motility
  3. Cell wall structure
  4. Colonial
  5. Filamentous
  6. Unicellular



Taxonomic Keys are available

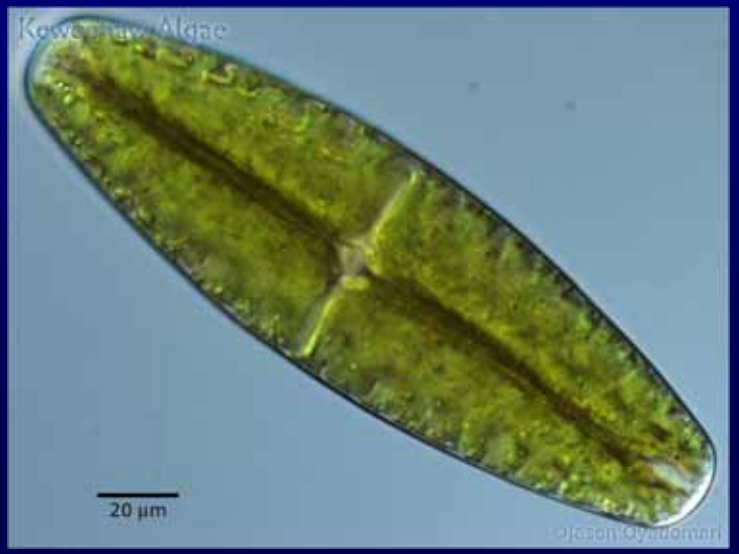
Chlorophyta (Green Algae) Planktonic



Volvox

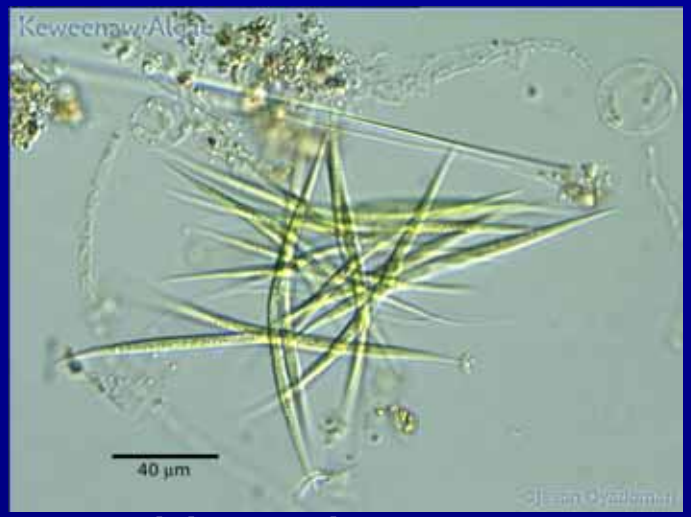
Botryococcus

Kirchneriella



Netrium

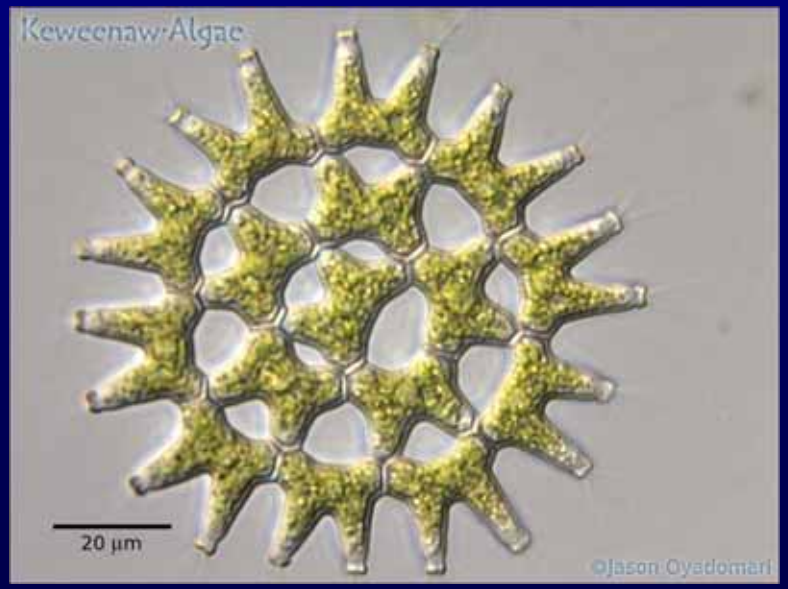
Green Algae (Planktonic)



Ankistrodesmus

Tetraedron

Scenedesmus



Pediastrum

Green Algae (Planktonic)

Eudorina

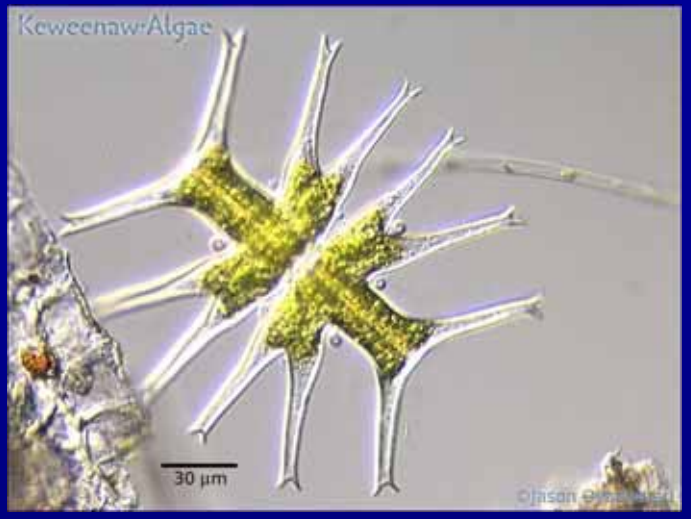
Pandorina

Gloeocystis

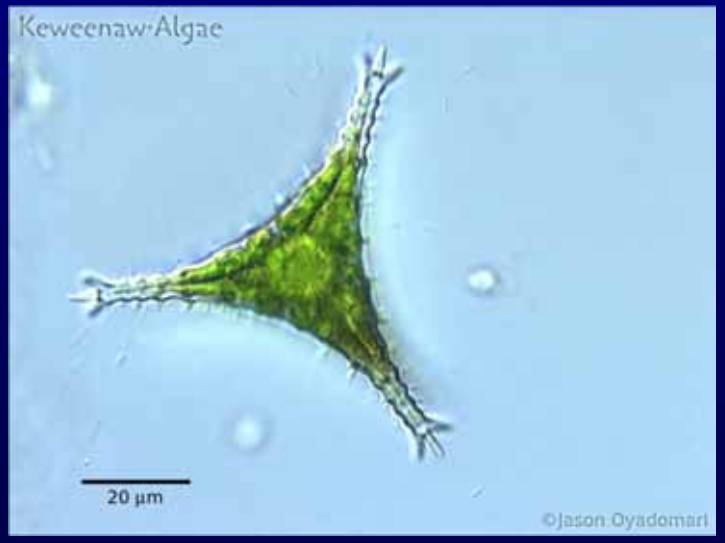
Oocystis

Green Algae (Planktonic Desmids)

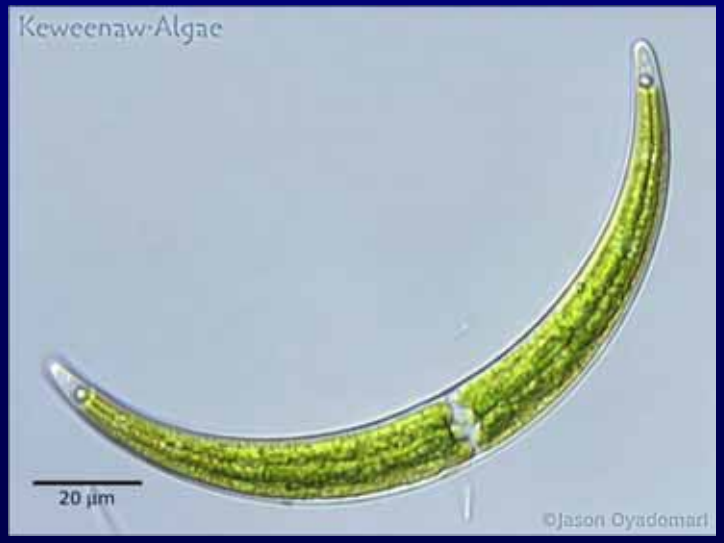
Euastrum



Micrasterias



Staurastrum

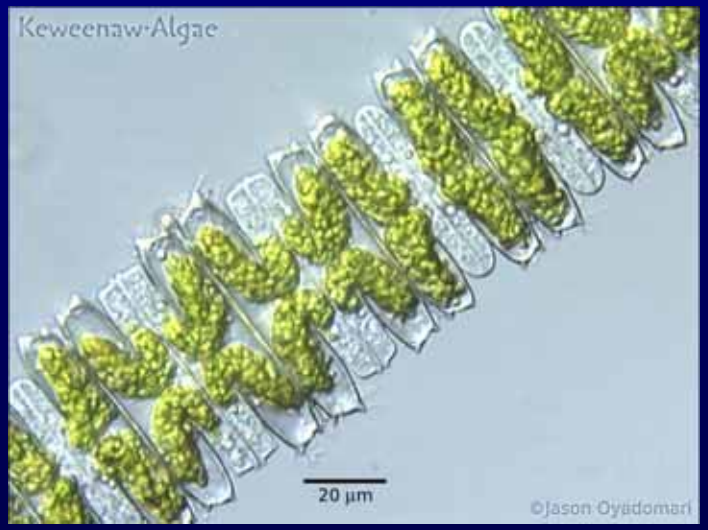


Closterium

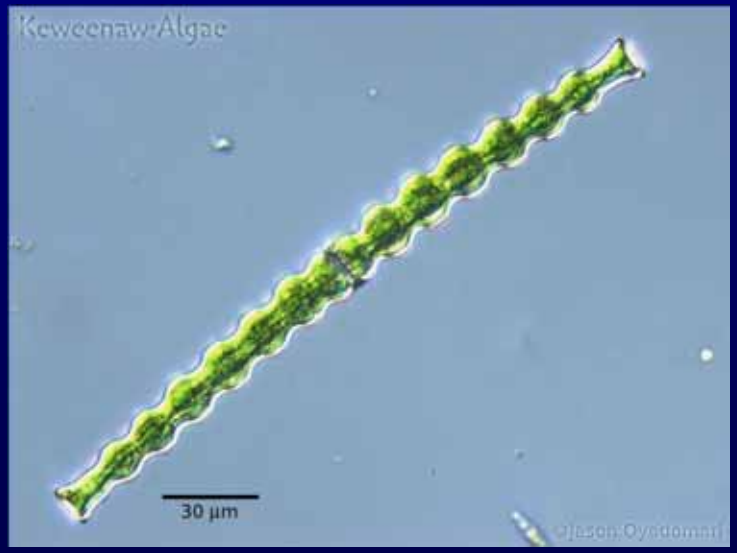
Green Algae (Planktonic Desmids)

