

Lake Chelan and Chelan River Algae

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1 Introduction

Lake Chelan is the longest (81 km) and deepest (>400 m) natural lake in Washington, formed by glacial retreat at the end of the last Ice Age. Based on water quality data collected in the 1980s, it is considered an oligotrophic lake (Rector and Hallock 1990) and has some of the clearest waters in the state. The Stehekin River is the primary tributary to the lake; the primary outlet is the Chelan River. Lake Chelan is used extensively for recreation and fisheries (Schoen and Beauchamp 2010). Lake Chelan's water level is maintained by a dam operated by Chelan County PUD. Water withdrawals include municipal, drinking water, and irrigation uses. Development in the watershed is concentrated around the shallower Wapato Basin, consisting primarily of agriculture, cattle grazing, logging, and residences (Rector and Hallock 1990).

Given the lake's importance for recreation and drinking water, there are concerns about the growth of algae in nearshore areas. One species of note is the invasive alga, *Didymosphenia geminata* ("Didymo"). *Didymosphenia* grows in low nutrient waters and has become established in rivers on most continents, and is widespread in western North America (Spaulding and Elwell 2007). *Didymosphenia* is a stalked diatom that can form thick mats and is considered a nuisance species. It is hypothesized that *Didymosphenia* spreads with human vectors (e.g., fishing equipment; Bothwell et al. 2009), though recent studies suggest that changing environmental conditions are also facilitating range expansion (e.g., Lavery et al. 2014). *Didymosphenia* has been found in a number of locations in Washington (Kumar et al. 2009), including the Chelan River. Regardless of the reasons for its range expansion, lake users should be aware of the presence of this invasive species and follow best practices to prevent the spread of this and other aquatic invasive species (e.g., Clean, Drain, Dry; Play, Clean, Go; WA Invasive Species Council 2021).



2 Methods

The algae samples were collected from the shoreline of Lake Chelan and the Chelan River by Philip Long, Executive Director, and the staff of the Lake Chelan Research Institute. Photographs of the sampling sites and shoreline algal growth are included in Appendix A (Figures A1–A18, pages 8–25).

The algae samples were preserved using Lugol’s iodine solution, then mailed to the Institute for Watershed Studies (IWS) or Dr. Matthews¹ for processing. A few unpreserved samples were also collected to help with general identifications. The unpreserved samples were kept cool and out of direct sunlight, then sent to IWS or Dr. Matthews for immediate examination.

The Lake Chelan and Chelan River taxa² are listed in Table 1 (page 5) and depicted in Appendix B (Figures B1–B42, pages 27–68). All identifications represent our best effort to provide accurate classifications using standard taxonomic keys and online sources. Uncertain identifications were flagged using ”cf.” prior to the species or variety name.³ Unknown taxa that could be separated using morphological features were given a unique name (e.g., unknown naviculoid diatom). Preserved samples are more difficult to identify because the iodine in Lugol’s imparts a dark brown or purple color to most of the cell contents and diagnostic features like mobility are lost. As a result, most of the taxa included in this report are identified to genus rather than species.

¹Current address: 1529 Old Buena Vista Rd., Buena Vista, VA, 24416

²The word “taxa” (singular “taxon”) is used to distinguish unique groups of organisms.

³Taxonomists often use “cf” (Latin: *conferre* or *conformis*) to indicate uncertainty.

Table 1: Lake Chelan algae species list. Taxonomic authority is from Guiry and Guiry (2021).

Type	Name and Authority	Page	
Cyanobacteria (bluegreens)	<i>Aphanothece</i> Nägeli	27	
	<i>Chroococcus</i> Nägeli or <i>Eucapsis</i> Clements & Shantz	27	
	<i>Coelomoron</i> Buell	28	
	<i>Dichothrix</i> Zanardini ex Bornet & Flahault	28	
	<i>Limnothrix</i> Meffert	29	
	<i>Merismopedia</i> Meyen	29	
	<i>Microcoleus</i> Desmazières ex Gomont	30	
	<i>Nostoc</i> Vaucher ex Bornet & Flahault	30	
	<i>Phormidium</i> Kützing ex Gomont or <i>Oscillatoria</i> Vaucher ex Gomont	31	
	<i>Phormidium</i> Kützing ex Gomont	31	
	<i>Pseudanabaena</i> Lauterborn	32	
	<i>Rhabdoderma lineare</i> Schmidle & Lauterborn	32	
	<i>Scytonema</i> Agardh ex Bornet & Flahault	33	
	<i>Tychonema</i> Anagnostidis & Komárek	33	
	Chlorophyta (green algae)	<i>Ankistrodesmus spiralis</i> (Turner) Lemmermann	34
		<i>Bulbochaete</i> Agardh	34
<i>Chaetophora</i> Schrank		35	
<i>Chaetosphaeridium globosum</i> (Nordstedt) Klebahn		35	
<i>Crucigenia</i> Morren		36	
<i>Desmodesmus</i> (Chodat) An, Friedl & Hegewald		36	
<i>Elakatothrix gelatinosa</i> Wille		37	
<i>Geminella interrupta</i> Turpin		37	
<i>Gloeocystis</i> Nägeli		38	
<i>Kirchneriella</i> Schmidle		38	
<i>Lemmermannia</i> cf. <i>tetrapedia</i> (Kirchner) Lemmermann		39	
<i>Monoraphidium</i> Komárková-Legnerová		39	
<i>Monoraphidium contortum</i> (Thuret) Komárková-Legnerová		40	
<i>Mougeotia</i> De Bary		40	
<i>Nephrocytium</i> Nägeli		41	
<i>Oedogonium</i> Link ex Hirn		41	
<i>Oocystis</i> Nägeli ex Braun		42	
<i>Oonephris</i> Fott		42	
<i>Pandorina</i> Bory	43		
<i>Planktosphaeria gelatinosa</i> Smith	43		

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Table 1: Lake Chelan algae list, continued

Type	Name and Authority	Page
	<i>Pseudopediastrum boryanum</i> var. <i>longicorne</i> (Reinsch) Tsarenko	44
	<i>Scenedesmus</i> Meyen	44
	<i>Schizochlamys gelatinosa</i> Braun	45
	<i>Sphaerocystis</i> Chodat	45
	<i>Spirogyra</i> Link	46
	<i>Stigeoclonium</i> Kützing	47
	<i>Tetradesmus dimorphus</i> (Turpin) Wynne	47
	<i>Tetradesmus obliquus</i> (Turpin) Wynne	48
	<i>Ulothrix</i> Kützing	48
	<i>Willea rectangularis</i> (Braun) John, Wynne & Tsarenko	49
	<i>Zygnema</i> Agardh	49
Streptophyta (desmids)	<i>Cosmarium</i> Corda ex Ralfs	50
	<i>Cosmarium abbreviatum</i> var. <i>planctonicum</i> West & G. S. West	50
	<i>Cosmarium bioculatum</i> Brébisson ex Ralfs	51
	<i>Cosmarium blyttii</i> Wille	51
	<i>Cosmarium laeve</i> Rabenhorst	52
	<i>Cosmarium moniliferum</i> Ralfs	52
	<i>Cosmarium norimbergensis</i> Reinsch	53
	<i>Cosmarium pseudoconnatum</i> Nordstedt	53
	<i>Gonatozygon kinahanii</i> (Archer) Rabenhorst	54
	<i>Hyalotheca mucosa</i> Ralfs	54
	<i>Spondylosium planum</i> (Wolle) West & G. S. West	55
	<i>Staurastrum</i> Meyen ex Ralfs	55
	<i>Staurastrum alternans</i> Brébisson	56
	<i>Staurastrum anatinum</i> Cooke & Wills	56
	<i>Staurastrum</i> cf. <i>bieneanum</i> Rabenhorst	57
	<i>Staurastrum cytocerum</i> var. <i>inflexum</i> (Brébisson) Coesel & Meesters	57
	<i>Staurastrum longipes</i> (Nordstedt) Teiling	58
	<i>Staurastrum lunatum</i> Ralfs	58
Bacillariophyta (diatoms)	<i>Achnantheidium minutissimum</i> (Kützing) Czarnecki	59
	<i>Cocconeis</i> Ehrenberg	59
	<i>Cyclotella</i> (Kützing) Brébisson	60
	<i>Cymbella</i> Agardh	60
	<i>Diatoma</i> Bory	61

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Table 1: Lake Chelan algae list, continued

Type	Name and Authority	Page
	<i>Didymosphenia geminata</i> (Lyngbye) Mart. Schmidt	61
	<i>Encyonema</i> Kützing	62
	<i>Fragilaria capucina</i> Desmazières	62
	<i>Fragilaria crotonensis</i> Kitton	63
	<i>Gomphonema</i> Ehrenberg	63
	<i>Melosira</i> Agardh	64
	<i>Rhopalodia</i> Müller	64
	<i>Tabellaria</i> Ehrenberg ex Kützing	65
	<i>Tabellaria flocculosa</i> (Roth) Kützing	65
	<i>Thalassiosira</i> Cleve	66
	<i>Ulnaria capitata</i> (Ehrenberg) Compère & Bukhtiyarova	66
	unknown naviculoid diatom	67
	unknown symmetric biraphid diatom	67
Dinophyta (dinoflagellates)	dinoflagellate cyst	68
Ochrophyta (golden algae)	<i>Stichogloea olivacea</i> Chodat	68

3 References

Bothwell, M. L., D. R. Lynch, H. Wright, and J. Deniseger, 2009. On the boots of fishermen: the history of didymo blooms on Vancouver Island, British Columbia. *Fisheries* 34:382–388.

Guiry, M. D. and G. M. Guiry. 2021. AlgaeBase. World-wide electronic publication, National University of Ireland, Galway. <https://www.algaebase.org>: searched on 15 February 2021.

Kumar, S., S. A. Spaulding, T. J. Stohlgren, K. A. Hermann, T. S. Schmidt, and L. L. Bahls. 2009. Potential habitat distribution for the freshwater diatom *Didymosphenia geminata* in the continental US. *Frontiers in Ecology and the Environment*, 7:415–420.

Lavery, J. M., J. Kurek, K. M. Rühland, C. A. Gillis, M. F. Pisaric, and J. P. Smol. 2014. Exploring the environmental context of recent *Didymosphenia geminata* proliferation in Gaspésie, Quebec, using paleolimnology. *Canadian Journal of Fisheries and Aquatic Sciences* 71:616–626.

Rector, J. and D. Hallock. 1993. Lake Water Quality Assessment Project. Washington Department of Ecology Publication 92–124.

Schoen, E. and D. A. Beauchamp. 2010. Predation impacts of lake trout and Chinook salmon in Lake Chelan, Washington: Implications for prey species and fisheries management. WA Cooperative Fish and Wildlife Research Unit.

Spaulding, S. A. and L. Elwell. 2007. Increase in nuisance blooms and geographic expansion of the freshwater diatom *Didymosphenia geminata*: U. S. Geological Survey Open-File Report 2007–1425.

Washington Invasive Species Council. 2021. Clean, Drain, Dry. <https://invasivespecies.wa.gov/campaigns/clean-drain-dry/>

Washington Invasive Species Council. 2021. Play, Clean, Go. <https://invasivespecies.wa.gov/campaigns/play-clean-go/>

A Lake Chelan and Chelan River Photographs

All the field photographs in this section were taken by Philip Long, Lake Chelan Research Institute.⁴ The site map in Figure [A1](#) was provided by P. Long.

⁴Lake Chelan Research Institute, PO Box 1547, Chelan WA 98816

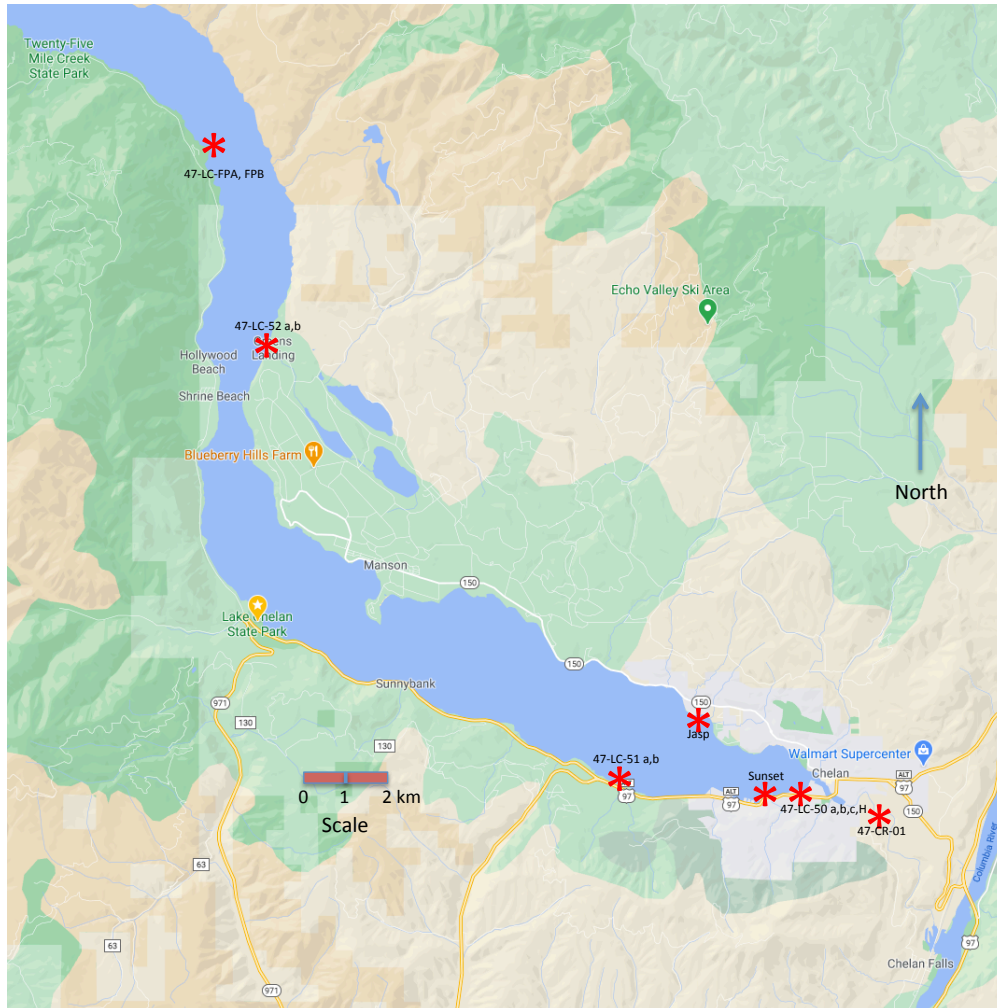


Figure A1: Location map for samples used in this study. The map shows the lower part of Lake Chelan, mainly the Wapato Basin, the area south of the narrowest part of the lake. Site identification labels include the WRIA watershed number (47); location (CR=Chelan River; LC=Lake Chelan); and sample ID number, with letters indicating separate samples that were collected at the same location.



Figure A2: Lake Chelan sampling location 47-LC-01, January 21, 2020 (Lat: 47.83766902, Long: -120.02472413).



Figure A3: Lake Chelan sampling location 47-LC-51 (south shore), January 21, 2020 (Lat: 47.84037360, Long: -120.08813200). This site was sampled because the property owner reported seeing more periphyton growth during the past year compared to earlier years.



Figure A4: Lake Chelan sampling location 47-LC-52 (near Stink Creek), January 21, 2020 (Lat. 47.92984459, Long: -120.19450556)



Figure A5: Periphyton growth on shoreline substrate at Lake Chelan sampling location 47-LC-50, April 3, 2018.



Figure A6: Periphyton samples from shoreline substrate at Lake Chelan sampling location 47-LC-50, April 3, 2018. The upper container (47-LC-50a) shows long strands of periphyton on rocks located slightly off-shore; the lower container (47-LC-50b) shows shorter periphyton on rocks located at the waterline.



Figure A7: Periphyton growth on shoreline substrate at Lake Chelan sampling location 47-LC-50a, January 21, 2020.



Figure A8: Periphyton growth on shoreline substrate at Lake Chelan sampling location 47-LC-50b, January 21, 2020.



Figure A9: Periphyton growth on shoreline substrate at Lake Chelan sampling location 47-LC-51, January 21, 2020. Note presence of Asian Clam shells, which were abundant at this location.



Figure A10: Periphyton growth on shoreline substrate at Lake Chelan sampling location 47-LC-52a, January 21, 2020. This type of dark gray to black algae coated the rocky shoreline of Lake Chelan in the Lucerne Basin (Figures [A10–A12](#)). As the lake level dropped in the fall, this material formed a “bathtub ring” visible on much of the rocky shoreline of the Lucerne Basin.



Figure A11: Periphyton growth on shoreline substrate at Lake Chelan sampling location 47-LC-52a, January 21, 2020.



Figure A12: Periphyton growth on shoreline substrate at Lake Chelan sampling location 47-LC-52a, January 21, 2020.



Figure A13: Chelan River sampling location 47-CR-01, April 3, 2018 (Lat. 47.83140220, Long: -120.00181390).



Figure A14: Periphyton growth at Chelan River sampling location 47-CR-01a, April 3, 2018. Long green strands are likely to be unbranched, filamentous green algae (e.g., *Mougeotia*, *Oedogonium*, *Spirogyra*).



Figure A15: Periphyton growth at Chelan River sampling location 47-CR-01b, April 3, 2018. Long green strands are likely to be unbranched, filamentous green algae; slimy golden brown growth is likely to be attached diatoms.



Figure A16: Periphyton growth at Chelan River sampling location 47-CR-01, January 21, 2020.



Figure A17: Periphyton growth at Chelan River sampling location 47-CR-01a, January 21, 2020. Long green strands are likely to be unbranched, filamentous green algae.



Figure A18: Periphyton growth at Chelan River sampling location 47-CR-01b, January 21, 2020. Long green strands are likely to be unbranched, filamentous green algae; bleached algae is decomposing, and could be a mixture of filamentous green algae and attached diatoms.

B Lake Chelan and Chelan River Algae Images

The images in Appendix B were photographed by Dr. Robin Matthews using a Nikon Eclipse 80i with phase contrast and Nomarski (DIC) objectives equipped with either a QImaging or Nikon DS-Fi2 digital camera. These images may be used for noncommercial purposes under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License (www.creativecommons.org), with appropriate credit given to the image copyright holder (Dr. Matthews) and the Institute for Watershed Studies, Huxley College of the Environment, Western Washington University.

The figure captions include abbreviated site names where the specimens were collected and dates that the digital images were created. Contact Philip Long, Lake Chelan Research Institute, for additional information about sampling dates and site locations.

