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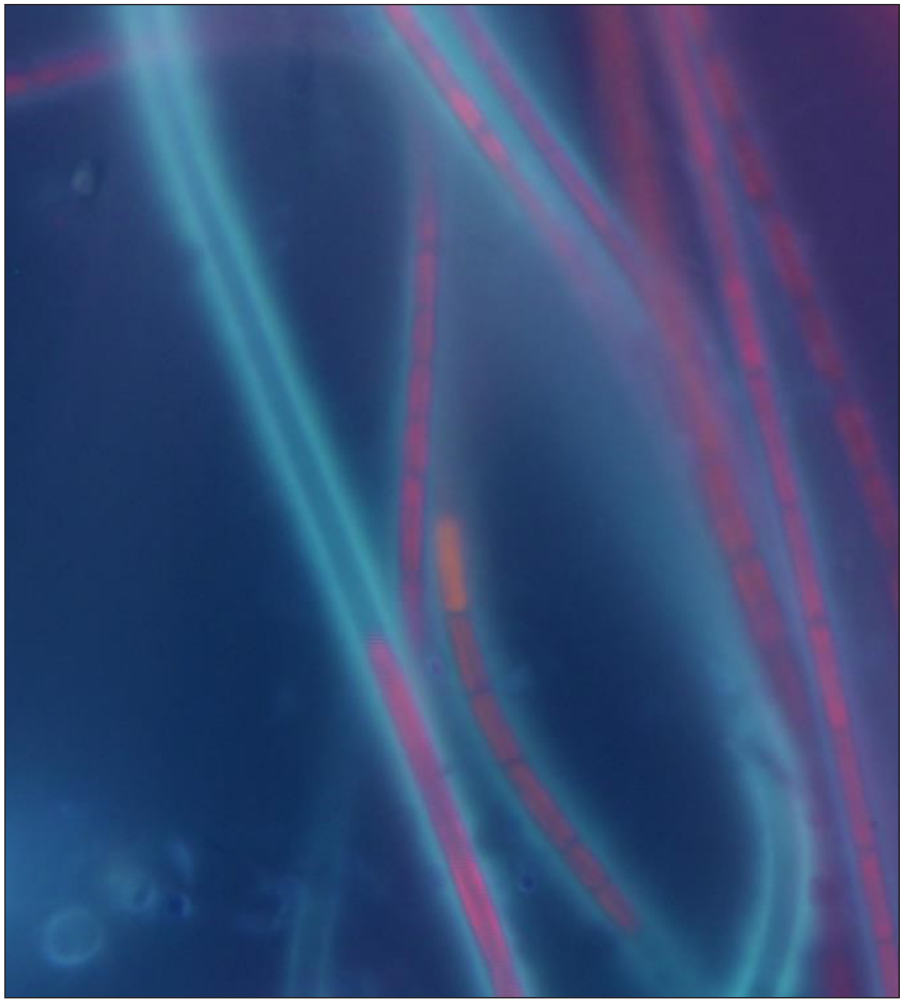
Catalog of Microscopic Organisms of the Everglades Part 1: The Cyanobacteria



Open-File Report 2016–1114

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

Cover. Microphotograph of *Schizothrix* from Water Conservation Area 3B in the Everglades, Florida. The living cells are illuminated with ultraviolet epifluorescence microscopy; pigments in the cells glow pinkish lavender, and the mucilaginous sheath material is blue, indicating the presence of calcium carbonate.

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By Barry H. Rosen and Jan Mareš

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Contents

Figures [All are photographs]

Abbreviations

cf.	Compare
DIC	Differential interference contrast microscopy
DNA	deoxyribonucleic acid
µm	micrometer
mm	millimeter
sp.	species
UV	ultraviolet (excitation cube)
WB	wide blue (excitation cube)
WG	wide green (excitation cube)

Acknowledgments

The U.S. Geological Survey has undertaken the task of documenting the microscopic organisms of the Everglades in a readily available digital format. These images and associated names are needed for current and future research as the Everglades responds to restoration and climate change. This project was funded by the U.S. Geological Survey Greater Everglades Priority Ecosystems Science program.

The authors are grateful for the taxonomic advice and thorough review of Jiří Komárek, Institute of Botany, Třeboň, and University of South Bohemia, České Budějovice, Czech Republic, and Jaroslava Komárková, Biology Centre, Institute of Hydrobiology, České Budějovice, Czech Republic. Images provided by Jaroslava Komárková are acknowledged in the respective figure captions.

We also thank Jaroslava Komárková for the suggested identity of the noncyanobacterial images.

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Catalog of Microscopic Organisms of the Everglades Part 1: The Cyanobacteria

By Barry H. Rosen[1] and Jan Mareš[2]

Abstract

The microscopic organisms of the Everglades include numerous prokaryotic organisms, including the eubacteria, such as the cyanobacteria and nonphotosynthetic bacteria, as well as several eukaryotic algae and protozoa that form the base of the food web. This report is part 1 in a series of reports that describe microscopic organisms encountered during the examination of several hundred samples collected in the southern Everglades. Part 1 describes the cyanobacteria and includes a suite of images and the most current taxonomic treatment of each taxon. The majority of the images are of live organisms, allowing their true color to be represented. A number of potential new species are illustrated; however, corroborating evidence from a genetic analysis of the morphological characteristics is needed to confirm these designations as new species. Part 1 also includes images of eubacteria that resemble cyanobacteria. Additional parts of the report on microscopic organisms of the Everglades are currently underway, such as the green algae and diatoms. The report also serves as the basis for a taxonomic image database that will provide a digital record of the Everglades microscopic flora and fauna. It is anticipated that these images will facilitate current and future ecological studies on the Everglades, such as understanding food-web dynamics, sediment formation and accumulation, the effects of nutrients and flow, and climate change.

Introduction

The base of the food web in the Everglades includes a vast array of microscopic organisms. Cyanobacteria, diatoms, and green algae are photosynthetic and are the most significant contributors to the microscopic flora. Understanding and documenting what species are present in the Everglades serve as the basis for current and future ecological studies related to restoration efforts and climate change. Part 1 documents the cyanobacteria found in the southern Everglades. This area has sawgrass ridges, sloughs, and adjacent canals of both peat and marl habitats (Gaiser and others, 2011). The source of organisms includes periphyton from vascular plants, resuspended slough sediments, and phytoplankton from open water of the sloughs and canals.

Some of these organisms are directly consumed by primary consumers, such as protozoans, nematodes, and rotifers. The organisms not consumed directly may contribute to the food web through bacterial and fungal uptake of their cellular components, such as carbon and phosphorus. Some cyanobacteria and eukaryotic algae produce cellular structures, such as the cell wall and mucilage that are highly resistant to biotic degradation, and these recalcitrant components contribute to the overall sediment accumulation.

Cyanobacteria also have an additional critical role in sediment accumulation in the Everglades. Certain species of cyanobacteria mediate calcium carbonate precipitation, also

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known as marl. Marl, along with peat from the recalcitrant vascular plant materials, adds to the overall accumulation of sediments in the Everglades.

All of the photosynthetic organisms rely on sunlight as an energy source and utilize carbon dioxide to synthesize a variety of sugar and complex carbohydrates. These organisms also need inorganic nutrients, such as nitrogen, phosphorus, calcium, potassium, and various trace metals, for growth and reproduction. Suitable temperature and water availability (hydroperiod) also are important to these primary producers, and optimal conditions for growth vary by species. The flora in a specific area has developed as a result of the interactions between all of these conditions; however, constant flux with these environmental factors means some species experience optimum growth conditions at any given time while others may have slowed or arrested growth. In any case, these interactions and fluxes lead to a diverse suite of species.

Cyanobacteria, especially those found in periphytic mats, represent important functional components of subtropical and tropical marsh ecosystems. Species composition of these mats is rather unique. On the basis of previous publications, the cyanobacterial assemblage occurring in the Florida Everglades (Mareš, 2006) can be considered characteristic of other locations with corresponding ecological characteristics. Similar cyanobacterial microvegetation have been found in shallow alkaline marshes of northern Belize (Rejmánková and Komárková, 2000; Rejmánková and others, 2004; Komárek and others, 2005a, b) and several places in Cuba as described by Komárek (1984, 1989b, 1995) in the Zapata peninsula and adjacent marshes along the southern coast, Isla de Pinos/de la Juventud - Ciénaga de Lanier. Some of the typical morphotypes also were described from southeast Mexico by Tavera and others (1994) (Papaloapan basin, Campeche region, Tamaulipas, marshes and littoral of lakes in Yucatan), Venezuela by Schiller (1956) (Islas de los Aves), and from Puerto Rico (Gardner, 1927; Bourrelly and Manguin, 1952; Komárek, 1989a,b, 1995; Komárek and Novelo, 1994; Komárek and Komárková-Legnerová, 2007; Turicchia and others, 2009).

Overall, this document follows the modern system of taxonomy, which uses the polyphasic approach of Komárek and others, 2014. In addition to morphological features, the genetics of the cyanobacteria have become important in the proper identification and taxonomic placement of organisms. The "reference library" that is needed to perform this task for cyanobacteria in general is sparse. To build the library, species need to be isolated from one another to prevent the comingling of DNA from more than one species of cyanobacteria. The most practical approach is to bring a single species into culture so enough material can be processed for DNA extraction and the morphological features documented simultaneously. Many species, however, are very small, thus "picking" them and bringing them into culture is difficult. Another significant hurdle is finding a growth medium conducive for a given isolate; the transfer of an organism from its natural water conditions to laboratory conditions often inhibits growth.

Cyanobacteria have an array of pigments, including chlorophyll *a*, phycocyanin, phycoerythrin, and several carotenoids. Many of these pigments extend the light-harvesting capability of the organism, while others are protective against photooxidation. In some species, the pigments give the cells a range of colors, from green/blue-green to olive brown, brown, or even purple. In some cases, fixed coloration can be used to distinguish one species from another.

Microscopic Organisms of the Everglades, Part 1, depicts the cyanobacteria found to date. In addition, this document is intended to provide documentation for an image database that will be available to anyone studying the biota of the Everglades. As primary producers, cyanobacteria are often the first to respond to nutrient changes, altered flow, and climate change. The cyanobacteria are particularly well-suited to warm temperatures, tolerating higher temperatures compared to their eukaryotic counterparts. This report documents the cyanobacteria group of organisms prior to the time when Everglades restoration will likely change flow and nutrient patterns in their habitat. Tracking changes in the species present, as well as their abundance over time, will contribute to understanding restoration success.

While observing the cyanobacteria, other eubacteria were encountered that had the same general appearance as cyanobacteria but lack photosynthetic pigments. Epifluorescence microscopy was used to determine if pigments were present. Several images of these eubacteria are included in Part 1 to aid users needing to differentiate the cyanobacteria from the nonphotosynthetic forms.

Many of the cyanobacteria in the Everglades produce copious amounts of mucilage that provide protection against desiccation (Donar and others, 2004). It is believed the cells inside the mucilage remain hydrated and viable, although they may not be reproducing. The feature allows a species to survive in short-hyrdoperiod areas of the Everglades or during droughts. Those organisms that can tolerate desiccation will be readily available to resume growth when wet conditions return to a habitat compared to those nondesiccation tolerant organisms that must be reintroduced to a habitat to establish their population.

The identification of cyanobacteria begins initially with discerning whether the organism is a cyanobacteria or another prokaryotic organism with similar morphology. In the Everglades, there is an abundance of other eubacteria that

have somewhat similar morphologies to the cyanobacteria. These noncyanobacteria may form colonies and, because the organisms are pigmented, the task of separating the two groups may be a bit challenging; a suite of images of these noncyanobacteria are included in this publication. Separating the cyanobacteria from eukaryotic algae is less difficult, as the morphology of most of the species encountered made this task relatively easy. The treatment of the eukaryotic algae is planned for presentation in a separate part of the Microscopic Organisms of the Everglades.

The taxonomic treatment of the Everglades cyanobacteria relied most heavily on the morphology of the organisms from light microscopy. Important features in cyanobacteria morphology include the shape of the cells; how cells are associated with one another, such as a colony, trichome, or a filament; and cell size (length and width). The images in this report include a "scale bar" that is used to depict measurements in micrometers. Certain species are distinguished by other features, such as the presence of heterocytes, a specialized cell capable of fixing atmospheric nitrogen in the order Nostocales. Some species also make a resting cell, an akinete, and the arrangement of these two cell types is indicative of certain genera. Many planktonic organisms produce gas vesicles that are used to regulate buoyancy, and a collection of the vesicles is visible as an "aerotope" in the cells; the location of these vesicles in the cell is often a distinguishing feature.

Filamentous cyanobacteria may produce a single trichome (a series of cells adjacent to one another), and (or) the trichome may be surrounded by a sheath; collectively the trichome and sheath are termed a filament. The presence and thickness of a sheath are also an important taxonomic feature, although the production of a sheath may be a function of environmental conditions. Sheaths can also acquire color by sequestering metabolites leaked from the cells or adsorbed from the surrounding water, and this characteristic is also somewhat species specific. Filamentous cyanobacteria can also be composed of a single trichome or multiple trichomes in a common sheath, either parallel to one another or intertwined. Additionally, some filaments are branched, and the nature of that branching is also an important taxonomic characteristic.

Some species of cyanobacteria are found as isolated cells. In contrast to the filamentous forms are the colonial forms, with cells arranged in regular or irregular masses. The colonial forms are surrounded by a mucilaginous sheath that varies by species and environmental conditions. As in the filamentous cyanobacteria, certain species are characterized by the color of their sheaths. Within the colony, some cells may also have their own individual sheaths, which is also a taxonomic feature.

Methods

Field Samples

Live and preserved material was collected in the southern Everglades, including the area between Water Conservation Area 3A and 3B (latitude 25º52' N., longitude 80º36' W.) and from Big Cypress National Preserve. Samples included a variety of periphyton and epiphyton, sediments that accumulated in sediment traps (Phillips and others, 2000). Samples were collected in Whirl-Pak® Sample Collection Bags or plastic centrifuge tubes and kept refrigerated until examined.

Microscopy

Samples initially were observed and photographed using differential interference contrast (DIC) microscopy using an Olympus BX51 research microscope at 200x, 400x, 600x (oil), or 1,000x (oil) magnifications. Images were all illuminated with DIC, unless otherwise noted. A micrometer (µm) scale bar was imbedded in the images. The accuracy of the imbedded scale was verified with a stage micrometer.

Some cells were further examined and photographed under epifluorescence microscopy with (1) U-MWU2: ultraviolet (UV) cube, with excitation wavelengths 330–385 nanometers and emission above 515 nanometer; (2) U-MWB2: wide blue (WB) cube, with excitation between 460–490 nanometers and emission above 515 nanometer; or (3) U-MWG2: wide green (WG) cube, with excitation wavelengths 510–550 nanometers and emission above 515 nanometer. The illumination source was a xenon lamp (X-Cite Series 120Q). Images illuminated with both DIC and epifluorescence on the same material were designated as a and b with the same figure number.

The images in this publication were taken by Barry Rosen unless otherwise noted.

Morphologically Based Taxonomy

Several sources were used to identify organisms on the basis of morphology (Komárek and Anagnostidis, 1998, 2005; Komárek and Komárková-Legnerová, 2007; Turicchia and others, 2009; Komárek, 2013; Komárek and others, 2014). The classification and groupings of the images are aligned by order, family within the order, and genus within the family. The abbreviation cf. in some of the figure captions is commonly read as "compare." Collectively, the images are in 6 orders, 25 families, and 43 genera:

Chroococcales
- **Aphanothecaceae**
  - *Aphanothece*
  - *Cyanogastrum*
  - *Gloeothece*
  - *Halothece*
- **Chroococcaceae**
  - *Asterocapsa*
  - *Chroococcus*
  - *Cyanosarcina*
  - *Geminocystis*
- **Cyanothrichaceae**
  - *Johannesbaptistia*
- **Entophysalidaceae**
  - *Chlorogloea*
- **Gomphosphaeriaceae**
  - *Gomphosphaeria*

Oscillatoriales
- **Borziaceae**
  - *Borzia*
- **Coleofasciculaceae**
  - *Geitlerinema*
- **Gomontiellaceae**
  - *Komvophoron*
- **Microcoleaceae**
  - *Arthrospira*
- **Oscillatoriaceae**
  - *Lyngbya*
  - *Oscillatoria*
  - *Phormidium*

Pseudanabaenales
- **Schizotrichaceae**
  - *Schizothrix*

Spirulinales
- **Spirulinaceae**
  - *Spirulina*

Synechococcales
- **Coelosphaeriaceae**
  - *Coelomoron*
- **Leptolyngbyaceae**
  - *Leptolyngbya*
- **Merismopediaceae**
  - *Aphanocapsa*
  - *Eucapsis*
  - *Merismopedia*
- **Pseudanabaenaceae**
  - *Limnothrix*
  - *Pseudanabaena*
- **Romeriaceae**
  - *Wolskyella*
- **Synechococcaceae**
  - *Lemmermanniella*
  - *Rhabdogloea*

Nostocales
- **Fortiaceae**
  - *Fortiea*
- **Gloeotrichiaceae**
  - *Gloeotrichia*
- **Nostocaceae**
  - *Anabaena*
  - *Cylindrospermum*
  - *Marcrospermum*
  - *Nostoc*
  - *Wollea*
- **Rivulariaceae**
  - *Calothrix*
  - *Microchaete*
- **Scytonemataceae**
  - *Chakia*
  - *Scytonema*
- **Stigonemataceae**
  - *Stigonema*
- **Tolypothrichaceae**
  - *Tolypothrix*

Organisms

Order: Chroococcales

Family: Aphanothecaceae

Genus: *Aphanothece*

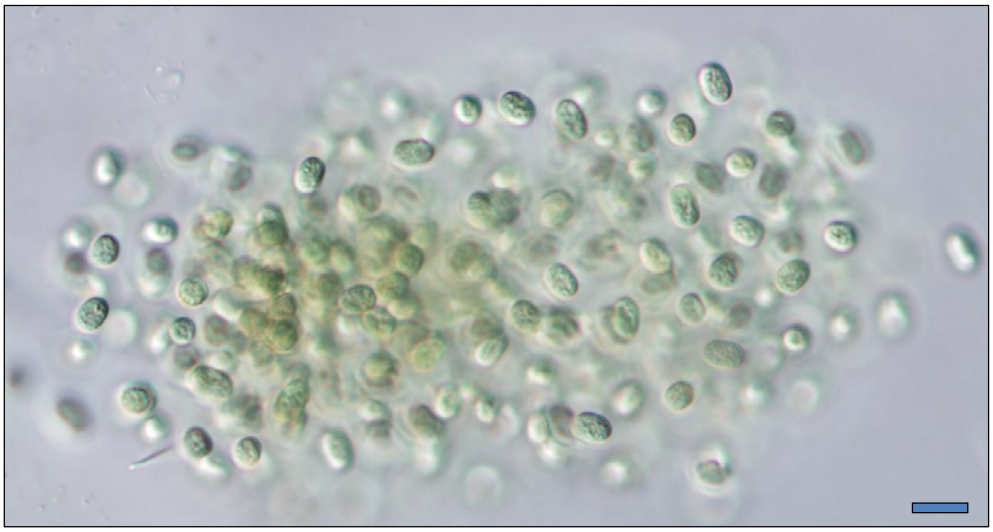

Figure 1. *Aphanothece* cf. *hardersii.* Bar is 10 μm in length.

Figure 2. *Aphanothece* cf. *hardersii.* Bar is 10 μm in length.

Figures 1 and 2 have the overall appearance of *Aphanothece* cf. *hardersii.* Cells are oval to rod-shaped, 2.4 μm wide by 5 μm long, arranged loosely in mucilaginous sheath.

Order: Chroococcales

Family: Aphanothecaceae

Genus: *Cyanogastrum*

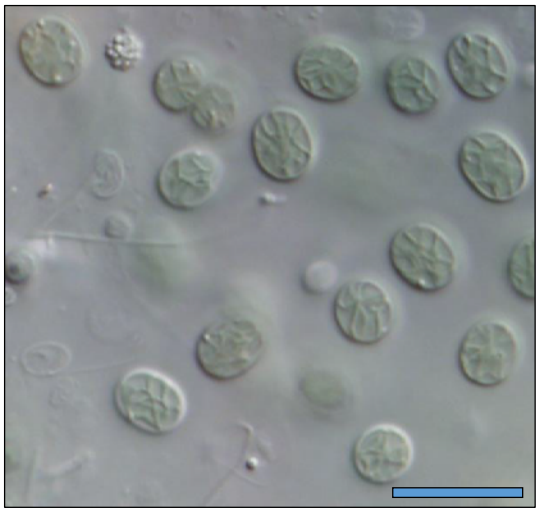

Figure 3. *Cyanogastrum variabile.* Bar is 10 μm in length.

Figure 4. *Cyanogastrum variabile.* Bar is 10 μm in length.

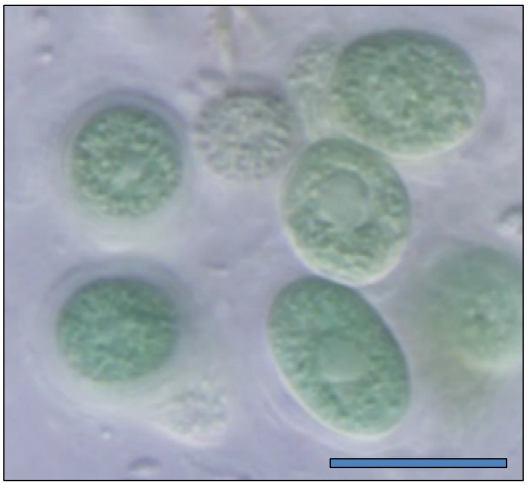

Figure 5. *Cyanogastrum variabile.* Bar is 10 μm in length.

Figures 3 to 5 illustrate the variability with the species *Cyanogastrum variabile*. Typically, cells are round to oval, arranged loosely in a common mucilaginous sheath. Size: 4.2 μm wide by 12 μm long. Keratomization may be present (fig. 3). Isolating stains and genetic sequencing may subsequently lead to revisions in this group. The synonym for this organism is *Aphanothece variabilis* (Schiller) after Komárek (1995).

Order: Chroococcales

Family: Aphanothecaceae

Genus: *Halothece* or *Cyanothece* or *Cyanobacterium*

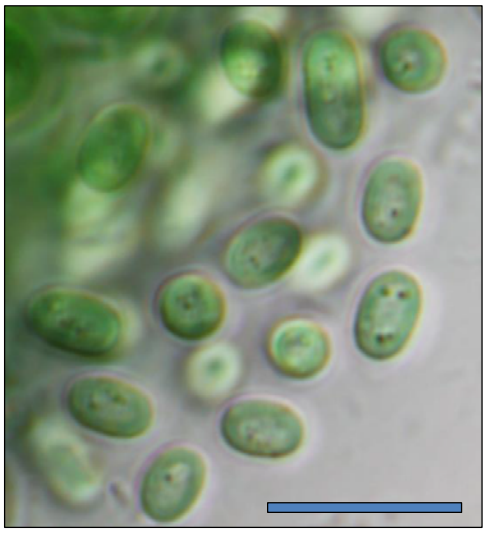

Figure 6. *Halothece or Cyanothece or Cyanobacterium*. Bar is 10 μm in length.

Figure 7. *Halothece or Cyanothece* or *Cyanobacterium*. Bar is 10 μm in length.

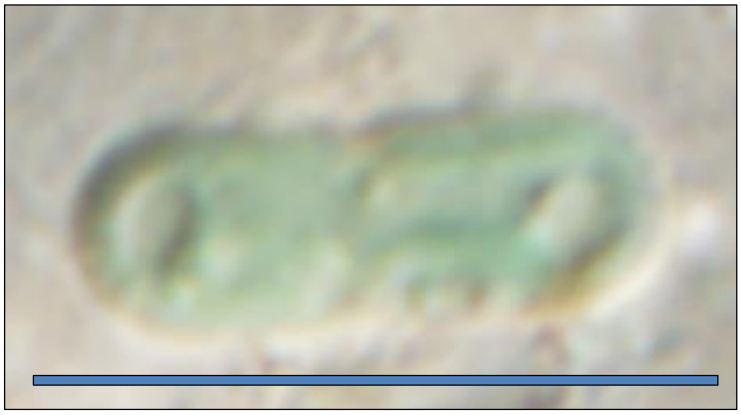

Figure 8. *Halothece or Cyanothece* or *Cyanobacterium*. Bar is 10 μm in length.

Order: Chroococcales

Family: Aphanothecaceae

Genus: *Halothece* or *Cyanothece* or *Cyanobacterium*

Figure 9. *Halothece or Cyanothece* or *Cyanobacterium*. Bar is 10 μm in length.

Figure 10. *Halothece or Cyanothece* or *Cyanobacterium*. Bar is 10 μm in length.

Figures 6 to 10 illustrate the morphology of very small cyanobacteria that are not associated with colonies. These cyanobacteria likely fall into the "Euhalothece" group and may be in the genus *Halothece*, *Cyanothece,* or *Cyanobacterium*. As single cells, often seen dividing. Cells are 2.9 μm wide by 5.2 μm long. These taxa are currently under taxonomic revision.

Order: Chroococcales

Family: Aphanothecaceae

Genus: *Gloeothece*

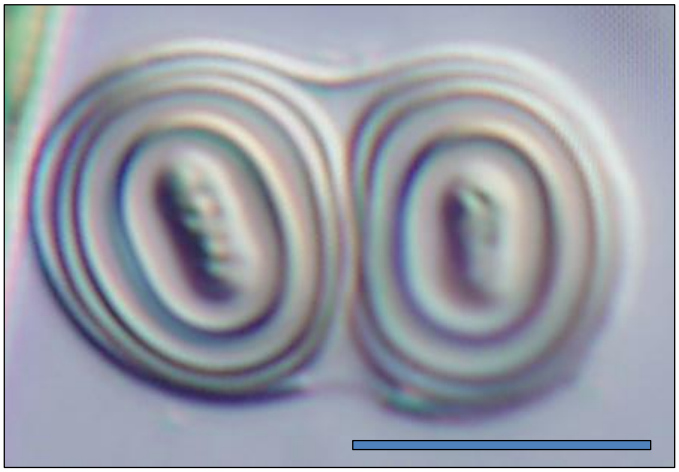

Figure 11. *Gloeothece interspersa.* Bar is 10 μm in length.

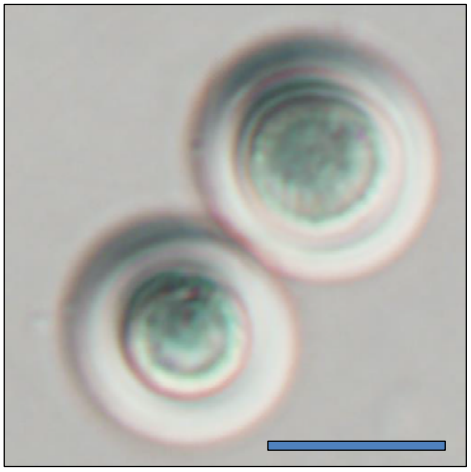

Figure 12. *Gloeothece interspersa.* Bar is 10 μm in length.

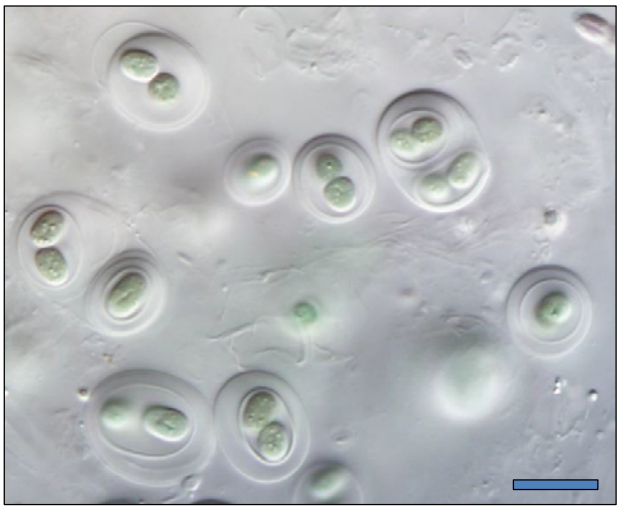

Figure 13. *Gloeothece interspersa.* Bar is 10 μm in length.

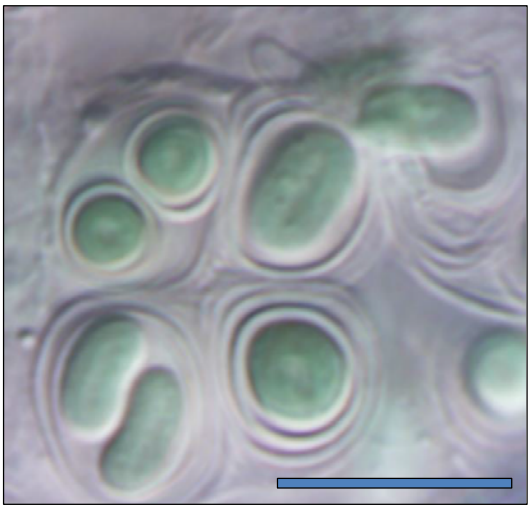

Figure 14. *Gloeothece interspersa.* Bar is 10 μm in length.

Order: Chroococcales

Family: Aphanothecaceae

Genus: *Gloeothece*

Figure 15. *Gloeothece interspersa.* Bar is 10 μm in length.

Figure 16. *Gloeothece interspersa.* Bar is 10 μm in length.

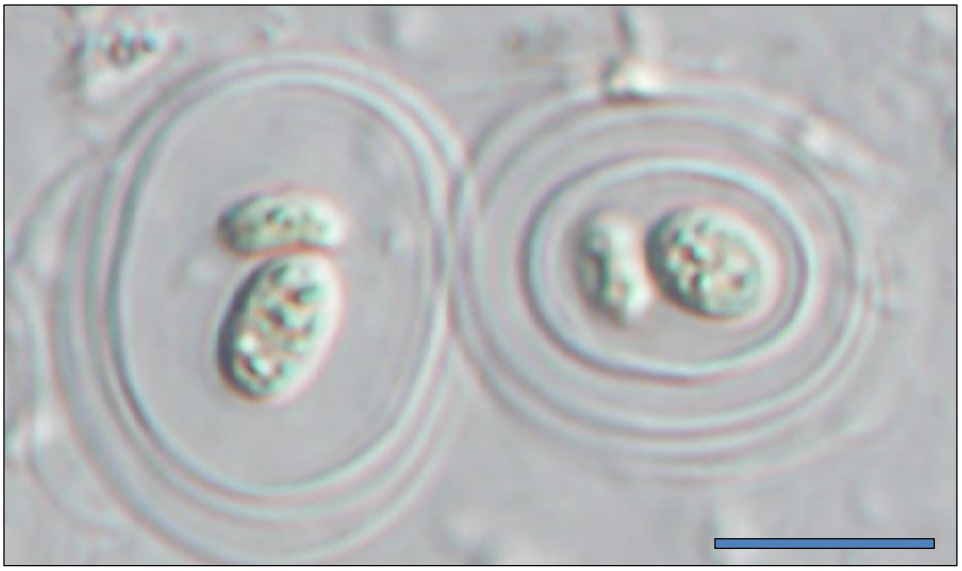

Figure 17. *Gloeothece interspersa.* Bar is 10 μm in length.

Figures 11 to 17 illustrate the variability in *Gloeothece interspersa*. Elongated cells approximately 4 μm wide by 8 μm long. Individual cells with mucilage envelopes, grouped into small colonies that have additional mucilage layers. Mucilage provides resistance to desiccation. Source: Komárek and Anagnostidis (1998).