Desmidium

Triploceras



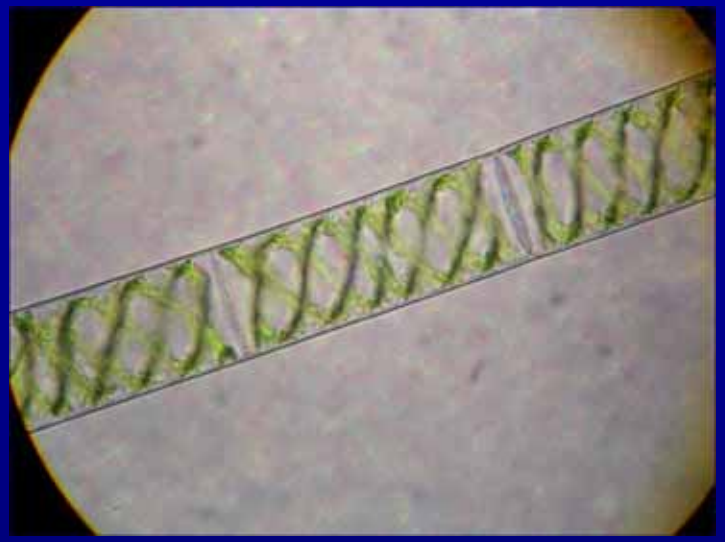
Spondylosium



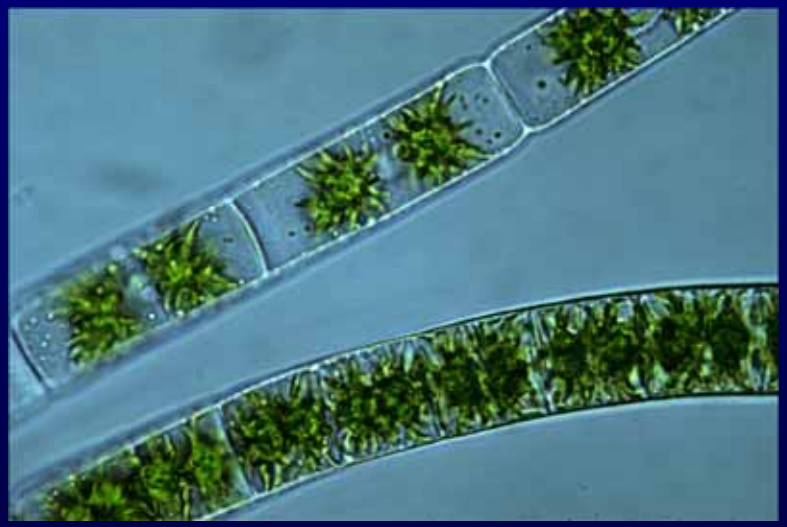
Docidium

Chlorophyta (Filamentous greens)

Mougeotia



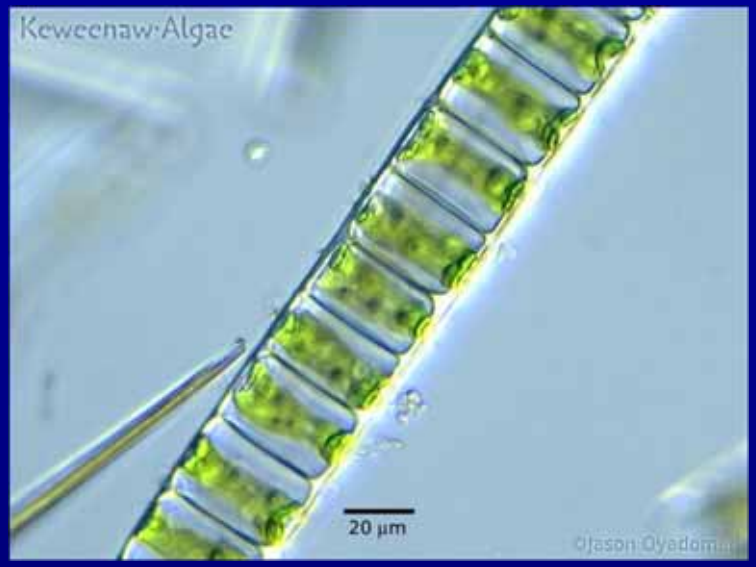
Spirogyra



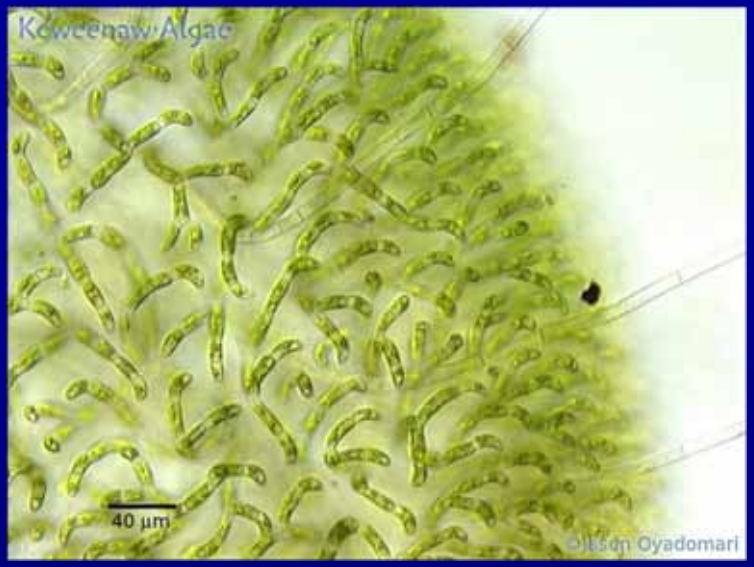
Zygnema

Draparnaldia

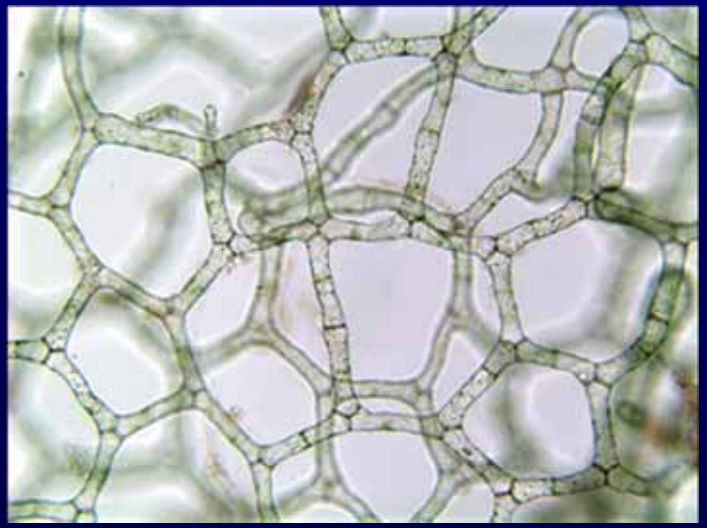
Filamentous greens



Ulothrix



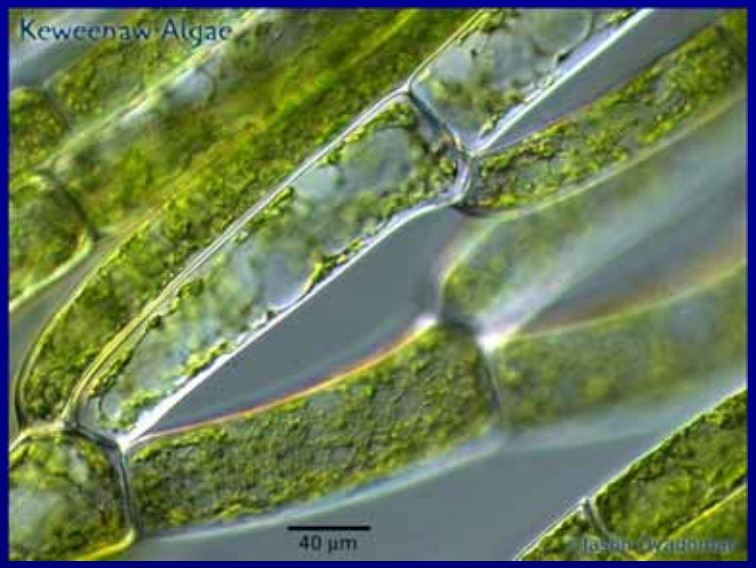
Chaetophora



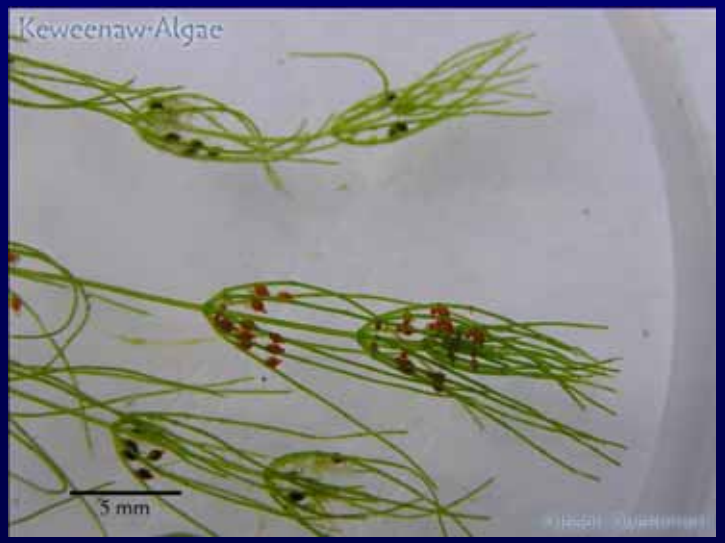
Hydrodictyon

Filamentous greens

Cladophora



Cladophora



Chara (Stonewort)