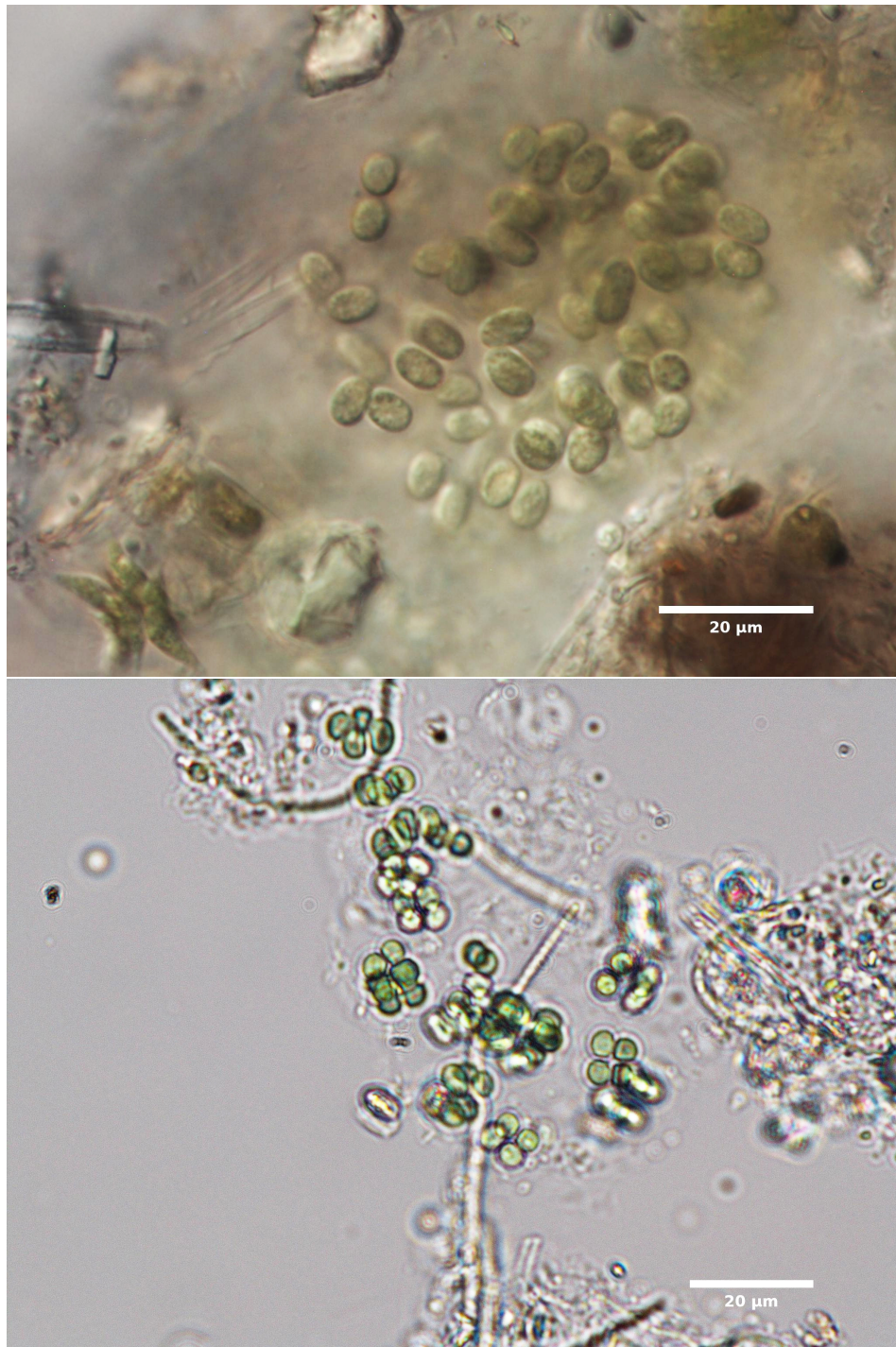


Figure B1: Cyanobacteria: *Aphanothece*, Site 47-CR-01b, January 2020 (upper image); *Chroococcus* or *Eucapsis*, Site CRA, May 2020 (lower image).

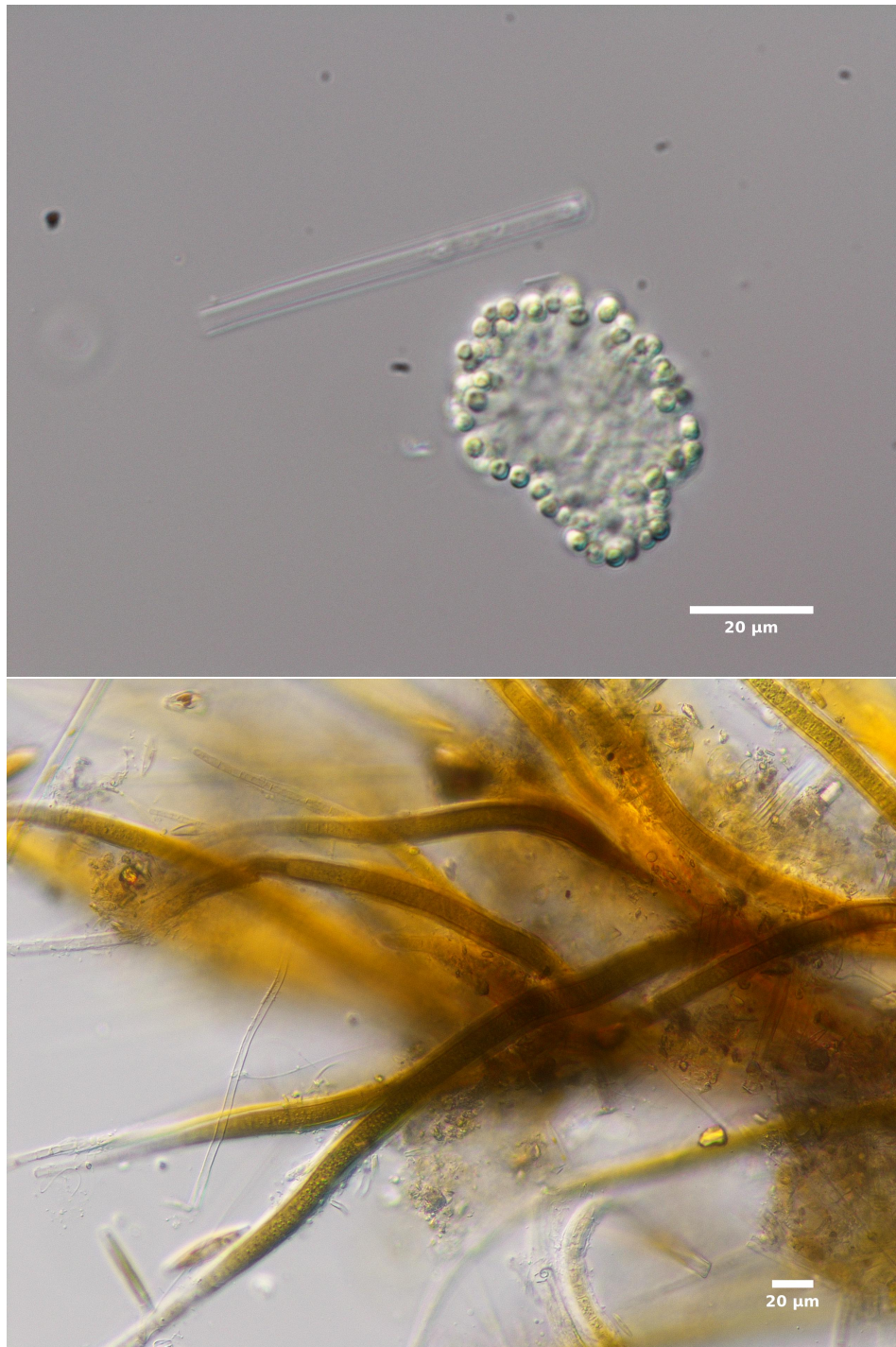


Figure B2: Cyanobacteria: *Coelomoron*, Site SUNp, November 2020 (upper image); *Dichothrix*, Site 50H, November 2020 (lower image).

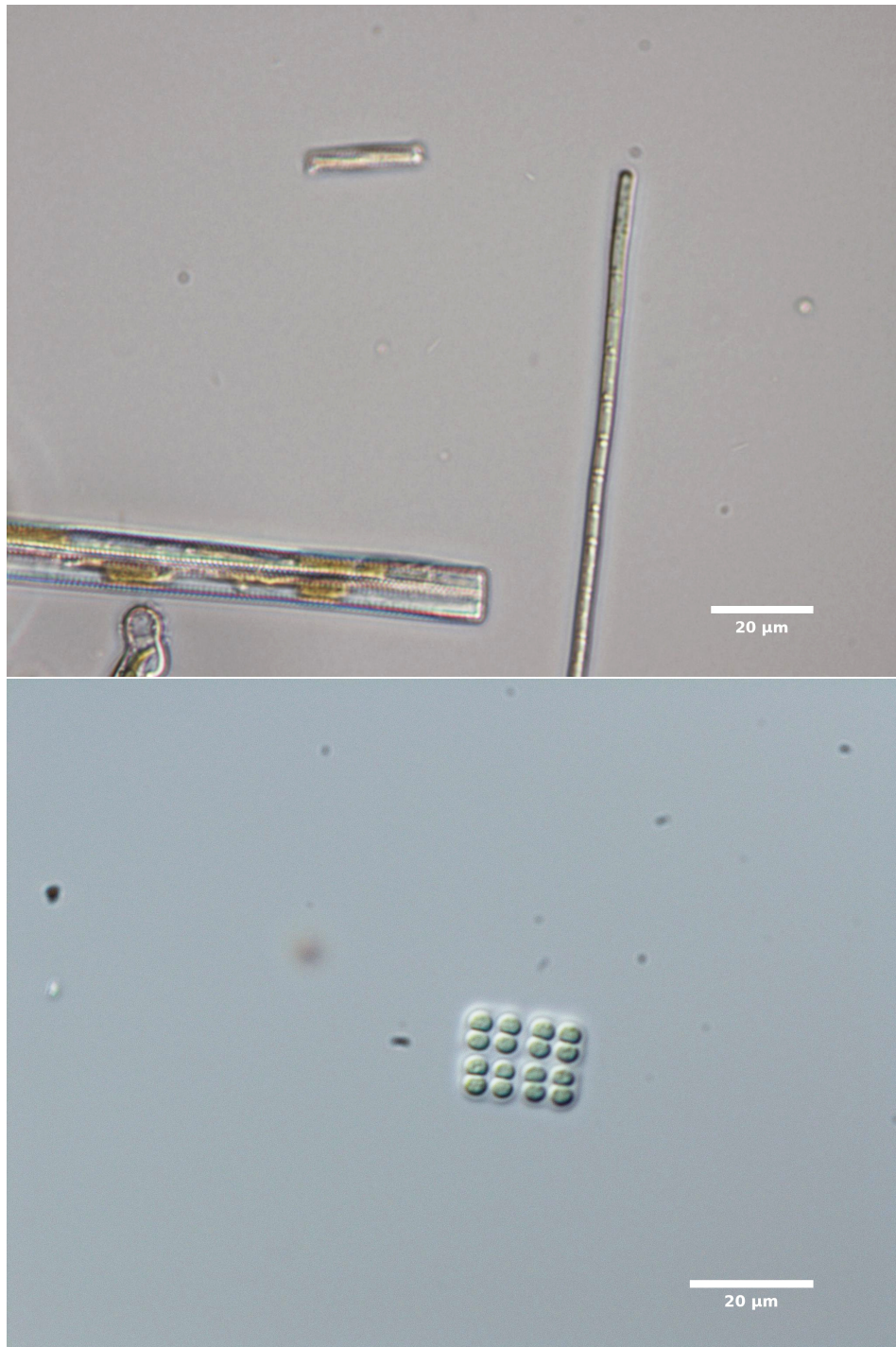


Figure B3: Cyanobacteria: *Limnothrix*, Site 47-CR-01a, January 2020 (upper image); *Merismopedia*, Site 50H, October 2020 (lower image).

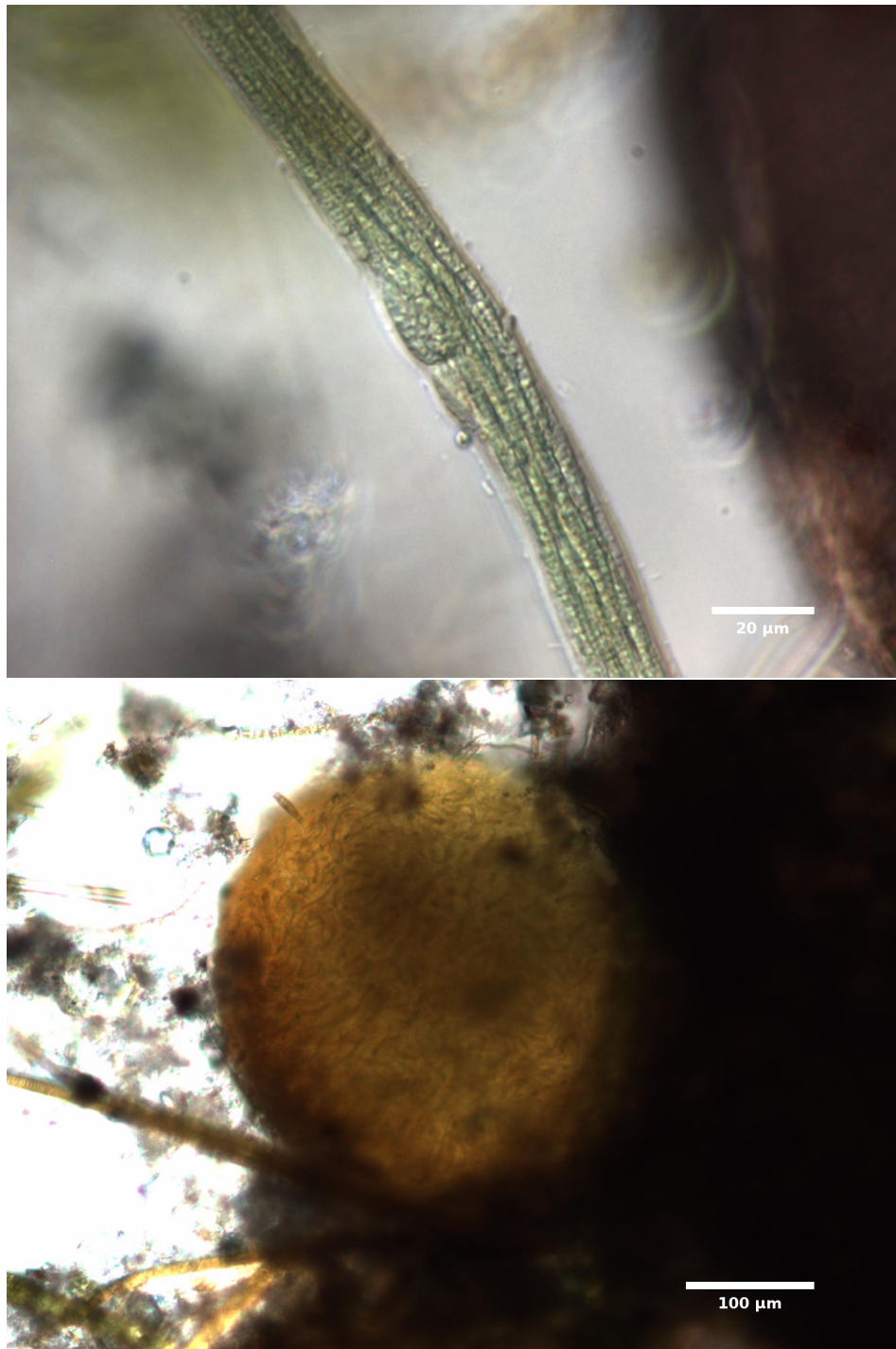


Figure B4: Cyanobacteria: *Microcoleus*, Site 47-LC-51, January 2020 (upper image); *Nostoc*, Site 47-LC-51, January 2020 (lower image).

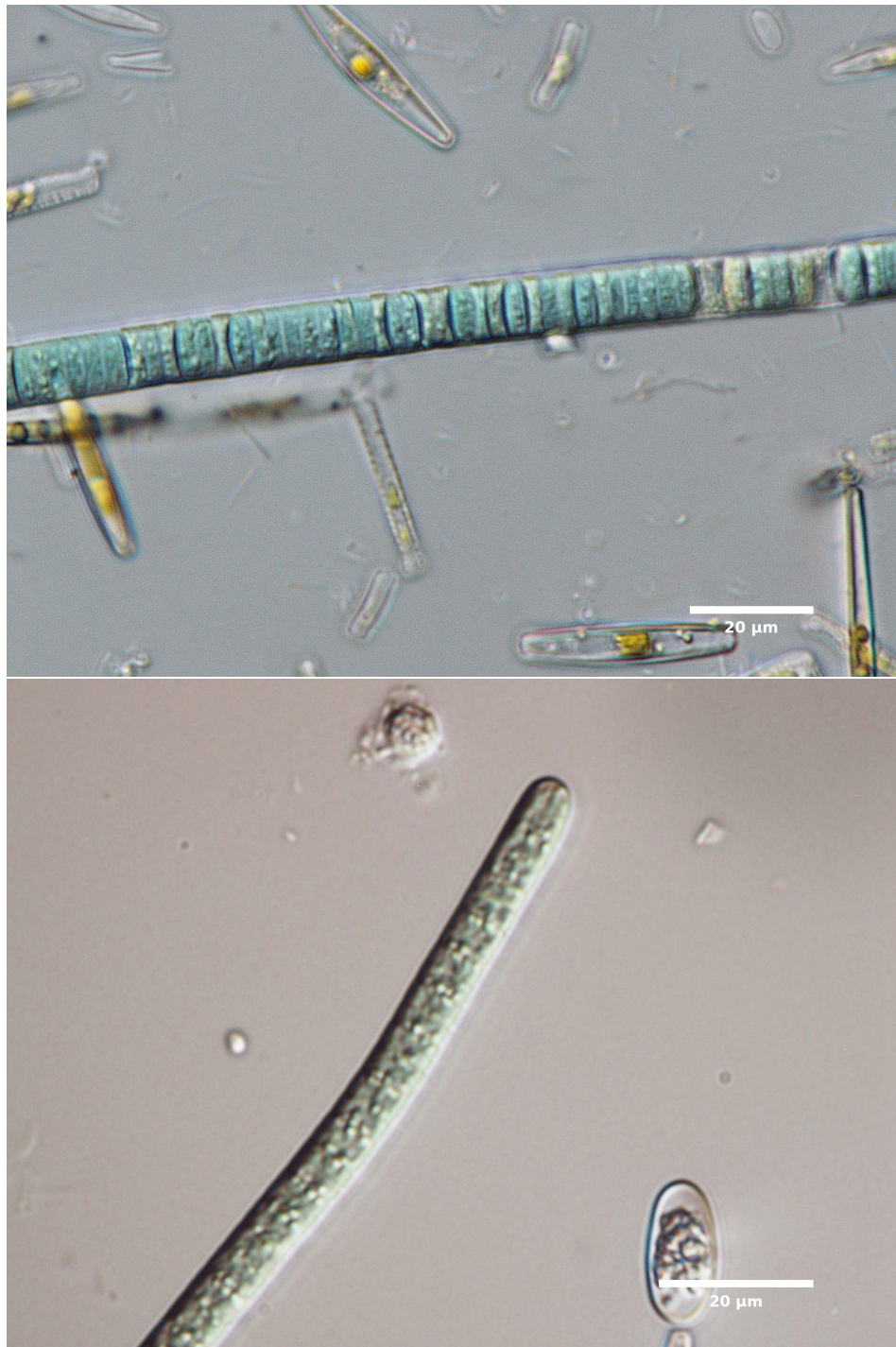


Figure B5: Cyanobacteria: *Phormidium/Oscillatoria*, Site CRb, April 2018 (upper image); *Phormidium*, Site 47-LC-52a, January 2020 (lower image).