Order: Chroococcales

Family: Aphanothecaceae

Genus: *Gloeothece*

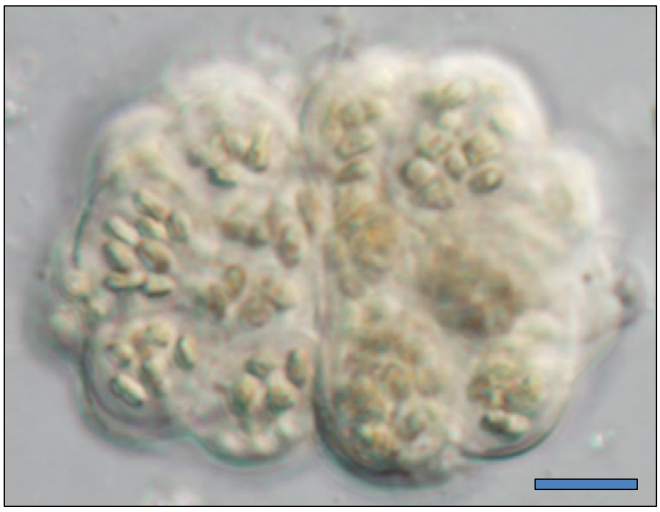

Figure 18. *Gloeothece* cf. *opalothecata*. Bar is 10 μm in length.

Figure 19. *Gloeothece* cf. *opalothecata*. Bar is 10 μm in length.

Order: Chroococcales

Family: Aphanothecaceae

Genus: *Gloeothece*

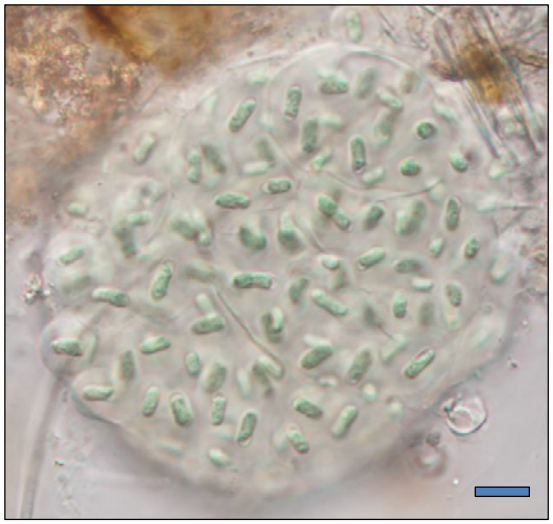

Figure 20a. *Gloeothece* cf. *opalothecata* illuminated with DIC microscopy. Bar is 10 μm in length.

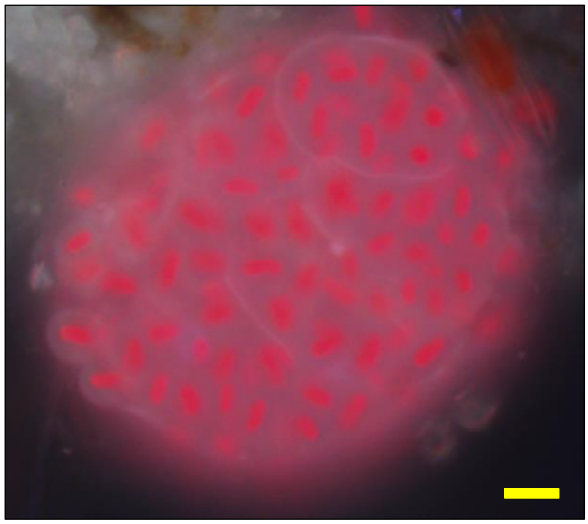

Figure 20b. *Gloeothece* cf. *opalothecata* illuminated with UV epifluorescence microscopy. Bar is 10 μm in length.

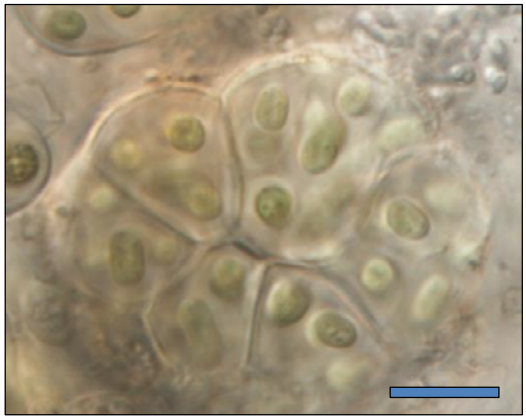

Figure 21. *Gloeothece* cf. *opalothecata*. Bar is 10 μm in length.

Figures 18 to 21 illustrate the variability in *Gloeothece* cf. *opalothecata*. Elongated cells approximately 3 μm wide by 5 μm long. Cells in mucilaginous groups with a somewhat spherical to wedge shape and these are grouped into more or less spherical colonies. This is likely a new species. The synonym for this organism is *Gloeothece* cf. *interspersa* after Komárek and Komárková-Leganderová (2007).

Order: Chroococcales

Family: Aphanothecaceae

Genus: *Gloeothece*

Figure 22. *Gloeothece* cf. *parvula.* Bar is 10 μm in length.

Figure 23. *Gloeothece* cf. *parvula.* Bar is 10 μm in length.

Figures 22 and 23 illustrate *Gloeothece* cf. *parvula* after Komárek and Komárková-Legnerová (2007). Elongated cells approximately 3 μm wide by 6 μm long. Cells have their own individual mucilage very loosely aggregated into a group. This is likely a new species.

Order: Chroococcales

Family: Chroococcaceae

Genus: *Asterocapsa*

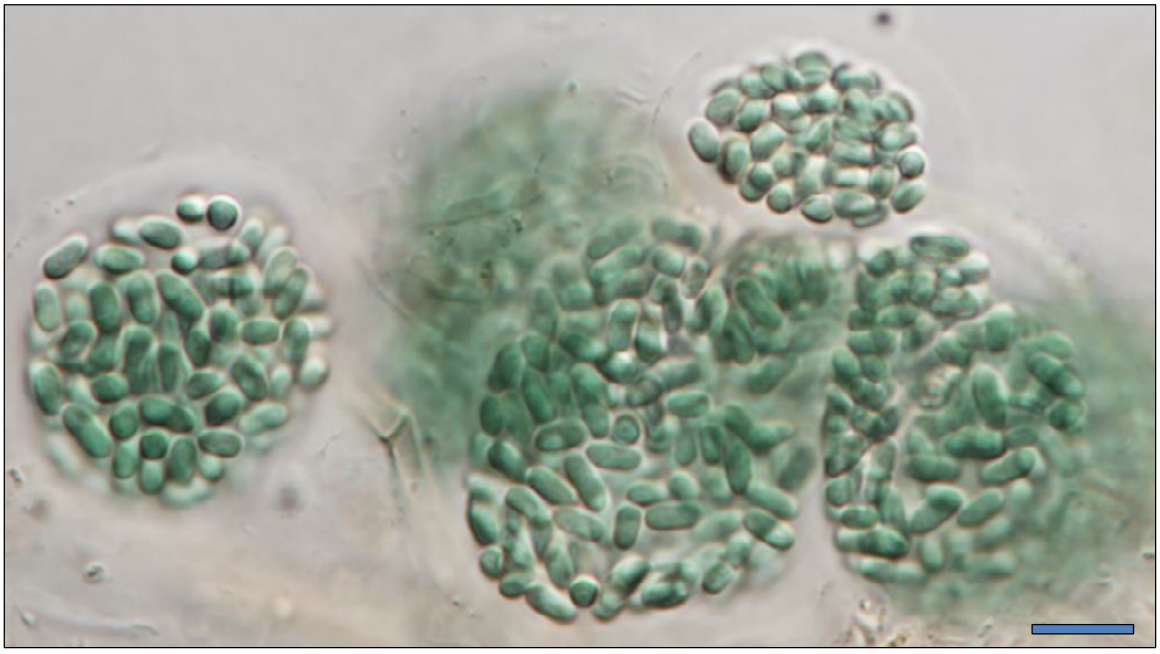

Figure 24. *Asterocapsa nidulans*. Bar is 10 μm in length.

Figure 25. *Asterocapsa nidulans*. Bar is 10 μm in length.

Figures 24 and 25 *Asterocapsa nidulans* with cells elongated to rod-shaped, 2.2 mm wide by 5.5 mm long, arranged in a common mucilaginous sheath into spherical/lobate colonies.

Order: Chroococcales

Family: Chroococcaceae

Genus: *Asterocapsa*

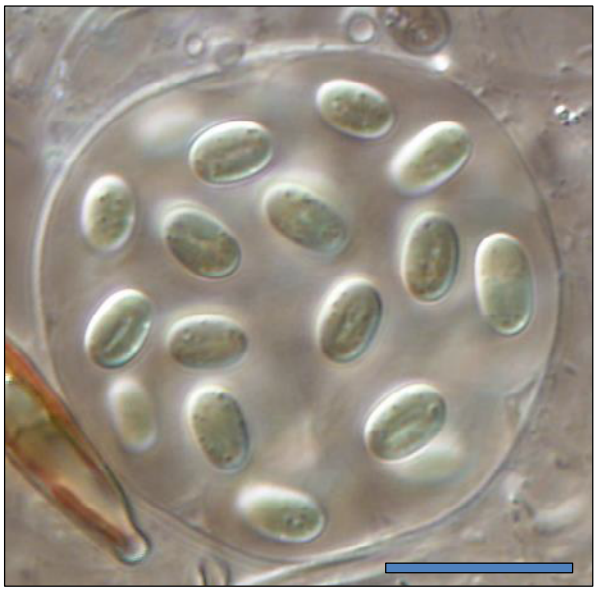

Figure 26. *Asterocapsa* sp. Bar is 10 μm in length.

Figure 27. *Asterocapsa* sp. Bar is 10 μm in length.

Figures 26 and 27 *Asterocapsa* sp. with cells elongated to wide, rod-shaped, 2.2 μm wide by 5.5 μm long, arranged in a common mucilaginous sheath into spherical/lobate colonies.

Order: Chroococcales

Family: Chroococcaceae

Genus: *Astercocapsa*

Figure 28. *Asterocapsa* cf. *stagnina.* Bar is 10 μm in length.

Figure 29. *Asterocapsa* cf. *stagnina.* Bar is 10 μm in length.

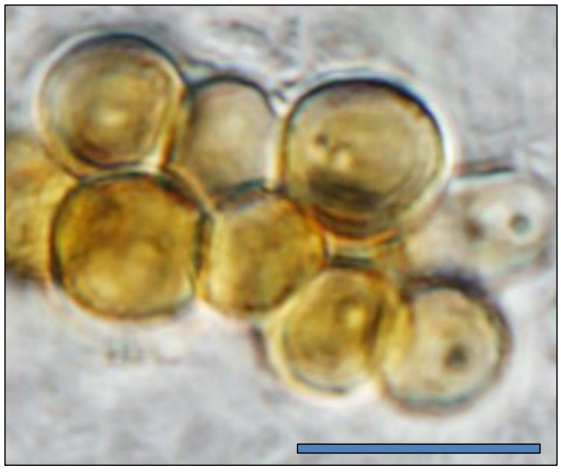

Figure 30. *Asterocapsa* cf. *stagnina.* Bar is 10 μm in length.

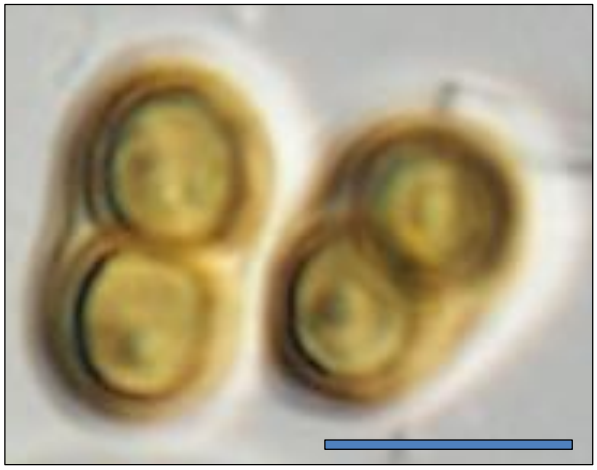

Figure 31. *Asterocapsa* cf. *stagnina.* Bar is 10 μm in length.

Figures 28 to 31 illustrate *Asterocapsa* cf. *stagnina* after Komárek and Komárková-Legnerová (2007). Round to elongated cells approximately 5 μm wide by 7 μm long. Cells have their own individual mucilage, and pairs are common and sometimes aggregated into a group. Color is distinctively olive to olive-brown.

Order: Chroococcales

Family: Chroococcaceae

Genus: *Asterocapsa*

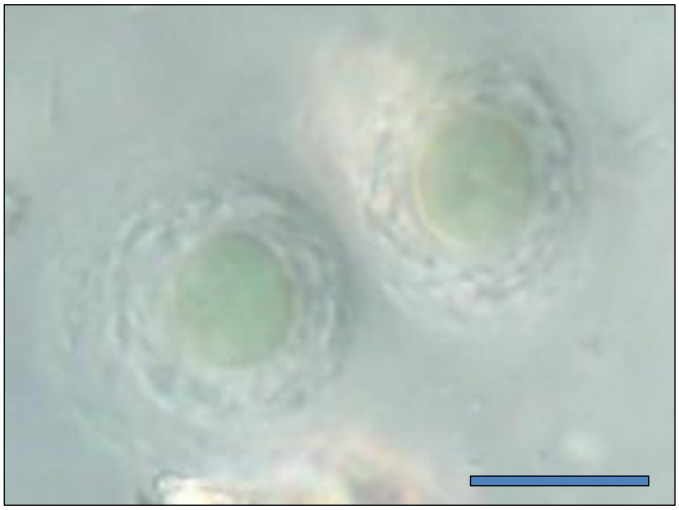

Figure 32a. *Asterocapsa* sp. illuminated with DIC microscopy. Bar is 10 μm in length.

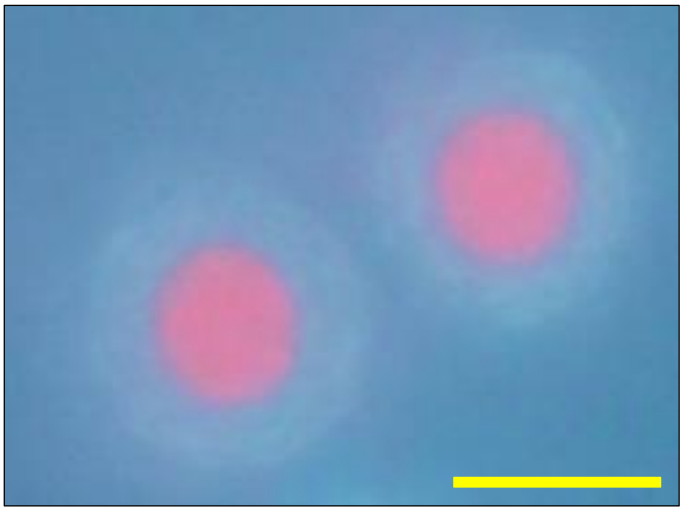

Figure 32b. *Asterocapsa* sp. illuminated with UV epifluorescence microscopy. Bar is 10 μm in length.

Figures 32a and 32b. Paired images: the identity of these cells is uncertain. Cells are spherical and found solitary or as groups of two, 6.6 μm wide by 7.2 μm long, surrounded by grainy sheath material. The light-blue glow surrounding the cells (pink) of the sheath in figure 32b is indicative of calcium carbonate.

Order: Chroococcales

Family: Chroococcaceae

Genus: *Chroococcus*

Figure 33. *Chroococcus* cf. *major*. Bar is 10 μm in length.

Figure 34. *Chroococcus* cf. *major*. Bar is 10 μm in length.

Figures 33 and 34 *Chroococcus* cf. *major*, with typically "sharp" deltoid shape after division, dark to dirty blue-green color, large granules in cells, 12.6 μm wide by 15 μm long.

Order: Chroococcales

Family: Chroococcaceae

Genus: *Chroococcus*

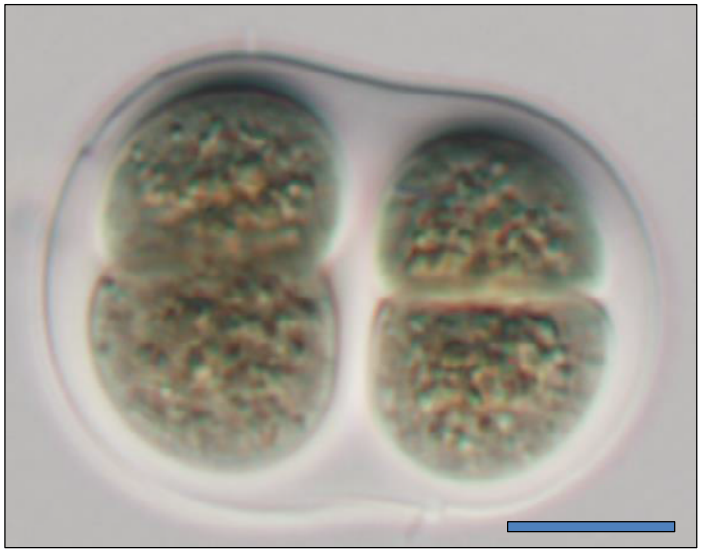

Figure 35. *Chroococcus mediocris*. Bar is 10 μm in length.

Figure 36. *Chroococcus mediocris*. Bar is 10 μm in length.

Figures 35 and 36 *Chroococcus mediocris*, with a smoothly rounded shape, intermediate cell size (10-20 μm) and typically a brownish or yellowish color.

Order: Chroococcales

Family: Chroococcaceae

Genus: *Chroococcus*

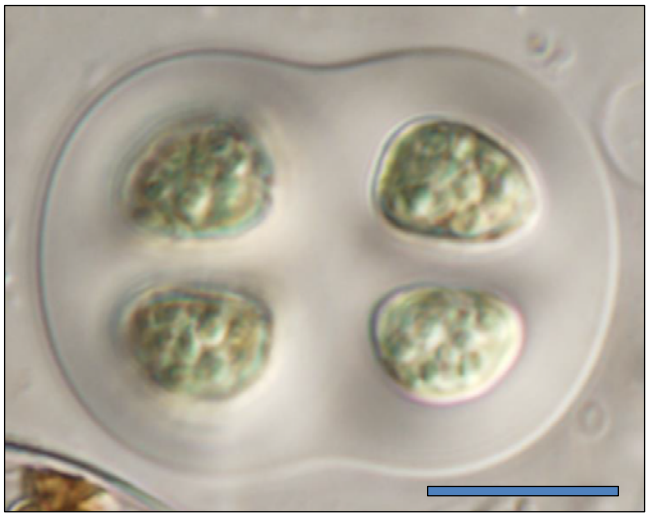

Figure 37. *Chroococcus mipitanensis*. Bar is 10 μm in length.

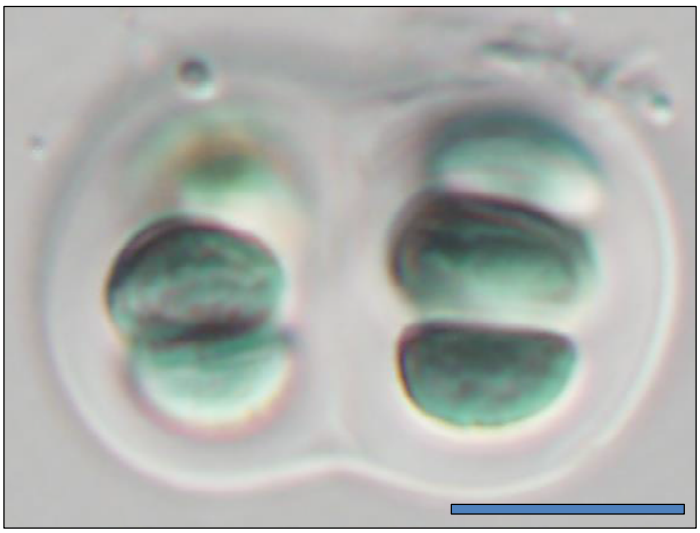

Figure 38. *Chroococcus mipitanensis*. Bar is 10 μm in length.

Order: Chroococcales

Family: Chroococcaceae

Genus: *Chroococcus*

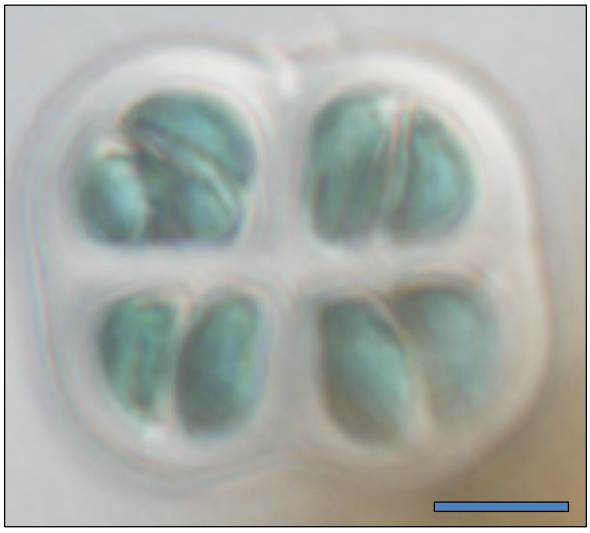

Figure 39. *Chroococcus mipitanensis*. Bar is 10 μm in length.

Figure 40. *Chroococcus mipitanensis*. Bar is 10 μm in length.

Figures 37 to 40 *Chroococcus mipitanensis*, with rounded to rounded-deltoid cells in typically 4-8 celled colonies with a well-delimited ("refractive"), smooth, and very broad mucilage (there is more space between and around the cells in the mucilage compared to other species in the Everglades). Cells are rather small, typically about 5-10 μm.

Order: Chroococcales

Family: Chroococcaceae

Genus: *Chroococcus*

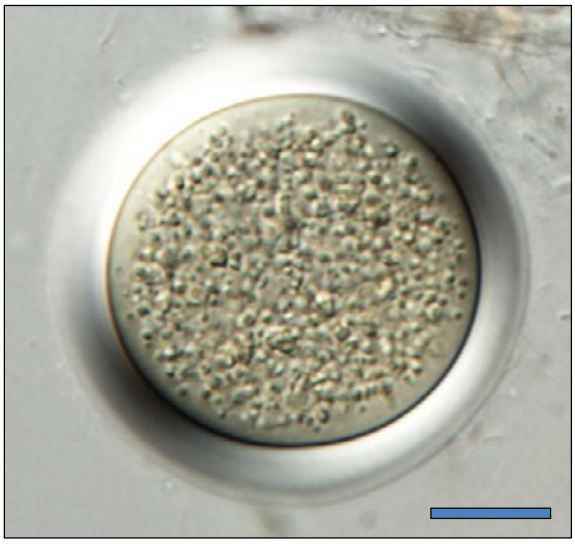

Figure 41. *Chroococcus occidentalis*. Bar is 10 μm in length.

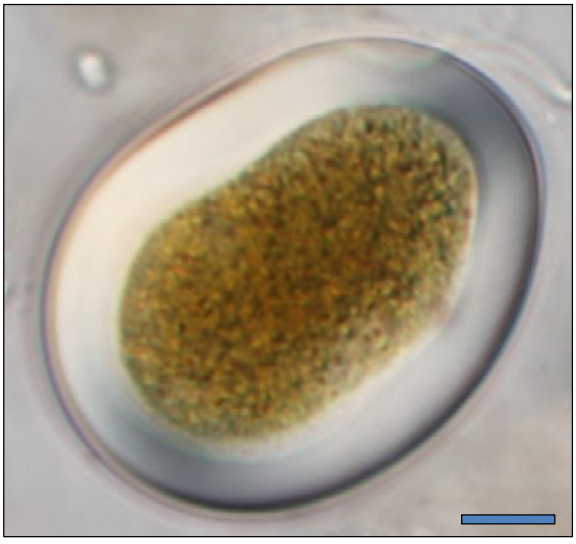

Figure 42. *Chroococcus occidentalis*. Bar is 10 μm in length.

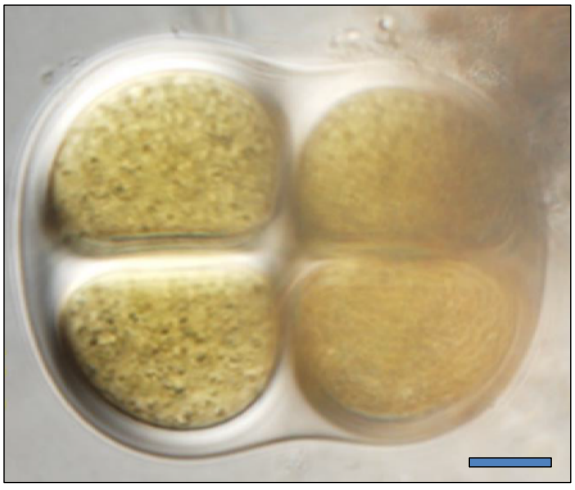

Figure 43. *Chroococcus occidentalis*. Bar is 10 μm in length.

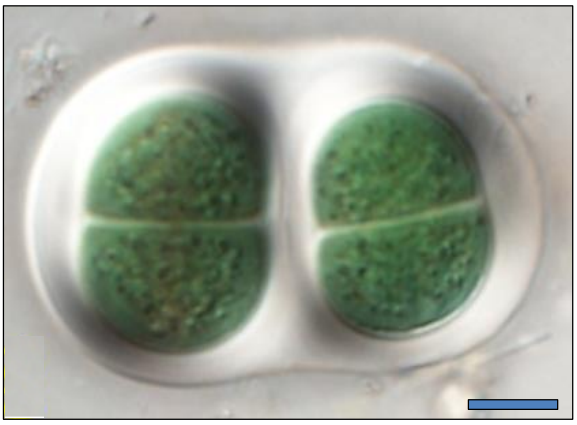

Figure 44. *Chroococcus occidentalis*. Bar is 10 μm in length.

Figures 41 to 44 illustrate the variability in *Chroococcus occidentalis*. In this species, cells are rounded and can be found solitary, in groups of two or four, and are over 20 μm but less than 50 μm, spherical to prolate spheroid in shape.

Order: Chroococcales

Family: Chroococcaceae

Genus: *Chroococcus*

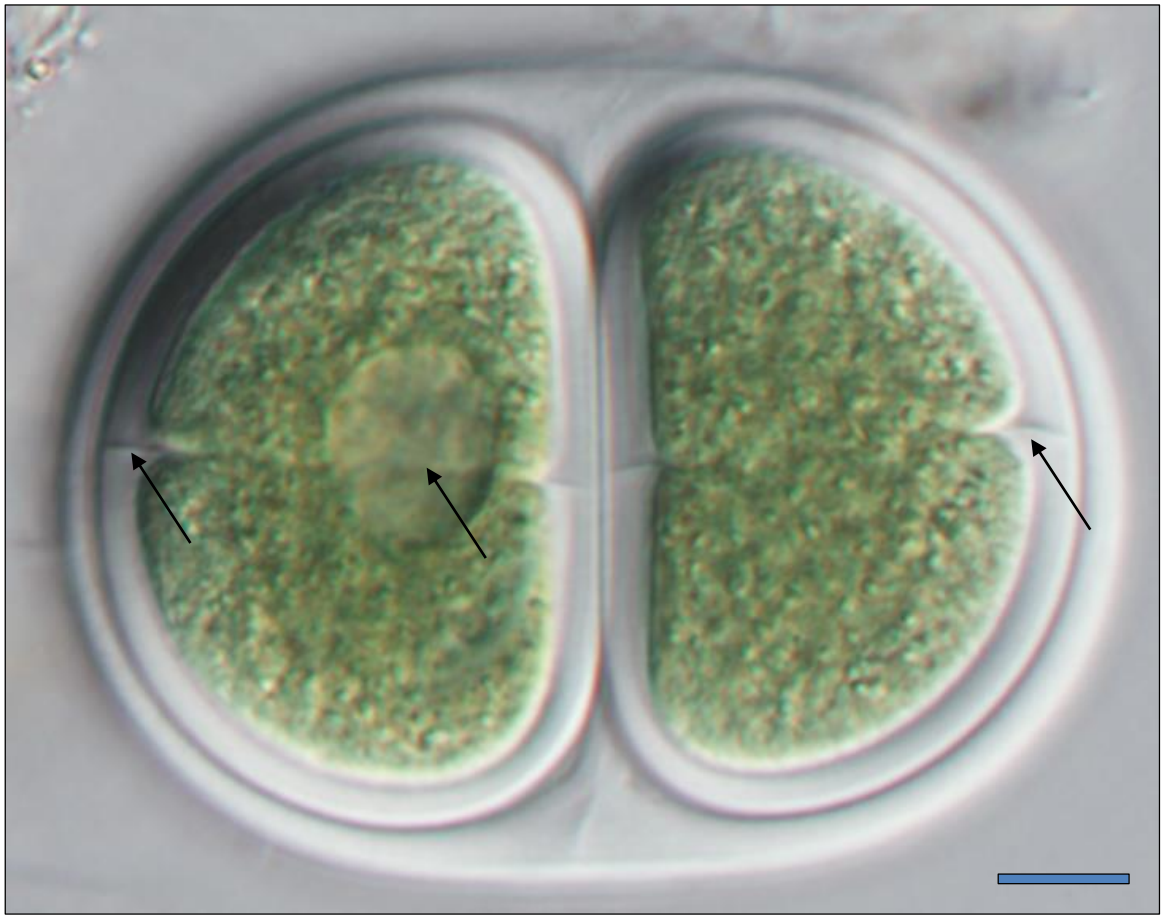

Figure 45. *Chroococcus* cf. *occidentalis*. Bar is 10 μm in length.

Figure 45 has the correct cell shape and sheath of *Chroococcus occidentalis*; however; the size exceeds what typifies this species. Note the cells show the new cross wall (at arrows) being formed that will lead to cell division.

Order: Chroococcales

Family: Chroococcaceae

Genus: *Chroococcus*

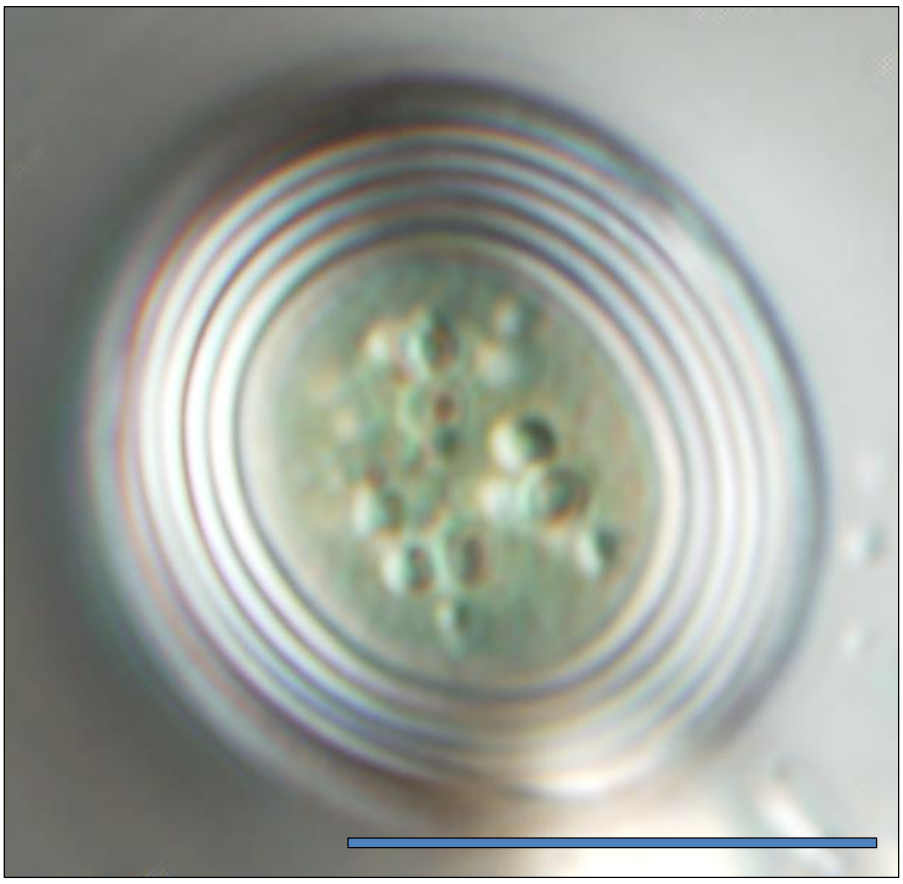

Figure 46. *Chroococcus* cf. *schizodermaticus*. Bar is 10 μm in length.

