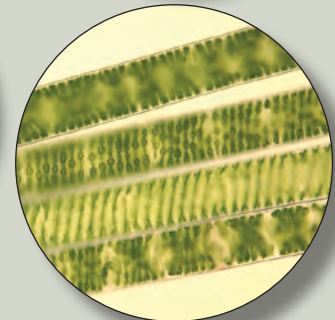
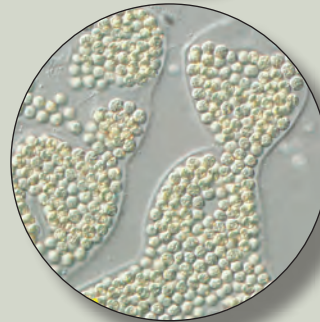
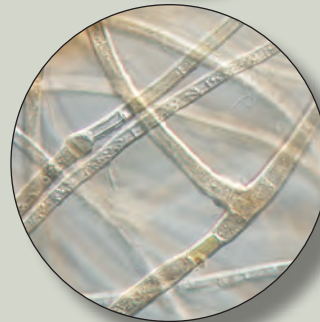
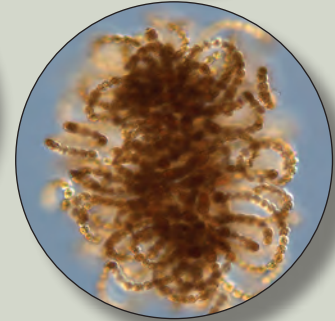
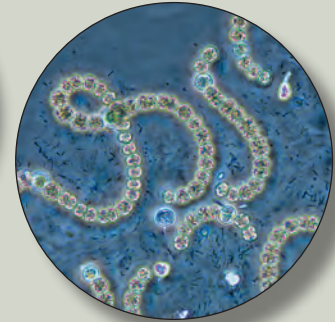
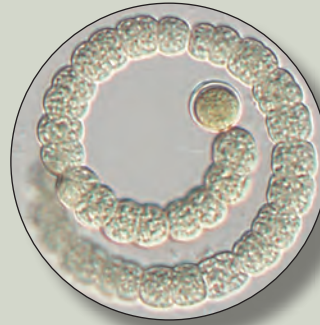
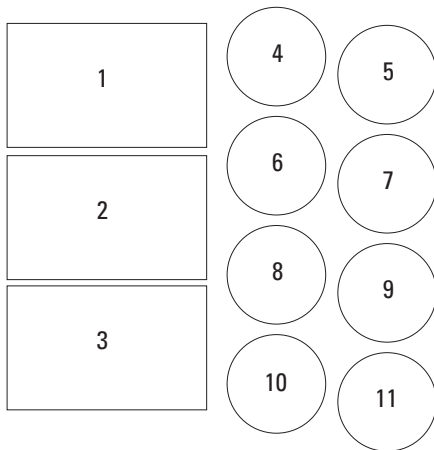


Field and Laboratory Guide to Freshwater Cyanobacteria Harmful Algal Blooms for Native American and Alaska Native Communities



Open-File Report 2015–1164

U.S. Department of the Interior
U.S. Geological Survey



Cover. Photographs showing

1. Cyanobacteria, *Gloeotrichia echinulata* (Midge Eliassen)
2. Euglenophyta, *Euglena* sp. (Ann St. Amand)
3. Euglenophyta, *Euglena sanguinea* (Barry H. Rosen)
4. *Anabaenopsis arnoldii* (Barry H. Rosen)
5. *Dolichospermum circinale* (Ann St. Amand)
6. *Dolichospermum crassum* (Ann St. Amand)
7. *Dolichospermum lemmermannii* (Ann St. Amand)
8. *Haplosiphon hibernicus* (Barry H. Rosen)
9. *Sphaerospermopsis torques-reginae* (Barry H. Rosen)
10. *Microcystis wesenbergii* (Barry H. Rosen)
11. *Spirogyra* sp. (Ann St. Amand)

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By Barry H. Rosen and Ann St. Amand

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**U.S. Department of the Interior
U.S. Geological Survey**

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Abbreviations

EPA	U.S. Environmental Protection Agency
HAB	harmful algal bloom
sp.	species

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Field and Laboratory Guide to Freshwater Cyanobacteria Harmful Algal Blooms for Native American and Alaska Native Communities

By Barry H. Rosen¹ and Ann St. Amand²

Abstract

Cyanobacteria can produce toxins and form harmful algal blooms. The Native American and Alaska Native communities that are dependent on subsistence fishing have an increased risk of exposure to these cyanotoxins. It is important to recognize the presence of an algal bloom in a waterbody and to distinguish a potentially toxic harmful algal bloom from a non-toxic bloom. This guide provides field images that show cyanobacteria blooms, some of which can be toxin producers, as well as other non-toxic algae blooms and floating plants that might be confused with algae. After recognition of a potential toxin-producing cyanobacterial bloom in the field, the type(s) of cyanobacteria present needs to be identified. Species identification, which requires microscopic examination, may help distinguish a toxin-producer from a non-toxin producer. This guide also provides microscopic images of the common cyanobacteria that are known to produce toxins, as well as images of algae that form blooms but do not produce toxins.

¹U.S. Geological Survey.

²PhycoTech, Inc.

Introduction

Algae are a group of organisms with similar traits that unify them as a group but with specific characteristics that are used to separate one organism from another. As an example, chlorophyll *a*, used by algae to capture sunlight for photosynthesis, is common to virtually all organisms called “algae.” One major separation of algae is the basic cellular organization into prokaryotic organisms, such as the cyanobacteria that do not have internal organelles, and eukaryotic organisms, which include all the rest of the algal groups. The eukaryotic organisms are further divided on the basis of pigments, cell wall composition, photosynthetic storage compounds, flagella, and genetics. Many flagellated forms have greater affinity and are often classified as Protozoa.

Most recently, genetic affiliations between the hierarchical organization of algae and the individual species has led to a continuous flux in the names of organisms. Many approaches are available for organizing these groups. Table 1, which is based on the “Freshwater Algae of North America, 2015” (Wehr and others, 2015), provides a list of the “groups” of algae as well as some common names and synonyms for most freshwater algae.

Table 1. Classification, common names, and synonyms for most freshwater algae.

Division, Phylum, Group, or Class	Common name	Synonyms
Cyanobacteria ¹	Blue-green algae, cyanobacteria, cyanophytes	Cyanophyta, Cyanophycota, Cyanophyceae
Chlorophyta ²	Green algae	Chlorophycota
Charophyceae ²	Stoneworts	Charophyta
Bacillariophyceae ³	Diatoms	Bacillariophyta ³
Rhodophyta ³	Red algae	
Euglenophyta ³	Euglenoids	Euglenophyta
Pyrrophyta ³	Dinoflagellates	Dinophyta, Pyrrophyta, Dinophyceae ³
Haptophyceae ³	Golden algae	Haptophyta, Prymnesiophyta
Synurophyceae, ³ Chrysophyceae ³	Golden or golden-brown algae	Chrysophytes, Synurophytes
Cryptophyta ³	Cryptomonads	

¹Oren (2004). ²Leliaert and others (2012). ³Wehr and others (2015).

2 Field and Laboratory Guide to Freshwater Cyanobacteria Harmful Algal Blooms for Native American and Alaska Native Communities

Algae are primary producers and serve as the base of the food web in most aquatic habitats. Phytoplankton is a term that describes the assemblage of algae that live in the water column of a waterbody, including ponds, lakes, reservoirs, rivers, and marine habitats. Periphyton are the algae attached to plants, rocks, sand, and wood in most aquatic habitats. For phytoplankton, each group of algae has unique qualities that allow it to thrive at a different time and under specific environmental conditions in a waterbody, typically seasonally, with one group giving way to another as conditions change in the process called succession. For example, diatoms typically dominate in colder months and cyanobacteria and green algae in warmer months. When the abundance of algae causes a “problem,” typically a surface scum or accumulation on or near a shoreline, it is given the name “algae bloom” and many times “harmful algae blooms” (HABs). An algae bloom forms under the correct environmental conditions, including nutrient abundance, stability of the water column, ample light, and optimal temperatures. Although many different types of algae are responsible for HABs, cyanobacteria pose the greatest problem and are the focus of this guide.

Cyanobacteria, also known as blue-green algae, are a group of microorganisms that live in moist terrestrial and aquatic habitats throughout the world. Several types of cyanobacteria are known to produce a variety of toxins that can cause a range of effects from simple skin rashes to liver and nerve damage and even mortality of fish, wildlife, and rarely, humans (Chorus and Bartram, 1999). The major groups of toxins are the microcystins, saxitoxins, anatoxins, cylindrospermopsins, nodularins, and dermatoxins. These toxins typically represent a family of structurally related compounds, termed derivatives, which have similar biological effects.

The complexity of these toxins and their derivatives makes attribution of a specific compound to a specific species difficult. A field sample is often a mixture of organisms, thus the toxin attribution to a given species in a sample is uncertain. The best method for attributing a specific compound to a specific species involves isolating an organism and culturing it to ascertain that it is the source of toxin production; however, this is a difficult task and creates a myriad of secondary issues. Much of the literature describes the dominant organism in a bloom and typically attributes the toxin present to that organism. Table 2 provides a synopsis of the toxins found in the 26 cyanobacteria illustrated in the Microscope Images section of this guide. Note that some species are known to produce multiple toxins, and it is beyond the scope of this report to identify all of the genera and species identified in the literature as toxin producers.

Added to this complexity is the definition of a species in the cyanobacteria. The long-standing identification of a species is dependent on the morphology of the organism, including the shape of the cells, the positioning of key features, size, and coloration. Some of these features are stable and conservative, while others are more unstable and change under certain environmental conditions. With the advent of genetic techniques, many of these traditional visual features

have become secondary to the genetic makeup of an organism; however, genetic affiliation relies on being able to analyze an individual isolated species. The cyanobacteria have undergone substantial name changes to align the genetically affiliated organisms into closely related taxa, especially at the genus level. Table 3 provides the current name of cyanobacteria described in this document, along with the synonyms used in the past, to assist in properly identifying organisms and interpreting the literature. It is beyond the scope of this report to identify all of the synonyms that are used for each purported toxin-producing species of cyanobacteria.

Most bloom-forming cyanobacteria can regulate their buoyancy to optimize their position in the water column and float to the surface. Wind can also cause massive accumulations of phytoplankton on downwind shorelines. Improperly treated drinking water containing toxic cyanobacteria can cause liver and nervous system impairment in mammals including humans (Chorus and Bartram, 1999). Although many cyanobacteria often produce taste and odor compounds as well, the presence or absence of taste and odor compounds is not predictive of the presence of algal toxins.

The human consumption of fish and shellfish exposed to a cyanobacteria (and cyanotoxins) is poorly documented. Only a few studies have been conducted to examine fish and shellfish concentrations for key compounds, such as the microcystins (*shrimp*: Zimba and others, 2006; *Ibelings* and Chorus, 2007; *catfish*: Zimba and others, 2001; *carp*: Li and others, 2004), the nodularins (*muller*: Stewart and others, 2012), and the saxitoxins (*freshwater mussel*, Pereira and others, 2004). In a report by the National Environmental Justice Advisory Council (2002), which provided advice to the “Environmental Protection Agency (EPA) on how to improve the quality, quantity, and integrity of our Nation’s aquatic ecosystems in order to protect the health and safety of people consuming or using fish, aquatic plants, and wildlife,” HABs are not discussed. This report does recognize that many Native American and Alaska Native communities are dependent on subsistence fishing, creating an increased risk of exposure to traditional toxins, such as mercury and dioxins, which accumulate in the aquatic food webs. By comparison, the impact of HABs and cyanotoxins on humans, especially the Native American and Alaska Native communities, warrants additional study.

Warming global temperatures may exacerbate the growth of cyanobacterial blooms (Paerl and Huisman, 2009). One reason is that cyanobacteria proliferate in warm water temperatures, generally above 25 degrees Celsius (Robarts and Zohary, 1987), and are more tolerant of these warmer conditions than their competitors, such as the green algae (Elliott and others, 2006; Jöhnk and others, 2008). Warmer surface waters also augment vertical stratification (Jöhnk and others, 2008), giving the cyanobacteria a unique advantage over eukaryotic algae because many of the cyanobacteria are able to regulate their buoyancy and overcome vertical stratification. Numerous other physiological adaptations will give cyanobacteria an advantage as global climate changes occur (Carey and others, 2012).

Table 2. Common cyanotoxin-producing cyanobacteria that are illustrated in this guide.

<i>Anabaenopsis</i> sp.	microcystins (Lanaras and Cook, 1994) saxitoxins (Ballot and others, 2010b-[genes present])	<i>Microcystis aeruginosa</i>	microcystins (Rinehart and others, 1994)
<i>Aphanizomenon flos-aquae</i>	saxitoxins (Ferreira and others, 2001; Ballot and others, 2010b-[genes present]) cylindrospermopsins (Preussel and others, 2006)	<i>Microcystis viridis</i>	microcystins (Watanabe and others, 1986; Kusumi and others, 1987)
<i>Aphanizomenon gracile</i>	saxitoxins (Ballot and others, 2010b) cylindrospermopsins (Kokociński and others, 2013)	<i>Microcystis wesenbergii</i>	microcystins (Namikoshi and others, 1992; Tanabe and others, 2009)
<i>Chrysochlorum ovalisporum</i>	cylindrospermopsins (Akcaalan and others, 2014)	<i>Nodularia spumigena</i>	nodularins (Carmichael and others, 1988; Sivonen and others, 1989b; Stewart and others, 2012)
<i>Cuspidothrix issatschenkoi</i>	saxitoxins (Ballot and others, 2010b-[genes present]) anatoxin-a (Ballot and others, 2010a)	<i>Nostoc</i> sp.	microcystins (Sivonen and others, 1990, 1992b) nodularins (Gehring and others, 2012)
<i>Cylindrospermopsis raciborskii</i>	cylindrospermopsins (Sinha and others, 2014)	<i>Oscillatoria</i> sp.	anatoxin-a (Aráoz and others, 2005)
<i>Dolichospermum circinale</i>	saxitoxins (D'Agostino and others, 2014) microcystins (Vezie and others, 1998; D'Agostino and others, 2014) anatoxin-a (Sivonen and others, 1989a, 1992a)	<i>Planktothrix agardhii</i>	microcystins (Sivonen and others, 1990)
<i>Dolichospermum crassum</i>	anatoxin-a(s) (Becker and others, 2010)	<i>Plectonema wollei</i>	saxitoxins (Mez and others, 1996)
<i>Dolichospermum lemmermannii</i>	anatoxin-a(s) (Henriksen and others, 1997)	<i>Raphidiopsis mediterranea</i>	anatoxin-a (Namikoshi and others, 2003; Watanabe and others, 2003)
<i>Dolichospermum mendotae</i>	cylindrospermopsins (Akcaalan and others 2014) anatoxin-a (Rapala and others, 1993)	<i>Schizothrix</i> sp.	dermatotoxins (Lippy and Erb, 1976; Mynderse and others, 1977)
<i>Dolichospermum planctonicum</i>	anatoxin-a (Bruno and others, 1994)	<i>Sphaerospermopsis torques-reginae</i>	anatoxin-a(s) (Molica and others, 2005)
<i>Gloeotrichia echinulata</i>	microcystins (Carey and others, 2007)	<i>Sphaerospermopsis aphanizomenoides</i>	microcystins (Bittencourt-Oliveira and others, 2011) cylindrospermopsins (Bittencourt-Oliveira and others, 2011)
<i>Haplosiphon hibernicus</i>	microcystins (Prinsep and others, 1992)	<i>Woronichinia naegeliana</i>	microcystins [perhaps] (Faassen and Lürling 2013)

Table 3. Cyanobacteria synonyms (see table 2).

