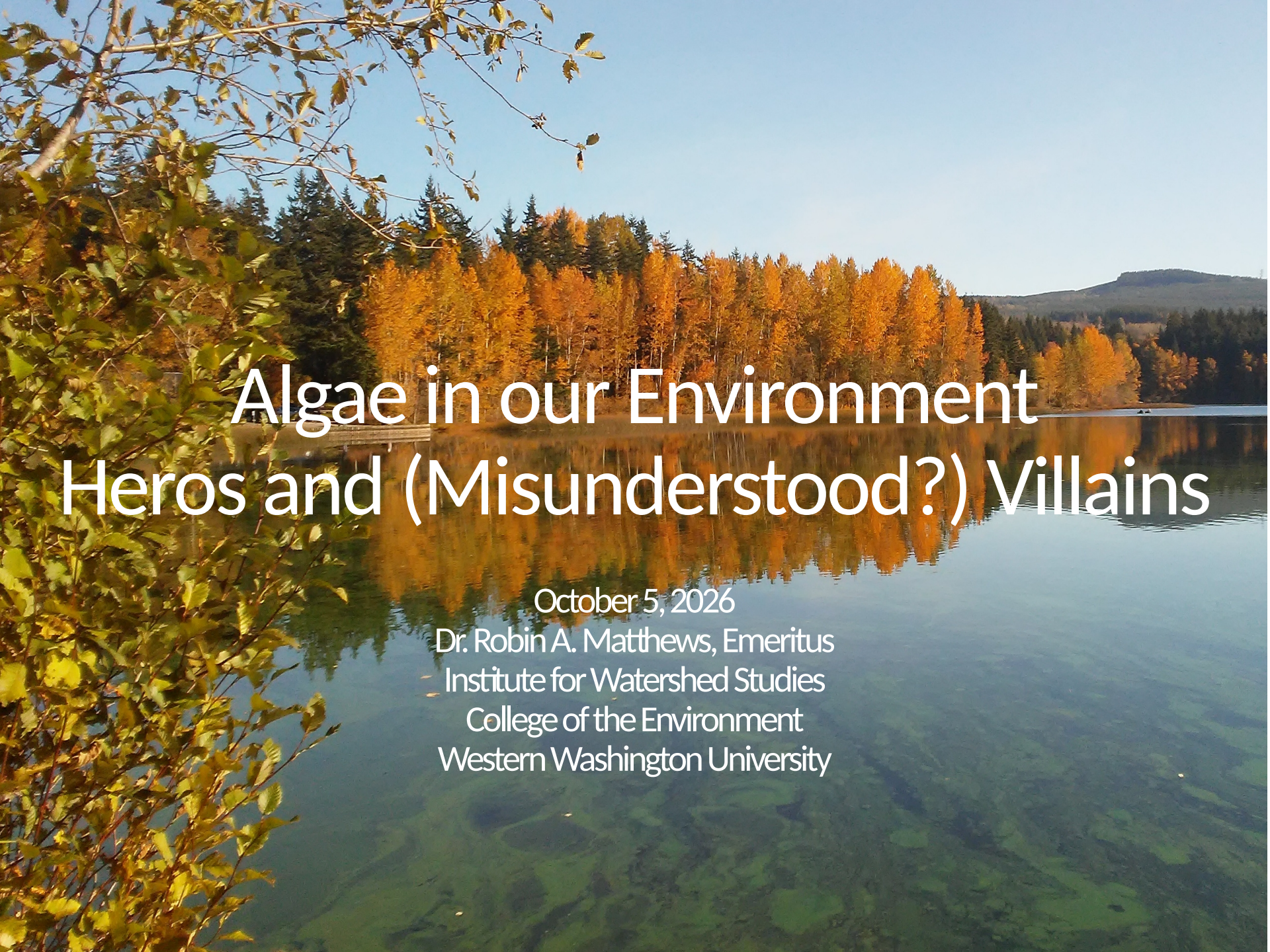
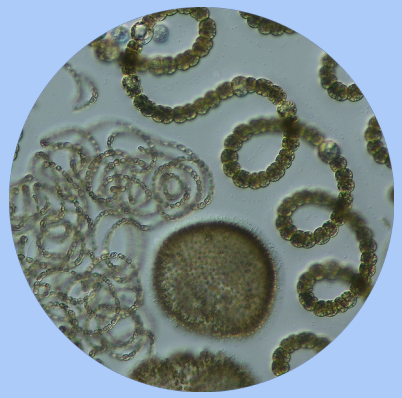
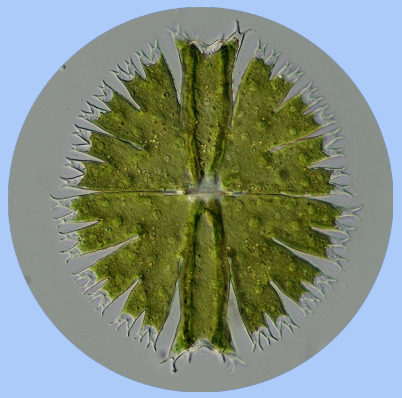


Algae in our Environment
Heros and (Misunderstood?) Villains

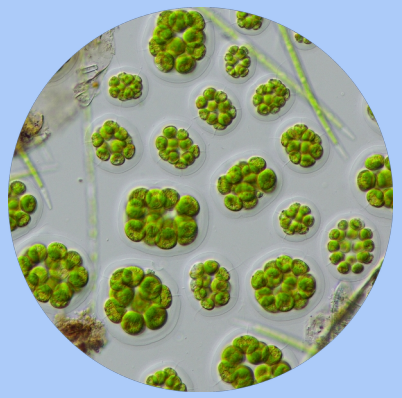
October 5, 2026

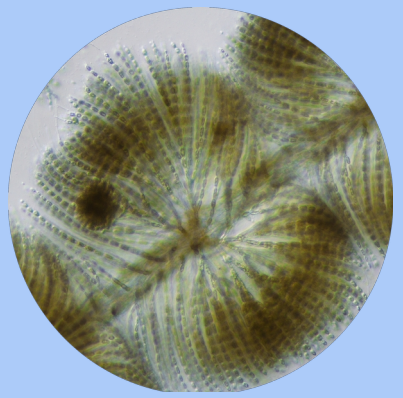
Dr. Robin A. Matthews, Emeritus
Institute for Watershed Studies
College of the Environment
Western Washington University



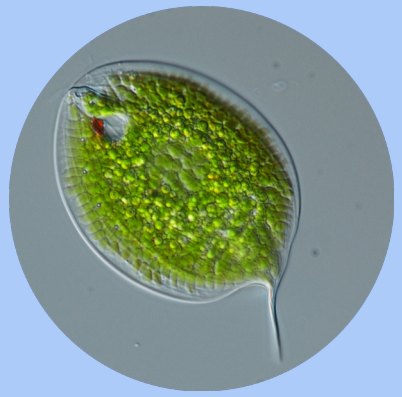


Cyanobacteria
(Kingdom Eubacteria)



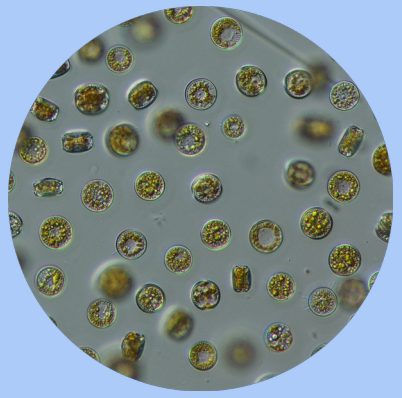


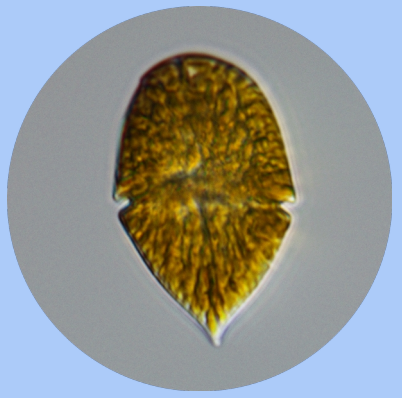
Desmids, green and red algae
(Kingdom Plantae)

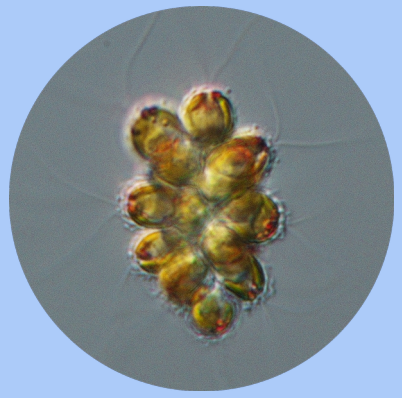


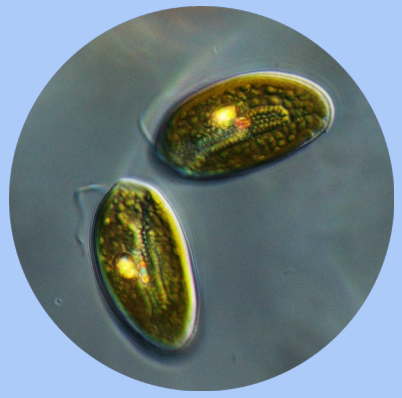
Euglenoids
(Kingdom Protista)

One word for 4 kingdoms?









Diatoms, dinoflagellates, golden and yellow-green algae, cryptomonads (Kingdom Chromista)

How Algae Can Help Save the Planet

- Carbon offsets/reduction
- Waste water management
- Architecture
- Plastics
- Fuel
- Food and supplements
- Clothing

Guttridge, J., 2023. 7 Algae uses that can help save the world, downloaded Aug 5, 2026, https://www.innovation-intelligence.com/7-algae-uses-that-can-help-save-the-world

McKinley, K and G. Ozbay. 2026. The power of microalgae: Cutting-edge applications and groundbreaking innovations. New Biotechnology 93:325-340

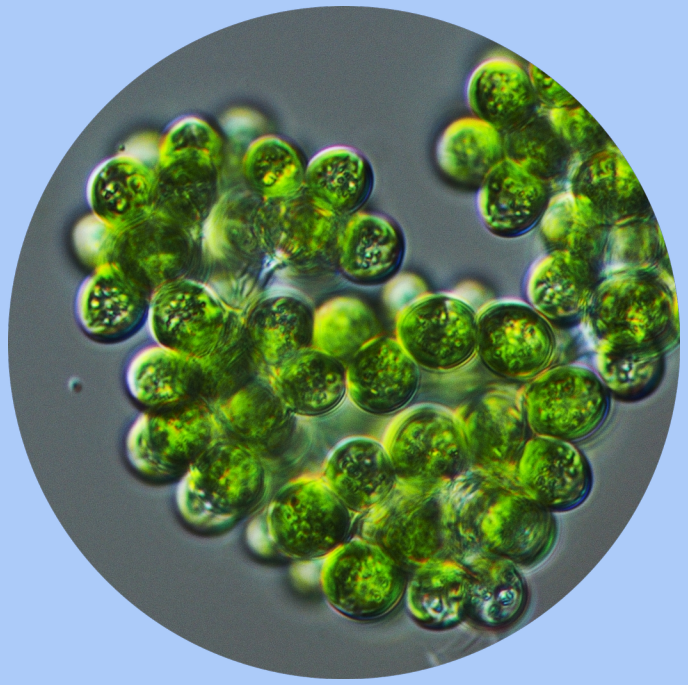

Cyanobacteria

Is it Cyanobacteria?

Yes



No



Recognizing Cyanobacteria



Cyanobacteria are prokaryotes

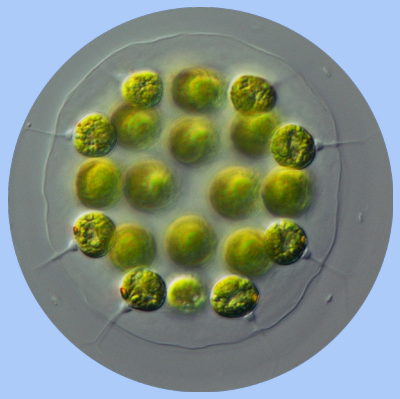
Cell content may appear granular, but will not have chloroplasts, pyrenoids, nucleus, flagella, eye spots

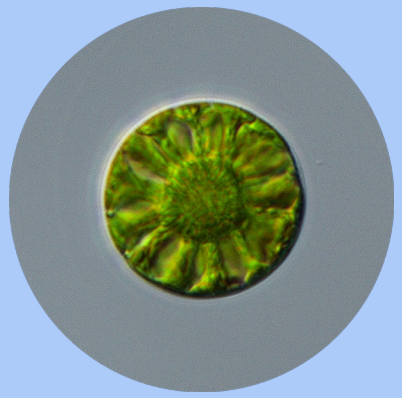
Cyanobacteria

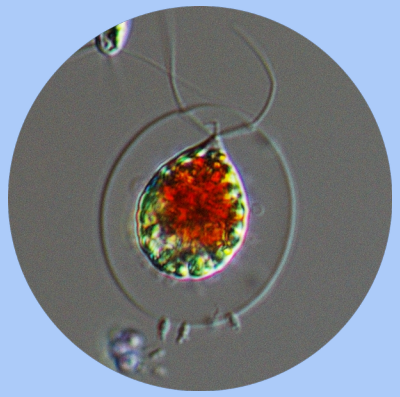


Not cyanobacteria









Recognizing Cyanobacteria

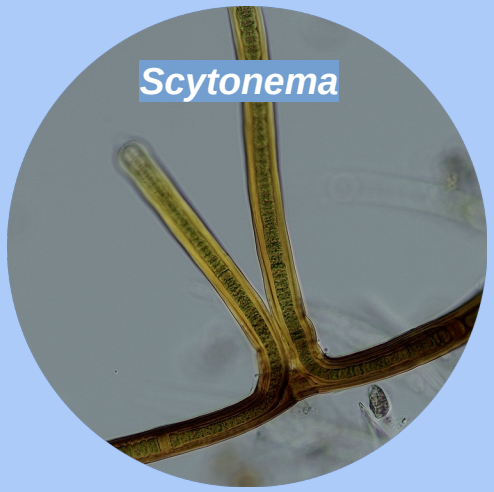
Occasionally solitary but usually in colonies or filaments