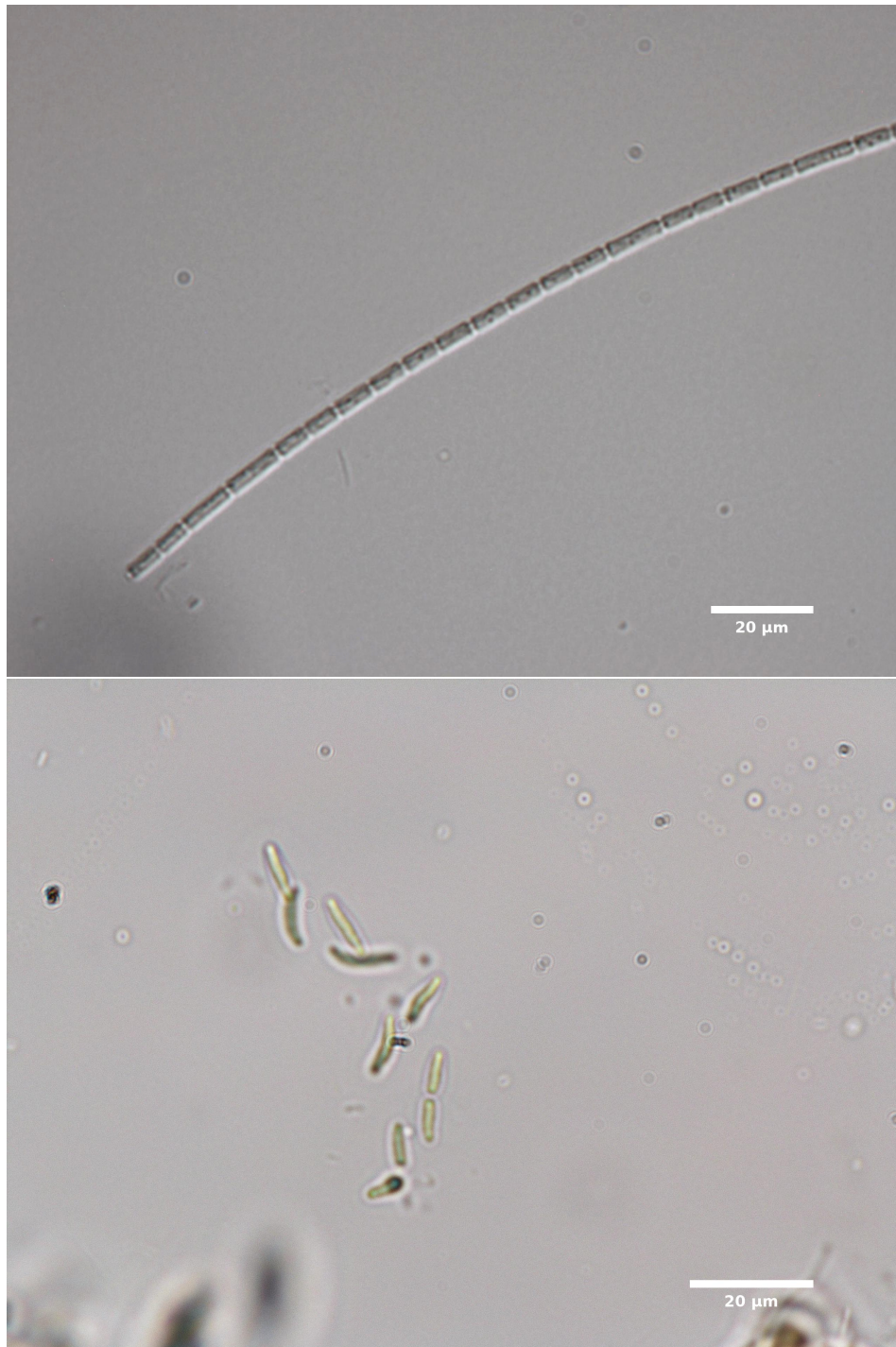


Figure B6: Cyanobacteria: *Pseudanabaena*, Site 47-CR-01a, January 2020 (upper image); *Rhabdoderma*, Site CRB, May 2020 (lower image).

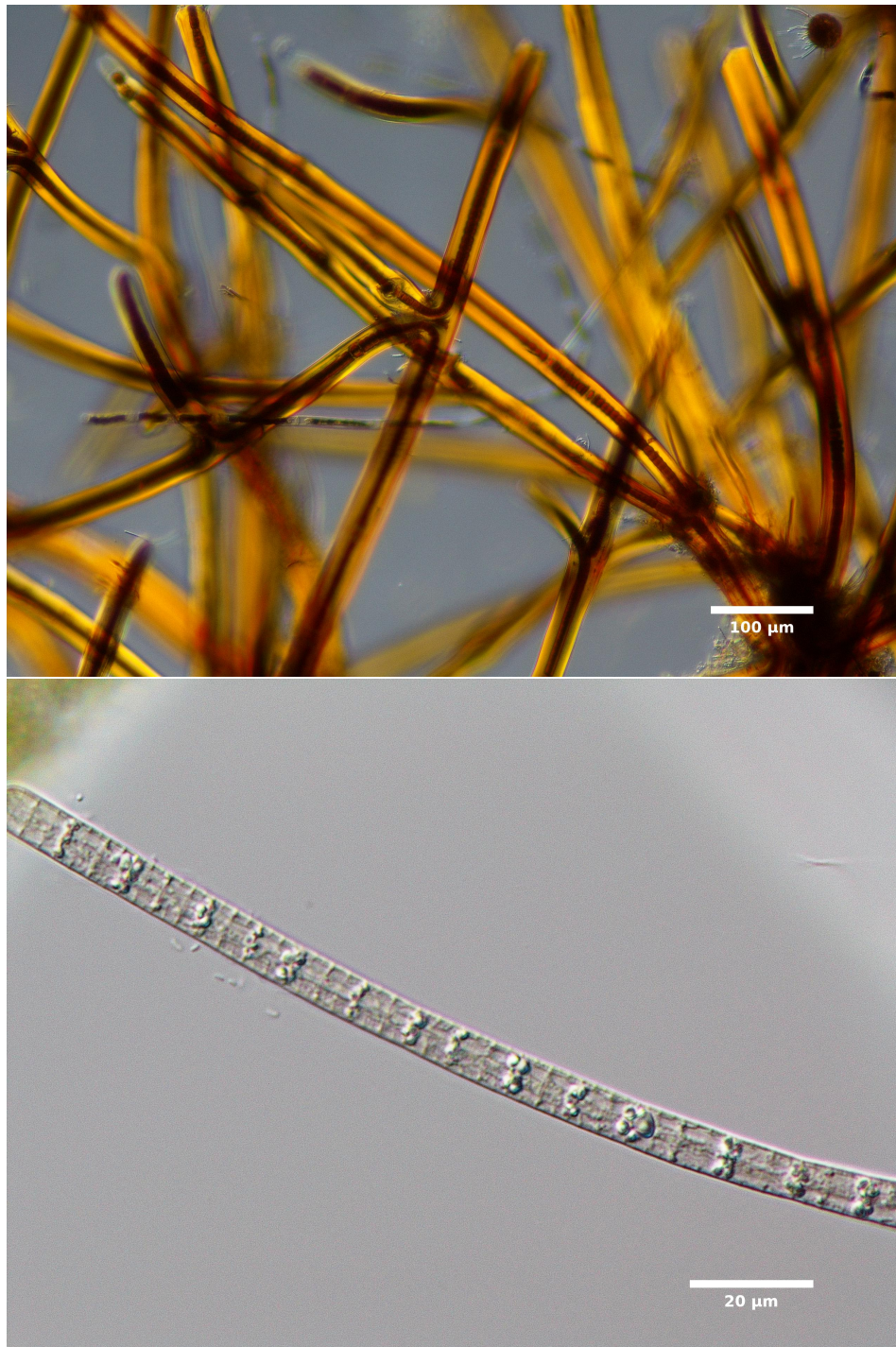


Figure B7: Cyanobacteria: *Scytonema*, Site LC-FPA, December 2020 (upper image); *Tychonema*, Site CRa, April 2018 (lower image).

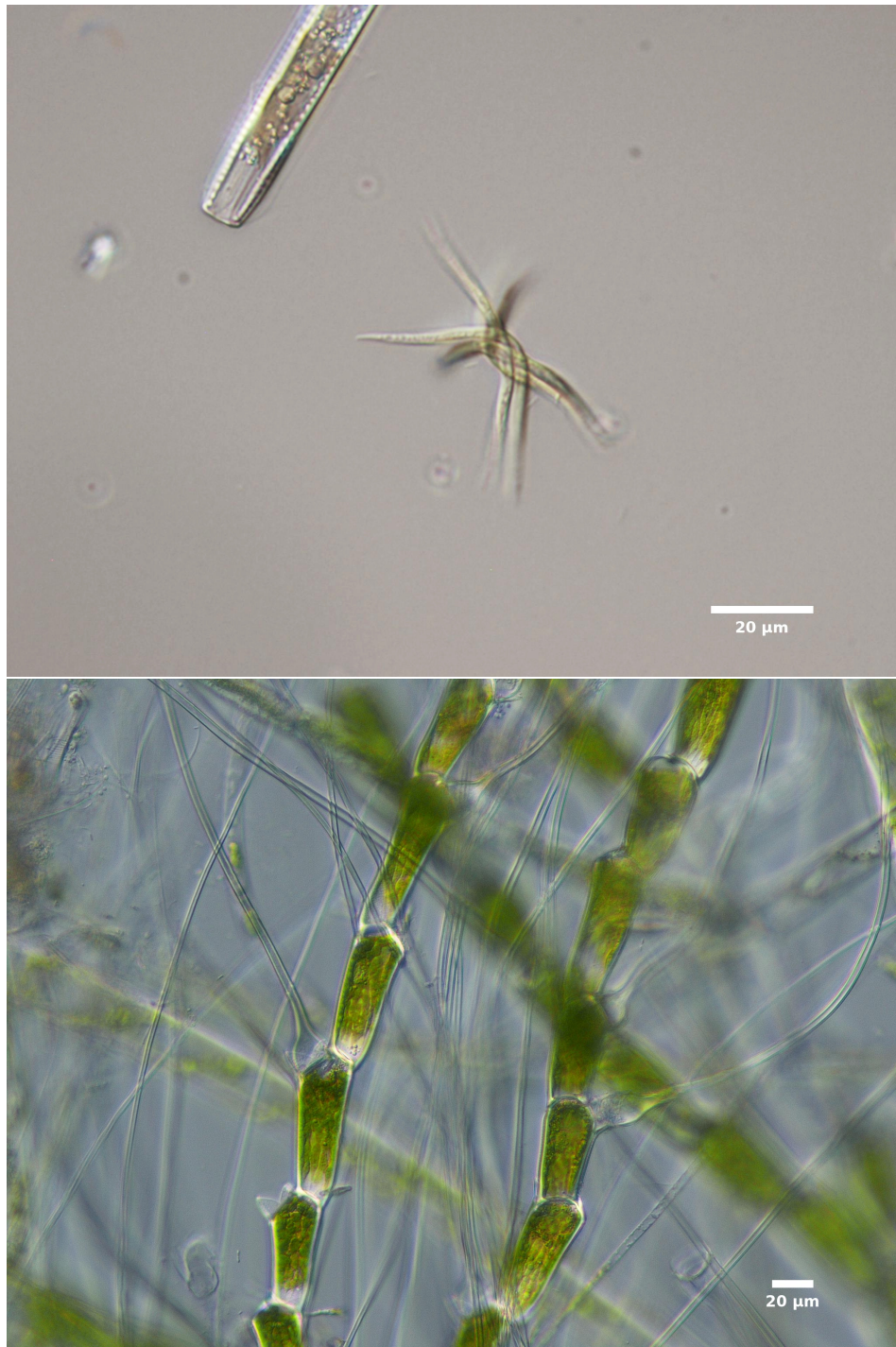


Figure B8: Chlorophyta: *Ankistrodesmus spiralis*, Site 47-CR-01b, January 2020 (upper image); *Bulbochaete*, Site SUND, October 2020 (lower image).



Figure B9: Chlorophyta: *Chaetophora*, Site SUNp, November 2020 (upper image); *Chaetosphaeridium globosum*, Site SUNd, October 2020 (lower image).

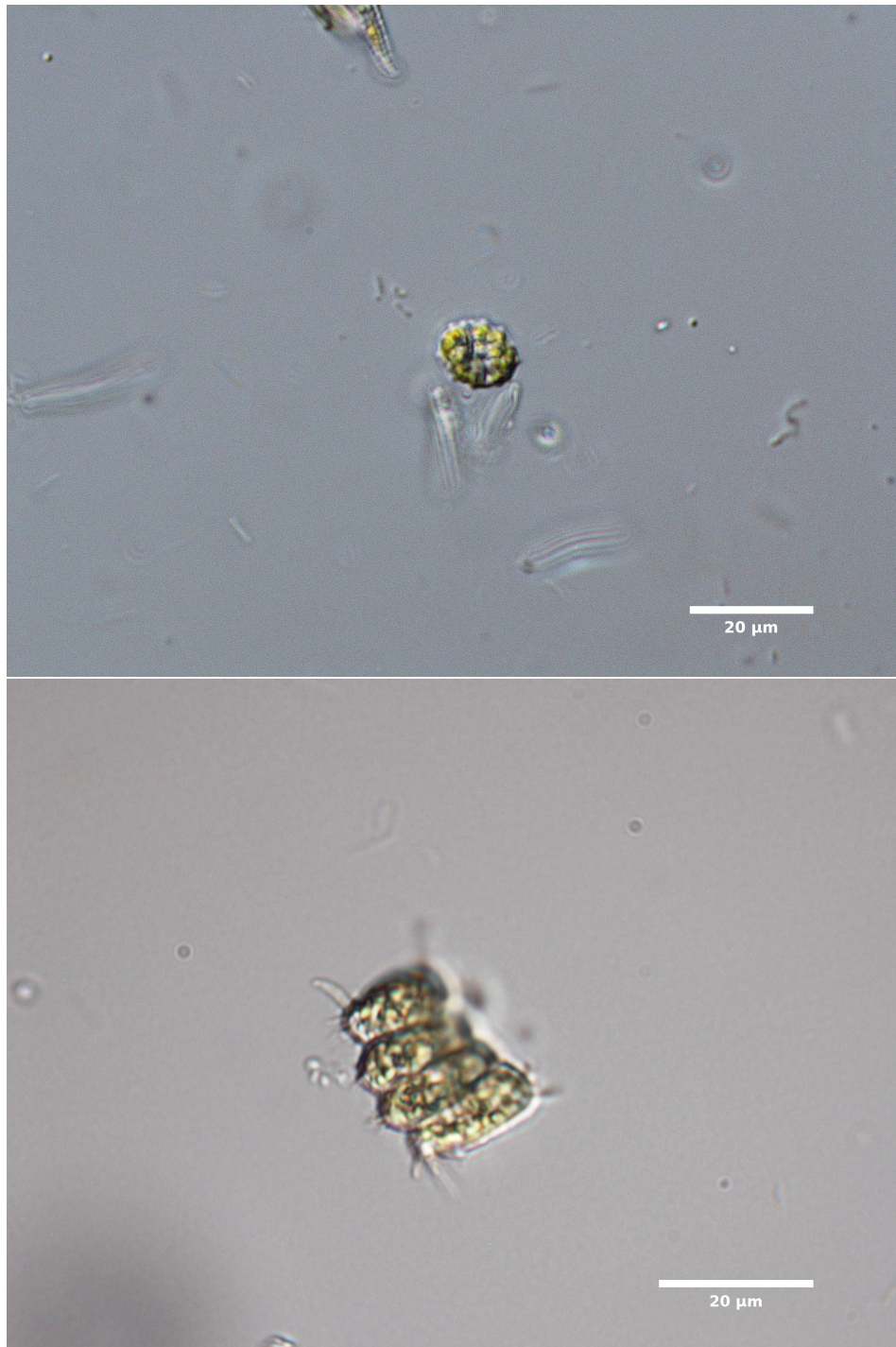


Figure B10: Chlorophyta: *Crucigenia*, Site CRb, April 2018 (upper image); *Desmodesmus*, Site 47-CR-01a, January 2020 (lower image).

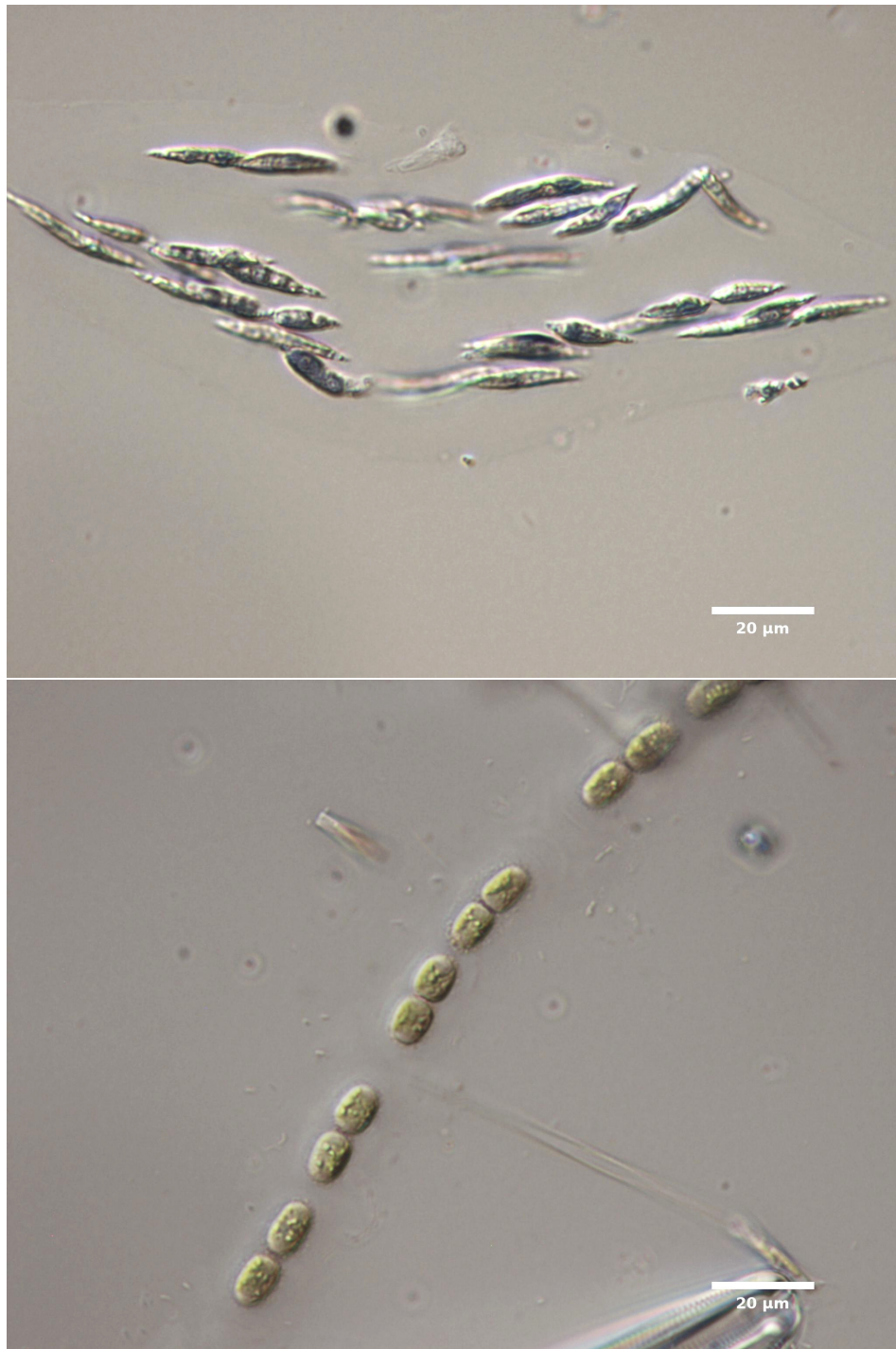


Figure B11: Chlorophyta: *Elakatothrix gelatinosa*, Site MARLIT, January 2020 (upper image); *Geminella interrupta*, Site 47-CR-01b, January 2020 (lower image).