Currently accepted genus/species	Synonym	Reference
<i>Chrysochlorum ovalisporum</i>	<i>Aphanizomenon ovalisporum</i>	Zapomelová and others, 2012
<i>Cuspidothrix issatschenkoi</i>	<i>Anabaena issatschenkoi</i> <i>Aphanizomenon issatschenkoi</i>	Rajaniemi and others, 2005
<i>Dolichospermum</i> (many species)	<i>Anabaena</i> (most planktonic forms)	Wacklin and others, 2009
<i>Planktothrix agardhii</i> (and many other species)	<i>Oscillatoria agardhii</i>	Anagnostidis and Komárek, 1988
<i>Sphaerospermopsis aphanizomenoides</i>	<i>Aphanizomenon aphanizomenoides</i>	Zapomelová and others, 2010
<i>Sphaerospermopsis torques-reginae</i>	<i>Anabaena torques-reginae</i>	Werner and others, 2012
<i>Woronichinia</i>	<i>Coelosphaerium</i>	Komárek and Hindák, 1988 (for many species)

4 Field and Laboratory Guide to Freshwater Cyanobacteria Harmful Algal Blooms for Native American and Alaska Native Communities

In an effort to help Native American and Alaska Native communities develop an awareness of what HABs look like in the field and distinguish HABs from a non-toxic bloom, the U.S. Geological Survey has developed this guide to illustrate the appearance of both typical algal and cyanobacteria blooms. Many of the organisms require the use of a microscope to correctly determine the type of bloom that is present. Included in this guide are microscopic images that illustrate many of the most common HABs and others that are known to be a nuisance or produce toxins that are not obvious surface bloom-forming organisms. Graham and others (2008) provide guidelines for the design and sampling for cyanotoxins in lakes and reservoirs.

Field Images

When approaching a water bloom, caution and safety procedures should be used to prevent direct contact with the bloom because some cyanotoxins can be absorbed through the skin. These field photographs illustrate the color, “texture,” and general appearance of water blooms, both harmful and non-toxic, including nuisance blooms of green algae, certain floating plants, and other known blooms that may be encountered. Recognizing a cyanobacterial bloom in a waterbody and distinguishing it from other blooms that may or may not be harmful is the first step in becoming aware of the potential risk in surface water blooms. Figure 1 illustrates the common coloration of a blue-green algae bloom, or cyanobacterium; many variations of blue-green algae exist as illustrated in figures 2–16. Coloration is not an indicator of the genus of the organism(s), although repeated sampling and microscopic confirmation from the same waterbody should increase the likelihood of correctly identifying the key organisms seen when in the field.



Figure 1. Cyanobacteria, *Dolichospermum lemmermannii*. (Photograph: Ann St. Amand)

Many cyanobacteria float and often accumulate along the shoreline as illustrated in figures 2–7. These accumulations often appear clumped or scummed (figs. 3–5). Cells stranded on the shoreline often leak their pigments. Phycocyanin is a blue pigment and can turn a waterbody or shoreline turquoise (fig. 6) or chartreuse (fig. 7). Blooms can also be evenly dispersed in the water (figs. 8–10) or evenly dispersed as clumps (fig. 11). Some cyanobacteria appear brown in color due to the red pigment phycoerythrin and its combination with other pigments (figs. 12–15). Red to pink blooms are another phenomenon due to phycoerythrin (fig. 16).



Figure 2. Cyanobacteria, *Microcystis aeruginosa*. (Photograph: Ann St. Amand)



Figure 3. Cyanobacteria, *Microcystis aeruginosa*. (Photograph: Ann St. Amand)



Figure 4. Cyanobacteria, *Dolichospermum lemmermannii*. (Photograph: Ann St. Amand)



Figure 5. Cyanobacteria, *Dolichospermum lemmermannii*. (Photograph: Ann St. Amand)



Figure 6. Cyanobacteria, *Dolichospermum mendotae*. (Photograph: Ann St. Amand)



Figure 7. Cyanobacteria, *Gloeotrichia echinulata*. (Photograph: Midge Eliassen)



Figure 8. Cyanobacteria, *Microcystis viridis*. (Photograph: Ann St. Amand)



Figure 9. Cyanobacteria, *Dolichospermum lemmermannii*. (Photograph: Ann St. Amand)



Figure 10. Cyanobacteria, *Aphanizomenon flos-aquae*.
(Photograph: Ann St. Amand)



Figure 11. Cyanobacteria, *Aphanizomenon flos-aquae*. (Photograph: Jacob Kann)



Figure 12. Cyanobacteria, *Nodularia spumigena*.
(Photograph: Wayne Wurtsbaugh)



Figure 13. Cyanobacteria, *Plectonema wollei*.
(Photograph: Ken Wagner)



Figure 14. Cyanobacteria, *Woronichinia naegeliana*. (Photograph: Ann St. Amand)



Figure 15. Cyanobacteria, *Cylindrospermopsis raciborskii*. (Photograph: Ann St. Amand)



Figure 16. Cyanobacteria, *Planktothrix agardhii/prolifera*. (Photograph: Richard Holmes)

Other types of HABs and floating plants can be distinguished from cyanobacteria blooms by color and texture. Green algae commonly are encountered and typically are grass-green in color (figs. 17–19). Many types of green algae consist of long, stringy filaments (fig. 20) that feel either slippery or like cotton. Some floating aquatic plants may look like algae (fig. 21), but close examination shows that individual plants are present, such as watermeal (fig. 22) and duckweed. One group of algae, the charophytes, are macroscopic and typically are rooted but can get dislodged and float in a waterbody (fig. 23). Although they may look like vascular plants, a closer look shows their characteristic features (fig. 24). Aquatic plants are distinct from algae (figs. 25–26). Another group of algae, the euglenoids (Euglenophyta), often form surface blooms—some are green in color (fig. 27), and others are red (fig. 28). *Azolla*, a small floating aquatic fern also forms a red surface mat (fig. 29). Occasionally, pollen from plants can form a thick accumulation, typically with a distinct yellowish color (fig. 30). Dinoflagellate (Pyrrophyta) blooms, although typically found in saline waters, occasionally bloom in freshwater and typically have a tan-brown and sometimes blackish appearance (fig. 31).



Figure 17. Green algae, *Mougeotia* sp. (Photograph: Steve Heiskary, Minnesota Pollution Control Agency)



Figure 18. Green algae, *Spirogyra* sp. (Photograph: Ken Wagner)



Figure 19. Green algae, *Cladophora* sp. (Photograph: Ann St. Amand)



Figure 20. Green algae, *Mougeotia* sp. (Photograph: Steve Heiskary, Minnesota Pollution Control Agency)



Figure 21. Duckweed: *Wolffia columbiana* (also called watermeal). (Photograph: Ann St. Amand)

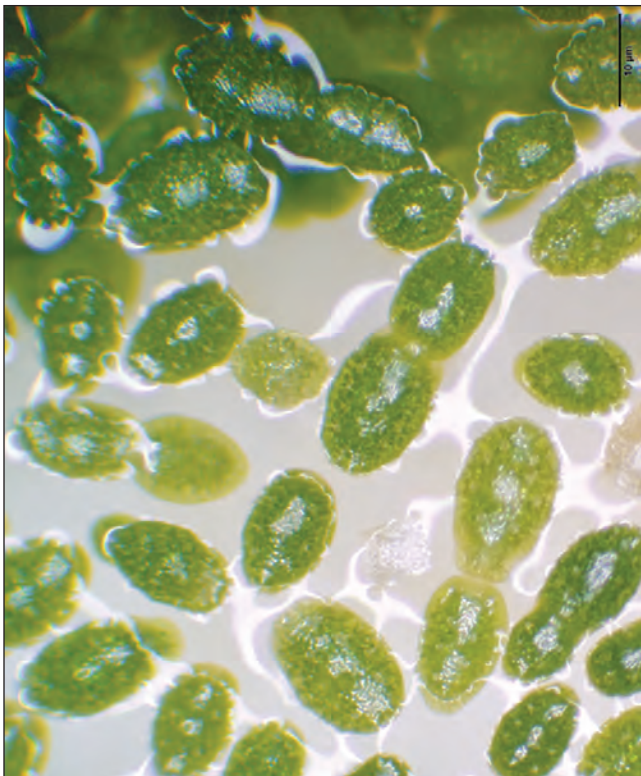


Figure 22. Duckweed: Left, *Wolffia columbiana*; Right, *Lemna minor*. (Photographs: Barry H. Rosen)



Figure 23. Charophyta, *Chara* sp. (Photograph: Barry H. Rosen)



Figure 24. Charophyta, *Chara* sp. (Photograph: Ann St. Amand)



Figure 25. Rooted macrophytes. (Photograph: Ann St. Amand)



Figure 26. Rooted macrophytes. (Photograph: Ann St. Amand)



Figure 27. Euglenophyta, *Euglena* sp. (Photograph: Ann St. Amand)



Figure 28. Euglenophyta, *Euglena sanguinea*, a known toxin producer. (Photograph: Barry H. Rosen)

Figure 29. Water fern, *Azolla* sp. (Photograph: Bob Kirschner, Chicago Botanic Garden, Illinois)



Figure 30. Pine pollen. (Photograph: Linda Green, University of Rhode Island Watershed Watch)



Figure 31. Pyrrhophyta, *Durinskia dybowskii*. (Photograph: Brian Magott, Oklahoma Department of Environmental Quality)

Microscope Images

Field collections of potentially HABs need followup examination with a microscope to determine that the bloom is in fact cyanobacteria and if it is or is not a known toxin producer. The following collection of images include some of the same organisms in the field image section of this guide, as well as additional organisms that are of importance because of the toxins they produce. In addition, some of the harmless organisms are illustrated so the user can distinguish between harmful and non-toxic organisms. Various laboratories are located around the country that specialize in the identification of organisms and perform toxin analyses. Each laboratory has a preferred collection methodology and preservation techniques that should be followed for the most accurate results.

Cyanobacteria Microscopic Identification Characteristics

Recognizing a cyanobacterium under the microscope involves observing characteristics associated with that morphology. Proper identification often relies on a species dichotomous key (Komárek and Anagnostidis, 2001, 2005; Komárek, 2013) to determine what the organism might be. Often times the shape and dimensions of the cells (length and width) are required for resolving a specimen to the species level.

Filament – a chain or stack of cells

- Some of these filaments consist of cells stacked like a roll of coins, with the individual cells being a single coin (fig. 32, image on the left).
- Some are round cells attached end to end like a string of pearls (fig. 32, image on the right).
- Some filaments are straight, some are coiled (fig. 32, the two images on the left and on the right, respectively).
- Some species make a resting spore, an *akinetete* (fig. 32, label A) along the length or at the end of a filament.
- Some species have *heterocytes*, specialized cells in the filament that fix atmospheric nitrogen (previously termed heterocysts) (fig. 32, label H), along the length or at the end of a filament.

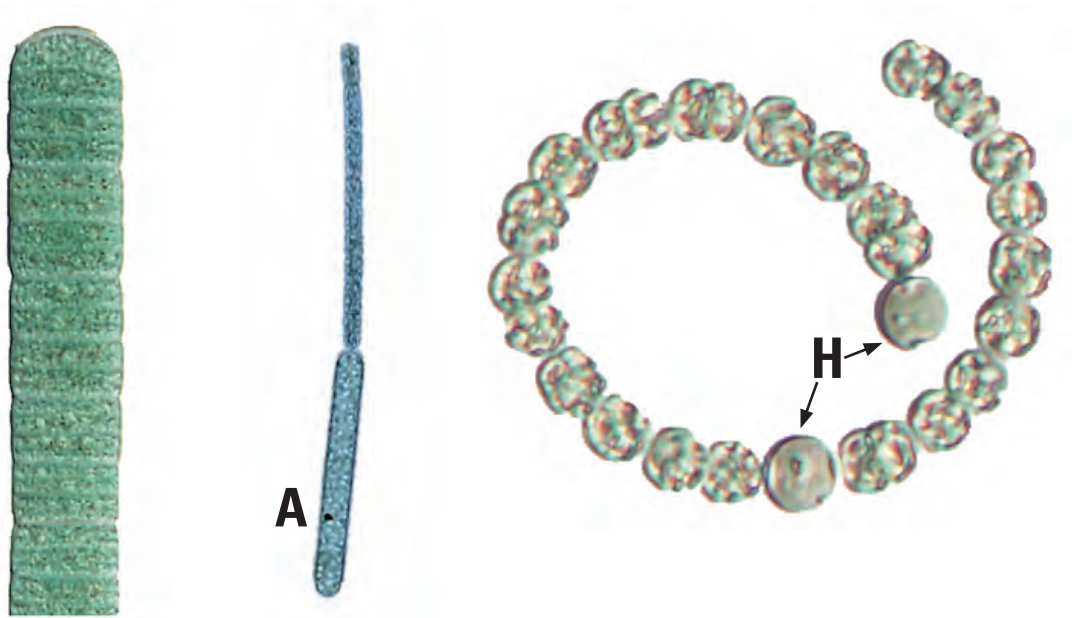


Figure 32. Morphology of cyanobacteria filaments. Straight and coiled forms, as well as features important in distinguishing the grouping of organisms. (Photographs: Left and right, Barry H. Rosen; Center, Ann St. Amand)

Colony – a collection of cells, most with a distinct or irregular pattern

- Many species are embedded in a common mucilaginous matrix that may or not be visible under the microscope (fig. 33).
- Some species have a set number of cells per colony, others are more heterogeneous.
- Some colonies are made up of filaments (fig. 33, bottom image).