Cells in colonies often form groups of 2 or 4

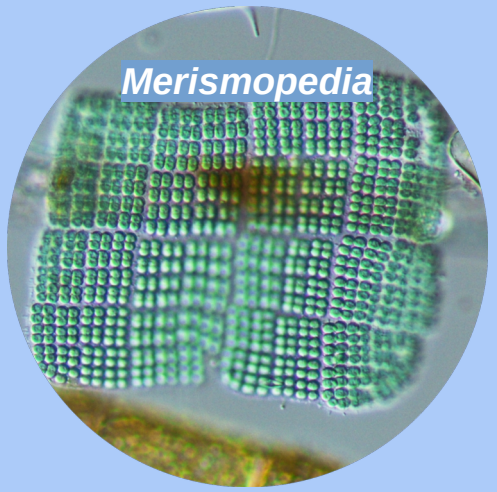








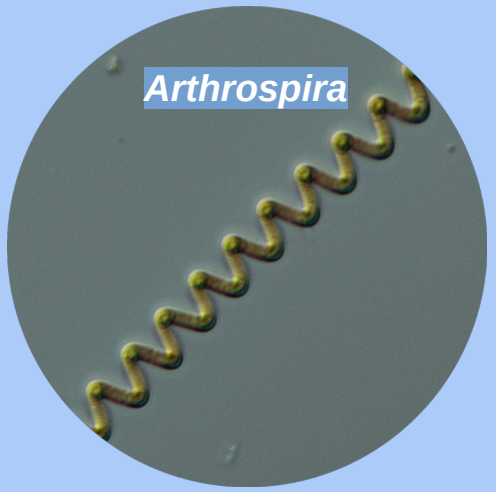




Recognizing Cyanobacteria

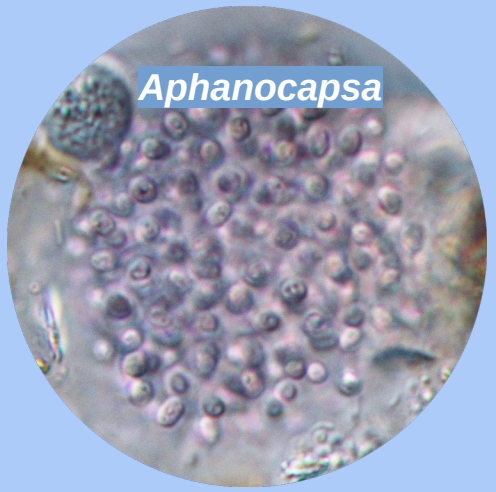
Color often blue-green, but can be green, gray, blue, red, orange, or even purple

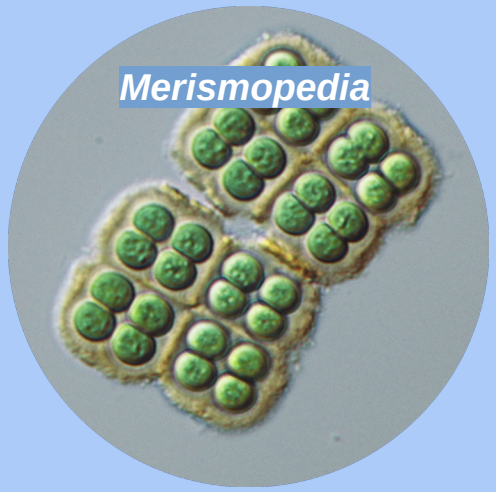
Cyanobacteria pigments include chlorophyll (green), phycocyanin (blue), phycoerythrin (red), carotenes (red/orange), and xanthophylls (yellow/orange)

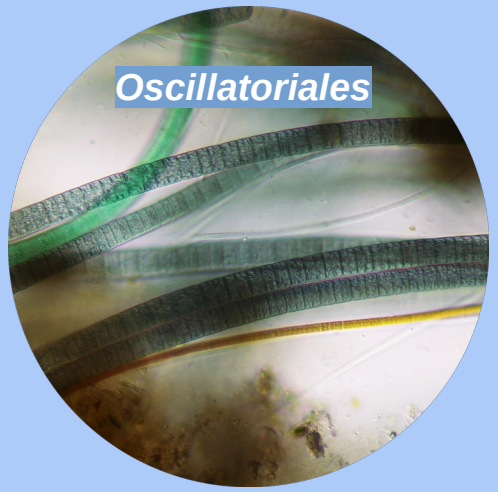








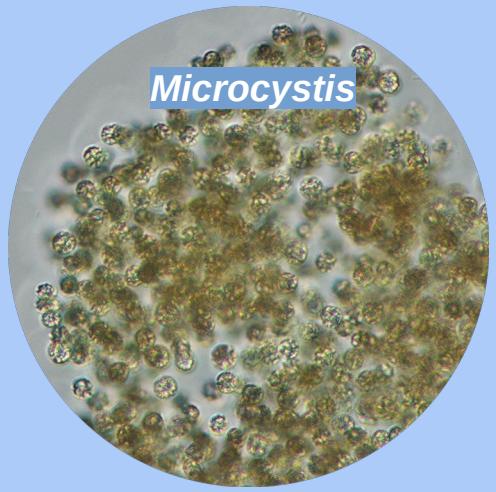




Recognizing Cyanobacteria

Despite absence of flagella or cilia, most cells are motile by twitching/spiralling, gliding on mucilage, or altering buoyancy (gas vesicles)





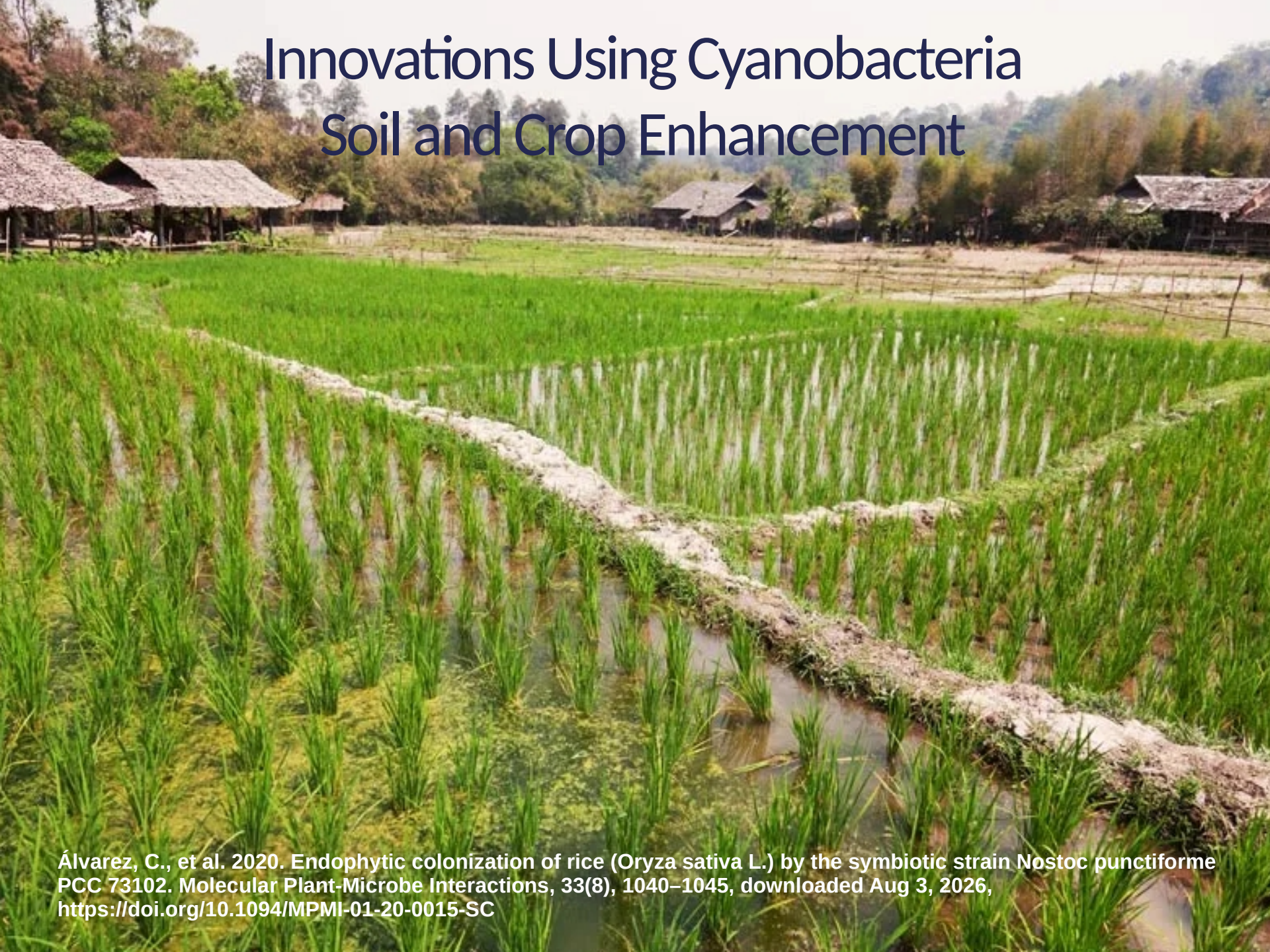








Innovations Using Cyanobacteria Soil and Crop Enhancement



Álvarez, C., et al. 2020. Endophytic colonization of rice (Oryza sativa L.) by the symbiotic strain Nostoc punctiforme PCC 73102. Molecular Plant-Microbe Interactions, 33(8), 1040–1045, downloaded Aug 3, 2026, https://doi.org/10.1094/MPMI-01-20-0015-SC

Innovations Using Cyanobacteria Increased Phosphorus Availability (not always a bad thing)



Deacon, J. 2015. Determining biologically available phosphorus in storm water entering Lake Whatcom, WA using dual the dual culture diffusion apparatus, M. S. Thesis, Environmental Sciences Dept, Western Washington University

Innovations Using Cyanobacteria

“Super” Foods with High Nutrient Content

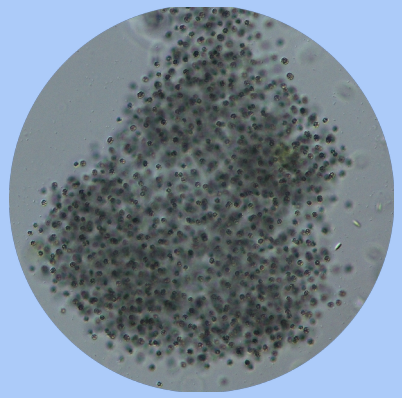


USFDA, www.fda.gov/food/natural-toxins-food/blue-green-algae-products-and-microcystins, downloaded August 2, 2026

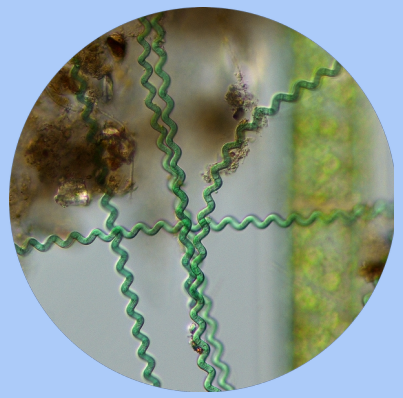
Is it Cyanobacteria?

Yes, but is it potentially toxic?

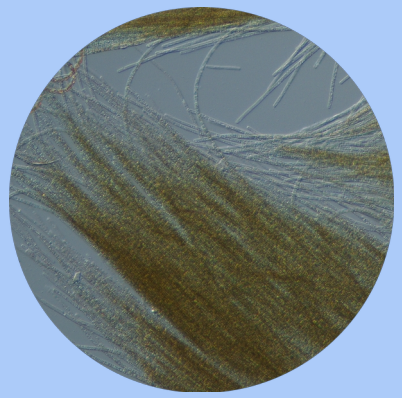
Yes



No*



Maybe



*All Cyanobacteria may be able to release compounds that can cause skin irritations and other responses

Major Cyanobacteria Toxins and Common Sources

Anatoxins/Guanitoxins (nerve damage)
Chrysosporum, *Cuspidothrix*, *Cylindrospermum*, *Dolichospermum* (previously *Anabaena*), *Microcystis*, *Oscillatoria*, *Planktothrix*, *Phormidium*, *Raphidiopsis*, *Tychonema*, and *Woronichinia* (?)

Microcystins (liver damage ++)
Dolichospermum (previously *Anabaena*), *Fischerella*, *Gloeotrichia*, *Microcoleus*, *Microcystis*, *Nodularia*, *Nostoc*, *Oscillatoria*, *Phormidium*, and *Planktothrix*

Cylindrospermopsin (liver/kidney damage)
Aphanizomenon, *Dolichospermum* (previously *Anabaena*), *Lyngbya*, *Microseira*, *Rhaphidiopsis*, and *Umezakia*

Saxitoxins (similar to PSP toxins)
Aphanizomenon, *Dolichospermum*, *Microseira*, *Planktothrix* and *Raphidiopsis*

Nodularins
Nodularia

EPA, www.epa.gov/habs/learnbout-harmful-algae-cyanobacteria-and-cyanotoxins, downloaded August 9, 2026





B-methylamino-L-alanine (BMAA)