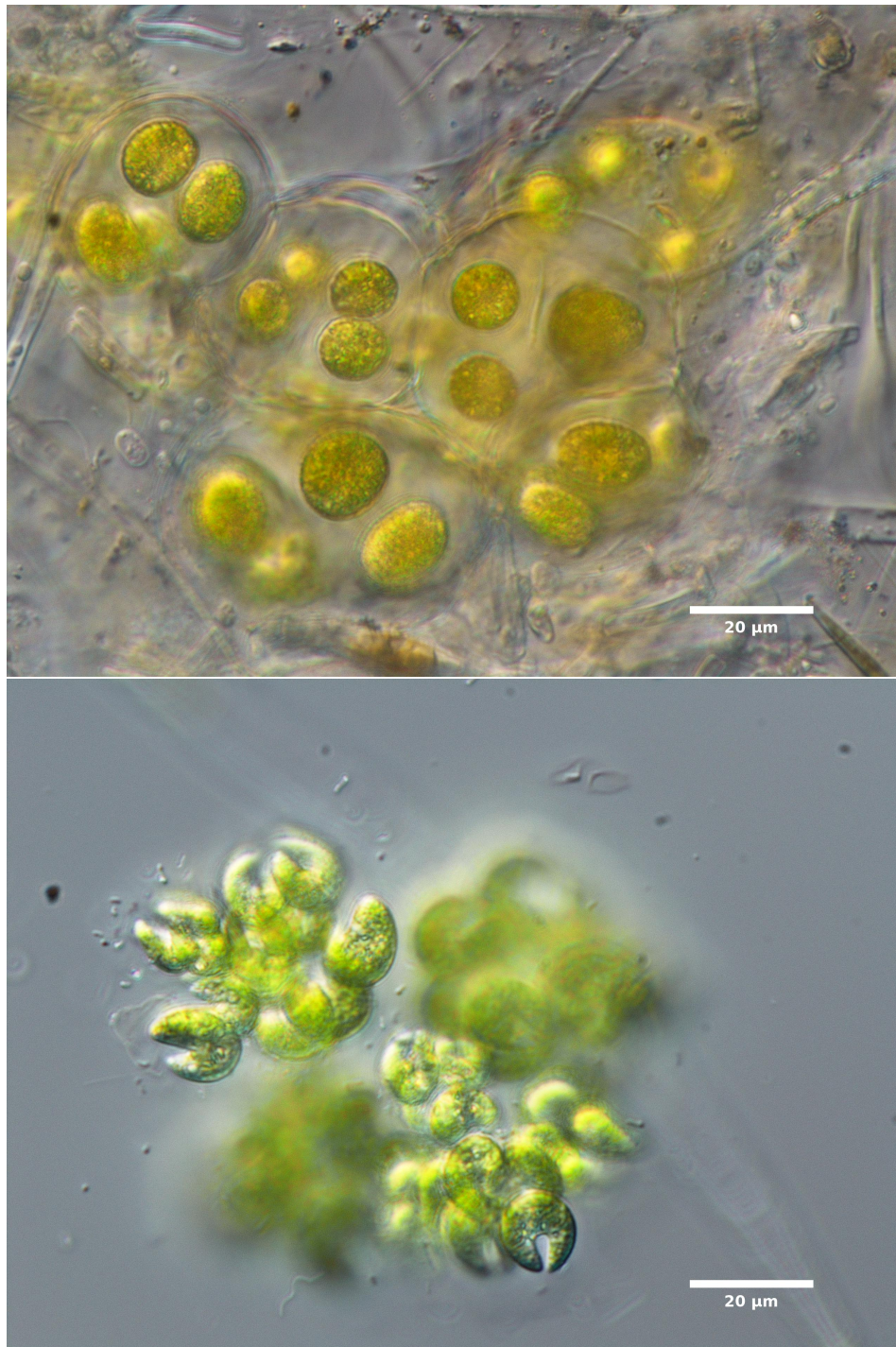


Figure B12: Chlorophyta: *Gloeocystis*, Site SUNp, November 2020 (upper image); *Kirchneriella*, Site SUNp, October 2020 (lower image).



Figure B13: Chlorophyta: *Lemmermannia cf. tetrapedia*, Site CRb, April 2018 (upper image); *Monoraphidium*, Site SUNp, November 2020 (lower image).



Figure B14: Chlorophyta: *Monoraphidium* cf. *contortum*, Site CRB, May 2020 (upper image); *Mougeotia*, Site CRa, April 2018 (lower image).



Figure B15: Chlorophyta: *Nephrocytium*, Site SUNp, November 2020 (upper image); *Oedogonium*, Site 47-CR-01a, January 2020 (lower image).

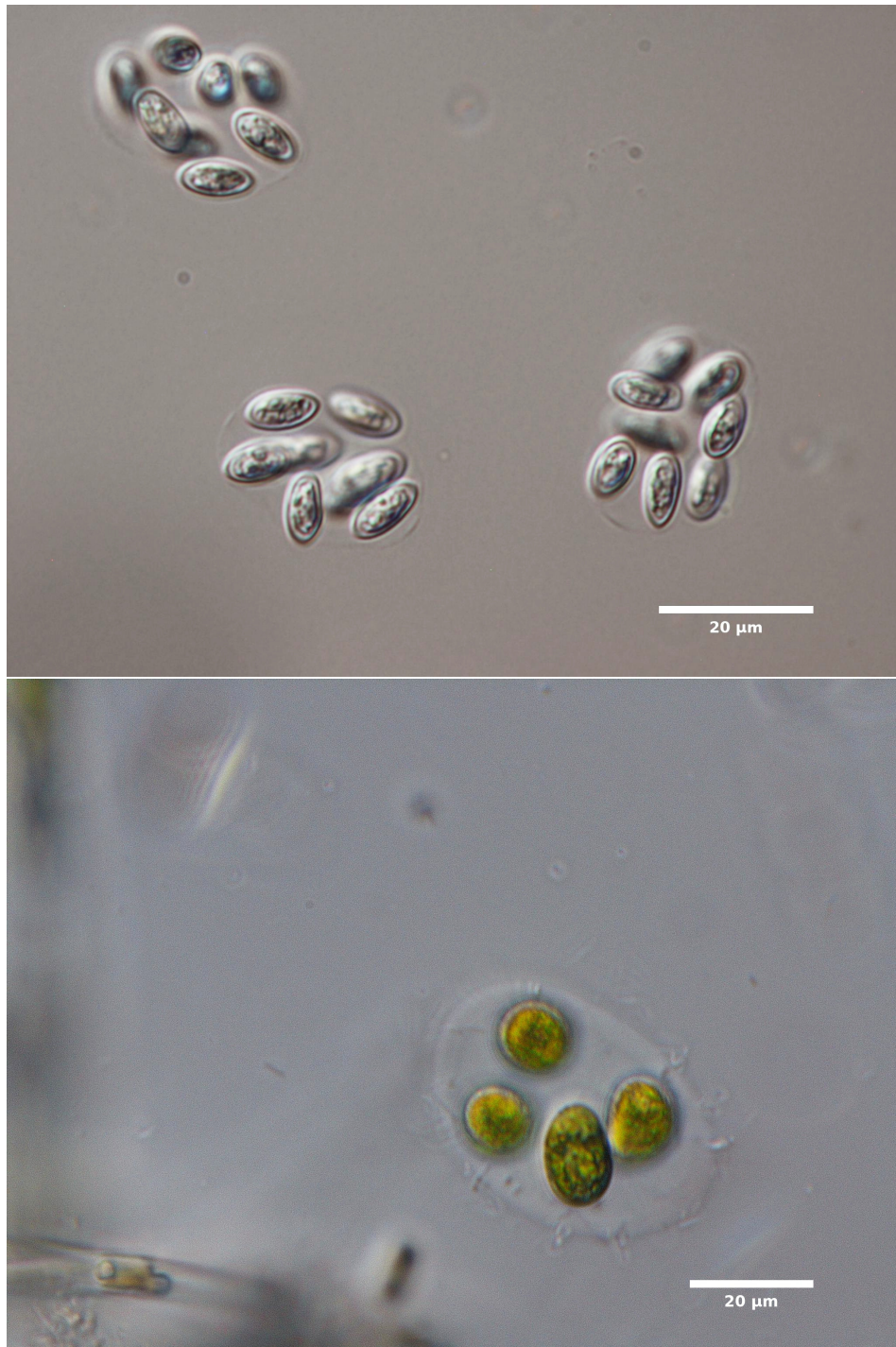


Figure B16: Chlorophyta: *Oocystis*, Site MARLIT, January 2020 (upper image); *Oonephris*, Site CRb, April 2018 (lower image).

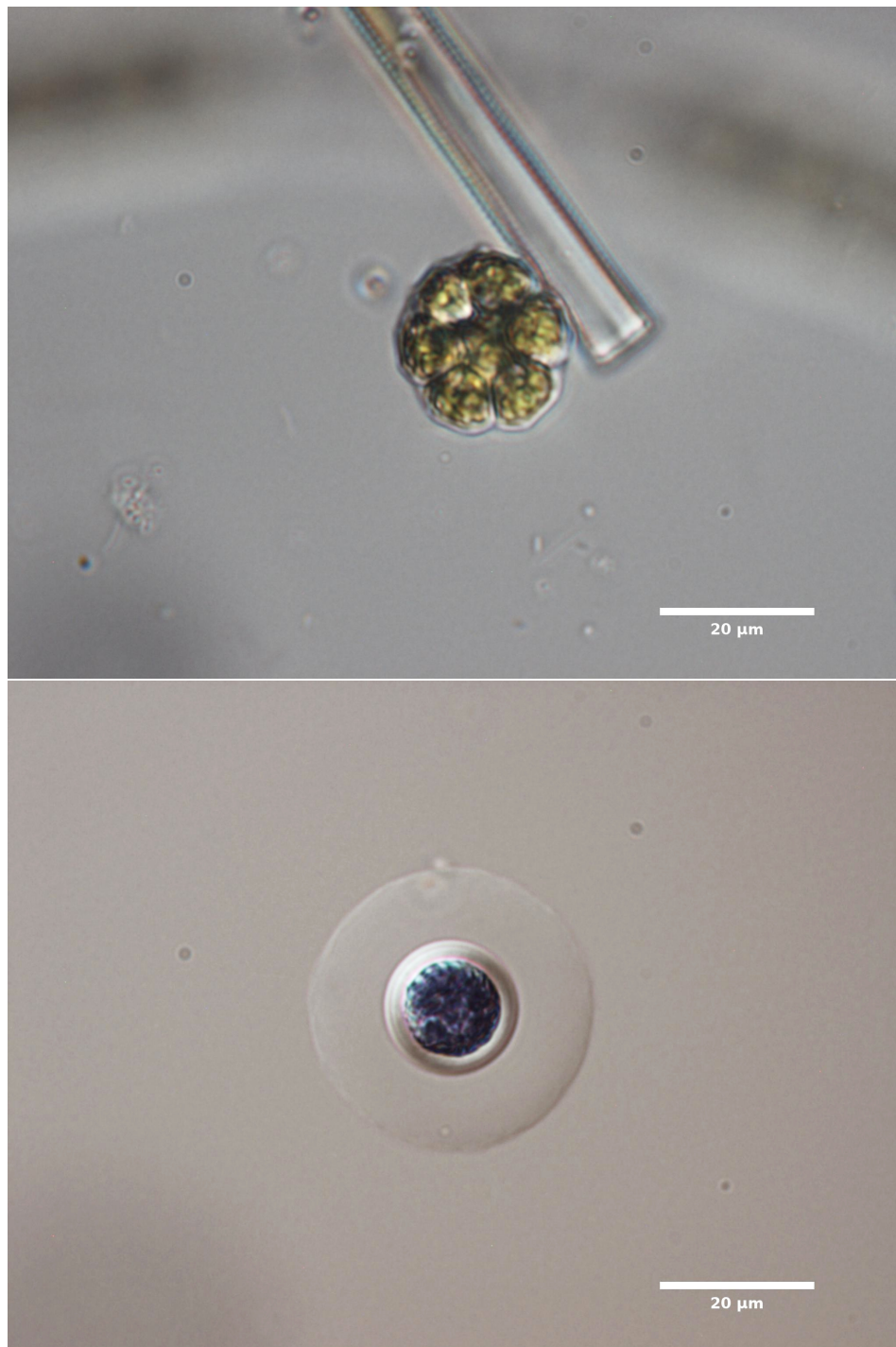


Figure B17: Chlorophyta: *Pandorina*, Site 47-CR-01a, January 2020 (upper image); *Planktosphaeria gelatinosa*, Site MARLIT, January 2020 (lower image).

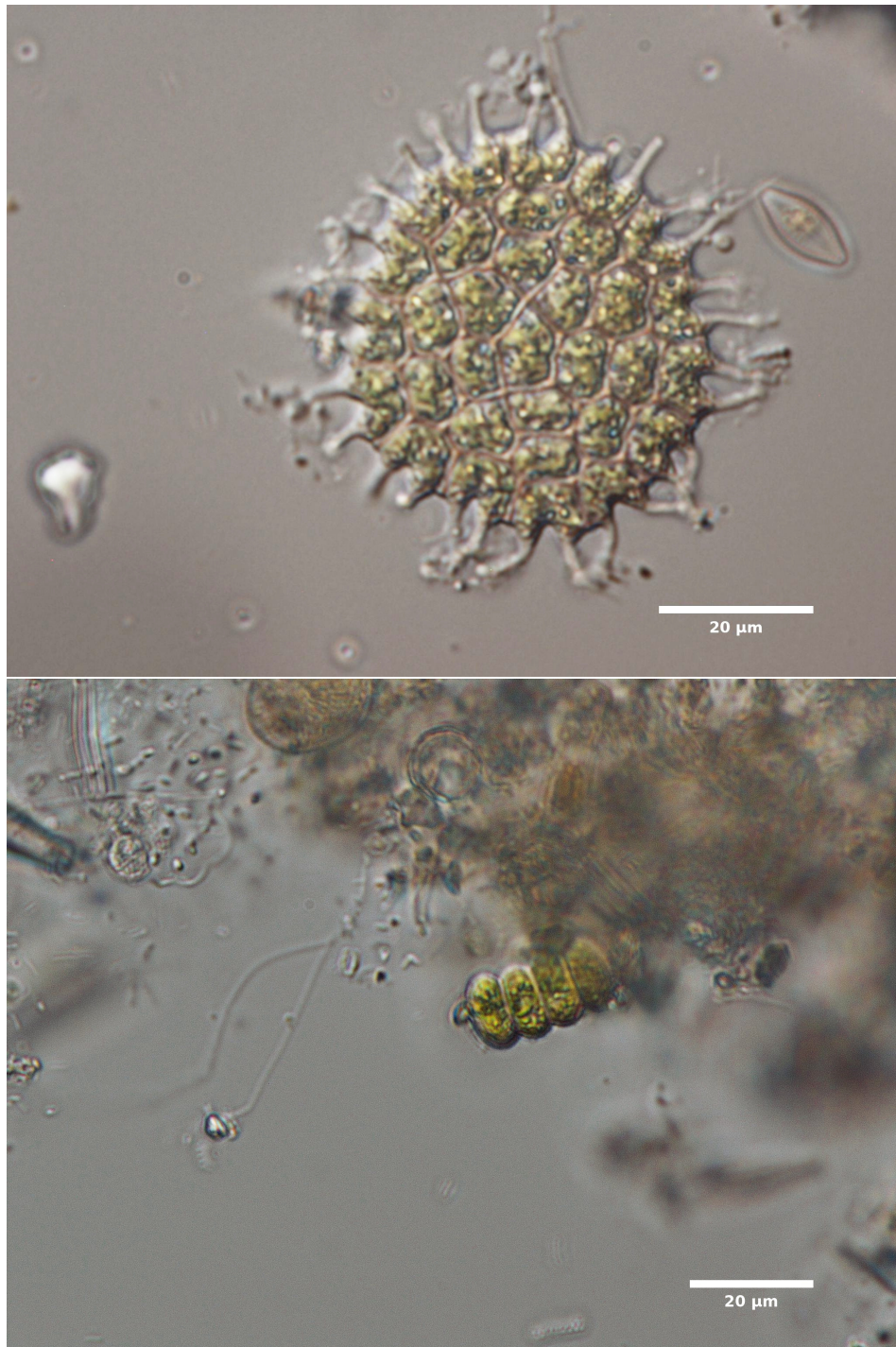


Figure B18: Chlorophyta: *Pseudopediastrum boryanum* var. *longicorne*, Site 47-LC-52a, January 2020 (upper image); *Scenedesmus*, Site CRa, April 2018 (lower image).