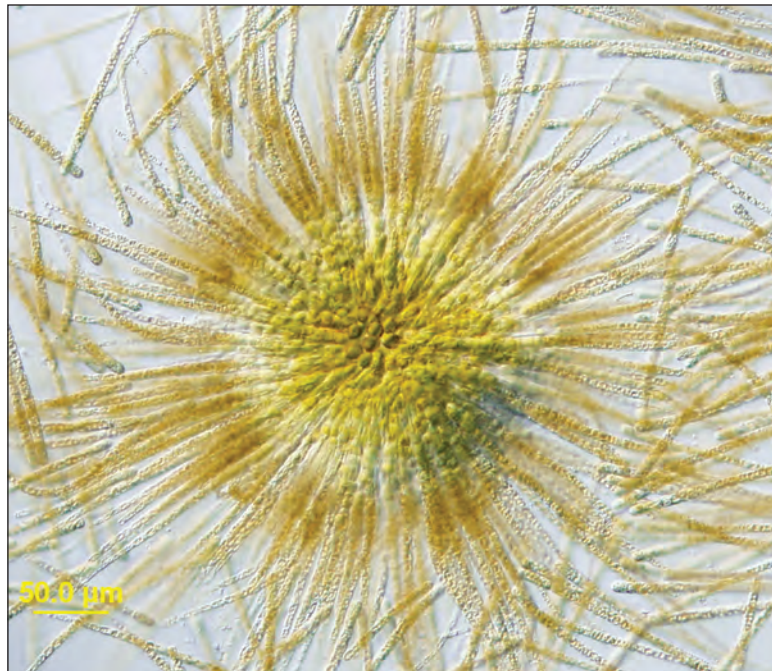
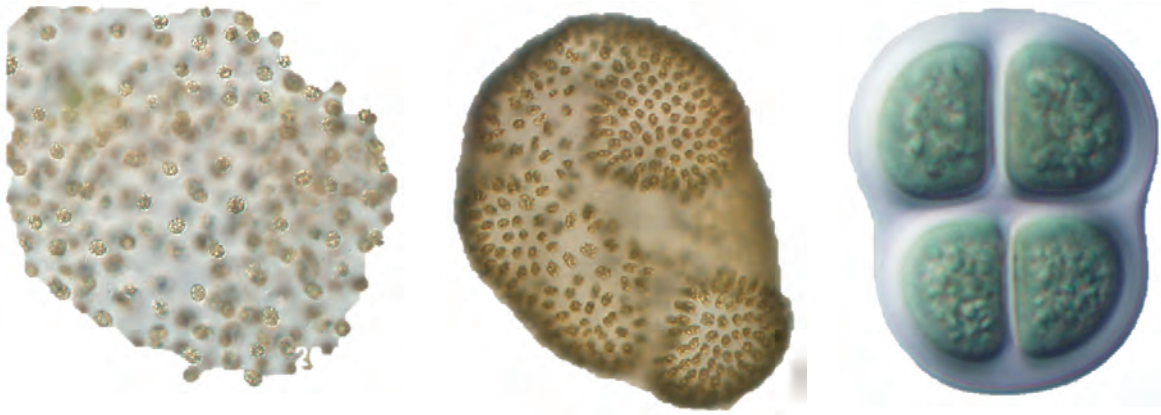


Figure 33. Morphology of cyanobacteria colonies. Round to oval cells or filaments embedded in a mucilaginous matrix; features important in distinguishing the grouping of organisms. (Photographs from Rosen and others, 2010)

Cyanobacteria

The following images are grouped alphabetically by genus and are based on the latest naming conventions at the time of publication. The recent use of genetics has led to the renaming of many organisms and the traditional genera; where appropriate, the previous name is included in parentheses.

Anabaenopsis

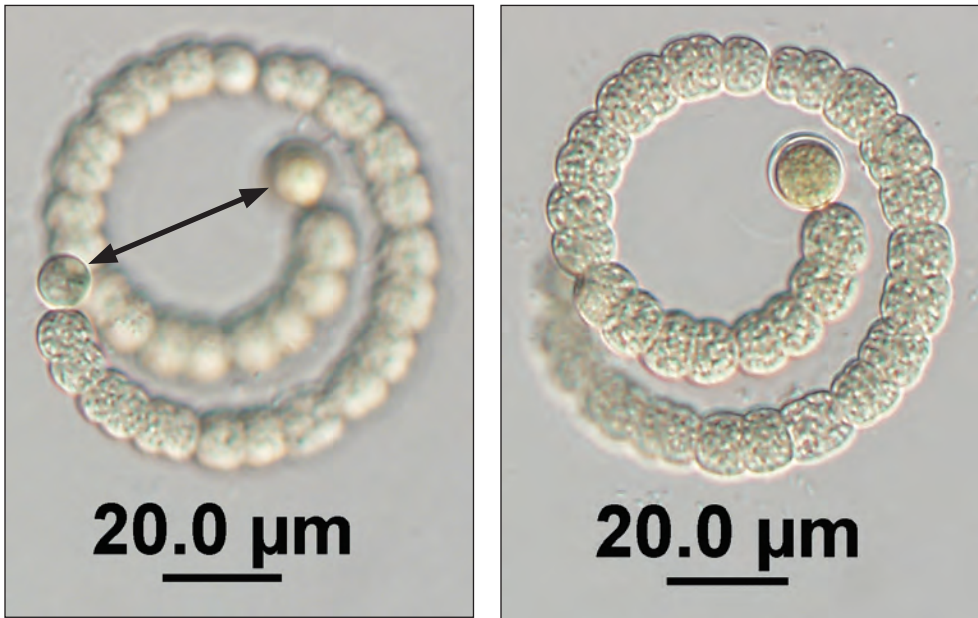


Figure 34. *Anabaenopsis arnoldii*. Two focal planes of the same filament. Note the heterocyst at both ends of this curled filament in the image on the left (arrow). (Photographs: Barry H. Rosen)

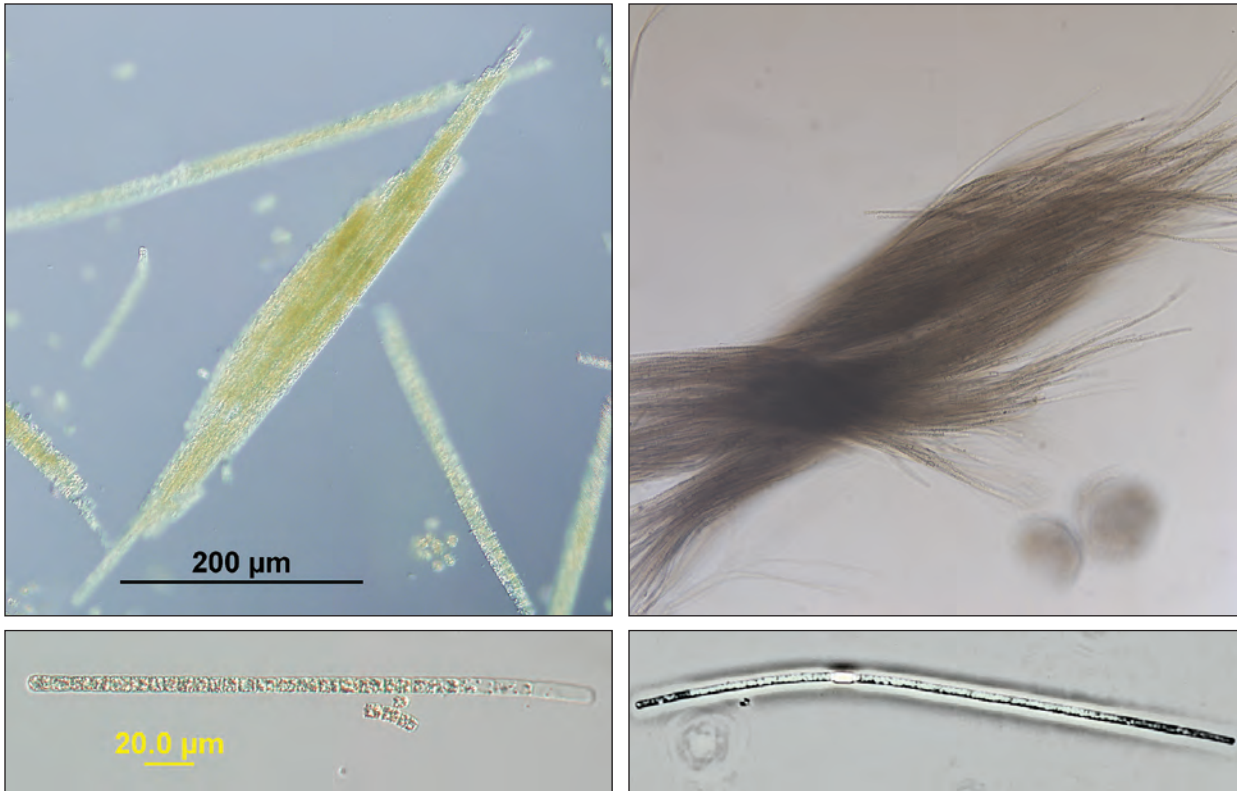
*Aphanizomenon**Aphanizomenon flos-aquae*

Figure 35. *Aphanizomenon flos-aquae*. Filaments clustered in bundles (upper) and individual filaments (lower). (Photographs: Left, Barry H. Rosen; Right, Ann St. Amand)

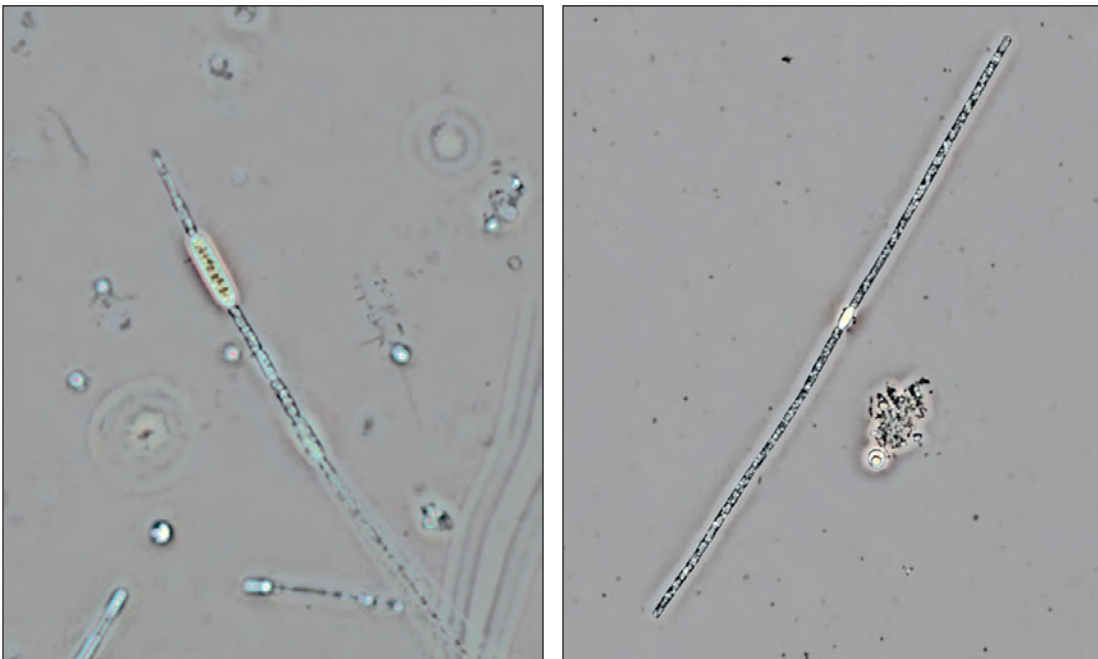
Aphanizomenon gracile

Figure 36. *Aphanizomenon gracile*. Filament showing akinetes (left) and a heterocyte (right). (Photographs: Ann St. Amand)

Chrysoosporum (Anabaena)

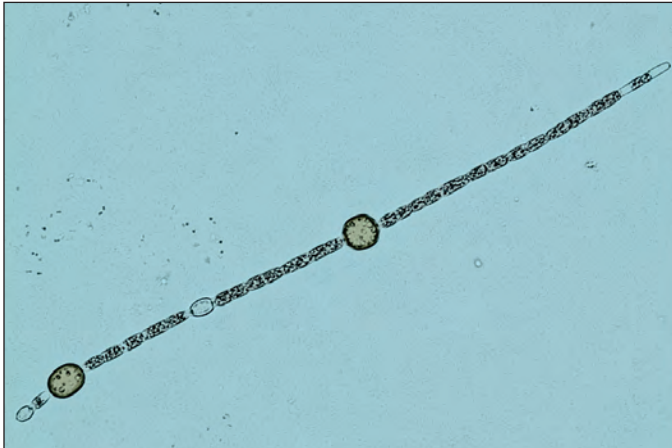


Figure 37. *Chrysoosporum ovalisporum*. Filament showing akinetes and heterocytes. (Photograph: Ann St. Amand)

Cuspidothrix (Aphanizomenon)

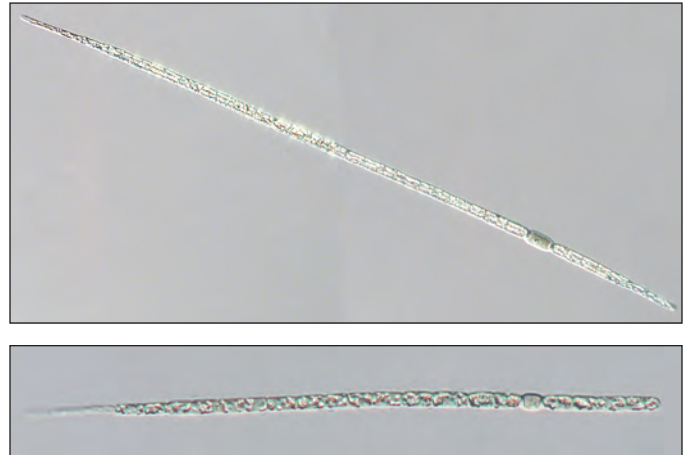


Figure 38. *Cuspidothrix issatschenkoi*. Filament showing a heterocyte. (Photographs: Barry H. Rosen)