Compound produced by many cyanobacteria

Function in cyanobacteria is not clear

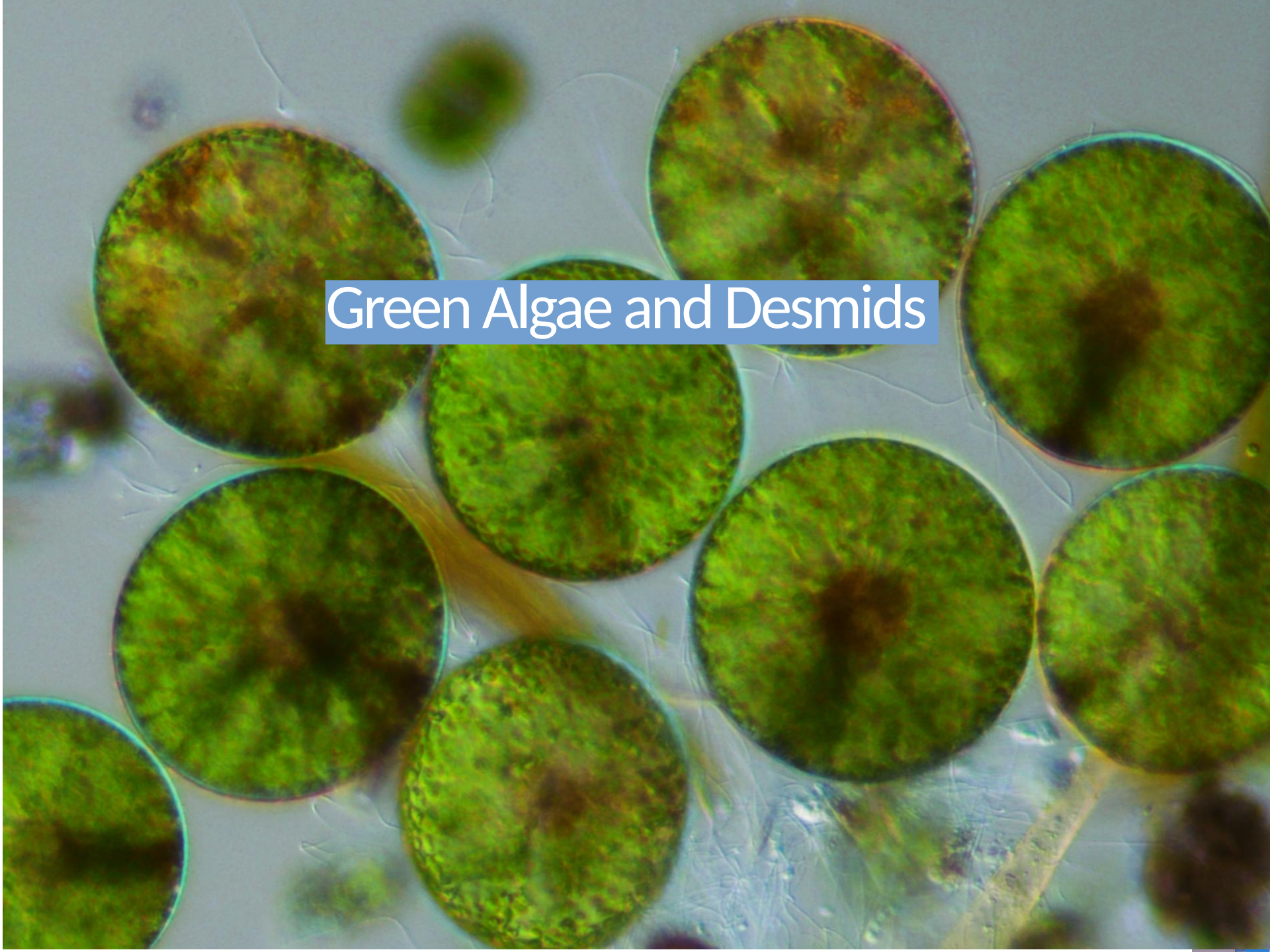
one study found that BMAA causes filaments to produce heterocytes when DIN is high

Mechanism of toxicity still not well understood

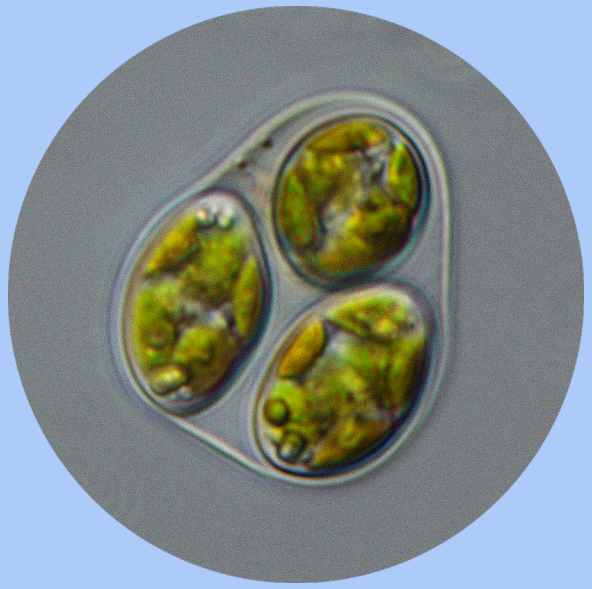
Bioaccumulates in food chain; may be linked to neurodegenerative diseases in humans

Exposure pathways are complex, but include direct/indirect food consumption (fish, cycad roots; *Nostoc* “jelly”)

Available online as Fat Choy (*Nostoc flagilliforme*) and Shaanxi Deep Mountain Wild Ground Vegetable (*Nostoc commune*)

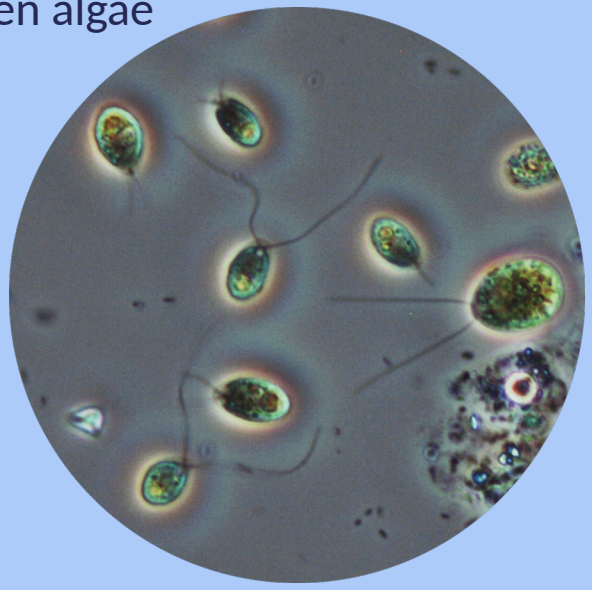

Green Algae and Desmids

Recognizing Green Algae

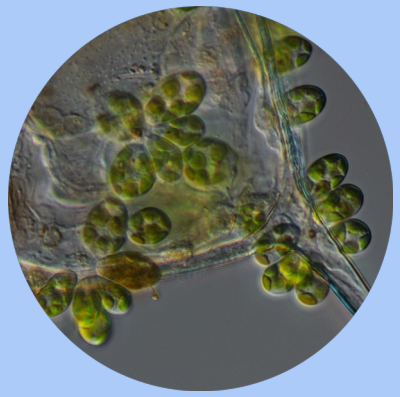


Eukaryotic, so cells contain chloroplasts, nucleus. other organelles; motile vegetative or reproductive cells have 2 or 4 equal flagella, often with eyespot

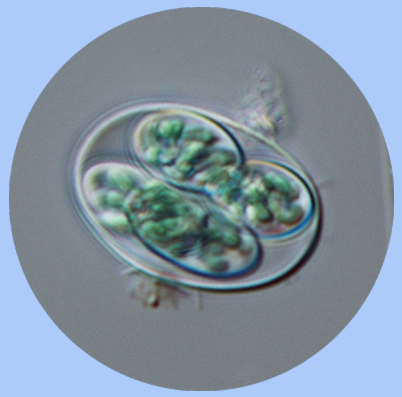
Green algae



Not green algae





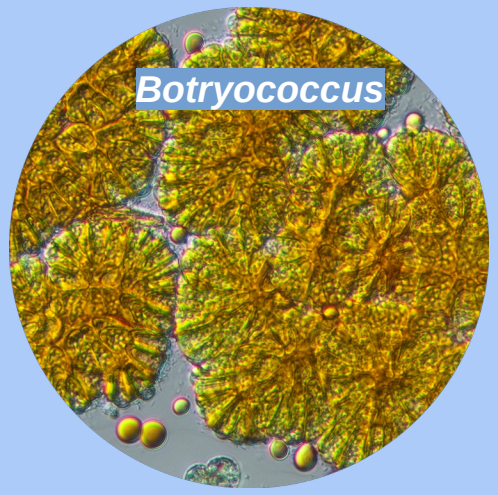




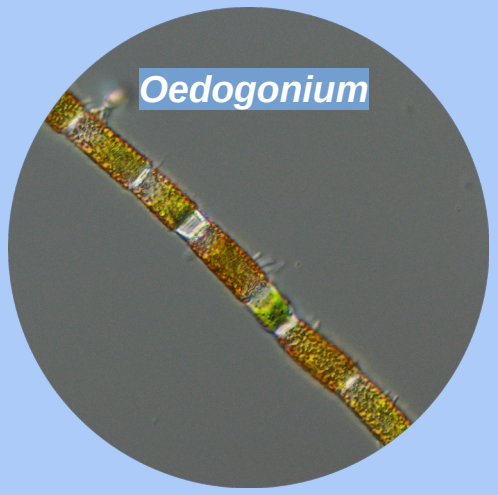
Recognizing Green Algae

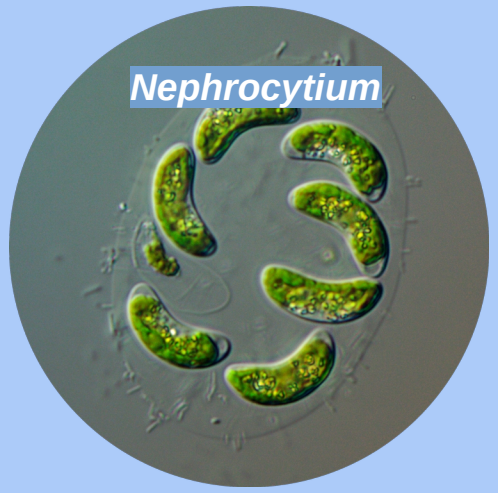
Color is usually bright green, but can also be red, orange, brown, purple

Pigments include chlorophyll (green), carotenes (red/orange), xanthophylls (yellow/orange)

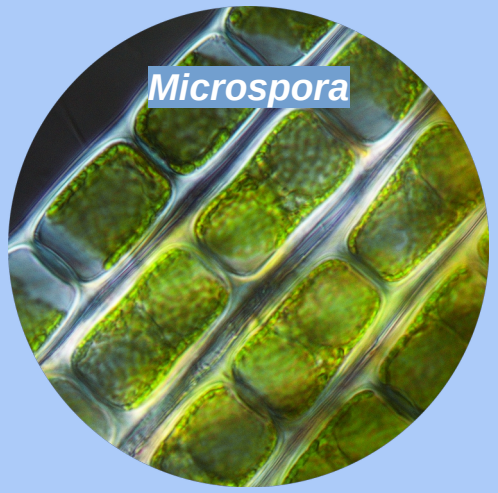












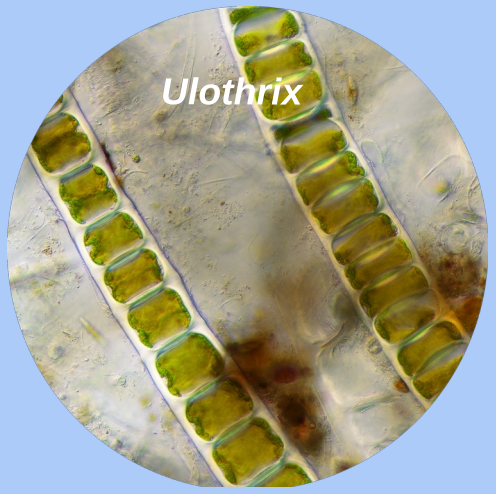
Recognizing Green Algae

Extremely diverse group found in wide range of aquatic and semi-aquatic habitats

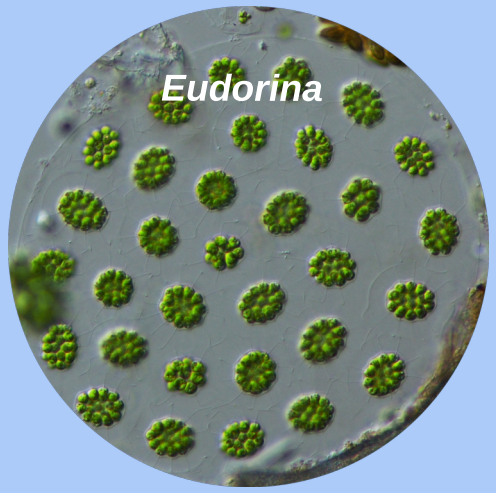
Cells may be solitary, colonial, or filamentous; reproductive cells often motile











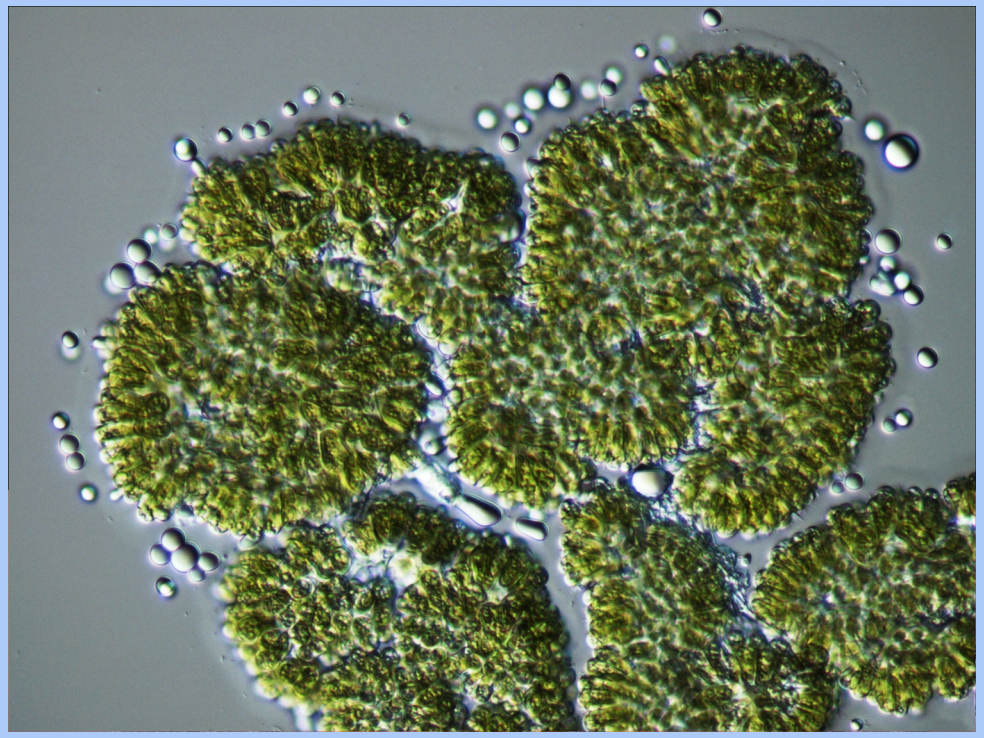


Innovations Using Green Algae Biofuels

Botryococcus is a colonial green alga that produces both starch and oil as a product of photosynthesis

Analysis of microfossils revealed that *Botryococcus* was the source of ~90% of oil shales and ~1% of crude oil

Its slow growth rate makes it an unlikely choice for new biofuels, but other green algae, especially genetically modified *Chlorella*, are proving to be attractive alternatives



Tennant, R.K., et al. 2019. Palaeogenomics of the Hydrocarbon Producing Microalga *Botryococcus braunii,* https://doi.org/10.1038/s41598-018-38236-5, downloaded Aug 6, 2026.