Figure 46 illustrates *Chroococcus* cf. *schizodermaticus,* with multiple layering surrounding a single cell, 7.3 μm wide by 8.3 μm long.

Order: Chroococcales

Family: Chroococcaceae

Genus: *Chroococcus*

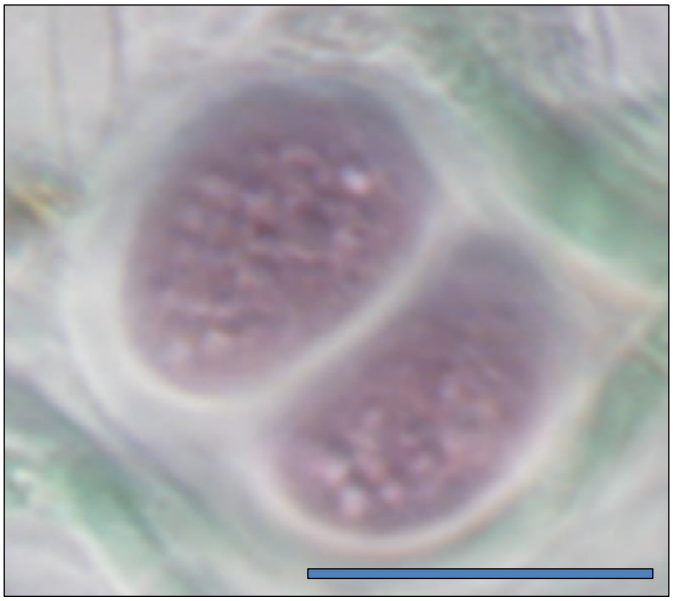

Figure 47. *Chroococcus subsphaericus*. Bar is 10 μm in length.

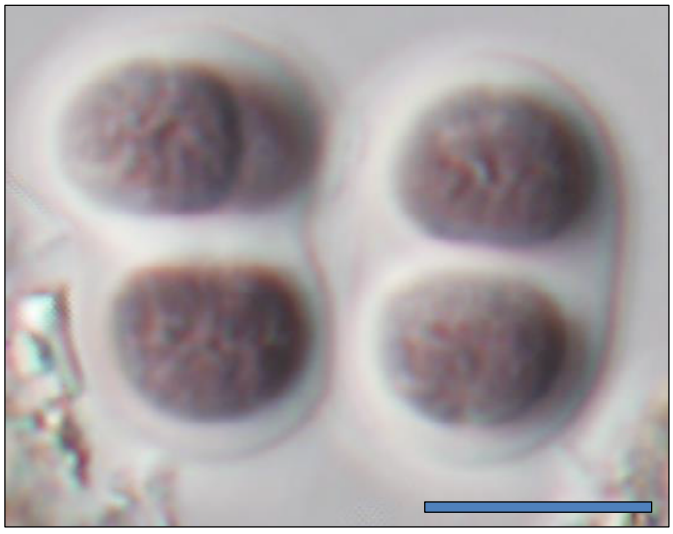

Figure 48. *Chroococcus subsphaericus*. Bar is 10 μm in length.

Figures 47and 48 illustrate *Chroococcus subsphaericus*, with violet cells found in pairs or groups of four, 6 μm wide by 10 μm long.

Order: Chroococcales

Family: Chroococcaceae

Genus: *Cyanosarcina*

Figure 49a. *Cyanosarcina* sp. illuminated with DIC microscopy. Bar is 10 μm in length.

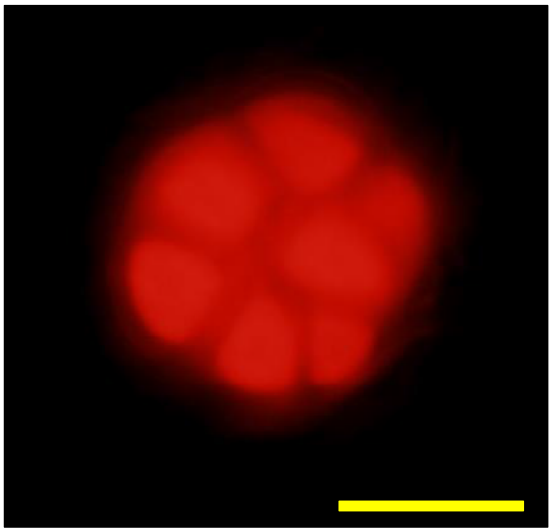

Figure 49b. *Cyanosarcina* sp. illuminated with WG epifluorescence microscopy. Bar is 10 μm in length.

Figure 50. *Cyanosarcina* sp. Bar is 10 μm in length.

Figure 51. *Cyanosarcina* sp. Bar is 10 μm in length.

Order: Chroococcales

Family: Chroococcaceae

Genus: *Cyanosarcina*

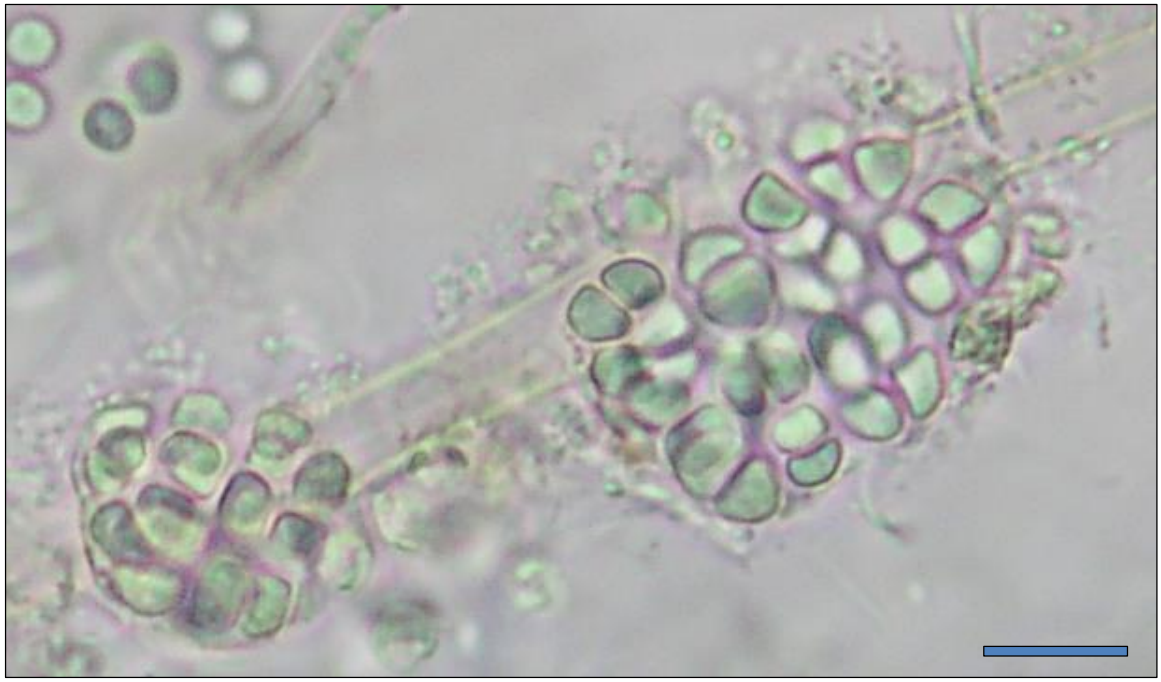

Figure 52. *Cyanosarcina* sp. Bar is 10 μm in length. Image from Mareš, 2006.

Figures 49 to 52 are unknown species of *Cyanosarcina*. When a colony is viewed from "on top," cells appear as wedges (fig. 49) with rounded corners, arranged into a colony of up to 16 cells, 4.9 μm wide by 11 μm long. When the colony is viewed from its side, the cells appear to be reniform. Colonies often attach to filaments of algae (fig. 52).

Order: Chroococcales

Family: Chroococcaceae

Genus: *Geminocystis*

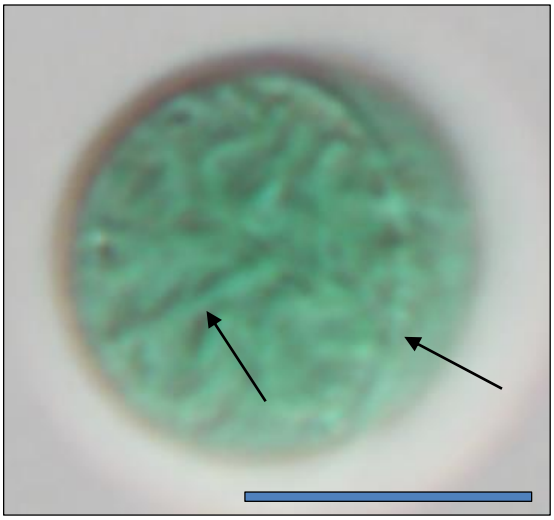

Figure 53. *Geminocystis* sp. Bar is 10 μm in length.

Figure 54. *Geminocystis* sp. Bar is 10 μm in length.

Figures 53 and 54 illustrate *Geminocystis* sp., a spherical unicell that appears 14-15 μm in diameter. Figure 53 shows the cell in the process of dividing in two planes (at arrows). Keritomization present. Taxonomic revision is needed in the future.

Order: Chroococcales

Family: Cyanothrichaceae

Genus: *Johannesbaptistia*

Figure 55. *Johannesbaptistia pellucida*. Bar is 10 μm in length.

Figure 56. *Johannesbaptistia pellucida*. Bar is 10 μm in length.

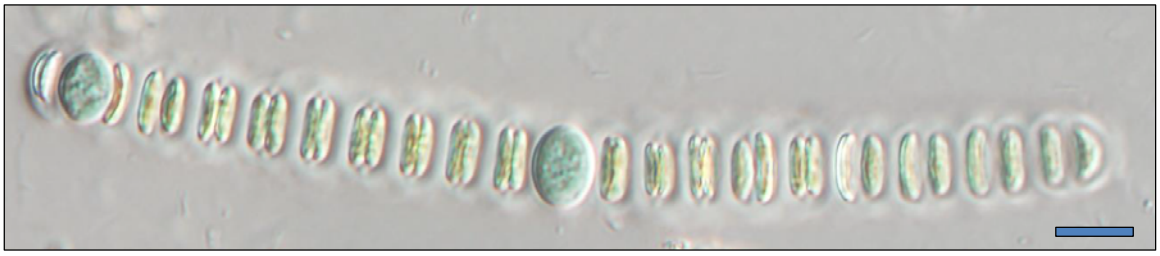

Figure 57. *Johannesbaptistia pellucida*. Bar is 10 μm in length.

Order: Chroococcales

Family: Cyanothrichaceae

Genus: *Johannesbaptistia*

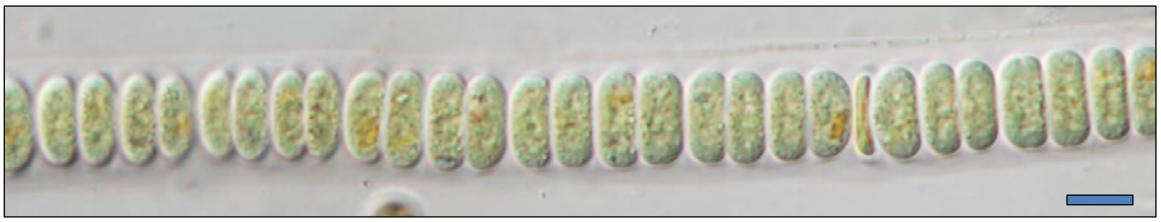

Figure 58a. *Johannesbaptistia pellucida* illuminated with DIC microscopy. Bar is 10 μm in length.

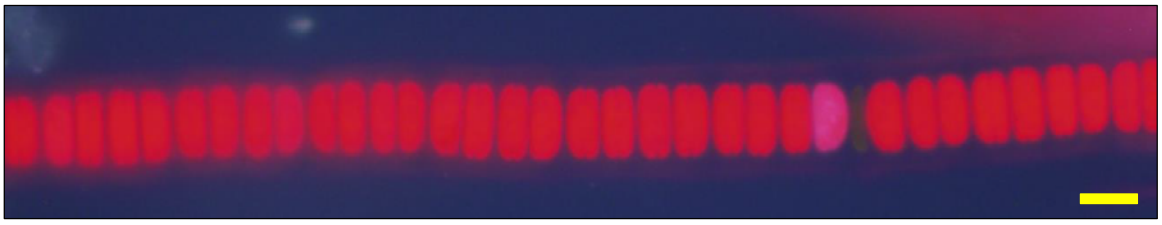

Figure 58b. *Johannesbaptistia pellucida* illuminated with UV epifluorescence microscopy. Bar is 10 μm in length.

Figure 59. *Johannesbaptistia pellucida*. Bar is 10 μm in length.

Figures 55 to 59 illustrate *Johannesbaptistia pellucida,* with the arrangement of round and dividing cells in a mucilaginous pseudo-filament, cells 10.2 μm wide by 4.3 μm long. Calcium carbonate crystals can be seen outside the sheath (fig. 59)

Order: Chroococcales

Family: Entophysalidaceae

Genus: *Chlorogloea*

Figure 60a. *Chlorogloea gardneri* illuminated with DIC microscopy. Bar is 10 μm in length.

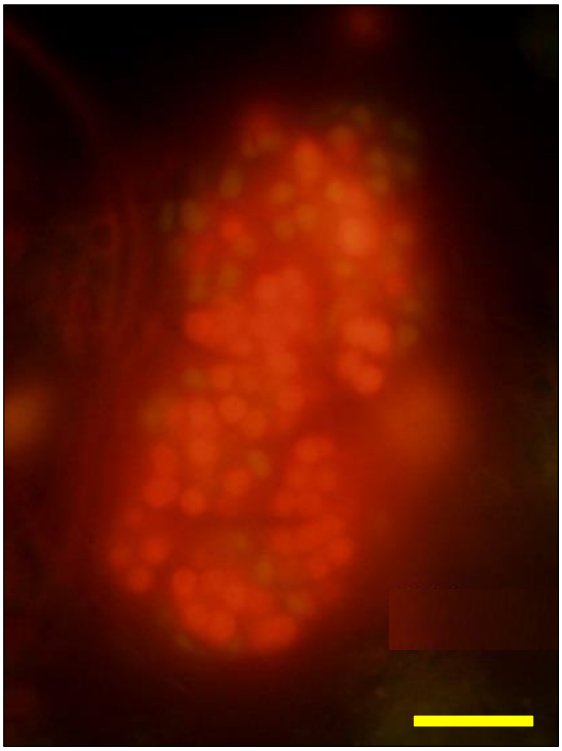

Figure 60b. *Chlorogloea gardneri* illuminated with WB epifluorescence microscopy. Bar is 10 μm in length.

Figures 60a and 60b illustrate *Chlorogloea gardneri*. Olive-green round to elongated cells arranged into an amorphous colony, cells 2.5 μm wide by 3 μm long, Komárek and Komárková-Legnerová (2007).

Order: Chroococcales

Family: Gomphosphaeriaceae

Genus: *Gomphosphaeria*

Figure 61. *Gomphosphaeria* cf. *natans*. Bar is 10 μm in length.

Figure 61 illustrates *Gomphosphaeria* cf. *natans*, with solitary, cordiform-shaped cells that are anchored to the center of the colony by a mucilaginous stalk and cells 5 μm wide by 12 μm long composing a colony.

Order: Chroococcales

Family: Gomphosphaeriaceae

Genus: *Gomphosphaeria*

Figure 62. *Gomphosphaeria semen-vitis*. Bar is 10 μm in length.

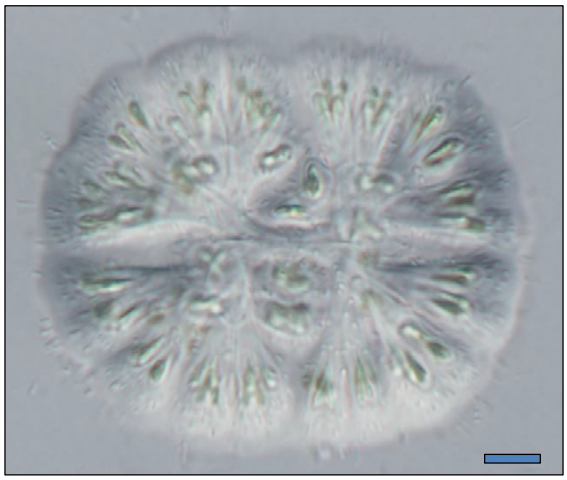

Figure 63a. *Gomphosphaeria semen-vitis* illuminated with DIC microscopy. Bar is 10 μm in length.

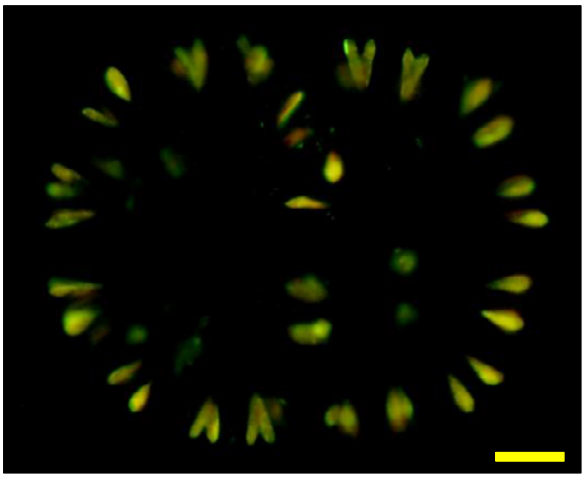

Figure 63b. *Gomphosphaeria semen-vitis* illuminated with WB epifluorescence microscopy. Bar is 10 μm in length.

Figures 62 and 63 illustrate *Gomphosphaeria semen-vitis*, with solitary cells that are anchored to the center of the colony by a mucilaginous stalk and cells 5 μm wide by 12 μm long composing a colony. Figure 63a shows thin cells, and figure 63b shows the reduced amount of pigment present, indicating this colony was under physiological stress.

Order: Oscillatoriales

Family: Borziaceae

Genus: *Borzia*

Figure 64. *Borzia* sp. Bar is 10 μm in length.

Figure 65. *Borzia* sp. Bar is 10 μm in length.

Figure 66. *Borzia* sp. Bar is 10 μm in length.

Figures 64 to 66 illustrate the variation in *Borzia* sp., with cells showing constrictions at the cross walls. The number of cells, almost always less than 8 in the trichome, are 7 μm wide by 4 μm long. Trichomes may be brown, green, or blue-green in color.

Order: Oscillatoriales

Family: Coleofasciculaceae

Genus: *Geitlerinema*

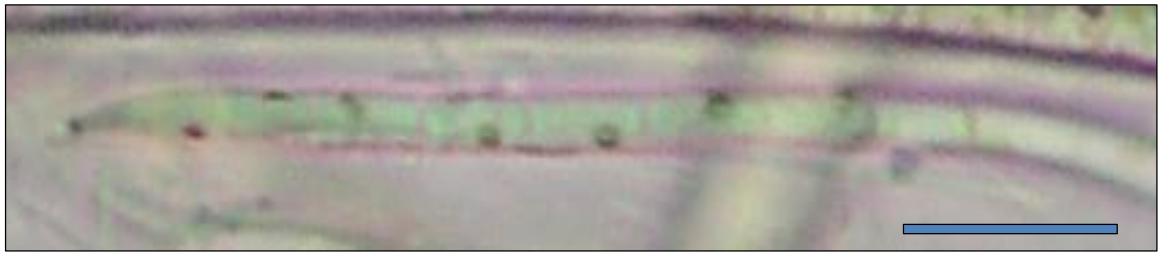

Figure 67. *Geitlerinema earlei*. Bar is 10 μm in length. Image from Mareš, 2006.

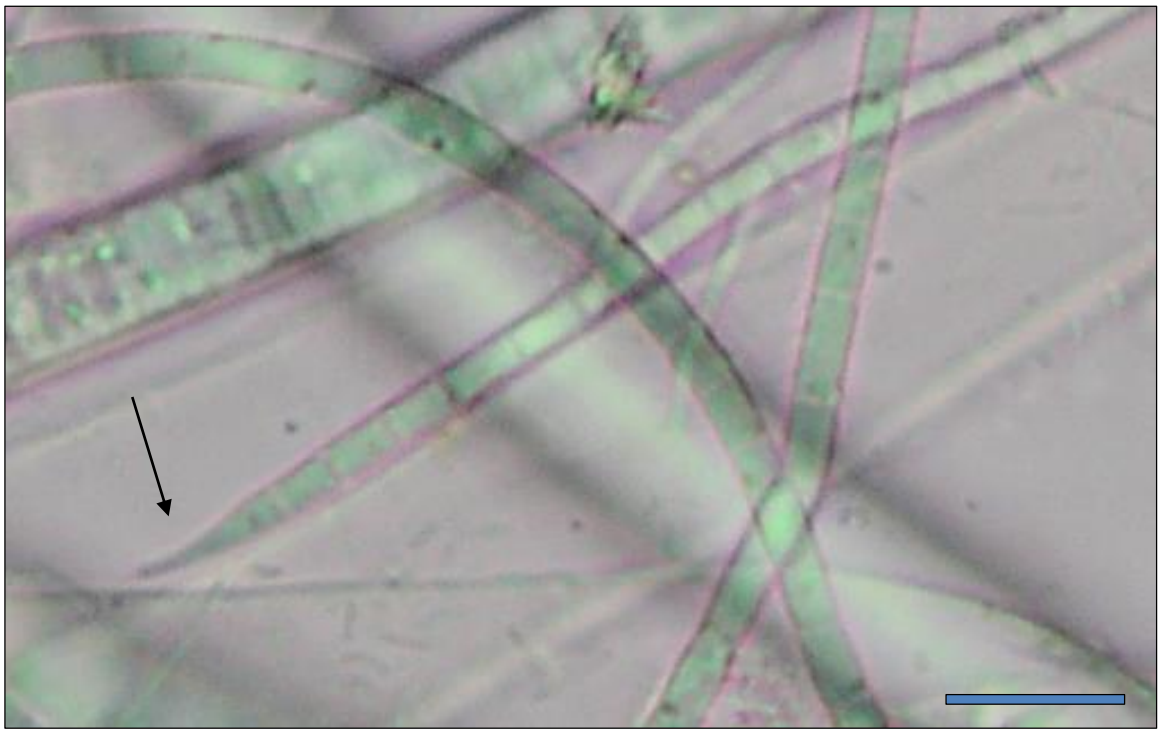

Figure 68. *Geitlerinema earlei*. Bar is 10 μm in length. Image from Mareš, 2006.

Figures 67 and 68 illustrate the morphology of *Geitlerinema earlei*, a slender (2.7 μm wide) trichome with cells 3.5-6.5 μm in length. Apical cell (at arrow) is pointed.

Order: Oscillatoriales

Family: Coleofasciculaceae

Genus: *Geitlerinema*

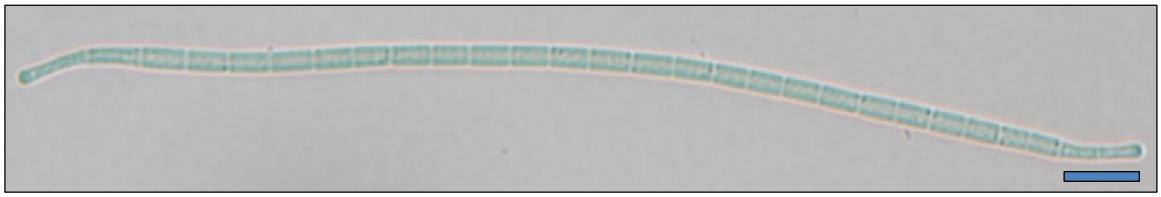

Figure 69. *Geitlerinema splendidum*. Bar is 10 μm in length.

Figure 70a. *Geitlerinema splendidum*. One end of a trichome. Bar is 10 μm in length.

Figure 70b. *Geitlerinema splendidum*. Other end of the same trichome as figure 70a. Bar is 10 μm in length.

Figures 69 and 70 illustrate the morphology of *Geitlerinema splendidum*, a slender (0.9-1.2 μm wide) trichome with cells 4-6 μm in length. Apical cell attenuated, hooked and spherical-capitate.

Order: Oscillatoriales

Family: Gomontiellaceae

Genus: *Komvophoron*

Figure 71. *Komvophoron apiculatum*. Bar is 10 μm in length.

Figure 72. *Komvophoron apiculatum.* Bar is 10 μm in length.

Figures 71 and 72 show the variation in cell length in *Komvophoron apiculatum,* after Turicchia and others (2009), with elongated cells 3.2-4.5 μm long (fig. 71) or 1.6-2.3 μm long (fig. 72) by 1.8 μm wide and a straight conical apical cell; from a calcium-rich habitat. Note the apical cell on one end is conical, while the other end is not.

Order: Oscillatoriales

Family: Gomontiellaceae

Genus: *Komvophoron*

Figure 73. *Komvophoron* cf. *apiculatum*. Bar is 10 μm in length.

Figure 74. *Komvophoron* cf. *apiculatum*. Bar is 10 μm in length.

Order: Oscillatoriales

Family: Gomontiellaceae

Genus: *Komvophoron*

Figure 75. *Komvophoron* cf. *apiculatum*. Bar is 10 μm in length.

Figure 76. *Komvophoron* cf. *apiculatum*. Bar is 10 μm in length.

Figures 73 to 76 show the variation in trichome length and color in *Komvophoron* cf. *apiculatum,* after Turicchia and others (2009), which is similar to figures 71 and 72, but with a different apical cell, that is not conical; from a calcium-rich habitat. This species is highly motile.

Order: Oscillatoriales

Family: Gomontiellaceae

Genus: *Komvophoron*

Figure 77a. *Komvophoron* cf. *apiculatum* illuminated with DIC microscopy. Bar is 10 μm in length.

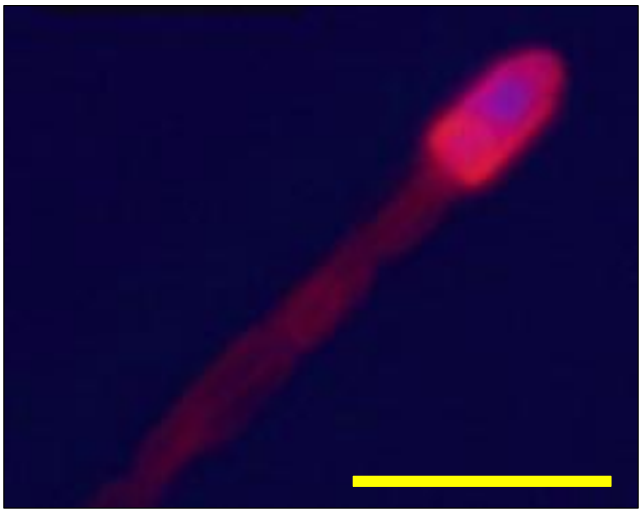

Figure 77b. *Komvophoron* cf. *apiculatum* illuminated with UV epifluorescence microscopy. Bar is 10 μm in length.

Figure 78. *Komvophoron* cf. *apiculatum*. Bar is 10 μm in length.

Figure 79. *Komvophoron* cf. *apiculatum*. Bar is 10 μm in length.

Figures 77 to 79 show the variation apical cells of *Komvophoron* cf. *apiculatum*. The apical cell (fig. 77b) has brighter fluorescence at the base of the cell and compared to the cells of the trichome is blue in an area lacking chlorophyll.

Order: Oscillatoriales

Family: Gomontiellaceae

Genus: *Komvophoron*

Figure 80. *Komvophoron rostratum*. Bar is 10 μm in length.

Figure 81. *Komvophoron rostratum*. Bar is 10 μm in length.

Figures 80 and 81 illustrate the *Komvophoron rostratum*, with cells in a trichome that is straight or waved, with strong constriction between spherical (fig. 80) or barrel-shaped cells (fig. 81). The spherical cells in figure 80 are 2.2 μm in diameter; the apical cell is 3.4 μm in length. The barrel-shaped cells in figure 81 are 2.5 μm wide by 3.6 μm long; the apical cell is 5.5 μm long. This species has an apical cell that is slightly bent and this species is highly motile.

Order: Oscillatoriales

Family: Gomontiellaceae

Genus: *Komvophoron*

Figure 82. *Komvophoron* cf. *rostratum*. Bar is 10 μm in length.

Figure 83. *Komvophoron* cf. *rostratum*. Bar is 10 μm in length.

Figures 82 and 83 *Komvophoron* cf. *rostratum* is similar to *Komvophoron rostratum*; however, there seems to be a deeper incision between the cells, which are 3.3 μm wide by 2.2 μm in length. The apical cell on the trichome has the same morphology as *Komvophoron rostratum*.

Order: Oscillatoriales

Family: Microcoleaceae

Genus: *Arthrospira*

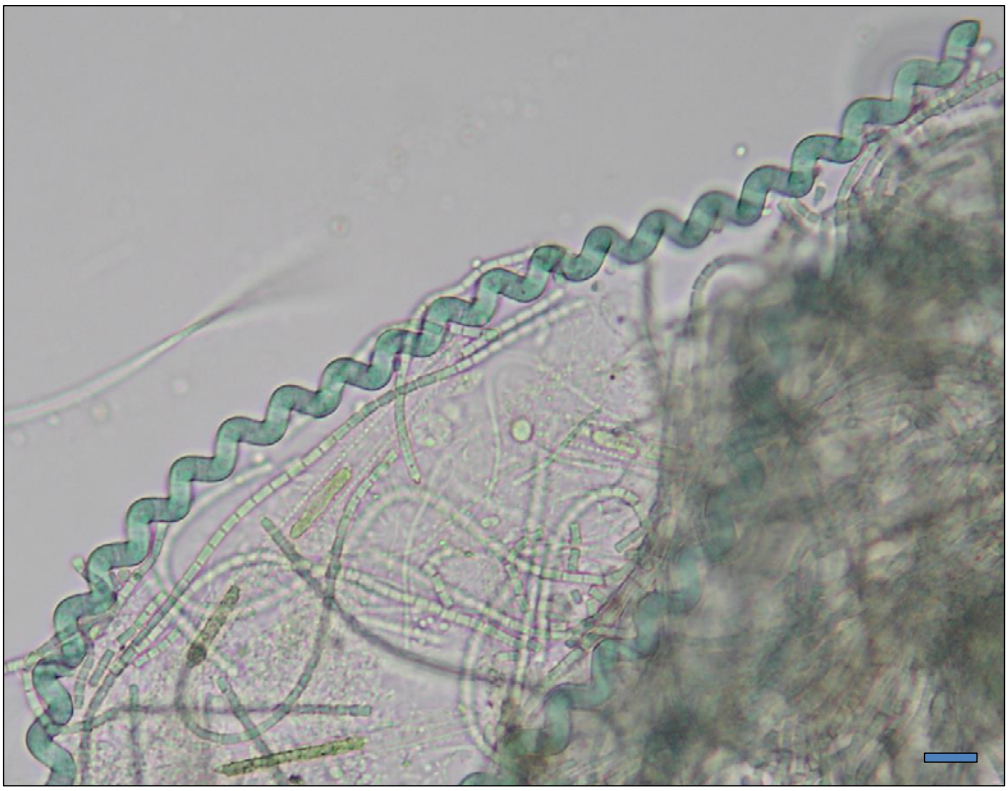

Figure 84. *Arthrospira jenneri*. Bar is 10 μm in length. Image from Mareš, 2006.

Figure 85. *Arthrospira jenneri*. Bar is 10 μm in length. Image from Mareš, 2006.