Nitella (Stonewort)

Euglenophyta (Euglenoids)

Euglena

Phacus

Pyrrhophyta (Dinoflagellates)

Peridinium

Ceratium

Gymnodinium

Cryptophyta (Cryptomonads)

Cryptomonas

Chloromonadophyta (Chloromonads)

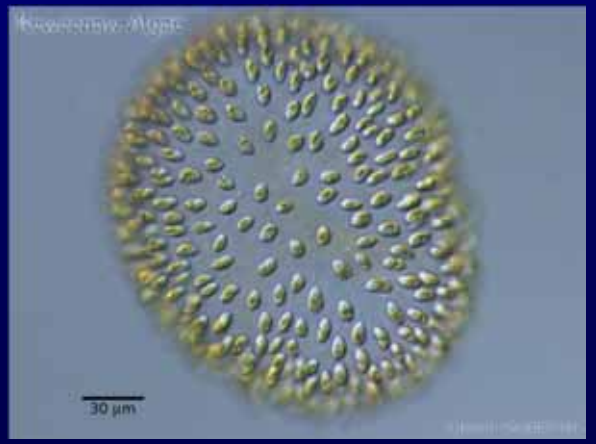
Vacuolaria

Chrysophyta (Yellow Brown Algae)

Dinobryon

Synura

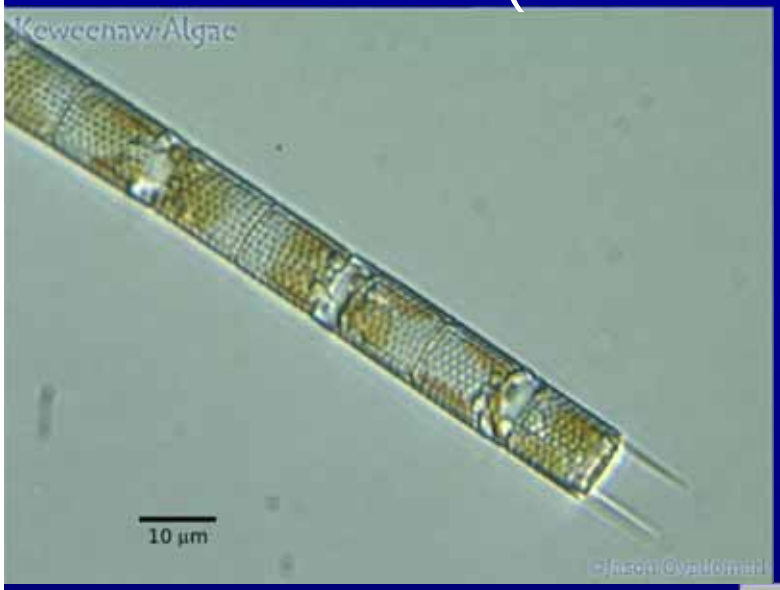
Chrysospharella



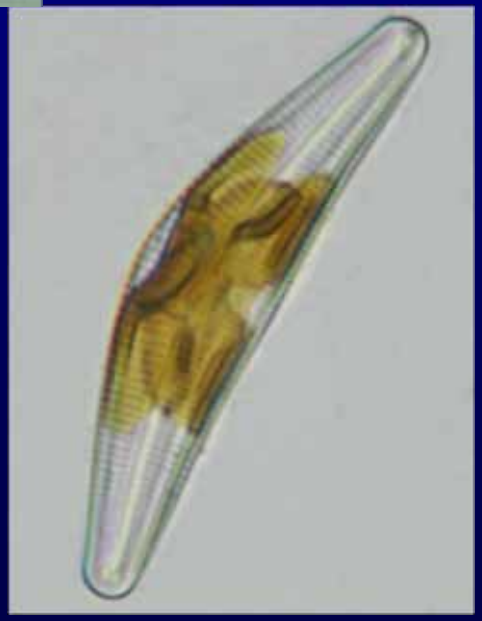
Uroglenopsis

Bacillariophyta (Diatoms)

(Can be attached or free floating)