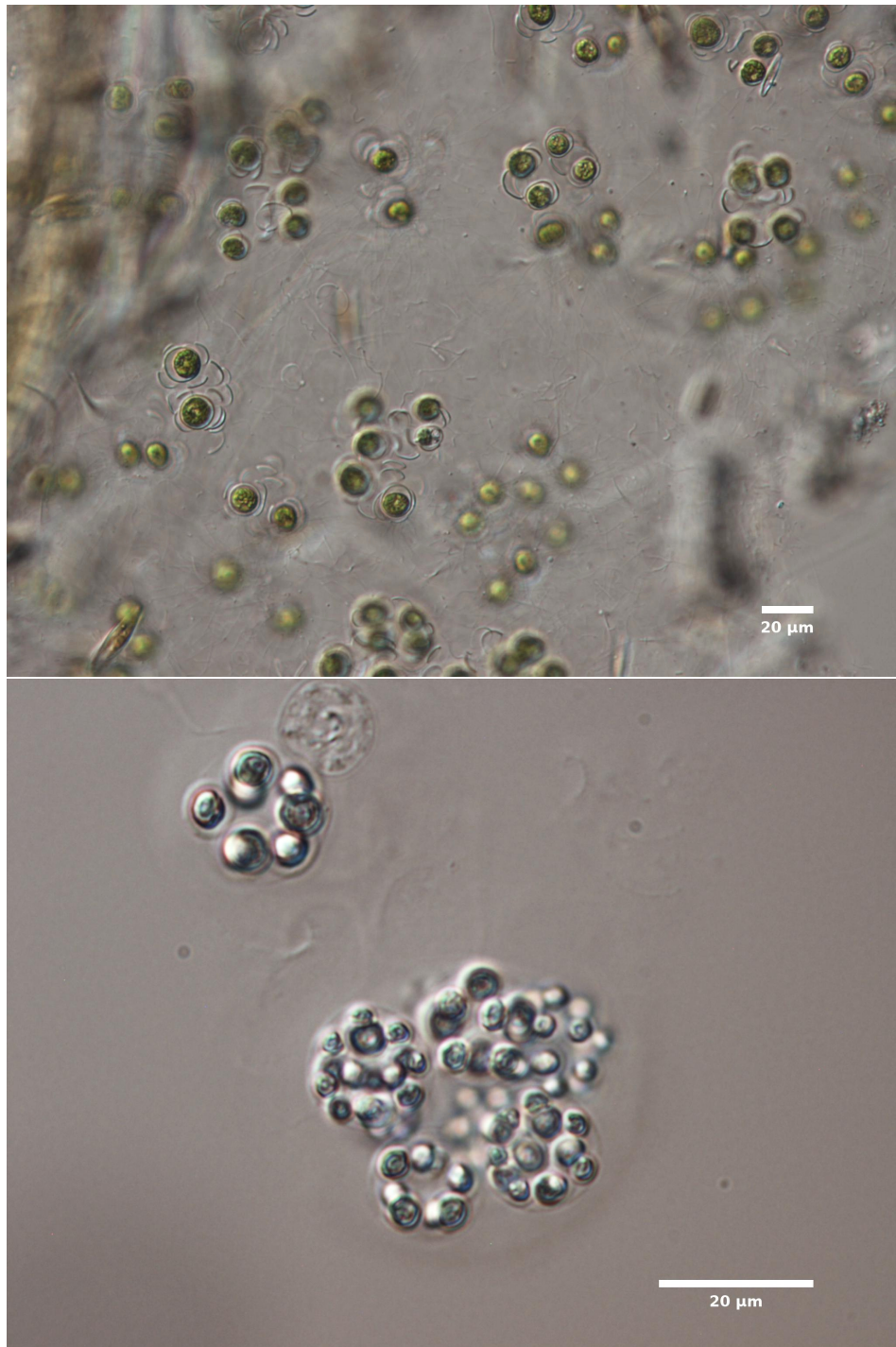


Figure B19: Chlorophyta: *Schizochlamys gelatinosa*, Site 47-CR-01b, January 2020 (upper image); *Sphaerocystis*, Site MARLIT, January 2020 (lower image).

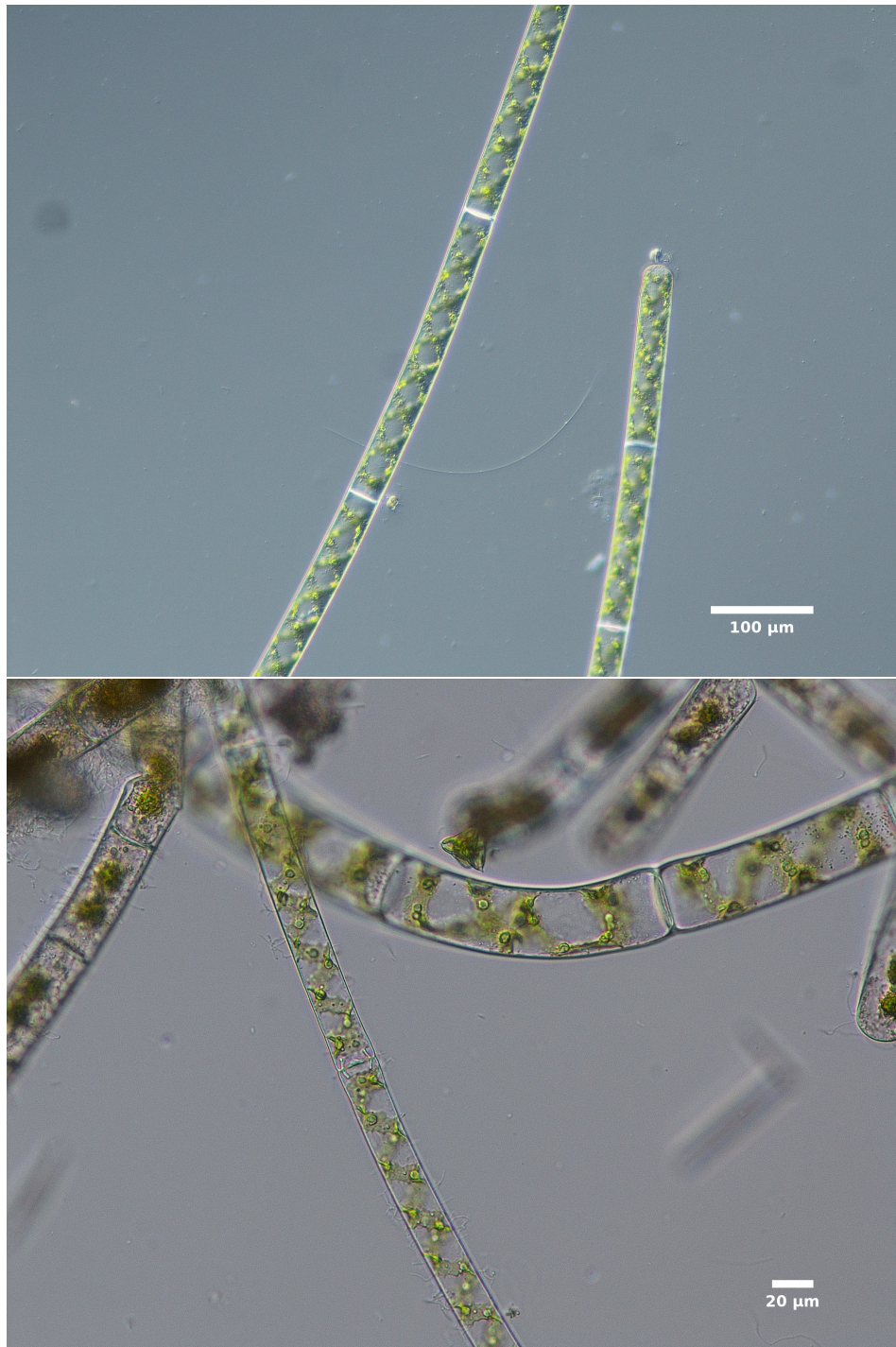


Figure B20: Chlorophyta: *Spirogyra*, Site SUNd, October 2020 (upper image); *Spirogyra*, Site CRa, April 2018 (lower image).

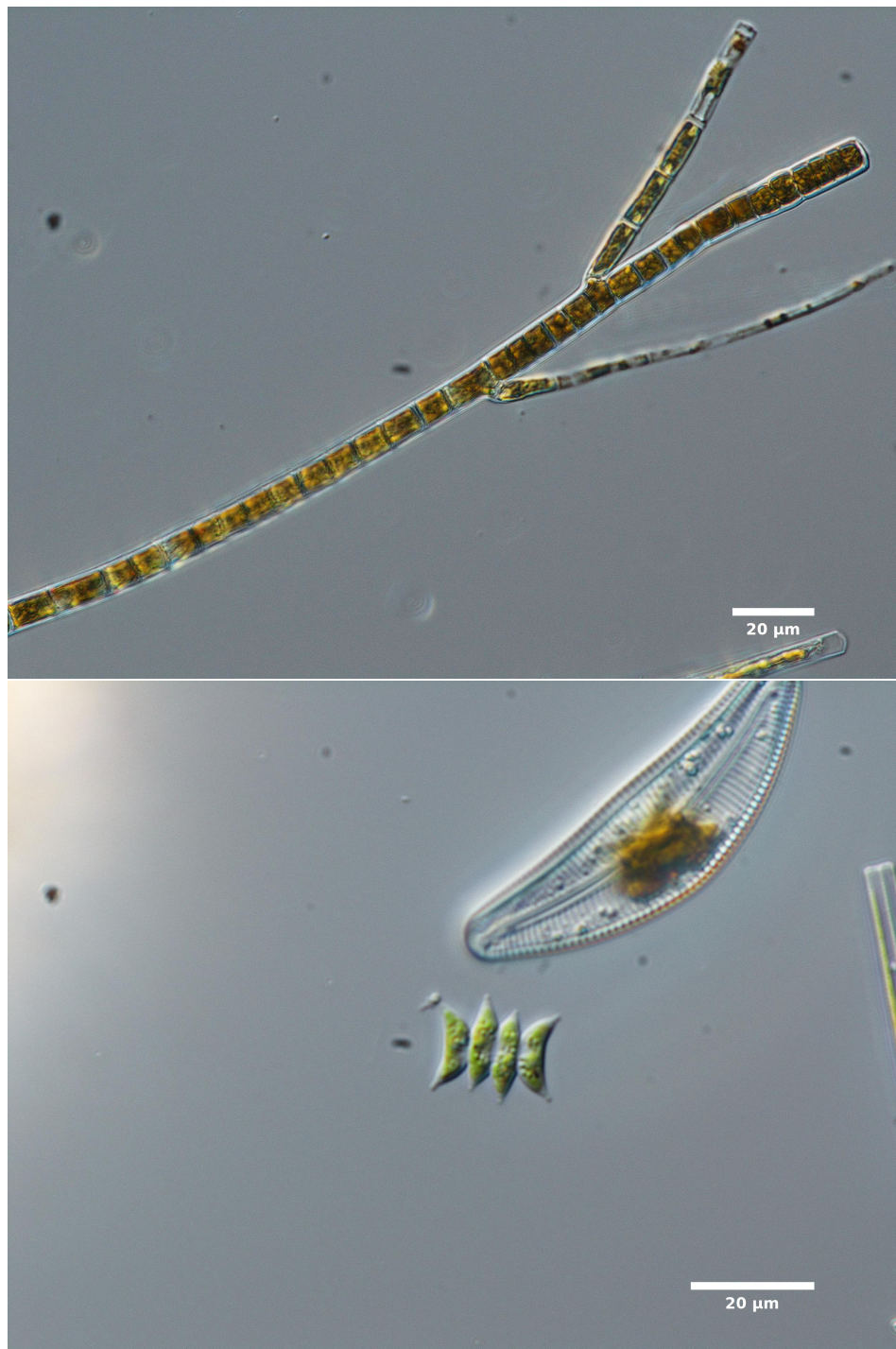


Figure B21: Chlorophyta: *Stigeoclonium*, Site SUNp, December 2020 (upper image); *Tetradesmus dimorphus*, Site JASP, October 2020 (lower image).



Figure B22: Chlorophyta: *Tetradesmus obliquus*, Site CRb, April 2018 (upper image); *Ulothrix*, Site CRb, April 2018 (lower image).

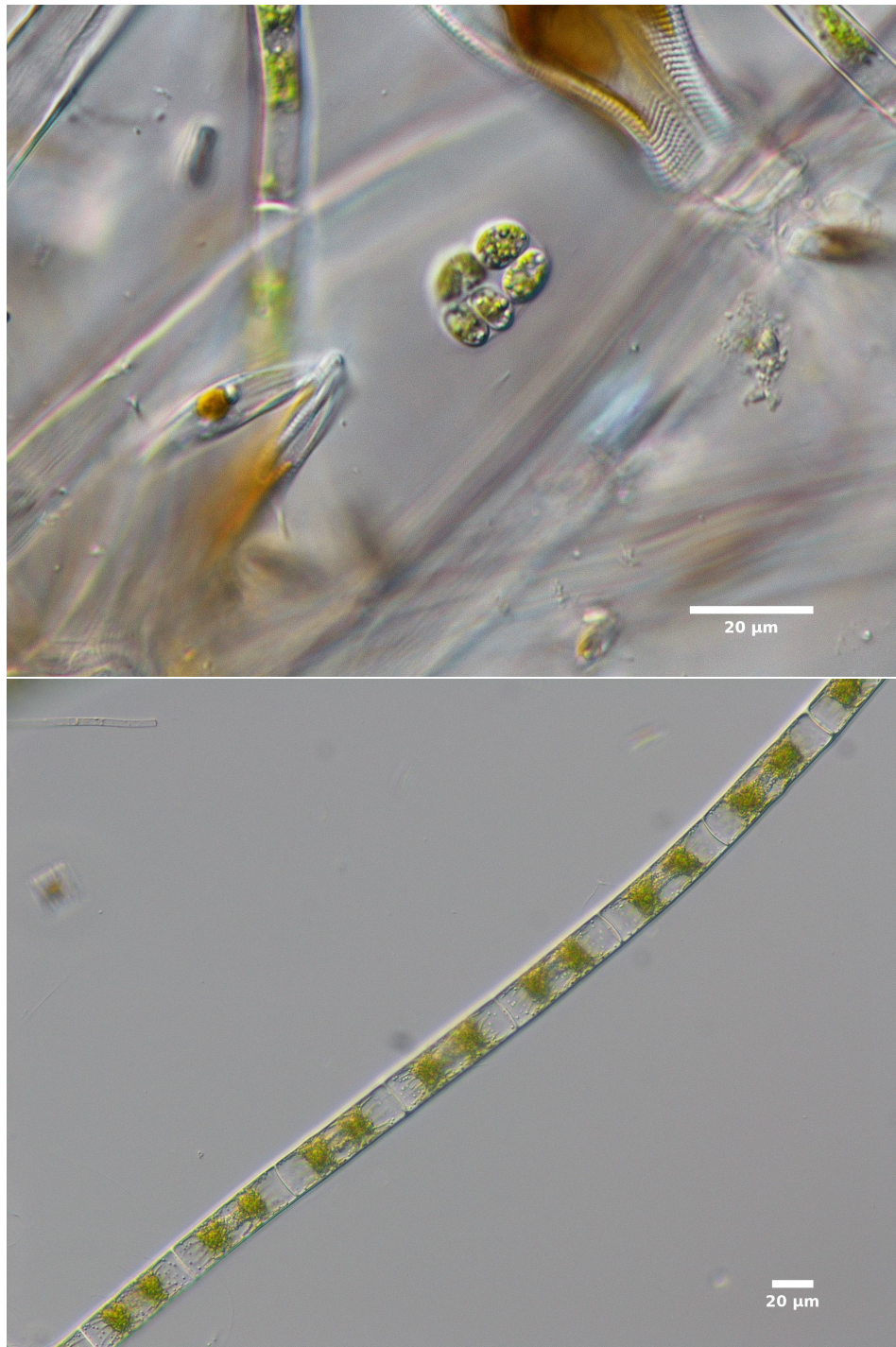


Figure B23: Chlorophyta: *Willea* cf. *rectangularis*, Site CRb, April 2018 (upper image); *Zygnema*, Site 50H, November 2020 (lower image).

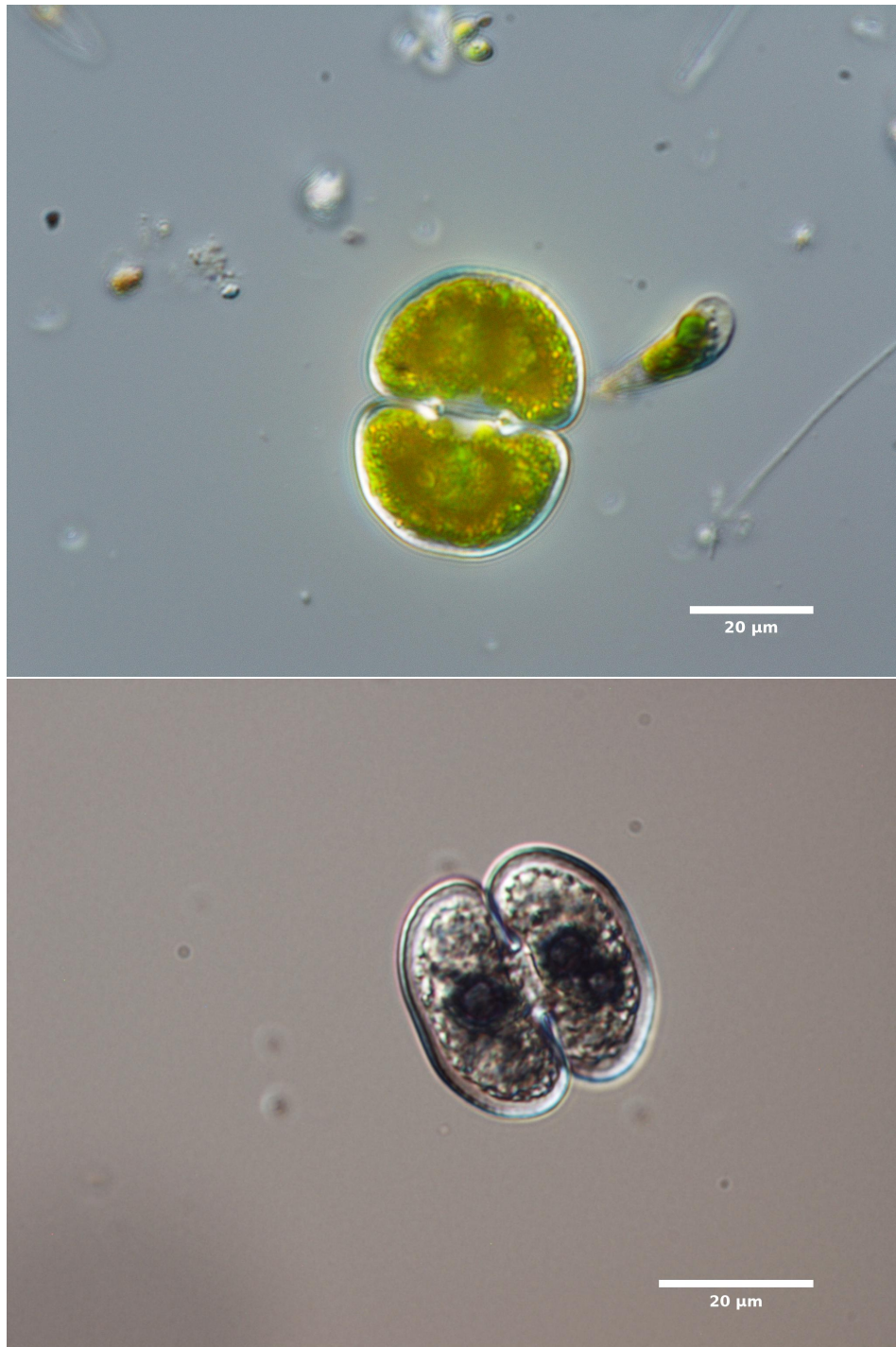


Figure B24: Streptophyta: *Cosmarium*, Site JASP, October 2020 (upper image); *Cosmarium abbreviatum* var. *planctonicum*, Site MARLIT, January 2020 (lower image).