Figures 84 and 85 illustrate the morphology of the species *Arthrospira jenneri,* a cylindrical trichome loosely coiled, and visible cross-walls, 4.5 μm in width and diameter; 12 μm per coil.

Order: Oscillatoriales

Family: Oscillatoriaceae

Genus: *Lyngbya*

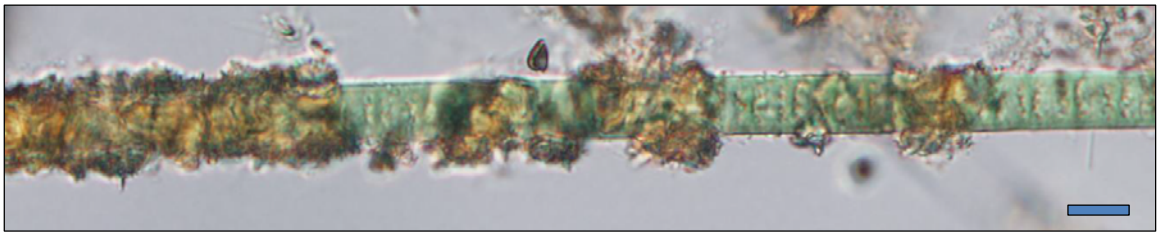

Figure 86a. *Lyngbya calcarea* illuminated with DIC microscopy. Bar is 10 μm in length.

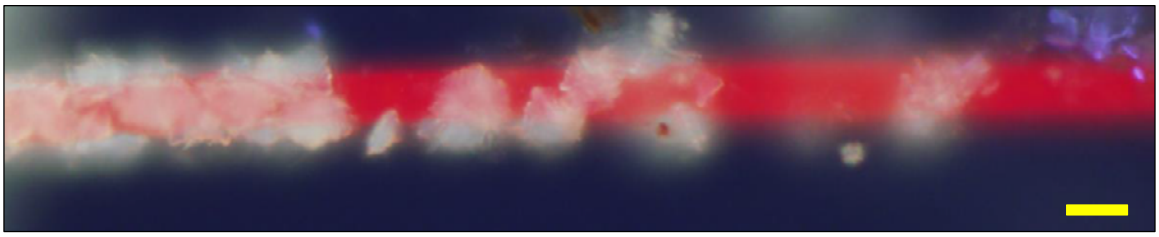

Figure 86b. *Lyngbya calcarea* illuminated with UV epifluorescence microscopy. Bar is 10 μm in length.

Figures 86a and 86b characterize the early stage of calcium carbonate deposition by *Lyngbya calcarea,* with groups of brown crystals under DIC and white under UV illumination. Trichomes are 9-10 μm wide, cells are 5-6 μm long.

Order: Oscillatoriales

Family: Oscillatoriaceae

Genus: *Lyngbya*

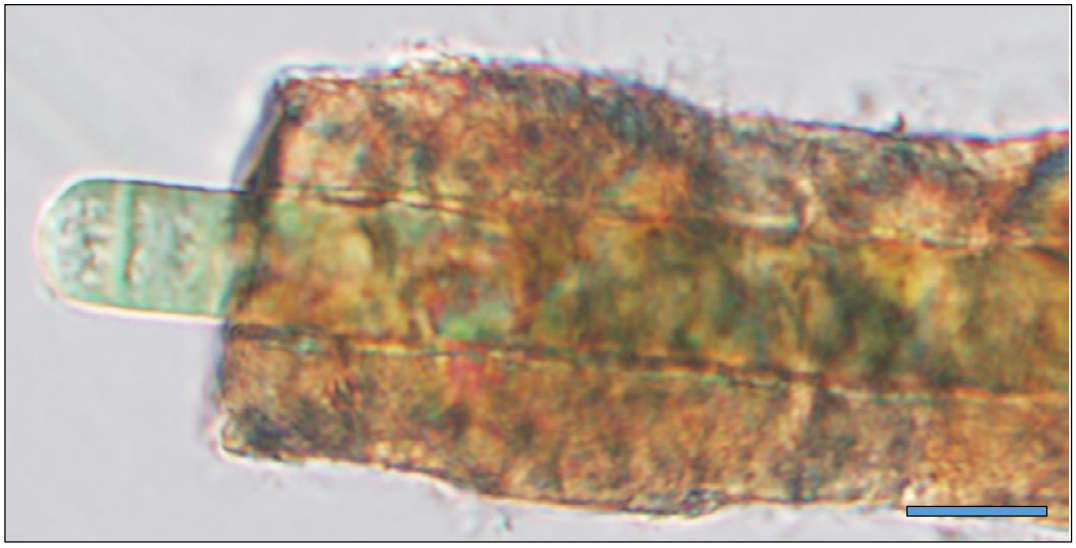

Figure 87a. *Lyngbya calcarea* illuminated with DIC microscopy. Bar is 10 μm in length.

Figure 87b. *Lyngbya calcarea* illuminated with UV epifluorescence microscopy. Bar is 10 μm in length.

Figures 87a and 87b Illustrates the later stage of calcium carbonate deposition, with mucilaginous sheath encrusted with calcium carbonate, brown under DIC and white under UV illumination. The motile trichome had extended beyond the calcium carbonate in figure 87b.

Order: Oscillatoriales

Family: Oscillatoriaceae

Genus: *Lyngbya*

Figure 88. *Lyngbya martensiana*. Image courtesy of Jaroslava Komárková. Bar is 20 μm in length.

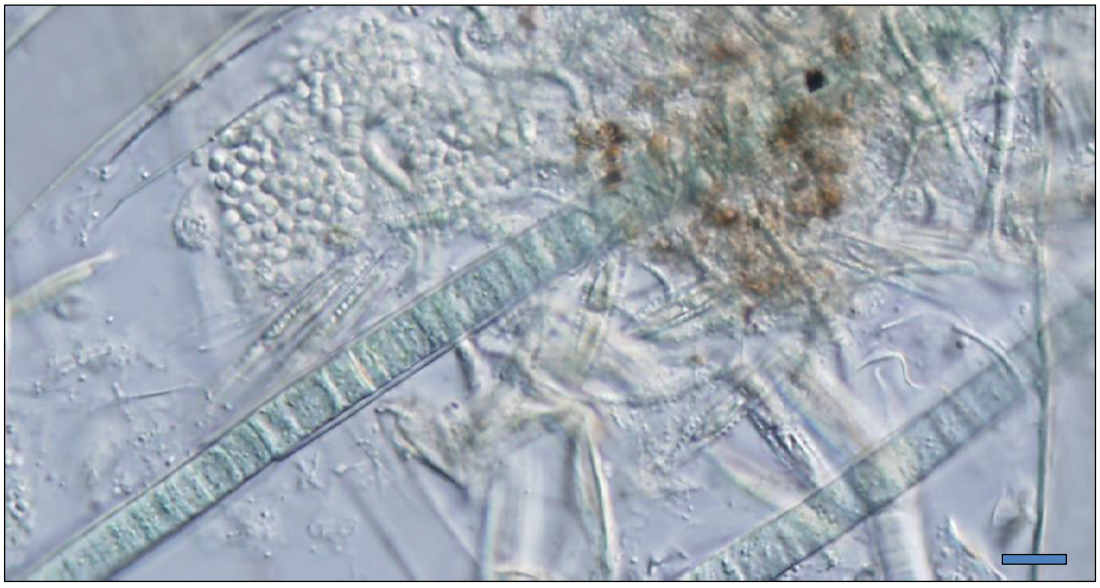

Figure 89. *Lyngbya martensiana*. Image courtesy of Jaroslava Komárková. Bar is 10 μm in length.

Figures 88 and 89 illustrate the morphology of *Lyngbya martensiana,* with short, cylindrical cells and the trichome 6-12 μm wide within a colorless sheath.

Order: Oscillatoriales

Family: Oscillatoriaceae

Genus: *Lyngbya*

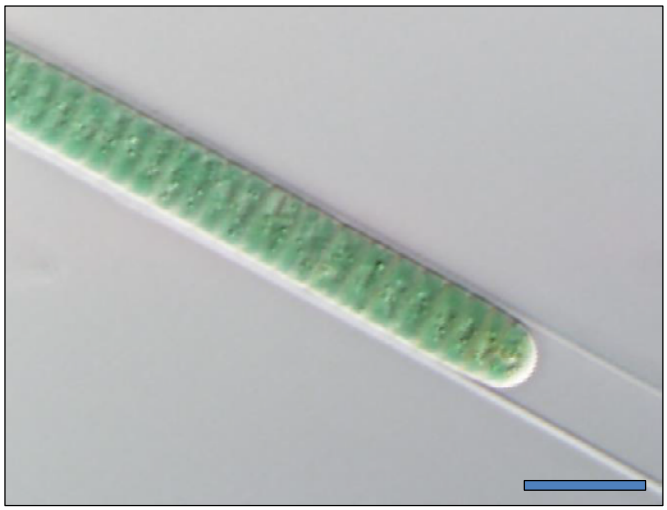

Figure 90a. *Lyngbya minor* illuminated with DIC microscopy. Bar is 10 μm in length.

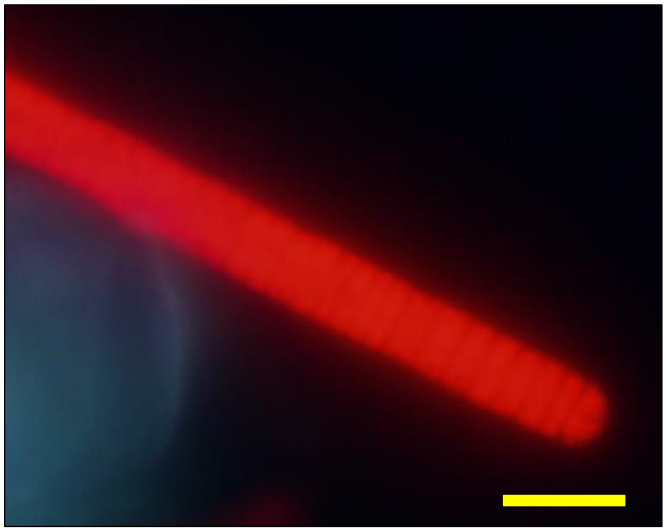

Figure 90b. *Lyngbya minor* illuminated with UV epifluorescence microscopy. Bar is 10 μm in length.

Figures 90a and 90b the characteristic morphology of *Lyngbya minor,* with cells that are 5-6 μm wide by 1.9 μm long. The UV epifluorescence image (fig. 90b) provides a better visual of the cell length.

Order: Oscillatoriales

Family: Oscillatoriaceae

Genus: *Lyngbya*

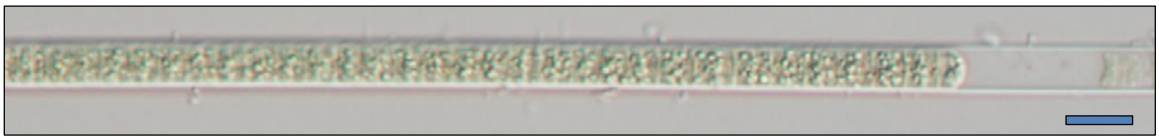

Figure 91. *Lyngbya minor*. Bar is 10 μm in length.

Figure 92. *Lyngbya minor*. Bar is 10 μm in length.

Figure 93. *Lyngbya minor*. Bar is 10 μm in length.

Figures 91 to 93 show the variation in the morphology and pigmentation of *Lyngbya minor*, with short, cylindrical cells 6.6 μm wide by 3.0 μm long (fig. 91), 5.1 μm wide by 4.6 μm long (fig. 92), and 5.3 μm wide by 5.1 μm long (fig. 93).

Order: Oscillatoriales

Family: Oscillatoriaceae

Genus: *Lyngbya*

Figure 94. *Lyngbya ocreata*. Image courtesy of Jaroslava Komárková. Bar is 10 μm in length.

Figure 94 illustrates the morphology of *Lyngbya ocreata* with a thick sheath that can be yellow to brown, and sometimes lamellated. The trichome is wide (up to 18.5 μm) and has an apical cell that is capitate.

Order: Oscillatoriales

Family: Oscillatoriaceae

Genus: *Oscillatoria*

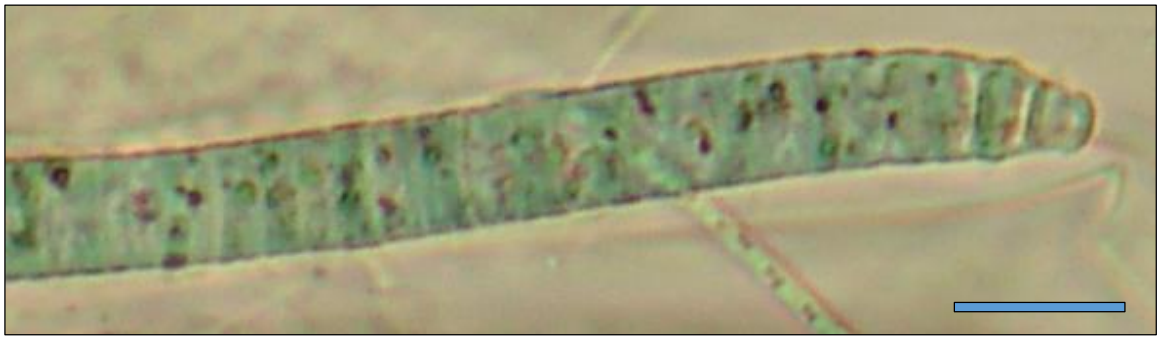

Figure 95. *Oscillatoria anguina*. Bar is 10 μm in length. Image from Mareš, 2006.

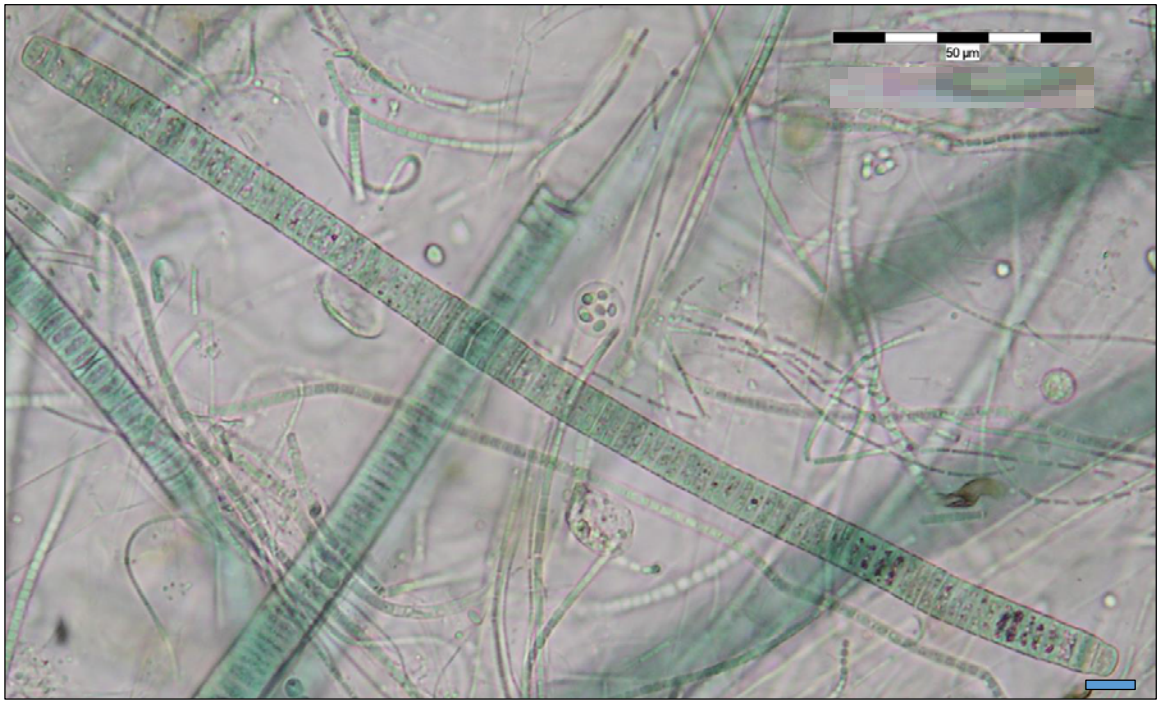

Figure 96. *Oscillatoria anguina*. Bar is 10 μm in length. Image from Mareš, 2006.

Figure 95 and 96 illustrate a typical species of *Oscillatoria*, which is similar to *Lyngbya* without the sheath. The trichomes, 7-8 μm wide, are cylindrical, unbranched, wide, and composed of short cylindrical cells.The end of the trichome in *Oscillatoria anguina* is gradually attenuated, with an apical cell that is capitate to flattened.

Order: Oscillatoriales

Family: Oscillatoriaceae

Genus: *Oscillatoria*

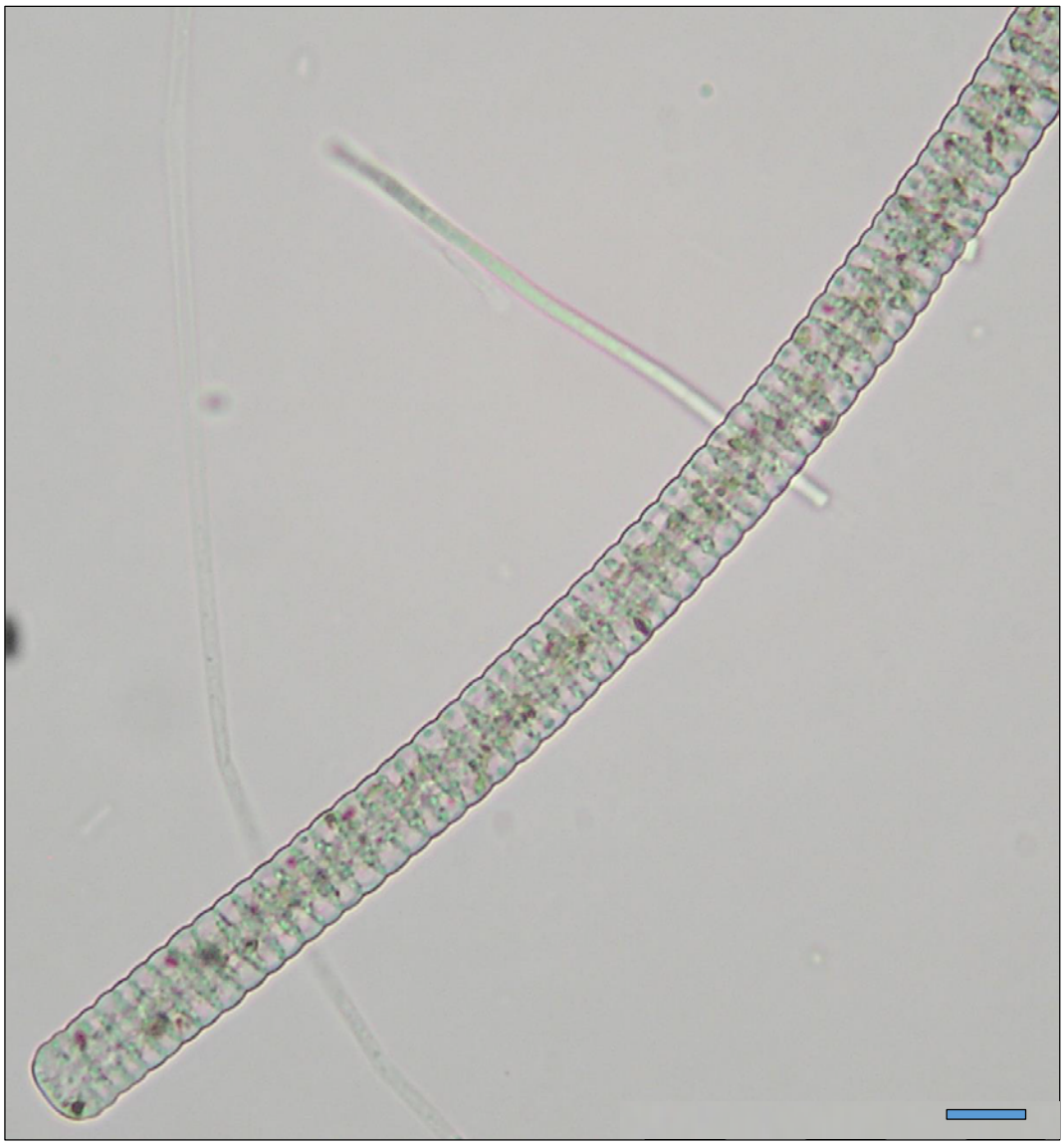

Figure 97. *Oscillatoria crassa*. Bar is 10 μm in length. Image from Mareš, 2006.

Figure 97 illustrates the morphology of *Oscillatoria crassa.* The trichome is 11-12 μm wide and does not taper or bend. Cells have a distinct constriction at the cross-walls and a broadly flattened apical cell.

Order: Oscillatoriales

Family: Oscillatoriaceae

Genus: *Oscillatoria*

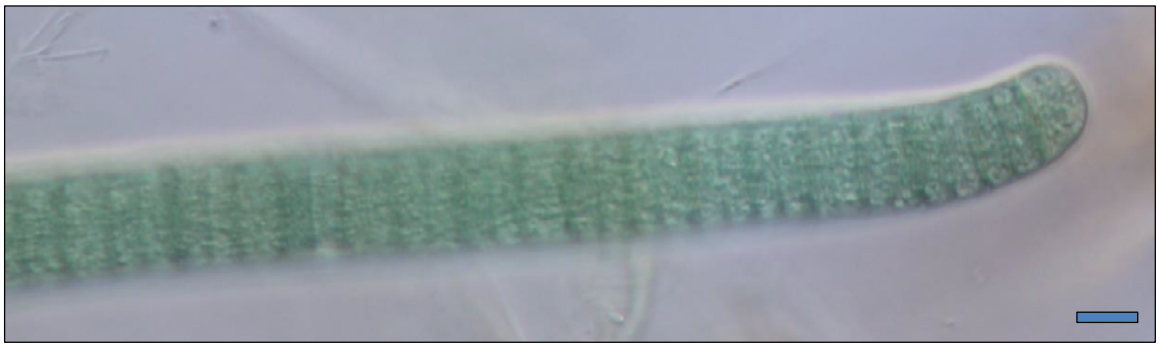

Figure 98. *Oscillatoria jenensis*. Bar is 10 μm in length.

Figure 99. *Oscillatoria jenensis*. Bar is 50 μm in length.

Figures 98 and 99 are a typical species of *Oscillatoria*, which is similar to *Lyngbya* without the sheath. The trichome is unbranched, wide, and composed of short cylindrical cells. The end of the trichome may be bent/curved. *Oscillatoria jenensis* is 20 μm wide, and the cells are 7.2 μm long.

Order: Oscillatoriales

Family: Oscillatoriaceae

Genus: *Phormidium*

Figure 100. *Phormidium chalybeum*. Bar is 20 μm in length. Image from Mareš, 2006.

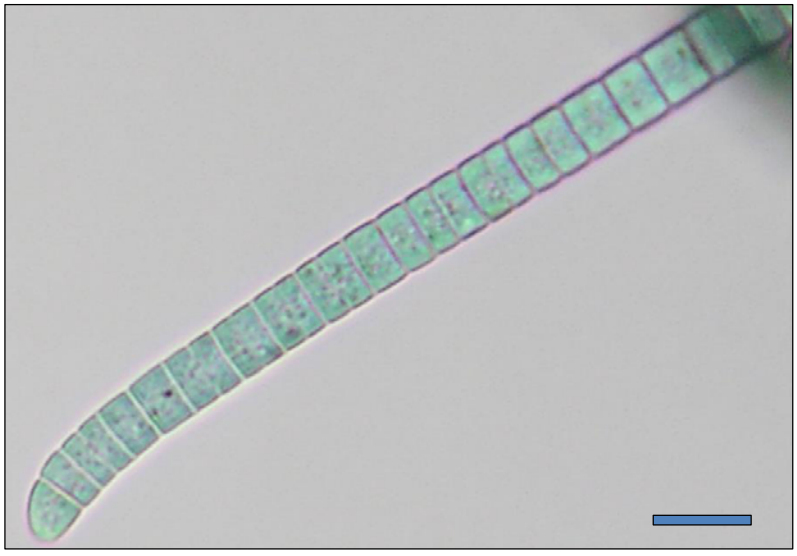

Figure 101. *Phormidium chalybeum*. Bar is 10 μm in length. Image from Mareš, 2006.

Figures 100 and 101 illustrate *Phormidium chalybeum*, which has a slightly curved trichome, 7-8 μm wide, with an apical cell that is hooked or obtuse, but not thickened.

Order: Oscillatoriales

Family: Oscillatoriaceae

Genus: *Phormidium*

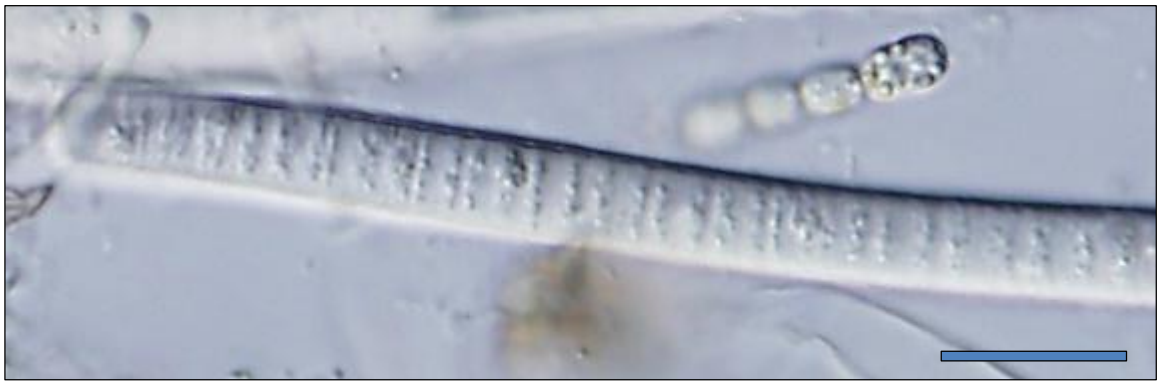

Figure 102. *Phormidium granulatum*. Image courtesy of Jaroslava Komárková. Bar is 10 μm in length.

Figure 102 illustrates *Phormidium granulatum*, with a cylindrical trichome with no sheath, 4.5-5 μm wide, with distinct granules at the cross-walls.

Order: Oscillatoriales

Family: Oscillatoriaceae

Genus: *Phormidium*

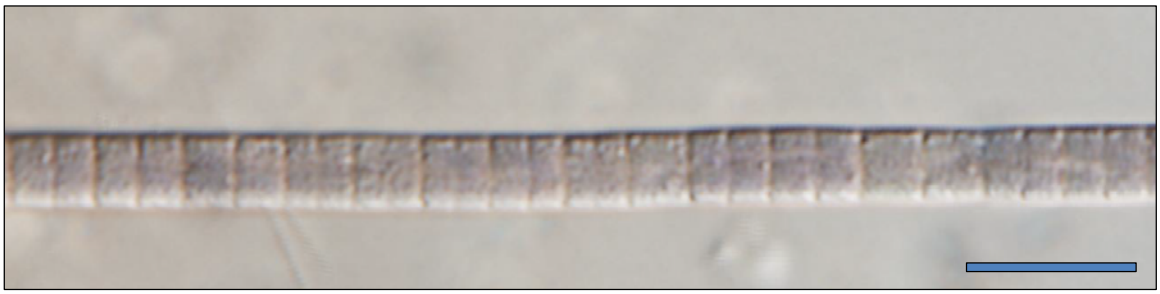

Figure 103. *Phormidium* sp. Bar is 10 μm in length.

Figure 104a. *Phormidium* sp. illuminated with DIC microscopy. Bar is 10 μm in length.

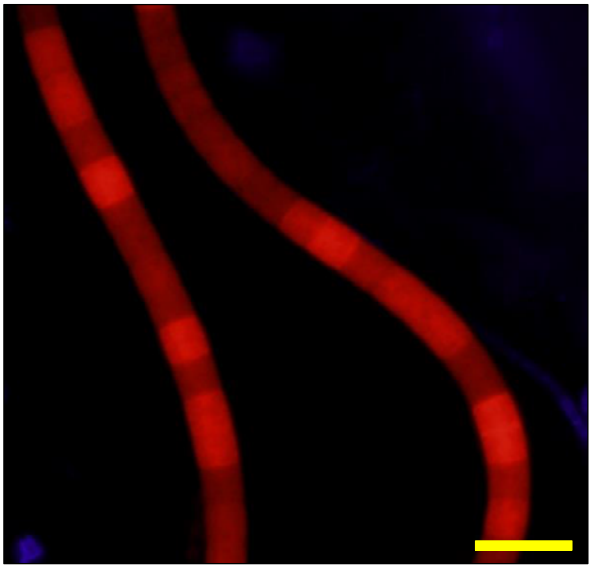

Figure 104b. *Phormidium* sp. illuminated with UV epifluorescence microscopy. Bar is 10 μm in length.

Figures 103 and 104 illustrate a *Phormidium* sp., with cells that range from 4.3-4.6 μm wide by 3.3 μm long. Epifluorescence microscopy reveals (fig. 104b) the variation in pigment content of adjacent cells that cannot be discerned in figure 104a.

Order: Pseudanabaenales

Family: Schizotrichaceae

Genus: *Schizothrix*

Figure 105a. *Schizothrix* sp. illuminated with DIC microscopy. Bar is 10 μm in length.

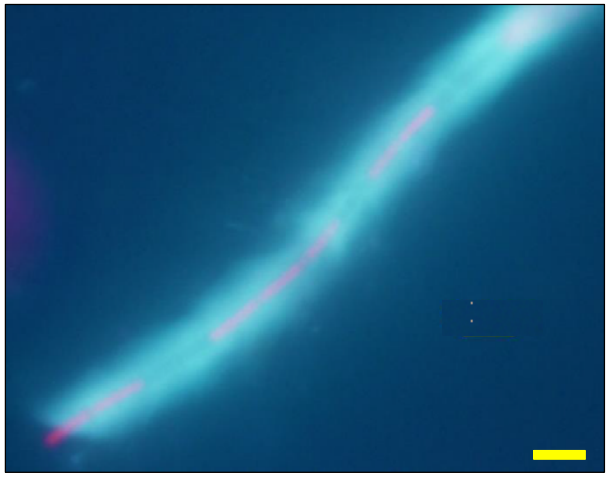

Figure 105b. *Schizothrix* sp. illuminated with UV epifluorescence microscopy. Bar is 10 μm in length.

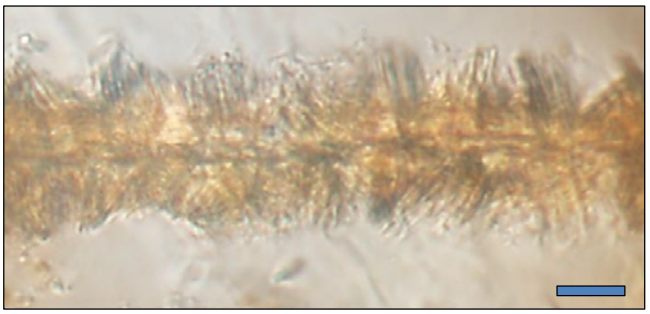

Figure 106. *Schizothrix* sp. Bar is 10 μm in length.

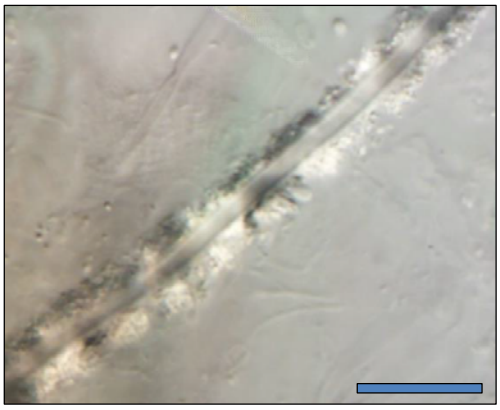

Figure 107. *Schizothrix* sp. Bar is 10 μm in length.

