This information originally appeared in the 2002 King County Lake Monitoring Report and has been modified for this fact sheet.

Algae & King County Lakes

Introduction

Algae are the basic food producers in lakes, using the energy of sunlight to change water and carbon dioxide dissolved in the water into substances that animals then use to stay alive, grow, and reproduce. The long chain of life that stretches from algae to large animals, including humans, has been studied intensively, and yet there is still much to learn.

Some algae live by attaching to surfaces such as rocks, docks and large aquatic plants. Others lay on the bottom sediments, and a third group floats freely through the water column. The last group, known as "phytoplankton," often makes the biggest contribution to the volume of algae growing in lakes through the year and is the most studied of the various groups.

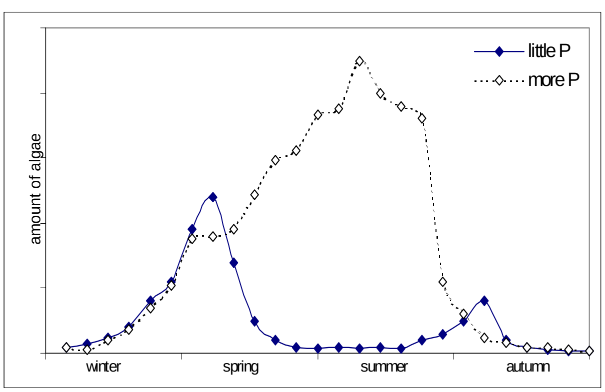
The interactions between phytoplankton and the environment within a lake can be quite complex and unpredictable. However, there are some generalizations that can be made about changes in populations through the year and how those relate to seasonal changes in lakes in temperate climates, such as that of the Pacific Northwest. Algae need all the same conditions as land-based plants in order to grow. In addition to the necessary elements for photosynthesis, they need a temperature range to which they are adapted, as well as appropriate concentrations of hydrogen ions (pH) and nutrients, including nitrogen, phosphorus, silica, calcium, magnesium, and iron.

The seasonal interplay between climate, water input and water circulation within a lake result in changes in water temperatures, light availability, and nutrient concentrations in the water. Changing conditions allow different algal groups to become dominant (i.e., high numbers relative to other algae) as time passes and seasons progress.

King County

While most algae like the warmer temperatures and bright, long days of spring through fall, others can survive in cool temperatures and short days. The general patterns of phytoplankton populations through the seasons ("succession") can be summarized for lakes situated in moderate climate areas like the Pacific Northwest. There are many variations, since each lake is unique. Commonly, phosphorus plays the role of "limiting nutrient" in lakes in the Puget lowlands. A limiting nutrient is the substance necessary for growth that will be exhausted first by the growing algae. When that nutrient is essentially gone from the lake, algal growth will be limited (Fig. 1). Algal growth reaches a maximum in spring in lakes with smaller amounts of phosphorus and then drops in summer when the phosphorus has been used up in the epilimnion (upper water). In lakes with more phosphorus, the phytoplankton continue to grow into the summer, reaching maximum levels in July, August, or even September before decreasing temperatures and light begin to limit growth. Sometimes lakes with algal peaks in spring also produce a second peak in fall, when cool temperatures mix the phosphorus from the hypolimnion (lower water) of the lake upwards and enough light enters the water to stimulate the second period of growth.

Figure 1: Illustration of Typical Seasonal Abundance of Algae in Lakes



This figure shows the two general patterns that volumes of algae in a lake can make over a calendar year. The solid line illustrates a common pattern when little phosphorus is available for growth. The dotted lines illustrate what may happen with more phosphorus available.

Chlorophyll and Algae

One simple way to estimate the size of the phytoplankton population in a lake is to measure the amount of chlorophyll *a* found in a liter of water.