Recognizing Desmids and Other Charophytes

Desmids and charophytes resemble green algae, but “all” cells are nonmotile

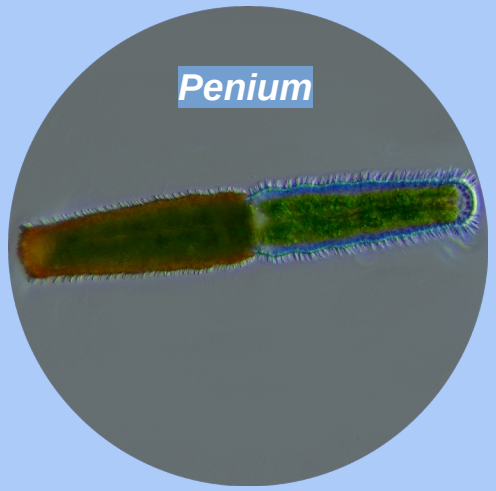
Most desmids form distinctive mirror-image semi-cells

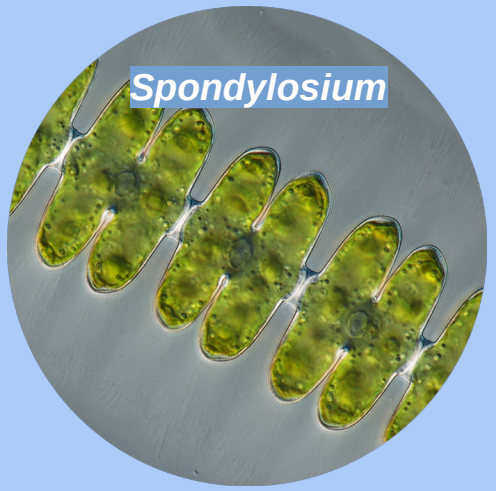












Some of the Most Common Algae are Charophytes

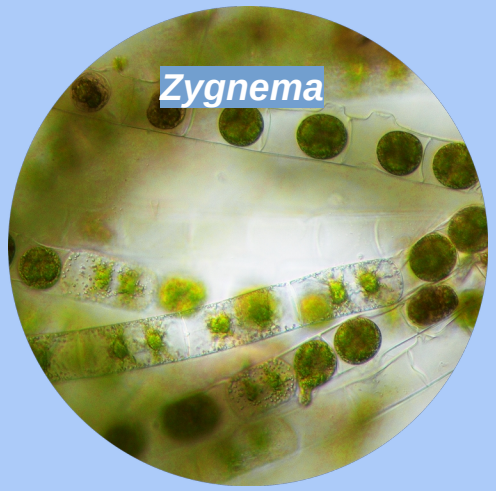
Charophyta are thought to the closest evolutionary link to terrestrial plants

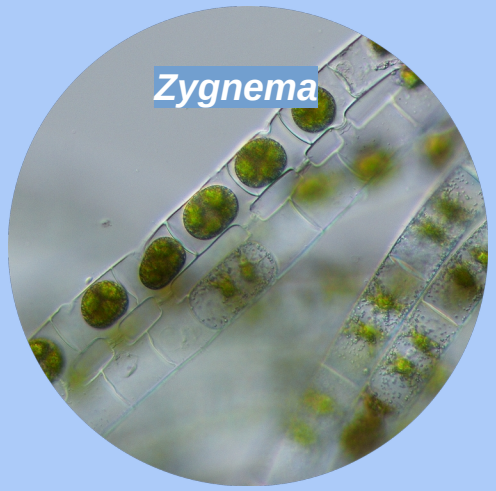
Most Charophyta lack motile reproductive cells and reproduce by conjugation

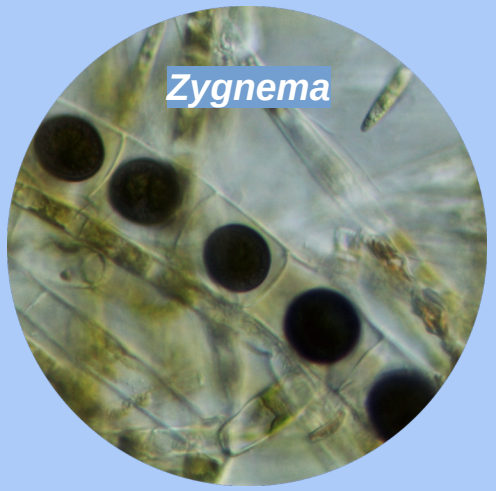












Innovations Using Desmids
Climate and Habitat Change Bioindicators

- Desmids are mostly freshwater algae, with the highest diversity found in shallow, slightly acidic, low conductivity, low alkalinity, mesotrophic or boggy (dystrophic) lakes and ponds

  →Desmids really like Sphagnum bogs!

- Desmids are intolerant of drought, water pollution, high salinity or dissolved solids, and almost any form of degraded habitat

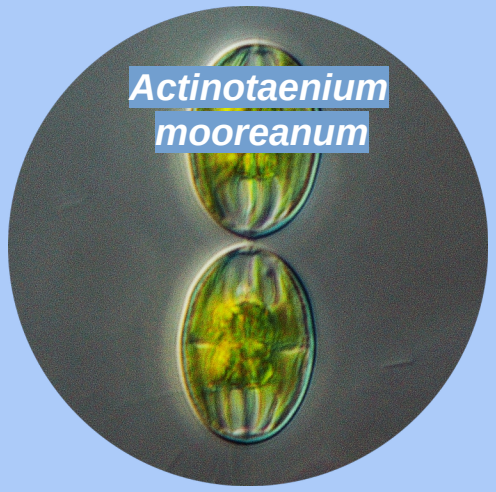
- Although present in a wide range of habitats, desmids do not adapt quickly to climate change; eutrophication, acidification, and other habitat alterations

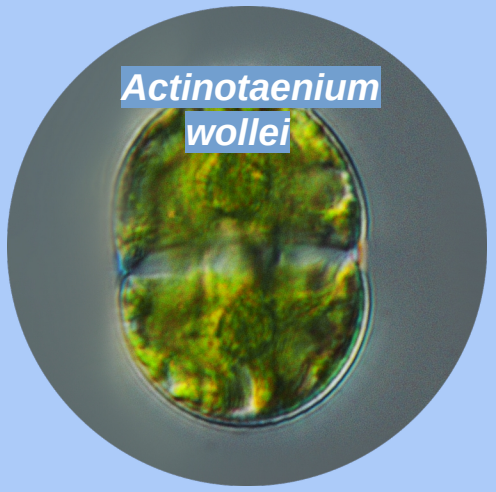
- European restoration programs (e.g., IUCN - UK Peatlands Program) have been successful at slowly restoring some desmid diversity in protected bogs

-

Examples of Desmids Critically Endangered or Extinct in the UK but Common in the Cascades





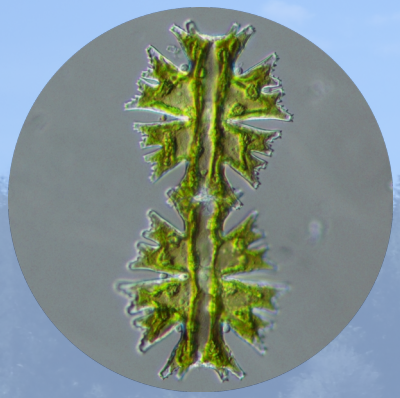




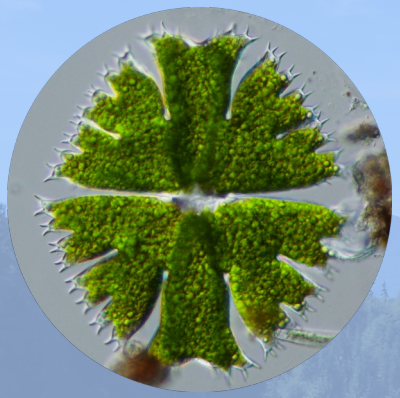




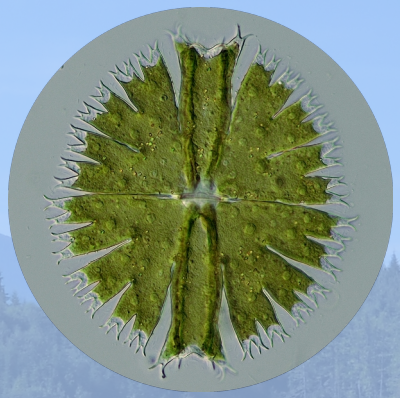
Micrasterias Diversity in a Single Washington Lake (Vogler)



