

Laboratory 2 – Common Klamath River Algae

Part I. Objectives

1. To be able to identify to genus, by sight, the list of common freshwater algae found in the Klamath River,
2. To understand the ecological role that algae have in aquatic ecosystems,
3. To understand how algal blooms, especially Harmful Algal Blooms (HABs), can negatively affect organisms within and around aquatic ecosystems,
4. To know some of the basic differences between cells with a prokaryotic organization versus a eukaryotic organization,
5. To know some of the basic features that characterize 3 algal groups – the cyanobacteria (blue-green algae), green algae, diatoms – and based on these features be able to determine if an algal species that you find in a water sample belongs to one of these 3 groups.

Part II. Those Blooming Algae!

Algae are those organisms that are usually photosynthetic, usually living in aquatic habitats, and are usually simply constructed relative to land plants. This, however, is a very weak definition. There are no unique, defining characters that are present in all algal groups. However, since most groups of algae are distantly related, specific groups do have distinctive characters. For example, the cyanobacteria (blue-green algae) are prokaryotic (i.e., no double membrane organelles like a nucleus, but do have DNA) in combination with having chlorophyll *a* and blue-green phycobiliproteins pigments for photosynthesis. There are uni-, multicellular and colonial species of cyanobacteria. Almost all other algae, like the green algae and diatoms, are eukaryotic (i.e., do have double membrane organelles like a nucleus). In green algae, the pigments chlorophyll *a* and *b* are present and so these algae usually have a Kelly green appearance and they produce starch during photosynthesis. Diatom cells are covered by a silica quartz layer called a frustule. Like all other algae, they also have chlorophyll *a*, but this pigment is masked by a gold pigment called fucoxanthin. The architecture of frustules can be very elaborate, and diatoms are either unicellular or colonial.

Although they are distantly related from an evolutionary point of view, different algal groups often have the same function in aquatic ecosystems. Along with the more recently evolved vascular plants (e.g., ferns, flowering plants), algae are the primary producers in aquatic ecosystems. By using photosynthesis, these organisms convert the energy of light into chemical bond energy, which is passed on to aquatic consumers and decomposers. Algae occur in different types of habitats; those growing in the water column are called phytoplankton whereas algae growing attached to the bottom are broadly referred to as benthic algae. The benthic algal communities growing on rocks in streams and rivers are often more specifically referred to as periphyton communities. Algae that grow on other algae or plants are living in epiphytic habitats whereas epizoic algae grow on animals. In the marine environment, the large algae are called seaweeds and include many types of algae, such as red seaweeds and brown seaweeds like kelp. Any one of these freshwater or marine habitats can be occupied by many distantly related groups of algae all of which are functioning as primary producers. Larger algae, like kelp, also create habitat by adding structure to the water column – in the same way that trees create new habitat on the landscape.