Cylindrospermopsis

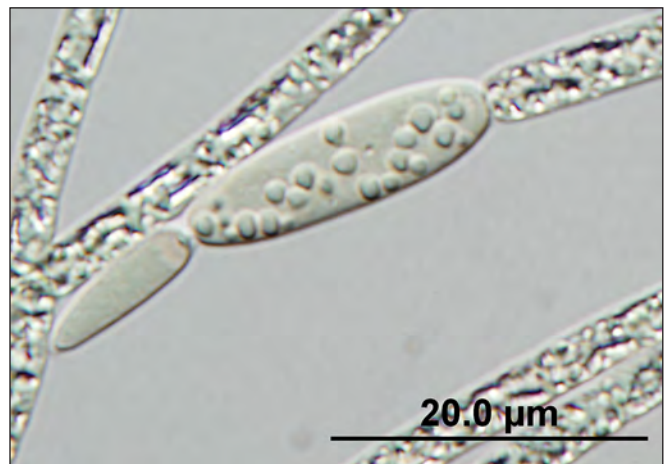
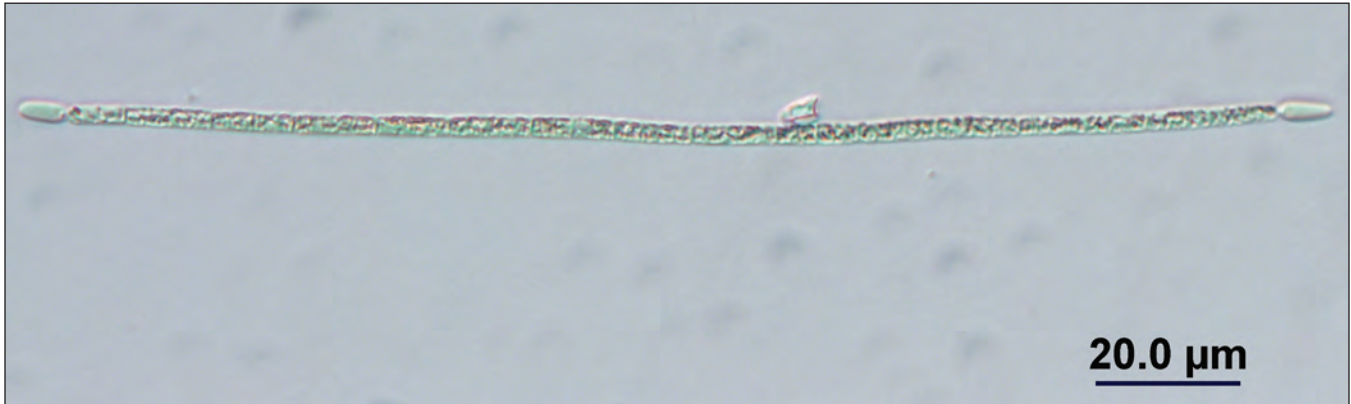


Figure 39. *Cylindrospermopsis raciborskii*. Filament showing straight and curled morphs. Heterocytes are found at the end of the filaments; akinete found adjacent to heterocyte (lower left). (Photographs: Barry H. Rosen)

*Dolichospermum (Anabaena)**Dolichospermum circinale*

Figure 40. *Dolichospermum circinale*. Spherical cells in the curved filaments. Heterocysts are along the length of the filaments and are about the same size as the vegetative cells. (Photograph: Ann St. Amand)

Dolichospermum crassum



Figure 41. *Dolichospermum crassum*. Spherical cells in the coiled filament. Heterocysts are along the length of the filaments and are about the same size as the vegetative cells. (Photograph: Ann St. Amand)

Dolichospermum lemmermannii

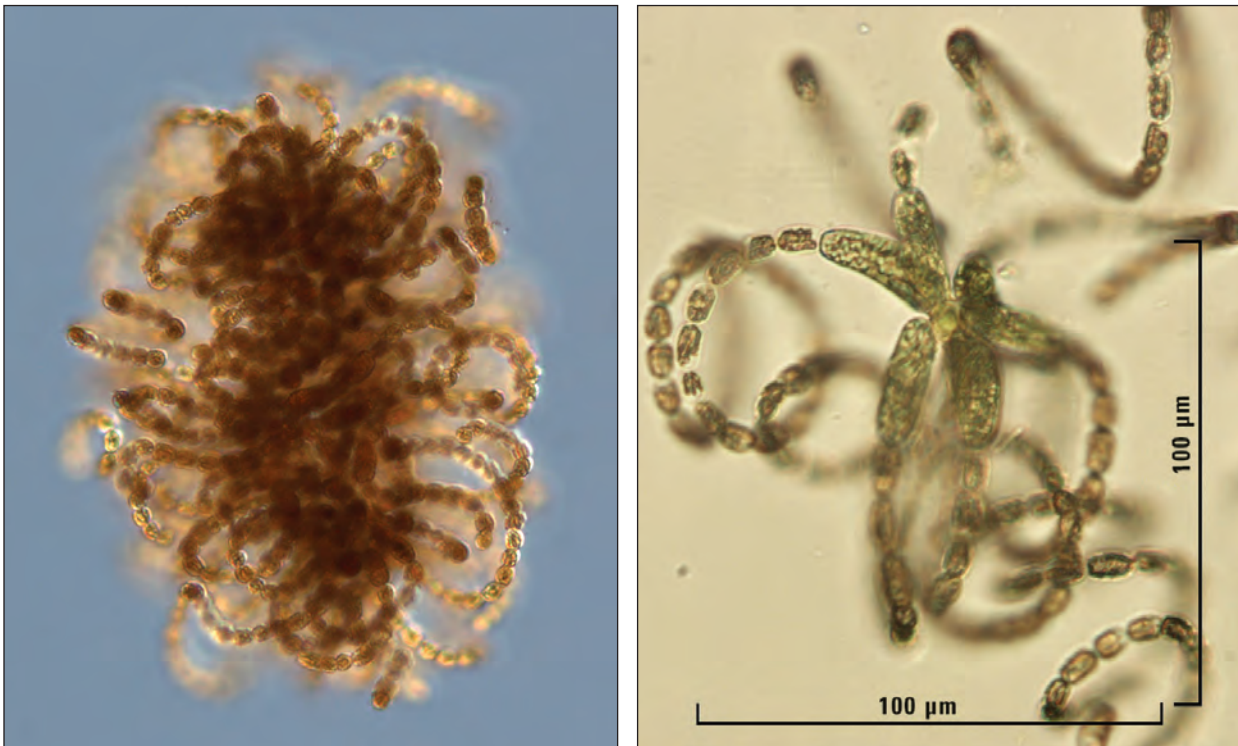


Figure 42. *Dolichospermum lemmermannii*. Coiled filaments connecting to form a colony. Akinetes enlarged, slightly bent (right image). (Photographs: Left, Ann St. Amand; Right, Margaret K. Spoo-Chupka)

Dolichospermum mendotae

Figure 43. *Dolichospermum mendotae*. Irregularly coiled filaments with heterocytes and elongated akinetes. (Photograph: Andrew Chapman)

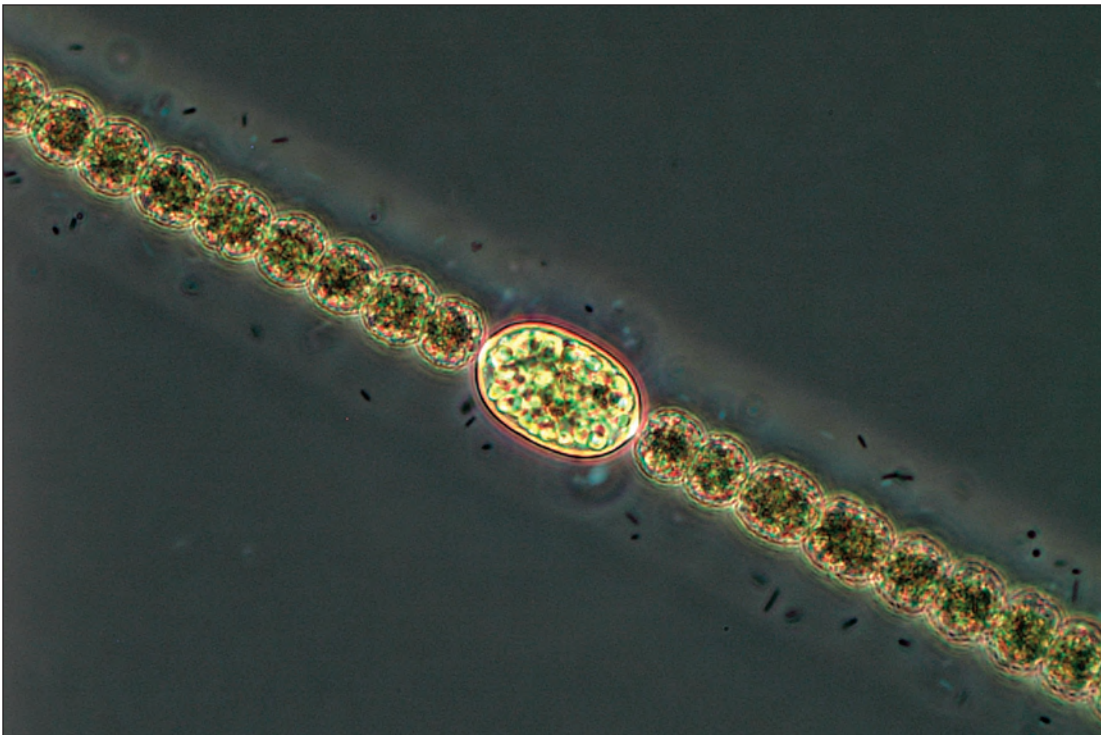
Dolichospermum planctonicum

Figure 44. *Dolichospermum planctonicum*. Round cells in a straight filament; enlarged akinetes. (Photograph: Ann St. Amand)

Gloeotrichia

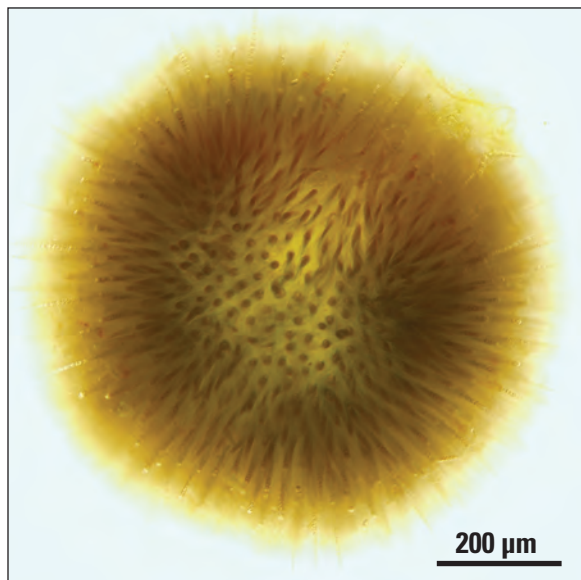
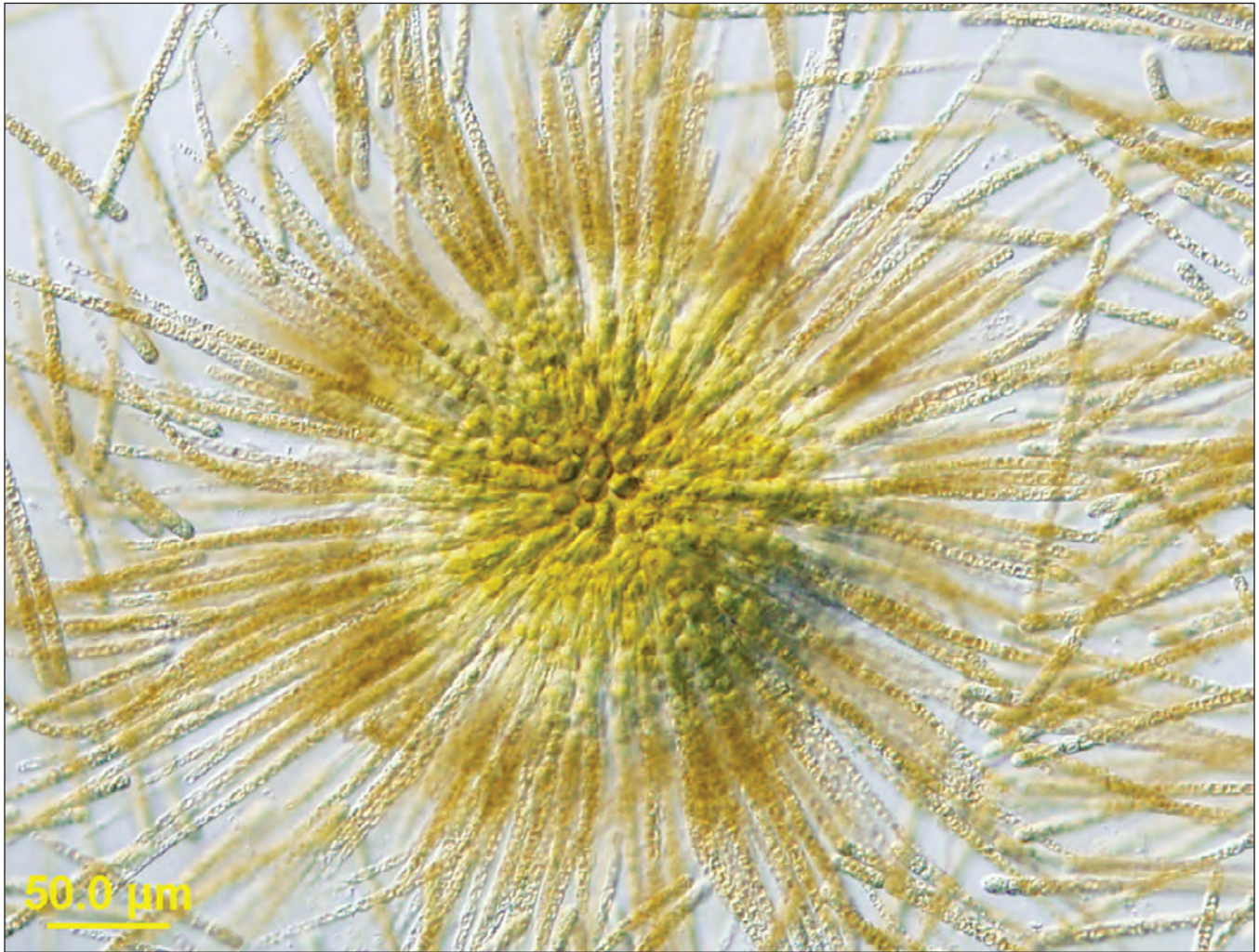