Figures 105 to107 illustrate *Schizothrix* sp. Figures 105a and 105b illustrate precipitated calcium carbonate (blue-white glow under UV illuminated epifluorescence microscopy) mediated by this species. Figure 106 shows one form of calcium carbonate that has needle-like structure. Figure 107 shows that the precipitate persists even after the trichome inside the sheath has degraded.

Order: Pseudanabaenales

Family: Schizotrichaceae

Genus: *Schizothrix*

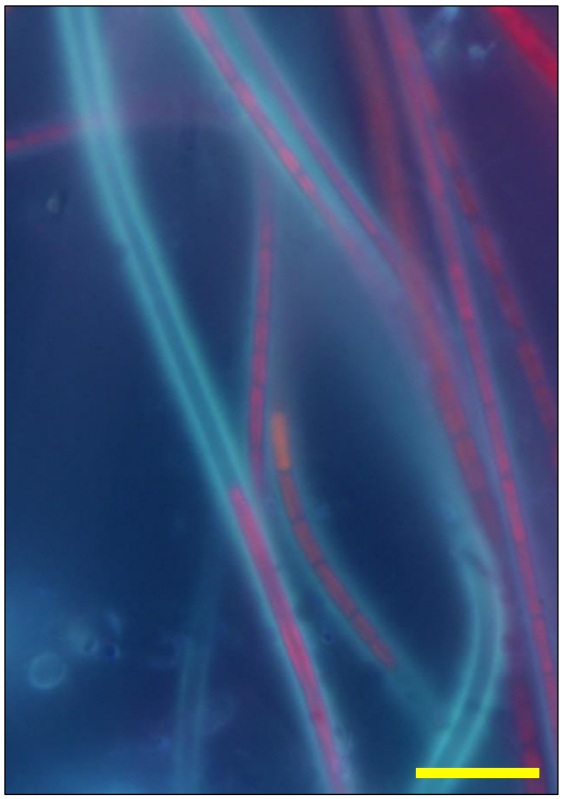

Figure 108. *Schizothrix* sp. illuminated with UV epifluorescence microscopy. Bar is 10 μm in length.

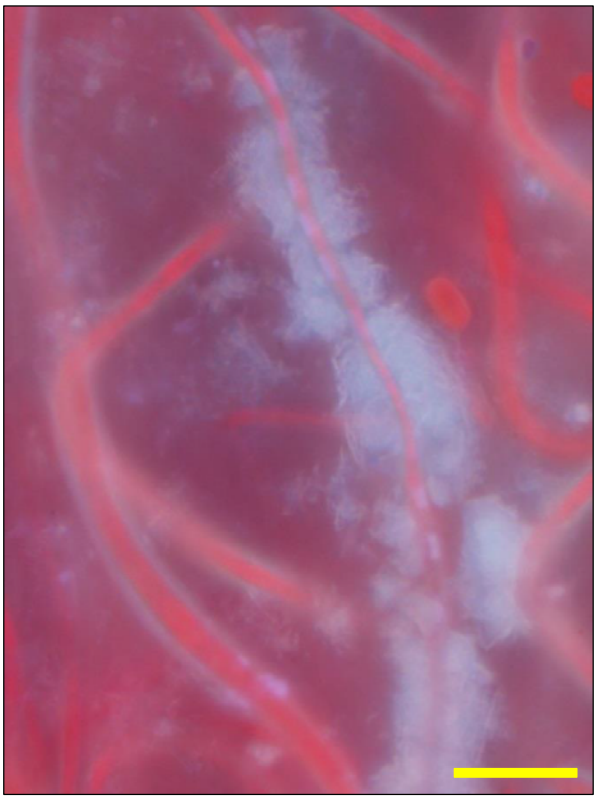

Figure 109. *Schizothrix* sp. illuminated with UV epifluorescence microscopy. Bar is 10 μm in length.

Figures 108 and 109 illustrate precipitates of calcium carbonate (blue-white glow under UV illuminated epifluorescence microscopy) mediated by *Schizothrix*.

Order: Pseudanabaenales

Family: Schizotrichaceae

Genus: *Schizothrix*

Figure 110. *Schizothrix* sp. Bar is 10 μm in length.

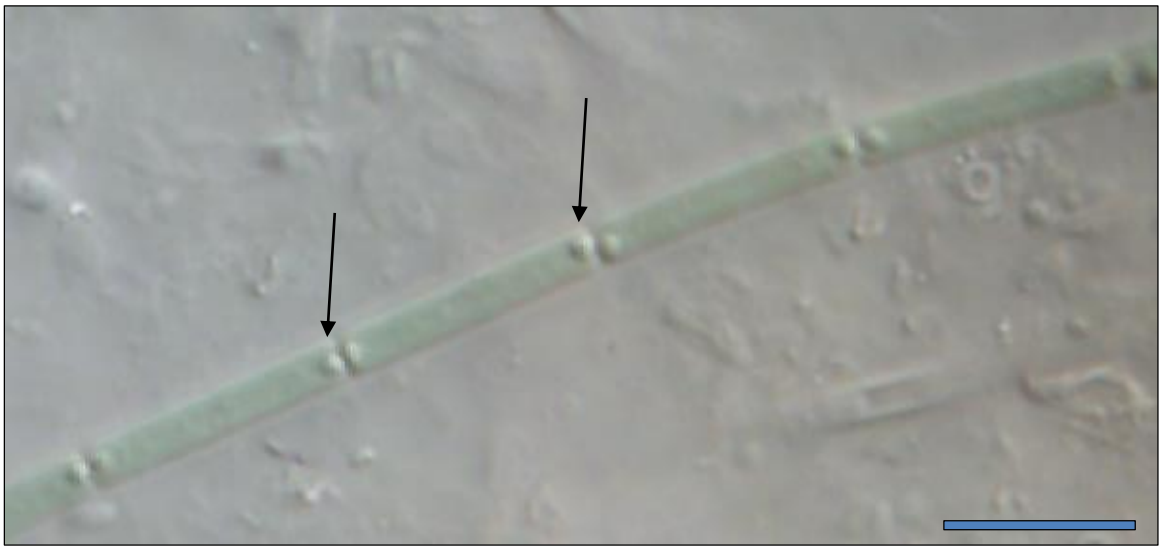

Figure 111. *Schizothrix* sp. Bar is 10 μm in length.

Figures 110 and 111 illustrate the genus *Schizothrix*, an abundant organism in the marl habitats of the Everglades. Intertwining filaments are common (fig. 109). The filaments are narrow, 1.4 μm (fig. 110) to 2.2 μm (fig. 111), and the cells are long, 7.7 μm (fig. 109) to 14.2 μm (fig. 111). Granules may be present near the ends of the cell (fig. 111, at arrows).

Order: Spirulinales

Family: Spirulinaceae

Genus: *Spirulina*

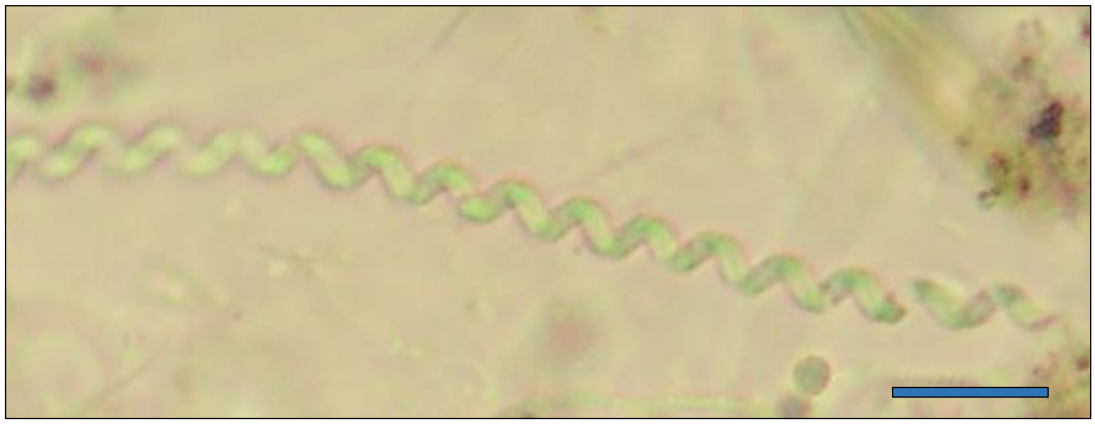

Figure 112. *Spirulina meneghiniana*. Bar is 10 μm in length. Image from Mareš, 2006.

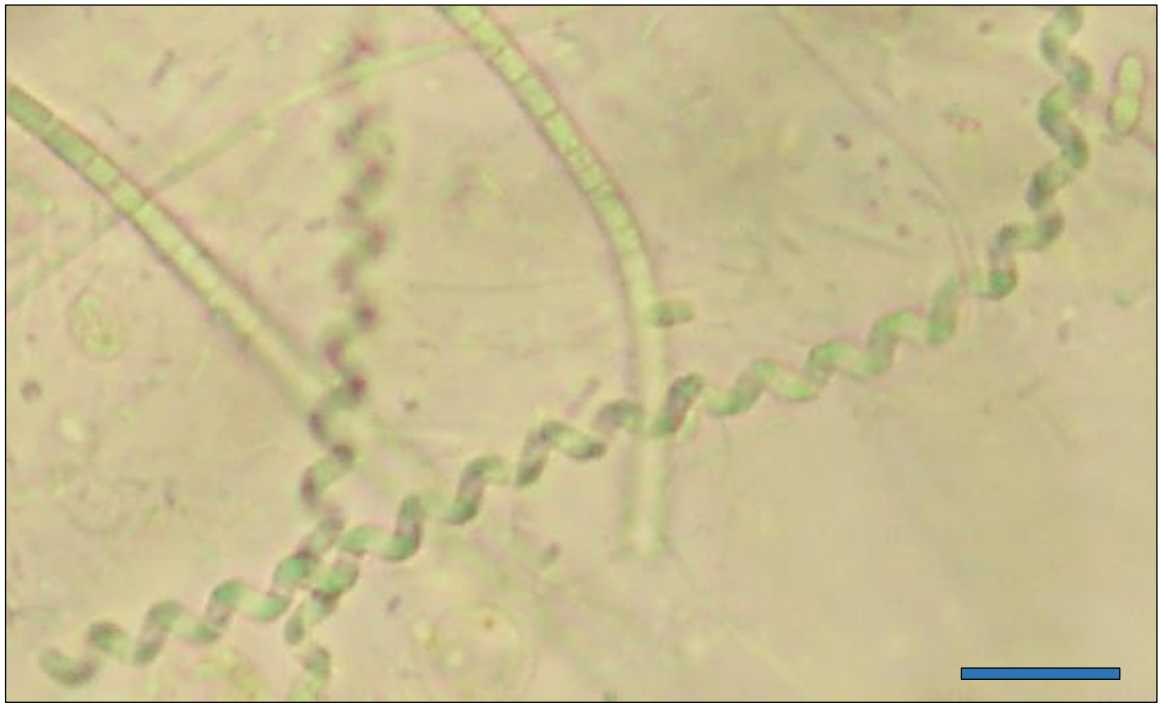

Figure 113. *Spirulina meneghiniana.* Bar is 10 μm in length. Image from Mareš, 2006.

Figures 112 and 113 illustrate *Spirulina meneghiniana,* a cylindrical trichome regularly helically coiled, with a homogenous cell content. Trichome is 1-2 μm wide, coils 2.5 to 8 μm.

Order: Spirulinales

Family: Spirulinaceae

Genus: *Spirulina*

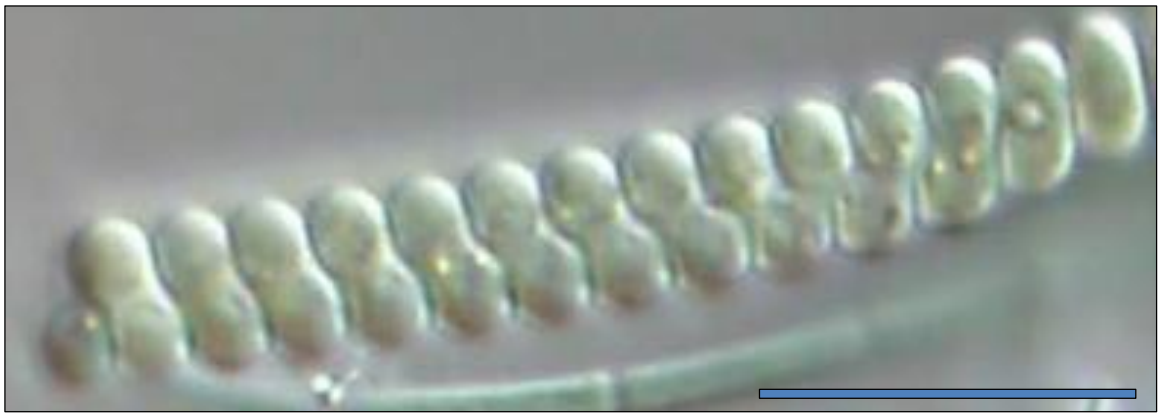

Figure 114. *Spirulina subsalsa*. Bar is 10 μm in length.

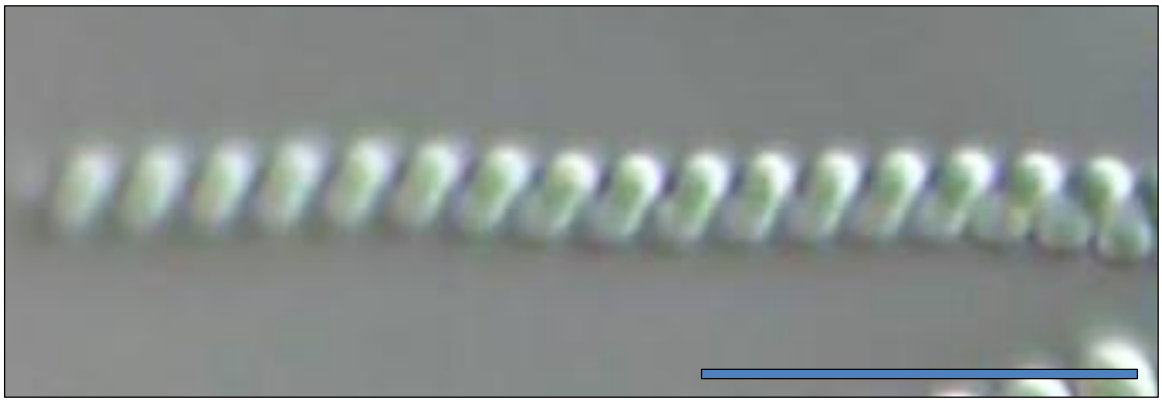

Figure 115. *Spirulina tenerrima.* Bar is 10 μm in length.

Figures 114 and 115 illustrate the genus *Spirulina*, with the species *S. subsalsa* having a wider trichome (4.3-4.8 μm) and cells ranging from 1.9 to 2.1 μm tightly attached to one another. *S. tenerrima,* (fig. 115) trichomes are 2.4 μm wide and the cells are 1.5 μm long.

Order: Synechococcales

Family: Coelosphaeriaceae

Genus: *Coelomoron*

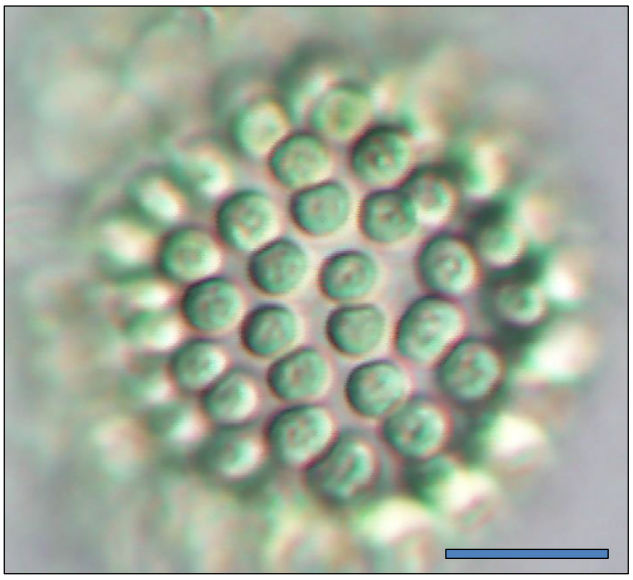

Figure 116. *Coelomoron tropicale.* Bar is 10 μm in length.

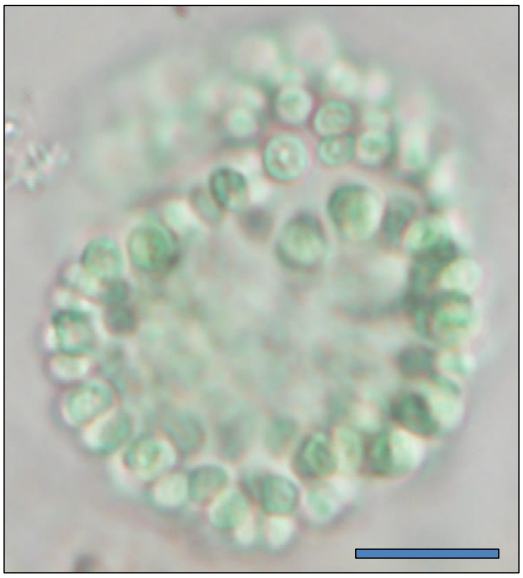

Figure 117. *Coelomoron tropicale.* Bar is 10 μm in length.

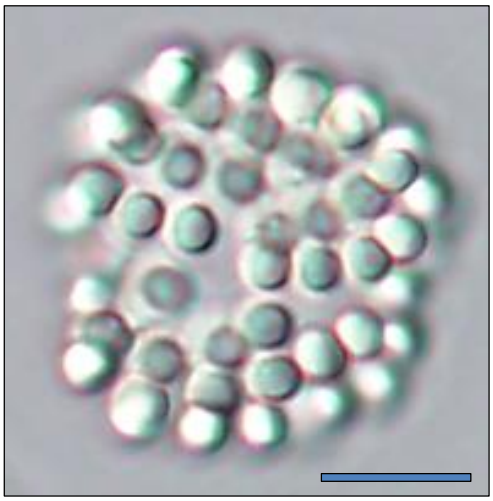

Figure 118. *Coelomoron tropicale.* Bar is 10 μm in length.

Figures 116 to 118 illustrate *Coelomoron tropicale*. A colony of cells on the outer edge of a hollow, mostly spherical colony. Figure 117 shows the absence of cells in the hollow interior of the colony; figure 116 shows the a colony focused on the outer layer of cells.

Order: Synechococcales

Family: Leptolyngbyaceae

Genus: *Leptolyngbya*

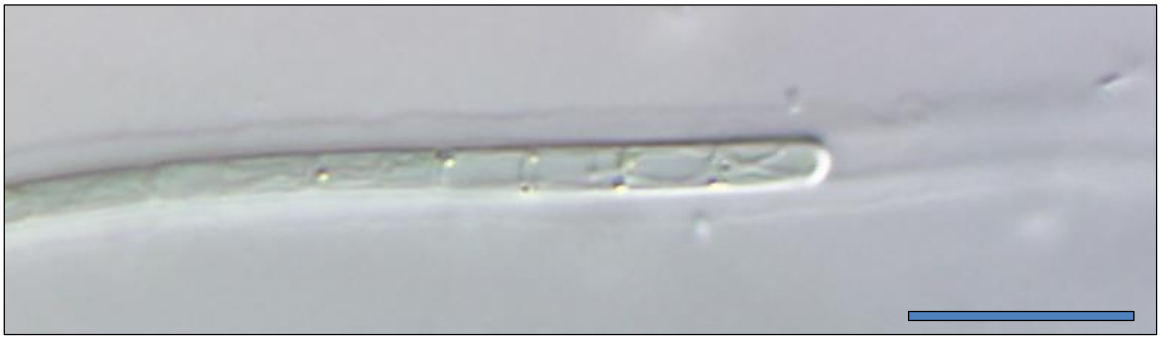

Figure 119. *Leptolyngbya eliskae.* Bar is 10 μm in length.

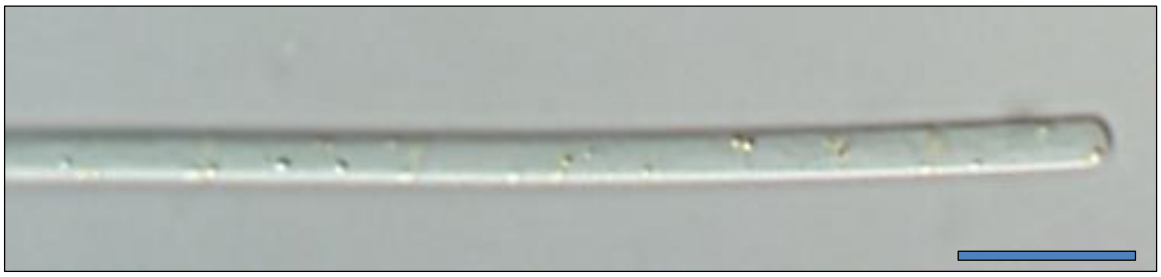

Figure 120. *Leptolyngbya eliskae.* Bar is 10 μm in length.

Figures 119 and 120 illustrate *Leptolyngbya eliskae* with pale grayish trichomes that have irregularly arranged granules. Trichomes are straight and without constrictions and indistinct cross-walls. The trichomes are narrow, 1.9 μm to 2.4 μm wide, and the cells are longer than wide, 3.9 μm to 4.4 μm long (Turicchia and others, 2009).

Order: Synechococcales

Family: Leptolyngbyaceae

Genus: *Leptolyngbya*

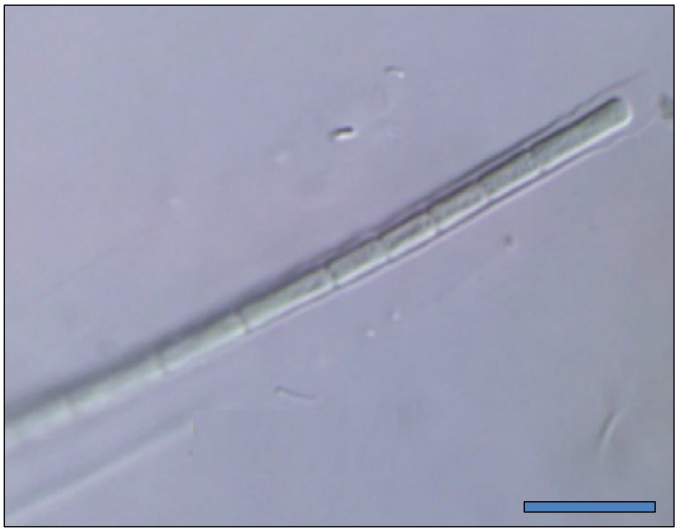

Figure 121. *Leptolyngbya eliskae*. Bar is 10 μm in length.

Figure 122. *Leptolyngbya eliskae*. Bar is 10 μm in length.

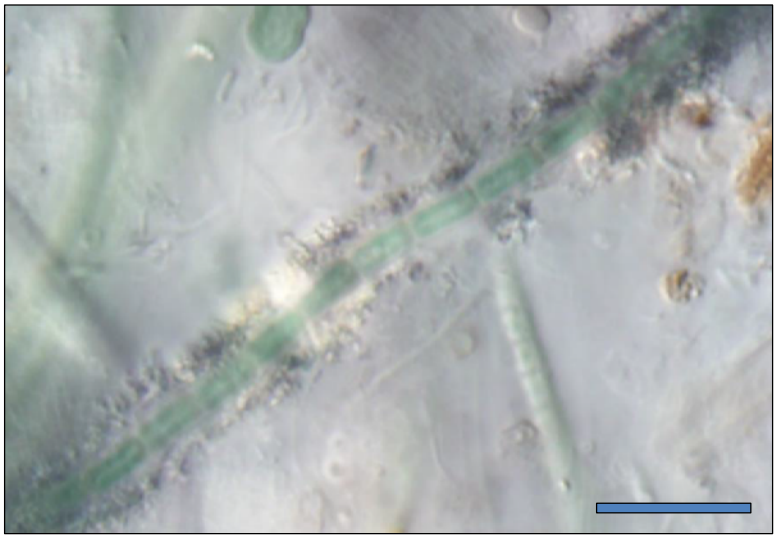

Figure 123. *Leptolyngbya eliskae*. Bar is 10 μm in length.

Figures 121 to 123 illustrate *Leptolyngbya eliskae*, with narrow trichomes, 1.8 μm (fig. 121) to 2.2 μm (fig. 122), and the cells are long, 4.4 μm (fig. 121) to 4.3 μm (fig. 123). Figure 123 also shows the calcium carbonate precipitate.

Order: Synechococcales

Family: Leptolyngbyaceae

Genus: *Leptolyngbya*

Figure 124. *Leptolyngbya lagerheimii*. Bar is 10 μm in length. Image from Mareš, 2006.

Figure 125. *Leptolyngbya lagerheimii*. Bar is 10 μm in length. Image from Mareš, 2006.

Figures 124 and 125 illustrate *Leptolyngbya lagerheimii,* with a cylindrical trichome with a thin sheath, regularly coiled, 2-2.5 wide. Thick, translucent cross-walls allow the individual cells to be distinguished.

Order: Synechococcales

Family: Merismopediaceae

Genus: *Aphanocapsa*

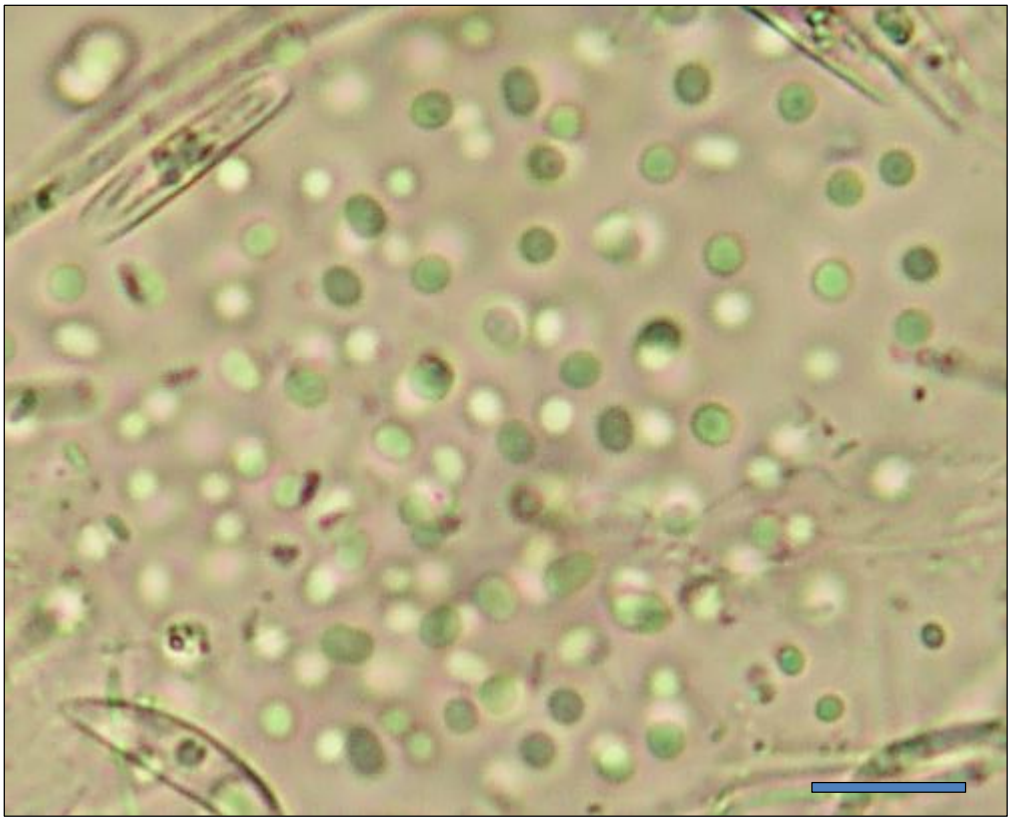

Figure 126. *Aphanocapsa venezuelae.* Bar is 10 μm in length. Image from Mareš, 2006.

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Figure 126 illustrates *Aphanocapsa venezuelae*, with spherical cells loosely embedded in a common mucilaginous matrix; cells 2.7 μm in diameter.

Order: Synechococcales

Family: Merismopediaceae

Genus: *Eucapsis*

Figure 127. *Eucapsis densa.* Bar is 10 μm in length.

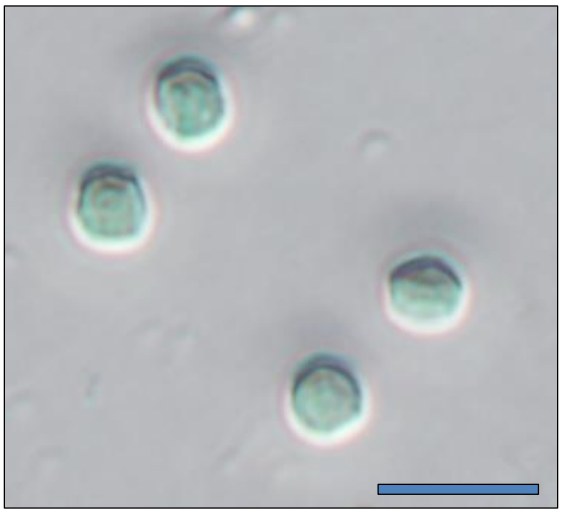

Figure 128. *Eucapsis densa.* Bar is 10 μm in length.

Figure 129. *Eucapsis densa.* Bar is 10 μm in length.

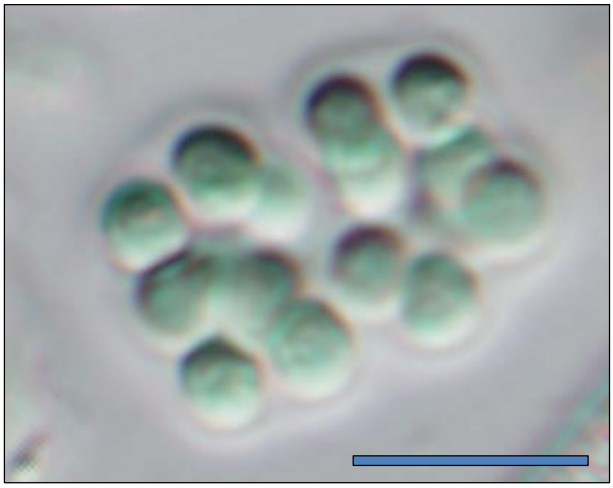

Figure 130. *Eucapsis densa.* Bar is 10 μm in length.

Figures 127 to 130 illustrate *Eucapsis densa*, with spherical cells in a common mucilaginous grouping, 4-16 cells, ranging from 3.3 μm (fig. 130) to 6.3 μm (fig. 127) in diameter. Colonies are often cuboidal in shape.

Order: Synechococcales

Family: Merismopediaceae

Genus: *Merismopedia*

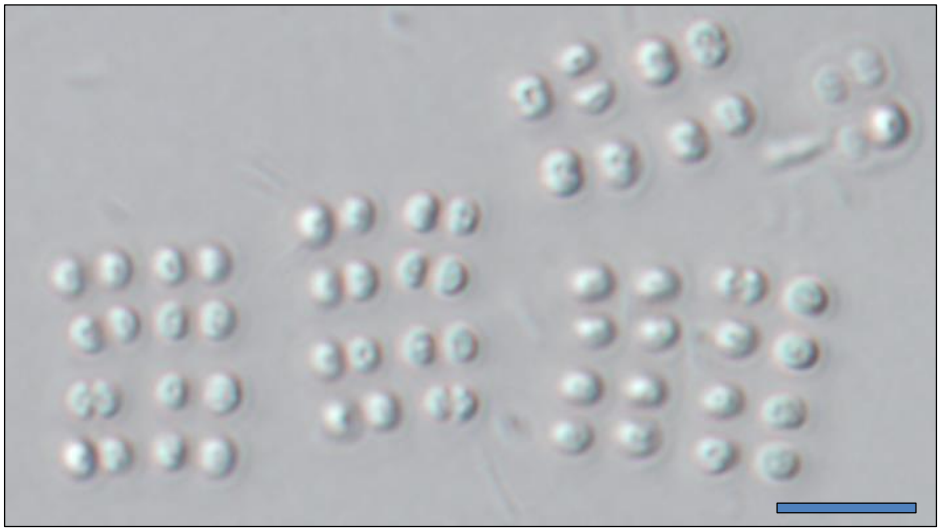

Figure 131. *Merismopedia punctata.* Bar is 10 μm in length.