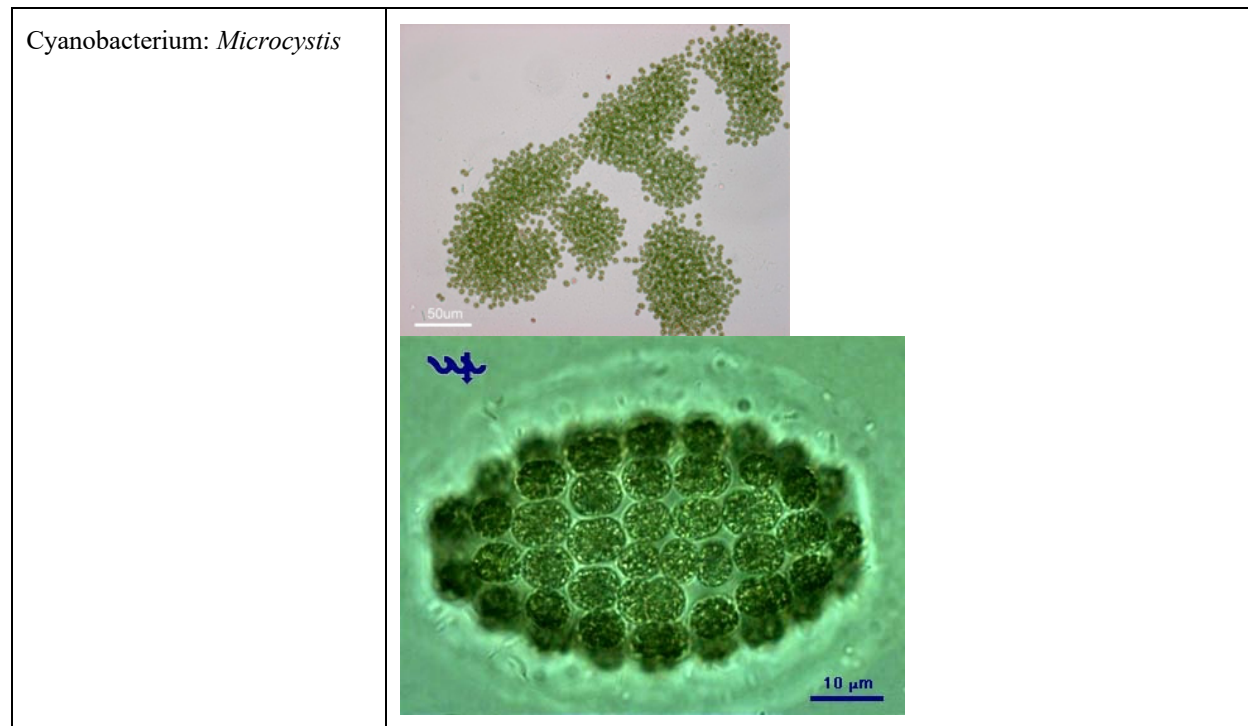
Algal populations that bloom can have negative effects on organisms that rely on aquatic ecosystems, in which case they are often referred to as Harmful Algal Blooms (HABs). Blooms are rapid expansions in the size of algal populations that occur because a resource that was limiting (e.g., light, a nutrient) becomes more available, and/or the abundance of a grazer of algae (e.g., zooplankton, fish) suddenly drops thereby allowing the algal populations to suddenly expand. HAB algal species do not have to produce toxins in order to negatively affect the ecosystem. For example, blooming algae will eventually use up the available resources in a system and begin to die, at which point the bacteria use up the oxygen as they decompose the algae. Many of the animals in the system therefore either migrate or die. Other HAB species do produce hepatotoxins and/or neurotoxins. It can be quite difficult to match a toxin to an algal species because there are usually several molecular forms of the same toxin, and even if genetic studies can establish that a particular algal species has the genes for a toxin, it doesn't mean that the species is actually producing the toxin – even when that species is shown to be present in the system. Why some algae produce toxins, and the environmental conditions that lead to toxin production, are not well understood.

Part III. Klamath River HABs

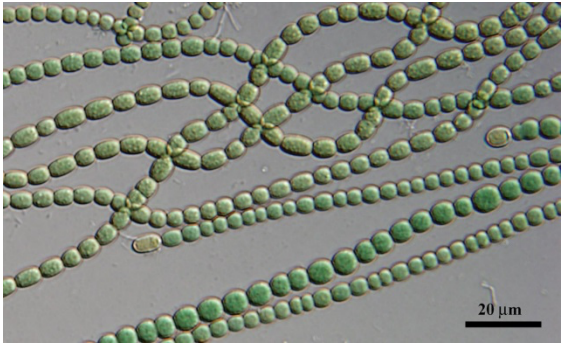

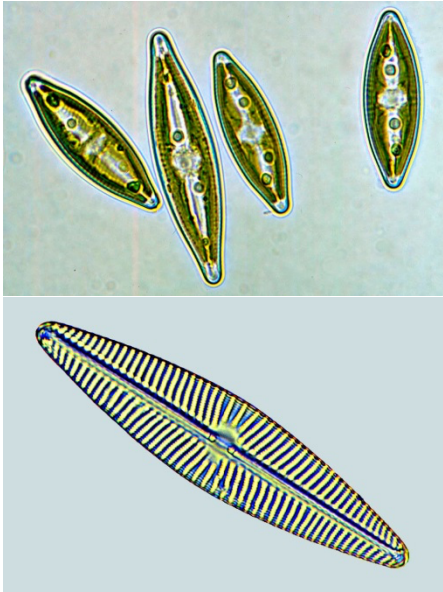
The Klamath River should contain a wide array of algal groups all of which, in combination with inputs from the surrounding landscape, are supporting the life in the river. Algal species capable of blooming are likely present throughout the entire river system but are usually present in such low numbers that they are not macroscopically visible. Toxic species of cyanobacteria, particularly *Microcystis aeruginosa*, bloom in the Klamath River during the later summer and early fall when nitrogen concentrations and water temperatures peak. Several forms of the molecule microcystin also appear at this time. As a hepatotoxin microcystin can destroy the liver of vertebrates, including people, and as a neurotoxin it can lead to respiratory failure. Blooms of *M. aeruginosa* and other toxic cyanobacteria occur in many places around the world and so, given their effects on livestock, fish and people, there is a strong need to understand what causes them, and then to develop policies that minimize their occurrence. The people of the Klamath River basin are concerned about toxic cyanobacteria because of its livestock and human health effects, as well as its potential negative effects on salmon. These fish can also be killed by the parasite ick (i.e., *Ichthyophthirius multifiliis*, a protozoan) that becomes more prevalent at high river water temperatures. Low river flows, which can result from holding water behind dams, water diversions and drought allow both nutrient levels to become more concentrated and water temperatures to rise.