Figure 45. *Gloeotrichia echinulata*. Filaments tapered, forming a colony, with an overall appearance of a pin cushion (lower left image). The base of each filament terminates in a heterocyst (lower right image). (Photographs: Barry H. Rosen)

Haplosiphon

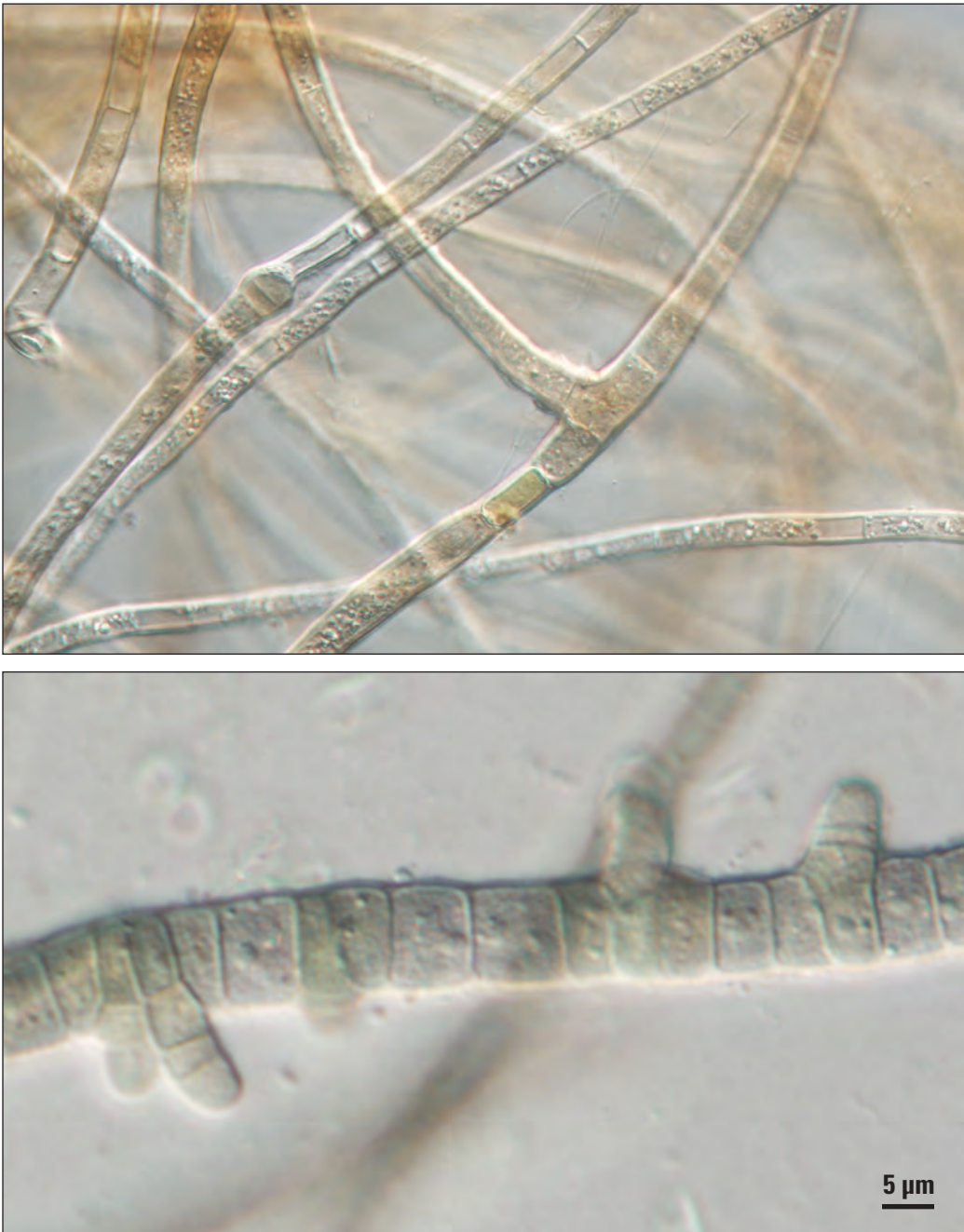


Figure 46. *Haplosiphon hibernicus*. Filament has true branching and rectangular heterocytes. (Photographs: Barry H. Rosen)

Microcystis

Microcystis aeruginosa

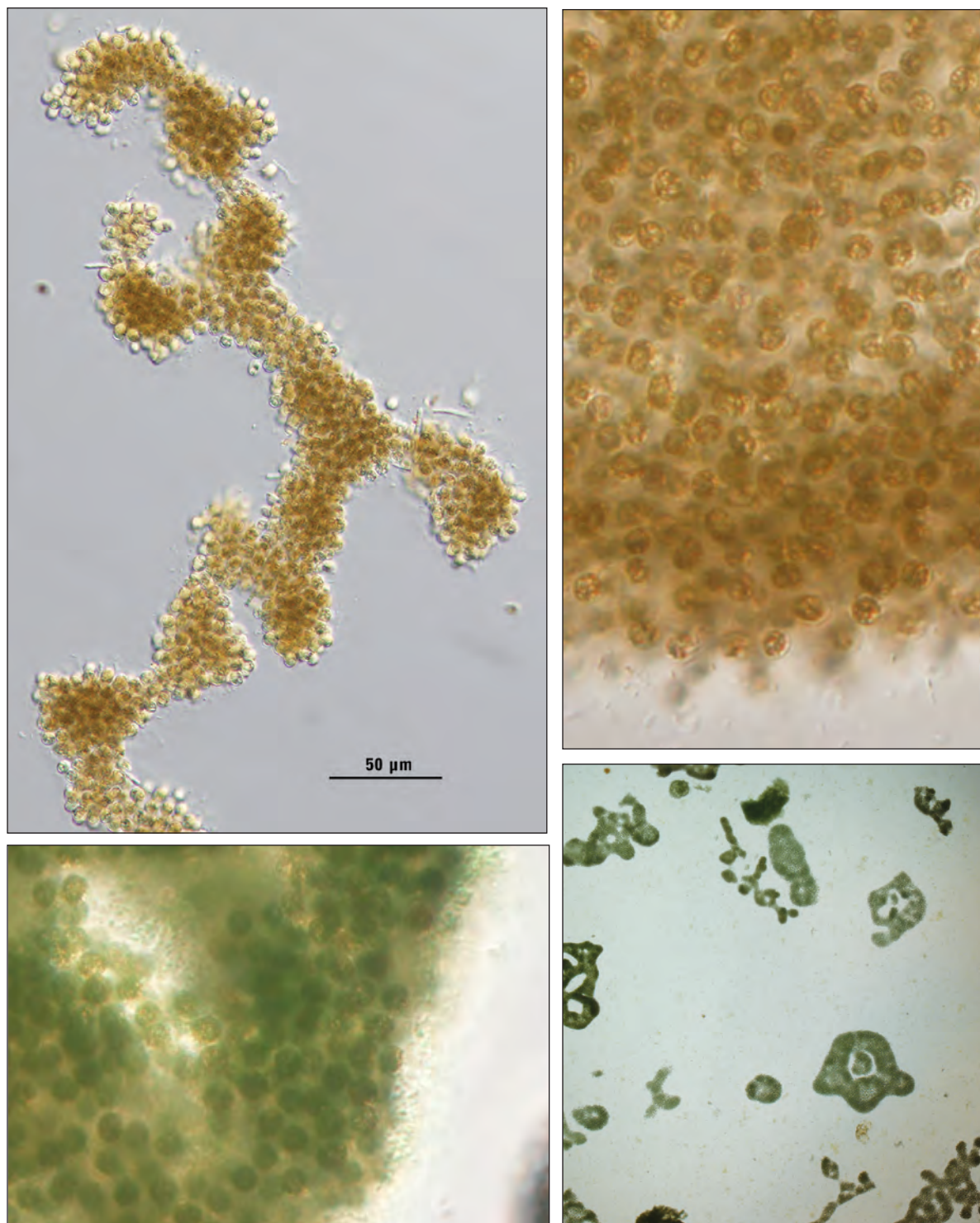


Figure 47. *Microcystis aeruginosa*. Round to oval cells embedding a mucilaginous matrix. Cell color varies from brown to various shades of green and blue-green. (Photographs: Barry H. Rosen)

Microcystis viridis

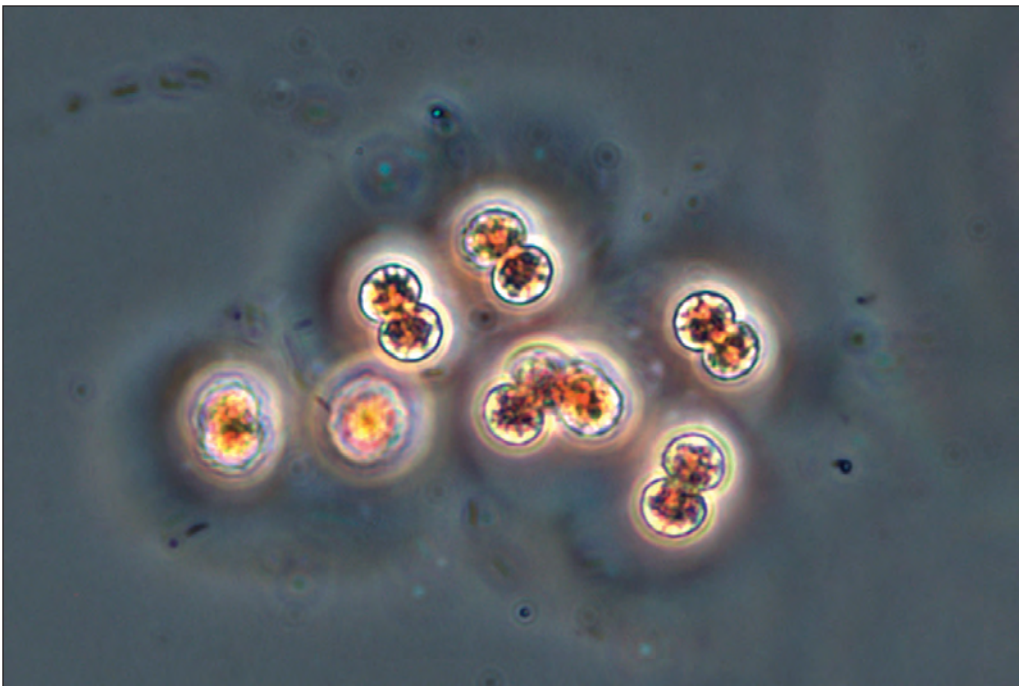
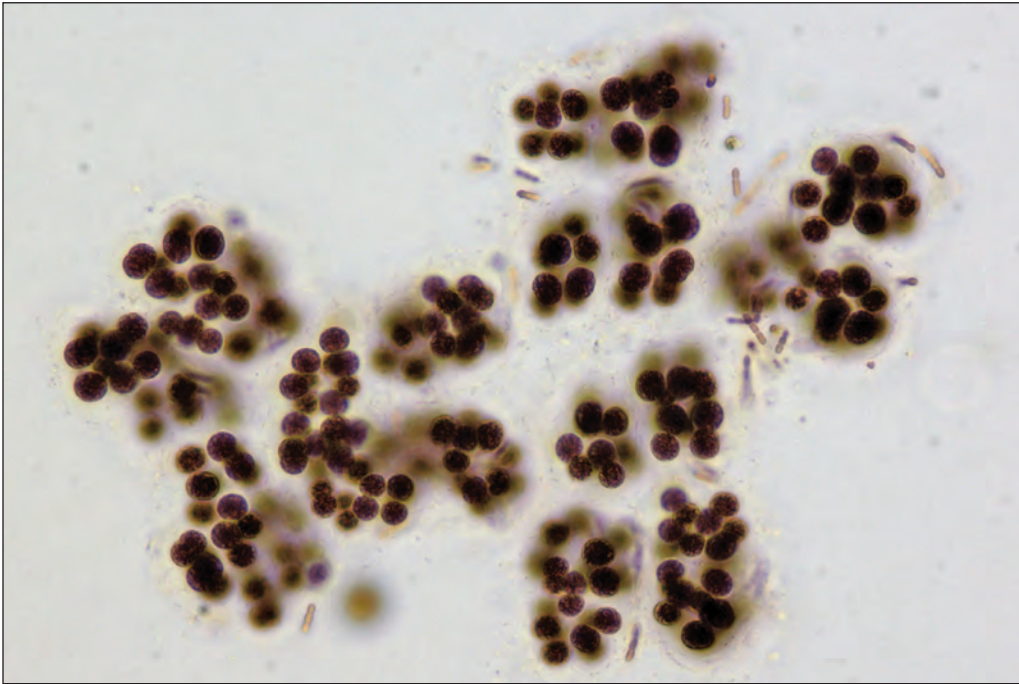


Figure 48. *Microcystis viridis*. Paired cells round to oval cells in “packets” embedded in a mucilaginous matrix. (Photographs: Ann St. Amand)

Microcystis wesenbergii

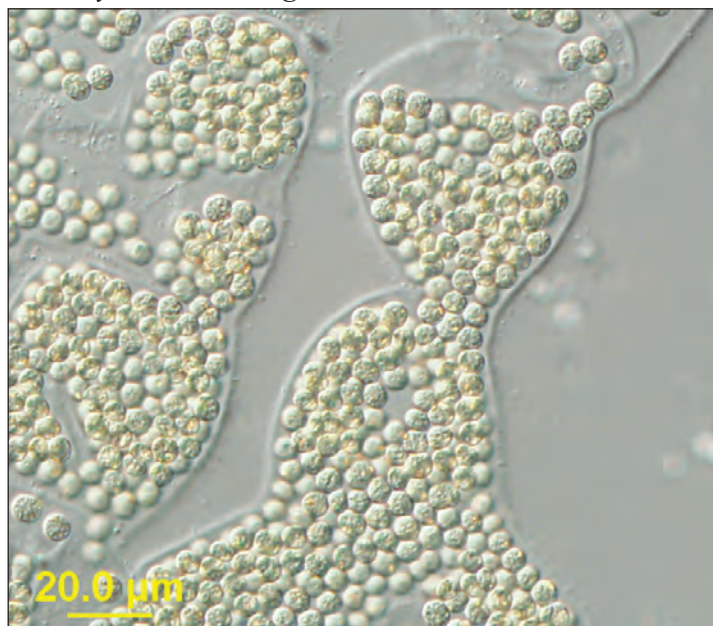


Figure 49. *Microcystis wesenbergii*. Round cells dispersed in a robust, well defined common mucilaginous envelope; individual. (Photographs: Barry H. Rosen)