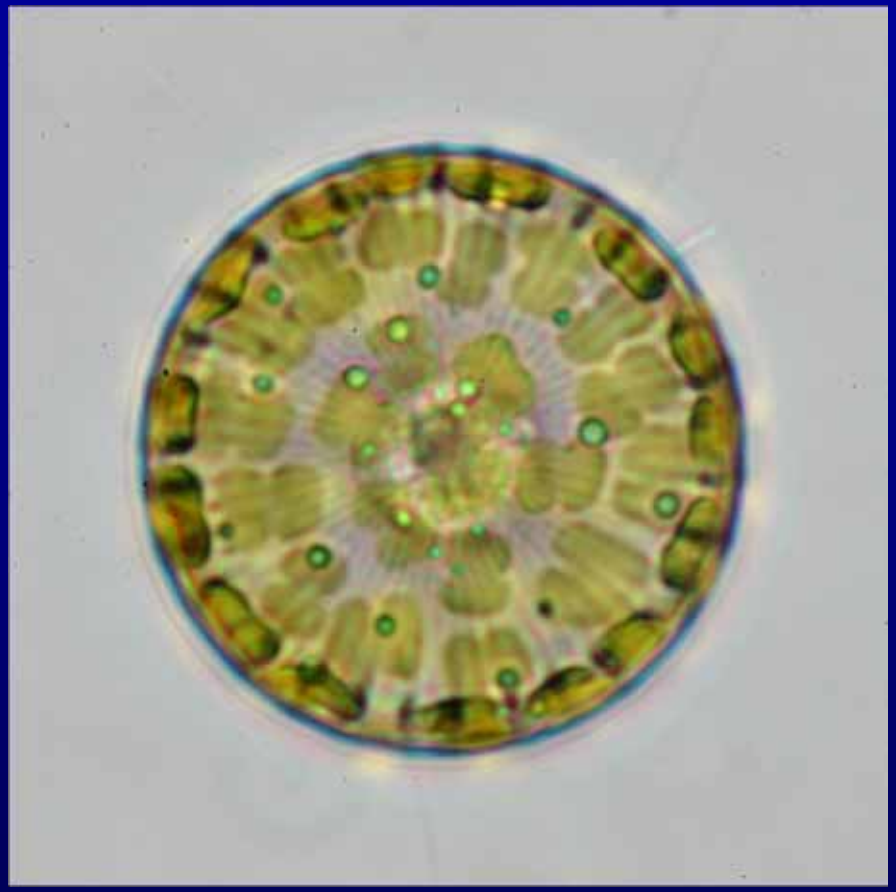
Melosira



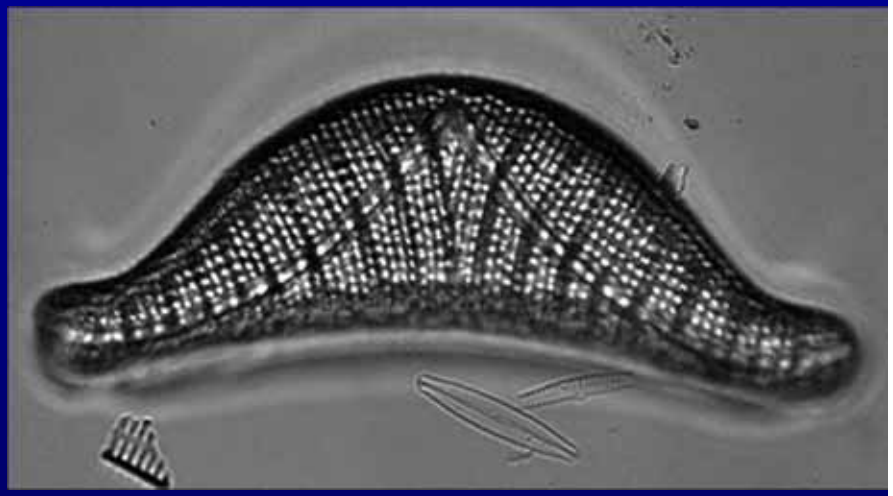
Cymbella

Pinnularia

Diatoms



Stephanodiscus

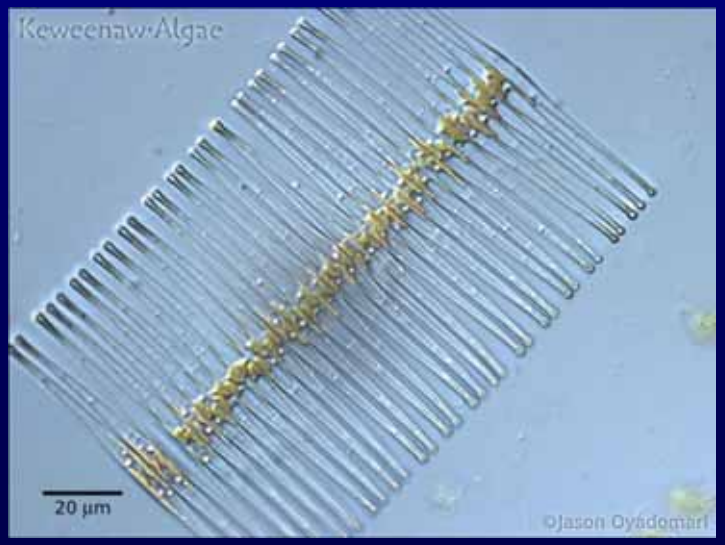


Epithemia

Diatoms

Cymatopleura

Eunotia



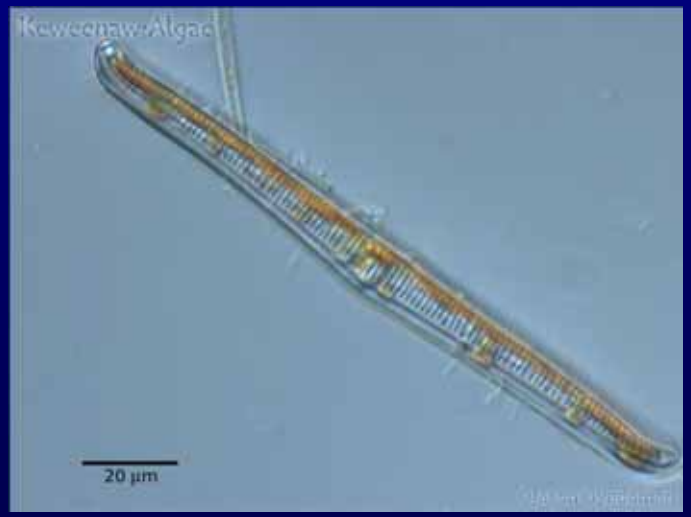
Fragilaria

Gomphonema

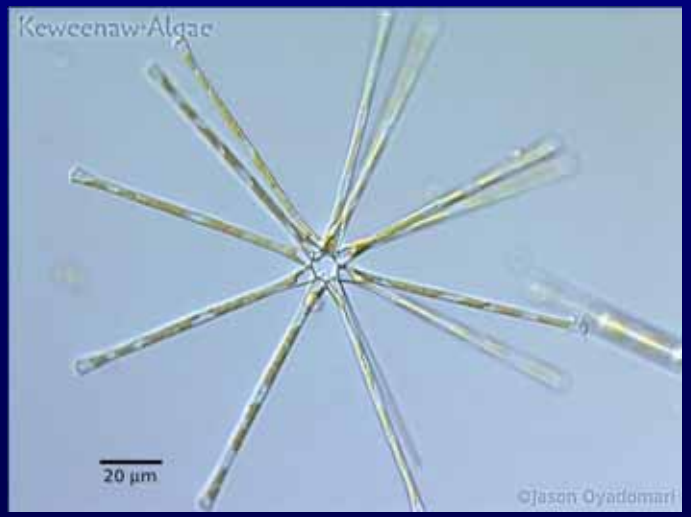
Diatoms

Gyrosigma

Nitzschia

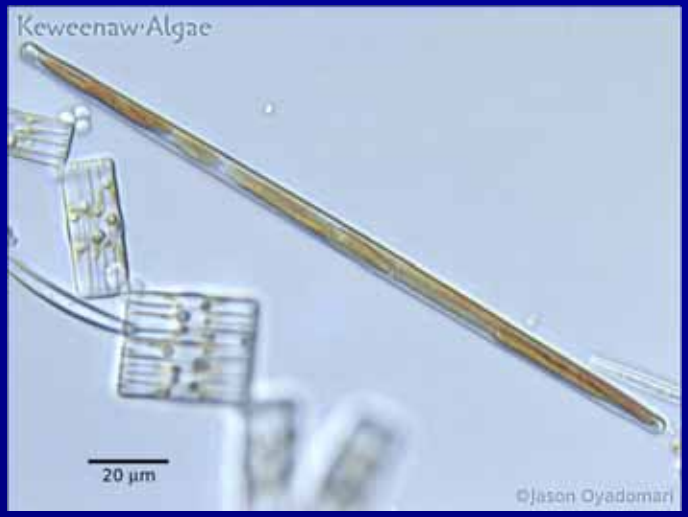


Rhopalodia



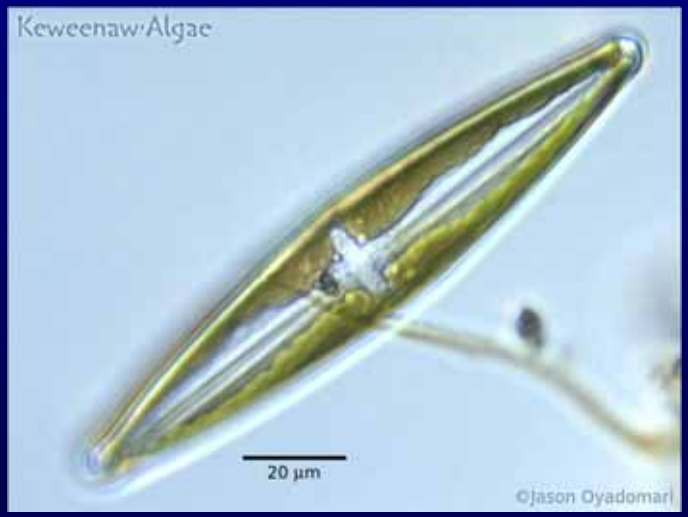
Asterionella

Diatoms

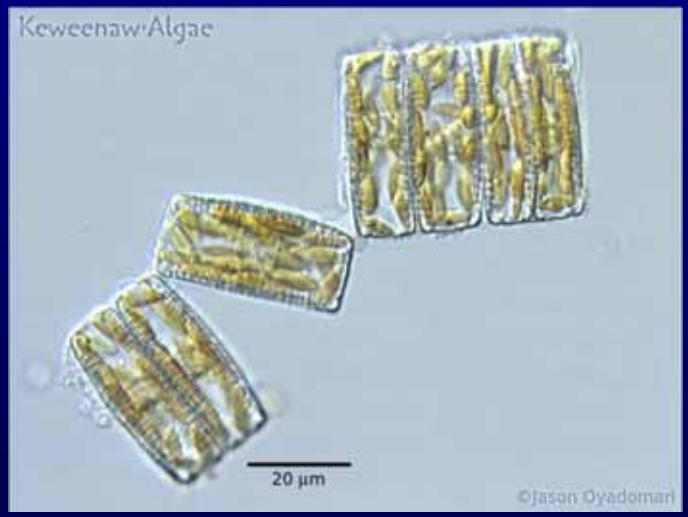


Synedra

Surirella



Stauroneis



Diatoma

Paleocore

- Provides a summary of “Lake History”
  - Sediment is dated
  - Sedimentation rates determined
  - Water quality changes can be determined using diatoms as indicators

Dead Pike Lake

Cyanophyta/Cyanobacteria

-A.K.A. blue-green algae (around 2.5-3.4 billion years)

- Differ from other bacteria:
  can perform photosynthesis

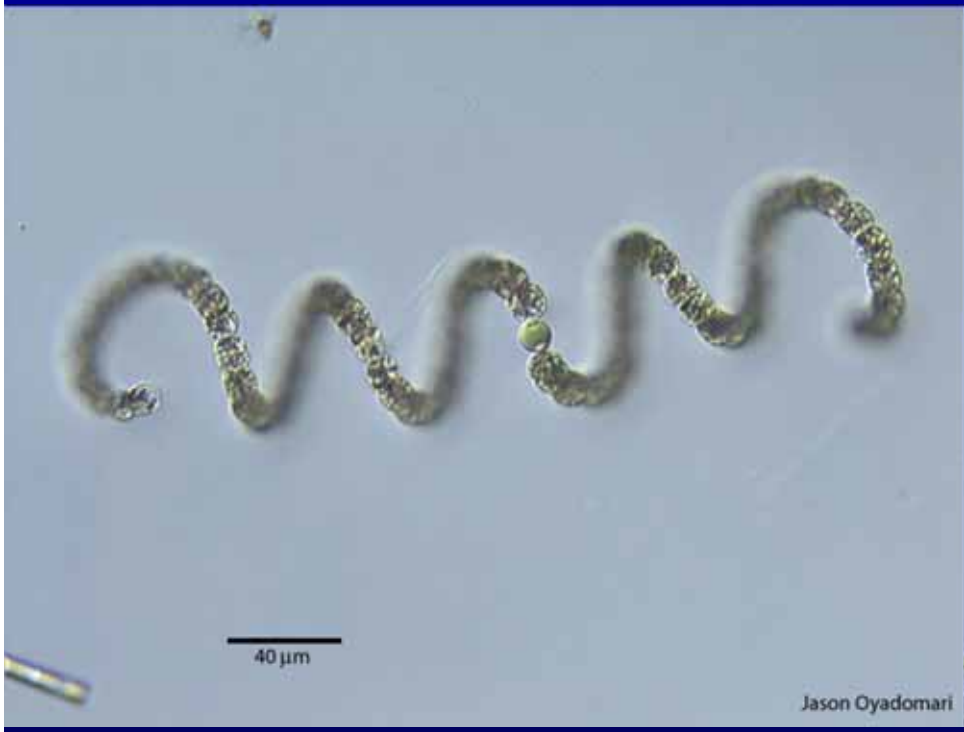
- Are true bacteria, so lack a
  well-defined nucleus, organelles

- Make up a portion of the
  phytoplankton, but largely
  inedible because of size or
  chemical defense system (toxins)

Anabaena sp.