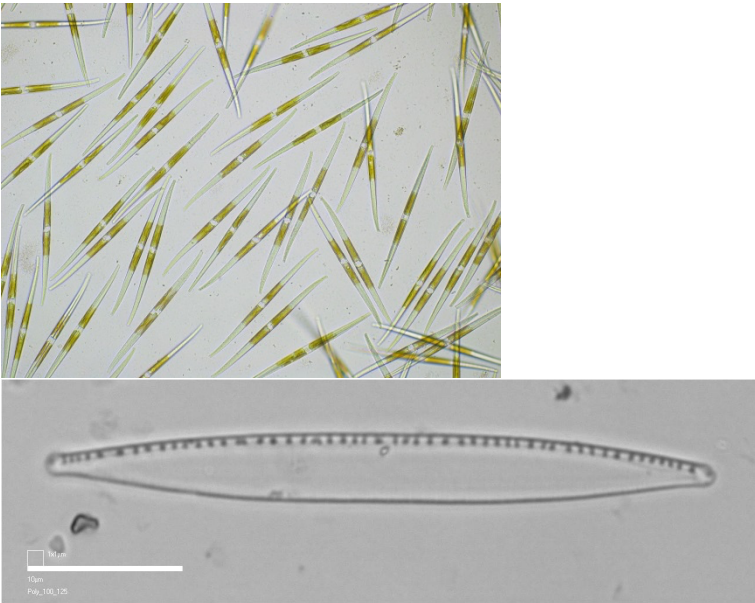
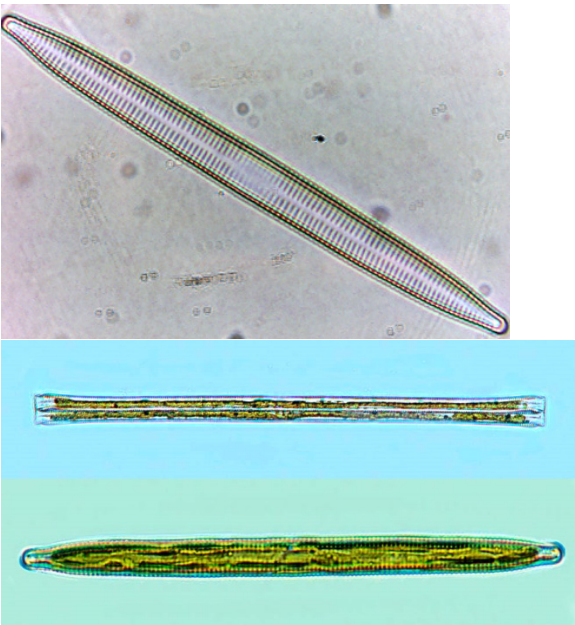
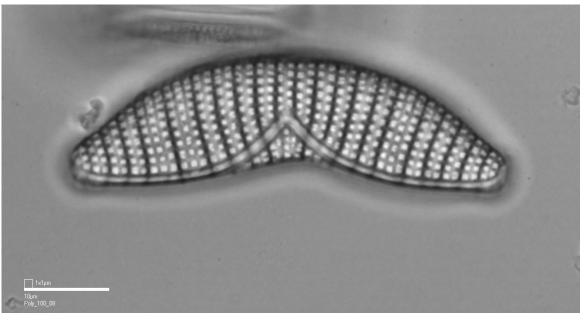
Part IV. Exercises for Klamath River Algae

- ♣ Review the Objectives of this lab and understand the background summarized in Parts II & III.
- ♣ Be able to recognize and name the genus of the 10 most common freshwater algae found in the freshwater samples located on one of the laboratory benches, which include samples from the Klamath River. Your lab instructor will let you know which algae will be on this 'top 10 list'. *Make wet mounts to look for the algae in the different water samples.* Use the below table of some common freshwater algae to help you identify what is in the samples.