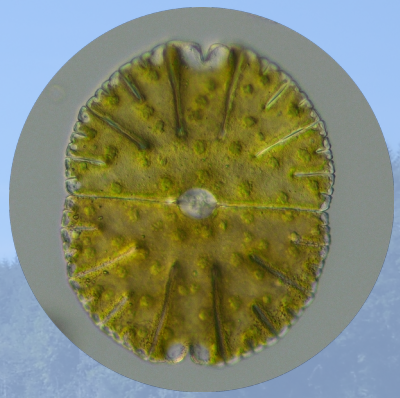
Micrasterias americana



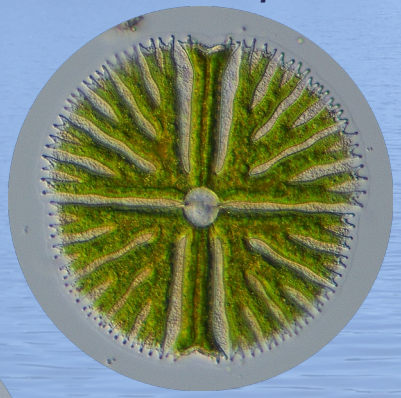
Micrasterias apiculata



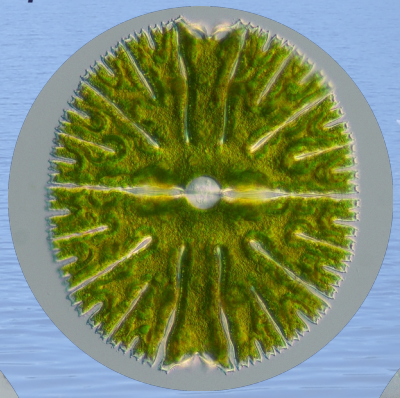
Micrasterias compereana



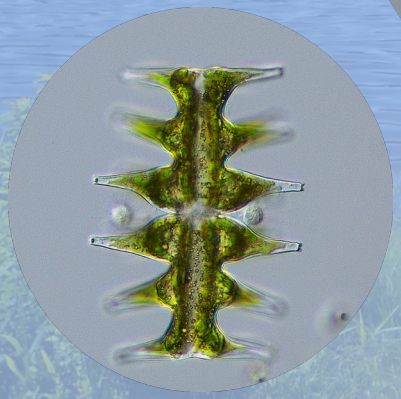
Micrasterias denticulata



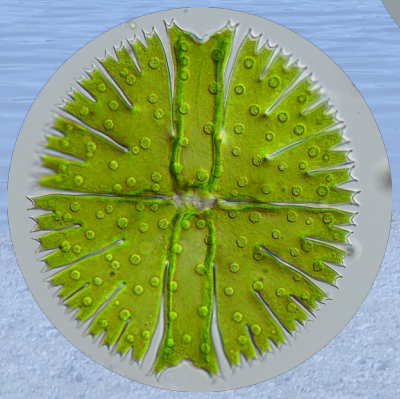
Micrasterias radiosa



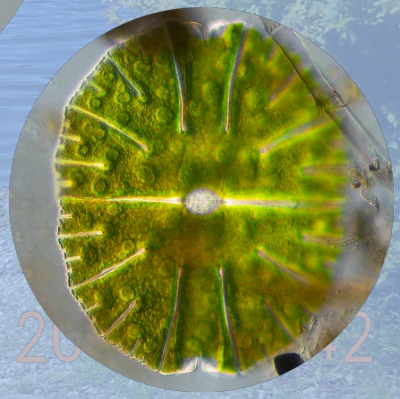
Micrasterias thomasiana



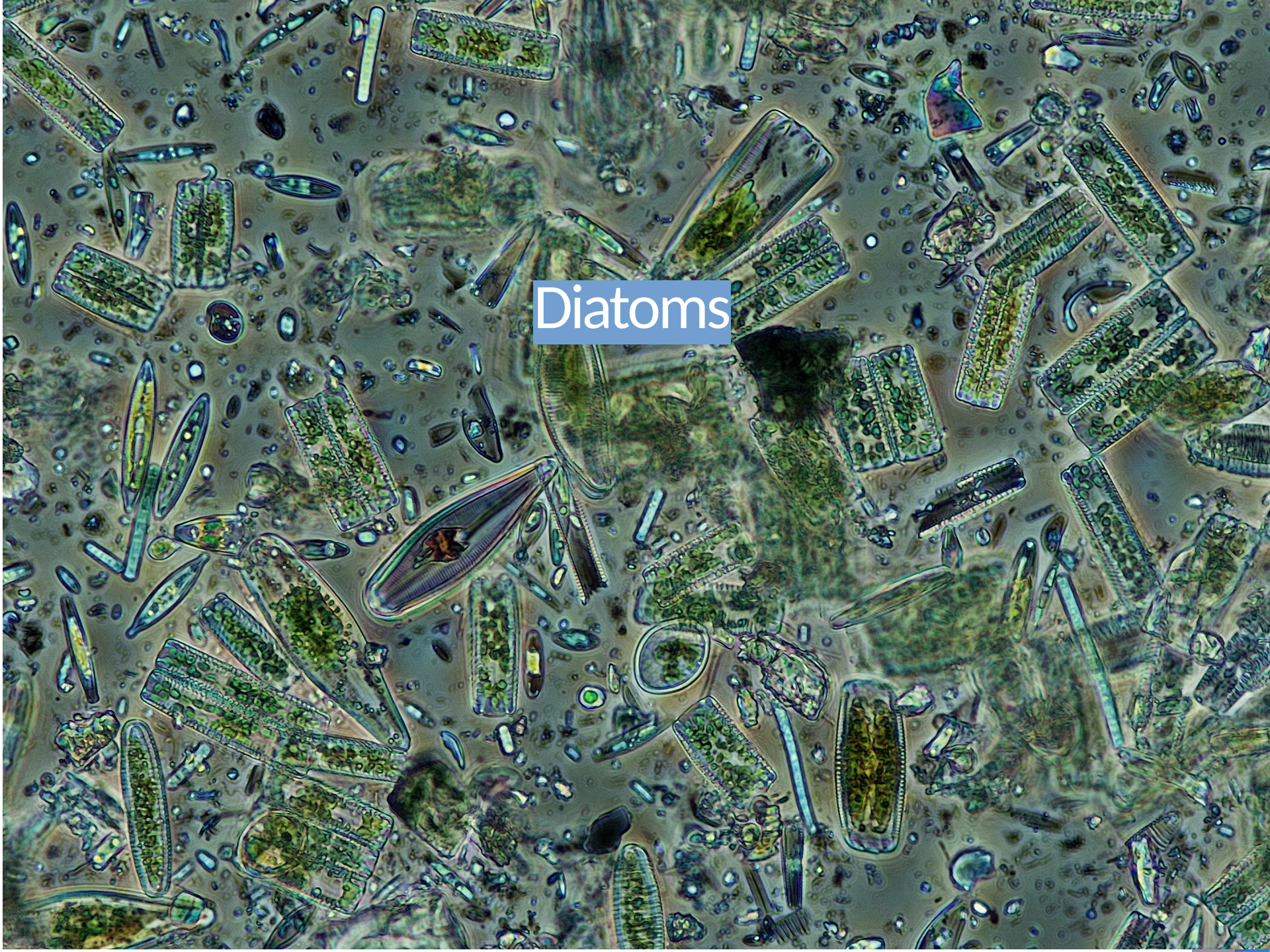
Micrasterias muricata



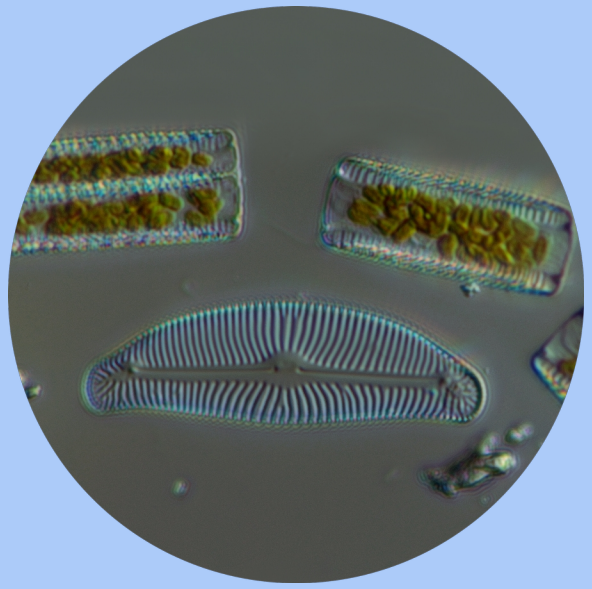
Micrasterias rotata



Micrasterias verrucosa

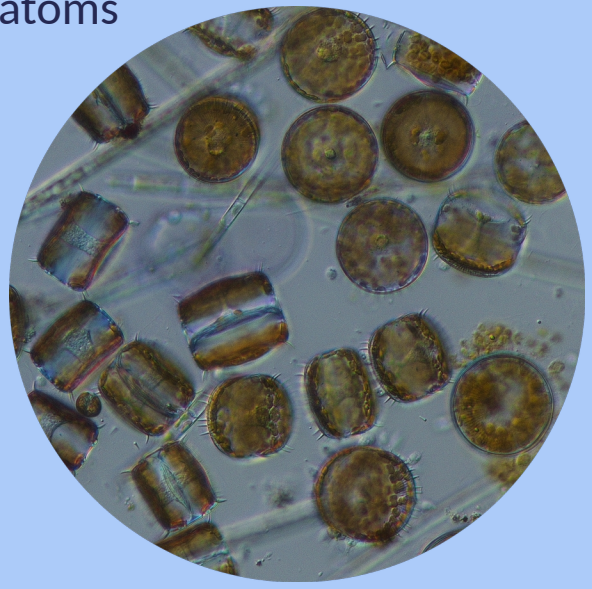

Diatoms

Recognizing Diatoms

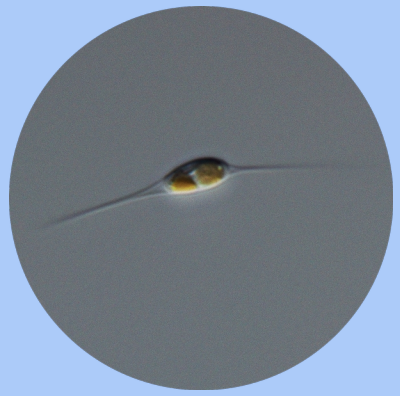


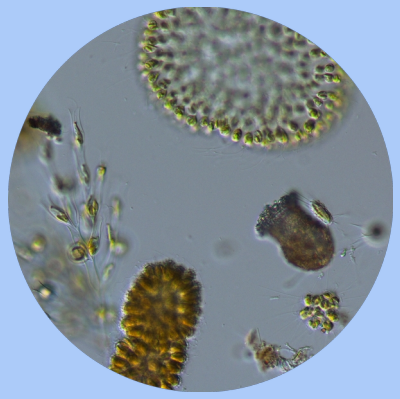
Eukaryotic, so cells contain chloroplasts, nucleus. other organelles; cells are often highly motile, but lack flagella (slime gliding)

Diatoms

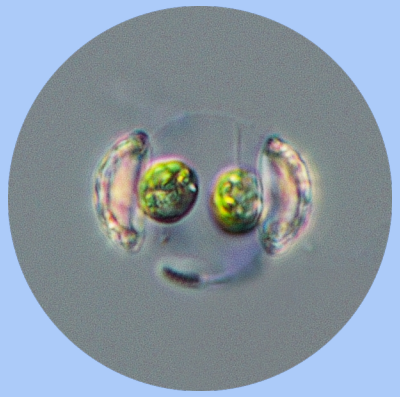


Not diatoms



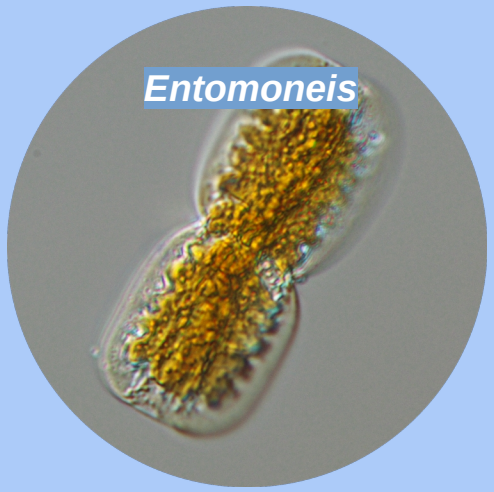


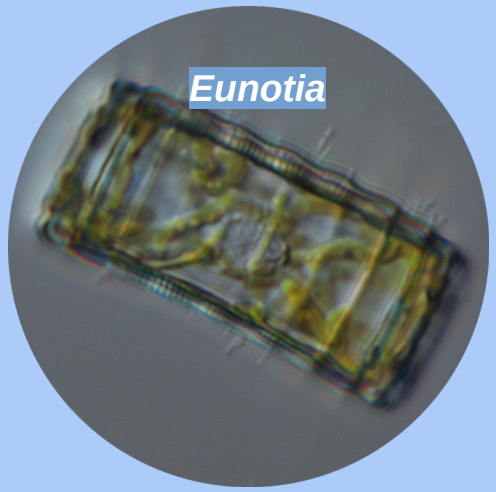


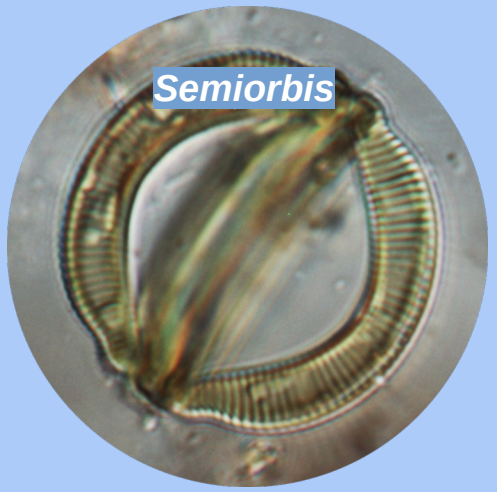


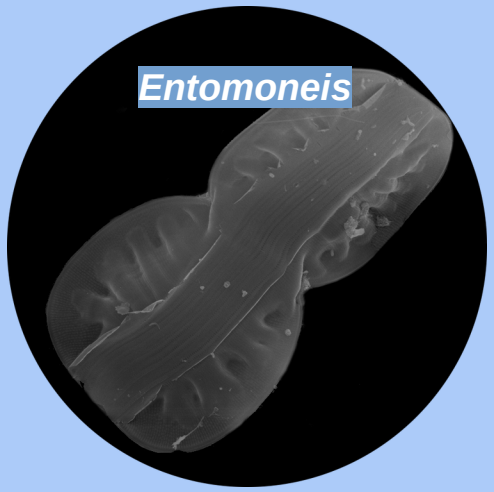
Recognizing Diatoms

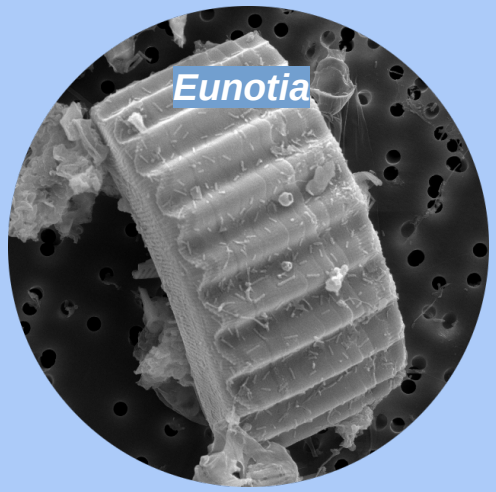
The living protoplast is enclosed inside a rigid, ornamental silica “frustule”

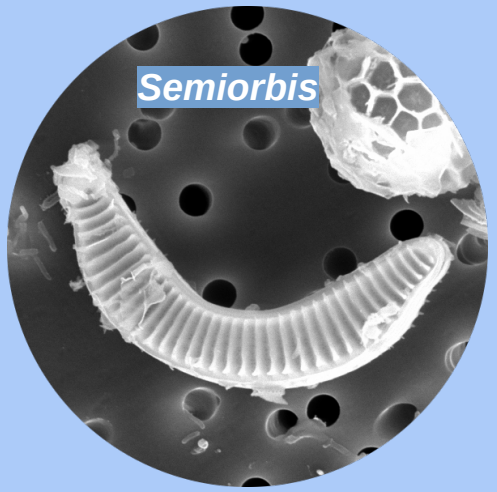










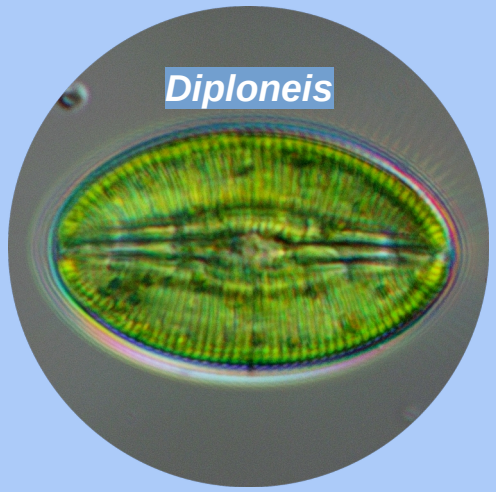


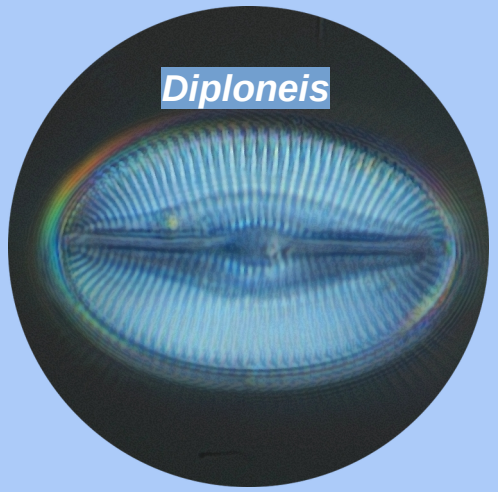
Recognizing Diatoms

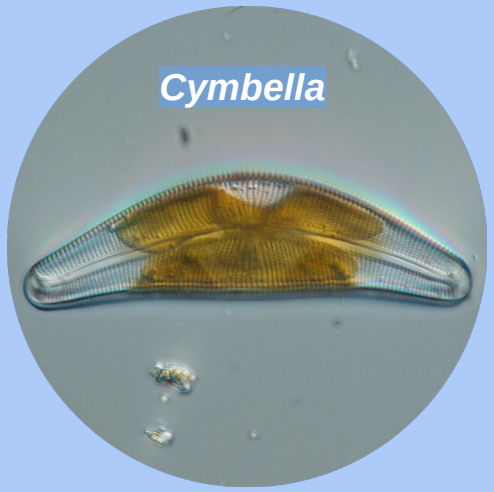
Color is usually golden brown but can also be green or yellow-green

Pigments include chlorophyll (green), carotenes (red/orange), fucoxanthin (yellow/orange)

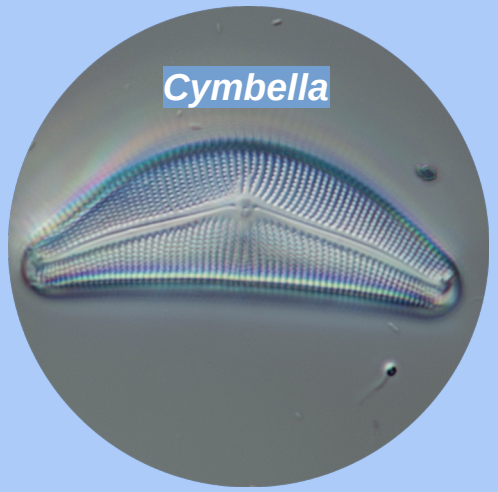








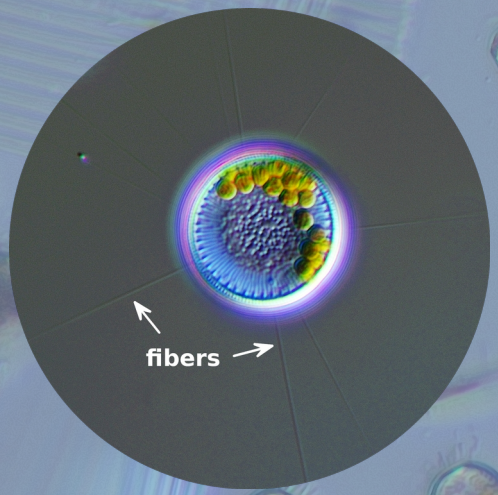


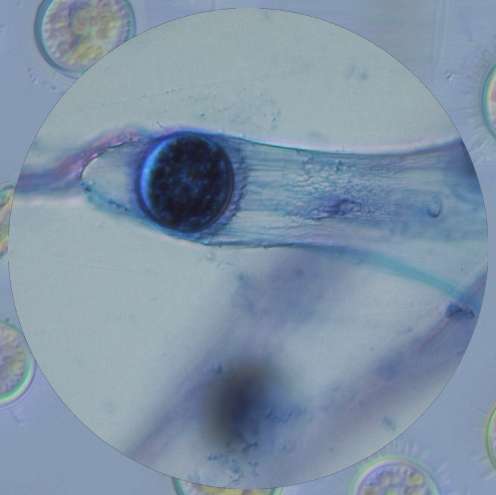


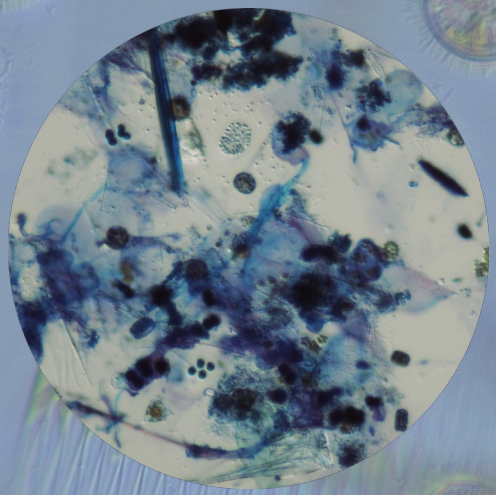
Problems Caused by Diatom Blooms

Diatoms store oil (chrysolaminarin) rather than starch; the oils often causes significant problems with water filtration and drinking water treatment