- Blue-green color from phycocyanin pigments
- Native to every lake in Wisconsin

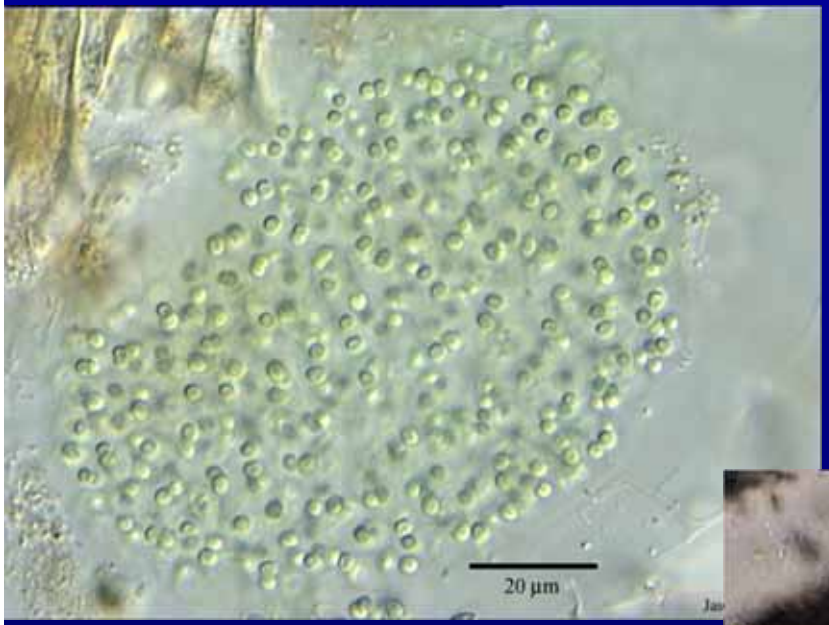
Cyanobacteria



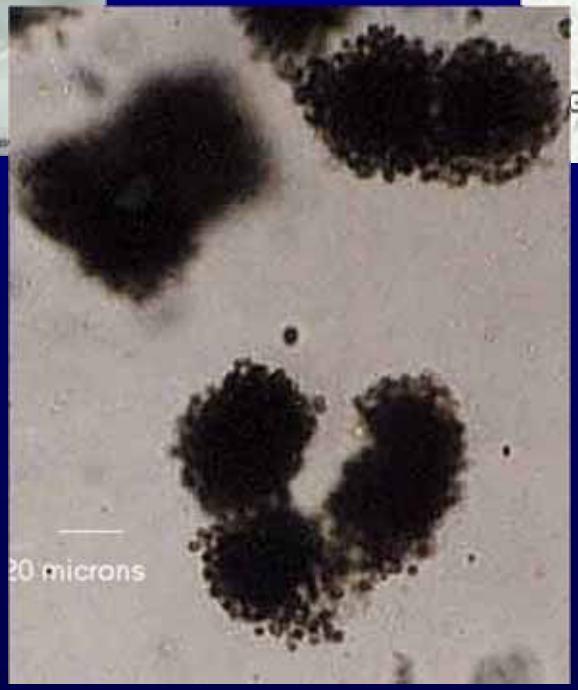
Anabaena

Aphanizomenon

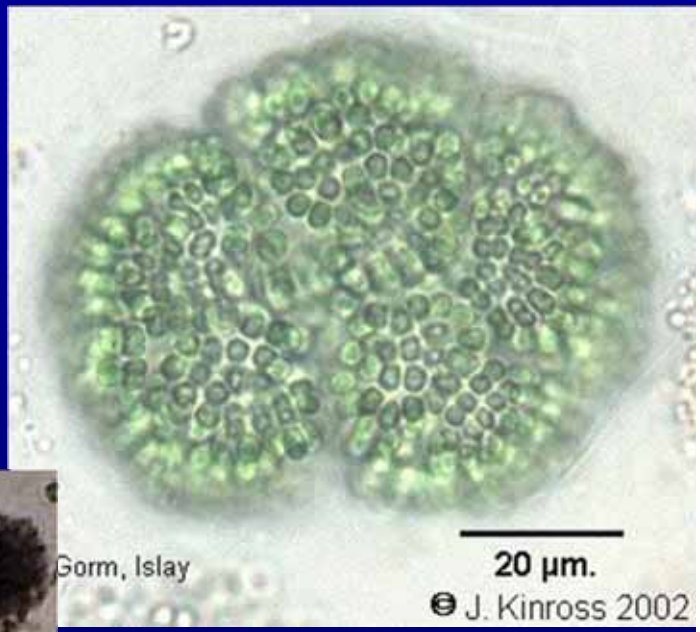
Cyanobacteria



Aphanocapsa

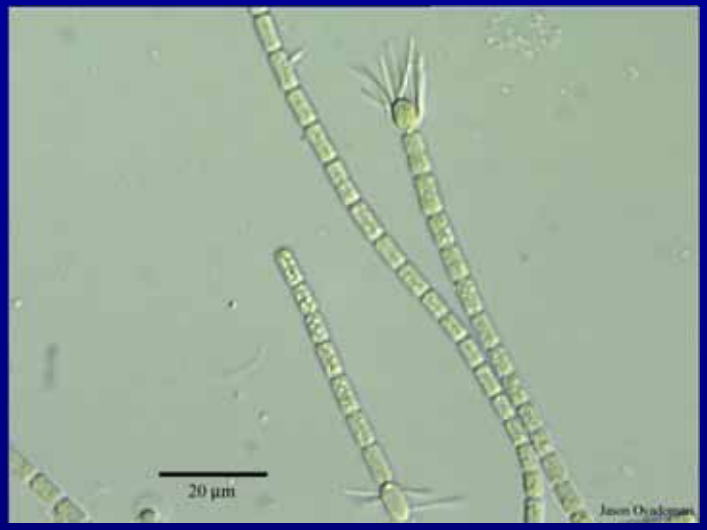


Microcystis

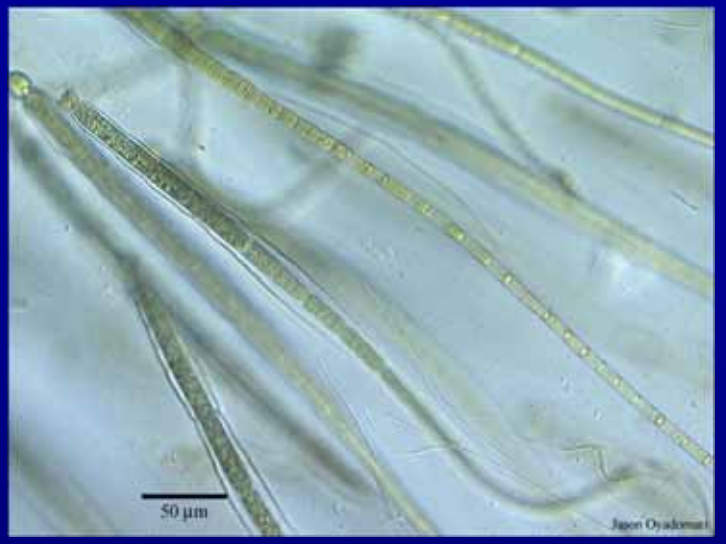


Coelosphaerium

Cyanobacteria



Cylindrospermum

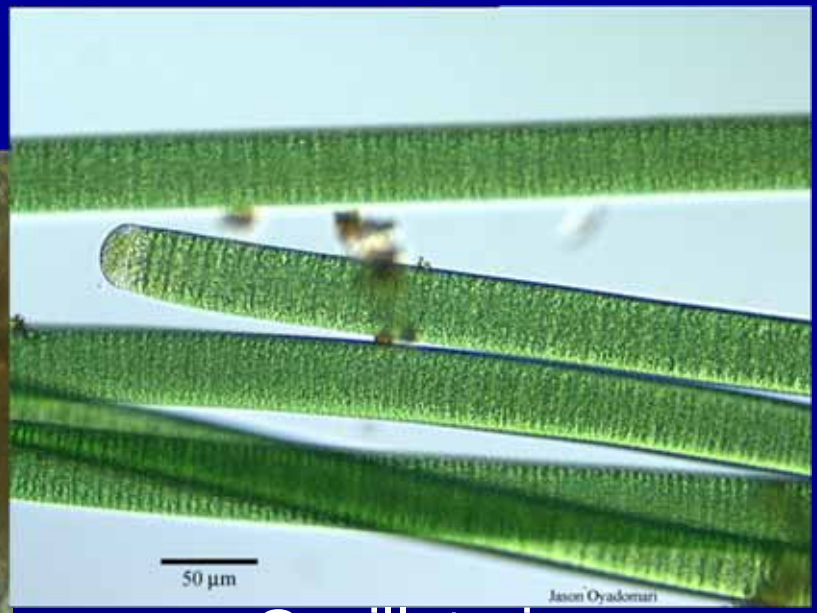


Cylindrospermopsis

Gloeotrichia

Cyanobacteria

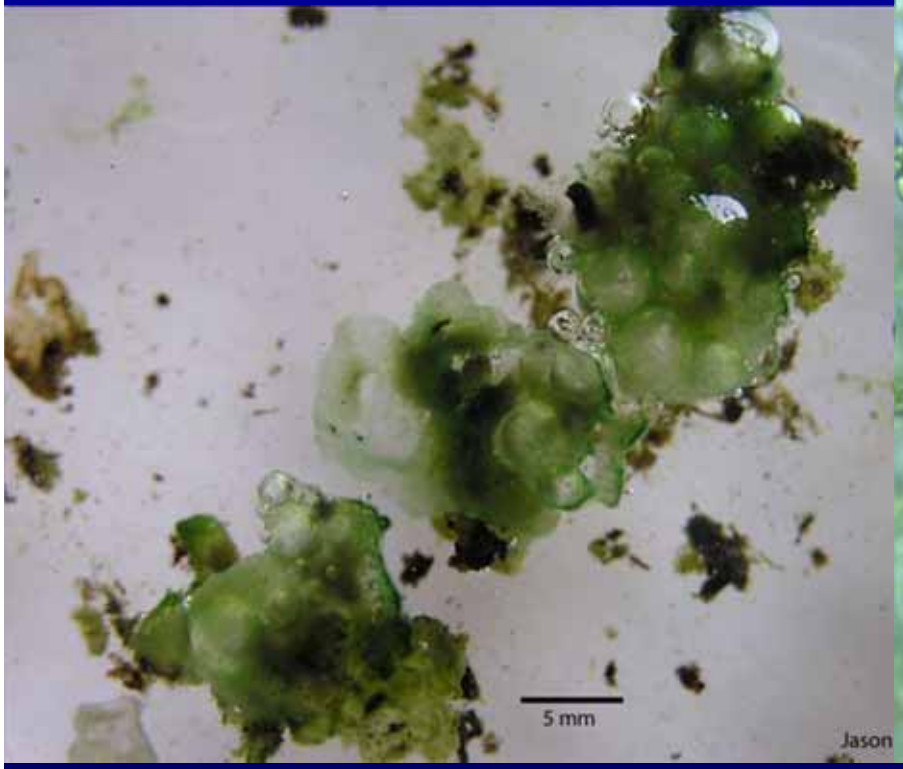
Lyngbya



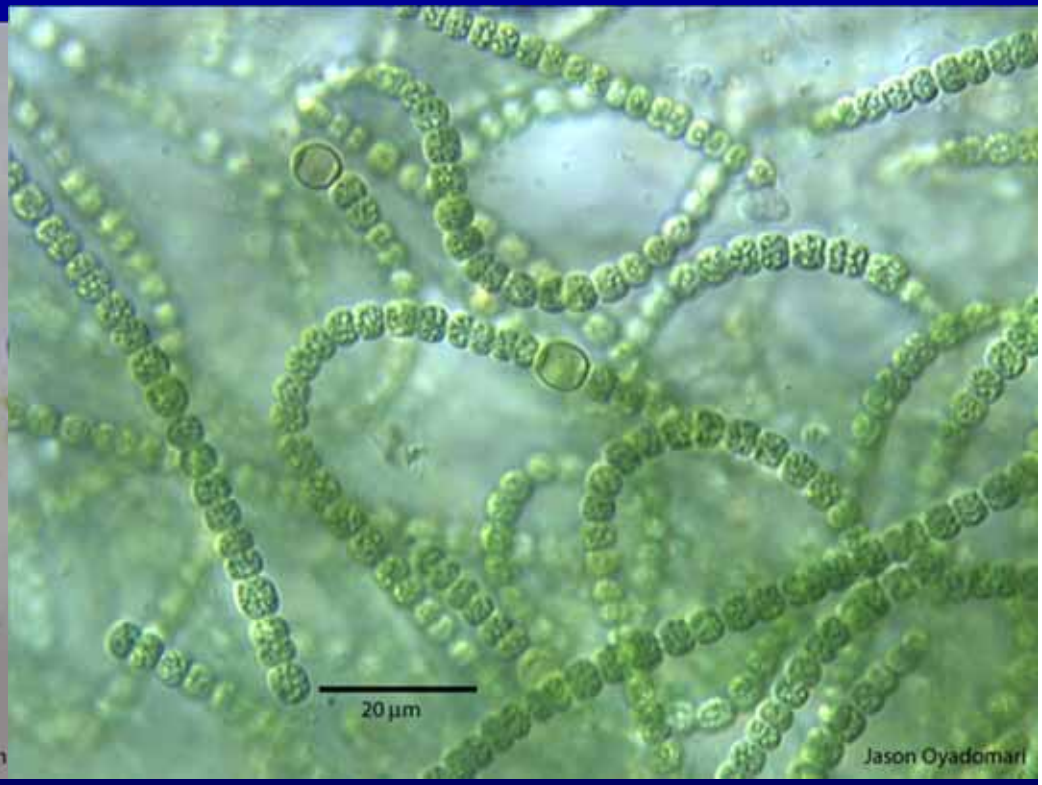
Oscillatoria

Planktothrix

Cyanobacteria



Nostoc (gelatinous balls)

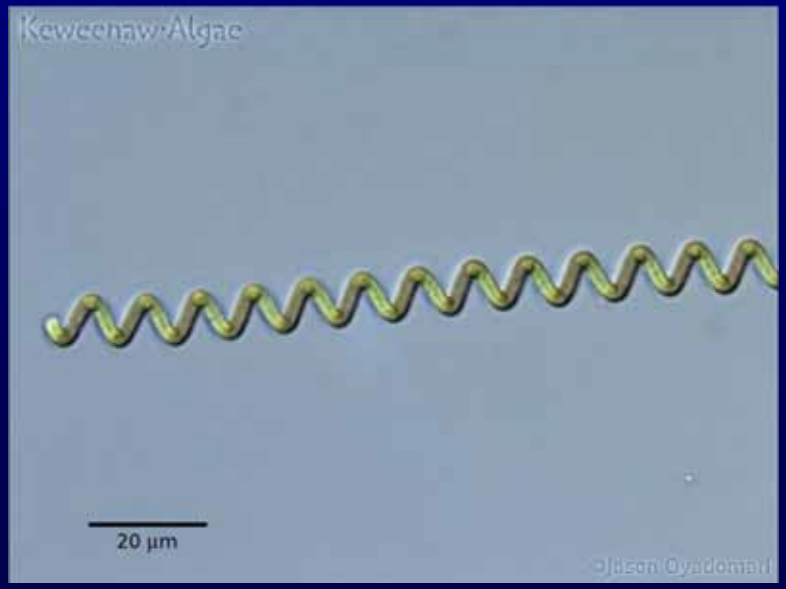


Nostoc

Cyanobacteria

Chroococcus

Merismopedia



Spirulina

Blue-Green Algae Blooms

Blue-green algae can increase in number to “bloom” densities when conditions are right:

Lake Menomin, Dunn County

-nutrients
  -esp. P (luxury consumption)