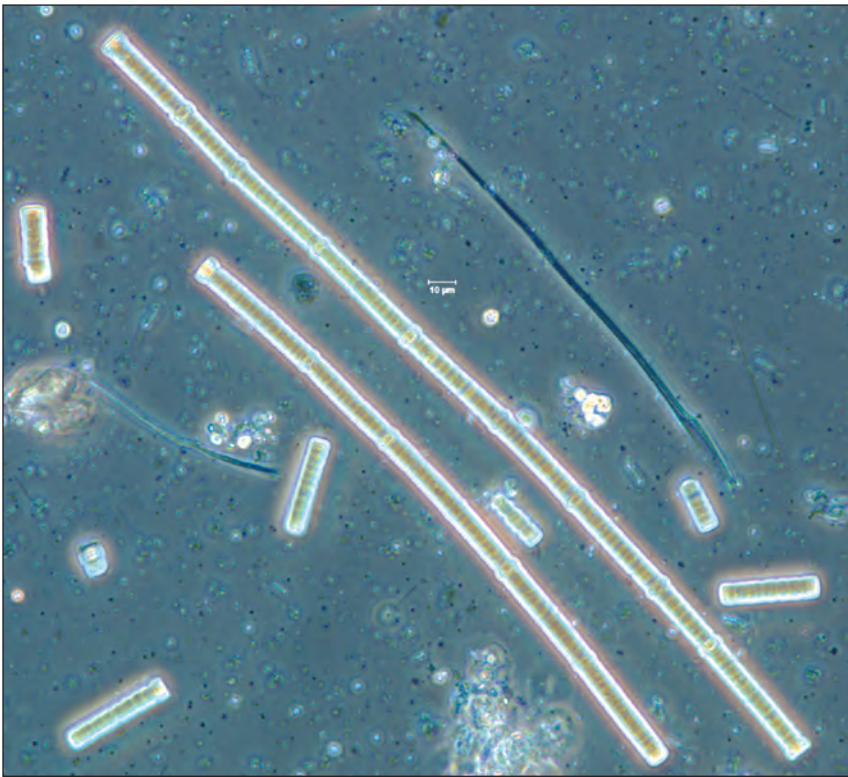
*Nodularia**Nodularia spumigena*

Figure 50. *Nodularia spumigena*. Cells arranged in filaments, heterocytes common and at somewhat regular intervals, with distinct constrictions at the junction between barrel-shaped cells. (Photograph: Ann St. Amand)

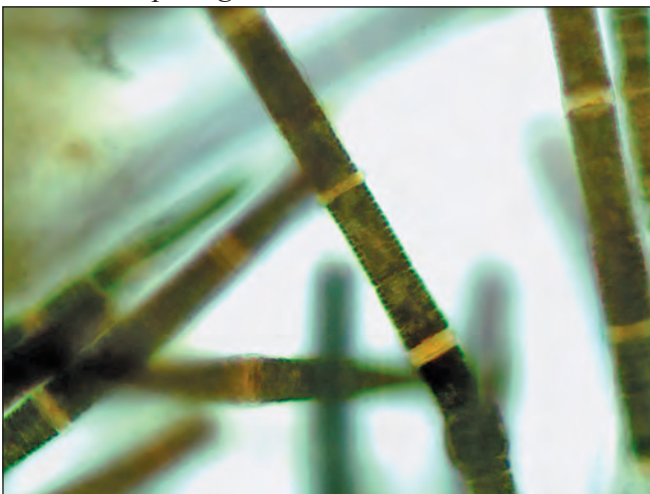
Nodularia spumigena

Figure 51. *Nodularia spumigena*. Cells arranged in filaments, heterocytes common, with distinct constrictions at the junction between cells. (Photograph: Ann St. Amand)

Nostoc sp.

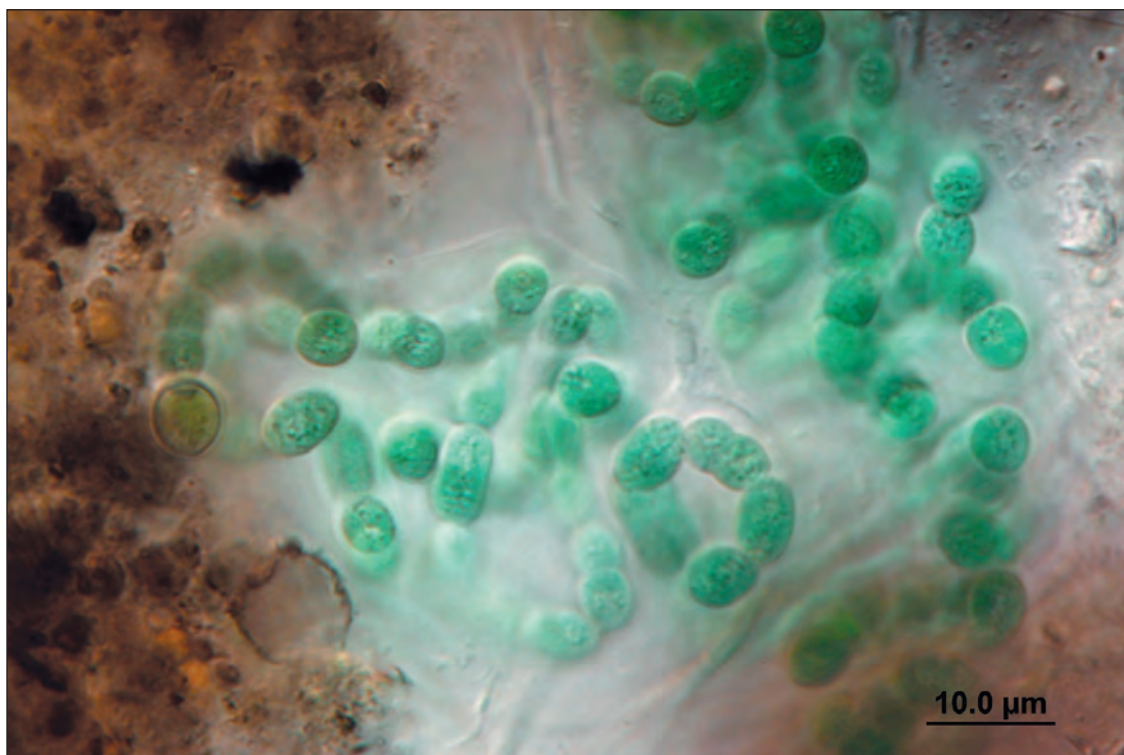
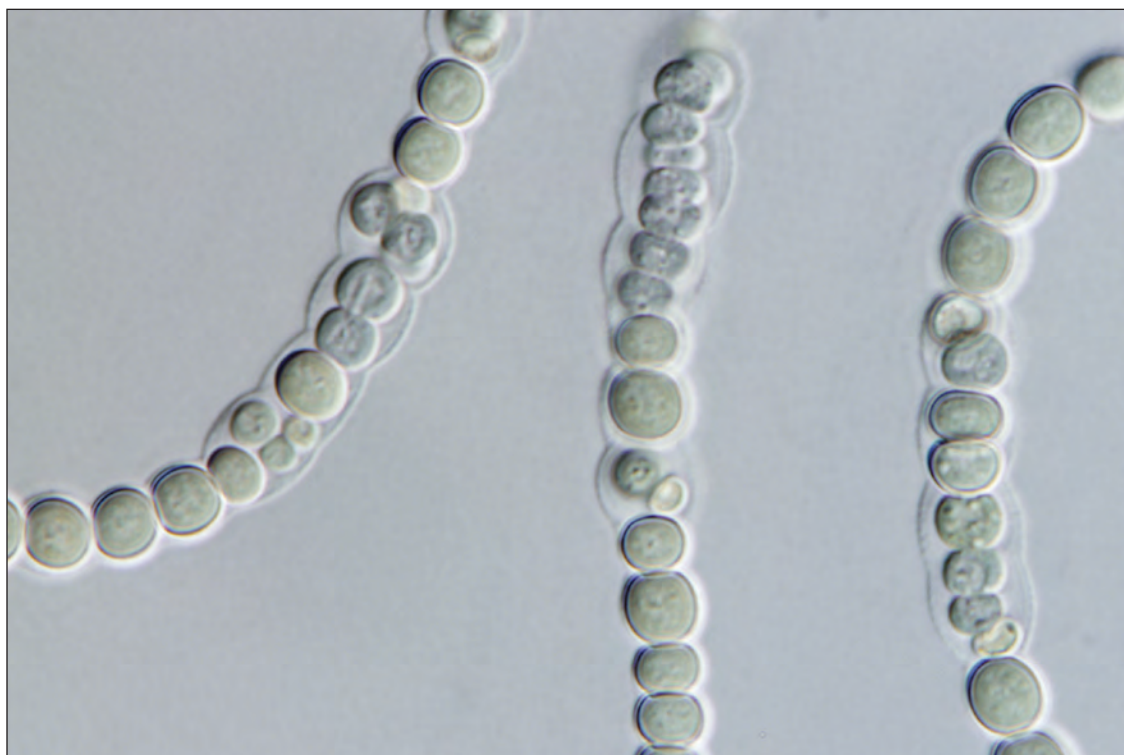


Figure 52. *Nostoc* sp. Filaments have round cells (elongated before cell division). Filaments embedded both individual and a common mucilaginous matrix. (Photographs: Barry H. Rosen)

Oscillatoria sp.

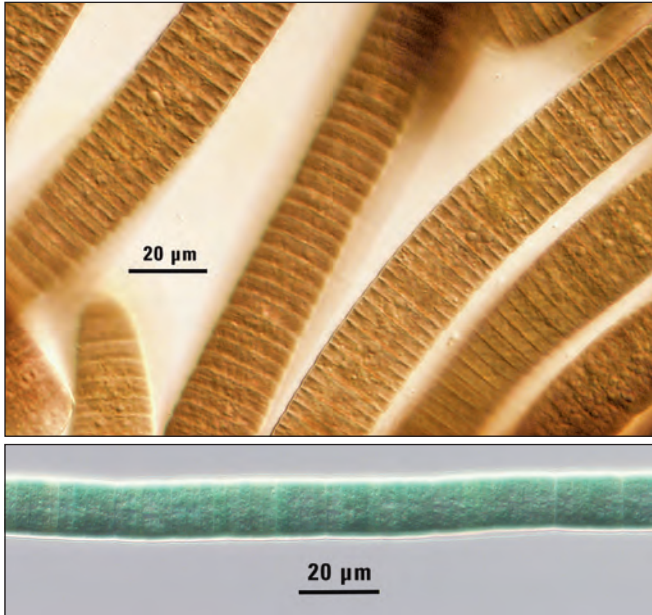


Figure 53. *Oscillatoria* sp. Cells in filaments, shorter than wide. Color varies from green, blue-green, to dark brown. Upper photograph is *O. limosa*. (Photographs: Barry H. Rosen)

Planktothrix (*Oscillatoria*)

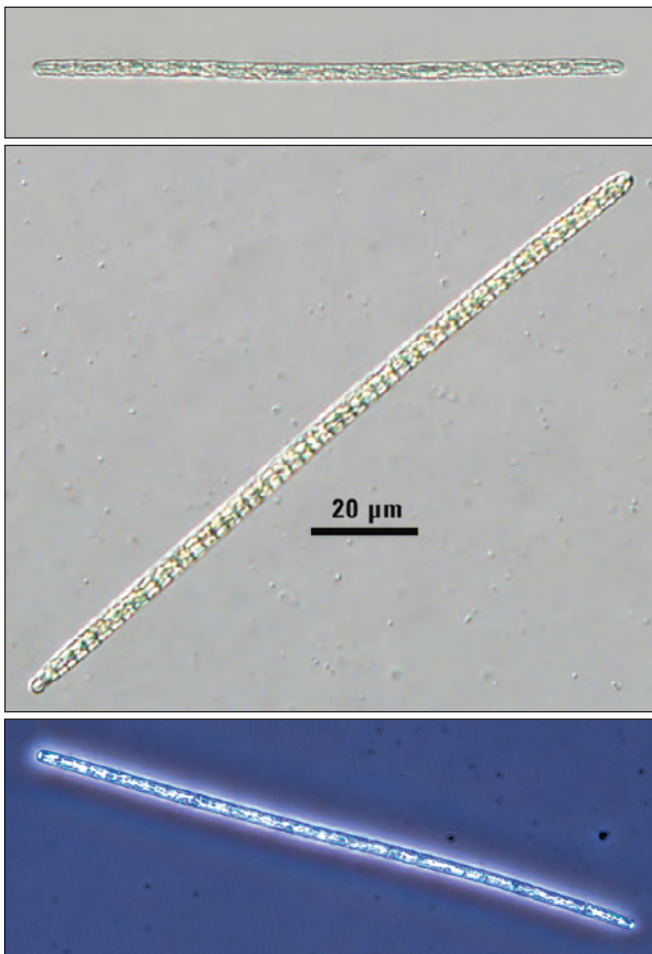


Figure 54. *Planktothrix agardhii*. Filaments composed of cells that range from longer than wide to slightly shorter than wide. Lightly pigmented. Can have both terminal cells tapered; often one end of a filament is rounded and the other end tapered. (Photographs: Upper and middle, Barry H. Rosen; Bottom, Ann St. Amand)

Plectonema (Lyngbya)