Some of the common bloom-forming diatoms release fibers and mucilage, which causes additional problems with water filtration and drinking water treatment

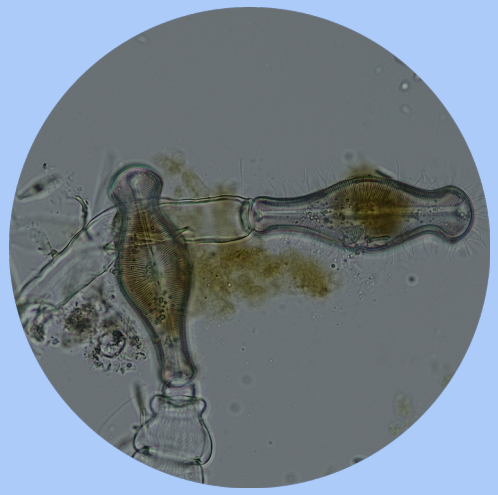


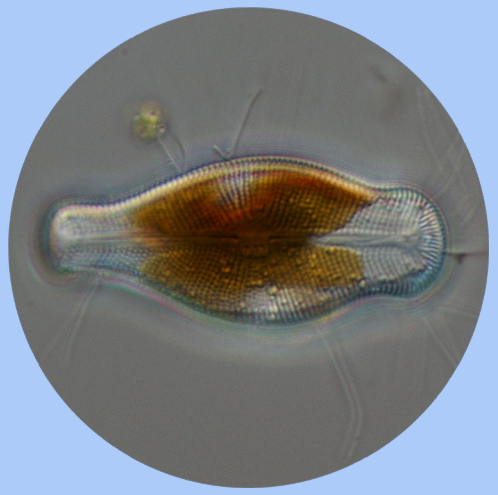
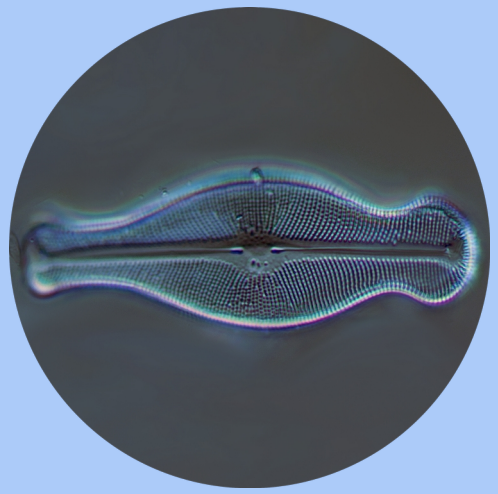
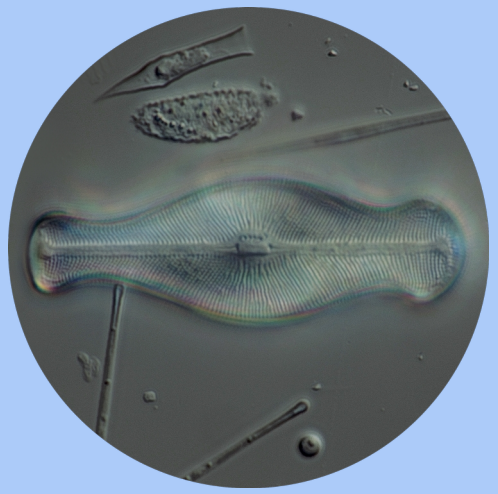
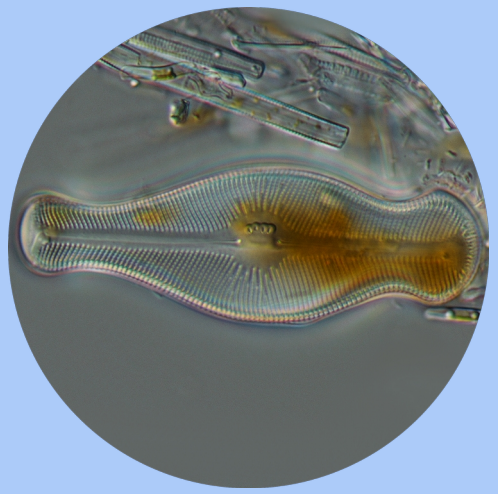




Problems Caused by Diatom Blooms

Didymosphenia geminata (aka rock snot) is expanding its range in North America, and is considered an invasive species. It is common in streams and rivers, and can cover the entire benthic surface, smothering other aquatic organisms

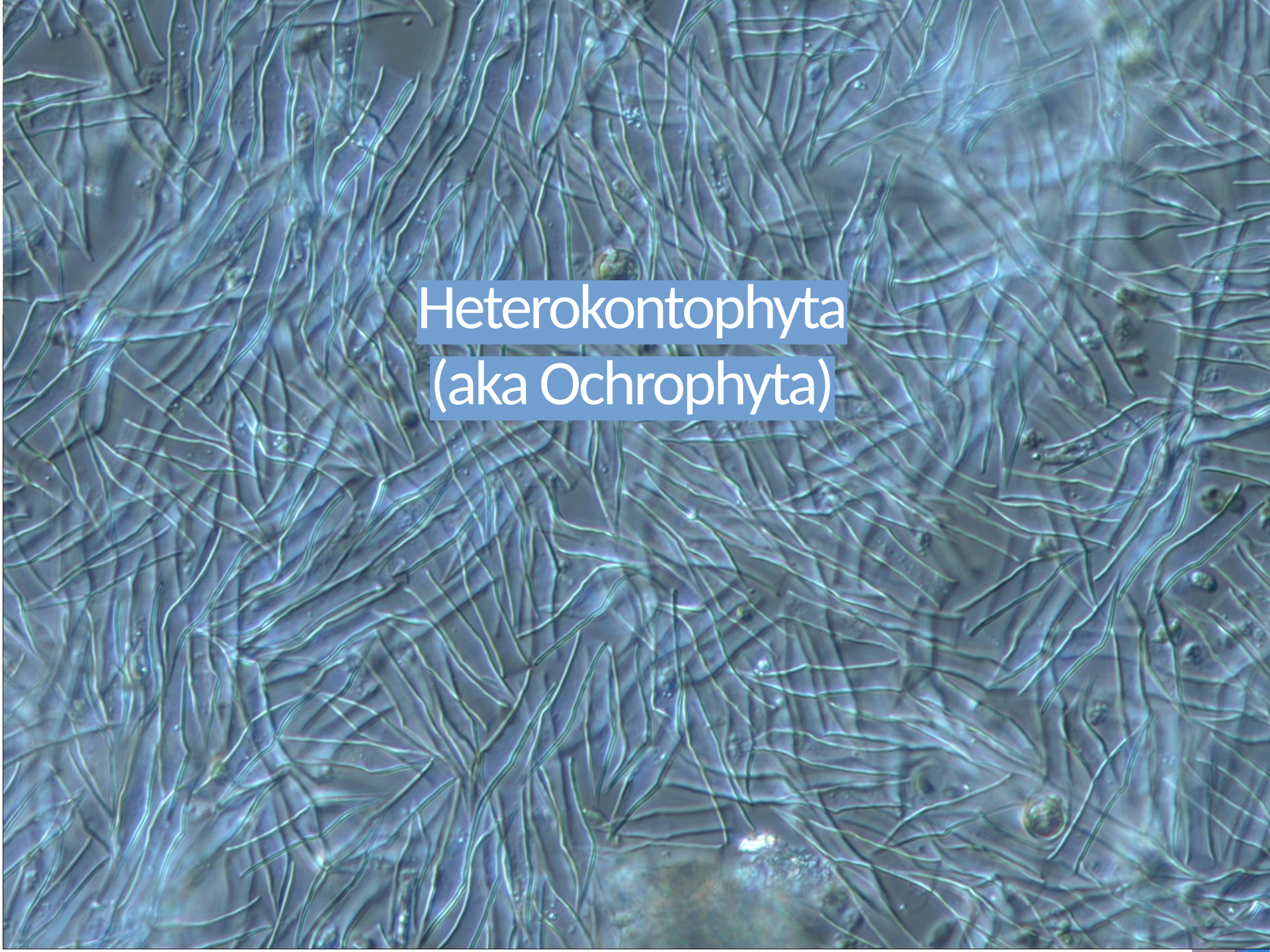


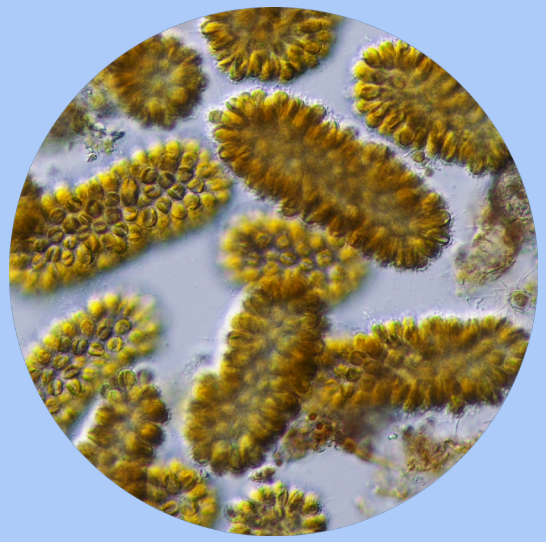
Innovations Using Diatoms (and Historic Use)

- Diatomaceous earth has been used extensively as a natural pesticide, abrasive in cleaning compounds and “whitening” toothpaste, pool and water treatment filters, industrial wastewater treatment, and many other applications
- One innovative use for diatoms is to create an inert silica “scaffold” for creating MoS_2 (molybdenum disulfide) nanosheets that can be used for solar, electrical, and medical applications

E. Lewis, et al. 2016. Diatom frustules as a biomineralized scaffold for the growth of molybdenum disulfide nanosheets, http://pubs.acs.org/cmatex/article-pdf/28/16/5582/8073897/cm6b01738.pdf , downloaded Aug 6, 2026.

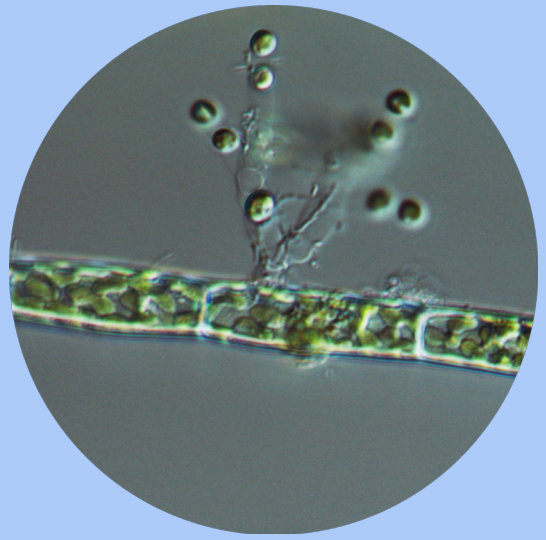

Heterokontophyta
(aka Ochrophyta)

Recognizing Heterokontophyta

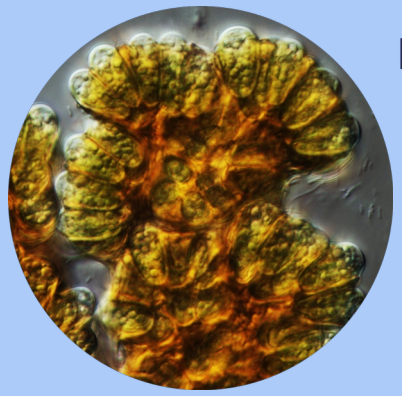


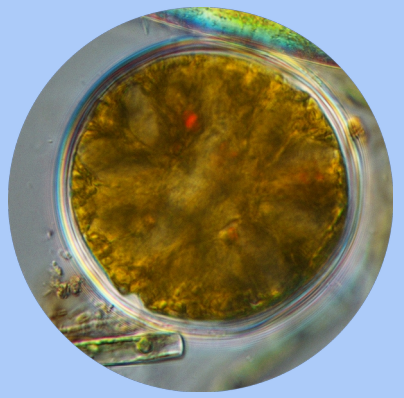
Eukaryotic cells contain chloroplasts, nucleus. other organelles; motile vegetative or reproductive cells have 2 dissimilar flagella (“heterokont”)

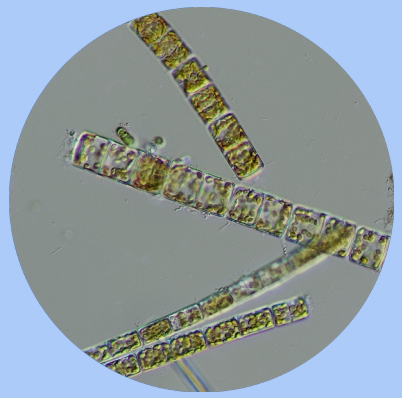
Heterokontophyta
(golden and yellow-green algae)