  some can fix N
  outcompete other phytoplankton
-temperature (optimal 68-86 degrees)
-wind
  -calm, low turbulence
  -gas-filled vesicles (regulate buoyancy)
  -accumulate as scums
-Chemical defense (prevent grazing)

Blue-Green Algae Blooms (con't)

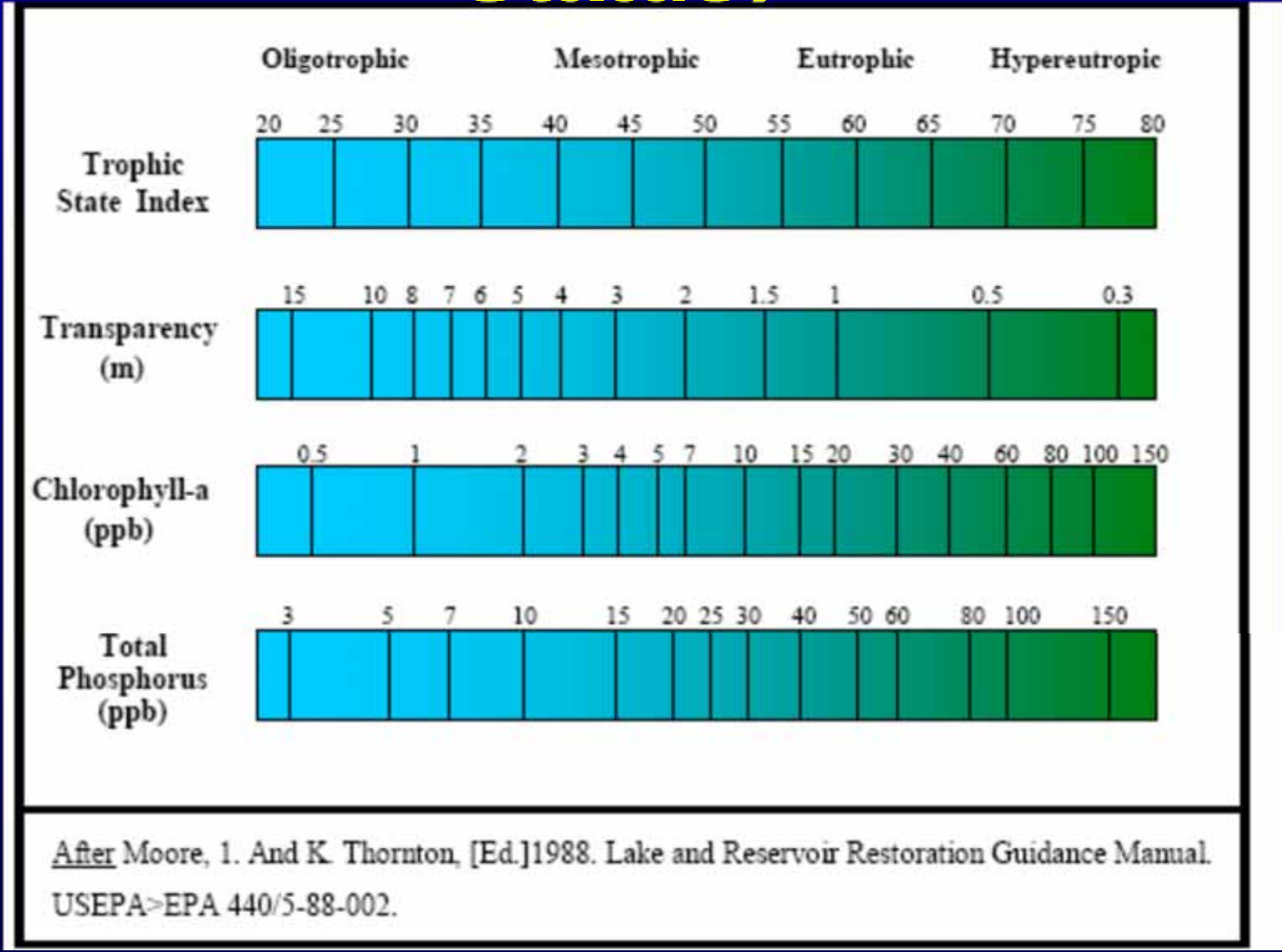
The relative abundance and bloom frequency in lakes is controlled by both phosphorus and nitrogen, but phosphorus appears to be primary control

Researchers (Downing et.al. 2001) analyzed 99 lakes around the world and found that the risk of cyanobacteria dominance in water blooms

1. Was less than 10 % when TP concentration was below 30 mg/l
2. The risk rises to about 40 % between 30 and 70 mg/l;
3. And levels off at 80 % above 100 mg/l

Nitrogen/phosphorus rations of < 10 to 1 favor bloom formation

Trophic State Index (Nutrient Status)



After Moore, 1. And K. Thornton, [Ed.]1988. Lake and Reservoir Restoration Guidance Manual. USEPA>EPA 440/5-88-002.