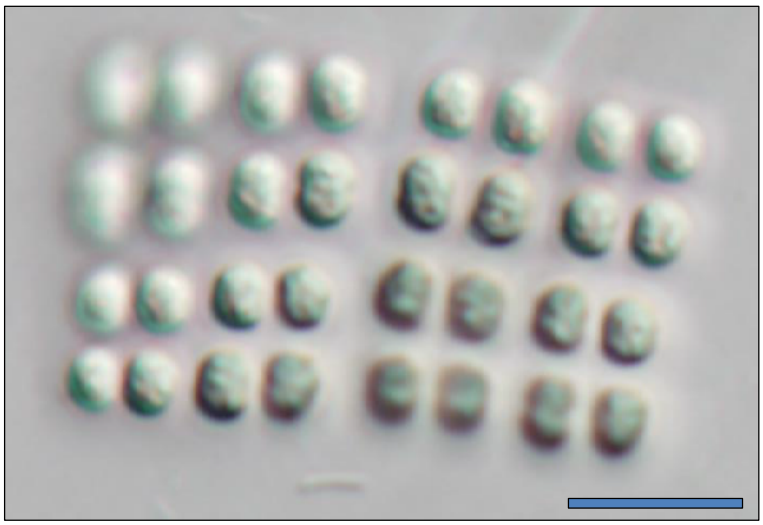

Figure 132. *Merismopedia punctata.* Bar is 10 μm in length.

Figures 131 and 132 illustrate the genus *Merismopedia*, a colonial form that has cells in a single plane. It commonly appears as hemispherical cells, typically in pairs or groups of 4. In *Merismopedia punctata*, the cells range from 2.3-3.0 μm by 2.6-3 μm and are not tightly packed.

Order: Synechococcales

Family: Merismopediaceae

Genus: *Merismopedia*

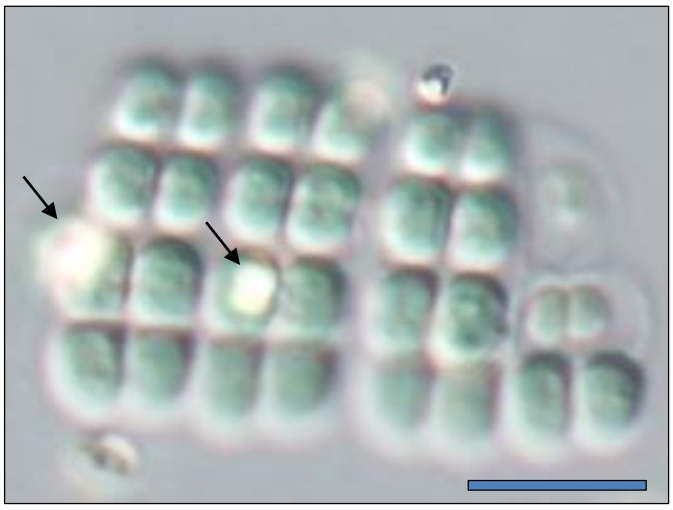

Figure 133. *Merismopedia glauca.* Bar is 10 μm in length.

Figure 133 illustrates *Merismopedia glauca*, with cells 3.3 μm by 4.4 μm that are more tightly packed compared to *Merismopedia puntata*. Also note that calcium carbonate appears to be associated with this organism (at arrows).

Order: Synechococcales

Family: Pseudanabaenaceae

Genus: *Limnothrix*

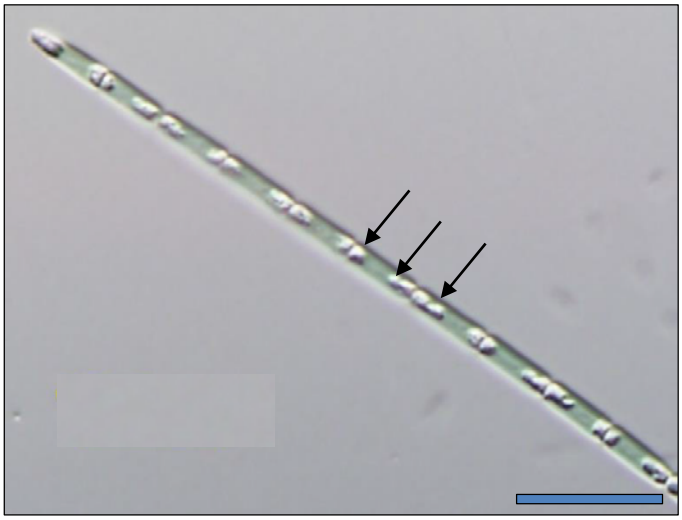

Figure 134. *Limnothrix* sp. Bar is 10 μm in length.

Figure 135. *Limnothrix* sp. Bar is 10 μm in length.

Figure 136a. *Limnothrix* sp. illuminated with DIC microscopy. Bar is 10 μm in length.

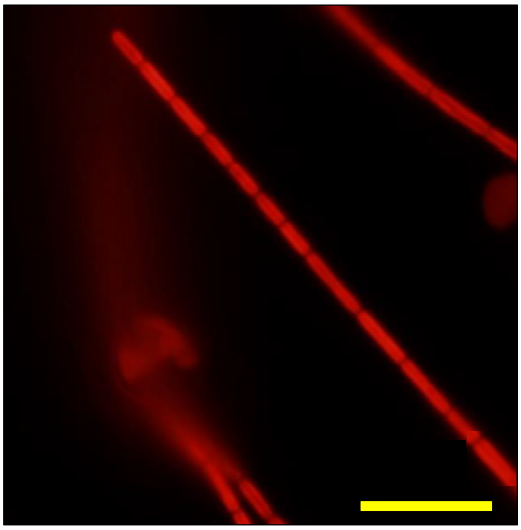

Figure 136b. *Limnothrix* sp. illuminated with WG epifluorescence microscopy. Bar is 10 μm in length.

Figures 134 to 136 illustrate *Limnothrix*, which has individual trichomes, straight or curved, without sheath (or very slight amount of sheath). Aerotopes are localized at the ends of each cell (arrows). Cylindrical cells are 1.6-1.8 μm wide by 5.3-6.4 μm long.

Order: Synechococcales

Family: Pseudanabaenaceae

Genus: *Pseudanabaena*

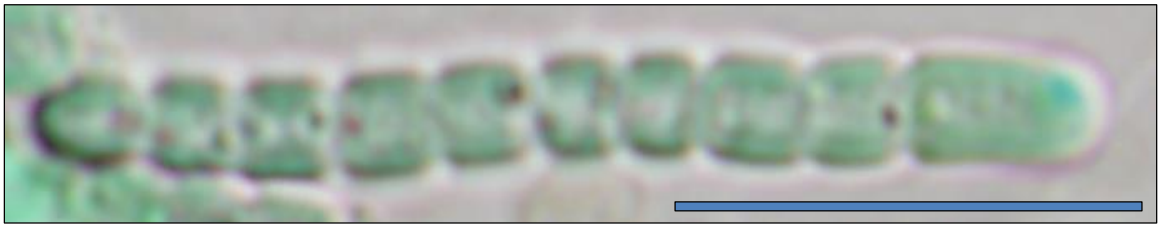

Figure 137. *Pseudanabaena* sp. Bar is 10 μm in length.

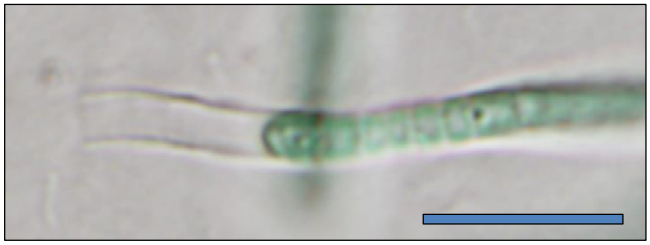

Figure 138. *Pseudanabaena* sp. Bar is 10 μm in length.

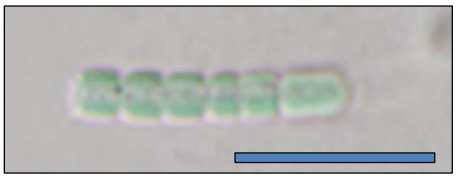

Figure 139. *Pseudanabaena* sp. Bar is 10 μm in length.

Figure 137 to 139 illustrate the genus *Pseudanabaena.* The cells are barrel-shaped, with a constriction between cells. The trichomes typically do not produce a sheath, although this organism did produce a thin sheath in culture (fig. 138). *Pseudanabaena* sp. is 2.3 μm wide and the cells are 1.9 μm long. The apical cell is 3.8 μm long.

Order: Synechococcales

Family: Romeriaceae

Genus: *Wolskyella*

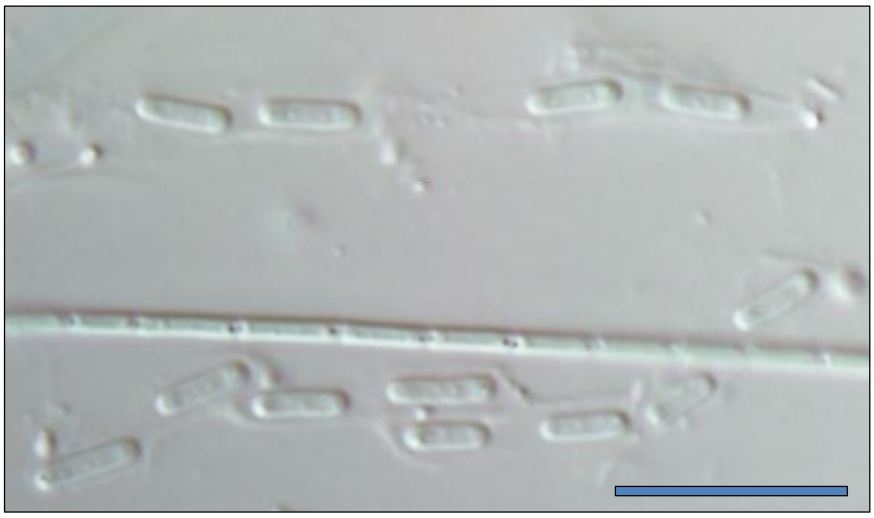

Figure 140a. *Wolskyella floridana* illuminated with DIC microscopy. Bar is 10 μm in length.

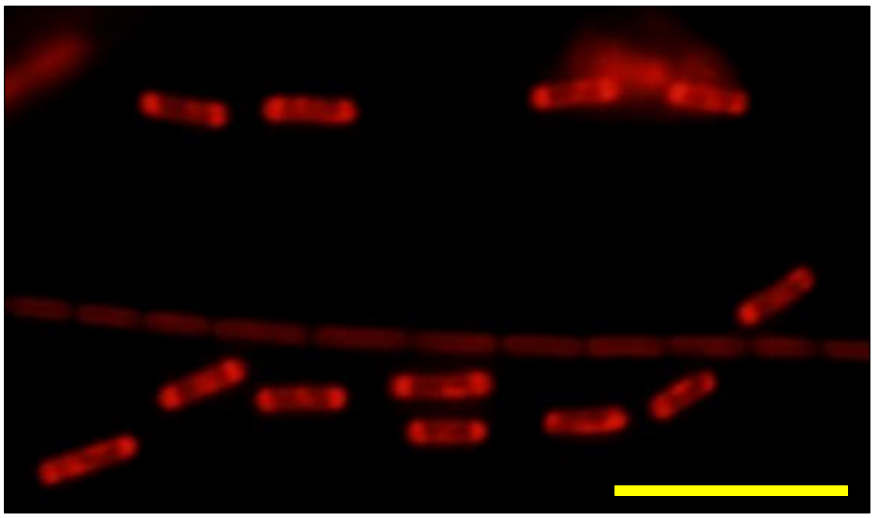

Figure 140b. *Wolskyella floridana* illuminated with UV epifluorescence microscopy. Bar is 10 μm in length.

Figures 140a and 140b illustrate the species *Wolskyella floridana* with a unicellular-pseudofilamentous appearance. Cells are 1.1 μm wide by 4.3 μm long. The epifluorescence microcopy (fig. 140b) shows greater accumulation of the pigmentation at the ends of these cells (Mareš and others, 2008).

Order: Synechococcales

Family: Synechococcaceae

Genus: *Lemmermanniella*

Figure 141. *Lemmermanniella uliginosa.* Bar is 10 μm in length.

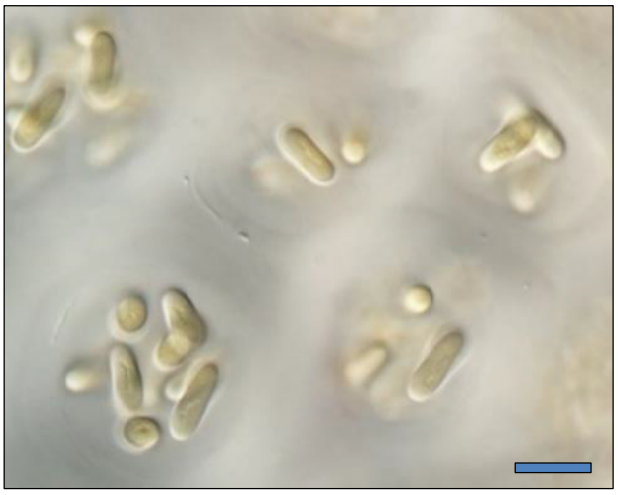

Figure 142. *Lemmermanniella uliginosa*. Bar is 10 μm in length.

Figures 141 and 142 illustrated *Lemmermanniella uliginosa*, with elongated cells 2.8 to 3.4 μm wide by 6.7 to 9.4 μm long. The cells are in one common thick mucilaginous sheath, and cells are irregularly arranged in the colony, just below the surface, leaving the center hollow.

Order: Synechococcales

Family: Synechococcaceae

Genus: *Rhabdogloea*

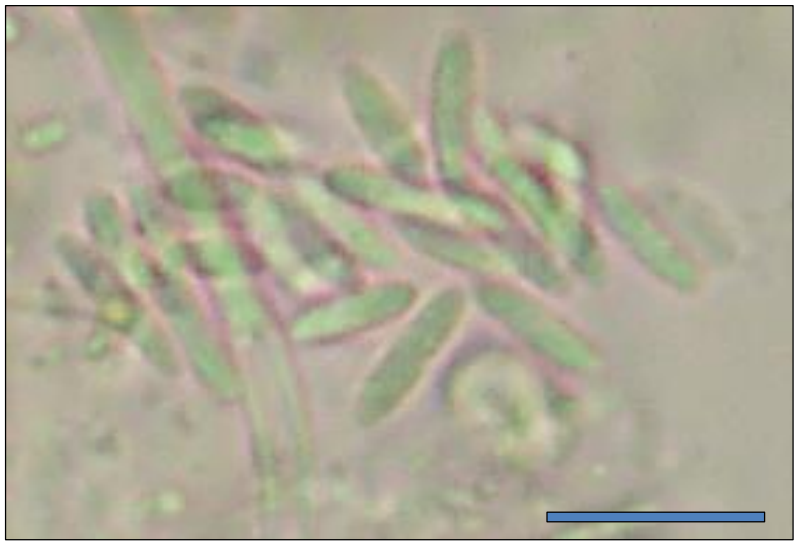

Figure 143. *Rhabdogloea subtropica*. Bar is 10 μm in length. Image from Mareš, 2006.

Figure 143 illustrates the species *Rhabdogloea subtropica*. Cells are elongated and tapered and form loose colonies without a common mucilage.

Order: Nostocales

Family: Fortiaceae

Genus: *Fortiea*

Figure 144. *Fortiea monilispora.* Bar is 10 μm in length.

Figure 145. *Fortiea monilispora.* Bar is 10 μm in length.

Figures 144 and 145 illustrate the species *Fortiea monilispora*, first described by Komárek (1984), a filamentous form with heterocytes and akinetes.

Order: Nostocales

Family: Gloeotrichiaceae

Genus: *Gloeotrichia*

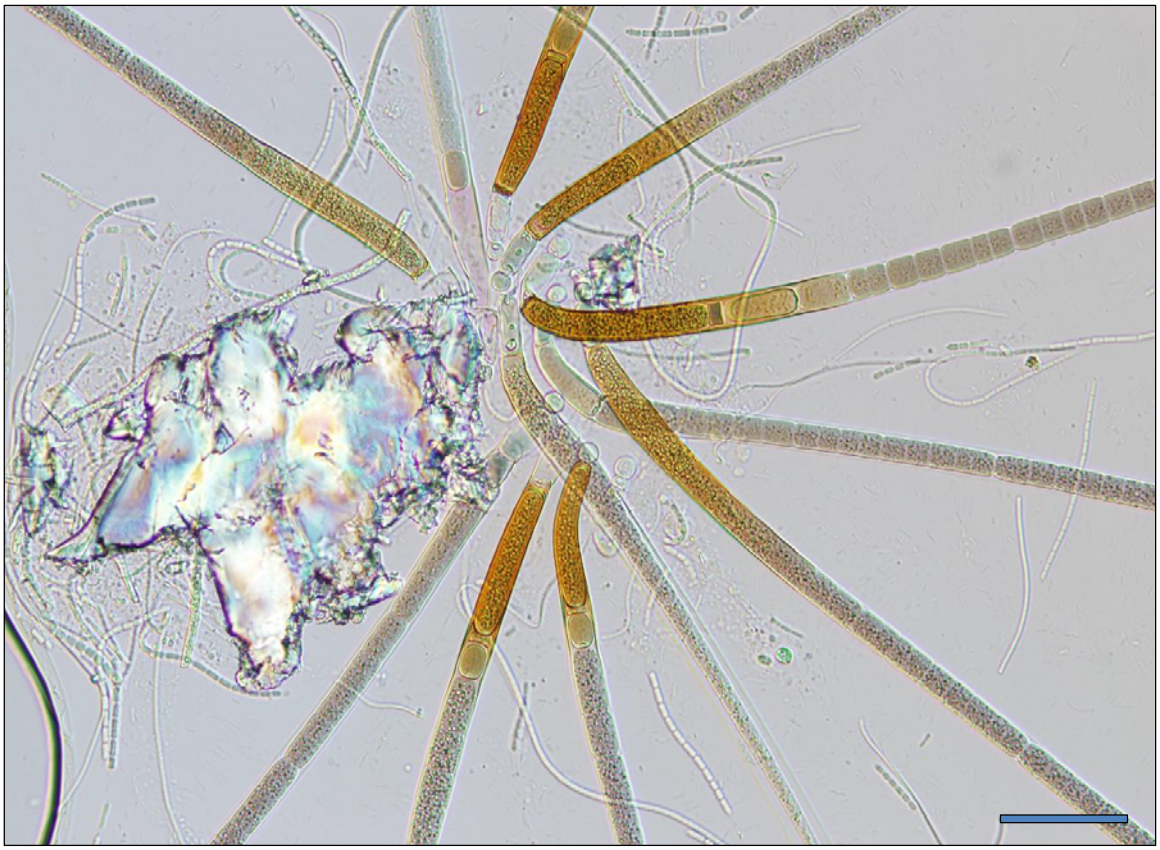

Figure 146. *Gloeotrichia* (new species). Colony detached from substrate. Bar is 50 μm in length.

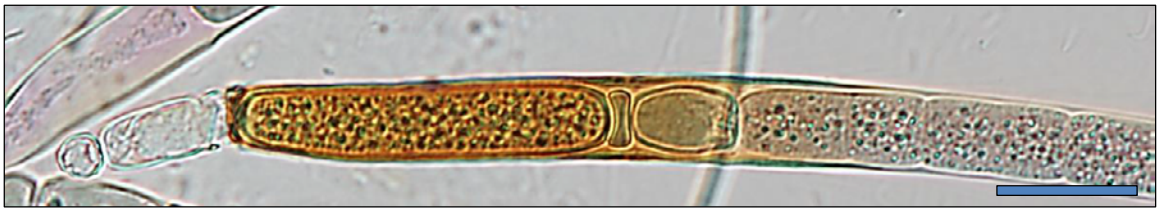

Figure 147. *Gloeotrichia* (new species). Individual filament basal cells. Bar is 20 μm in length.

Order: Nostocales

Family: Gloeotrichiaceae

Genus: *Gloeotrichia*

Figure 148a. *Gloeotrichia* (new species) illuminated with DIC microscopy. Basal cells arrangement. Bar is 20 μm in length.

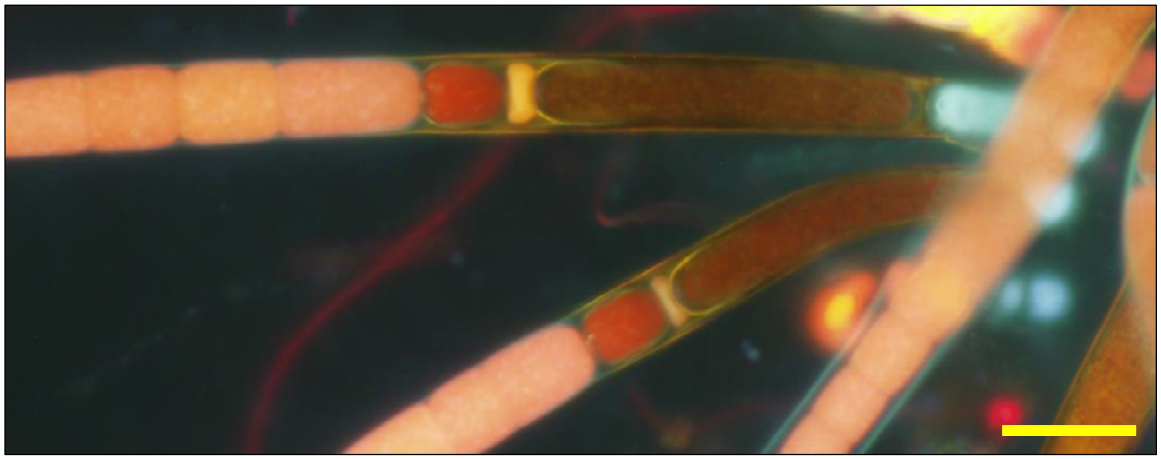

Figure 148b. *Gloeotrichia* (new species) illuminated with UV epifluorescence microscopy. Basal cells arrangement. Bar is 20 μm in length.

Order: Nostocales

Family: Gloeotrichiaceae

Genus: *Gloeotrichia*

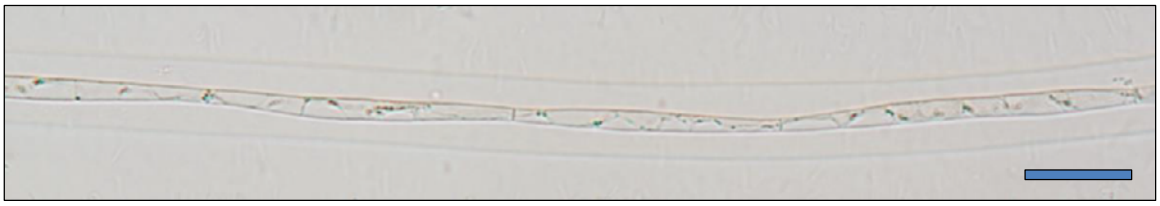

Figure 149a. *Gloeotrichia* (new species) illuminated with DIC microscopy. Hair cells with sheath. Bar is 20 μm in length.

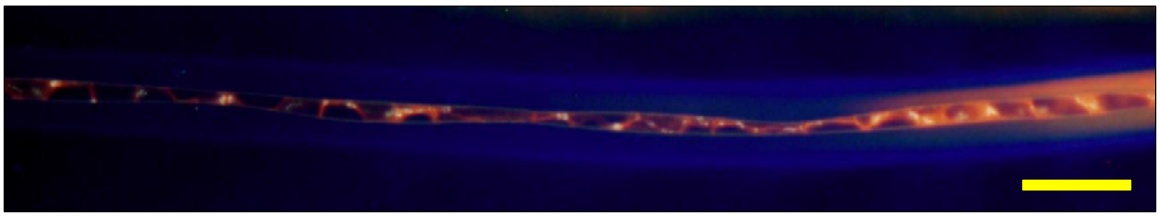

Figure 149b. *Gloeotrichia* (new species) illuminated with UV epifluorescence microscopy. Hair cells with sheath. Bar is 20 μm in length.

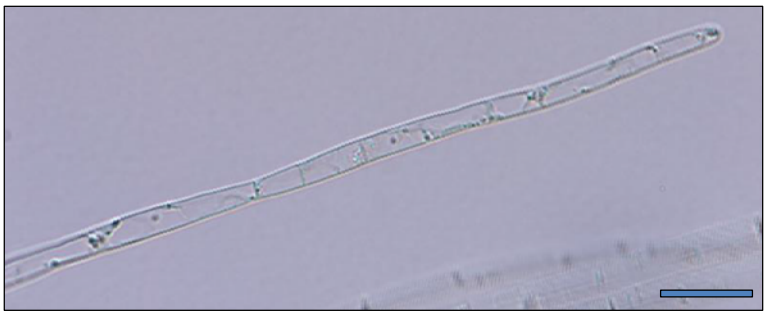

Figure 150. *Gloeotrichia* (new species). Tip of hair cell at end of trichome. Bar is 20 μm in length.

Figures 146 to 150 illustrate a new species of the genus *Gloeotrichia* (J. Komárek, written communication, March 14, 2016), found attached to a stem of a submerged aquatic plant. The growth morphology of the colony (fig. 146) and the arrangement of various cells and structures at the base of filament (figs. 147 and 148). Figures 149 and 150 show the morphology of the hair cells, with a total filament length of 1.5 mm.

Order: Nostocales

Family: Nostocaceae

Genus: *Anabaena*

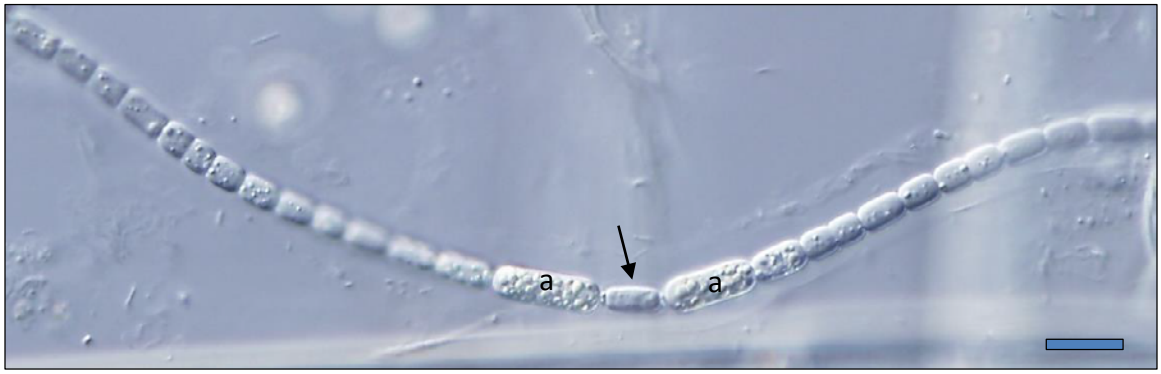

Figure 151. *Anabaena* cf. *cylindrospora.* Image courtesy of Jaroslava Komárková. Bar is 10 μm in length.

Figure 151 illustrates the *Anabaena* cf. *cylindrospora,* with barrel-shaped cells, solitary intercalary heterocytes (at arrow) and akinetes (a) with rounded ends near the heterocyte. The cf. designation is used because the description of this species describes the heterocyte as rounded (Komárek, 2013).

Order: Nostocales

Family: Nostocaceae

Genus: *Anabaena*

Figure 152. *Anabaena fuscovaginata.* Bar is 20 μm in length. Image from Mareš, 2006.

Figure 153. *Anabaena fuscovaginata.* Bar is 20 μm in length.

Figures 152 and 153 illustrate the species *Anabaena fuscovaginata,* with filaments commonly in dense clusters, and with a thin, colorless mucilage, has akintes on both sides of the heterocytes and barrel-shaped cells, 2.5-3.5 μm wide. Image from Mareš, 2006 and described by Mareš (2010).

Order: Nostocales

Family: Nostocaceae

Genus: *Cylindrospermum*

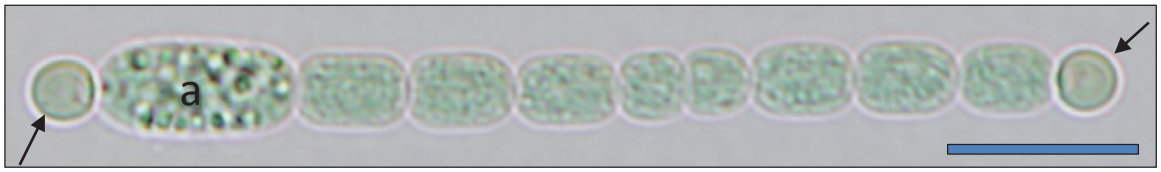

Figure 154a. *Cylindrospermum breve* illuminated with DIC microscopy. Bar is 10 μm in length.

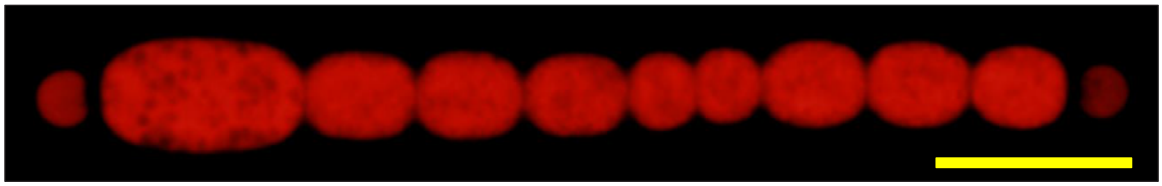

Figure 154b. *Cylindrospermum breve* illuminated with WG epifluorescence microscopy. Bar is 10 μm in length.

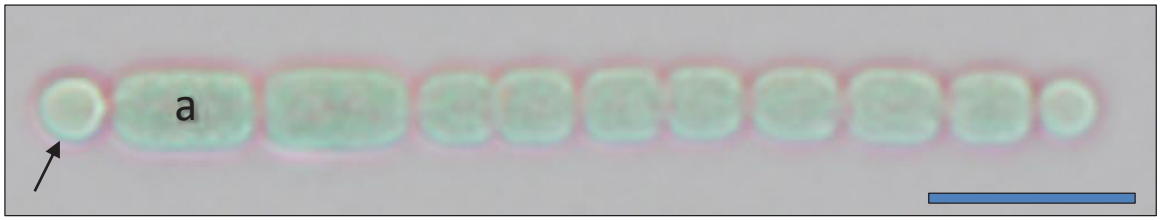

Figure 155. *Cylindrospermum breve*. Bar is 10 μm in length.

Figure 156. *Cylindrospermum breve*. Bar is 10 μm in length.