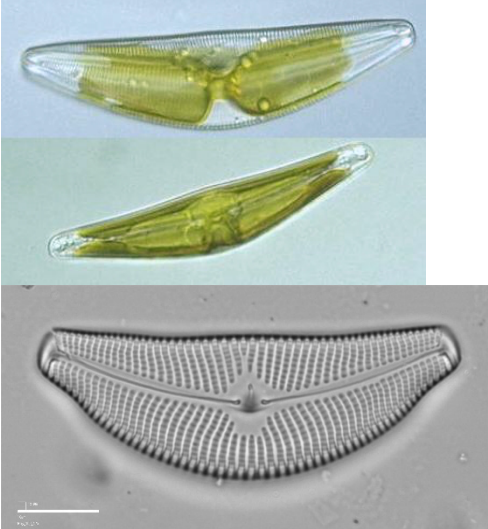
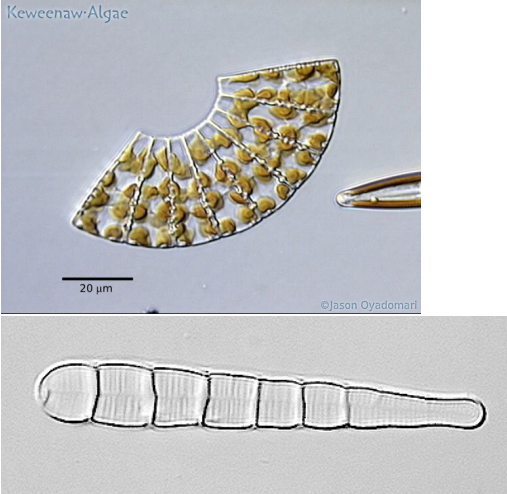



Supplementary Material 3. Botany Microscopy Laboratory


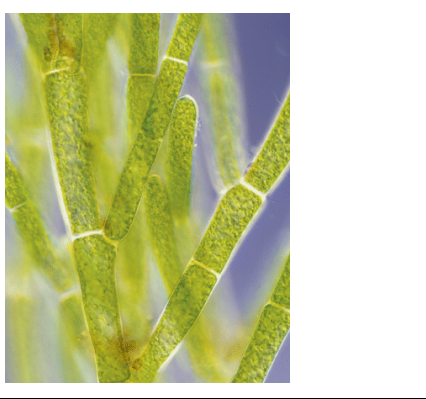
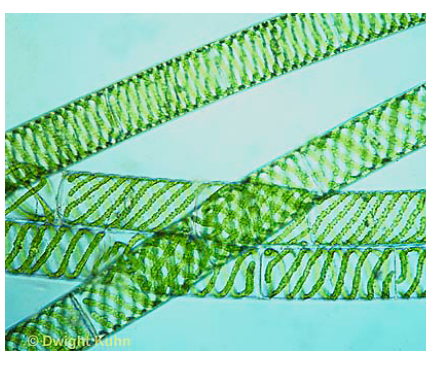
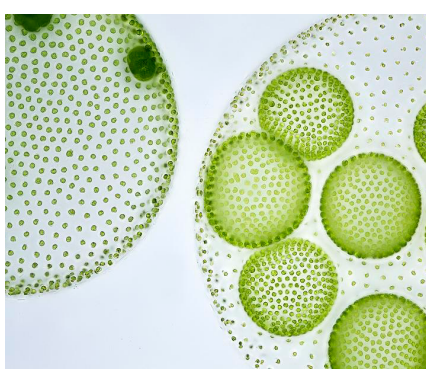
<p>Cyanobacterium: <i>Anabaena</i></p>	 <p>A light micrograph showing several chains of <i>Anabaena</i> cyanobacteria. The chains are composed of numerous small, spherical, green cells. The chains are arranged in a somewhat overlapping, zig-zag pattern. A scale bar in the bottom right corner indicates 20 μm.</p>
<p>Cyanobacterium: <i>Gloeocapsa</i></p>	 <p>A light micrograph of a <i>Gloeocapsa</i> colony. The colony is a large, roughly spherical, translucent structure containing many smaller, green, spherical cells. The colony is surrounded by a thin, clear membrane. A copyright notice "© AJ Silverside" is visible in the bottom left corner.</p>
<p>Diatom: <i>Navicula</i></p>	 <p>Two light micrographs of <i>Navicula</i> diatoms. The top image shows four individual diatoms, which are elongated, spindle-shaped cells with a central longitudinal line and several transverse lines. The bottom image shows a single, larger diatom with a similar spindle shape and prominent transverse lines.</p>