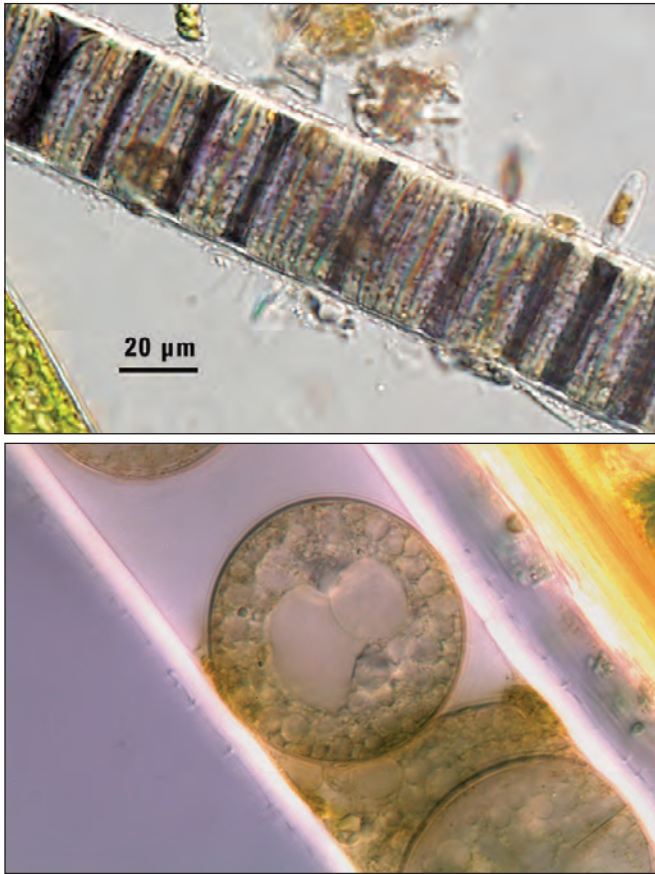


Figure 55. *Plectonema wollei*. Cells in filaments with sheaths. Large diameter filaments, with cells stacked like coins in the filaments. Bottom image illustrates a cell turned on its side. Most dark brown in color. (Photographs: Top, Barry H. Rosen; Bottom, Ann St. Amand)

Raphidiopsis

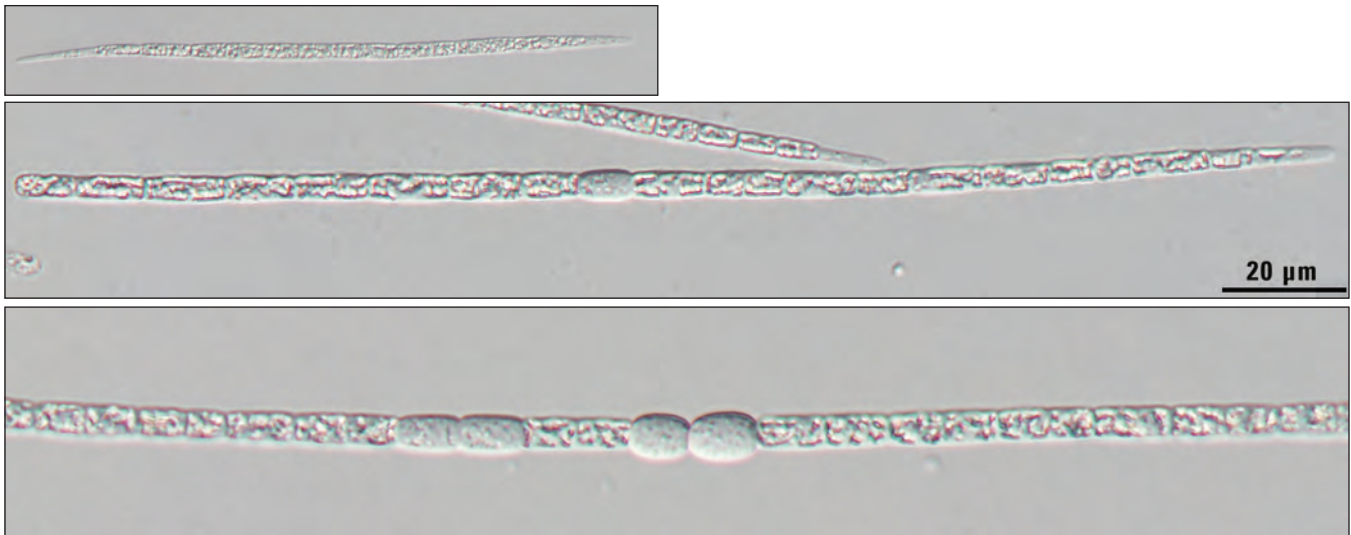


Figure 56. *Raphidiopsis mediterranea*. This genus is characterized by curving filaments and the presence of akinetes but not heterocytes. This genus may eventually be merged with *Cylindrospermopsis*. (Photographs: Barry H. Rosen)

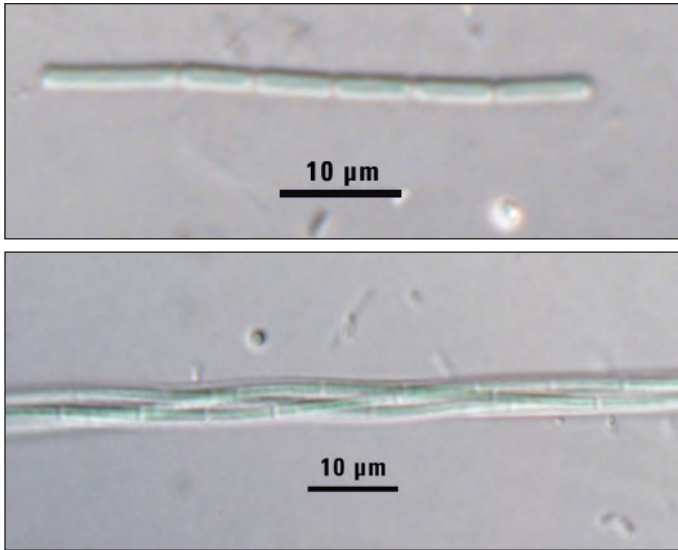
Schizothrix sp.

Figure 57. *Schizothrix* sp. Thin, slender filaments with cells longer than wide, within a sheath and typically multiple filaments intertwined. (Photographs: Barry H. Rosen)

Sphaerospermopsis (*Anabaena*)

Figure 58. *Sphaerospermopsis torques-reginae*. Filaments composed of round cells and coiled, with some regularity. Heterocyst with two adjacent, spherical akinetes (top image), often on both sides of the heterocyst. (Photographs: Barry H. Rosen)



Figure 59. *Sphaerospermopsis aphanizomenoides*. Filaments composed of rounded cells but not coiled, akinetes adjacent to both sides of heterocytes (not in this image). (Photograph: Ann St. Amand)

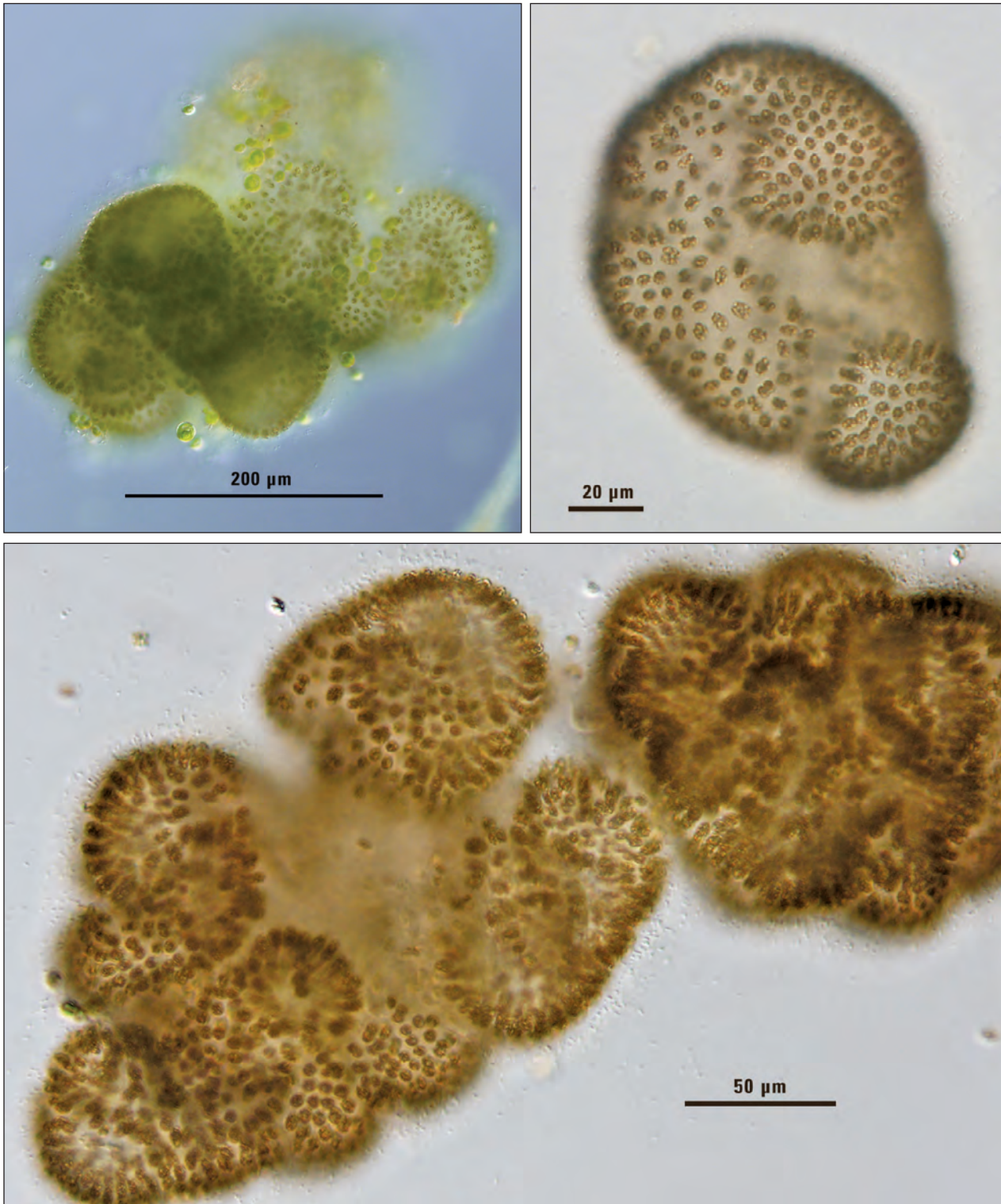
Woronichinia (Coelospherium)

Figure 60. *Woronichinia naegeliana*. Cells, round to oval, in colonies embedded on the outer edge of the mucilaginous matrix (not throughout like *Microcystis*). (Photographs: Barry H. Rosen)

Other Organisms Viewed Under the Microscope

The remaining collection of images include some of the same organisms in the field image section of this guide, as well as additional organisms that are of importance because they can cause issues in a waterbody or may be an indicator of a water quality concern. In addition, some of the harmless organisms are illustrated so the user can distinguish between harmful and harmless organisms.

Euglenophyta (Euglenoids)

Euglena

This organism can form a surface scum on waterbodies that have been enriched with nutrients that look almost oily. One species, *Euglena sanguinea*, is known to produce the alkaloid fish and mammal toxin, euglenophycin (Zimba and others, 2010).

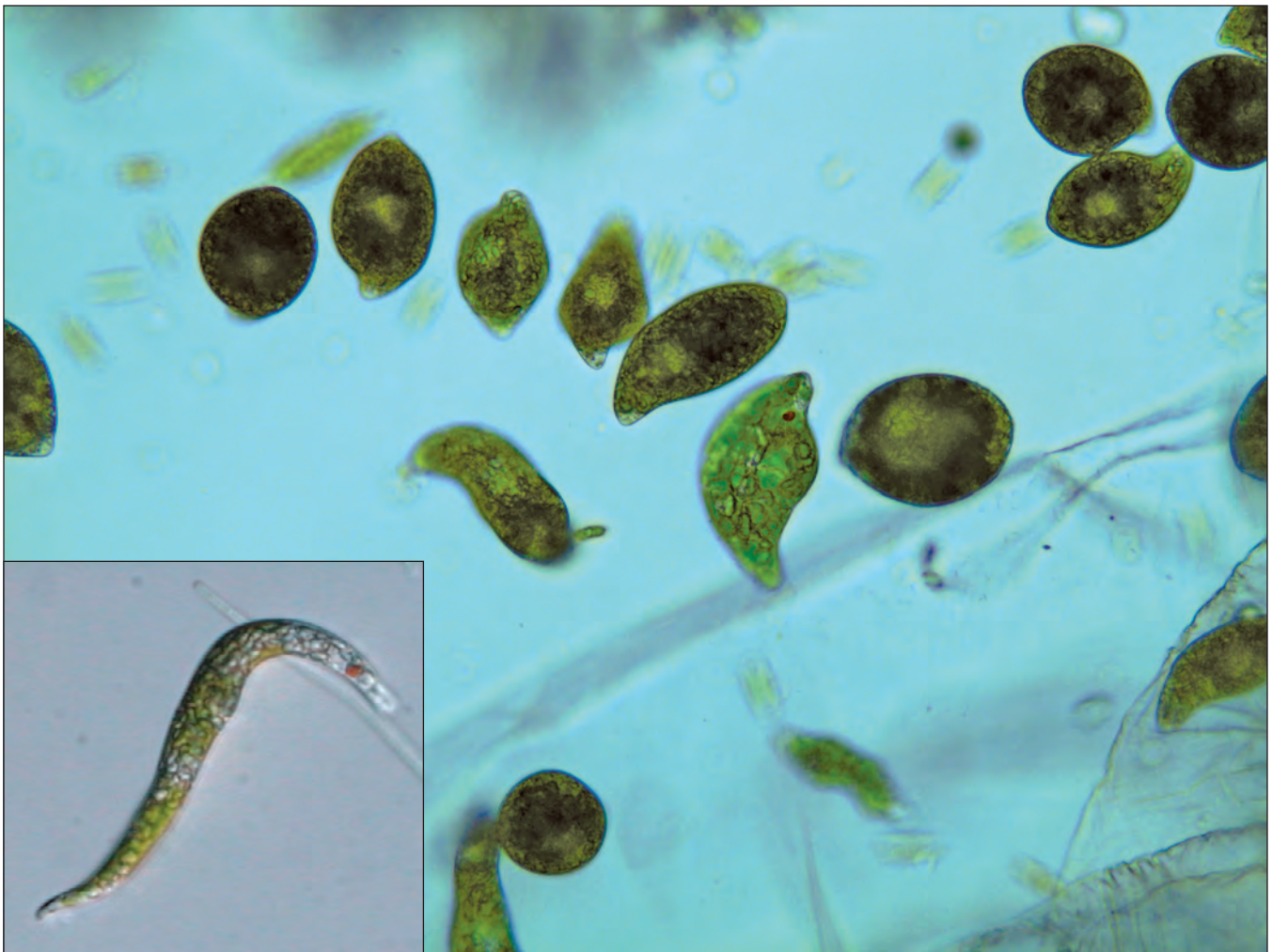


Figure 61. *Euglena* sp. (see figure 27). Surface scums indicate nutrient enrichment. *Euglena* cells can swim using a long flagellum, and they typically have a visible red eyespot (inset). (Photograph: Ann St. Amand; Inset photograph: Barry H. Rosen)

Euglena sanguinea

Figure 62. *Euglena sanguinea* (see figure 28). This organism accumulates the pigment astaxanthin and imparts a red color to individual cells and to surface scums. (Photograph: Barry H. Rosen)

Pyrrhophyta (Dinoflagellates)

The Pyrrhophyta, more commonly called dinoflagellates, include both freshwater and marine representatives. In the marine environment, approximately 5 percent are known to produce toxins. These toxins are associated with red tides and shellfish poisoning. Saxitoxin is a common and potent paralytic neurotoxin produced by some marine species. The following figure illustrates some common freshwater dinoflagellates that may bloom, but they are not known to produce toxins.