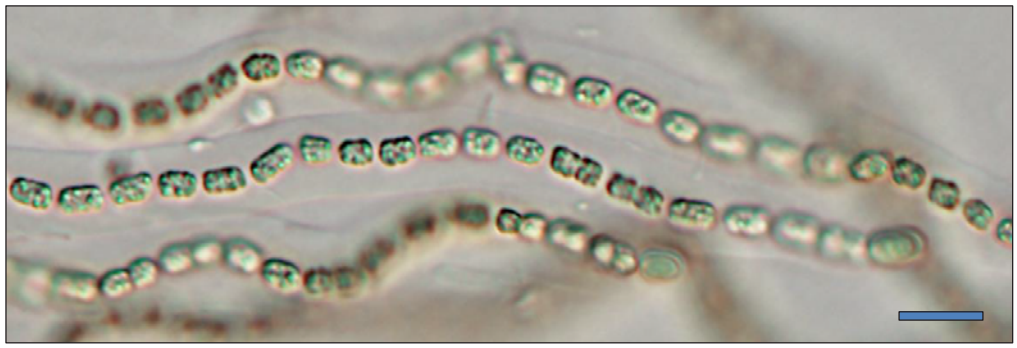

Figure 157. *Cylindrospermum breve.* Bar is 10 μm in length.

Order: Nostocales

Family: Nostocaceae

Genus: *Cylindrospermum*

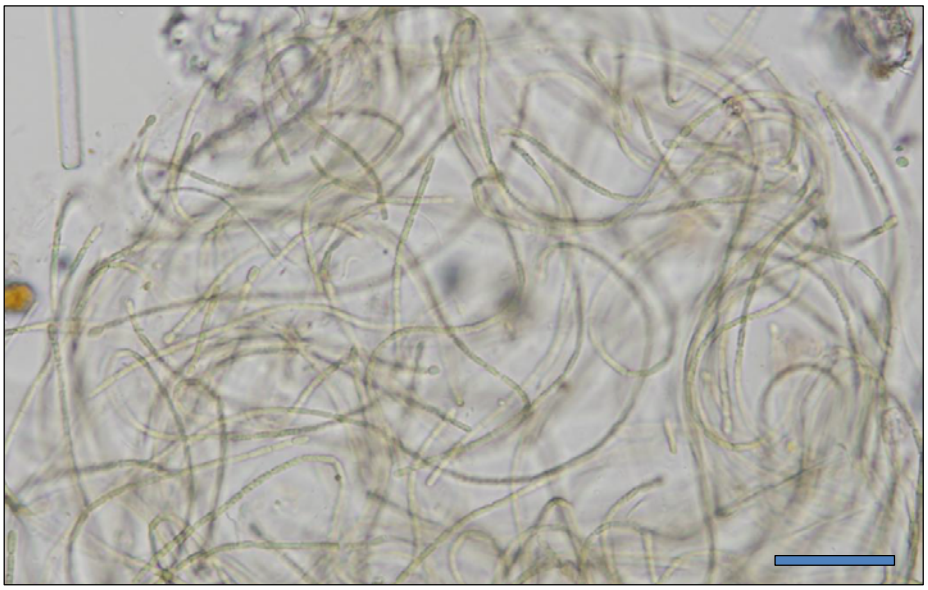

Figure 158. *Cylindrospermum breve*. Bar is 50 μm in length.

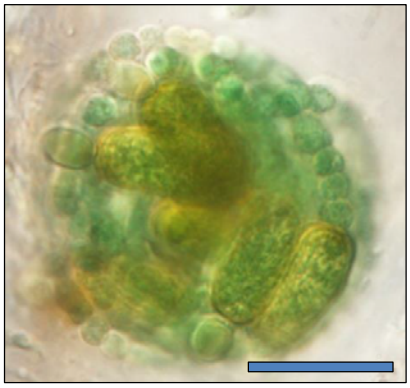

Figure 159. *Cylindrospermum breve.* Bar is 10 μm in length.

Figures 154 to 159 illustrate the genus *Cylindrospermum,* a filamentous form that has basal heterocytes. *Cylindrospermum breve,* has an akinete adjacent to the heterocytess (fig. 154a labeled with an “a”). In young filaments, the akinetes can be recognized as elongated cells (fig. 155, “a”). Some filaments develop akinetes at both ends of the filament (fig. 156). The cells are barrel-shaped, spherical to slightly longer than wide, ranging from 2.4 μm to 4.0 μm in diameter, and are often coiled into a mass (figs. 158 and 159).

Order: Nostocales

Family: Nostocaceae

Genus: *Macrospermum*

Figure 160. *Macrospermum fuellerbornii.* Image courtesy of Jaroslava Komárková. Bar is 10 μm in length.

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Figure 160 illustrates the genus *Macrospermum,* described as a new genus by Komárek (2008), which has unusually large and spherical akinetes on either side of a spherical heterocyte. In this species, *Macrospermum fuellerbornii,* the akinetes are brown and slightly barrel-shaped.

Order: Nostocales

Family: Nostocaceae

Genus: *Nostoc*

Figure 161. *Nostoc* sp. Image courtesy of Jaroslava Komárková. Bar is 10 μm in length.

Figure 162. *Nostoc* sp. Image courtesy of Jaroslava Komárková. Bar is 10 μm in length.

Figure 163. *Nostoc* sp. Bar is 10 μm in length.

Figures 161 to 163 illustrate the genus *Nostoc,* a filamentous form that has heterocytes (at arrow). The cells of the trichomes are spherical 5.4 μm to 5.8 μm in diameter coiled into a mass with mucilage.

Order: Nostocales

Family: Nostocaceae

Genus: *Wollea*

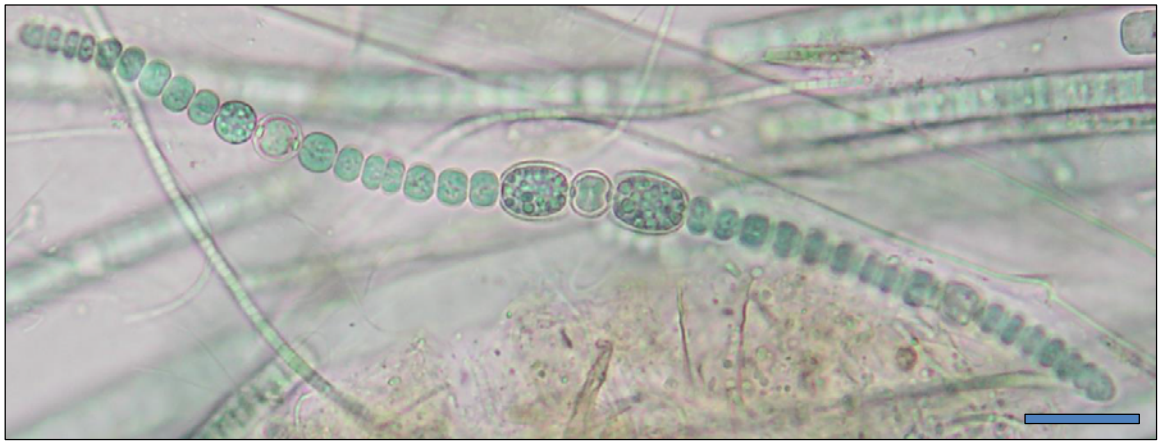

Figure 164. *Wollea ambigua*. Bar is 20 μm in length. Image from Mareš, 2006.

Figure 164 illustrates the genus *Wollea,* without a tapering trichome, no sheath, and akinetes adjacent to each side of a spherical heterocyte. Cells are barrel-shaped and constricted at the cross-walls.

Order: Nostocales

Family: Rivulariaceae

Genus: *Calothrix*

Figure 165a. *Calothrix* sp. illuminated with DIC microscopy. Bar is 10 μm in length.

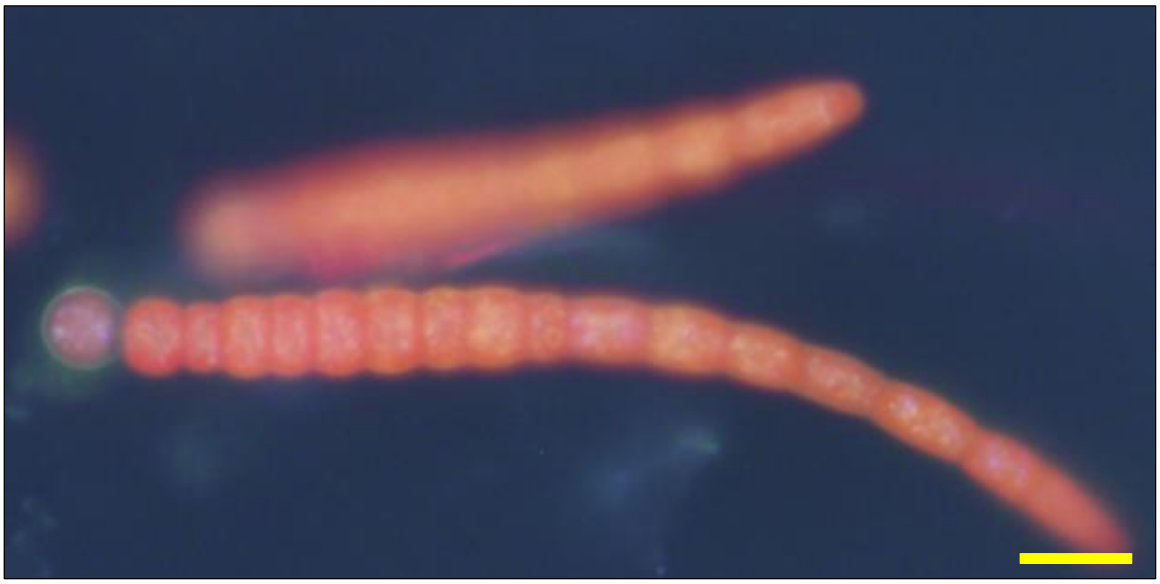

Figure 165b. *Calothrix* sp. illuminated with UV epifluorescence microscopy. Bar is 10 μm in length.

Order: Nostocales

Family: Rivulariaceae

Genus: *Calothrix*

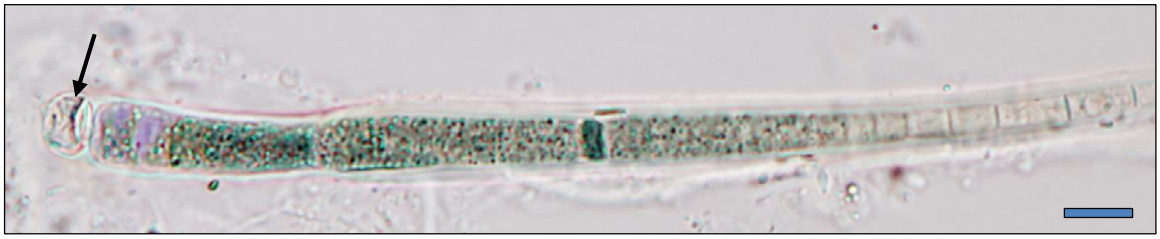

Figure 166. *Calothrix* sp. Bar is 10 μm in length.

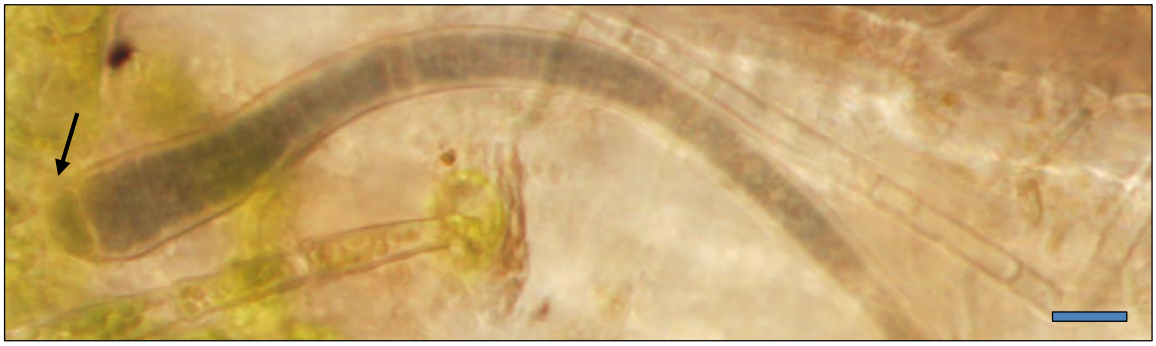

Figure 167. *Calothrix* sp. Bar is 10 μm in length.

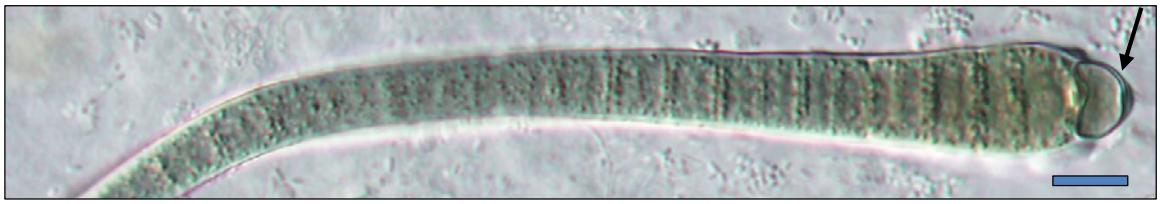

Figure 168. *Calothrix* sp. Bar is 10 μm in length.

Figures 165 to 168 illustrate *Calothrix* sp., with a basal heterocyte (arrow), and a long, tapering filament, approximately 4.5 μm wide near the base.

Order: Nostocales

Family: Rivulariaceae

Genus: *Microchaete*

Figure 169. *Microchaete robusta*. Image courtesy of Jaroslava Komárková. Bar is 10 μm in length.

Figure 169 illustrates *Microchaete robusta,* with filaments in small clusters, with basal heterocytes, a distinct sheath open near the apical end of the filament, and cells that are cylindrical, have some constriction at the cross-walls and an apical cell that is rounded.

Order: Nostocales

Family: Scytonemataceae

Genus: *Chakia*

Figure 170. *Chakia ciliosa*. Image courtesy of Jaroslava Komárková. Bar is 20 μm in length.

Figure 170 illustrates *Chakia ciliosa*, a cylindrical filament, false-branching at a basal heterocyte, and thick, densely laminated sheath (at arrow). Cells are spherical or flattened spheres with constrictions at the cross-walls (Komárková and others, 2013).

Order: Nostocales

Family: Scytonemataceae

Genus: *Chakia*

Figure 171. *Chakia cubana*. Bar is 10 μm in length.

Figure 172. *Chakia cubana*. Bar is 10 μm in length.

Figures 171 and 172 illustrate *Chakia cubana,* with false-branching at a heterocyte (arrows). Sheath is a single layer compared to *Chakia ciliosa* (fig. 170).

Order: Nostocales

Family: Scytonemataceae

Genus: *Scytonema*

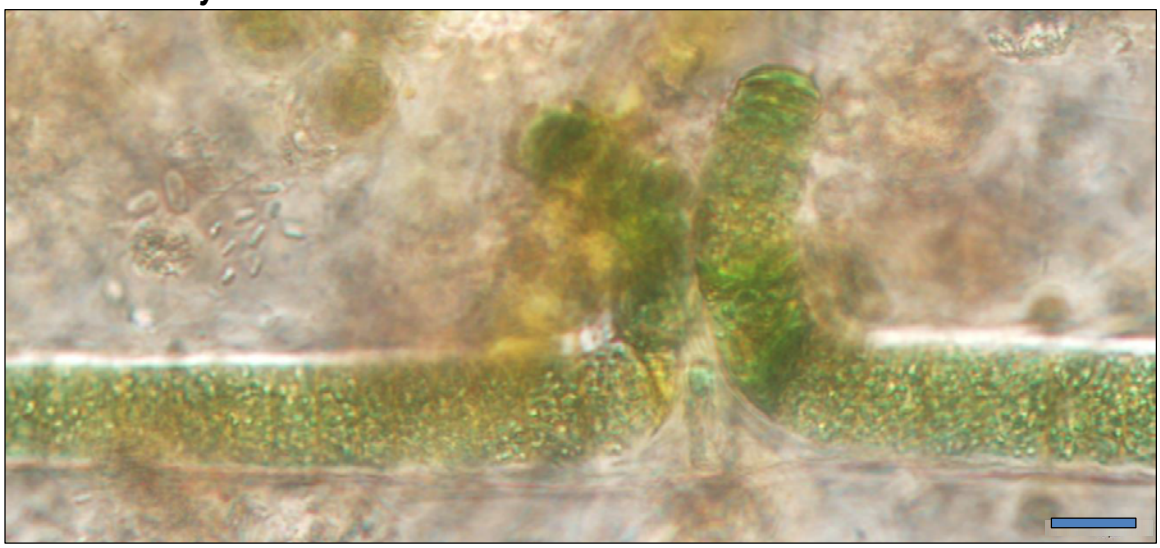

Figure 173a. *Scytonema* sp. illuminated with DIC microscopy. Bar is 10 μm in length.

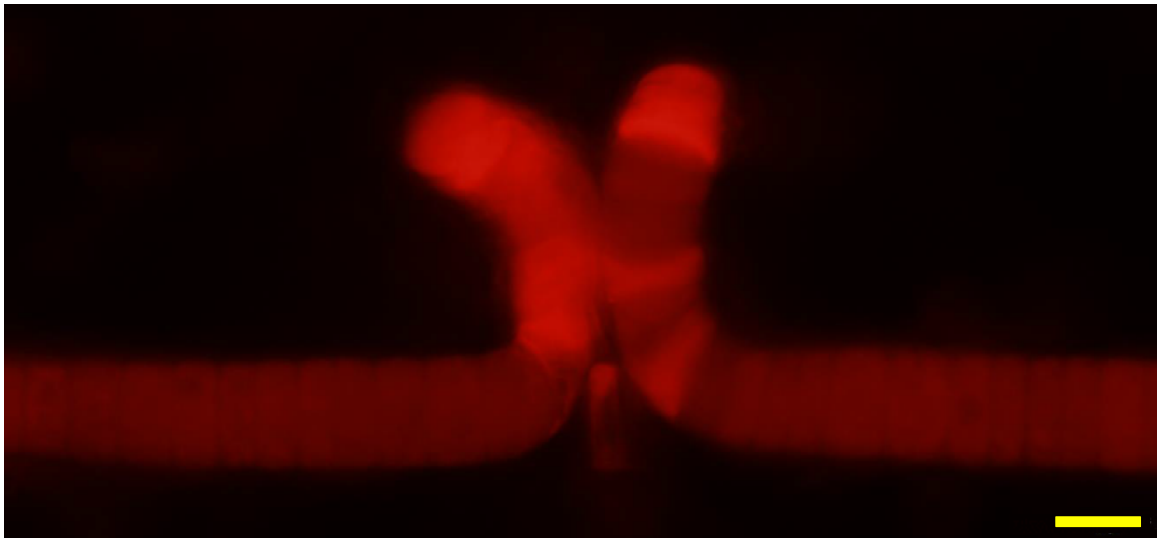

Figure 173b. *Scytonema* sp. illuminated with WG epifluorescence microscopy. Bar is 10 μm in length.

Figures 173a and 173b illustrate *Scytonema* sp., with the characteristic false-branching arising in two lateral branches.

Order: Nostocales

Family: Scytonemataceae

Genus: *Scytonema*

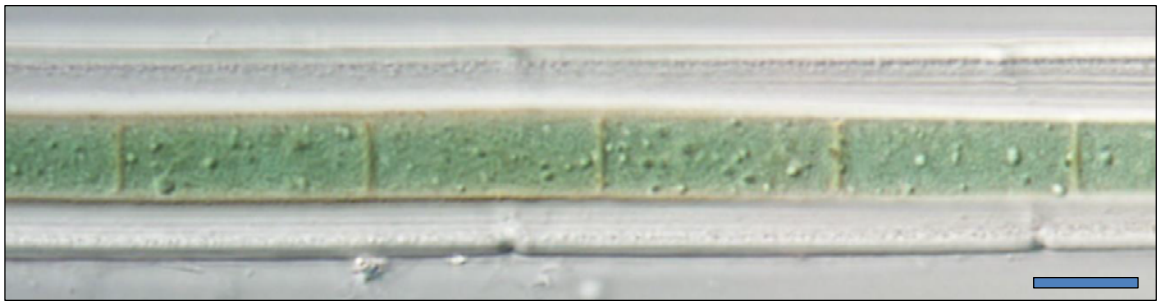

Figure 174. *Scytonema* sp. Bar is 10 μm in length.

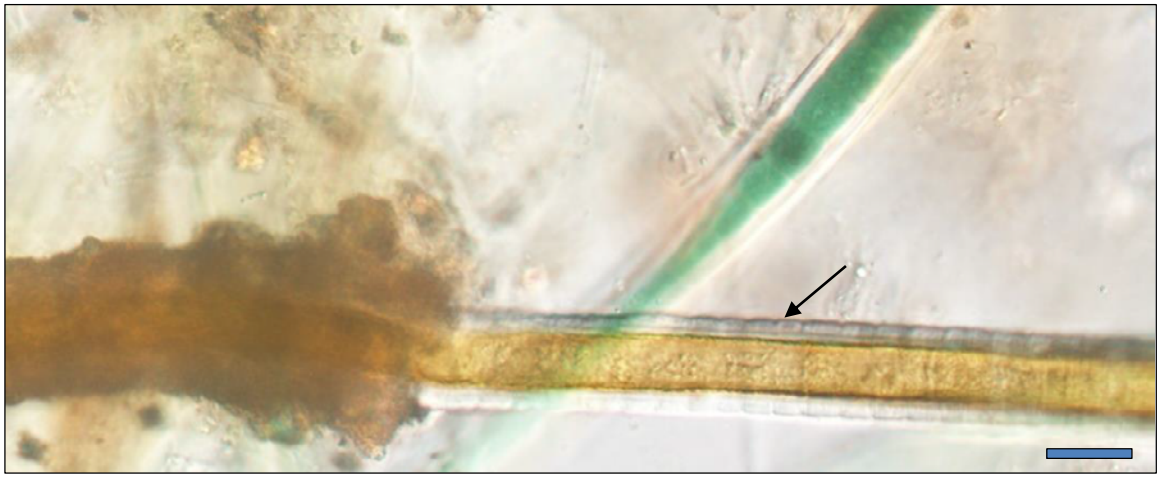

Figure 175. *Scytonema* sp. Bar is 10 μm in length.

Figures 174 and 175 show the variation in the filaments and cells in this genus. Figure 174 shows cells longer than wide and the layers of sheath. Figure 175 shows an older filament that is brown, an abundance of sheath (arrow), and the accumulation of calcium carbonate. The young filament is a bright blue-green color.

Order: Nostocales

Family: Scytonemataceae

Genus: *Scytonema*

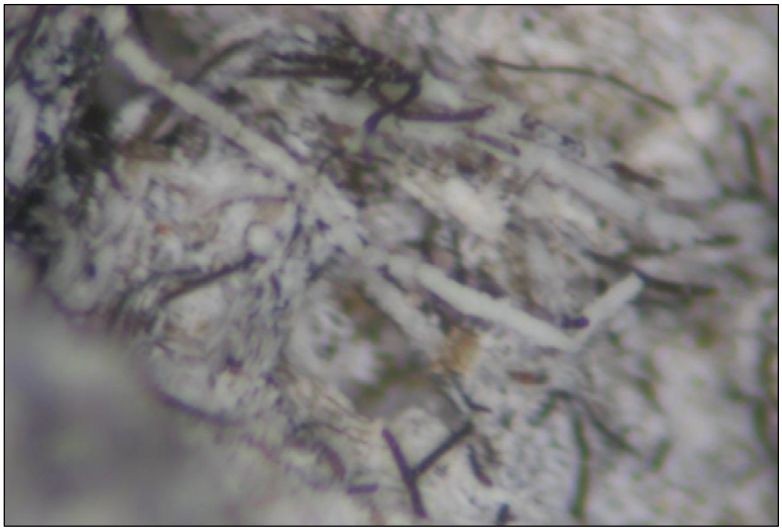

Figure 176. *Scytonema* sp. Photographed at 4x with a dissecting scope.

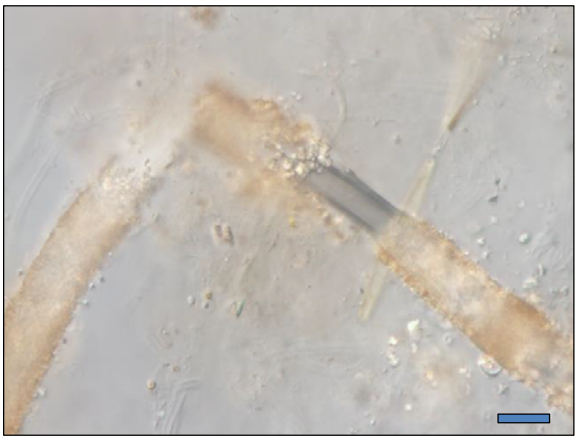

Figure 177a. *Scytonema* sp. illuminated with DIC microscopy, showing an accumulation of calcium carbonate around a filament. Bar is 20 μm in length.

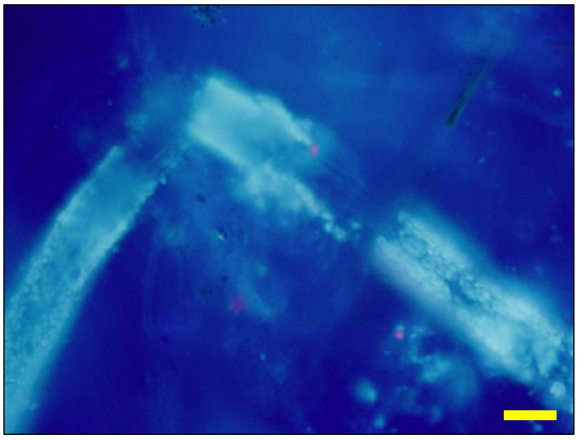

Figure 177b. *Scytonema* sp. illuminated with UV epifluorescence microscopy, showing an accumulation of calcium carbonate around a filament. Bar is 20 μm in length.

Figures 176 and 177 illustrate the accumulated calcium carbonate on the filaments of *Scytonema*. Figure 176 illustrates the accumulation of calcium carbonate precipitation around the filaments (white), along with brown and green filaments without accumulation.

Order: Nostocales

Family: Stigonemataceae

Genus: *Stigonema*

Figure 178a. *Stigonema eliskae* illuminated with DIC microscopy Bar is 50 μm in length.

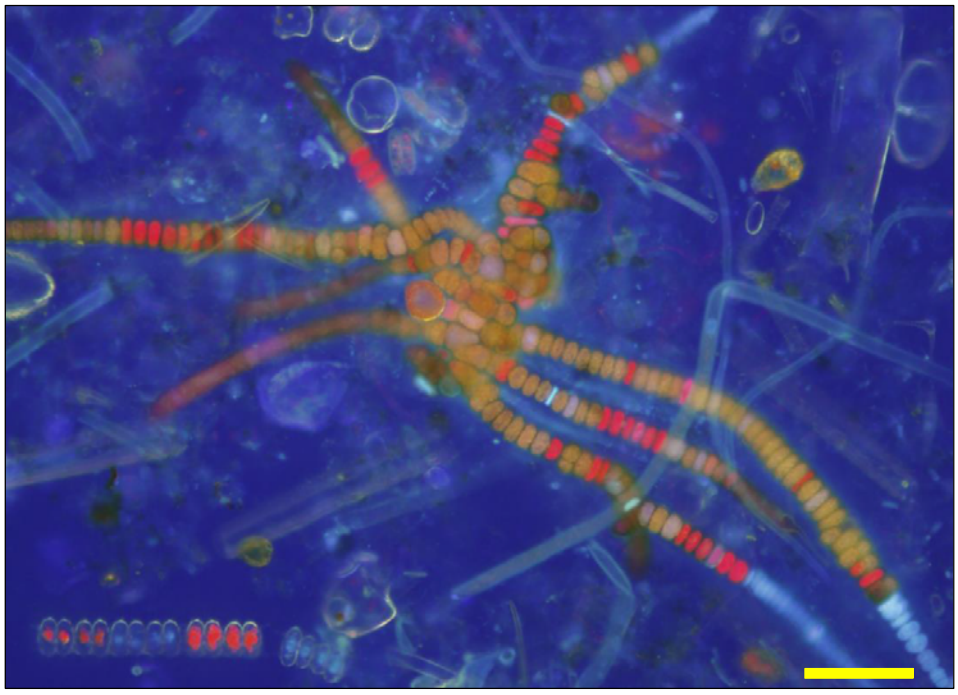

Figure 178b. *Stigonema eliskae* illuminated with UV epifluorescence microscopy Bar is 50 μm in length.

Order: Nostocales

Family: Stigonemataceae

Genus: *Stigonema*

Figure 179. *Stigonema eliskae*. Bar is 10 μm in length.

Order: Nostocales

Family: Stigonemataceae

Genus: *Stigonema*

Figure 180. *Stigonema eliskae*. Bar is 10 μm in length.

Figure 181. *Stigonema eliskae*. Bar is 10 μm in length.

Figure 182. *Stigonema eliskae*. Bar is 10 μm in length.

Figures 178 to 182 illustrate the genus *Stigonema eliskae*, with a filamentous form that has true branching and the thallus is multiseriate. Cells in the filaments display a variety of pigments (fig. 178b). Heterocytes (figs. 180 and 181 at arrows) can be distinctly pigmented a blue-green color. The cells are variable in shape, and young filaments with a single trichome are 26 μm wide with cells that are discoid and 9.2-10 μm long and are embedded in abundant mucilage.

Order: Nostocales

Family: Tolypothrichaceae

Genus: *Tolypothrix*

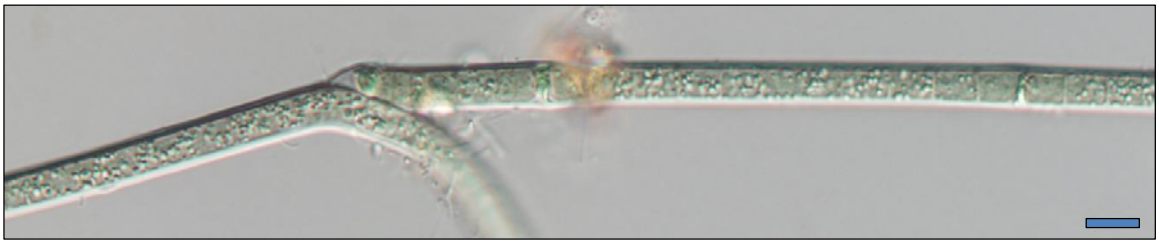

Figure 183a. *Tolypothrix* sp. illuminated with DIC microscopy. Bar is 10 μm in length.

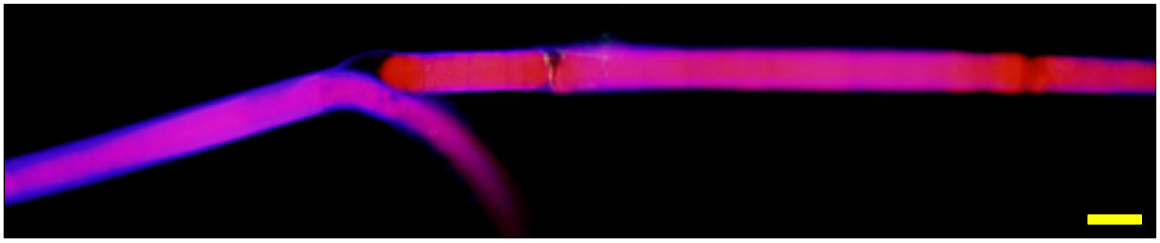

Figure 183b. *Tolypothrix* sp. illuminated with UV epifluorescence microscopy. Bar is 10 μm in length.