Not Heterokontophyta







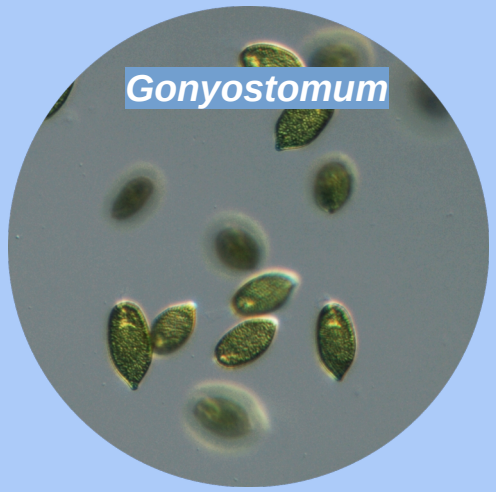


Recognizing Heterokontophyta

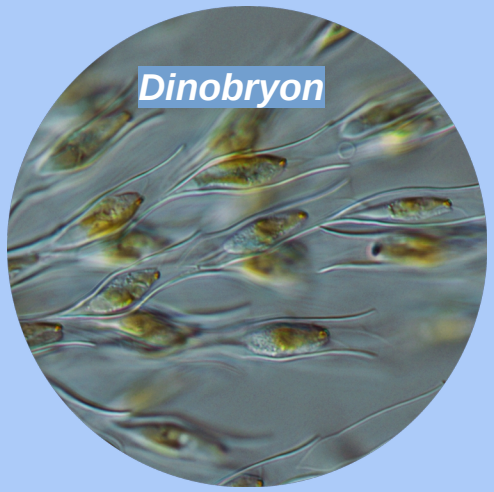
Color is usually golden yellow, yellow-green, or brown

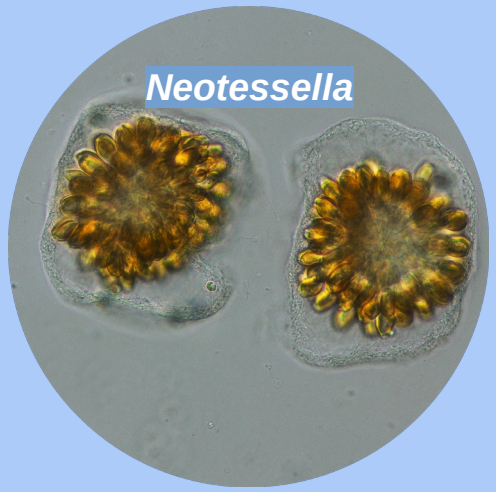
Pigments include chlorophyll (green), carotenes (red/orange), fucoxanthin (yellow/orange)













Recognizing Heterokontophyta

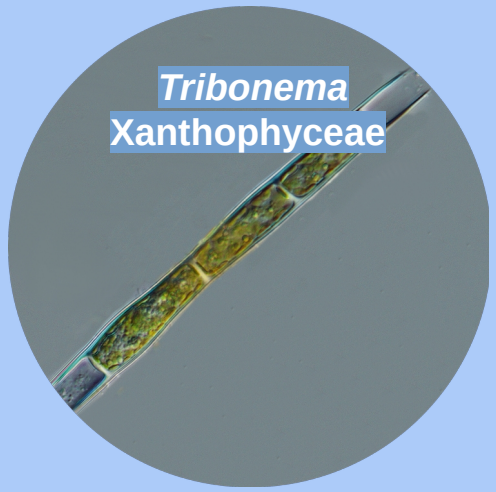
Heterokontophyta includes golden algae, yellow-green algae, brown algae, raphidophytes, eustigmatophytes, and several other groups









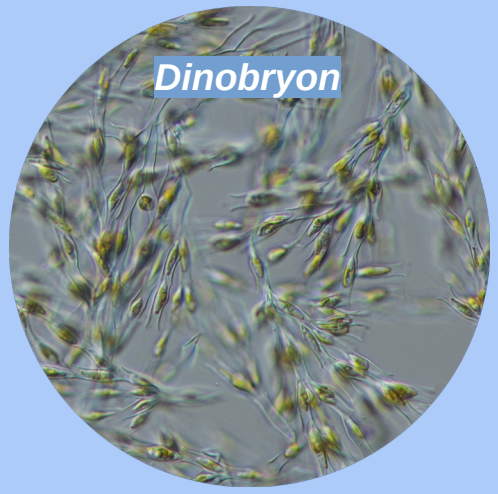


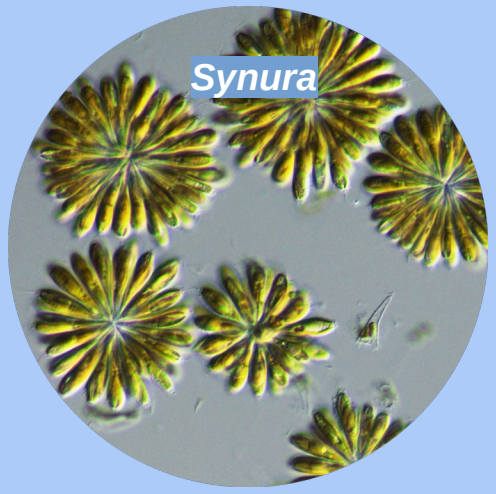


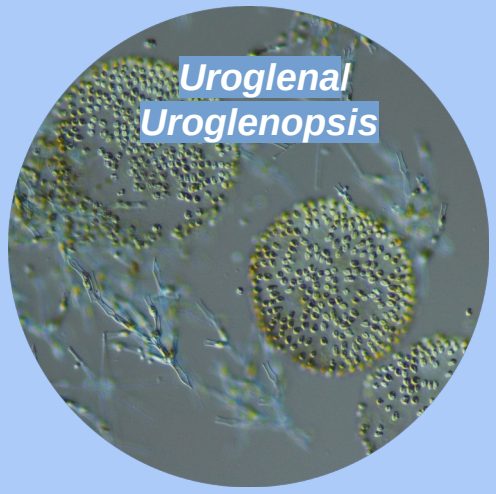
Problems Caused by Heterokontophyta

Most taxa in this phylum store oil rather than starch, so they cause significant problems with water filtration and drinking water treatment (similar to diatoms)

Chrysophytes are especially common in northwest Washington lakes (probably throughout the Pacific Northwest); some species develop blooms that cause a rancid, fishy or oily smell in the water





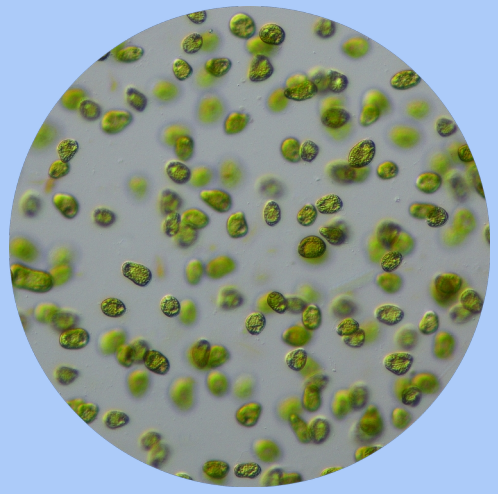


Problems Caused by Heterokontophyta

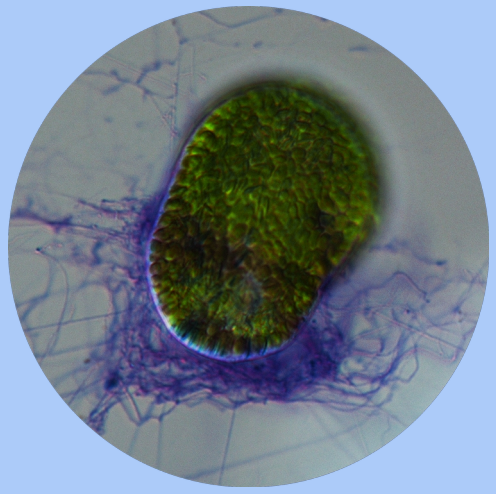
The raphidophyte *Gonyostomum* has trichocysts in its cell wall that are triggered by irritants (like methylene blue or lake swimmers); the trichocysts can cause skin irritation and allergic responses

Gonyostomum blooms are a significant problem in Nordic countries, where a substantial number of summer algal blooms in boggy lakes are dominated by this genus

Gonyostomum is not extremely common in northwest Washington, but blooms may occur in boggy lakes and ponds



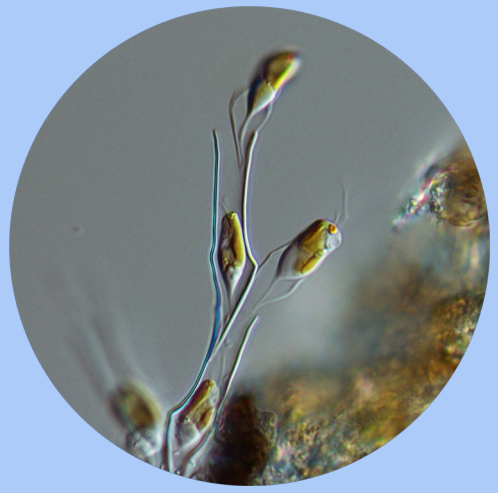


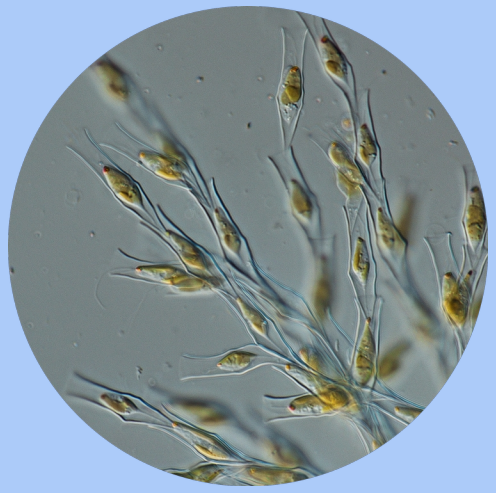


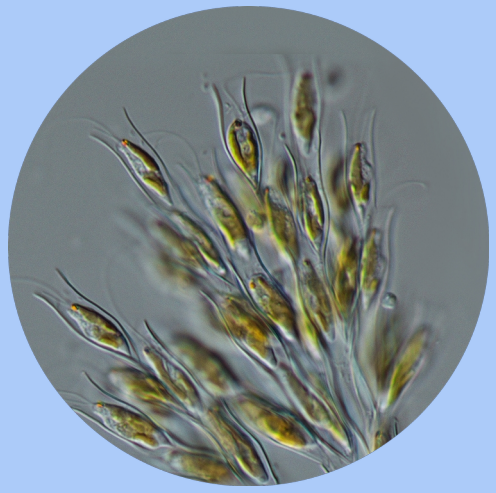
Innovations Using Heterokontophyta

The *Dinobryon* lorica contains cellulose that can be used in nanotechnology

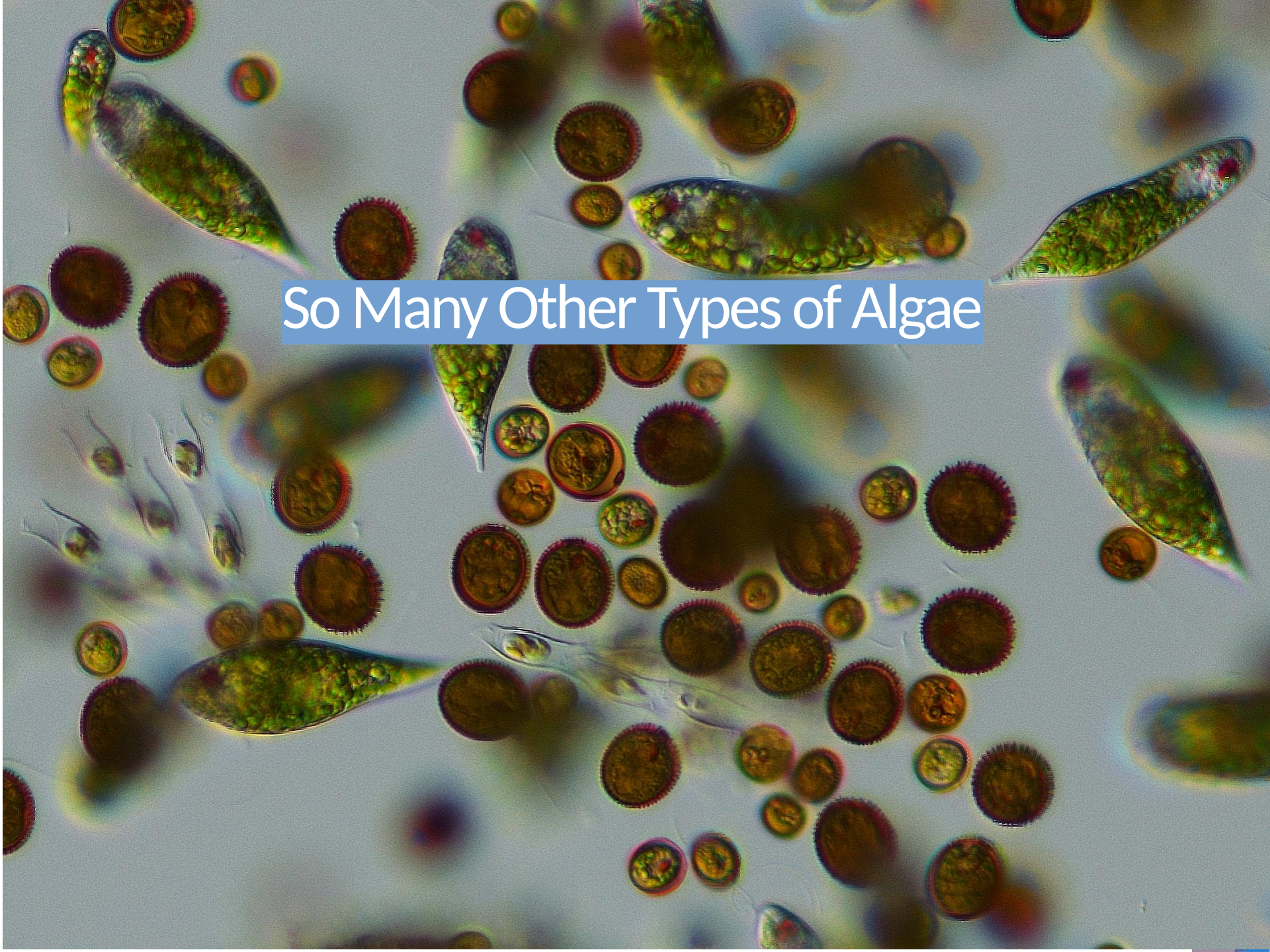
Researchers are exploring ways to use *Dinobryon* (and diatoms) to extract gold from “secondary” material containing low concentrations of gold. This could replace the current technology using cyanide