Issues Associated with Blue-Green Algae Blooms

-Discolored water

-Taste and odor problems

-Reduced light penetration

-Dissolved oxygen depletions during die-off

-Diurnal swings in D.O. and pH

-Recreational use impairment

-Toxin production

Blue-Green Algal Toxins

Red Cedar R.

-Some species can produce one or more toxins

-Those that can produce toxins do not produce toxins at all times (strain, environmental conditions, zooplankton grazing)

-Reports of livestock deaths date back to 1878

-Report of human deaths in Brazil, 1996

-Controversial report of a human death here in WI, 2002

-Reports of dog deaths in WI (e.g., June 2004)

Exposure Routes to Humans and Animals

1. Skin Contact (dermal)
2. Inhalation (respiratory/ gastrointestinal
3. Consumption of water (swimming/D.W. supplies)
4. Bioaccumulation in food chain (shellfish, fish/Klamath River Study)

Lake Nokomis (Oneida and Lincoln Counties)

Dermatotoxins (Endotoxins)

-Lypopolysaccharides (LPS)-found in outer membrane of cell wall of all gram negative bacteria
-Affect skin and mucous membranes
-Can cause rashes, respiratory illness, headaches, gastrointestinal upset

Hepatotoxins

-Affect the liver (sometimes kidneys)
-Can cause hemorrhage, tissue damage, tumors, liver cancer, death
-e.g., microcystin (Microcystis)

Neurotoxins

-Affect the central nervous system
-Can cause seizures, paralysis, respiratory failure, death
-e.g., anatoxin-a (Anabaena, Aphanizomenon)
Saxitoxin (Anabaena, Planktothrix, Cylindro.)

Cytotoxins

-Affect the liver and other organs (protein synthesis)
-Can cause chromosome loss, DNA strand breakage, damage to organs
-Cylindrospermopsin

BMAA

- *beta*-methylamino-L-alanine
  - Neurotoxic amino acid produced by blue-green algae
  - first observed in association with cycad (tree-like tropical plant) on Guam
  - Blue-green algae fix nitrogen for cycad, and toxins are present in seeds
  - high prevalence of Amyotrophic Lateral Sclerosis (ALS) and Parkinson's dementia complex observed while cycad was a significant part of the local diet
  - Bioaccumulates in food chain
  - Recently found in blue-green algae from elsewhere in the world

Persistence

Microcystin

-Most cyanotoxin poisoning worldwide are associated with microcystin
-are very stable molecules and can persist for months in the environment
-degrade very slowly inside cells, so if cells dry intact, the microcystin remains in the cell
-In water, (if cell lyses), sunlight breaks down molecule slowly, from 2-6 weeks for 90 % breakdown

Anatoxin

-Second most common cyanotoxin found in US
-In water, degrades rapidly in sunlight

Cylindospermopsin

-In water, breaks down in 2-3 days by sunlight

Saxotoxin

-Have been reported from only a few US locations, but are likely to be widespread
-Break down rates for saxitoxin are unknown

Measures People Can Take To Protect Themselves

- Do not swim in water that looks like “pea soup”
- Do not boat, water ski, etc. over such water (people can be exposed through inhalation)
- Do not let children play with scum layers, even from shore
- Do not let pets swim in or drink waters experiencing blue-green algae blooms
- Always take a shower after coming in contact with surface water

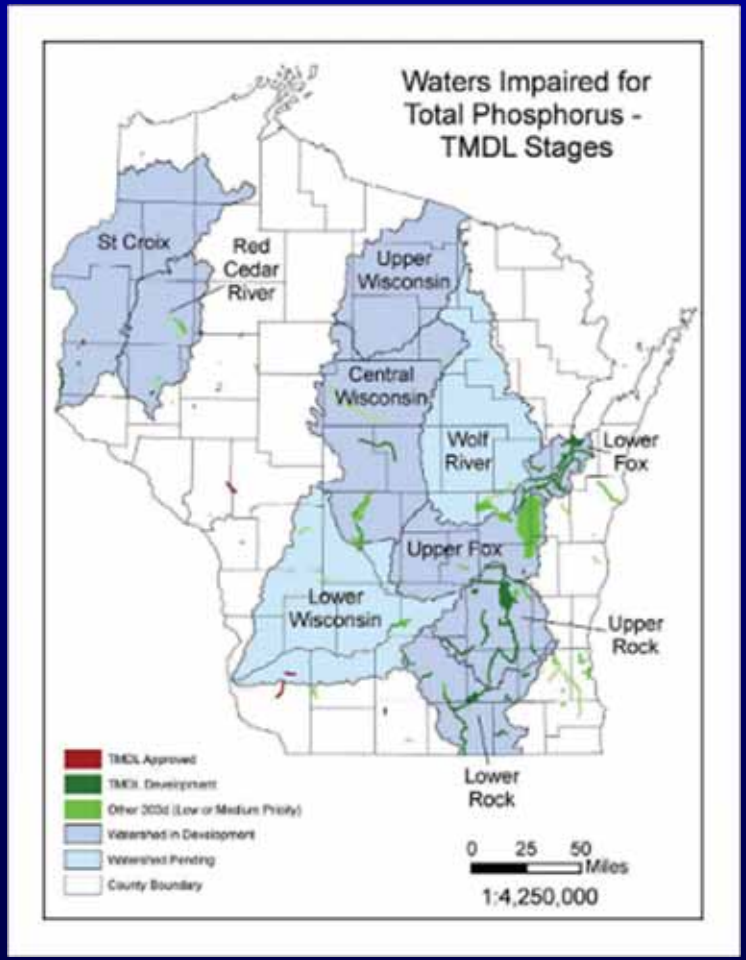
Measures People Can Take to Help Reduce Future Blooms (Control Nutrient Loading (Mainly phosphorus)

- Maintain native vegetation along shorelines as buffer areas
- Minimize activities that result in erosion
- Reduce the amount of fertilizers used on lawns
- Use only phosphorus-free fertilizer
- Fix leaking or failing septic systems
- Control sources within watershed (TMDLs and Lake Protection Plans)
- In-lake management

Addressing the Cause – Reducing Nutrients in the Watershed

- Impaired waters 303(d)
- TMDLs (Total Maximum Daily Loads)
- Point and non-point source reduction
- Grants

The WDNR is actively developing several large-scale basin-wide TMDLs – many of these are in basins with chronic severe algal blooms and measured toxins



Cyanobacteria Studies in Wisconsin

Karl (1970)

-sampled 20 lakes around the state and found that 20-40% of the samples contained toxins
-Mouse bioassay

Vennie, Wedepohl et al. (1986)

-statewide survey of 86 lakes and ponds
-Cyanobacteria capable of producing toxins were found in all sites, and 25% of the samples contained toxins
-mouse bioassay

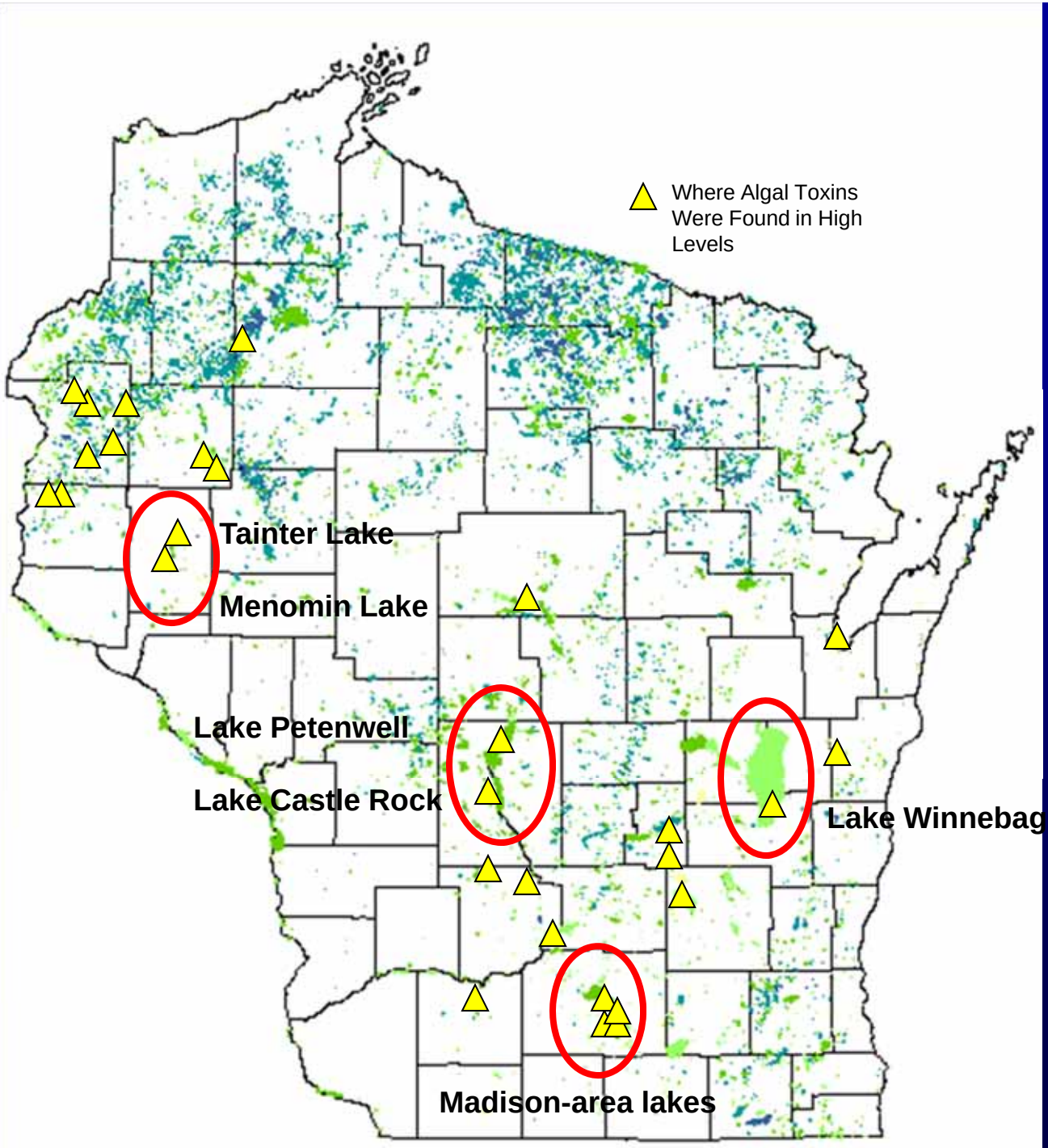
Harrahy et al. (2007)