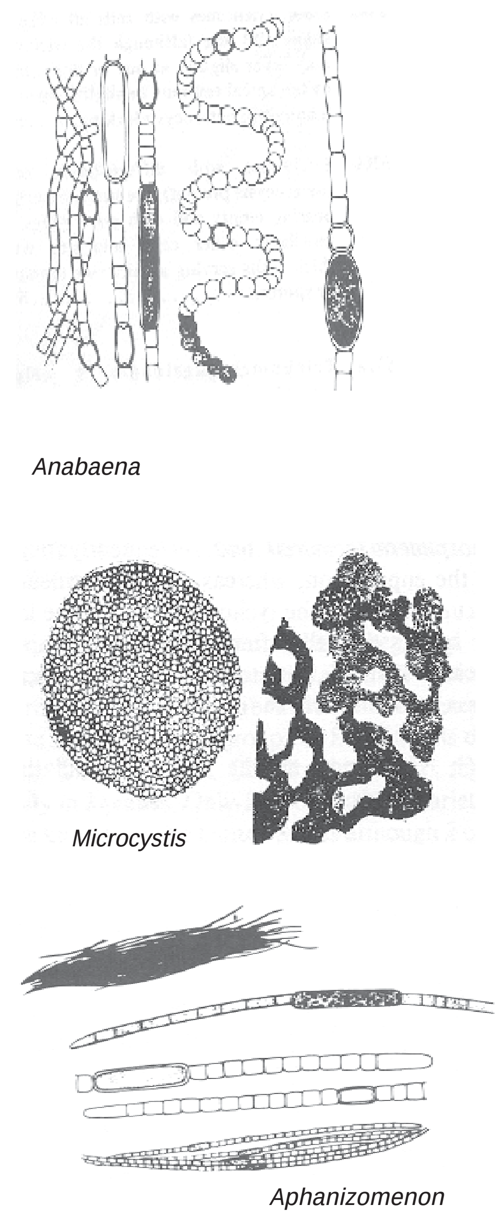
All algae have chlorophyll, generally contained in special organelles called chloroplasts, since this substance is necessary for photosynthesis (food production). The chlorophyll measurement is sometimes used as an analogue for the volume of phytoplankton present. There are several problems with this method, but it can be a useful tool for classifying lakes in broad terms of productivity.

Algae can have differing amounts of chlorophyll per volume of cell contents, depending on the species present as well as the time of year and the health of the cells. Sometimes quite a large volume of algae will have relatively little chlorophyll and vice versa. For example, the diatoms tend to have less chlorophyll per volume because many have large vacuoles or inclusions inside the cells, which take up space but are not chloroplasts, so do not add to the amount of chlorophyll. Other algae, such as the bluegreens, have pigments in addition to chlorophyll that are used to capture light, so the amount of chlorophyll in each cell may be commensurately less. In addition, as algae age, or senesce, they may lose chlorophyll, so older populations may have less chlorophyll than young, rapidly growing groups.

Major Groups of Phytoplankton

Algae that float in the water of lakes are diverse and come from all the major groups of algae classified by scientists. However, several groups are predominant in this area. Many have something particular about their requirements that can be used to characterize the environment of the lake in which they are found. Lakes with water colored by large amounts of humic substances from adjacent wetlands often feature different phytoplankton species than lakes with clear water, but similar amounts of phosphorus. The following is a description and discussion of the major groups and some representative species of algae that are common in the small lakes of King County. Besides the Latin botanical names of the groups, algae are commonly distinguished by their coloration.

Figure 2: Common Bluegreen Algae



Illustrations obtained from: *How to Know the Freshwater Algae* by G.W. Prescott, 1978.

Cyanobacteria: Bluegreen Algae

Bluegreens are simple organisms that share many features with bacteria, but produce food in the same way as plants, thus making their place in biological classifications open to argument. For this reason, some people refer to them as algae although strictly speaking it may not be appropriate. The bluegreens also share many of the environmental requirements of true algae and are important competitors for nutrients and light in the phytoplankton communities of lakes.

Bluegreens can actually be bluish-green in color, but they can also be red, brown, purple, yellow-green and olive. They always have at least a small amount of chlorophyll to complete the photosynthetic reactions, but they also can have a wide variety of other pigments that act as auxiliary light catchers for photosynthesis.