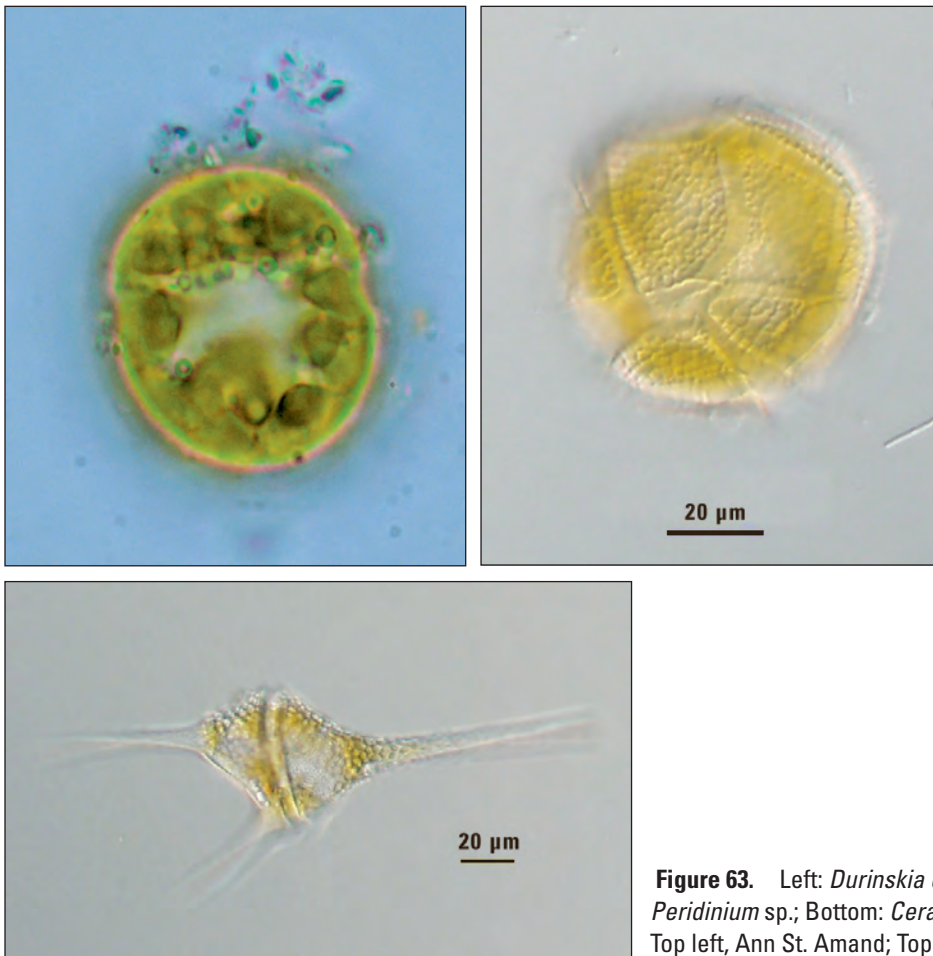


Figure 63. Left: *Durinskia dybowskii* (see figure 31). Right: *Peridinium* sp.; Bottom: *Ceratium hirundinella*. (Photographs: Top left, Ann St. Amand; Top right and bottom: Barry H. Rosen)

Haptophyta (Golden Algae)

This group of algae is infamous because of one species, *Prymnesium parvum*. It is known to cause large fish kills in brackish waters and is widely distributed, but does not seem to affect humans. Texas, Oklahoma, New Mexico, Colorado, Wyoming, North Carolina, South Carolina, Georgia, Arkansas, and Alabama have all reported waterbodies with this organism.

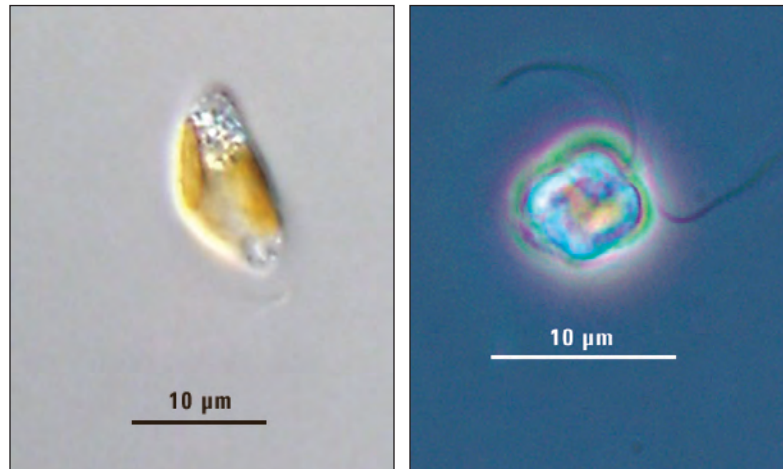


Figure 64. *Prymnesium parvum*. Note the color of the chromoplast (left) and the two flagella (right) that allow this organism to swim. (Photographs: Left, Barry H. Rosen; Right, Ann St. Amand)

Chlorophyta (Green Algae)

The green algae generally do not produce toxins; however, enriched waterbodies often experience excess green algal growth, visible as long bright or grassy green and sometime dark green filaments. These filaments are typically slippery or cottony to the touch, depending on which group of organisms they are associated with. The following figure shows three characteristic filamentous green algae and can be compared to the cyanobacteria images.

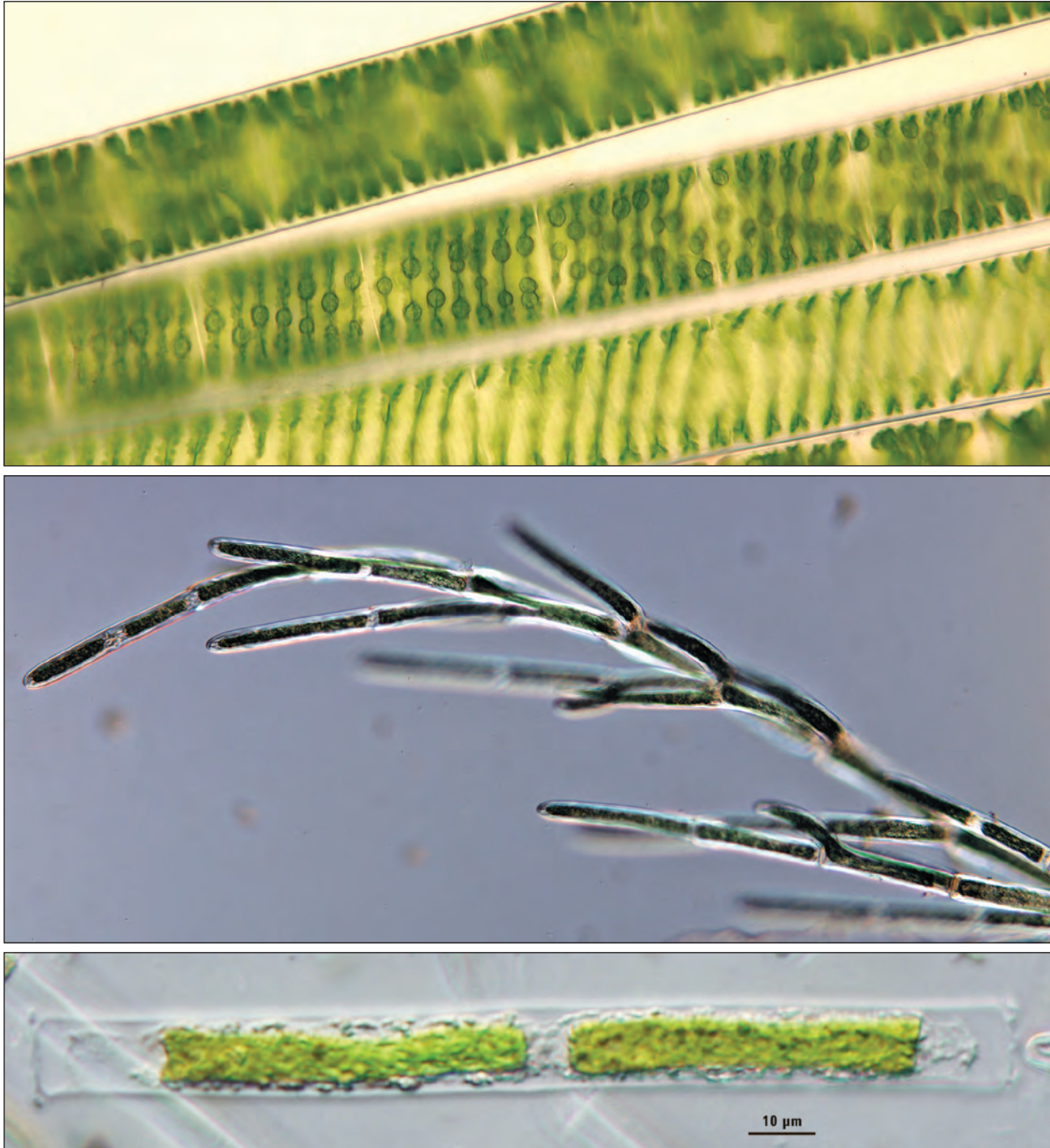


Figure 65. Green algae. Top: *Spirogyra* sp., with helical or spiral chloroplast (see figure 19). Middle: *Cladophora* sp., showing branched filaments (see figure 18). Bottom: *Mougeotia* sp., with flat, plate-like chloroplast (see figure 20). (Photographs: Top and middle, Ann St. Amand; Bottom, Barry H. Rosen)

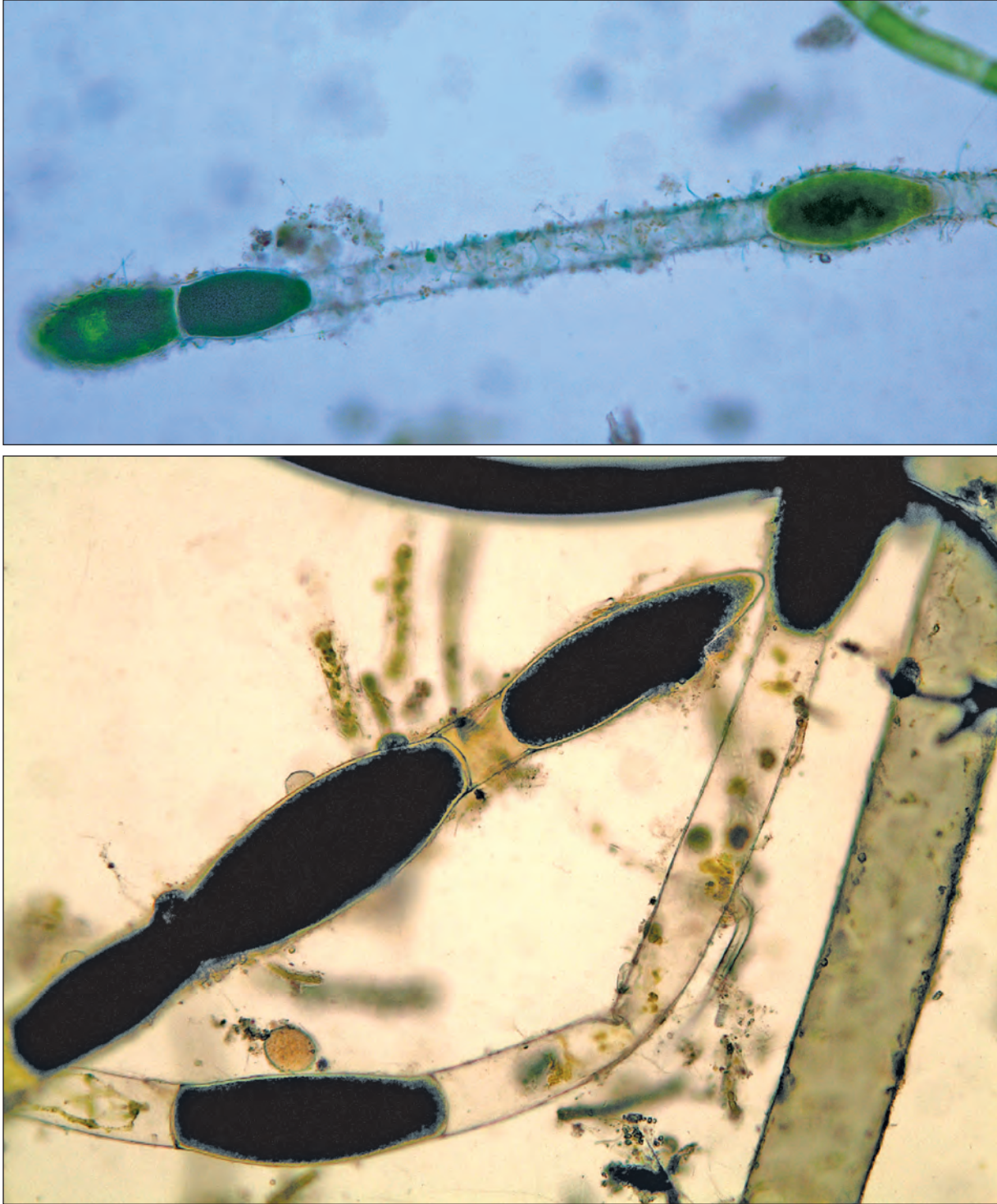


Figure 66. Green algae, *Pithophora* sp. with characteristic swollen “akinetes” (Photographs: Ann St. Amand)

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