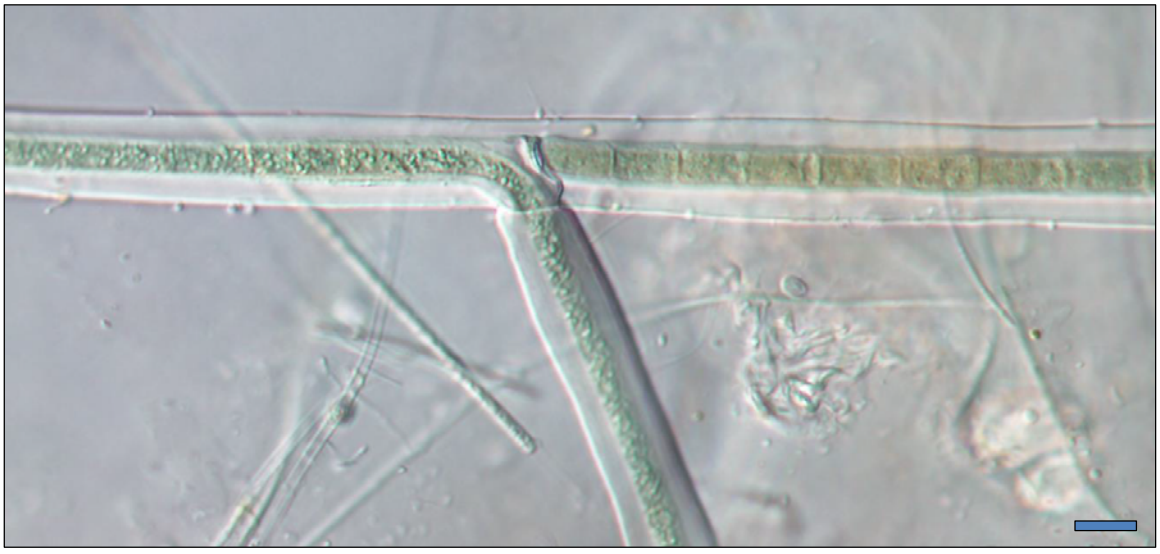

Figure 184. *Tolypothrix* sp. False-branching at collapsed heterocyte. Bar is 10 μm in length.

Order: Nostocales

Family: Tolypothrichaceae

Genus: *Tolypothrix*

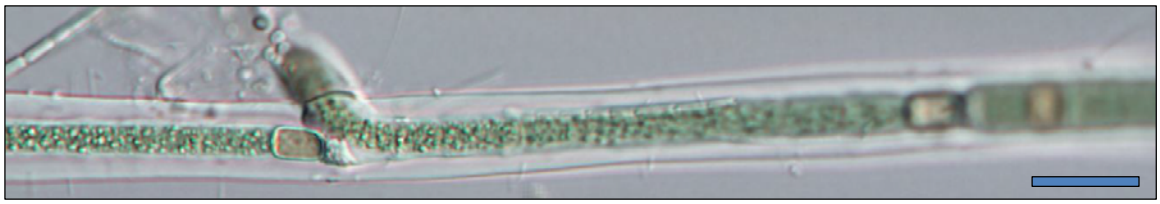

Figure 185a. *Tolypothrix sp*. False-branching at heterocyte--image is focused on the heterocyte. Bar is 20 μm in length.

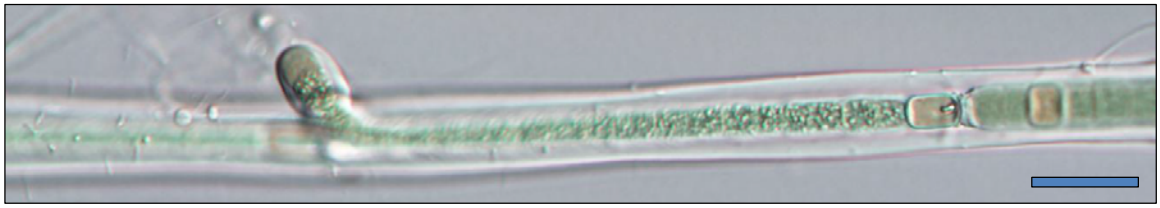

Figure 185b. *Tolypothrix sp*. Image is focused on the branch arising from the filament. Bar is 20 μm in length.

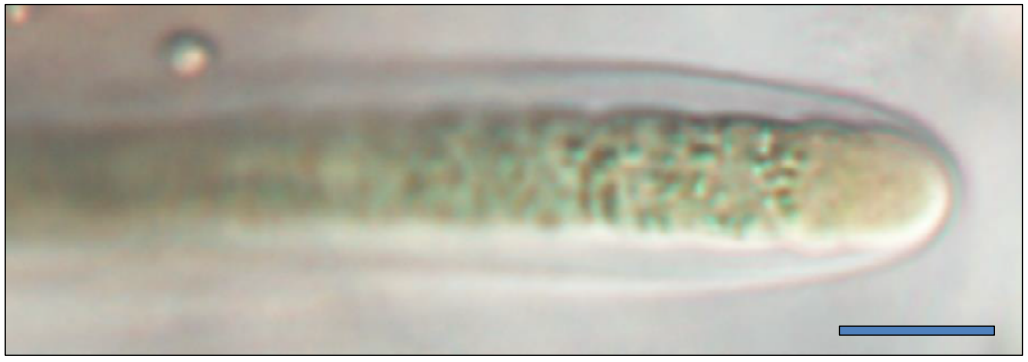

Figure 186. *Tolypothrix sp*. Tip of the filament, surrounded by sheath. Bar is 10 μm in length.

Figures 183 to 186 illustrate *Tolypothrix* sp., with a single false-branching with a basal heterocyte. The filament width of 5.8 μm and individual cells 1.6 μm long. Individual cells are visible near the branch point of the upper filament in figure 185b.

Other Eubacteria

While examining samples for cyanobacteria, bacteria were observed but when illuminated with epifluorescence microscopy, typical cyanobacterial fluorescence was absent. It is possible these organisms are forms of cyanobacteria in a degraded condition, or they are truly bacteria that are not cyanobacteria at all. Many of these bacteria are large in size and abundant in the samples examined and are included in this chapter of the Microscopic Organisms of the Everglades because they are more closely related to cyanobacteria than the eukaryotic algae. The authors are grateful to Jaroslava Komárková for those images that have been identified.

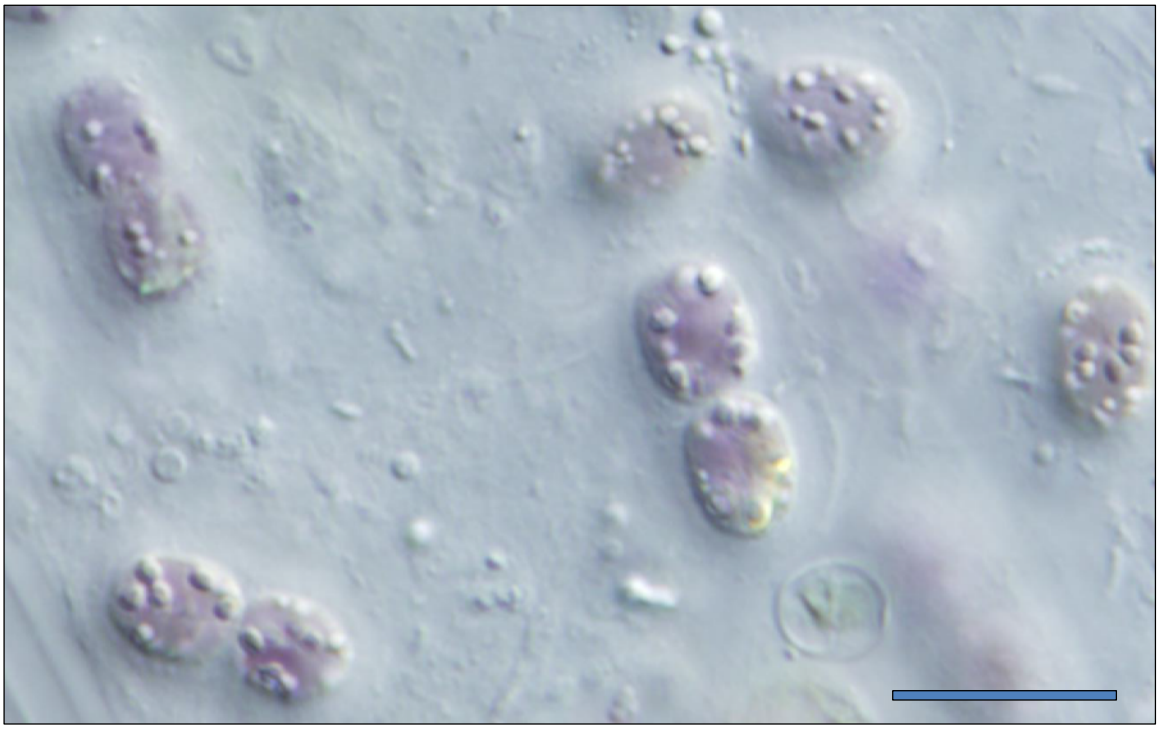

Figure 187. Purple-colored bacteria. Newly divided cells surrounded sheath. Bar is 10 μm in length.

Other Eubacteria

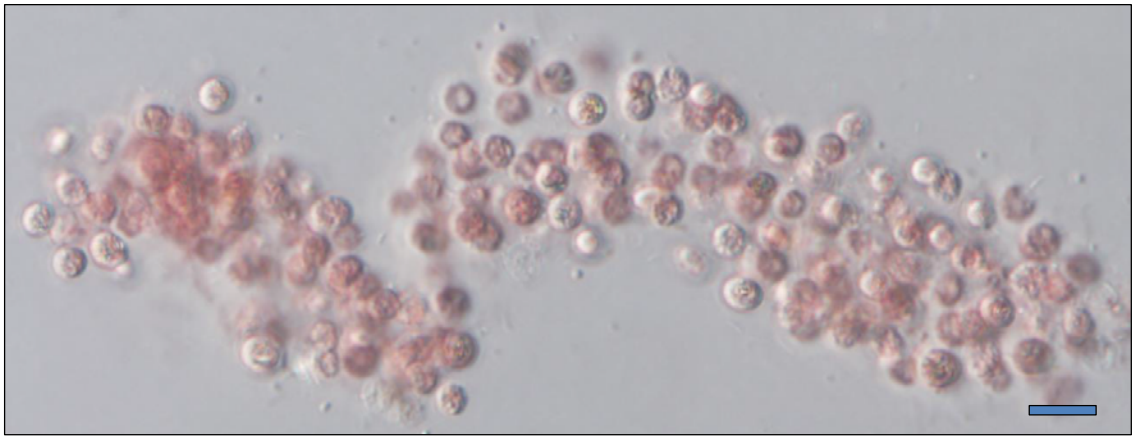

Figure 188. *Lamprocystis rubra.* A pink-reddish bacteria that appears colonial. Bar is 10 μm in length (Häusler, 1982).

Figure 189. cf. *Thiocystis* sp. Pink-reddish bacteria that appear to be colonial. Bar is 10 μm in length (Häusler, 1982).

Other Eubacteria

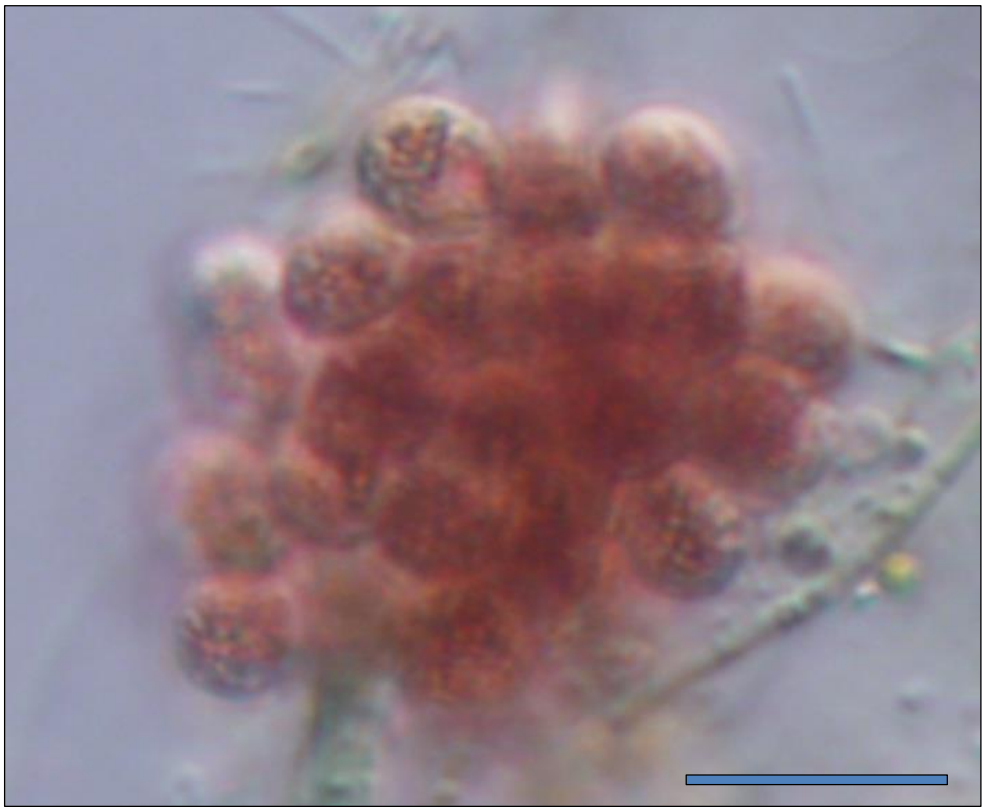

Figure 190. Reddish bacteria that appear to be colonial. Bar is 10 μm in length.

Other Eubacteria

Figure 191. cf. *Thiocystis* sp. Pink-purple bacteria that appear to be colonial. Bar is 10 μm in length (Häusler, 1982).

Other Eubacteria

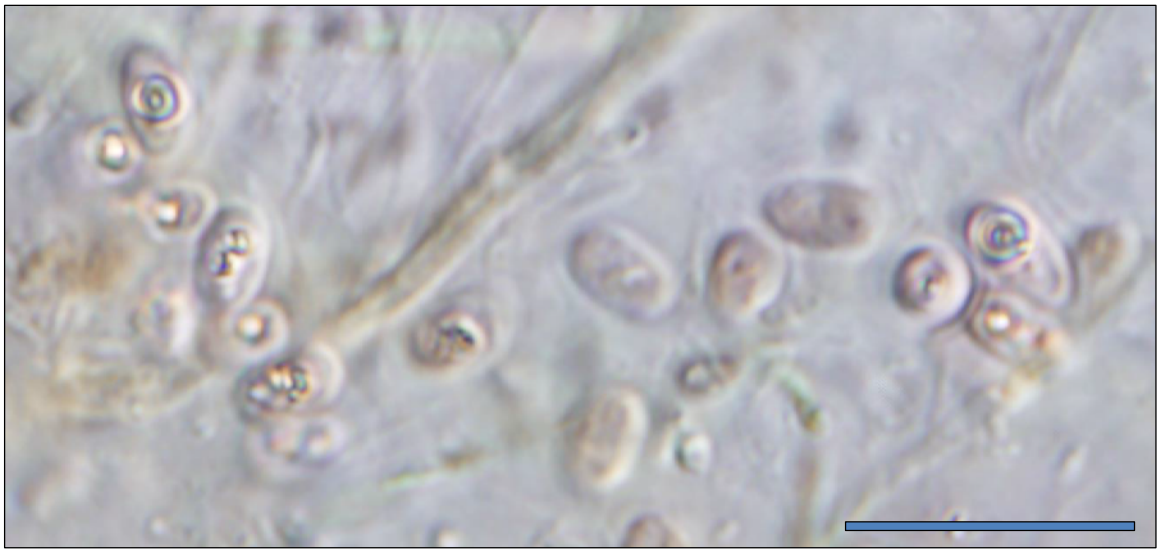

Figure 192. Pink-purple bacteria. Bar is 10 μm in length.

Figure 193. Pink-purple bacteria that appears colonial. Bar is 10 μm in length.

Other Eubacteria

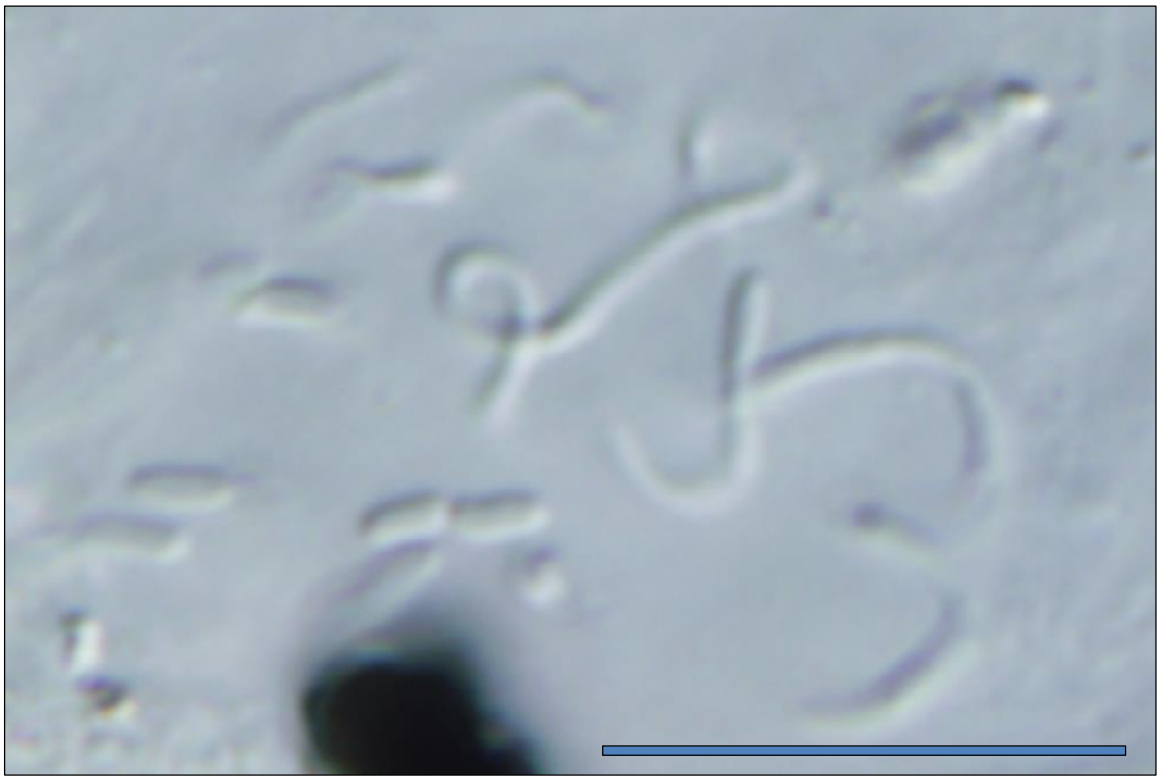

Figure 194. Bacteria with elongated cells. In a common mucilage or colony. Bar is 10 μm in length.

Figure 195. Bacteria with elongated cells. In a common mucilage or colony. Bar is 10 μm in length.

Figure 196. Bacteria with elongated cells. In a common mucilage or colony. Bar is 10 μm in length.

Other Eubacteria

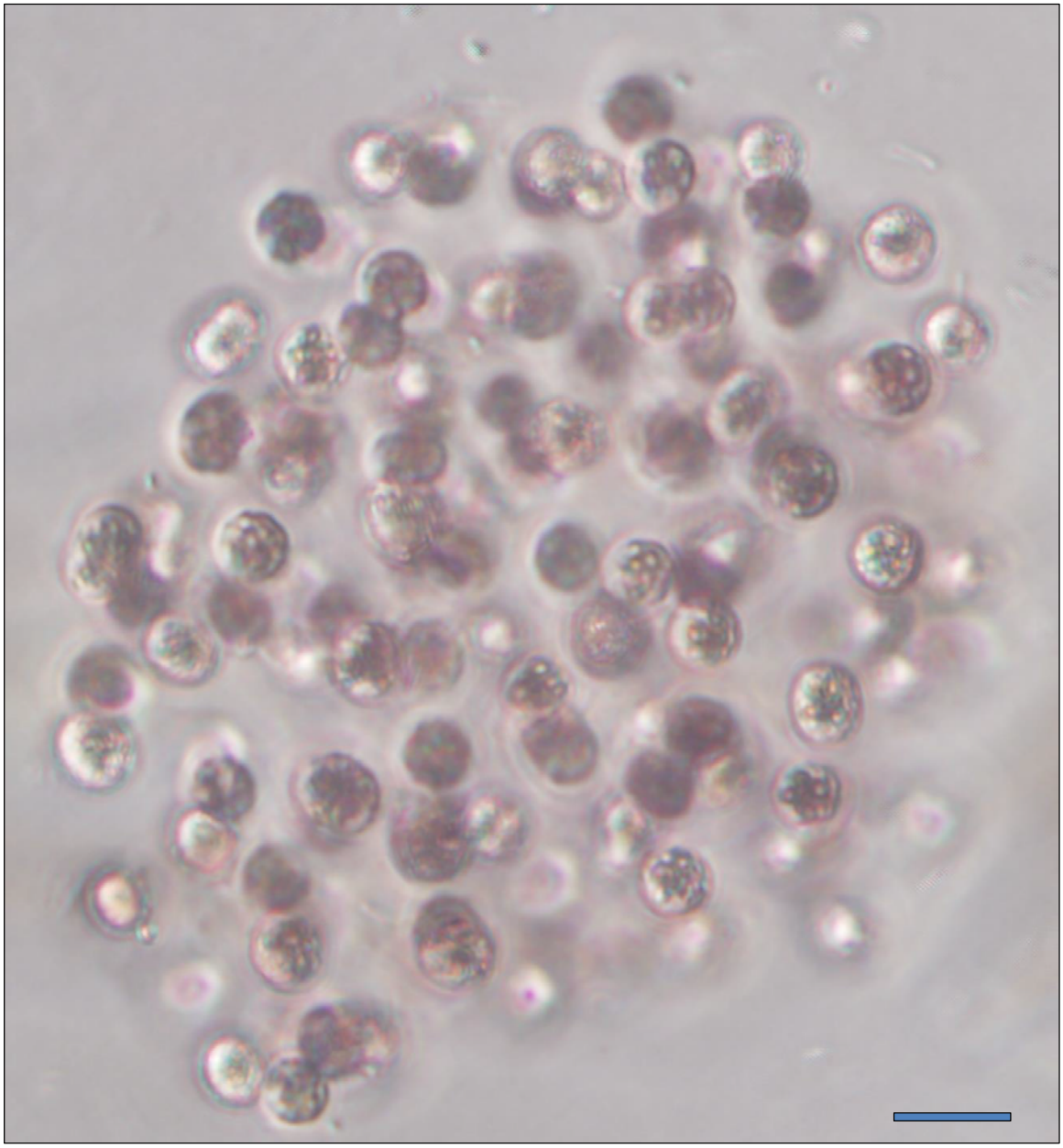

Figure 197. *Lamprocystis rubra.* Bacteria that appear to be colonial. Bar is 10 μm in length (Häusler, 1982).

Other Eubacteria

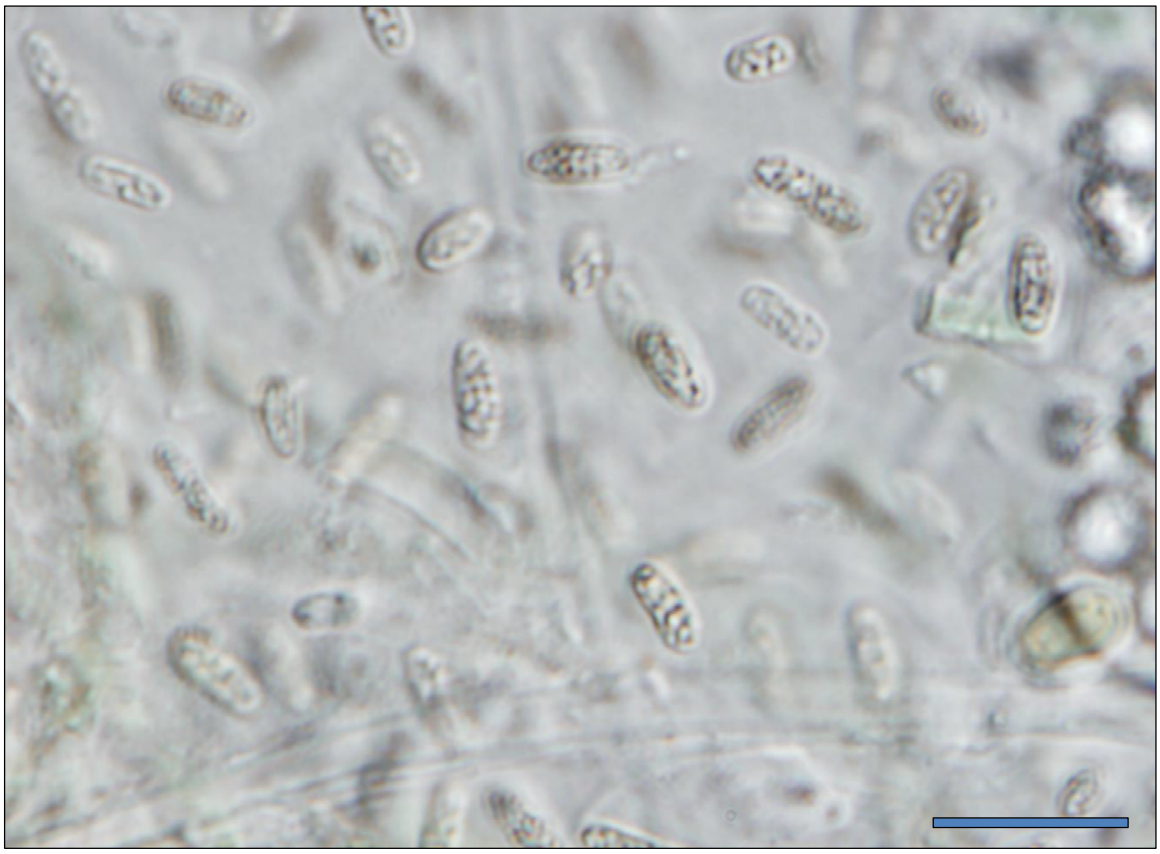

Figure 198. *Microchloris* sp. Bacteria that appear to be colonial. Bar is 10 μm in length (Häusler, 1982).

Figure 199. Bacteria that have colonized a dead cell of green algae. These bacteria were highly motile. Bar is 10 μm in length.

Other Eubacteria

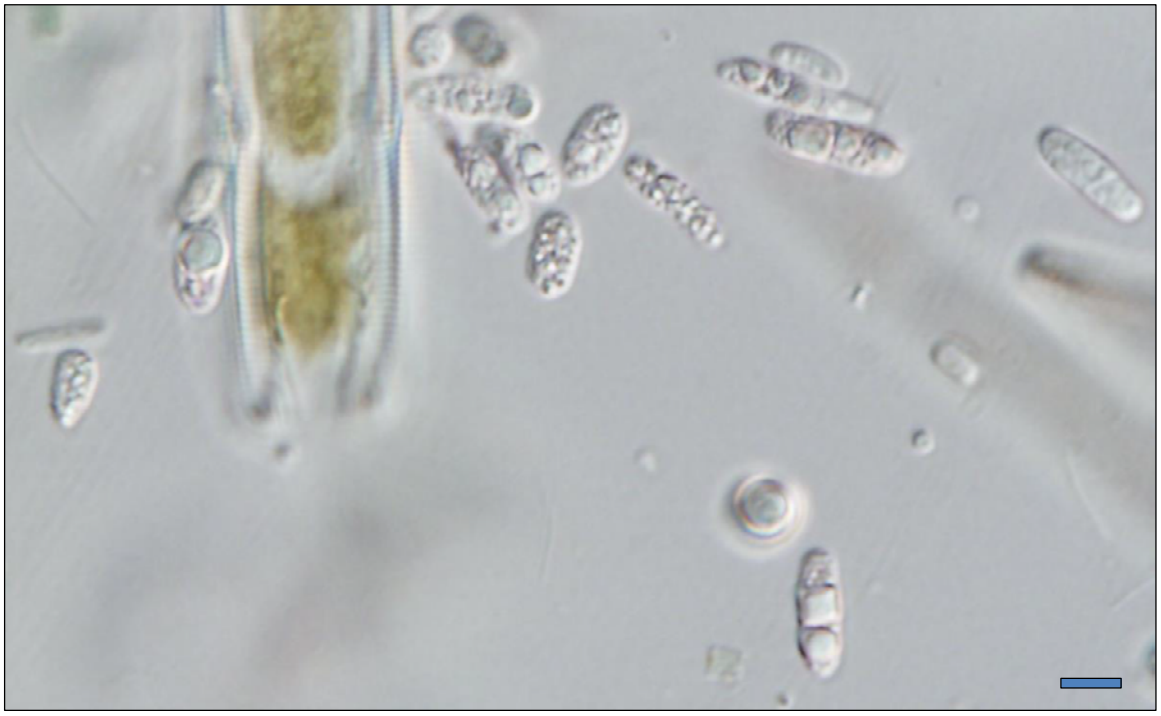

Figure 200. Large bacteria. Cells over 10 μm in length, with inclusions and adjacent to the diatom *Mastogloia*. Bar is 10 μm in length.

Other Eubacteria

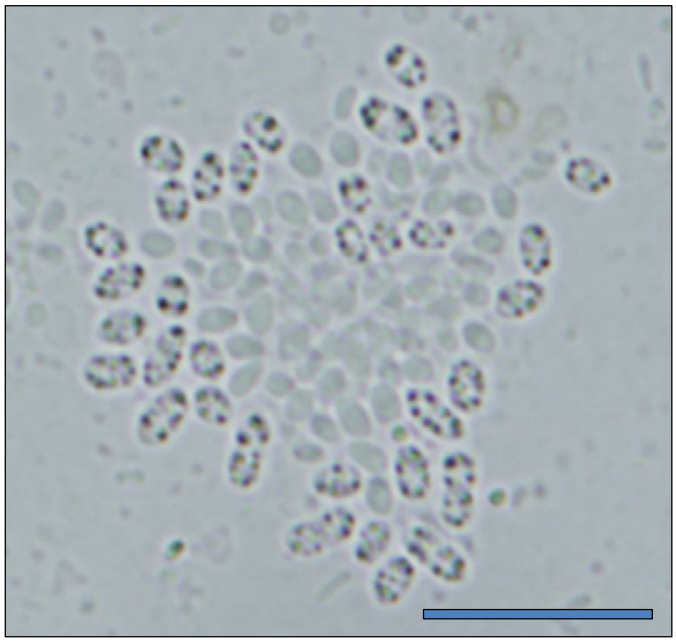

Figure 201. Flagellated bacteria. Cells with inclusions. Bar is 10 μm in length.

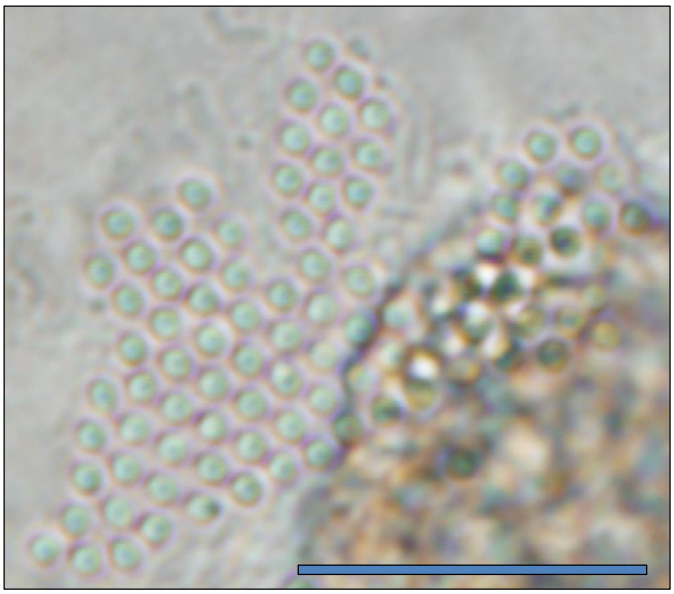

Figure 202. *Tetrachloris merismopedioides.* Spherical, regularly arranged bacteria. Bar is 10 μm in length (Häusler, 1982).

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