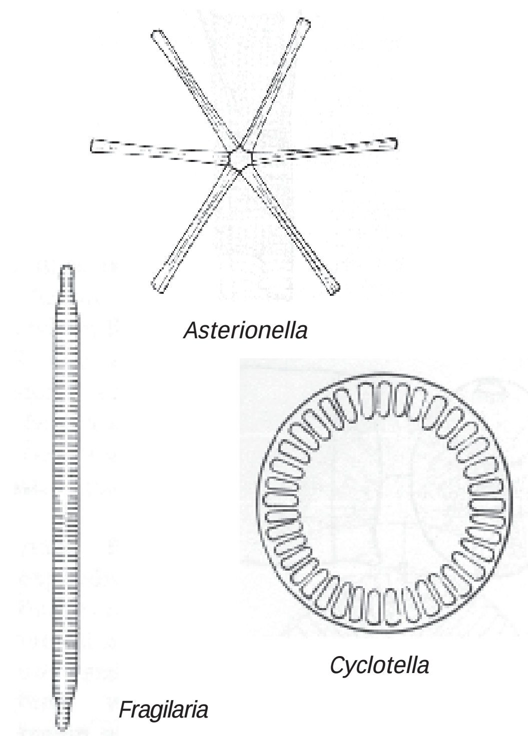
Bluegreens have become especially notorious in lake studies because several species can grow quickly in waters rich in phosphorus, which can be increased by land use changes or other human impacts. On occasion they can outnumber and exclude other naturally occurring species, leading to reduced water clarity, bad smells, and floating scums of decaying colonies, thus adding to their reputation as the algae of polluted waters. In addition, some species are known to release compounds toxic to mammals and fish. Although this is a rare occurrence, when it happens the results are often dramatic and make newspaper headlines.

Bluegreens are most often colonial, which means that the cells band together in groups rather than occur alone in nature. The two major colony forms are simple clusters of cells and cells arranged in long filaments. Some of the filamentous varieties can absorb nitrogen from sources not available to other algae, thus giving them an advantage in lakes where nitrogen may run out before phosphorus. Thus, when the nitrogen to phosphorus ratio is low in a lake, some bluegreens may have the opportunity to grow faster than the other algae present.

In general, bluegreens do very well in warm water and in high light levels, and therefore are considered to be summer algae. However, several species, such as *Aphanizomenon flos-aquae*, seem to be able to increase their population size in every season of the year in temperate lakes if other conditions are right, and they have been found making significant blooms in fall, winter and spring.

Common bluegreens found in King County lakes include *Aphanizomenon flos-aquae*, *Microcystis aeruginosum* and several species of *Anabaena* (Fig. 2). The last two named are most often implicated when toxic blooms are reported, but in fact most occurrences of these species are not toxic and should not cause concerns merely because of their identification in the phytoplankton of a particular lake.

Figure 3: Common Diatom Algae



Illustrations obtained from: *How to Know the Freshwater Algae* by G.W. Prescott, 1978.

Chrysophytes: Golden Brown Algae

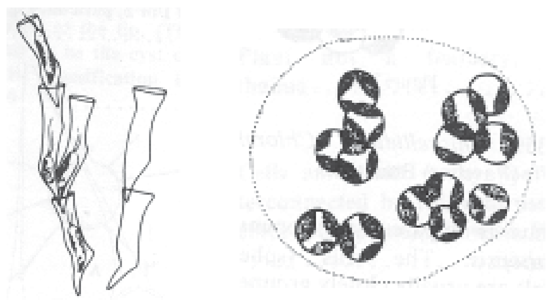
The chrysophyte algae have all the necessary chlorophyll *a*, but also have pigments that give them a characteristic golden to brown color. Many are most common in spring through early summer, although one or two varieties can make large populations in late summer under the right conditions.