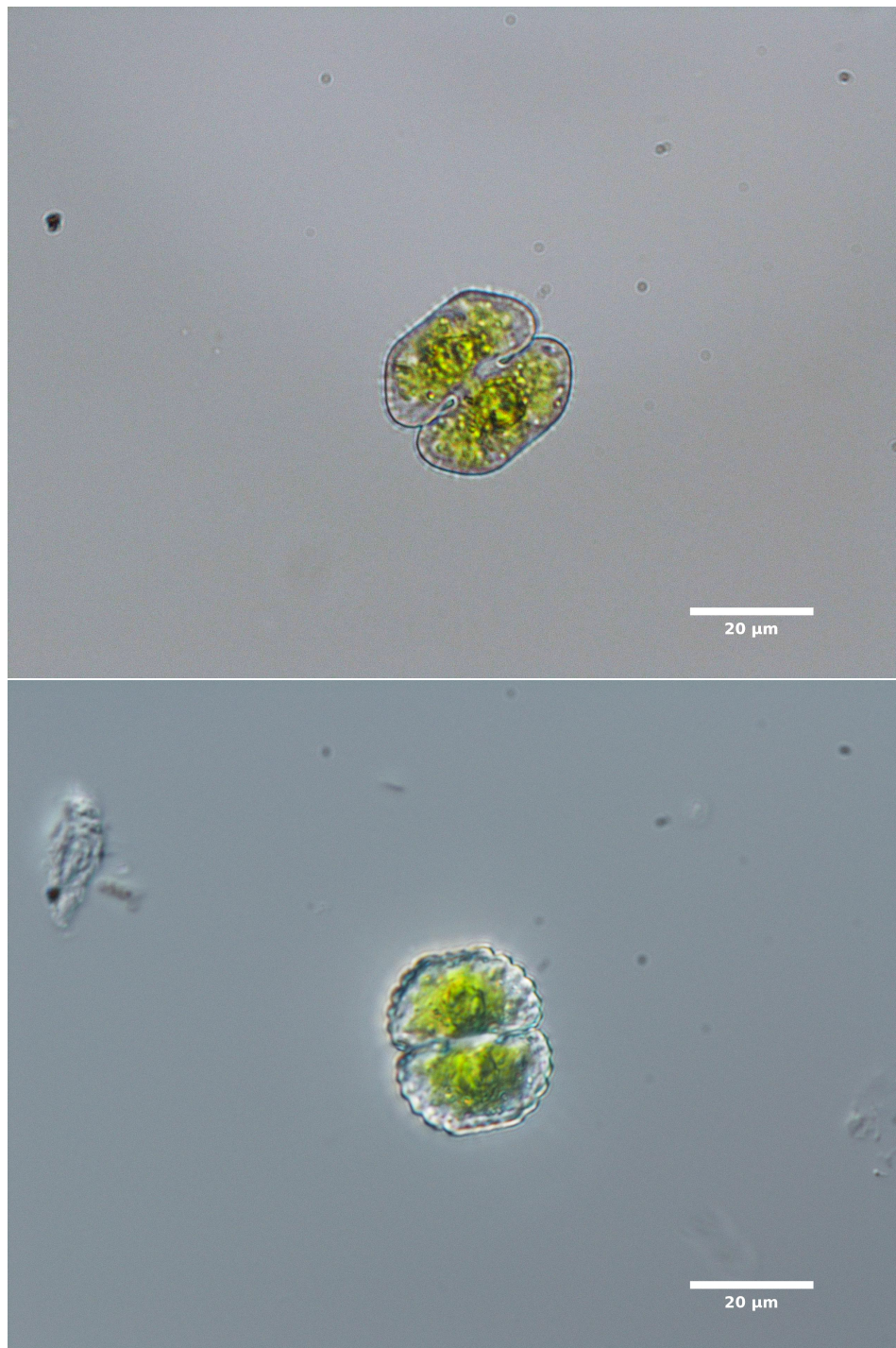


Figure B25: Streptophyta: *Cosmarium cf. bioculatum*, Site ROB, June 2020 (upper image); *Cosmarium cf. blytti*, Site SUNd, October 2020 (lower image).

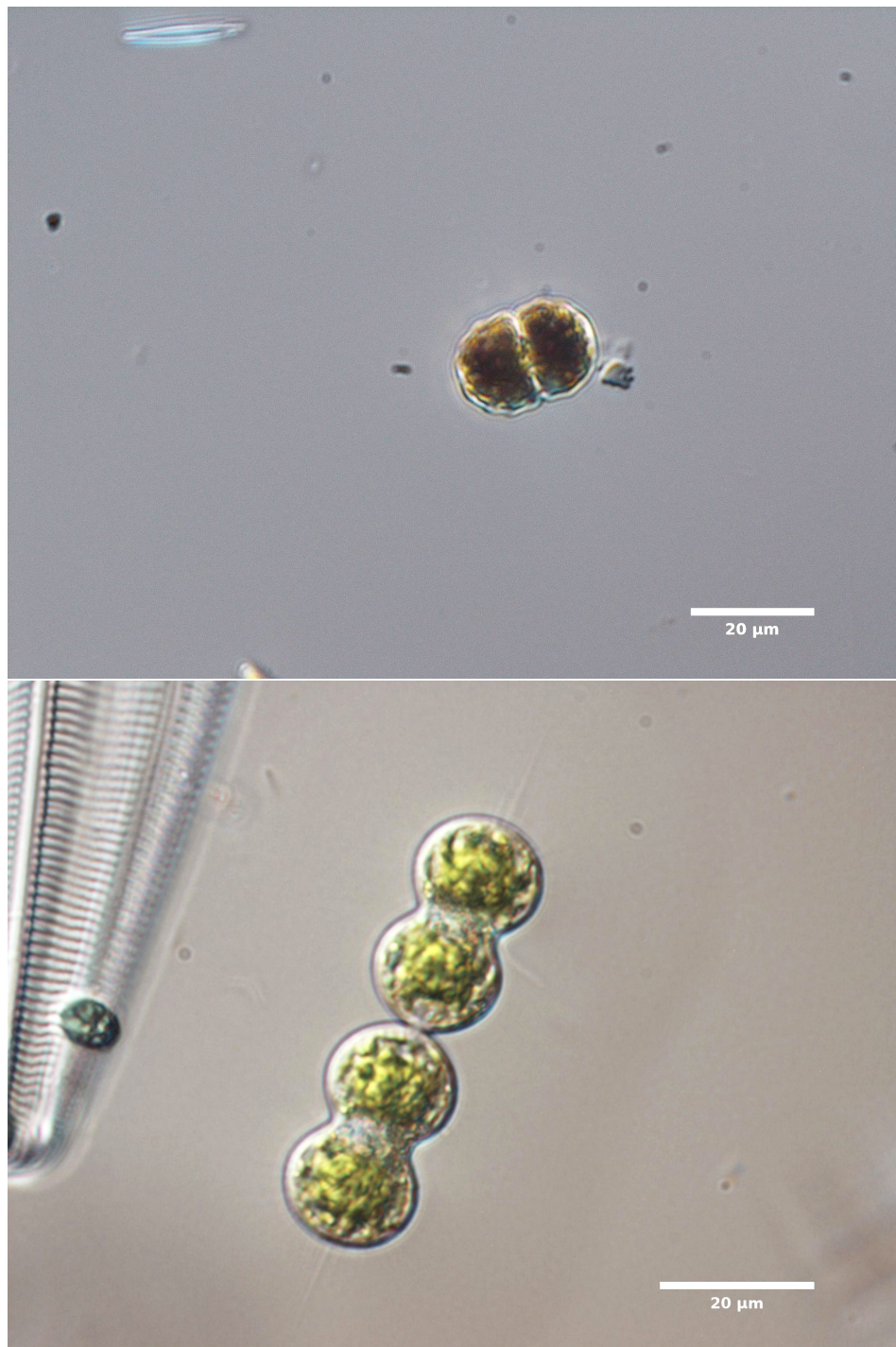


Figure B26: Streptophyta: *Cosmarium laeve*, Site LC-FPA, December 2020 (upper image); *Cosmarium moniliferum*, Site 47-CR-01b, January 2020 (lower image).

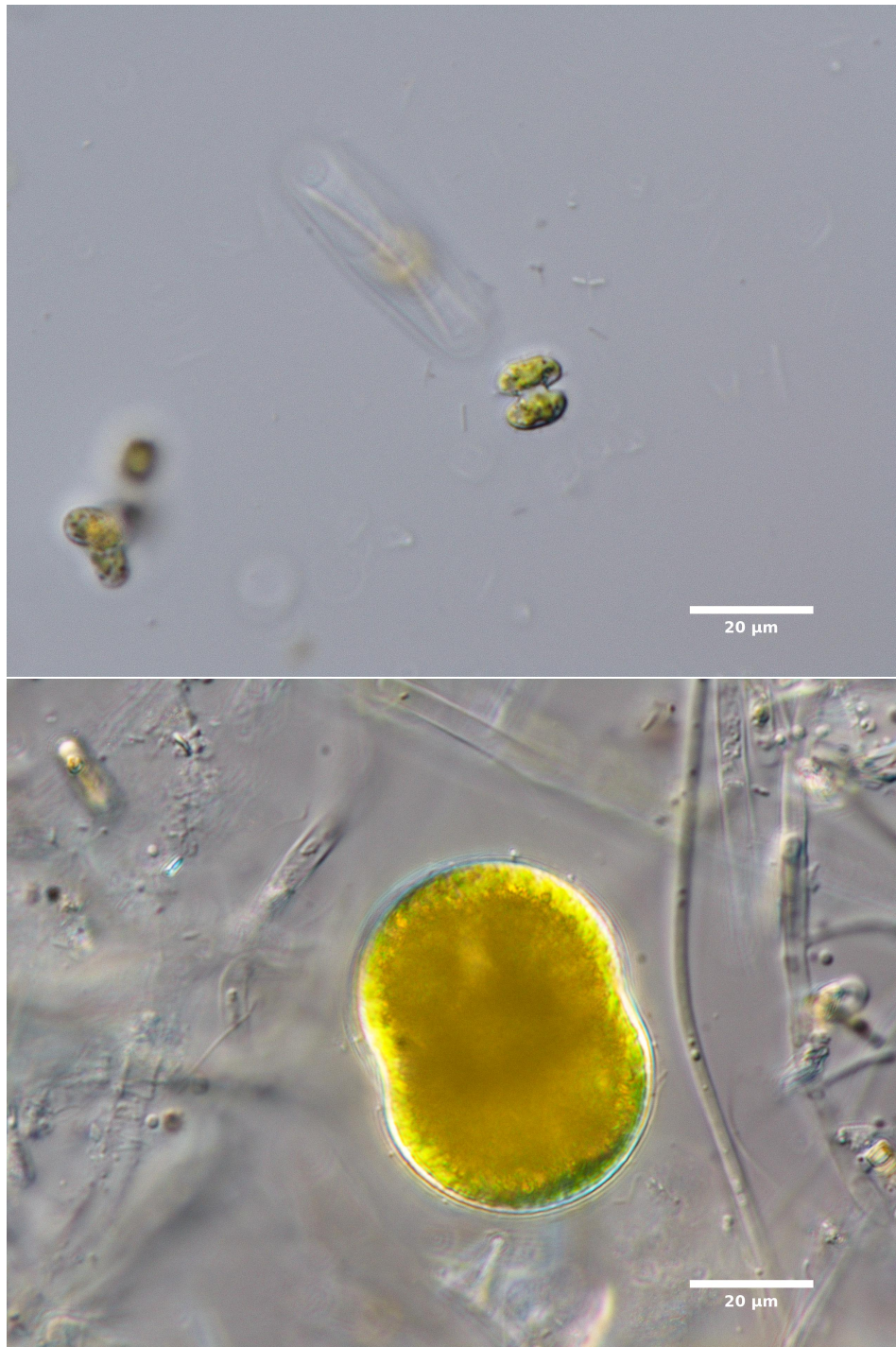


Figure B27: Streptophyta: *Cosmarium* cf. *norimbergensis*, Site CRb, April 2018 (upper image); *Cosmarium pseudoconnatum*, Site SUNp, November 2020 (lower image).

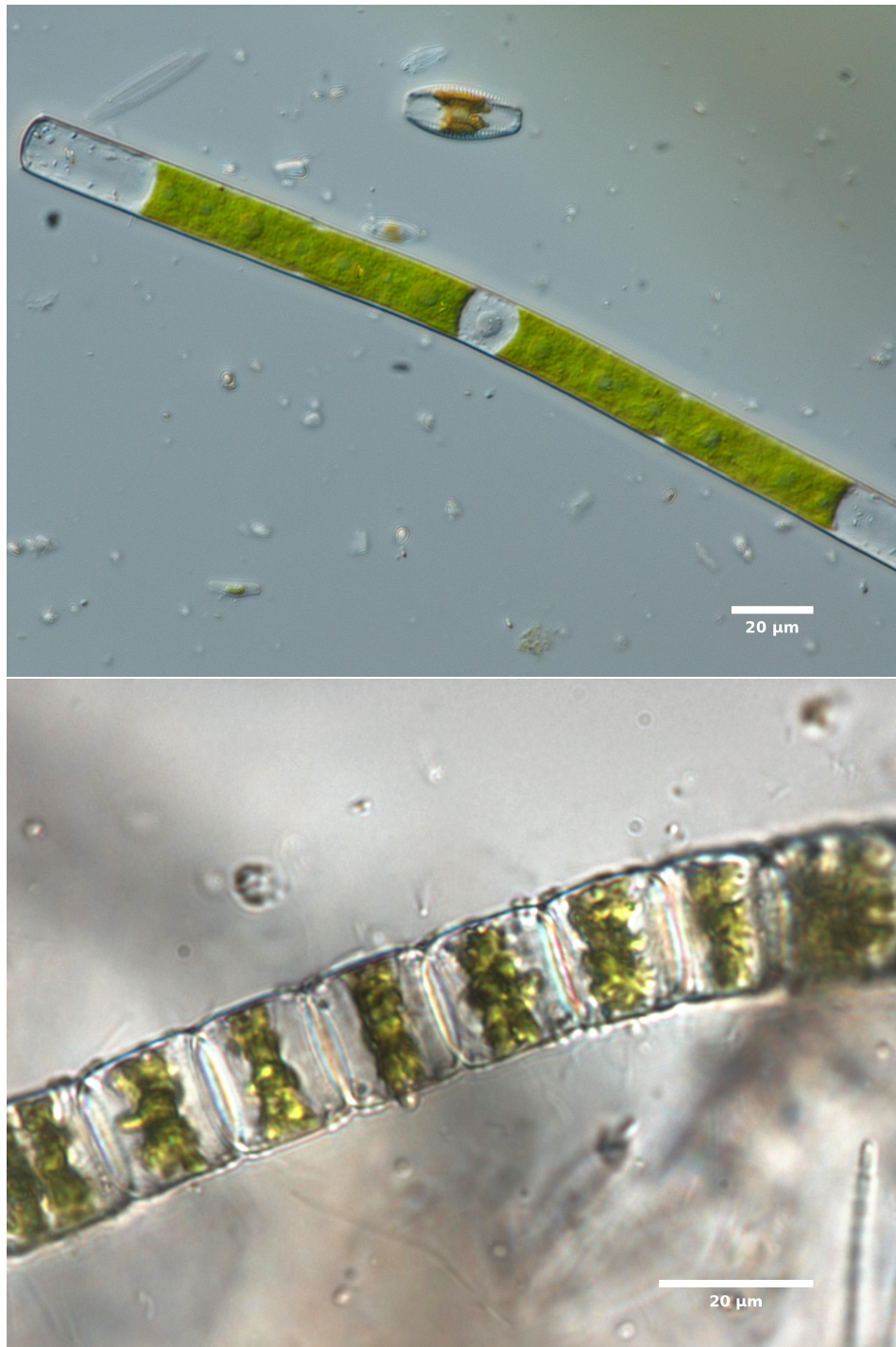


Figure B28: Streptophyta: *Gonatozygon kinahanii*, Site JASP, October 2020 (upper image); *Hyalotheca mucosa*, Site 47-LC-52a, January 2020 (lower image).

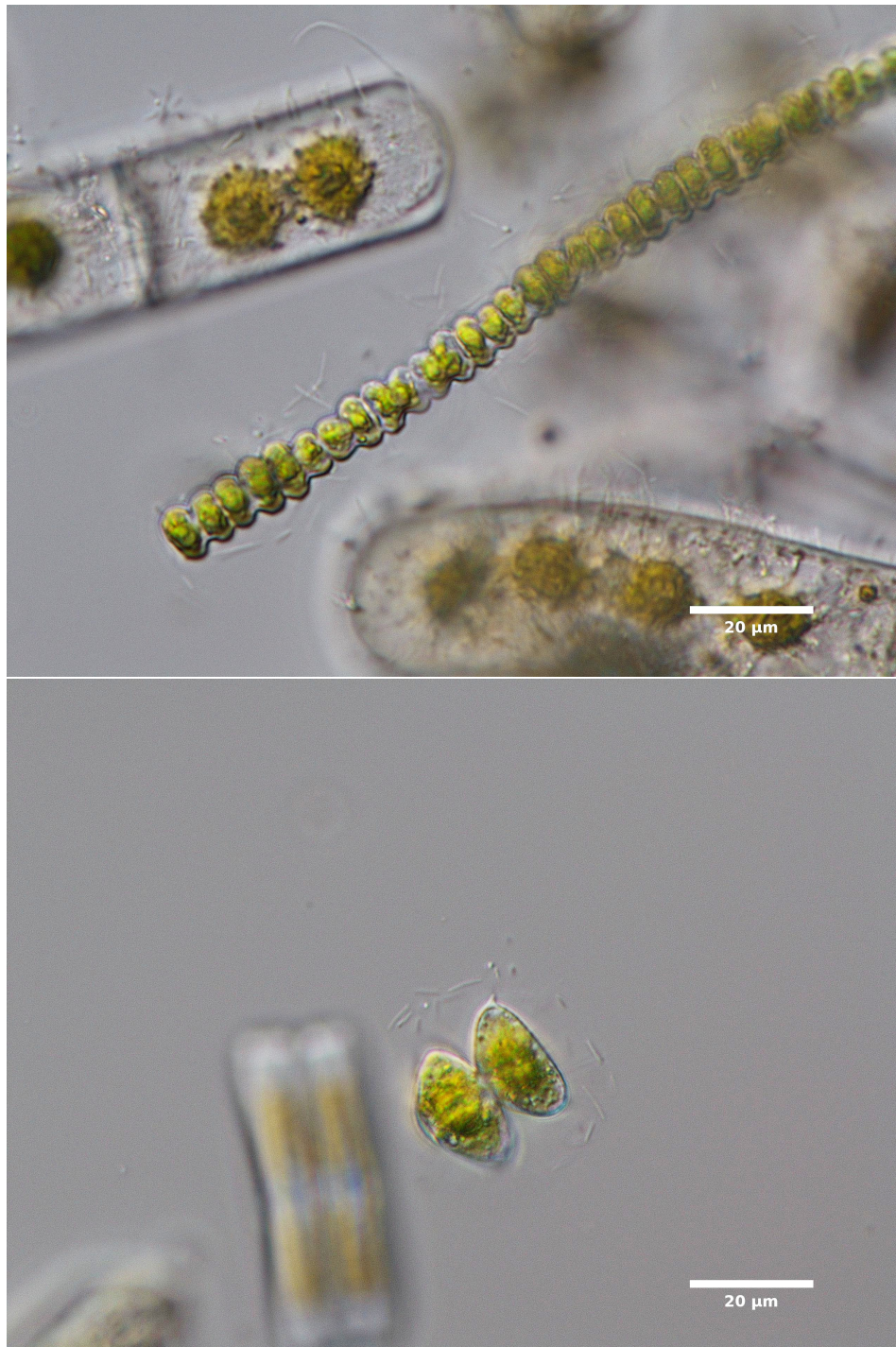


Figure B29: Streptophyta: *Spondylosium planum*, Site CRa, April 2018 (upper image); *Staurastrum*, Site CRa, April 2018 (lower image).