Ficeriova, et al. 2020. Acquirement of Gold from Concentrate (Pezinok, Slovakia) with Utilization of Algae in Mechanochemical Processes, IOP Copnf. Series: Earth and Environmental Science 609:(2020) 012040


So Many Other Types of Algae

Recognizing Other Algal Groups

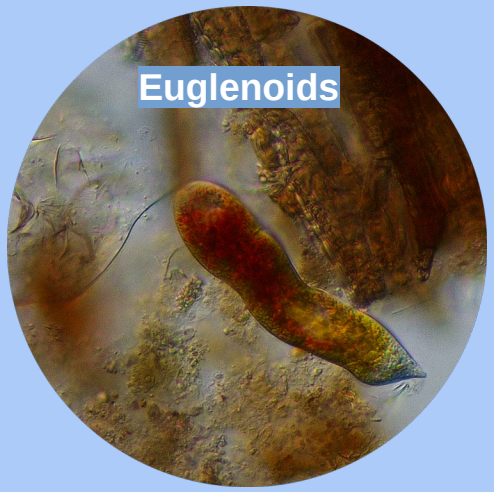
Diverse group with few unifying features other than containing chlorophyll

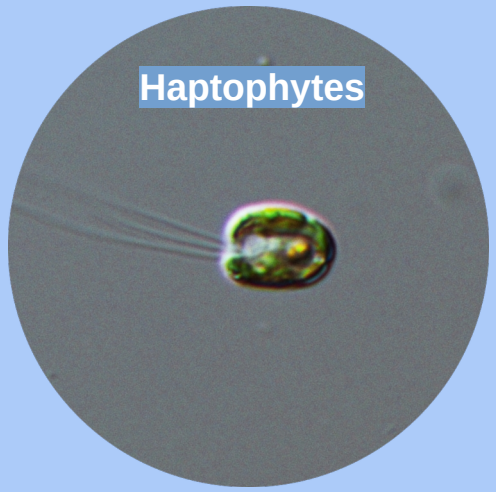
Red algae and glaucophytes are closely related; neither have motile cells; the remaining groups are mostly unicellular and motile











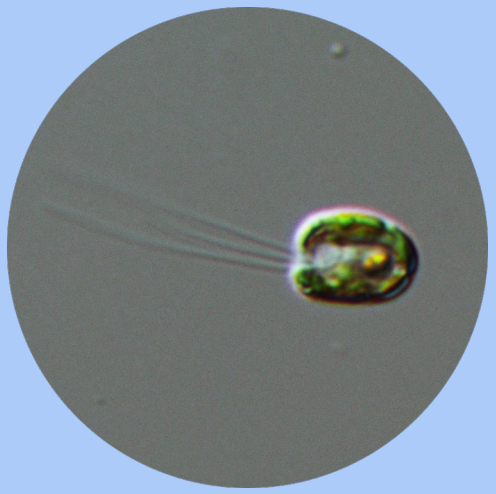


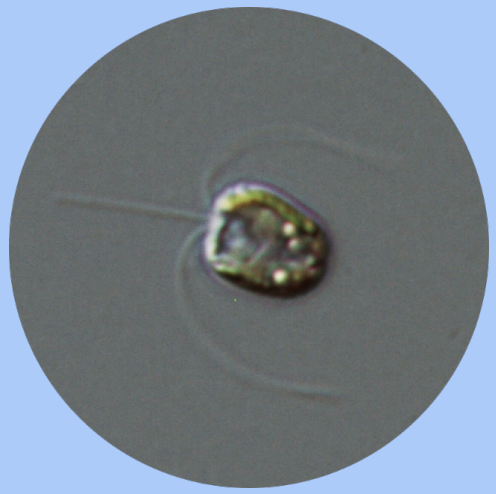
Problems Caused by Haptophytes

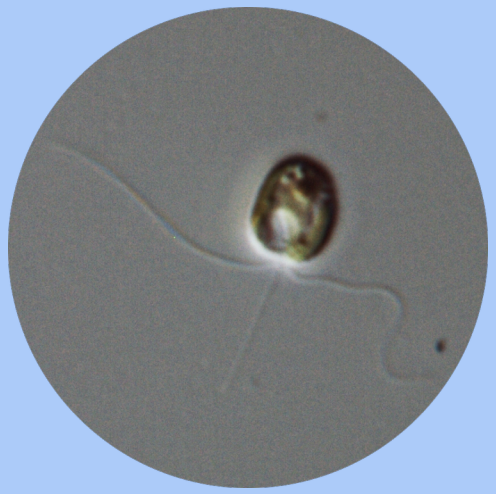
Haptophytes are solitary and motile, with two slightly dissimilar flagella on either side of a haptonema, which is used for food capture and ingestion (cells are mixotrophic)

Although not as widespread as cyanobacteria, there are potentially harmful taxa in this group. Several marine species of the haptophyte *Chrysochromulina* can release toxins that cause extensive fish kills

Chyrsochromulina parva, a freshwater species, is associated with fish kills and is considered a HAB species (https://hab.whoi.edu/species/species-by-name/golden-algae)



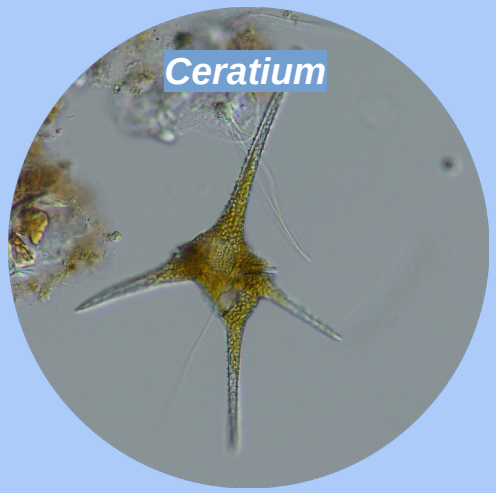


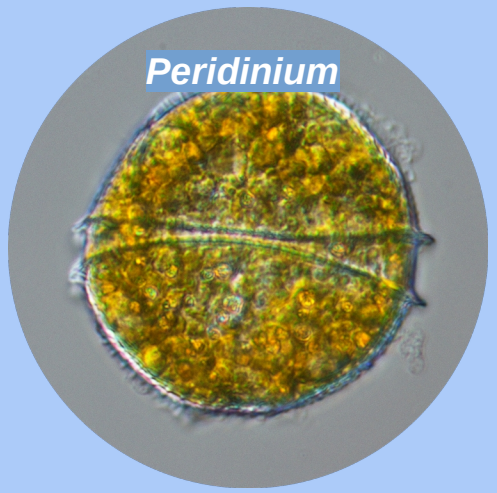


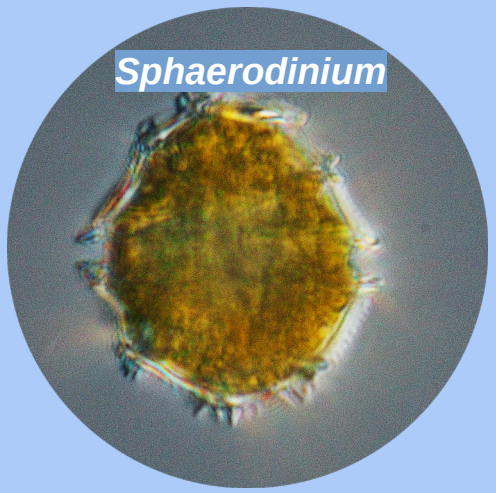
Innovations Using Dinoflagellates

Like many other freshwater algae, the cellulose in dinoflagellate walls can be used to create high quality nanocellulose for biomedical and other uses

Bioluminescent marine dinoflagellates are being used to create structures that emit light when stretched or compressed, with no outside energy source

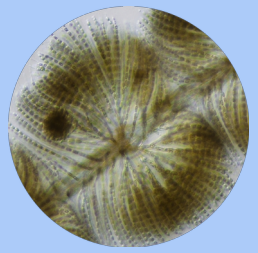






L. Chenghai, et al. 2022. Highly robust and soft biohybrid mechanoluminescence for optical signaling and illumination. Nature Communications https://doi.org/10.1038/s41467-022-31705-6, downloaded August 8, 2026

Innovations Use Other Algal Groups



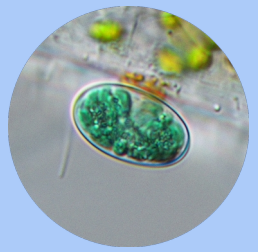
Unlike marine red algae, freshwater red algae are not used commercially for food and food production. But most freshwater species live in fast flowing, clear water, are intolerant of pollution, thus making them good bioindicators



Cryptomonad cells contain antimicrobial compounds that are being evaluated as an option for food preservation



Some euglenoids are very tolerant of organic pollution or heavy metals; some species can accumulate high concentrations of metals in their cells, which makes the species highly effective in bioremediation



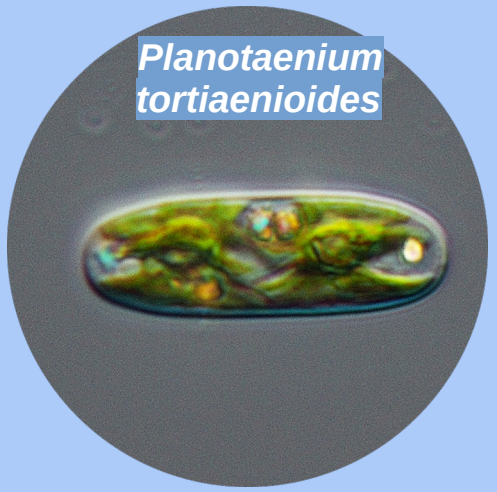
Glaucocystis can be used to produce high quality nanocellulose without the need for hazardous extraction chemicals

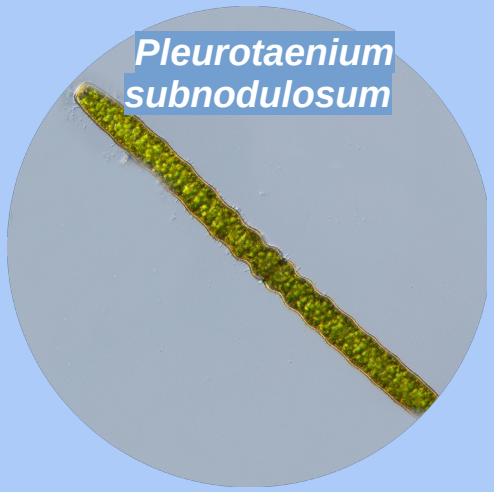
Final Thoughts

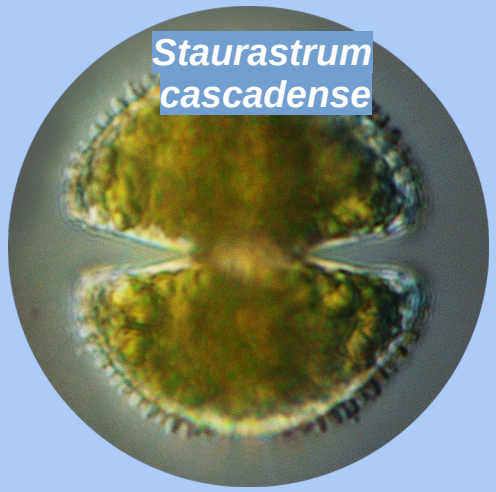
The freshwater algae in the Pacific Northwest need to be studied comprehensively. These lakes contain more than just toxic cyanobacteria; many are likely to contain sensitive, rare, or undescribed species that play critical roles in maintaining a healthy aquatic ecosystem







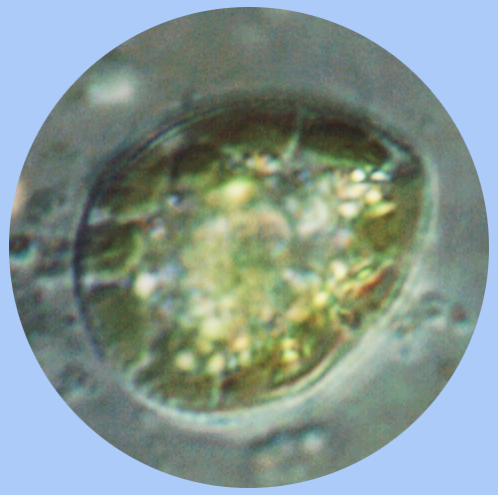


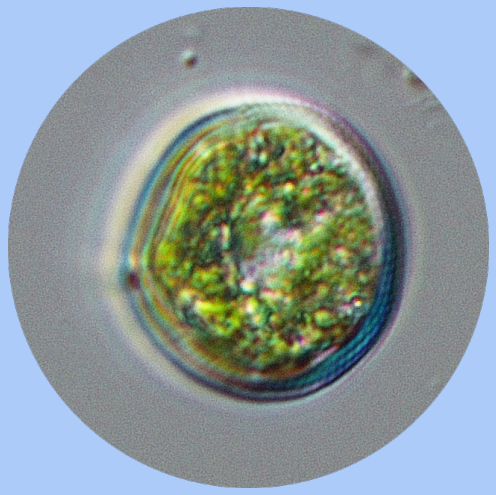


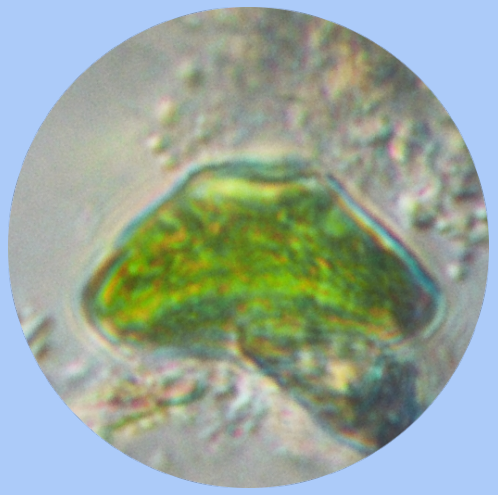


Final Thoughts

What the heck is this? (Hint: Eustigmatophyceae, new genus?)











Thanks!

I want to thank Dr. Angela Strecker, IWS Director, and the wonderful students and staff working with the Institute for Watershed Studies who have collected countless algae samples over the years. I also want to thank my husband Geoffrey for leading me up trails and around mountains to make sure I find all the best sampling spots; my daughter Liz, who helped with file formats, presentation style, and algae sampling; and my office cat Gracie, who insists I take plenty of breaks to play cat games

Unless otherwise noted, all algal photographs were taken by R. Matthews