Diatoms are an important subgroup of the chrysophytes, often dominating spring phytoplankton since they can grow better than other algae in low light and cool temperatures, thus getting a head start on the growing season. Diatoms make hard siliceous coverings for their cells, known as "frustules." This characteristic has two effects: their growth can be limited by the amount of silica present as well as the phosphorus that limits other algae, and the extra weight of the frustule makes it harder for some diatoms to stay in the shallow water where light is most available. Therefore, many diatom populations will be found in spring before the beginning of thermal layering in area lakes, or in fall after it begins to break down, with one or two specific exceptions.

Diatom species can either be found as groups of cells (colonial) or solitary. Typical diatoms found in King County include *Cyclotella* species (solitary) and colonial varieties of *Fragilaria*, and *Asterionella* (Fig. 3). Some diatoms, such as several species of *Cyclotella*, have a reputation as indicators of clean water or oligotrophic conditions. Others, such as *Fragilaria*, are known to be more common in mesotrophic lakes.

Several other chrysophytes are quite common in lakes of our area. The colonial species *Dinobryon* does not make a frustule, but does make a thin protective covering shaped like a goblet or drinking glass, termed a "lorica." Individual cells connect to each other in a manner reminiscent of tree branching, and large colonies are more buoyant

Figure 4:
Other Chrysophyte Algae



Dinobryon *Gioeobotrys*

Illustrations obtained from: *How to Know the Freshwater Algae* by G.W. Prescott, 1978.

because of this shape, allowing *Dinobryon* to stay higher in the water column and persist through the summer in many lakes (Fig. 4).

Chlorophytes: Green Algae

Green algae produce chlorophyll as their predominant pigment, hence their bright green coloration. They are a large and varied group, with some characteristics closer to the vascular (higher) plants than found in other groups of algae, and therefore some authorities have considered some chlorophytes as evolutionary links to land plants. They can occur in lakes all year, but tend to reproduce and grow much better in warm temperatures and high light levels, thus they generally produce their biggest populations in summer.

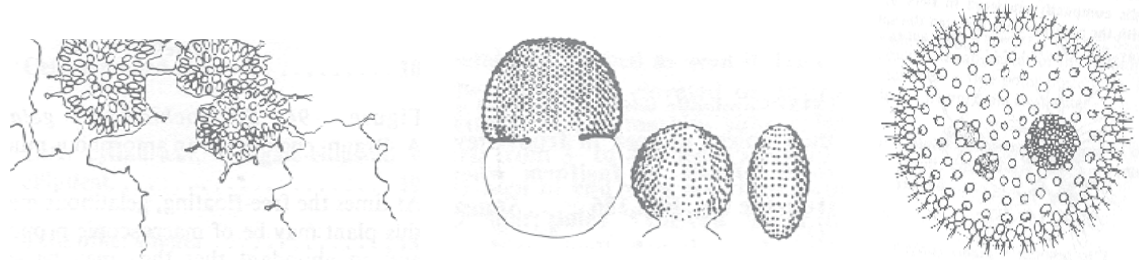
Green algae can be solitary or colonial, and both single cells and colonies can take many different shapes from spherical to elaborately geometrical to filamentous. Most of the filamentous green algae grow attached to surfaces rather than floating in the water. Some cells have the means to be mobile, having from one to four whip-like tails called “flagella,” which they use to move through the water. Colonial balls of green algae, when each member cell has flagella, can move in characteristic tumbling, rolling motions through the water as all the flagella beat the water. Typical colonial greens found in area lakes include *Volvox* and a rather peculiar large colonial form called *Botryococcus*, which makes large amounts of oils that keep it buoyant through the season (Fig. 5). It often turns from green to bright orange as it gets old and dies off, in the same fashion as the changing color of leaves on deciduous trees.

Another specialized group of green algae, called the desmids, are often found in highly colored, acidic waters such as bogs and cool water wetlands. The desmids make a hard cell surface out of an organic material that can have an elaborate shape, ornamented with many spines and knobs. *Cosmarium* is one commonly found in King County lakes (Fig. 6).