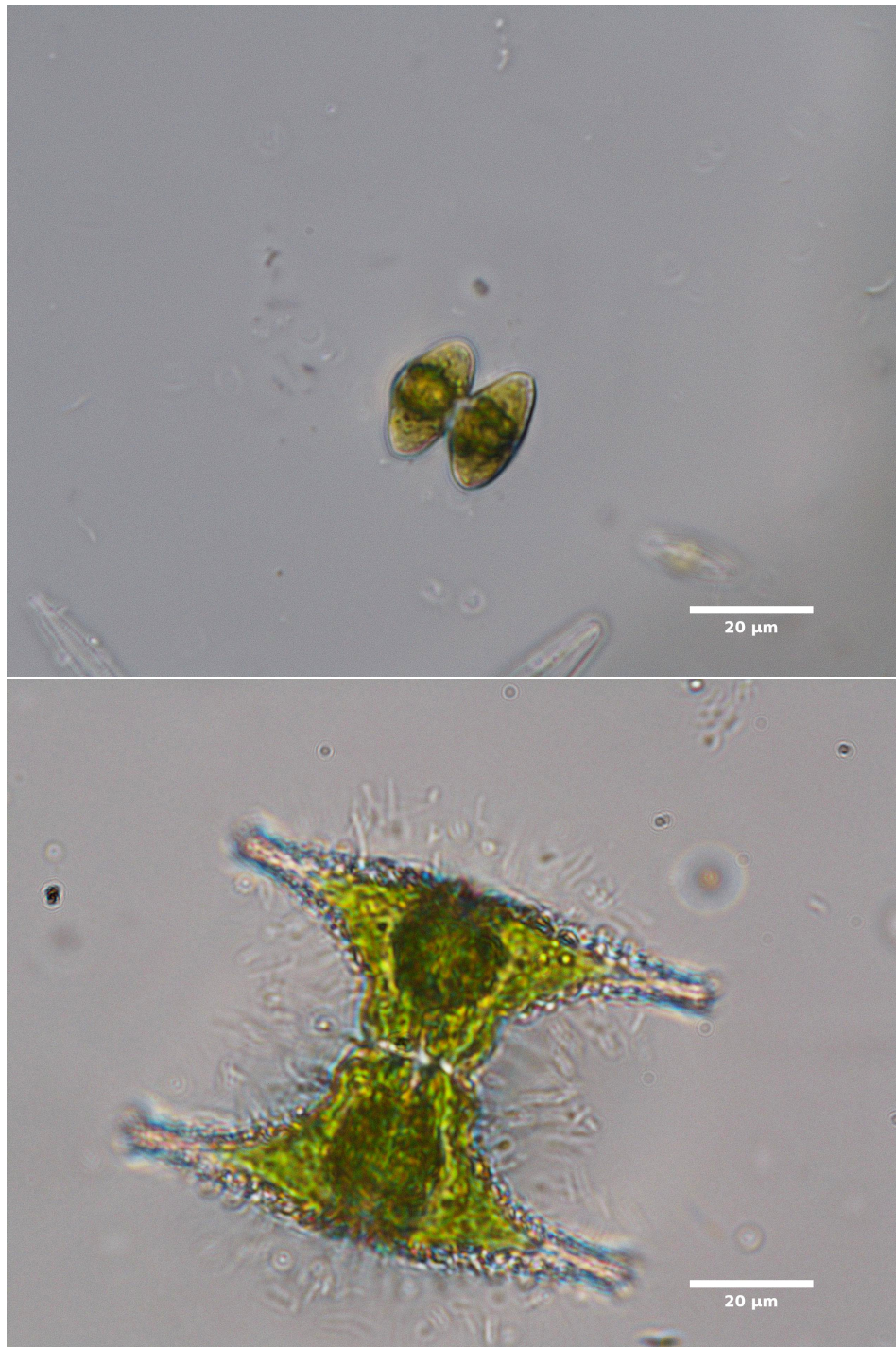


Figure B30: Streptophyta: *Staurastrum* cf. *alternans*, Site CRb, April 2018 (upper image); *Staurastrum* cf. *anatinum*, Site CRA, May 2020 (lower image).

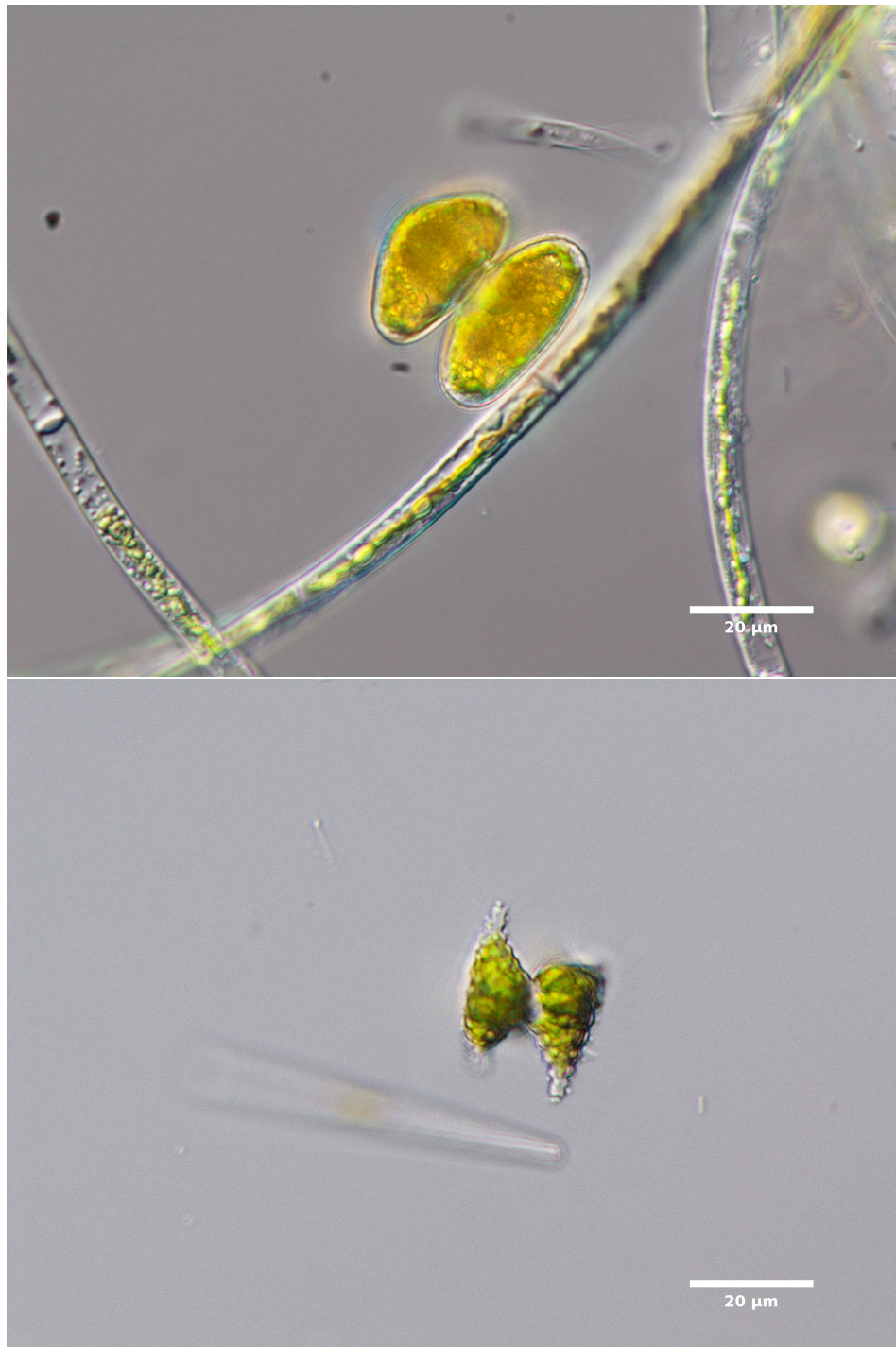


Figure B31: Streptophyta: *Staurastrum* cf. *bieneanum*, Site SUNp, November 2020 (upper image); *Staurastrum cytocerum* var. *inflexum*, Site CRa, April 2018 (lower image).

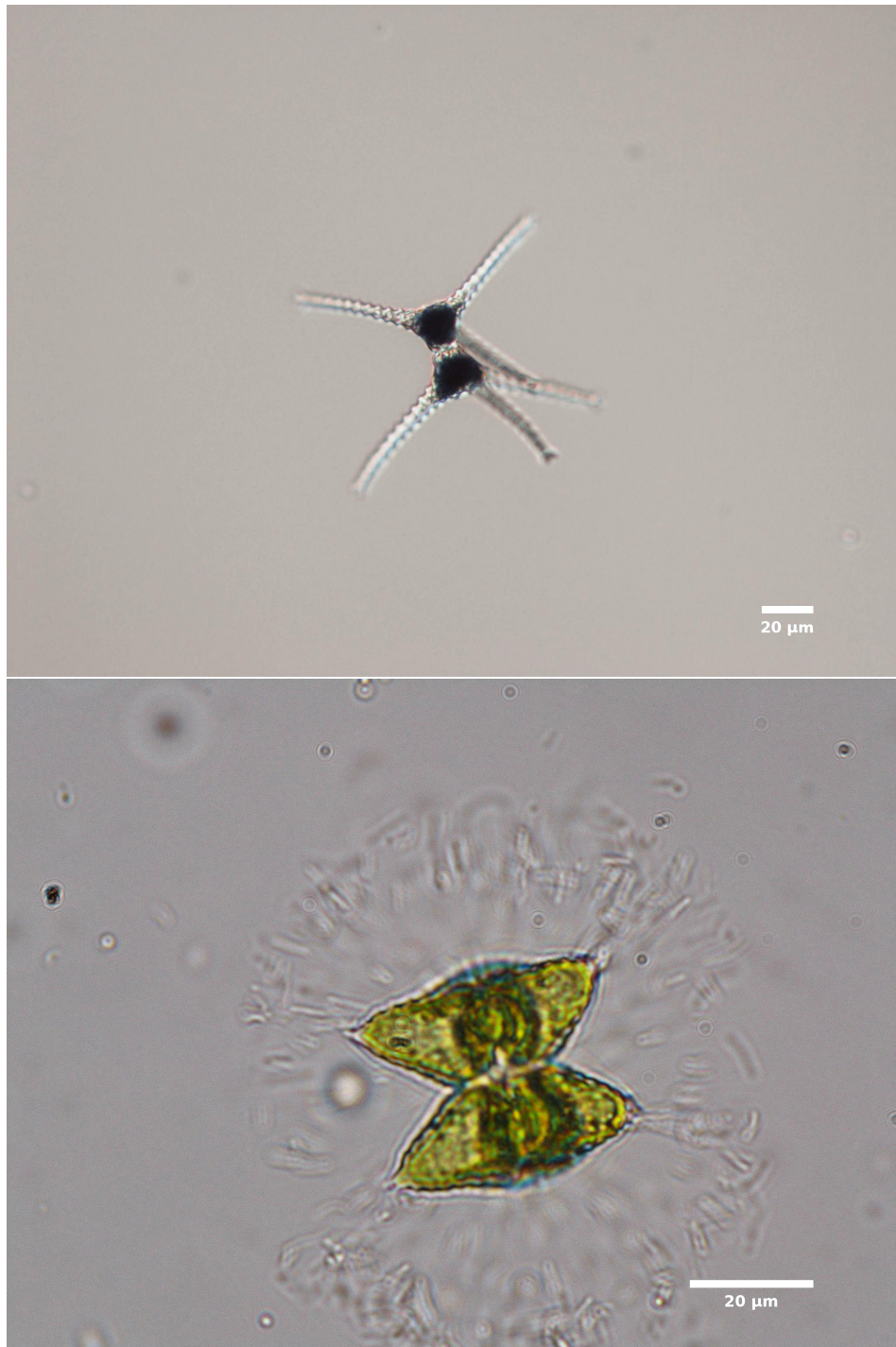


Figure B32: Streptophyta: *Staurastrum cf. longipes*, Site MARLIT, January 2020 (upper image); *Staurastrum cf. lunatum*, Site CRA, May 2020 (lower image).

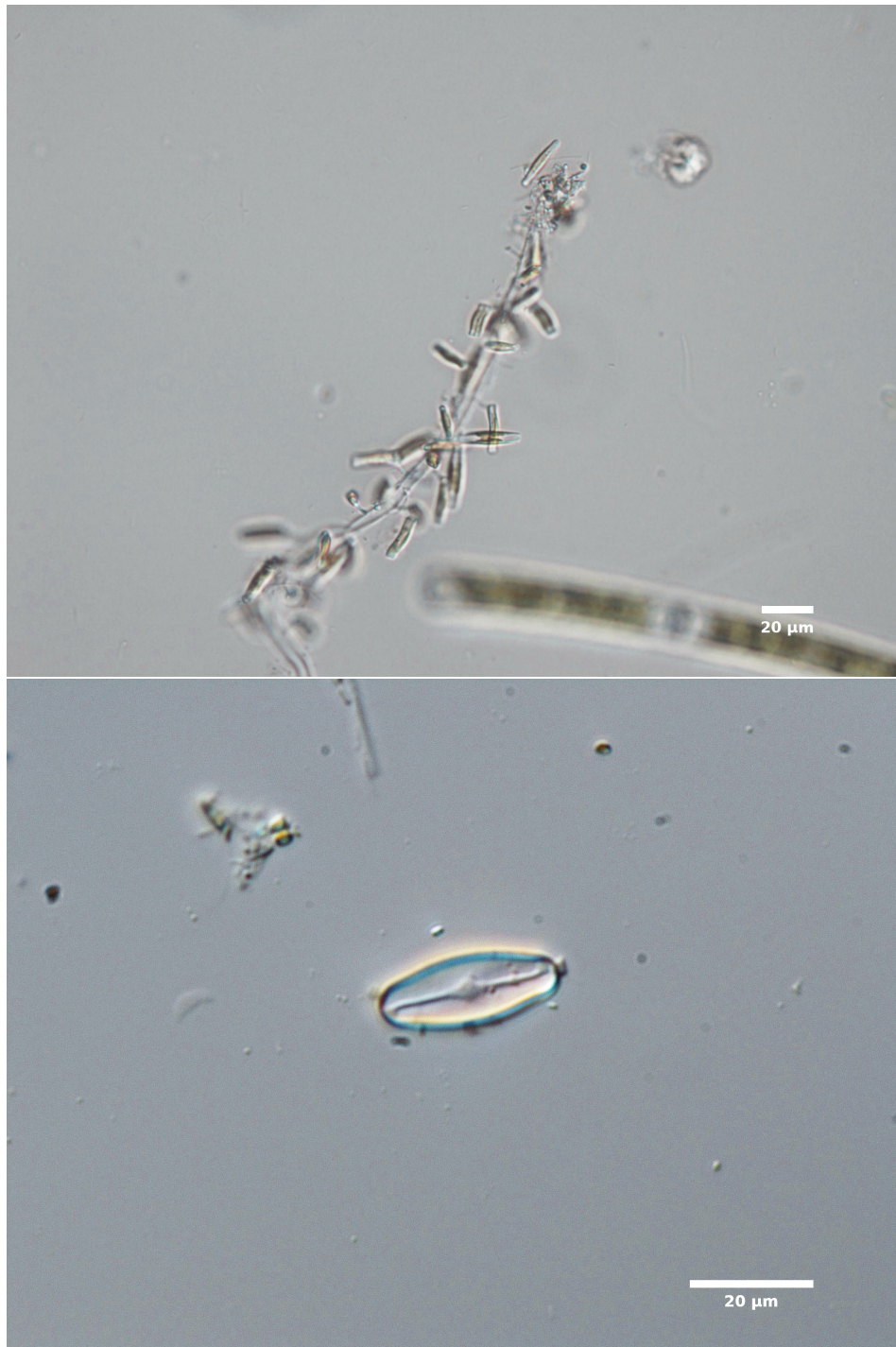


Figure B33: Bacillariophyta: *Achnantheidium minutissimum*, Site 47-CR-01a, January 2020 (upper image); *Cocconeis* group, Site LC-FPA, December 2020 (lower image).



Figure B34: Bacillariophyta: *Cyclotella*, Site MARLIT, January 2020 (upper image); *Cymbella* type, Site JASP, October 2020 (lower image).



Figure B35: Bacillariophyta: *Diatoma*, Site CRa, April 2018 (upper image); *Didymosphenia geminata*, Site CRb, April 2018 (lower image).