-Sampled Lakes and ponds with a history of cyanobacteria blooms in 2004-05
-Cyanobacteria capable of producing toxins were found in 74% of samples in 2004-05
-Toxins (Microcystin/Anatoxin) were found in 69% (2004) and 41% (2005) of the samples analyzed
-Blue-green algal toxin analysis was performed by HPLC/MS/MS

Wisconsin Department of Health Services Study (2009-present)

-Department of Health Services/Wisconsin DNR (Report a Case)

Algal Toxin Occurrences 1986 and 2003-2006



8 of the Largest Most Popular Lakes

Wisconsin Department of Health Services

Blue-Green Algae Surveillance Program

The Wisconsin Division of Public Health is working with the Centers for Disease Control and Prevention to collect information about human and animal illness and death resulting from exposure to blue-green algae. This information will provide a better understanding of the public health problem posed by algae blooms in our lakes and rivers and enhance efforts to prevent exposures from occurring.

Program staff are asking the public to notify them of any known or suspected human or animal exposures to blue-green algae that may have resulted in illnesses such as breathing problems, vomiting, or skin rashes. Researchers will collect information about symptoms and any treatment received. They will also collect exposure information such as date and location, and may collect water samples for analysis.

People should not swim or boat through heavy algal blooms. Keep children and pets away from algal blooms. Individuals experiencing symptoms of blue-green algae exposure should seek medical attention.

For More Information or To Report a Case

Log on to http://dhs.wi.gov/eh/bluegreenalgae
or
Call (608) 266-1120

REPORT A CASE
http://dhs.wi.gov/eh/bluegreenalgae

Case Reporting Pathways

- DHS website case reporting tool
- DNR and local health agency referral
- WI Poison Center
  1-800-222-1222

Sampling Methods

-Samples are collected near shore at each location
  -BGA ID and enumeration
  -chlorophyll-a analysis
  -blue-green algal toxin analysis
-Shipped overnight to WI State Laboratory of Hygiene

Identification and Enumeration Methods

Tier I Analysis

-algae identified to genus level

-Cell counts (5000 natural units or colonies/ml or 100,000 cells/ml)

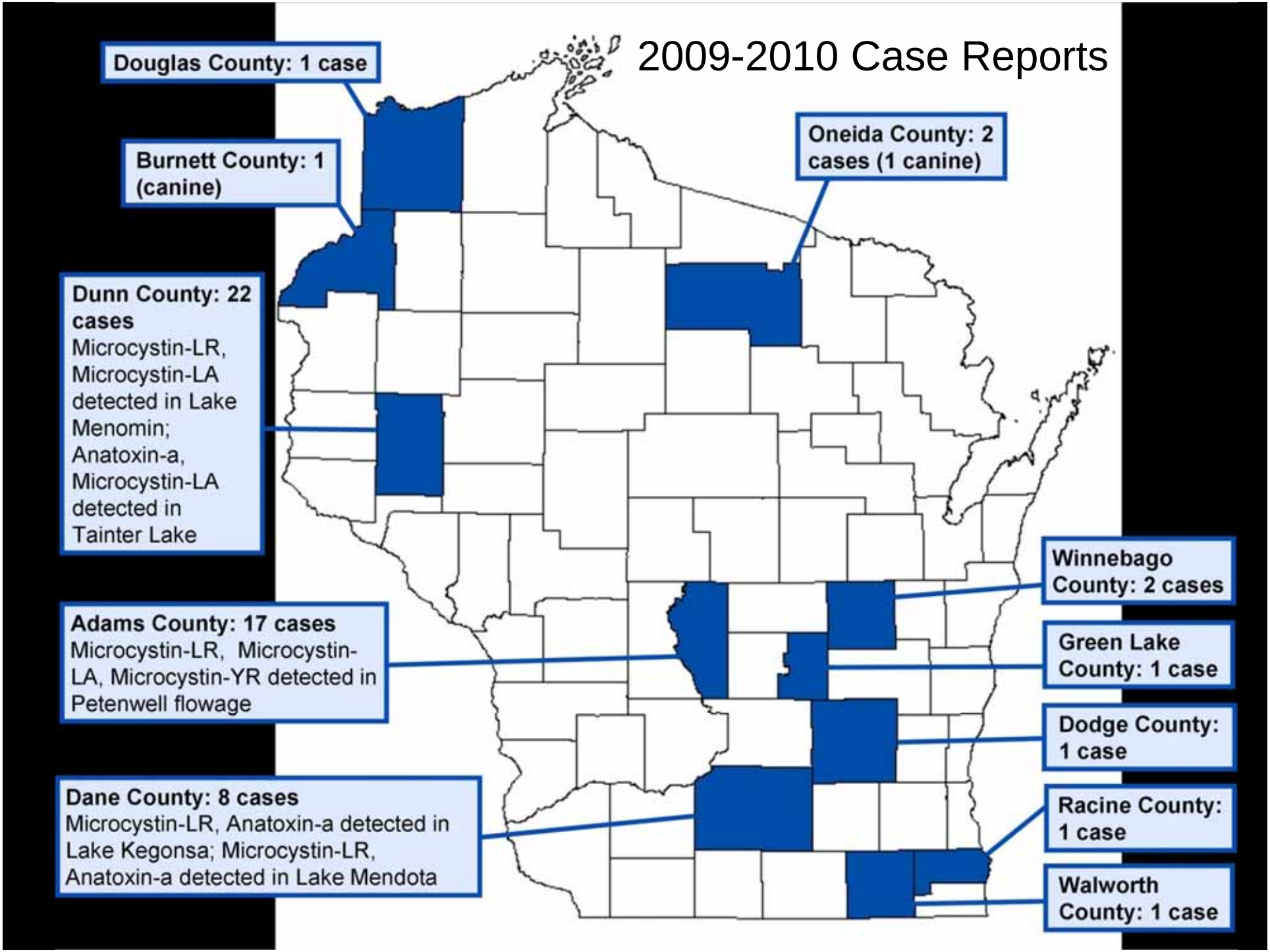
Tier II Analysis

-Toxin analysis (not real time)

Toxin Guideline Values

Microcystin 1 µg/L
Anatoxin-A 0.5 µg/L
Cylindrospermopsin 0.5 µg/L

L. Menomin
2004
microcystin


2009-2010 Case Reports
Douglas County: 1 case
Burnett County: 1 (canine)
Oneida County: 2 cases (1 canine)
Dunn County: 22 cases
Microcystin-LR, Microcystin-LA detected in Lake Menomin; Anatoxin-a, Microcystin-LA detected in Tainter Lake
Winnebago County: 2 cases
Adams County: 17 cases
Microcystin-LR, Microcystin-LA, Microcystin-YR detected in Petenwell flowage
Green Lake County: 1 case
Dodge County: 1 case
Dane County: 8 cases
Microcystin-LR, Anatoxin-a detected in Lake Kegonsa; Microcystin-LR, Anatoxin-a detected in Lake Mendota
Racine County: 1 case
Walworth County: 1 case

Information Sharing

-Program not designed to provide real-time information

-Results shared with local and state public health agencies when Tier I analysis showed sum concentration BGA > 5,000 natural units/mL or > 100,000 cells/mL

-Notified public health officers

-Only the public health agencies have authority to close or post advisories at beaches

Research Needs/Emerging issues

-Studies on the effectiveness of nutrient management plans in reducing the frequency, duration, and severity of blue-green algae blooms
-What environmental conditions cause toxins to be produced?
-Studies on the persistence of toxins in water after bloom subsides
-Studies on bioaccumulation of toxins by freshwater fish
-Monitoring and guidance for triathlons
-Real-time testing methods and bloom prediction
-Beach closure criteria
-More research on BMAA

Blue-green Algae Contacts

Statewide (Gina LaLiberte, 608-221-5377)

DHS (Emelia McAuliff, 608-267-3242)

Lake Petenwell

North (Jim Kreitlow, 715-365-8947)

Southeast (Heidi Bunk, 262-574-2130)

South Central (Sue Graham, 608-275-3329)

Northeast (Rob McLennan, 920-424-7894)

Algae Photo Credits: Jason Oyadomari (Keweenaw.Algae Website)

Information sources:

1. Cyanbacteria: Biology, Water Blooms, Cyanotoxins, and Prohibited Species in Wisconsin (Gina LaLiberte, July 2011)
2. Talking Points on Blue-green Algae (Gina LaLiberti, June 2011)
3. The Emerging Science of BMAA (Wendee Holtcamp,Environmental Health Perspectives, March 2112)
4. Blue-green Algae in Eutrophic Fresh Waters (Val H. Smith, LakeLine, Spring 2001)
5. Cyanobacteria in Wisconsin (Elisabeth Harrahy, WDNR, 2005)
6. Blue-green Algae Informational Item to N.R Board (Power Point Presentation, September, 2011)