Pyrrhophytes: the Dinoflagellates

The dinoflagellates are a group that has been characterized both as algae and protozoa because

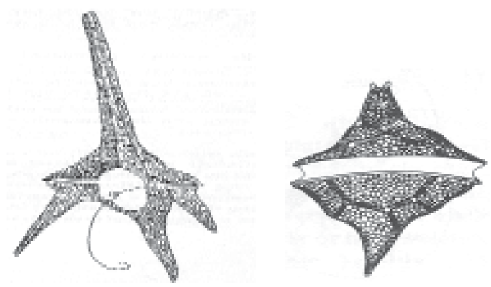
Figure 5: Common Chlorophyte Algae



Botryococcus *Cosmarium* *Volvox*

Illustrations obtained from: *How to Know the Freshwater Algae* by G.W. Prescott, 1978.

Figure 6: Common Dinoflagellates



Illustrations obtained from: *How to Know Freshwater Algae* by G.W. Prescott, 1978.

of their ability to move quickly through the water using two flagella. Their movements are vigorous, more characteristic of animals, but the dinoflagellates can also make food like plants. To confuse the issue, they can also ingest other foods as animals do.

Dinoflagellates are nearly always solitary and are common in marine water, where they are notorious for toxic blooms (red tides) that render shellfish poisonous for humans and other animals to eat. Freshwater dinoflagellates are mostly harmless to people, but can color the water red or brown on rare occasions. Large populations will generally occur in the summer, if at all, in King County. The most common forms seen are species of *Peridineum* and *Ceratium*.

Two Lesser Known Groups of Algae

There are two other groups of algae that have no common names, but which are found frequently in the lakes of King County.

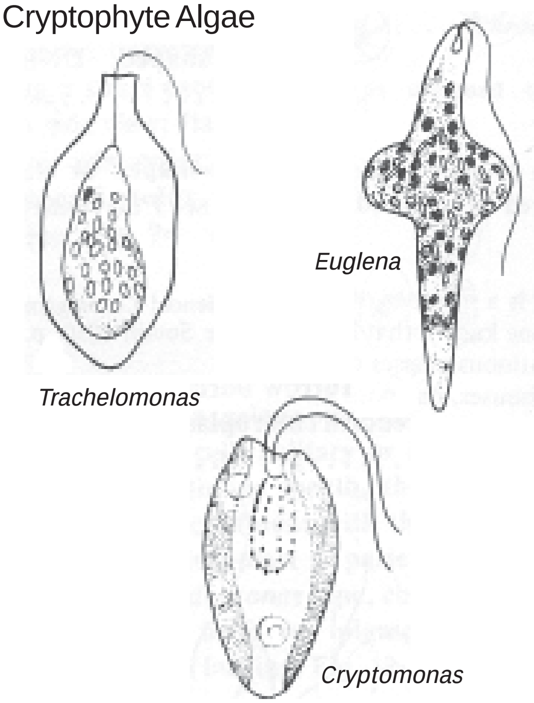
Euglenophytes

Euglena and its allies are often the first algae introduced to students in high school. Its large size and clear structure make it a good subject for beginning biologists to see through a microscope. These algae are always solitary, quite mobile, and generally are found in small bodies of water such as ponds and ditches rather than lakes. However, they have been found in several of the lakes in the Lake Stewardship Program, such as Jones and Paradise. Examples of common euglenoids include *Euglena* and the unusual *Trachelomonas*, which makes an organic shell often colored golden or brown (Fig. 7).

Cryptophytes

The cryptophytes are a group of solitary, mobile algae quite distinct from other groups, but with little variation among the species. They are generally small, solitary, and can move quickly using flagella. They are known as an excellent food source for many small planktonic animals. The amount present of these algal species can vary throughout the year, filling in quickly when other algal populations fail to thrive, but disappearing just as fast as the animals graze on them. *Cryptomonas* is a common inhabitant of lakes in King County (Fig. 7).

Figure 7: Common Euglenophyte and Cryptophyte Algae



Illustrations obtained from: *How to Know the Freshwater Algae* by G.W. Prescott, 1978.