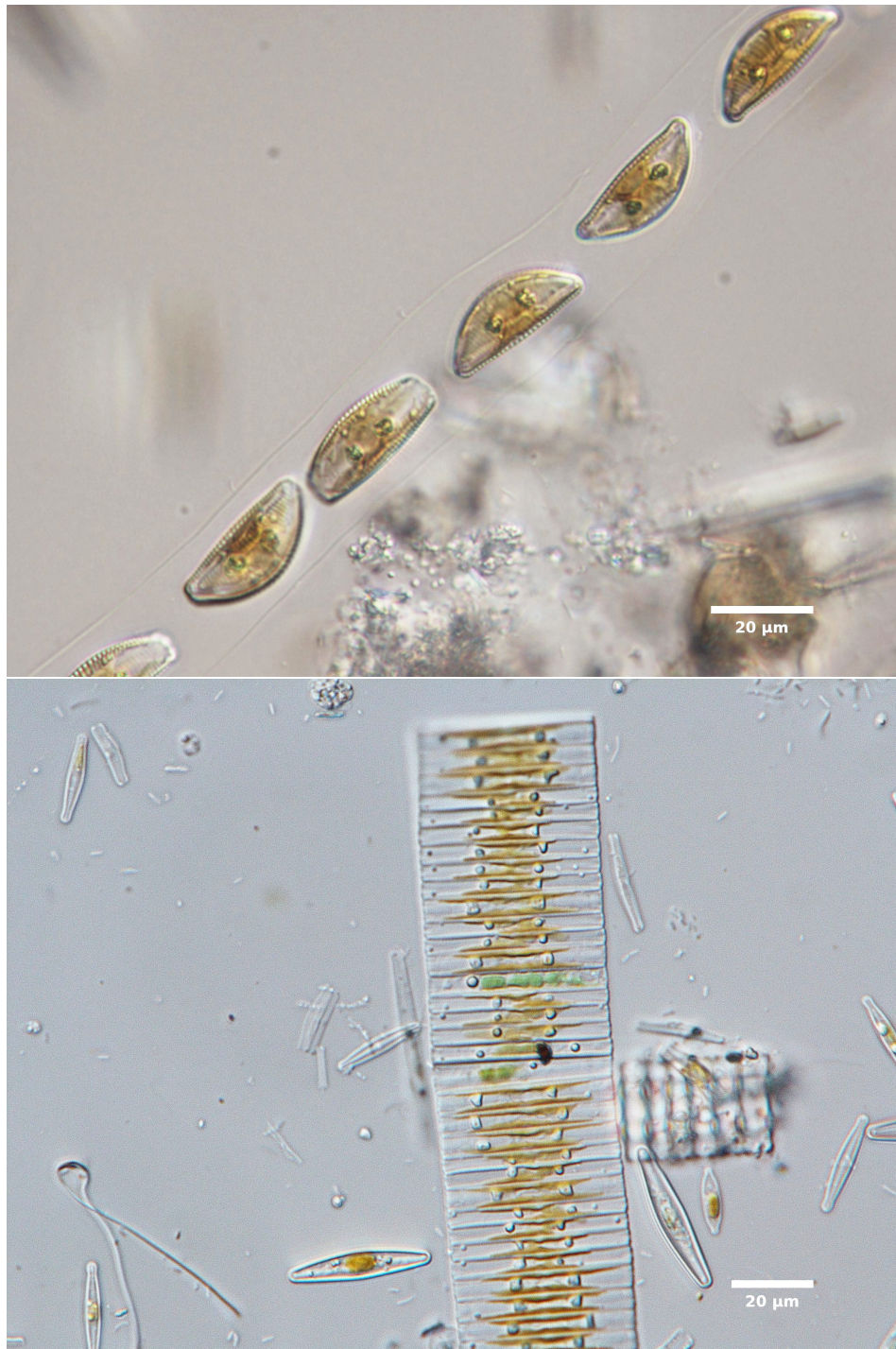


Figure B36: Bacillariophyta: *Encyonema*, Site CR-01b, January 2020 (upper image); *Fragilaria capucina*, Site CRb, April 2018 (lower image).

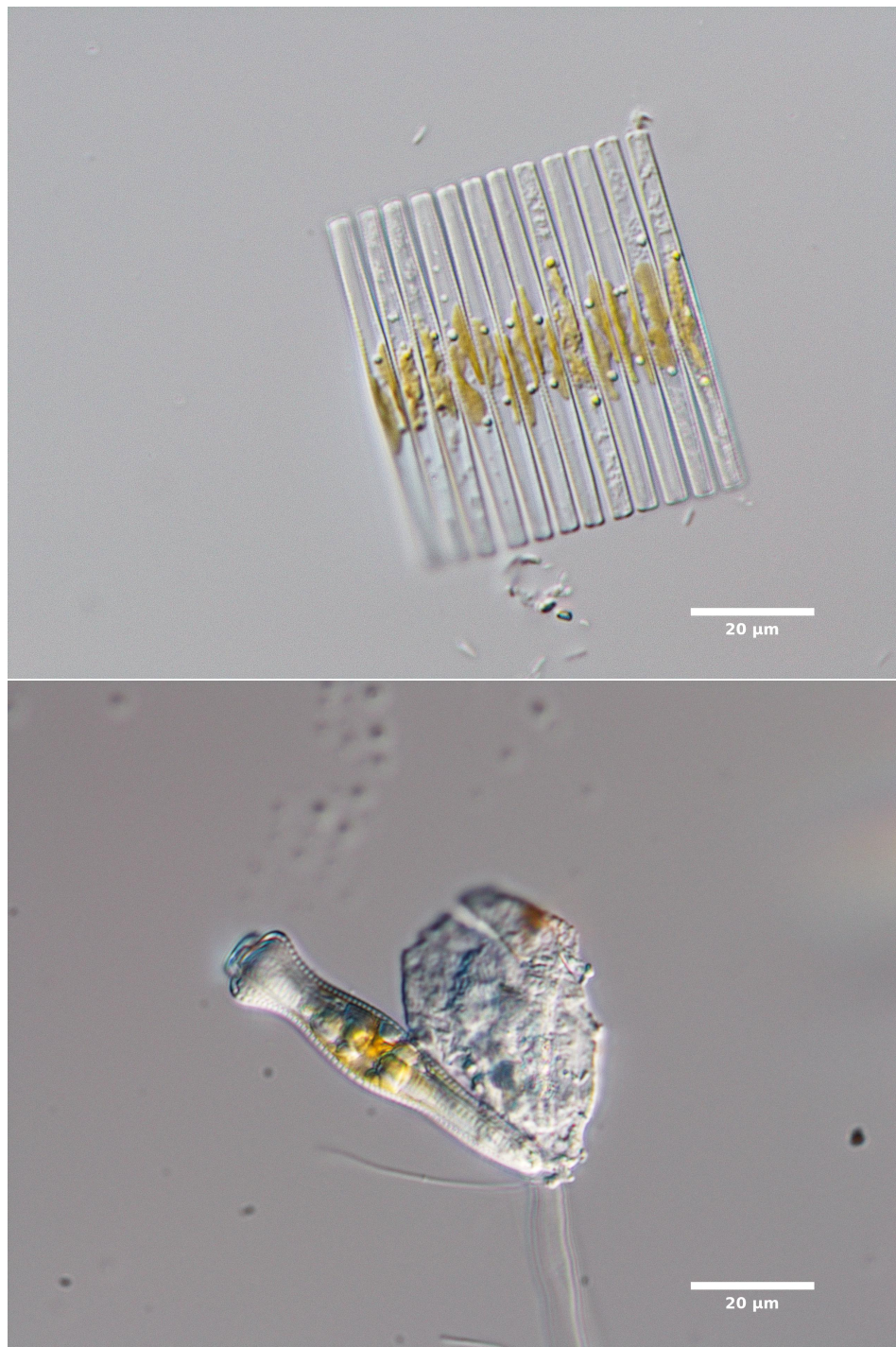


Figure B37: Bacillariophyta: *Fragilaria crotonensis*, Site CRa, April 2018 (upper image); *Gomphonema*, Site SUNp, November 2020 (lower image).



Figure B38: Bacillariophyta: *Melosira*, Site 47-CR-01b, January 2020 (upper image); *Rhopalodia*, Site CRA, May 2020 (lower image).

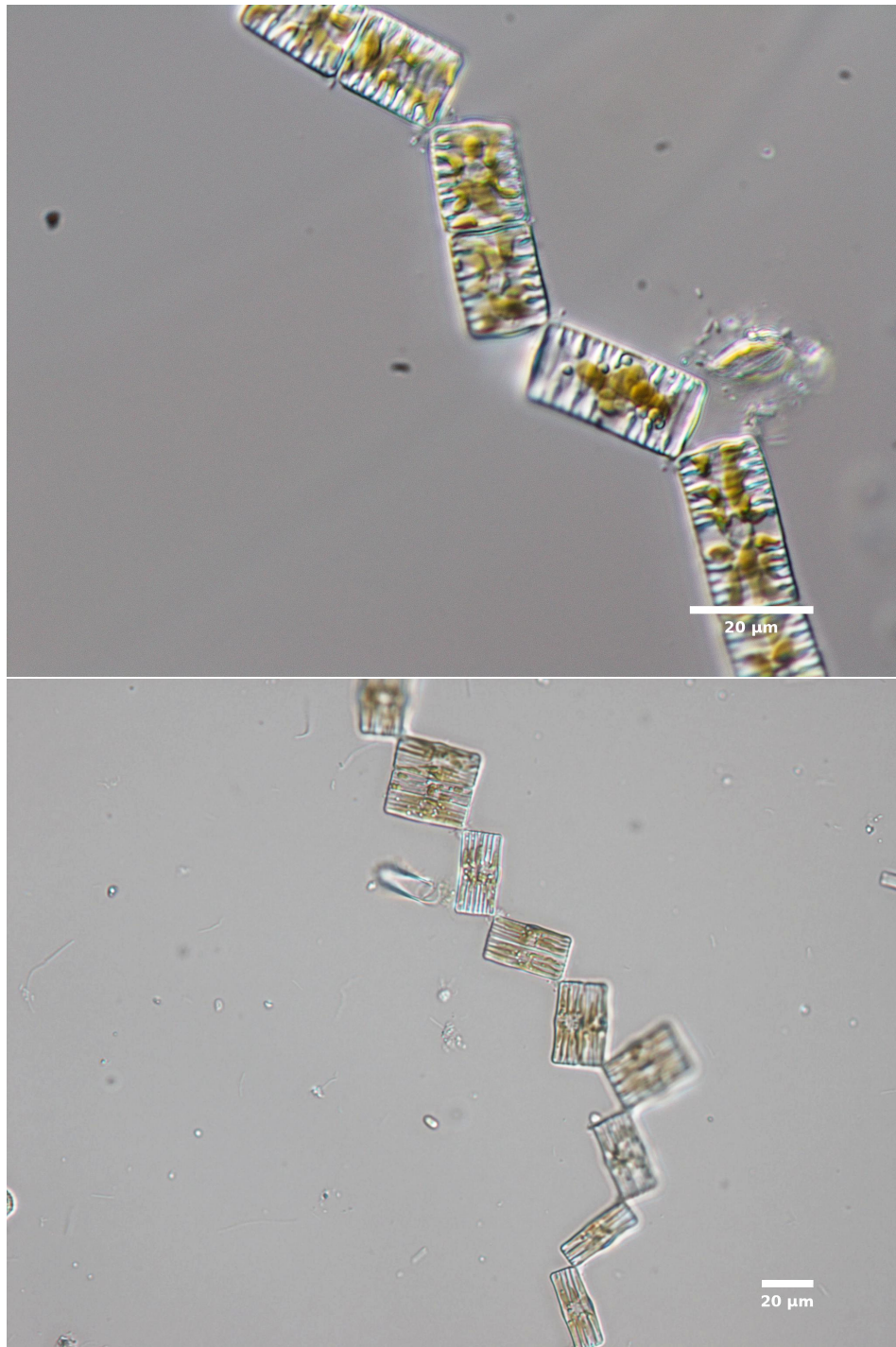


Figure B39: Bacillariophyta: *Tabellaria*, Site 50H, November 2020 (upper image); *Tabellaria flocculosa*, Site 47-CR-01a, January 2020 (lower image).

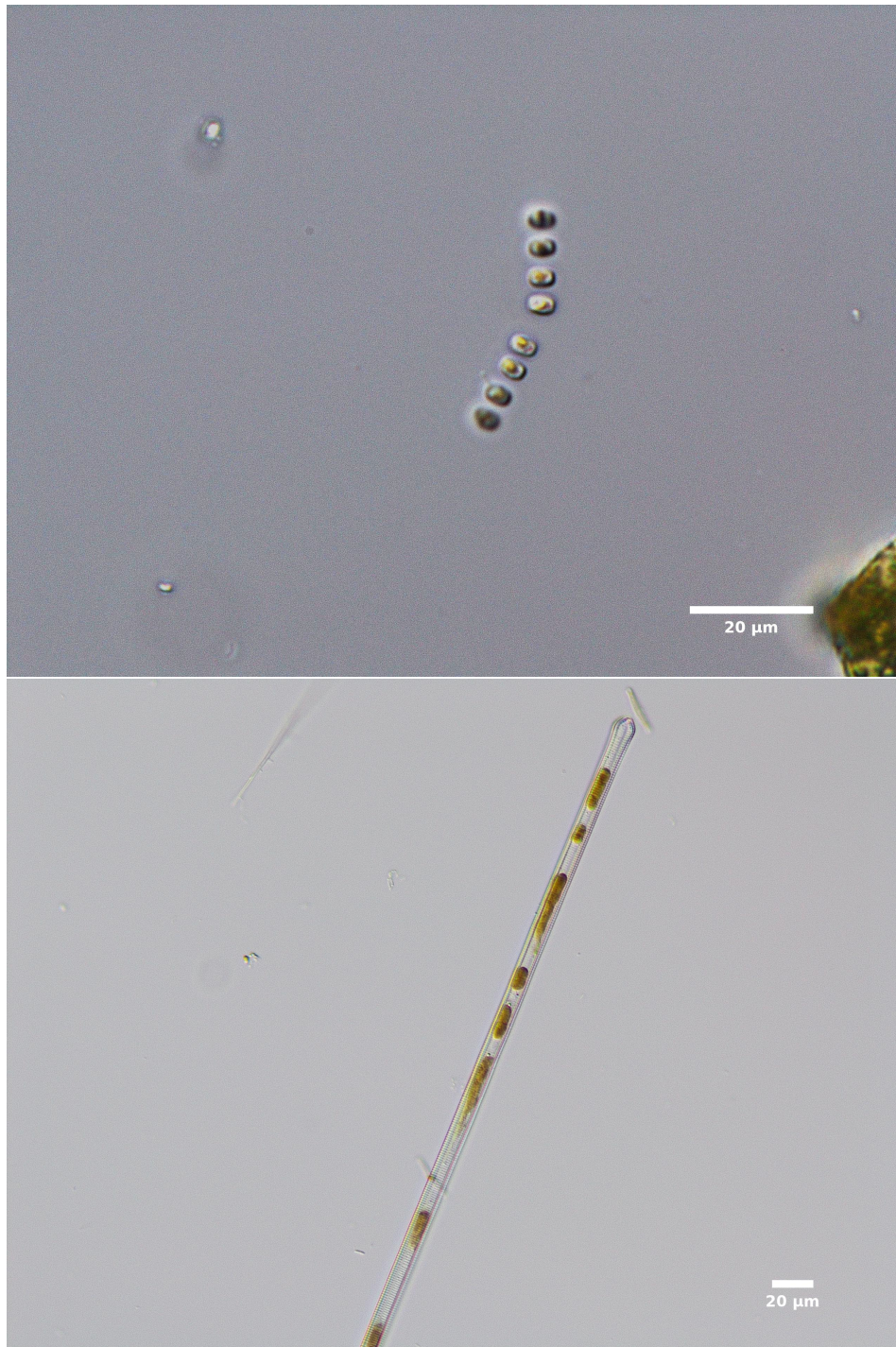


Figure B40: Bacillariophyta: *Thalassiosira*, Site CRa, April 2018 (upper image); *Ulnaria capitata*, Site CRa, April 2018 (lower image).



Figure B41: Bacillariophyta: unk. naviculoid diatom, Site 47-LC-50b, January 2020 (upper image); unk. symmetric biraphid diatom, Site JASP, October 2020 (lower image).

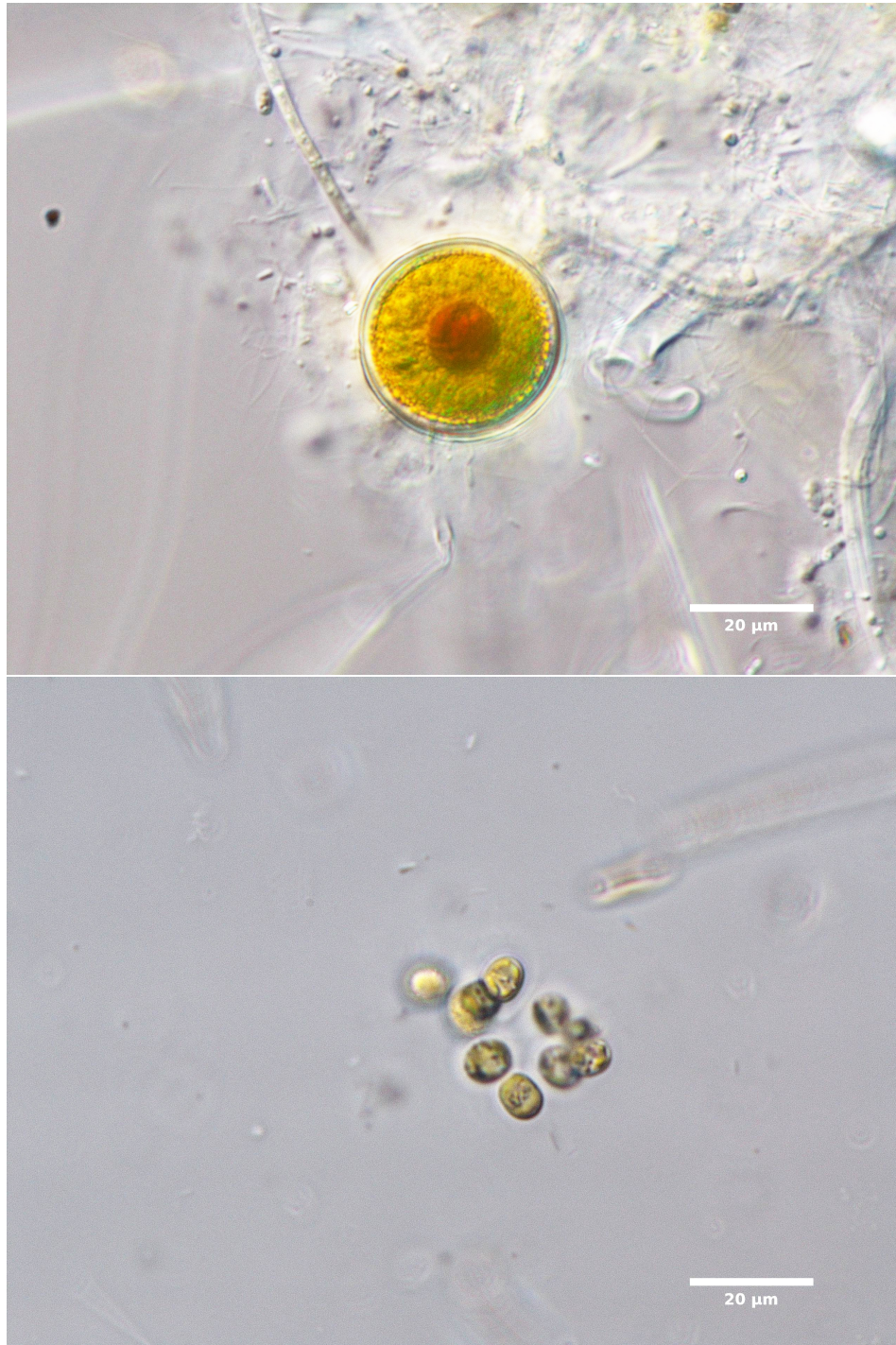


Figure B42: Dinophyta: dinoflagellate cyst, Site SUNd, November 2020 (upper image); Ochrophyta: *Stichogloea olivacea*, Site CRb, April 2018 (lower image).