<p>Diatom: <i>Nitzschia</i></p>	 <p>This block contains two micrographs of <i>Nitzschia</i>. The top image is a field of view showing numerous individual diatom cells, which are elongated and spindle-shaped with distinct transverse striae. The bottom image is a high-magnification view of a single cell, showing its elongated, spindle-like shape and the fine transverse striae. A scale bar in the bottom left corner of the second image indicates 10 μm, with the text '10 μm', 'Diatom', and 'PW_100_125' below it.</p>
<p>Diatom: <i>Synedra</i></p>	 <p>This block contains three micrographs of <i>Synedra</i>. The top image shows a single, long, spindle-shaped diatom cell with prominent transverse striae. The middle image shows a similar cell against a light blue background. The bottom image shows a similar cell against a light green background. The cells are elongated and spindle-shaped with distinct transverse striae.</p>
<p>Diatom: <i>Epithemia</i></p>	 <p>This block contains a single micrograph of <i>Epithemia</i>. The diatom is shown in a high-magnification view, revealing its fan-shaped or semi-circular structure and the dense, regular grid of striae. A scale bar in the bottom left corner indicates 10 μm, with the text '10 μm', 'Diatom', and 'PW_100_01' below it.</p>

Supplementary Material 3. Botany Microscopy Laboratory

<p>Diatom: <i>Cymbella</i></p>	 <p>The image displays three micrographs of the diatom <i>Cymbella</i>. The top two images show lateral and oblique views of a single, elongated, spindle-shaped cell with a yellowish-green color. The bottom image is a high-magnification ventral view showing the intricate, parallel striae (silica bands) that form the cell's structure. A scale bar is visible in the bottom left corner of this image.</p>
<p>Diatom: <i>Meridion</i></p>	 <p>The image shows two micrographs of the diatom <i>Meridion</i>. The top image is a fan-shaped colony of cells, with a scale bar indicating 20 μm. The bottom image shows a single, elongated, cylindrical cell with a distinct longitudinal structure. The text 'Keweenaw Algae' and '©Jason Oyadomari' are visible in the top right corner of the upper image.</p>
<p>Green alga: <i>Stigeoclonium</i></p>	 <p>The image shows a micrograph of the green alga <i>Stigeoclonium</i>, characterized by its branched, filamentous structure. The filaments are composed of individual cells, and the overall appearance is that of a complex, branching network.</p>

Supplementary Material 3. Botany Microscopy Laboratory

<p>Green alga: <i>Asterococcus</i></p>	 A light micrograph showing several spherical colonies of the green alga Asterococcus. Each colony is composed of numerous small, individual cells arranged in a roughly circular pattern. The colonies are bright green and set against a light blue background.
<p>Green alga: <i>Cladophora</i></p>	 A light micrograph of the green alga Cladophora. It shows several branched filaments of cells. The filaments are composed of rectangular cells with distinct cell walls, and they are arranged in a characteristic branched pattern. The color is a pale yellowish-green.
<p>Green alga: <i>Spirogyra</i></p>	 A light micrograph of the green alga Spirogyra. It shows several long, cylindrical filaments of cells. Each filament contains a single, large, spiral-shaped chloroplast that runs the length of the cell. The filaments are arranged in a somewhat overlapping manner. A small copyright notice "© DWIGHT" is visible in the bottom left corner of the image.
<p>Green alga: <i>Volvox</i></p>	 A light micrograph of the green alga Volvox. It shows several spherical colonies of different sizes. Each colony is composed of many individual cells, each with two flagella, arranged in a hollow sphere. The colonies are bright green and set against a light blue background.

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Green alga: <i>Scenedesmus</i>	
Green alga: <i>Closterium</i>	

Part V. Vocabulary

- Algae
- Benthic algae
- Bloom
- Blue-green algae
- Chlorophyll a
- Colonial
- Cyanobacteria
- Diatoms
- Epiphytic
- Epizoic
- Eukaryotic
- Frustule
- Fucoxanthin
- Green algae
- Harmful Algal Bloom
- Hepatotoxin
- Ick
- Multicellular
- Neurotoxin
- Periphyton
- Phycobiliprotein pigments
- Phytoplankton
- Primary producer
- Prokaryotic
- Seaweeds
- Starch
- Unicellular
- Zooplankton